MINISTRY OF EDUCATION AND SCIENCE OF UKRAINE

NATIONAL UNIVERSITY OF LIFE AND ENVIRONMENTAL SCIENCES OF UKRAINE

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FUNDAMENTALS OF BIODIVERSITY

Textbook
for training students in the specialty
162 "Biotechnologies and bioengineering"

Kyiv - 2023

UDC 574.1(075)
O-75

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Recommended for publication by decision of the academic council
National University of Life and Environmental Sciences of Ukraine
(protocol No. _ dated, 2023)

O-75 **Fundamentals of biodiversity**: textbook. / O.L. Klyachenko, M.M. Lisovyy, O.Yu. Kvasko., 2023. – 315 p.

ISBN

The textbook contains basic theoretical information about the basic concepts of studying biodiversity, its classification, methods of assessment, and preservation. The indicated main threats and problems of today are related to the impoverishment of biodiversity. The textbook is aimed at familiarizing future specialists with the basic principles of monitoring, inventory of species diversity and wealth, analysis of primary information, etc.

For students, postgraduates, teachers, and research staff of biological, ecological, and agricultural universities specializing in the field of biology, biotechnology and ecology, and environmental protection.

У підручнику викладено основні теоретичні відомості про базові концепції вивчення біорізноманіття, його класифікації, методи оцінки та збереження. Вказані основні загрози та проблеми сьогодення пов’язані зі збідненням біорізноманіття. Підручник спрямований на ознайомлення майбутніх фахівців з базовими принципами моніторингу, інвентаризації видового різноманіття і багатства, аналізу первинної інформації та ін.

Для студентів, аспірантів, викладачів та наукових співробітників біологічних, екологічних та аграрних вузів, які спеціалізуються в галузі біології, біотехнології і екології та охорони навколишнього середовища.

UDC 574.1(075)

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CONTENT

PREFACE

The biological diversity of our planet is the product of long-term evolution, which developed through complication of the systemic organization of living organisms and through increase of numbers and variety of life forms. Biodiversity itself became the potential on the basis of which the Earth's biosphere was revived every time it was on the verge of destruction. At the same time, the biological mass of living organisms and their diversity tended to grow and increase. However, this trend had an unstable temporal character: periods of rapid growth were replaced by sharp declines, which were caused by not always established causes, global in nature. In the initial periods of the formation of the biosphere, the species diversity of the biosphere was increasing, but then stabilized and remains relatively constant since then.

Nowadays, there is a significant reduction in biological diversity due to the elimination of species. Under the influence of anthropogenic factors, the rate of extinction of species has exceeded the natural rate by many times. An irreversible and uncompensated process of destruction of the planet's unique gene pool is taking place. Destabilization of the biota can lead to the loss of the ability of the biosphere to maintain the necessary quality of the environment and, ultimately, the sustainable development of civilization.

Awareness of biological diversity as a unique property of nature and its role in preserving life on Earth has become an integral part of modern views on the relationship between nature and society.

The problem of preservation and rational use of natural biodiversity has become one of the priorities for the developed countries of the world. Authoritative international organizations, scientific institutions, and the progressive world community are involved in its solution. The future of countries, their sustainable development, and the preservation of the moral and ethical platform of civilization depend on success in this difficult task.

The textbook "Fundamentals of Biodiversity" for students studying "Biotechnology" is aimed at familiarizing future specialists with the basic principles of monitoring, inventorying species diversity and richness. Young scientists and specialists in the biological, ecological and agricultural specialities must possess the basic concepts of biogeography, evolutionary ecology, take into account diversity at different levels of life organization: molecular, genetic, cellular, taxonomic, ecological and others, understand the laws of anthropogenic transformation of flora and fauna, be able to take into account the peculiarities of the spread of invasive species and predict their impact on species richness and stability of natural ecosystems and assess possible risks.

The textbook "Fundamentals of Biodiversity" explains the concept of modern diversicology, which developed through the formation of idea about the emergent properties of ecosystems, classifications of biodiversity, levels of diversity research and synecological relationships, modern threats to biological diversity and measures to preserve flora and fauna.

The theoretical course is supported by the practical developments of the authors of the textbook, which provide an opportunity for future specialists to master the skills of collecting and analyzing primary information, assessing species richness and diversity, determining the level of dominance of individual species in the biocenosis, assessing the age composition of organisms in populations, and determining indices of similarity of flora and fauna.

The textbook "Fundamentals of Biodiversity" will be useful for students and postgraduates of biological profile, ecologists and biotechnologists.

INTRODUCTION

Biodiversity is the national wealth of Ukraine, the preservation and tireless use of which is recognized as one of the priorities of state policy in the field of nature management, ecological safety, and environmental protection, an integral condition for improving its condition and ecologically balanced socio-economic development.

Biological diversity is one of the fundamental phenomena that characterize life on the planet. The diversity of biological structures and processes is the basis of the organization of the biosphere in all its global manifestations. Based on biodiversity, the structural and functional organization of the living matter of the biosphere and the components of its ecosystems is created, which determines the stability and resistance of the latter to external influences.

Biodiversity has a dominant role in the circulation of matter, energy, and information, which ensures ecological stability. It occupies the main areas of the planet and takes part in various ecological processes, and also plays a significant role in the functioning of ecosystems. Until recently, the role of biodiversity in biogeocenoses, and especially in its future, was actually not investigated. It is not known exactly how many species of biodiversity live on the planet. To date, about 1.5 million species have been described, while, according to experts, there are 5 to 100 million species living on the planet today. Taking into account the anthropogenic and climatic factors that pose a threat to biodiversity, it is extremely important to study the state of fauna and flora, and study and preserve the species biodiversity of Ukraine.

DEFINITION OF BIODIVERSITY

The modern biosphere, the habitat of all living organisms, is at the same time a product of their biological processes: constant reproduction, metabolism (substance exchange) and postmortem decomposition of living beings. All components of the living environment – in soil, water, land, air – are the result of constant interaction and interpenetration of living and non-living matter. No species of living organism can exist exclusively among its own kind. Life is possible only in multicomponent communities (biocenoses) and with a certain set of conditions characterizing their habitat (biotope).

The number and diversity of the planet's inhabitants corresponds to the diversity of ecological niches in biogeocenoses. Millions of biological species are the main resource and the basis of stability (homeostasis) of the biosphere. When describing the structure and properties of ecosystems, indicators of species diversity are usually described first. In addition, structural diversity, which characterizes the number of habitats and ecological niches, and genetic diversity within populations are considered. All these indicators are important for the formation of adaptive capabilities of the ecosystem. Protecting the biodiversity of our planet is an urgent task of our time, as many species are dying out due to man-made impact on natural ecosystems. This process accelerated catastrophically in the 20th century and lead to the loss of stability of individual ecosystems and the biosphere as a whole.

The phrase "biological diversity" was probably first used by Bates Henry Walter (1825–1892), English naturalist and traveler, known mainly for his work on mimicry of insects. He was so impressed by the 700 species of butterflies that were encountered during an hour-long excursion in the Amazon forests that he coined the term, which over time gained enormous popularity.

This concept entered wide scientific use in 1972 at the Stockholm UN Environment Conference, where ecologists managed to convince politicians that the protection of nature should become a priority in the implementation of any human activity on Earth.

The concept of "biodiversity" acquired a wide international recognition since the signing of the Convention on Biological Diversity (1992, Rio de Janeiro). To date, the concept of biodiversity has acquired global significance, as scientific problems and aspects of today are closely intertwined with social, legal, economic, political ones, etc.

Biological diversity is one of the few general biological terms, the wording of which is fixed at the level of international agreements:

" Biological diversity » means the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems. – Convention on biological diversity Rio de January from 5 June 1992.

Biodiversity is considered at three levels: genetic, species and ecological (ecosystem) (Fig. 1).

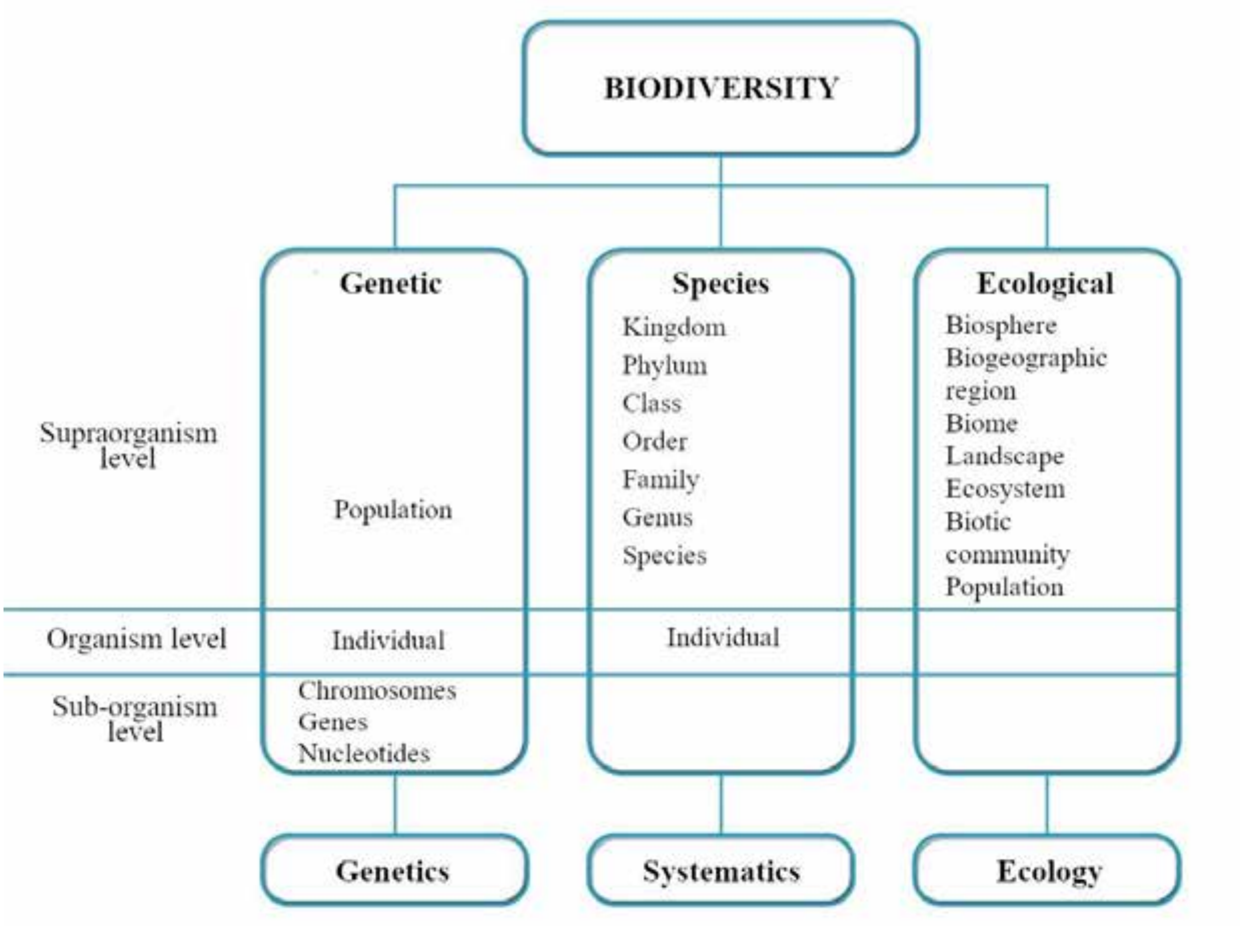

Fig. 1 **The structure and levels of studying biodiversity**

Genetic diversity is the entire volume of heritably fixed information contained in the genes of all living organisms on the planet.

Species diversity reflects the number of species and the frequency of occurrence of individuals of different species in specific territories.

Ecological (ecosystem, landscape) diversity is formed by a set of various locations of biotic communities and ecological processes within individual ecosystems and the biosphere as a whole.

Sometimes a variety of landscapes is allocated to a separate category, which reflects the peculiarities of the territorial structure and the influence of local, regional and national cultures of society.

All types of biological diversity are interconnected: genetic diversity provides species diversity; the diversity of ecosystems and landscapes creates conditions for the formation of new species; increase in species diversity increases the overall genetic potential of living organisms of the Biosphere. Each species contributes to diversity – from this point of view, there are no unnecessary or harmful species.

Biological diversity is a unique feature of living beings. It is thanks to it that the structural and functional organization of ecosystems is formed, which ensures their stability and resistance to changes in the external environment, including those caused by anthropogenic influences.

IMORTANCE OF BIODIVERSITY

The emergence of the diversity of living systems during the evolution of the biosphere was due to differences in the living conditions of organisms and their different functional roles in biocenoses. The existence of biological diversity on Earth is of fundamental importance.

1. Biological diversity provides the main functions of the biosphere:

- production of organic matter;
- destruction of organic matter;
- course of biogeochemical cycles of substances and energy flows.

Groups of organisms – producers, consumers and decomposers form chains in which each species and each group performs certain functions. No species and no functional group can perform all stages of biogeochemical cycles, this requires the interaction of all groups:

- producers – synthesis of organic matter;
- consumers – the flow of energy through the stages of the food goal;
- decomposers – destruction and mineralization of organic matter.

2. Biological diversity allows for the most efficient use of environmental resources. Each of the currently available species is adapted for the most effective functioning in certain ecological conditions – its own ecological niche. At the same time, multispecies communities are able to use environmental resources as fully as possible and with the least intensity of competitive relations.

3. The presence of biological diversity ensures the continuity of the biospheric layer of the Earth, according to V.I. Vernadskyi: "In different climatic zones, different types of ecosystems function, in different environments of the biosphere (aquatic, terrestrial, soil) live certain types of organisms adapted to them. Even within one species there is a variety of alleles, genotypes, geographic races, populations that are adapted to specific conditions".

4. Biological diversity ensures continuity of life over time. In various historical eras, changes in the conditions of habitats occurred and are occurring on

Earth, but among organisms there were always forms capable of existing in new conditions – pre-adapted to them, while other organisms that did not have such adaptations died out.

5. Biological diversity ensures biosphere homeostasis: each species in the ecosystem is under the regulatory influence of other species that prevent its excessive reproduction, which would harm the ecosystem. In species-poor communities, outbreaks of the number of individual populations often occur, which has a devastating effect on ecosystems.

When attempting to reduce the biological diversity of ecosystems by limiting it to one or several species, as humans do in artificial ecosystems – agrocenoses, the efficiency of their use of environmental resources decreases to such an extent that they cannot exist on their own, without human input of additional energy.

6. Biological diversity provides the function of ecosystem development during ecological succession, restoration of communities after damage. In the course of succession, there is a gradual replacement of some species by others, more effective in the changed conditions. As a rule, special (climax) species that are better adapted to stable conditions and saturation of the environment complete the succession. But the species that are characteristic of the early stages are not completely displaced, but form dynamic equilibrium systems with the species of the mature communities. When environmental conditions change or external stressors act on ecosystems, the presence of species characteristic of different stages of succession allows ecosystems to "heal" damage faster.

The principle of human interaction with the planet's biodiversity can be illustrated by taking into account the scale of human influence on natural systems and the role that biodiversity plays in sustaining life on Earth. The main condition for sustaining life on Earth is the ability of the biosphere to create and maintain balance between the ecosystems that make up its composition. Within the biosphere there should be territorially balanced ecosystems of a lower rank. In other words, the Earth should have the necessary amount of tundras, forests, deserts, etc. – like a biome, but inside a biome of tundras should be preserved as an optimum of tundras, within the biome of coniferous forests – an optimum forest cover. And the same goes for the smallest ecosystems, such as meadows, forests, lakes and others.

The functioning of the planet as a whole and its climatic balance are determined by the interaction of the cycles of water, carbon, nitrogen, phosphorus and other substances driven by the energy of ecosystems. Vegetation is the most important factor in preventing erosion, preserving the arable layer of the earth, ensuring infiltration and replenishing groundwater reserves. Without a sufficient level of biodiversity of swamp ecosystems, it is impossible to prevent the eutrophication of water bodies, and a high level of species diversity of animals is a key to the stability of any ecosystem and the biosphere as a whole.

If you imagine that a person is left alone on planet Earth, then it is not difficult to predict the further course of events: there is no food, ionizing radiation increases, which will no longer be retained by the ozone layer, breathing becomes impossible due to the lack of oxygen, and the climate turns out to be incompatible with life.

Millions of species of animals and plants support the conditions necessary for the continuation of life on Earth. It is possible that these conditions could be provided by a smaller number of species, but this is not reliably known. Just as the limit beyond which the reduction of biodiversity will begin the irreversible process of destruction of ecosystems and life will be put on the edge of existence is also unknown. When biodiversity is destroyed, there are no reliable ways to compensate for its loss.

A pragmatic view of biodiversity allows us to see it as an inexhaustible source of biological resources. Biological resources provide us with all kinds of products: food, fiber for clothing, building materials, dyes, synthetic substances, medicines, etc. They are the basis of most types of human activity, and the state of the world economy largely depends on them. Microorganisms, which play a vital role in many ecosystems, have contributed to advances in food production.

Modern medicine shows increased interest in biological resources in the hope of obtaining new means of treatment of dangerous diseases. The greater the diversity of living beings, the greater the opportunities for the discovery of new drugs; and the history of medicine provides excellent examples of such a possibility. Potentially, any species can have commercial value or be used in medicine as well as in other industries.

In agriculture, the genetic diversity of cultivated plants is of great importance for the development of pest control methods. The centers of origin of cultivated plants are the places in which, at one time, man first introduced many traditional species into culture. In these territories, the connection between agricultural plants and their wild relatives can be clearly traced. Farmers are increasingly interested in the genetic diversity of agricultural crops, as one of the priorities of modern research is the development of methods to increase the productivity of agricultural crops and increase their adaptability to changing environmental conditions.

Biodiversity is also of great importance for recreation. Beautiful landscapes, multi-species and diverse ecosystems are the most important conditions for the development of tourism and recreation. The rapid expansion of this type of activity is often the main source of income for the local population. Often the object of increased interest is individual species of animals and plants.

In addition to the pragmatic aspects of the value of biodiversity, aesthetic aspects must also be considered. The beauty of biodiversity is a source of inspiration. Without aesthetic pleasure, a huge number of our hobbies, be it sport fishing, hunting, hiking or bird watching, would lose their meaning. People have a need to contemplate beautiful landscapes. And yet, the aesthetic value of biodiversity is something more than simply admiring a beautiful landscape. What would happen to a person, his emotional state, his worldview, if instead of a beautiful lake or a patch of pine forest, he would see around him only piles of garbage or a landscape mutilated by rude intervention? Apparently, the aesthetic side of the perception of biodiversity is not just enjoying the beauty of individual landscapes; rather, it is an organic need inherent in every person, as the perception of various forms of life objectively improves the quality of it.

GENETIC DIVERSITY

The natural wealth of our planet is associated with a variety of genetic variations. Genetic diversity, i.e. maintenance of genotypic heterozygosity, polymorphism and other genotypic variability, which is caused by the need for adaptation in natural populations, is represented by hereditary diversity within and between populations of organisms.

Genetic diversity is a set of gene pools of different populations of the same species or, in other words, diversity within each species. Genetic diversity ensures species diversity. Genetic diversity refers to the existence within the same species of subspecies, races, varieties, strains, clones, varieties, forms, etc. Each individual species has a large number of genes, which are the source of its characteristic features.

A population is a group of individuals of the same species that live in a certain territory for a long time, and also interbreed freely and are isolated from other populations. A species may include one or more populations. A population can consist of a few individuals or millions.

Genetic diversity in a population is determined by the number of genes with more than one allele (so-called polymorphic genes) and the number of alleles in each such gene. In the population there are heterozygous individuals who received different alleles of the gene from their parents. Genetic variability allows species to adapt to environmental changes, such as rising temperatures or the outbreak of a new disease. Rare species have less genetic diversity than widespread species, so they are more prone to extinction when environmental conditions change.

As you know, genetic diversity is determined by variation in the sequences of 4 complementary nucleotides in nucleic acids, components of the genetic code. Each species carries a huge amount of genetic information: the DNA of bacteria contains about 1,000 genes, fungi – up to 10,000, higher plants – up to 400,000. New genetic variations arise in individuals due to gene and chromosomal mutations, as well as in organisms that are characterized by sexual reproduction through gene recombination. Genetic variation can be estimated in any organism, from plants to humans, as the number of possible combinations of different forms from each gene sequence. Other types of genetic diversity, such as the amount of DNA per cell, the structure and number of chromosomes, can be determined at all levels of the organization of a living organism.

A huge amount of genetic variation is present in cross-breeding populations and can be accomplished through selection. Different viability is reflected in changes in gene frequencies in the gene pool and is a real reflection of evolution. The importance of genetic variations is obvious: they make it possible to carry out evolutionary changes and, if necessary, artificial selection.

Only a small part (about 1%) of the genetic material of higher organisms has been studied to a sufficient extent where we can know which genes are responsible for certain manifestations of the organism's phenotype. For most of the DNA, its significance for the variation of life forms remains unknown.

Each of the 10^9 different genes distributed in the world's biota does not make an identical contribution to the formation of diversity. In particular, genes that control fundamental biochemical processes are strictly conserved across taxa and mostly show weak variability that is strongly related to organismal viability.

If we judge the loss of the gene pool from the point of view of genetic engineering, taking into account that each life form is unique, the extinction of just one wild species means the irreversible loss of thousands to hundreds of thousands of genes with unknown potential properties. Genetic engineering could use this diversity to develop medicine and create new food resources. However, the destruction of the habitat and the limitation of reproduction of many species leads to a dangerous decrease in genetic variability, reducing their ability to adapt to pollution, climate change, disease and other adverse factors.

The main reservoir of genetic resources – natural ecosystems – turned out to be significantly changed or destroyed. The reduction of genotypic diversity, which occurs under the influence of humans, puts the possibility of future adaptations in ecosystems at risk.

The natural wealth of our planet is associated with a variety of genetic variations. Genetic diversity, that is, the maintenance of genotypic heterozygosity (polymorphism) and other genotypic variability, which is caused by the need for adaptation in natural populations, is represented by hereditary diversity within and between populations of organisms.

The study of patterns of distribution of genotypes in populations was started by Pearson. He showed that in the presence of different alleles of one gene and the action of free crossing in populations, a certain distribution of genotypes occurs, which can be represented by the equation:

$$p^2 AA + 2pqAa + p^2 aa,$$

where p is the concentration of gene A; q is the concentration of gene a.

H. Hardy and V. Weinberg, independently of each other, researching this distribution, expressed the opinion that it is balanced, because in the absence of factors that disturb it, it can be preserved in populations for an unlimited time. This became an impetus for the development of population genetics. The main merit in the development of population genetics, and especially its theoretical and mathematical aspects, belongs to S. S. Chetverikov, S. Wright, R. Fisher, J. Haldane, A. S. Serebrovsky and N. P. Dubinin.

Biological evolution is the process of accumulating changes in organisms and increasing their diversity over time. Evolutionary changes cover all aspects of the existence of living organisms: their morphology, physiology, behavior and ecology. All these changes are based on genetic changes, i.e. changes in hereditary material, which, interacting with the environment, determines all the characteristics of organisms. At the genetic level, evolution is the accumulation of changes in the genetic structure of populations.

Evolution at the genetic level can be considered as a two-stage process. On the one hand, mutations and recombinations occur – processes that cause genetic variability; on the other hand, there is gene drift and natural selection, the processes by which genetic variability is transmitted from generation to generation.

Evolution is possible only if there is hereditary variability. The mutation process is the only provider of new genetic variants, but these variants can recombine in a new way during sexual reproduction, i.e. during independent divergence of chromosomes and as a result of crossing over. Genetic variants that arose as a result of mutational and recombination processes are transmitted from generation to generation by no means with equal success: the frequency of some of them may increase at the expense of others. In addition to mutations, the processes that change allele frequencies in a population include natural selection, gene flow between populations, and random gene drift.

At first glance, it may seem that individuals with a dominant phenotype should be found more often than with a recessive one. However, the 3:1 ratio is observed only in the offspring of two individuals heterozygous for the same two alleles. With other types of crossing, a different splitting of traits occurs in the offspring, and such crossings also affect the frequencies of genotypes in the population. Mendel's laws tell us nothing about the frequencies of genotypes in populations. It is these frequencies that are referred to in the Hardy-Weinberg law. The basic statement of the Hardy-Weinberg law is that in the absence of elementary evolutionary processes, namely mutation, selection, migration and gene drift, gene frequencies remain constant from generation to generation. This law also states: if crossing is random, then the frequencies of genotypes are related to the frequencies of genes by simple (quadratic) ratios. The following conclusion follows from the Hardy-Weinberg law: if allele frequencies in males and females are initially the same, then with random crossing, the equilibrium frequencies of genotypes at any locus are reached in one generation. If the allele frequencies of the two sexes are initially different, then for autosomal loci they become the same in the next generation, since both males and females receive half of their genes from the father and half from the mother. Thus, the equilibrium frequencies of genotypes are reached in this case in two generations.

However, in the case of sex-linked loci, equilibrium frequencies are reached only gradually.

Organisms possessing successful trait variants are more likely (compared to other organisms) to survive and leave offspring. As a result, useful variations will accumulate in a number of generations, and harmful, less useful ones will be displaced and eliminated. This is called the process of natural selection, which plays a leading role in determining the direction and speed of evolution.

The direct relationship between the degree of genetic variability in the population and the speed of evolution under the influence of natural selection was proved mathematically by R. Fisher in his fundamental theorem of natural selection. Fisher introduced the concept of fitness and proved that the rate of growth of population fitness at any moment in time is equal to the genetic variant of fitness at the same moment in time. However, direct evidence of this fact was obtained only at the end of the 60s of the 20th century.

The mutation process serves as a source of the appearance of new mutant alleles and rearrangements of genetic material. However, the increase in their frequency in the population under the influence of mutational pressure is extremely slow, even on an evolutionary scale. In addition, the vast majority of emerging mutations are eliminated from the population within a few generations due to random reasons.

An important step in population genetics was made in 1926 by S. S. Chetverikov Based on the Hardy-Weinberg law, S.S. Chetverikov proved the inevitability of genetic heterogeneity of natural populations, given that new mutations appear continuously, but usually remain hidden (recessive), and free interbreeding takes place in the population.

It followed from Chetverikov's calculations, and later it was fully confirmed by practice, that even rare and harmful mutant genes will be reliably protected from the purifying action of natural selection in heterozygotes (organisms with mixed heredity) with dominant harmless genes of the normal wild type. This means that even a harmful heterozygous (organism with homogeneous inheritance) mutation will persist as a genetic "admixture" for several generations. The mutation will seem to be absorbed by the population, due to which the external uniformity of the individuals of one population inevitably hides their enormous genetic heterogeneity.

Chetverikov put it this way: "A species, like a sponge, absorbs heterozygous gene variations, while remaining outwardly (phenotypically) uniform all the time". For the life of populations, this feature can have two different consequences. In the vast majority of cases, when environmental conditions change, a species can realize its "mobilization reserve" of genetic variability not only due to new hereditary changes in each individual, but also due to the "genetic capital" inherited from ancestors. Thanks to this mechanism of inheritance, the population acquires plasticity, without which it is impossible to ensure the stability of adaptations in changing environmental conditions. However, another result is occasionally possible: rare hidden harmful mutations can sometimes be found in the offspring of completely healthy parents, leading to the appearance of individuals with hereditary diseases. And this is also a natural, indestructible biological phenomenon, a kind of cruel payment of the population for maintaining its hereditary heterogeneity.

SPECIES BIODIVERSITY

The term "biodiversity" is often seen as a synonym for "species diversity", specifically "species richness", which is the number of species in a particular location or habitat. In general, biodiversity is usually estimated as the total number of species in different taxonomic groups.

Species diversity includes the entire set of species living on Earth. There are two main definitions of species. The first, *morphological definition of a species:* a species is a collection of individuals that differs from other groups by one or another morphological, physiological or biochemical characteristics. Nowadays, differences in the DNA sequence and other molecular markers are increasingly used to distinguish species that are practically identical on the outside (for example, bacteria). The second definition, *the biological definition of a species*, is a collection of individuals between which there is free interbreeding, but at the same time there is no interbreeding with individuals of other groups.

The morphological definition of a species is usually used in taxonomy, that is, by systematic biologists who specialize in the identification of new species and the classification of species. The biological definition of a species is usually used in evolutionary biology because it is based more on measurable genetic relationships than on certain subjectively selected physical traits. However, in practice, it is quite difficult to use the biological definition of a species, since it requires knowledge about the ability of individuals to interbreed, and this is, as a rule, difficult to obtain information.

To date, about 1.5 million species have been described, while, according to experts, there are 5 to 100 million species living on the planet today. More conservative researchers believe that there are 12.5 million of them (Table 1).

Table 1

Species biodiversity (according to Kobeniok et al., 2008)

Taxonomic groups of organisms	Number of species, thousands	
	described	estimate of the total number
Viruses	4	400
Bacteria	4	1000
Fungi	72	1500
Protozoa	40	200
Algae	40	400
Plants	270	320
Nematodes	25	400
Crustaceans	40	150
Arachnids	75	750
Insects	950	8000
Molluscs	70	200
Vertebrate	45	50
Others	115	250

Scientists are constantly describing and naming new species of animals, plants and microorganisms. No one can give the exact number of species living on the planet, but it is known that the number of animal species significantly exceeds the number of plant, fungi and bacterial species. It is also known that insects predominate among animals in terms of the number of registered species. Their diversity is such that in terms of the total number of species they surpass not only all other animals, but also plants and microorganisms combined. In the kingdom of plants, the largest number is occupied by angiosperms (Fig. 2).

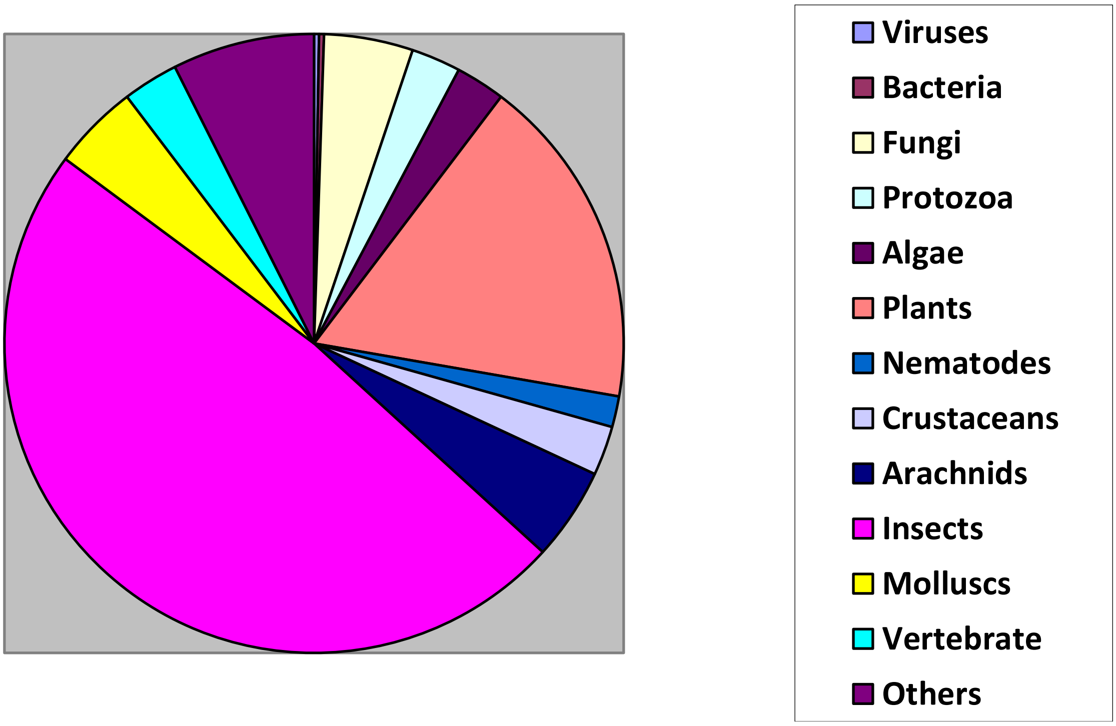

Fig. 2 **Estimated number of species** (according to Kobeniok et al., 2008)

The diversity of biological species is a necessary condition for the stability of cycles of synthesis, transformation and destruction of organic matter of the biosphere. In natural ecosystems, the biota maintains a balance between production and destruction of organic matter with high precision. Biota plays the most important role in the destruction of rocks and soil formation. In addition, the biota effectively manages the hydrological regime, the composition of the soil, atmosphere, and water. It has been established that the biota fully retains this ability, as humanity uses no more than 1% of the net primary production of the biota. The rest of the production should go to support the vital activities of species that stabilize the natural environment (V.G. Horshkov, 1980, 1995).

In the 20th century, humanity directed the flow of biospheric energy into the anthropogenic channel. At the beginning of the 20th century, humanity consumed approximately 1% of net biosphere production, at the end of the same century, this figure increased 10 times. As a result of human activity, biogeochemical cycles are disturbed: phytocenoses are disturbed and their productivity decreases; the share of the heterotrophic link in ecosystems increases, part of plant biomass is removed from circulation for the benefit of humans. In addition, a huge amount of waste accumulates, the destruction of which is impossible with natural reductants. The processes of degradation of the natural environment are increasing catastrophically. In 1900, natural ecosystems were destroyed on 20% of the land, now – on 63%. Marine ecosystems are also being destroyed, starting, first of all, with inland seas. Many species of living organisms disappear from the face of the Earth. Lists of rare and endangered biological species ("red books") contain thousands of names.

ECOLOGICAL (ECOSYSTEM) BIODIVERSITY

On the planet there is a huge range of biodiversity of terrestrial and aquatic ecosystems: from icy polar deserts to forests and from coral reefs to the open ocean. All the diversity of ecosystems can be classified either by functional or by structural features (Odum, 1986).

Ecosystem diversity refers to different habitats, biotic communities, and ecological processes in the biosphere, as well as the enormous diversity of habitats and processes within an ecosystem.

Quantitative indicators of biodiversity in ecosystems vary greatly depending on the influence of various factors. It should be noted that the biocenosis includes not only species that permanently live in the ecosystem, but also species that spend only part of their life cycle in it (for example, mosquito larvae, dragonflies).

The species composition and overall diversity of the biocenosis can be described only at a certain point in time, as species richness changes as a result of processes of immigration and elimination of species that continuously occur in the biocenosis.

At each moment of time, the biocenosis has a certain type of opulance.

One of the constituent parts of the natural environment is the relief of the earth's surface, existing in its continuous variability at the border of three natural shells, or spheres of our planet – the earth's crust, or lithosphere, atmosphere and hydrosphere. The earth's surface with its relief – picturesque or harsh mountains, vast plains, behind which smoothly meander rivers, dunes and sand ridges of deserts, high-altitude glaciers – represents the arena of life, one of the most important components of the biosphere.

The more diverse the environmental conditions in a given region, the more time organisms have at their disposal for evolutionary transformations, the more diverse their species composition is here. Topography and geological structure can create a variety of conditions within regions with a uniform climate. In a hilly area, its slope and exposure determine the temperature and moisture content of the soil. On steep slopes, the soil is well drained, which often leads to a lack of moisture for plants, although in the surrounding lowlands the soil is saturated with moisture. In arid regions, in floodplains and along riverbeds, well-developed forest communities can often be observed, which contrast sharply with the surrounding desert vegetation. On the warm and dry slopes of the hill facing south, different tree species grow than on the cold and wet northern hills. The hilly topography is often associated with the beauty of the landscape, which means that there are rich and diverse communities nearby.

Any landscape on the globe undergoes changes under the influence of climatic conditions. A huge influence on them is also from the plant world. Landscapes in all their diversity were formed over many millennia, as well as a result of human activity. They are constantly changing thanks to the constant search for effective forms of land use and mineral extraction. Man builds cities and paves roads. Thus, landscapes consist of a number of natural and cultural elements. They embody the collective memory of nature and those who inhabit it, forming a complex element of the environment.

Cultural landscapes are characterized by peculiar anthropogenic biocenoses.

The problem of studying the structure and functioning of anthropogenic biocenoses is of great scientific interest. The fact is that anthropogenic biocenoses, formed and developed under the complex influence of natural and socio-economic factors, have their own characteristic features; the specific laws of their development are still poorly understood. We can mention such features that are characteristic of anthropogenic biocenoses, such as oligodominance (a sharp predominance of one or more species in plant and animal diversity), instability of the system, which is expressed in sharp changes in the number of biomass and products not only in seasons, but also in years, increased vulnerability structures, taking into account the relative simplicity and unambiguity of the connections between the components of the biocenosis. The latter is explained by the historically small age of anthropogenic biocenoses, the structure of which usually does not reach the level of complexity and balance observed in natural biocenoses. Therefore, sudden changes in conditions and influence on anthropogenic biocenosis at that time lead to radical violations of its structure or to its complete destruction. Knowledge of the regularities of the structure and life of anthropogenic biocenoses will allow us to regulate and direct the development of the geographical environment, increasingly involving it in the sphere of human activity.

CLASSIFI OF BIODIVERSITY

Inventory and differentiated biodiversity

In 1960, R. Whittaker proposed the concept of α-, β-, γ-biodiversity in order not to confuse biodiversity within one habitat or region with the diversity of a landscape or region that contains several habitats.

α- biodiversity – diversity within a place of residence or one community.

β-biodiversity – diversity between habitats.

γ-biodiversity – diversity in vast regions of the biome, continent, islands, etc.

In 1979. Kruger and Taylor added Δbiodiversity to this classification.

Δ-biodiversity – diversity determined by changes in climatic factors, expressed in changes in vegetation zones, provinces, etc.

R. Whittaker (1977), in addition, distinguished two forms of diversity: inventory (estimation of the diversity of ecosystems of different scales as a whole) and differential (estimation of diversity between ecosystems) (Table 2).

Differential diversity characterizes the degree of similarity or difference of habitats or samples in terms of their species composition and the large number of species along the environmental gradient. The four levels of inventory diversity (alpha, beta, gamma, epsilon) correspond to three levels of differential (internal beta-diversity or mosaic diversity – variation between parts of a mosaic community; beta-diversity of habitats along an environmental gradient; delta-diversity – geographic differentiation along climatic gradients).

Delta-diversity is determined both by changes in species composition and by a large amount of gamma-diversity between territories; it represents the differential diversity of large biogeographic regions within the area of epsilon-diversity. Mosaic diversity is defined as the differential difference between samples within a homogeneous locality.

Table 2

Forms and types of biodiversity (according to R. Whittaker, 1960, 1977)

Inventory diversity	Differential diversity
Point alpha diversity – diversity within a plot or location within a community	Internal beta diversity (mosaic diversity, variation between parts of a mosaic community)
Alpha diversity (within-site diversity for a description representing a homogeneous community)	Beta diversity (diversity between different communities along an environmental gradient)
Gamma-diversity (for a landscape or sample series that includes more than one community type, specific flora or fauna)	Delta diversity (geographic differentiation, community change along climatic gradients or between geographic regions)
Epsilon-diversity (for a biome, a geographic region that includes different landscapes)	Omega diversity (biome diversity within epsilon diversity)

Omega biodiversity is the diversity of biomes on the territory of epsilon space. Geographical maps of various scales and the methodology of their study using geoinformation systems are used for its analysis.

Taxonomic and typological biodiversity

B.A. Yurtsev (1994) defines biodiversity as the diversity of organisms and their natural combinations, although it can also be traced at lower levels of living organization (molecular, subcellular, cellular and tissue levels, organ levels, etc.). At the same time, he considers organisms as the smallest units of biodiversity, possessing autonomy, the ability to support life and adaptation, and are carriers of other forms of biodiversity.

The diversity of organisms can be divided into taxonomic, or phyletic (grouping by kinship), and typological, or non-phyletic (grouping by certain categories of features that do not lead to kinship, for example, structural, functional, structural-functional, geographical, ecological, synecological and etc.) The range of features taken into account in the analysis of typological diversity can be infinitely wide and depends on the tasks of the research. Examples can be life forms, life strategies, xenotypes, metabolic types, successional status of species (i.e. place in successional ranks or systems).

Taxonomic diversity is further divided into hierarchical levels with a series of sublevels: species, population-genetic (sublevels are populations of different ranks, subspecies), genotypic (phenotypic), genes and their alleles. It is possible to distinguish the levels of supraspecific taxa (genus, family...kingdom).

Estimates of taxonomic and typological diversity complement each other. The description of taxonomic diversity (biota of a certain territory), usually represented by long systematic lists, is usually supplemented by the characterization of each taxon according to a complex of typological features. The relationship between taxonomic and typological diversity forms the basis of the organization of databases and banks of typological information about organisms. However, information on any type of diversity comes through species as the fundamental units of biodiversity.

Biohorological diversity

Biohorological diversity means the diversity of combinations of organisms of certain territorial groups, parts of the biosphere (Yurtsev, 1994). The variety of natural territorial associations of organisms, in turn, is subdivided by territorial levels.

The experience of geobotany and floristry suggests that with the expansion of the area in which species diversity is taken into account, phases of relative stabilization of the composition of plant species occur, when the increase in the number of species slows down sharply and even temporarily stops. This happens when the species diversity of the community is exhausted within a homogeneously extended ecotope, and further, when the composition of all ecotopes within a given landscape is revealed quite completely. It is obvious that the diversity of communities reflects not only the diversity of locations (that is, relief elements with a certain composition of soil-forming rock), but also the diversity of successional stages at each location. Within the framework of a long landscape with a single macroclimate, the diversity of location is exhausted and the stability of successional processes is maintained , which leads to the stability of the set and composition of communities, and therefore to the stability of the composition of this elementary or specific flora.

B. N. Yurtsev singles out the community level (rough equivalents in terms of related scientific disciplines: ecotope, facies in landscape science, biogeocenosis) and then the level of elementary regional biota as the two lower reference levels for assessing biochorological diversity. Between the reference levels there are a number of intermediate stages. Above is the hierarchy of biogeographic zoning departments (district, province, region), the contours of which in different systems of biogeographic division of the Earth may not coincide significantly, depending on the zoning criteria.

Depending on the level of biohorological units, the taxonomic level of units by which biodiversity is assessed can also change significantly. As the most universal, mandatory unit (for all levels) is the species.

Structural biodiversity

Structural diversity is a consequence of zonation, stratification, periodicity, patchiness, the presence of food webs, and other ways of ranking the components of microlocations. Different methods of distribution of organisms present in the community at the same time characterize their structural diversity:

• stratified principles (vertical layering, vegetation layering, structure of soil profiles);

• zonality (horizontal disconnection, vertical zonality in the mountains or littoral zone);

• nature of activity (periodicity);

- the structure of the food network;
- reproductive systems (associations of parents and offspring, plant clones, etc.);
- social structures (herds and herds);
- interaction systems (arising as a result of competition, antibiosis, mutualism, etc.);
- stochastic structures (arising as a result of random forces).

THREATS TO BIOLOGICAL DIVERSITY

A healthy environment is of enormous economic, aesthetic and ethical value. Maintaining the health of the environment means keeping all its components in good condition: ecosystems, communities, species and genetic diversity. Initial small disturbances in each of these components can eventually lead to its complete destruction. At the same time, communities degrade and shrink spatially, lose their importance in the ecosystem and eventually collapse, but as long as all the original species for the community are preserved, it can still recover. When the number of species decreases, intraspecific variability is reduced, which can cause such genetic changes from which the species will no longer be able to recover. Potentially, after timely and successful rescue measures, the species can restore its genetic variability through mutations, natural selection and recombination. But in an endangered species, the uniqueness is contained in its DNA, the genetic information and combinations of traits it possesses are lost forever.

The rate of extinction of species

The term "endangered" or "endangered" has many nuances and its meaning can vary depending on the context. A species is considered completely extinct (extinct) when there are no living individuals of this species left anywhere in the world. If only certain individuals remain alive in captivity or they somehow survived only under direct human control, then the species is said to have disappeared in natural ecosystems, for example, the Franklin Tree has disappeared in nature, but grows well in nurseries. In both cases, the species is considered universally extinct. A species is considered locally extinct if it is no longer found in the entire area of its original range, but is still found in some places. In addition, ecologically extinct species are defined, in the event that the species remained at such a small number that its impact on other species in the community is very small.

The most important question for conservation biology is how long will this species be able to survive until its complete disappearance, following extreme reduction in numbers, degradation or fragmentation of its habitat? When the size of the population decreases to a certain critical level, the probability of its extinction becomes very high. In some populations, the remaining individual individuals can live for years or decades and even reproduce, but still their future fate is extinction, unless decisive measures are taken to preserve them. In particular, among woody vegetation, the last isolated non-reproductive specimens of a species can survive for hundreds of years. Such species are called potentially extinct: even if formally the species is not yet extinct, but the population is no longer able to reproduce, and the future of the species is limited by its lifetime (Janzen, 1986).

In the geological history of the Earth in the biosphere, the emergence and disappearance of species constantly occurred - all species have a finite time of existence. Extinction was compensated by the appearance of new species, and as a result, the total number of species in the biosphere increased. Extinction of species is a natural process of evolution that occurs without human intervention.

The number of species that make up the present organic world represents only a tiny fraction of the total number of species that have existed on our planet from the earliest times to our era. Finally, incomparably more than 99% of all species that arose on earth died out.

Extinction of species is a gradually regular or suddenly occurring evolutionary process characterized by slowed reproduction and increased mortality. It leads to a reduction in the number, and then to the complete disappearance of individuals of any systematic group of animals, including humans, as well as the disappearance of any taxon from species and above, as a result of the indirect influence of humans and their economic activities, including destruction of habitats. In the evolutionary sense, a group that disappeared and did not leave behind any (even modified) descendants is considered extinct.

It has been studied that not all species have the same probability of extinction; certain categories of species are especially exposed to it and require careful protection and control:

Species with narrow ranges. Some species are found only in one or more geographically limited areas, and if the entire range is exposed to human activity, these species may disappear. Extinct species of birds that lived on oceanic islands are numerous examples of this. Many species of fish that lived in a single lake or in the basin of a single river also disappeared;

Species formed by one or several populations. Any population of species can become locally extinct as a result of earthquakes, fires, disease outbreaks and human activities. Therefore, species with large populations are less prone to global extinction than species that are represented by only one or a few populations;

Species with small population sizes, or the "small population paradigm." Small populations are more likely to become extinct than large ones because of their greater susceptibility to demographic and natural changes, as well as loss of genetic diversity. Species characterized by small population sizes and highly specialized species are more likely to die out than species characterized by large populations;

Species in which the size of populations gradually decreases is the so-called "decline paradigm". In normal cases, populations have a tendency to self-recovery, so a population showing persistent signs of decline will most likely disappear if the cause of the decline is not identified and eliminated;

Species with low population density. Species with an overall low population density, if the integrity of their range has been disturbed by human activity, will be represented in low numbers in each fragment. The population size within each fragment may be too small for the species to survive. It begins to disappear within its entire range;

Species that need large areas. Species in which individuals or social groups forage over large areas are prone to extinction if part of their range is destroyed or fragmented by human activity;

Species of large sizes. Compared to small animals, large animals usually have larger individual territories. They need more food, they often become the object of human hunting. Large predators are often exterminated because they compete with humans for game, sometimes they attack domestic animals and people, and they are also the object of sport hunting. In each species guild, the largest species are the most prone to extinction;

Fig. 3 **Amur tiger *(Panthera tigris altaica)***, a species that was purposefully destroyed by man

Species incapable of dispersal. In the natural course of natural processes, changes in the environment force species to physiologically adapt to new conditions, or to adapt by changing their behavior. Species that are unable to adapt to environmental changes must either migrate to more suitable habitats or face the threat of extinction. The rapid pace of human-induced change often outpaces adaptation, leaving migration as the only alternative. Species that are unable to cross roads, fields, and other human-altered habitats are doomed to extinction as their "native" habitats are transformed by pollution, new species invasions, or global climate change. Low dispersal ability explains why 68% of North American aquatic invertebrates are extinct or threatened with extinction, as opposed to 20% for dragonflies, which can lay eggs by flying from one body of water to another;

The seasonal migrant species. Seasonally migratory species are associated with two or more distant habitats. If one of the habitats is disturbed, the species cannot exist. The survival and reproduction of the billions of songbirds of 120 species that migrate between Canada and South America each year depends on the availability of suitable habitats in both territories. Roads, fences or dams create barriers between essential habitats that some species need to complete their life cycle;

Species with low genetic diversity. Intrapopulational genetic diversity sometimes allows species to successfully adapt to a changing environment. With the introduction of a new disease, a new predator, or other changes, species with low genetic diversity may be more likely to go extinct;

Species with highly specialized requirements for an ecological niche. Some species are adapted only to unusual types of rare, scattered habitats. If the habitat is disturbed by man, the probability of survival of such a species is catastrophically low. Species with highly specialized food requirements are also at particular risk. A vivid example of this is the species of ticks that feed only on the feathers of a certain species of birds. If the species of birds disappears, so does the species of feather mite;

Species living in stable environments. Many species are adapted to environments whose parameters change very little. Often, such species grow slowly, have low reproductive rates, and give offspring only a few times in a lifetime. When there is a rapid change in the habitats of these species by humans, they are unable to survive in the new conditions that arise: changes in the microclimate (increased illumination, decreased humidity, temperature fluctuations), when competition with successional and invasive species appears.

Species forming permanent or temporary aggregations. Species that form clusters in certain places are very prone to local extinction. For example, bats feed in a large area at night, but usually spend the day in a certain cave. Herds of bison, flocks of passenger pigeons, and shoals of fish are aggregations that have been actively used by humans until the species is depleted or even extinct, as happened with the passenger pigeon. Some species of social animals cannot exist when their population falls below a certain level, because they can no longer forage, mate, and defend themselves (Fig. 4).

Fig. 4 **Bison *(Bison bison)***, an endangered species due to uncontrolled extermination by humans

Species that humans hunt or gather. The prerequisite for the extinction of species has always been their utilitarianism. Overexploitation can rapidly reduce the population size of species of economic value to humans. If hunting or gathering is not regulated by law or by local traditions, species may become extinct.

Abiotic and biotic factors leading to the extinction of species are interrelated. The density of populations, forms of struggle for existence, the degree of competition between populations, and the immediate course of population extinction in one way or another depend on the general geographical situation.

The main threats to biodiversity caused by anthropogenic activities

The main threats to biological diversity arising from human activity are: destruction of habitats, fragmentation of habitats, degradation of habitats (including pollution), global climate change, overexploitation of species by humans, invasion of exotic species, increasing spread of diseases.

Destruction of local growth. The main threat to biological diversity is the disturbance of habitats, and therefore the most important thing for the preservation of biological diversity is their protection. The loss of habitats is associated with both their direct destruction and damage in the form of pollution and fragmentation. For most plants and animals that are on the verge of extinction, it is the loss of habitat that is the primary threat. Other important factors include the negative impact of introduced species and overexploitation.

Many highly valued wildlife species have lost much of their original range, and only a few of their remaining habitats are protected.

The plight of rainforests is probably the most widely known case of habitat destruction, but other habitats are also in mortal danger. They include:

Marsh areas and water habitats. Wetlands are habitats for fish, aquatic invertebrates and birds. They regulate the flood level, serve as sources of drinking water and energy. Wetlands are often filled, drained, or transformed by restricting flow travel through artificial channels, dams, or chemical pollution;

Temperate prairies. Another type of ecosystems, almost completely destroyed by human activity. It is quite simple to turn large areas of the steppes into arable or pasture lands;

Coral reefs. Tropical coral reefs occupy only 0.2% of the oceanic area, but one-third of all known species of oceanic fish live here. Already, 10% of all coral reefs have been destroyed, and up to 50% more may be destroyed in the coming decades;

Desertification. As a result of human activity, many biological groups characteristic of regions with a seasonally arid climate have degraded to the state of artificial deserts – a process known as desertification (Fig. 5). Such groups include tropical and shrub savannas, deciduous forests, and in temperate climates - shrub and herbaceous groups in the Mediterranean, South Africa, and Chile. These areas were originally suitable for agriculture, but their intensive cultivation led to soil erosion and the loss of the last water-holding capacity. Shrub and tree vegetation was cut down here, and the land was trampled by cattle, sheep and goats. As a result, there is a progressive and largely irreversible degradation of the soil cover, which brings it to such a state that the region takes on the appearance of a desert;

Fig. 5 **Oleshkiv sands** (Ukraine, Kherson region) is a vivid example of the desertification of the territory as a result of human economic activity

Fragmentation of local growth. In addition to total destruction, settlements that used to occupy large areas are often crushed into small pieces by roads, fields, cities, and other structures. Habitat fragmentation is a process in which a continuous habitat area is simultaneously reduced and split into two or more fragments. These fragments are often separated from each other by altered or degraded landscape forms. Fragmentation occurs with almost any large reduction in habitat area, but it can also occur with relatively minor reductions, for example, when the original habitat is cut by highways and railroads, canals, power lines, fences, oil pipelines, fire trails, and other barriers that prevent the free movement of species.

Habitat fragmentation can also accelerate the extinction of populations, as it results in a widespread population splitting into two or more isolated subpopulations. These small populations are subject to the processes of inbreeding and gene drift characteristic of them. If one complete large population can live normally on a large area of the habitat, then often none of its fragments can support a subpopulation large enough for long-term sustainable existence

Fragmentation of habitats makes, among other things, the inevitable contact of wild animals and plants with domestic ones. As a result, domestic animal diseases spread rapidly among wild species lacking adequate immunity. It should be borne in mind that such contact ensures the transmission of diseases from wild species of plants and animals to domestic ones, and even to humans.

Despite the fact that the habitat has not undergone obvious destruction or fragmentation, the groups that inhabit it can be deeply affected by human activity. External factors that do not change the dominant plant structure of the group can, however, lead to disturbances in biological communities and eventually to the disappearance of species, although these disturbances are not immediately noticeable;

Pollution of habitats. Environmental pollution is the most universal and insidious form of its destruction. It is most often caused by pesticides, fertilizers and chemicals, industrial and urban sewage, gas emissions from factories and cars, and sediments washed down from the highlands. Visually, these types of pollution are often not very noticeable, although they happen around us every day in almost every part of the world. The global impact of pollution on water quality, air quality, and even the planet's climate is in the spotlight not only because of the threat to biological diversity, but also because of the impact on human health. Although sometimes environmental pollution is very visible and frightening, for example in the case of massive oil spills. Hidden forms of pollution are the most dangerous, mainly because their effects are not immediately apparent.

Water pollution has negative consequences for human populations: food products – fish, shellfish – disappear, drinking water is poisoned. In a broader sense, water pollution seriously disrupts aquatic communities.

Unlike pollution of the terrestrial environment, in which waste is stored relatively locally, in aquatic environments, toxic substances are carried by currents over large areas. Yes, even very small concentrations of toxic substances can accumulate in aquatic organisms to a lethal concentration, since they filter large volumes of water while feeding. Birds and mammals that eat these animals are thus exposed to the concentrated effect of toxicants.

Even mineral elements necessary for plants and animals can become harmful pollutants in high concentrations. Sewage, field and lawn fertilizers, detergents, and industrial emissions deliver such large amounts of nitrogen and phosphorus compounds to aquatic systems that they cause a process called eutrophication. Small amounts of these substances stimulate the growth of plants and animals, and their high concentrations often lead to abundant "blooming" of algae (Fig. 6). These algae clusters can be so dense that they crowd out other plankton species and prevent light from reaching bottom-attached plant species. As the carpet of algae thickens, its lower parts sink to the bottom and die. Bacteria and fungi that decompose dead algae actively multiply in response to their additional influx and, accordingly, absorb all the oxygen in the water. Due to the lack of oxygen, most of the animals begin to die, sometimes this can be seen by the mass of dead fish floating on the surface. As a result, poor simple groups are formed, formed only by species resistant to water pollution and low oxygen content. Large marine systems, especially their coastal areas and relatively closed water areas, such as the Gulf of Mexico, the North and Baltic Seas in Europe, and the seas surrounding Japan, are also subject to the process of eutrophication.

Fig. 6 **Eutrophication of water bodies** (Kyiv Sea (Dnipro River), photo by the authors, 2017)

Acid rain lowers the pH of groundwater and water bodies – ponds and lakes. Acids themselves are harmful to many types of plants and animals. As the acidity of water bodies increases, many fish stop spawning or die completely. In industrial areas, many ponds and lakes have lost a significant part of their animal communities due to acid rain.

Cars, power plants and various industrial facilities emit hydrocarbons and nitrogen oxides as waste. Under the influence of sunlight, these compounds react in the atmosphere with the formation of ozone and other secondary compounds under the common name of photochemical smog. Although ozone in the upper layers of the atmosphere is necessary to delay harmful ultraviolet radiation, its high concentrations in the lower layers damage plant tissues, harm biological communities and reduce the productivity of agricultural plants.

High-octane fuel, mine development, metallurgy and other types of industrial production are accompanied by the release of large quantities of lead, zinc and other toxic metals into the atmosphere. Their compounds are poisonous to plant and animal organisms. The impact of these toxic metals is especially noticeable around large metallurgical enterprises, where nature is destroyed for many kilometers around;

Climate change. Carbon dioxide (carbon dioxide), methane and other gases in the atmosphere are transparent to sunlight, they transmit light energy through the atmosphere heating the Earth's surface. However, these gases, along with water vapor (visible as clouds), absorb the energy radiated from the Earth's surface as heat, slowing the rate at which heat leaves the Earth and is returned to space. These gases are called greenhouse gases because they act like glass in a greenhouse, allowing sunlight to pass through but trapping the energy inside the greenhouse after it has been converted into heat. The greater the concentration of these gases, the more heat is trapped around the Earth, and the higher the temperature on the planet. This phenomenon is called the greenhouse effect.

The current problem is that, as a result of human activity, the concentration of greenhouse gases has increased to such an extent that, according to scientists, it has begun to affect the Earth's climate. The term "global warming" is used to define the greenhouse effect caused by human activity.

It is likely that many species will not be able to adapt quickly enough to these global anthropogenic changes, which are occurring much faster than all previous natural climate changes.

In order to survive, man always hunted, gathered fruits, used natural resources. As long as the population was small and its technology primitive, man could sustainably use the environment, hunt and harvest without driving the desired species to extinction. However, as the population grew, the pressure on the environment increased. Crop cultivation methods became incomparably more large-scale and efficient, and led to the almost complete displacement of large mammals from many biological communities, resulting in strangely "empty" habitats. In tropical forests and savannas, hunting rifles have replaced bows, darts and arrows. In all oceans of the world, powerful fishing motor vessels and fish processing "floating bases" are used for fishing.

Exploitation of natural resources. In traditional societies, restrictions on excessive exploitation of natural resources are often introduced: rights to use agricultural land are strictly controlled; hunting is prohibited in certain areas; there are bans on the destruction of females, young and animals with low numbers, fruit picking is not allowed at certain seasons and times of the day, or barbaric harvesting methods are prohibited. These types of restrictions allow traditional societies to use natural resources on a long-term sustainable basis, as, for example, in the strict fishing restrictions developed and proposed for the fisheries of many industrialized countries.

In many cases, the mechanism of overexploitation is notorious. A resource is discovered, a market for it is determined, and then the local population is mobilized for its extraction and sale. A resource is consumed so widely that it becomes rare or even disappears, and the market replaces it with another species, resource, or opens up a new region for exploitation. According to this scheme, industrial fishing is carried out, when one species after another is successively produced until exhaustion.

For many exploited species, the only hope for recovery is when they become so rare that they no longer have commercial value. Unfortunately, the number of populations of many species, such as rhinoceroses or some wild cats, has already been reduced so much that these animals are unlikely to be able to recover. One of the most heated controversies surrounding the exploitation of wild species has arisen over whaling;

Infections and diseases. Infections caused by disease-causing organisms are common in both wild and captive species. Diseases can be caused by microparasites: viruses, bacteria, fungi and protozoa, or macroparasites – helminths or parasitic arthropods. For some rare species, such diseases can be the strongest threat. The three basic principles of epidemiology have obvious practical applications in captive breeding and rare species management.

Firstly, both wild and captive animals in dense populations are at greater risk of infection. In fragmented protected areas, animal populations can temporarily reach an unnaturally high density, which ensures a high rate of pathogen transmission. Under normal natural conditions, the risk of infection is usually lower because animals have less contact with excrement, saliva, shed skin and other sources of infection. In artificial ones situations animals are in closer contact with these potential sources of infection and the risk of disease transmission increases.

Secondly, the susceptibility of the organism to the disease can be an indirect result of the destruction of the place of residence. When, due to habitat destruction, the host population accumulates in a small area, this often leads to a deterioration in the quality of the environment and a decrease in the amount of forage, which leads to poor nutrition, weakening of the animals and, accordingly, to their greater susceptibility to disease.

Thirdly, in many protected areas, in zoos, national parks and in new agricultural areas, wild animals come into contact with new species, including humans and domestic animals, with which they rarely or never encounter in nature and, accordingly, exchange pathogens with them.

Processes, causes, and consequences of biodiversity depletion the agricultural sector of Ukraine

The richest land fund of Ukraine in Europe, combined with favorable climatic conditions, should ensure a high level of production of agricultural products. At the same time, the productivity of Ukraine's agro-ecosystems is 2–3 times inferior to the EU indicators, and this trend has been observed for many years, regardless of the course of socioeconomic formations, the structure of land use, the development of scientific support for the agrarian industry, etc. What is the reason for the insufficient productivity of domestic agrocenoses?

The world scientific community at the end of the 20th century concluded that the development of the global ecological crisis of the biosphere and its component – the agrosphere, is caused by a catastrophic decrease in the biodiversity of the planet due to excessive anthropogenic load. The UN document "Convention on Biological Diversity" (CBD), which was ratified by Ukraine, was adopted. Understanding the importance of biological diversity and the need to preserve it for sustainable development is now at the forefront of the global environmental agenda.

The ecological and economic value of biodiversity is formalized as follows. The main characteristic of the biosphere is the cosmic degree of diversity of life in all its manifestations, the diversity of biota reflects the diversity of ecological conditions on the planet. As a result of the interaction of biota with the abiotic and biotic environment, the space of ecological factors of the biosphere forms a network of ecological niches in which elementary ecosystems carry out a continuous circulation of matter, energy, and information. As a result of the vital activity of the biota, each life cycle of the biosphere is replenished with drinking water and clean air, soil fertility is restored. In this way, biodiversity supports the ecological stability of ecosystems and reproduces the conditions for the continued existence of life on the planet.

What happens as a result of the anthropogenic transformation of landscapes in the process of agricultural activity? The impoverishment of the diversity of ecological niches, as a result – impoverishment of biodiversity. In the network of ecological niches, "holes" are formed, where natural resources fall out of the circulation of matter, energy, and information, which leads to the development of such ecological phenomena as soil degradation, deterioration of water quality, etc. The speed of development of the global environmental crisis is constantly increasing.

One of the aspects of the problem of increasing the productivity of domestic agroecosystems under the conditions of preserving the ecological stability of the environment is the preservation and reproduction of agrobiodiversity.

Modeling the main factors of the current ecological state of the agricultural sector of Ukraine based on the CBD concept (Fig. 7) allows us to substantiate the connection between depleted agrobiodiversity and environmental and socioeconomic problems of agricultural production. Let's consider the blocks of the model and the functional connections between them step by step.

Plowability of the land fund of Ukraine

Exceeds ecologically justified norm. It is known that for the formation of highly productive ecologically sustainable agrolandscapes, the level of plowed land should not exceed 40–50%. So, for example, 36% was plowed in France, 32% in Germany, 18.5% in England, and 20% in the USA. In Ukraine, agricultural land occupies 41 million hectares, or approximately 70% of the land, among which 79.3% is arable land.

Impoverished agrobiodiversity

The ecologically unjustified level of plowing of the land fund causes a catastrophic impoverishment of agro-biodiversity. Thus, according to the data of the National Academy of Sciences of Ukraine, crisis phenomena are observed in the state of the wild and associated agrobiodiversity.

It was determined that the greatest impact on agrobiodiversity has: changes in land use (37%), unsatisfactory environmental management (16%), habitat fragmentation (7%), exploitation of natural resources (9%), poisoning (7%), disturbance (6 %) and other. The calculation of indicative indicators shows that the natural capital index for agriculture in 2001 compared to 1994 was 52%.

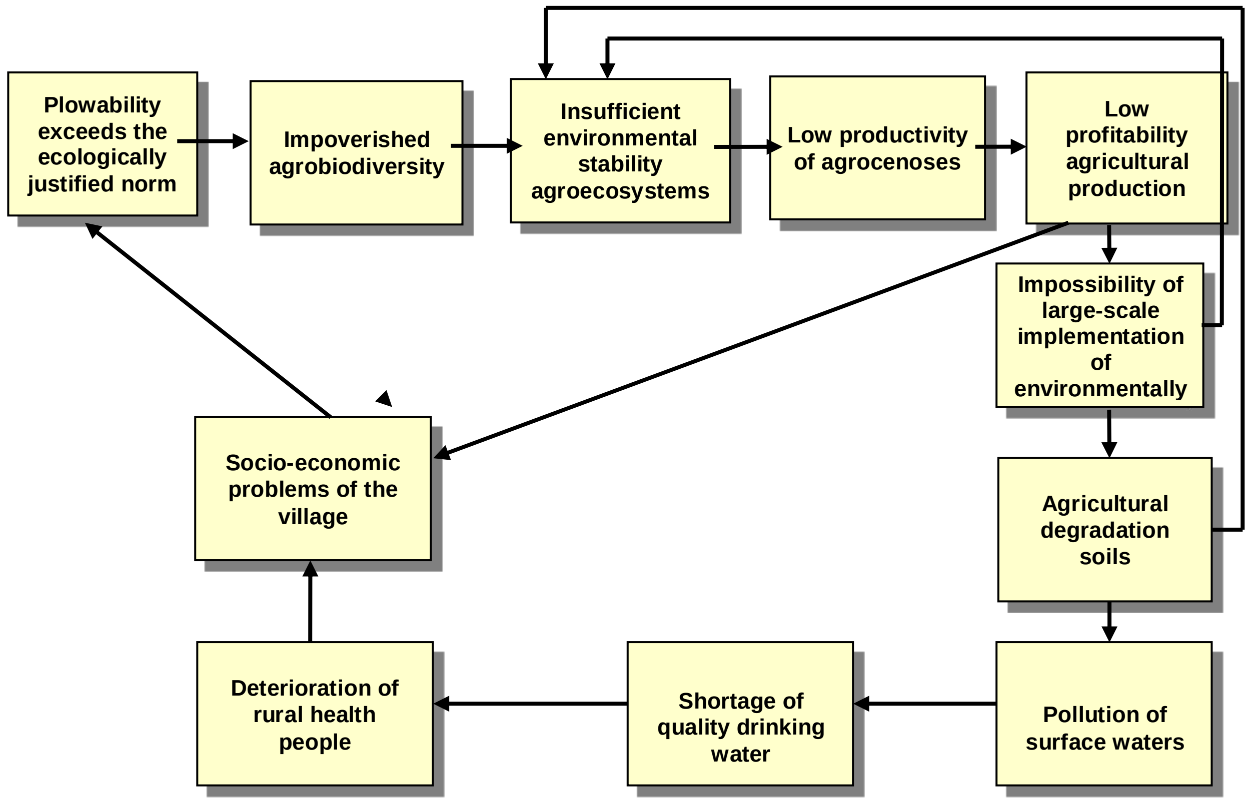

Fig. 7 **Model of the causes and consequences of the pre-crisis state of the agricultural sector of Ukraine**

Insufficient environmental sustainability of agroecosystems

It is known that the high stability of more diverse ecological systems is due to the close packing of ecological niches, the mechanisms of support of which, primarily – various types of competition, determine the mutual regulation of the number of populations, and their access to ecosystem resources. The insufficient ecological stability of agro-landscapes as a result of the impoverishment of agrobiodiversity is manifested in the constant deterioration of the phytosanitary state of agrocenoses, which has been happening for many years even under conditions of stabilization of plant protection measures. Thus, in some years, the country does not harvest almost 50% of the harvest of the main grain crop – winter wheat – from harmful populations.

Low productivity of agrocenoses

Insufficient ecological sustainability of agro-landscapes, a tense phytosanitary condition determines the existing level of productivity of agroecosystems, which does not correspond to the quality of the land fund of Ukraine. So, for example, according to the data of the European Economic Commission, the average multi-year productivity indicators of winter and spring wheat in Ukraine are 2.3 against 5.8 t/ha in the EU, potatoes, respectively, 11.9 against 33.9, sugar beet 18.3 against 51.2 t/ha.

Low profitability of agricultural production

According to the review and forecast report on the development of the Agro-industrial Complex of Ukraine (Ukrainian Academy of Agrarian Sciences, (UAAS), in 2007, the average level of profitability of agricultural products in agricultural enterprises of Ukraine was 25.2%, including crop production – 37.3 and livestock production – 5, 7%, in 2008 – only 9.2, 12.2 and 2.6%, respectively. The trend of rising cost prices continues.

Impossibility of large-scale implementation of environmentally safe technologies

The level of profitability makes it economically impossible not only for large-scale greening of agricultural production but also for the introduction of modern technologies. So, for example, according to the Institute of Plant Protection of the Ukrainian Academy of Sciences, the implementation of modern systems of chemical protection of winter wheat is cost-effective under conditions of a yield level of 3 t/ha. The lack of agroecological innovations in agriculture worsens the level of sustainability of agroecosystems due to feedback loops.

Degradation of agricultural soils

The degradation of agricultural soils is caused by a lack of innovation. Thus, according to the data of the National Scientific Centers "Institute of Soil Science and

Agrochemistry named after O.N. Sokolovsky" and "Institute of Agriculture of the Ukrainian Academy of Sciences" in Ukraine, up to 600 million tons of soil, up to 15 million tons of humus, 0.3–0.9 million tons of nitrogen, 700–900 thousand tons of phosphorus, 6–12 million tons of potassium, which is much more than is applied with fertilizers. Crop yields on eroded soils are 20–60% lower than on non-eroded ones. Losses of agricultural products due to erosion exceed 9–12 million tons of grain units, and ecological and economic losses amount to $10 billion every year. The area of agricultural land subject to water erosion is 13.3 million hectares (32% of the total area), including 10.6 million hectares of arable land.

As part of the eroded lands, 4.5 million hectares were strongly and moderately eroded, and 68 thousand hectares lost the humus horizon. More than 6 million hectares are systematically exposed to wind erosion, and in years with dust storms – up to 20 million hectares. The dust storm of 2007 covered 125 thousand km^2, up to 20% of the area of Ukraine, and 50% of the area of the steppe zone.

The level of land erosion through feedback suppresses both the ecological sustainability of agroecosystems and their productivity.

Pollution of surface waters

According to the information provided by the Ukrainian National Academy of Sciences to the National Report on the State of the Environment in Ukraine in 2000. ecological degradation caused by agricultural activities most significantly affected watercourses and basins of small rivers of Ukraine, which is the main structural unit of Ukrainian agricultural landscapes.

The network of small rivers includes more than 63 thousand watercourses with a total length of 135.8 thousand km, of which about 60 thousand are very small with a length of less than 10 km with a total length of 112 thousand km. These rivers are the most vulnerable to environmental disturbances. The catchment area of small rivers ranges from 20 to 500 km^2, i.e. they are characterized by rugged terrain that is easily subject to erosion processes, and the channels are silted by fine soil, agrochemicals, and pesticides carried away from the catchment area.

Shortage of quality drinking water

The condition of Ukraine's surface waters determines the ecological quality of drinking water. In Ukraine, there are 15,281 waterworks under the control of the State Sanitary and Epidemic Service of the Ministry of Health of Ukraine. In the course of state sanitary control measures, 43,300 inspections of water supply facilities were carried out, of which 5,060 (11.7%) revealed gross violations of the anti-epidemic regime. Out of 281,500 samples of drinking water, deviations from the standard regarding bacteriological contamination were found in 12,000 samples (4.3%).

Deterioration of the health of the rural population

The pre-crisis state of the natural environment determines the level of health of the population. Thus, constant monitoring of population health indicators indicates its deterioration due to the spread of some classes of diseases. First of all, this is evidenced by the increase in general morbidity rates. In the regions, there have been significant changes compared to previous years in the prevalence of diseases of the endocrine system, indigestion, metabolic disorders, 1.8 times the number of diseases of the endocrine system, the prevalence of diseases of the circulatory system (by 10.6%), diseases of the blood and hematopoietic organs (by 7.4%), as well as neoplasms (by 3%).

The socioeconomic problems of the village are at the top of the pyramid of environmental violations and their consequences. Thus, according to the National Academy of Sciences, in 2007, 15.5% of rural households were below the poverty line, and 25% had total expenses that did not exceed the subsistence level. Despite the low availability of social facilities in rural settlements, their network continues to degrade. In 2000–2007, it decreased by 13,500 village shops, 2,600 public catering establishments, 0.3 thousand children's preschools, 0.3 thousand secondary schools, 1,000 cultural institutions, and 0.9 thousand paramedics and midwives points. The countryside is further depopulated and settlements are removed from the register. The settlement network decreased by 147 settlements from 2000–2007.

The insufficient profitability of agricultural production increases the social problems of the village, which, in turn, negatively affect the level of productivity of agroecosystems due to feedback. At the same time, the social problems of the village determine the existing level of plowing of the land fund as a factor of extensive growth of production.

According to the model, the socioeconomic state of rural areas is in a systemic relationship with the ecological state of the agrosphere of Ukraine, the system's feedback reinforces crisis phenomena. The model shows that the main factor of the ecological state of the system is excessive plowing of the land fund of Ukraine, which causes the impoverishment of agrobiodiversity.

In the presented model, the real state of biodiversity remains an unexplained block. Thus, the scientific verification of the working hypothesis primarily consists in determining the state of biodiversity

BIODIVERSITY OF ALIEN (INVASIVE) SPECIES

Alien species for a certain area are species that are outside their natural range, are present as a result of intentional or unintentional human activity, or species that have entered without the help of humans.

An invasive species is an alien taxon that is potentially significant to the recipient ecosystem, that has economic significance and historical, biogeographical, bioecological opportunities for invasion.

The geographical ranges of many species are limited mainly by natural and climatic barriers. As a result of the introduction of foreign species into these faunal and floral complexes, man disrupted the natural course of events. In the modern era, a huge number of species have been introduced, either intentionally or accidentally, into areas where they never existed. The introduction of many species was due to the following factors:

• ***European colonization:*** Arriving at new settlements in New Zealand, Australia, South Africa, and wanting to make the environment more familiar to the eye and provide themselves with traditional entertainment (in particular, hunting), Europeans brought hundreds of European species of birds and mammals there;

• ***Horticulture and agriculture***. A large number of species of ornamental plants, crops and pasture grasses have been introduced and grown in new areas. Many of these species "broke free" and settled in local groups;

Accidental entry. Species are often transported by humans unintentionally. Typical examples of this are weed seeds, accidentally collected together with the crop of cultivated plants and then sown in a new place; rats and insects that travel on ships and planes; pathogenic and parasitic organisms carried by their hosts. Along with ballast, ships often bring exotic species. Weed seeds and soil arthropods arrive with soil ballast dumped in port areas; water ballast contains algae, invertebrates and small fish. The vast majority of exotic species, i.e. species that have found themselves outside their natural range due to human activity, do not take root in new places, because the new environment does not meet their needs. However, a certain percentage of species adapt very well to new "homes" and become invasive species, that is, those that increase in number at the expense of native species. Through competition for a limiting resource, such exotic species can displace native species (Fig. 8).

Fig. 8 **Colorado potato beetle *(Leptinotarsa decemlineata* L.*),*** an invasive species that has spread widely throughout Europe

All alien species overcome the geographical barrier, thanks to which they appear in a new territory. Random alien species either "stop" at this stage or overcome local ecological barriers, which allows them to persist for some time, although their existence in the new territory depends only on repeated introductions. Naturalization begins when environmental and reproductive barriers are clearly overcome. At this stage, the disappearance of the species from the new territory is unlikely. We can talk about invasive species when the barrier of distribution within a new territory and introduction into disturbed or semi-natural communities is overcome. Reasons for classifying a species as alien:

- the species is assigned only to secondary habitats;
- was not previously found in this area;
- was not found in archaeological excavations in this area;
- it is rare in secondary habitats;

- does not pass the entire life cycle or passes it extremely rarely;
- there are no closely related species in this area;
- its location is removed from the main range;
- the main factor of spread is man.

Adventitious (alien, introduced) species of plants are distinguished by three parameters – the time of introduction, the method of introduction and the level of adaptation to new geographical conditions.

They are distinguished by the time of entry:

archaeophytes – introduced before the 16th century (examples include a number of Mediterranean plant species that were introduced to the territory of our country during ancient trade contacts and now grow as common weeds);

neophytes – that appeared much later (Sosnovsky's borschivnik *(Heracleum sosnowskyi* Manden).

They are distinguished by the method of entry and naturalization:

xenophytes – entered accidentally (ragweed wormwood (*Ambrosia artemisiifolia* L.), hemp nettle *(Urtica cannabina* L.);

ergasiophytes – entered intentionally (*plants of the genus Irga*, American maple (*Acer negundo* L.);

xenoergasiophytes – a transitional group with an unclear scenario of appearance in a new area.

They are distinguished by the degree of adaptability:

ephemerophytes – fluctuating species that appear and disappear in local locations (clasping pepperweed *(Lepidium perfoliatum* L.);

colonophytes – species that are firmly established in new locations, but do not spread from them (Manchu tubergourd *(Thladiantha dubia* Bunge);

epicophytes – alien species that settle in disturbed habitats (*Reynoutria japonica* Houtt.);

agrophytes – entered plants that are introduced into natural communities (Himalayan balsam *(Impatiens glandulifera* Royle).

A species can become invasive and be introduced into new regions and ecosystems that are not typical for it due to various reasons:

- natural range expansion by diffusion type;
- movements associated with population fluctuations, including movements as a result of extraordinary climatic or geological phenomena;
- anthropogenic changes in abiotic and biotic factors of the environment, which caused corresponding changes in the range boundaries;
- deliberate introduction and reintroduction of species of living organisms important from the point of view of human economic activity;
- accidental entries.

By penetrating previously uncharacteristic habitats, alien species will significantly transform the structure of biocenoses:

- change the structure and functions of ecosystems, habitats of native species;
- enter into competitive relations with native species and contribute to their displacement;
- turn out to be predators of native species and reduce the number of their populations;
- are carriers of pathogens of native species.

As a rule, natural changes in species ranges occur relatively gradually and consistently. Changes caused by direct or indirect human activity are much faster (recorded by one or more generations of people) and occur in a given period of time or have occurred relatively recently.

Thus, we can distinguish between the expansion of the range of species due to natural causes, on the one hand, and the introduction of glandular bindweed on the other.

Introduction is a purposeful human activity to introduce genera, species, subspecies, varieties, breeds and forms that have not been previously encountered in a given natural and historical area.

Intentional introduction includes:

movement without breeding to achieve, directly or indirectly, any utilitarian goal. This includes the widespread practice of moving species to "fill empty ecological niches" to increase ecosystem productivity;

breeding of species valuable for anthropogenic activities. Breeding is understood as artificial support and/or artificial provision of a separate component of a species' life cycle outside its natural range;

the practice of "classical" biological control, i.e. the targeted dispersal of living organisms to combat harmful or undesirable species of animals, plants or microorganisms (for example, in Australia, the introduction of the cactus moth to destroy thickets of prickly pear cactus).

The intentional release (without utilitarian purposes) of breeding objects, an example of which is aquarium production objects simply thrown into natural water bodies, along with which aquarium plants also enter natural water bodies.

Unintentional introduction includes a large number of cases of transfer of organisms carried out by accident, without setting a specific purpose for the transfer. It can be divided into two groups:

- introduction of a species together with objects of intentional settlement;
- introduction on a "non-biological" (ballast water with plankton, railway transport) or "biological" carrier (e.g., Colorado potato beetle, potato moth, chestnut moth).

During the introduction, subsequent acclimatization and naturalization, the natural range of plants changes. A new area is formed, which is proposed to be called cultivated.

Cultigeneic area is an area that arose and formed outside the current natural distribution of a taxon and is directly related to its cultivation.

The cultivated introduction area is the area of survival and preservation of a taxon (outside its natural distribution), which occurs only with the direct assistance of humans.

Within the cultivated naturalization area, the plant culture gets the opportunity to enter certain local plant communities.

Similar to natural habitats, cultivated areas tend to both expand and contract. The latter is much less common and can be associated with a decrease in the need for a given species, the displacement of a given species from culture by another, more promising species, increased exposure to pests and diseases, and, finally, the degeneration of the introducer, primarily due to genetic factors.

Adventitious (alien) species in the flora of different regions

The average share of adventitious species in the flora of different parts of the world is 16%, with 11% on the continents and 31% on the islands.

The picture of the adventization of flora on different continents is as follows: North America – 19%, Australia – 17%, South America – 13%, Europe – 9%, Africa – 7%, Asia – 7%. The maximum share of alien species – 31% – was found in agricultural and urban ecosystems, followed by temperate forests, where the share of invasive species reaches 22%. Adventive species are found in the flora of every region except Antarctica.

The most commonly encountered adventitious species are often from the families Poaceae, Asteraceae, and Brassicaceae.

A large number of East Asian plants become weeds in North America, and North American species become very aggressive invasive species in Europe.

European plants are being introduced into the flora of Australia, America and Africa, and Australian species are becoming weeds in Africa.

Problems of invasive insect species in Ukraine

More than 20 species of mottled moths have been found in green areas of settlements and agrocenoses in Ukraine. In recent years (2004–2022), the number of species of this group of phytophages has increased. These are mostly adventive species: *Lhyllonorycter platini* Staudinger, 1870, *Phyllonorycter issikii* Kumata, 1963, *Cameraria ohridella* Deschka & Dimic, 1986, *Acrocercops phaespora* Meyer., *Phtorimea operculella* Zell., *Tuta absoluta* Meyrick. etc. Research on trophic specialization showed that 6 species of phytophagous insects are polyphages, in particular: *Gracillaria syringella, Phyllocnistis labyrinthella, Phyllonorycter emberizaepennella, Phyllonorycter salicicolella, Phyllonorycter sorbi, Phyllocnistis labyrinthella, oligophages* (14 species) – *Caloptilia semifascia, Caloptilia rufipennella, Parectopa robiniella, Phyllonorycter acerifoliella, Phyllonorycter apparella, Phyllonorycter blancardella, Phyllonorycter cerasicolella, Phyllonorycter coryli, Phyllonorycter guercifoliella, Phyllonorycter issikii, Phyllonorycter populifoliella, Phyllonorycter strigulatella, Phyllonorycter tenerella, Phyllonorycter ulmifoliella* and *monophagous* (3 species) – *Cameraria ohridella, Phyllonorycter faginella, and Phyllonorycter platani.*

For the first time, three species of spotted moths were discovered in Kyiv: *Phyllonorycter issikii, Phyllonorycter platani, and Phyllonorycter emberizaepennella.* It becomes obvious that the entomofauna of Ukraine is constantly replenished with new species immigrants, which can have unpredictable consequences, for example, the chestnut moth, potato moth, etc. It has been established that adventive species that have entered new territory in favorable conditions for their development and reproduction, in the presence of a sufficient amount of food resources and the absence of natural enemies, expand their range extremely quickly. Therefore, to prevent the mass spread of such species, it is necessary to conduct regular monitoring with the aim of timely detection of insect foci.

Global climate change as a threat to the planet's biological resources is one of the most acute environmental problems today. Scientific data, presented in 2007 by the UN expert group on climate change (IPCC, 2017), conclusively confirm the reality of global warming caused by human activity. During the 20th century, the average temperature on the planet increased by 0.6°C. Climate warming can be seen in changes in surface temperature and atmospheric air temperature, as well as in the ocean to a depth of several hundred meters, which is more significant in northern latitudes.

The main cause of climate warming, according to the international scientific community, is anthropogenic influence. Global emissions of greenhouse gases as a result of human activity increased by 70% between 1970 and 2004. Industry and agriculture emit four long-lived greenhouse gases: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and carbohydrates that contain fluorine, chlorine, and bromine. In 2005, CO_2 and CH_4 concentrations significantly exceeded the natural range over the past 650,000 years. The main source of the increase in global CO_2 concentration is considered to be the use of fossil fuels. The growth of CH_4 and N_2O concentrations is mainly caused by agriculture. The dynamics of the actual values of warming are closely consistent with mathematical models that take into account the natural and anthropogenic influence on the atmosphere.

Numerous violations of abiotic and biotic systems are registered on the planet, the frequency of which is higher in the northern hemisphere, which coincides with the latitudinal distribution of the warming phenomenon. The impact of climate change on terrestrial ecosystems is manifested through:

• changes in areas; the distribution of plant and animal species is directed towards the poles;

• an earlier start of spring phenomena, such as the blooming of leaves, bird migrations, and egg-laying periods;

• increasing the growing season of plants;

• in agriculture in the high latitudes of the northern hemisphere, earlier spring sowing dates are followed;

• in forestry in the Northern Hemisphere, the frequency of fires and mass breeding of harmful insects is increasing;

• changes in the distribution of carriers of infectious disease agents, the earlier appearance of allergenic plant pollen.

According to forecasts of UN experts, an increase in the average temperature to 1–3°C will lead to the extinction of 30% of biota, and with a warming of 2–4°C, 15 to 40% of the planet's ecosystems will be affected. In the field of agriculture, with an increase in temperature, there will be significant changes in the formation of the productivity of agricultural crops and an increase in the number of populations of harmful organisms.

In the conditions of threats to biological resources caused by global warming, systematic studies of ecological violations in the biocenoses of Ukraine are extremely relevant for ecological substantiation and the development of a set of measures to prevent them.

BIODIVERSITY OF UKRAINE: TODAY

Ukraine occupies 6% of the area of Europe, and the biocenoses of Ukraine contain almost 35% of Europe's biodiversity. This is because the territory of Ukraine is located in different natural zones, such as the steppe, forest-steppe, broad-leaved forest, and the Mediterranean. The wealth of landscapes in Ukraine increases in the following sequence: meadows, marshes, floodplains, steppes, and forests. Representatives of more than 70,000 taxa live in Ukraine.

The results of research into the planet's biodiversity show that insects and their relatives dominate terrestrial and freshwater ecosystems. According to any available scientific estimates, insects account for 53% to 75% of biota species, and their combined biomass exceeds the biomass of all other animals. Thus, insects provide a significant part of the biotic circulation of matter, energy, and information in the biosphere, which determines the maintenance of ecological balance. Insects have evolved consumers of different levels, which are embedded in several orders between producers and reducers. As a result of this evolution, the chain of transmission of energy in the form of regenerated carbon and hydrogen, as well as biogenic elements within the ecosystem, has been lengthened. The lengthening of the chain, in turn, led to an easier closing of the cycle and a reduction in the loss of energy and biogenic elements buried in the dead biomass. It should be noted that in nature, not more productive, but more frugal biotic groups are selected, capable of minimizing losses and maximally closing the cycle of matter and energy.

The problem of preservation of natural diversity is especially relevant for our country since only a third of the natural vegetation has survived on the territory of Ukraine, moreover, in an altered form. There are almost no landscapes in Ukraine that have not been distorted by economic activity. Little-changed landscapes make up 12.7% of the territory. These are mainly secondary forests, wetlands, nature reserves, and other nature conservation areas. According to experts, the area of such landscapes should be 40% to compensate for the anthropogenic impact.

The area of protected areas in 2010–2011 was 4% (total area of 2.8 million hectares), which is more than 2.5 times less than the European average.

Of the 220 types of natural landscapes of Ukraine, only 40% are represented in the nature reserve fund.

In the 20th century, considerable damage was caused to biological diversity, as the rapid development of the industrialization of production, drainage of wetlands, construction of reservoirs and canals, chemicalization of agricultural lands and other factors became one of the main factors of anthropogenic landscape changes. Today, this trend remains almost unchanged. Irrational human economic activity destroys landscapes. The extraction of minerals leads to the formation of quarries, dumps, and terricones. Polluting substances emitted by enterprises into the atmosphere and hydrosphere affect almost all landscapes. Drainage and irrigation change the natural water regime of landscapes and cause physical-geographical processes that are not typical for them (blowing out peatlands, flooding and salinization of chernozems, etc.).

Despite the significant anthropogenic load, due to its geographical location, Ukraine still preserves an extremely rich biota. This is large because Ukraine has four natural zones in a relatively small area: broad-leaved forest, forest-steppe, steppe, and Mediterranean. The physical and geographical conditions of Ukraine contributed to the formation of a rich flora and fauna, numbering more than 70,000 species (according to experts, one-third of the species – mostly mushrooms and insects – have not yet been described).

Occupying only 6% of the area of Europe, Ukraine possesses at least 35% of its species diversity and by this indicator is ahead of almost all European countries, only slightly inferior to France and Italy. This is explained by the fact that Ukraine is a crossroads of historically different migratory waves of animal and plant life from different centers of origin that passed through its territory, leaving living monuments of these waves – to the taiga swamps with tundra species of Polissia, from the Central Asian steppes, which are already absent further west, to completely different Central European steppes in Podillya. The Tovtrovy ridge is a unique natural monument in

Ukraine. The beech forests of the Ukrainian Carpathians, the largest in Europe in terms of area, are of European importance. To a large extent, this also applies to the halophilic vegetation of the Azov-Black Sea coast and the relic massifs of the oak forests of the Forest Steppe, etc.

The flora and its geography in Ukraine are relatively well studied. Ukraine belongs to the countries with a great diversity of flora. Of the 300–350 thousand species of higher plants in the world, there are more than 25 thousand species in Ukraine, including about 4 thousand algae, more than 15 thousand mushrooms and slime molds, more than 1 thousand lichens, almost 800 mosses, and vascular plants – more than 6.5 thousand species.

The following comparisons testify to the richness and high species saturation of the flora per unit area of Ukraine. The natural flora of higher vascular plants includes 4523 species, while in Belarus – 1460, Moldova – 1762, and Poland – 2300 species.

The families with the richest species composition are Asteraceae (Compositae), Gramineae (Poaceae), Fabaceae, Rosaceae, Lamiaceae, Brassicaceae, and Caryophyllaceae. More than 150 species of plants are listed in the first edition of the Red Book of Ukraine, which was founded in 1976. More than 400 species of vascular plants have already entered the second edition. There are especially many endemic, rare, and endangered species in the Carpathians – almost half of all endemic and about 30% of all rare and endangered species. Natural vegetation has been preserved on only 20% of the territory; more than a thousand species of plants are cultivated.

In the process of economic activity, the flora changed significantly: during the 16th–19th centuries. the area of forests in the forest-steppe zone decreased more than 5 times, and the area of the most valuable oak and beech forests was only in the 19th century. decreased by a quarter. Natural vegetation is mostly preserved in forests, protected areas, permanent meadows and pastures, slopes of gullies, and ravines.

Forest cover in different parts and regions of Ukraine is uneven. It is significantly higher than the national average in the west and north, especially in the

Carpathians. As you move south and southeast, the forest cover gradually decreases. In the western and northern parts of the republic, the area covered by forests is 20–40%, in the Carpathians – more than 60%, and in Polissia – 30%. In the south of Ukraine, forest areas are small: in the Steppe – up to 4%.

Among the valuable plants used in medicine, almost 250 species are recognized as medicinal in Ukraine, including 150 – in scientific medicine. About 100 species are harvested, of which 40–50 species are harvested on a large scale. The regions of Polissia and Forest-Steppe, as well as the Carpathians, are the main ones for harvesting medicinal plants.

Ukraine is rich in such medicinal plants as field chamomile, valerian, rosehip, celandine, St. John's wort, yarrow, plantain, sea buckthorn, tricolor violet, sage, dahlia, dandelion, common motherwort, periwinkle, sedge, sedum, honeysuckle), lily of the valley and others. Many species of wild medicinal plants are already listed in the Red Book of Ukraine.

The animal world, which includes almost 45,000 species in Ukraine, includes protozoa (over 1,200 species), flatworms (1,290), nematodes (540), arthropods (39,000), fish (over 270), birds (344), mammals (108). The first edition of the Red Book of Ukraine included 85 species and subspecies of animals (29 mammals, 28 birds, 6 reptiles, 4 amphibians, and 18 insects), and the second edition included almost 400 species of invertebrates and vertebrates. There are more than 6,640 species of freshwater and brackish water animals in Ukraine.

Among 45 European countries, Ukraine ranks 1–5 in terms of the number of species of individual groups of vertebrate animals, and in terms of the number of preserved globally vulnerable species in Europe, it ranks 5th. This shows that Ukraine can be one of the main reservoirs for the restoration of Europe's biodiversity, in particular bison, the number of which in Ukraine is the largest in the world.

Occupying less than 6% of Europe's area, Ukraine possesses approximately 35% of its biodiversity. This is because the territory of Ukraine is located in different natural zones, such as steppe, forest-steppe, broad-leaved forest, and the

Mediterranean. The wealth of landscapes in Ukraine increases in the following sequence: meadows, marshes, floodplains, steppes, and forests. Representatives of more than 70,000 taxa live in Ukraine.

The fauna of Ukraine is divided into two systematic taxa of high rank – vertebrates and invertebrates, and the number of the latter is much greater than the former. According to rough estimates, one-third of the species, in particular fungi and insects, have not yet been described.

The forest-steppe zone occupies about a third of the territory of Ukraine and, despite significant anthropogenic pressure, a variety of vegetation has been preserved within its borders: forests formed by common oak (oak, hornbeam-oak, linden-oak), rock oak (in the southwestern part of the forest-steppe) are represented. , as well as common hornbeam. Pine and oak-pine forests occur on the sandy soils of the second terrace of the Dnipro and its left-bank tributaries. Meadow vegetation forms in river floodplains. Swamps are also confined to river floodplains and are mostly represented by high-grass eutrophic species. Steppe vegetation (mainly meadow sedge-grass steppes) was preserved only in the form of small fragments in areas inconvenient for plowing and intensive use and the territories of the nature reserve fund.

In general, the vegetation cover of Ukraine is represented by forests, meadows, swamps, steppes, tomilaria, and shrub thickets (halo-, psamo-, calce-creto, petrophilic, and aquatic communities). According to Y.R. Shelyaga-Sosonka forest refund of the Ukrainian Carpathians consists of 801 associations of 16 formations, Ukrainian Polissia – of 409 associations of 10 formations, Podilsk part of the forest zone – of 246 associations of 12 formations, forest-steppe zone of 405 associations of 13 formations and steppe zone – of 380 associations of 18 formations.

The allocation of the rare vegetation confound of Ukraine will contribute to the solution of several issues in the field of forest conservation, in particular, the development of their protection regimes, the support of phytogenetic potential, the formation of sustainable communities, the stabilization of the ecological state of regions, etc.; the cenofund of Ukraine is its national wealth.

As a result of management, especially in the last century, there have been significant changes in landscapes and natural habitats. The area occupied by natural groups decreased sharply – up to 29%, including forests – up to 14.3% of the country's territory, the steppe as a natural biome was practically destroyed, the hydrological conditions of the territory underwent significant changes in connection with the construction of lowland hydroelectric power stations and the creation of reservoirs, the draining of the Polissia marshes and the irrigation of the Steppe. Anthropogenic pollution of significant territories is observed, including heavy metals, radionuclides, persistent organic compounds, manifestations of devastation, and syn anthropization of ecosystems have been noted, which threatens the loss of the gene-, ceno-, and eco-fund and creates social and ecological discomfort of the population.

Agrobiodiversity, its definition, and structure

The biodiversity of agricultural landscapes (agrobiodiversity) is a rather complex biological object, which to some extent functions as a natural object, but in general, it is quite dependent on the entire process of agricultural production. Agrobiodiversity is also a rather diverse object that can be classified based on biological properties, diversity, and the presence of various constituent elements.

Biodiversity in the agroecosystem, as in any ecosystem, contains genesis fractions of biota - aboriginal (autochthonous), adventive (allochthonous), and the newest, which is the result of their mutual penetration. In addition to these three, the biota of agroecosystems contains a cultigen fraction, which was introduced by man and cannot exist without anthropogenic support.

Landscape biodiversity has three components: wild biodiversity, genetic biodiversity, and associated biodiversity. Wild biodiversity includes wild relatives of domesticated plants and animals that live, for example, in the steppe or the forest outside the countryside, and can be used to breed new species of domesticated plants or animals in the future. Also, soil microorganisms, pollinators, insect pests and predators, and other plants and animals, are associated with functions related to the importance of the local agroecosystem.

Example:

• decomposition of organic substances and return to the circulation of nutrients to maintain soil fertility for the tireless development of plants and animals;

• decomposition of pollutants – to preserve clean air and water;

• mitigation of climatic effects;

• preservation of soil and water resources;

• pollination of agricultural crops;

• keeping under control the vital activity of pests of agricultural crops.

Genetic biodiversity includes:

Higher plants – agricultural crops and their wild relatives; plants that grow on pastures and semi-natural pastures; trees grown in agricultural landscapes; weeds;

Mammals – domestic and wild mammals that use agrolandscapes as habitat;

Birds – domestic and wild, that use agro-landscapes as a habitat;

Reptiles, amphibians, and hydrophones also use agro landscapes as habitat;

Arthropods – pollinators, pests, entomophagous other arthropods (for example, termites, ants);

Other macroorganisms such as earthworms, mollusks;

Microorganisms – soil bacteria, fungi, algae, nematodes, actinomycetes, pathogenic microorganisms, etc.

Associated biodiversity includes plants and animals that do not always support key agroecosystem functions, but that use agricultural areas for food and shelter.

At the fifth Conference of the Parties to the Convention on Biological Diversity (Nairobi, May 2000), in the special program of work on biodiversity, which is closely related to the field of agriculture, agricultural biodiversity is defined as "the diversity and variability of animals, plants, and microorganisms at the genetic, species and ecosystem levels, which are necessary for maintaining the most important functions of the agroecosystem, its structure, and processes that ensure food production and food security".

Cromwell et al. pays attention to the following features that distinguish agrobiodiversity from another biodiversity:

• agrobiodiversity is actively managed and many of its components would cease to exist if it were not for human intervention;

• knowledge and culture of indigenous peoples are an integral part of agrobiodiversity management;

• a significant number of economically successful farms base their activities on the cultivation of varieties of agricultural crops of non-local origin, brought from other parts of the world (for example, corn and potatoes were brought to Europe from America);

• diversity of varieties of plants and breeds of animals, which are involved in agricultural production, is as important as the diversity of wild species of plants and animals;

• agrobiodiversity is closely related to relentless land use and nature conservation practices; protecting it only by creating nature reserves is not a sufficient step.

An overview of the main elements of agrobiodiversity allows us to build a generalized scheme (Table 3).

Table 3

Elements of agrobiodiversity

Level	Cultivated component	Spontaneous (natural) component
Genetic	1. Diversity within the used plant varieties, strains of microorganisms, and animal breeds	7. Genetic heterogeneity of populations of wild organisms in agroecosystems
Population	2. Diversity of widely used varieties of plants, strains of microorganisms, and breeds of animals	8. Diversity of genetically determined ecotypes, cenopopulations, geographic races, subspecies, etc. among wild organisms

Continued table 3

Species	3. Diversity of used types of cultivated organisms	9. Species diversity of wild organisms
Coenotic	4. Diversity of agrocenoses (agroecosystems)	10. Diversity of spontaneous coenoses on agricultural lands
Landscape	5. Diversity of farm types from the point of view of ecology (according to the nature of substance and energy exchange)	11. Diversity of preserved fragments of natural landscapes
Zonal	6. Diversity of zonal types of agriculture	12. Diversity of types of ecosystems inherent in natural zones (biomes)

The diversity of agricultural crops, to a greater extent, is provided by gene banks, that is, thanks to closed conditions, rather than open conditions of farms.

Preservation of biological diversity is inextricably linked to the preservation of the natural environment – landscape diversity (diversity of biotopes, econiches, trophic chains). That is, landscapes should also be considered ecosystems, which are subsystems of larger ecosystems within which biodiversity can be preserved.

Regarding the distribution of agrobiodiversity in Ukraine in a zonal context, it differs significantly within the boundaries of the natural zones – Polissia, Forest Steppe, and Steppe, as well as the mountain system – the Ukrainian Carpathians. Based on the dependence of the coenotic and species diversity of the spontaneous phyto- and zoobiota of agrobiodiversity on soil and hydrological conditions, further analysis of its distribution according to natural zonal-ecological features within the given zones, but taking into account the degree of their transformation into disturbed natural or agroecosystems, is possible.

At the level of natural landscapes (including their parts developed for agriculture), the following main types can be distinguished: 1 – fragmented landscapes with broad-leaved forests, 2 – leveled landscapes with broad-leaved forests, 3 – fragmented landscapes with steppes, 4 – leveled landscapes with steppes and salt marshes, 5 – sandy and peaty landscapes of Polissia and pine terraces, 6 – sandy and meadow-black soil landscapes of floodplains, 7 – landscapes of lowland swamps and deltas, 8 – mountain forest landscapes of the Ukrainian Carpathians, 10 – high mountain landscapes of the Ukrainian Carpathians. Regarding these types of natural landscapes, different agricultural production management systems are used.

The basic basis for preserving the biodiversity of agricultural landscapes is the rational use of soil cover, its protection and reproduction of fertility, as well as the preservation of soil diversity. The number of ecosystems located in a certain territory is determined taking into account the condition of the ground cover. The diversity of soil cover is controlled by quantitative and qualitative indicators that characterize the direction of changes in the natural environment in space and time.

Different types of agroecosystems can include natural, spontaneous, and agrocenoses. Thus, at the level of natural coenoses, coenoses with a natural structure and species composition are common; natural cenoses changed to some extent; natural coenoses, transformed in an indigenous way; spontaneous coenoses formed on fundamentally changed ecotopes, often with reduced productivity, and island spontaneous coenoses, the area of which is insufficient to support biodiversity, as well as strip coenoses (along roads, rivers, on the edges of fields, etc.).

Among the spontaneous coenoses and ecotopes, the following groups are distinguished: remains of steppe vegetation (including ravines, gullies, banks, old fallows), spontaneous meadows, wastelands and psammophyte groups, natural areas of forests (changed to varying degrees, as well as naturalized plantings), young trees on wastelands (spontaneous), shrubby secondary groups, swamps (undrained and drained), salt marshes, salt marshes, rocks, etc., abandoned quarries and peat works, unused reservoirs, watercourses, spontaneous vegetation of rural settlements.

Some of the agrolandscapes include anthropogenically little-changed lands and reservoirs belonging to agricultural producers, as well as lands and reservoirs that have been withdrawn from agricultural production or planned by state programs for decommissioning and renaturalization. These lands are characterized by the highest level of biodiversity among agricultural lands. Although the biodiversity of these lands is not always included in the concept of agrobiodiversity (and sometimes loses the signs of agrobiodiversity over time), in most cases it is a source of replenishment of agrobiodiversity and actively interacts with it.

Landscapes of Ukraine were maintained in a harmonious state only until the first half of the 19th century, after which the systematic felling of forests in the Forest-Steppe, draining of lands in the polyzone, and plowing in the Steppe zones began.

In the process of anthropogenic transformation of modern spontaneous biota, the role of agro landscapes is wide and diverse, it is connected with impoverishment, cosmopolitan nation and unification of biota, serious evolutionary consequences and distortions in it caused by chemical, physical, and biological pollution of the environment. Introduction and expansion of adventive species are processes of the syn anthropization of plant cover and animal population, the most important factor of which is human activity in the agricultural sphere.

According to the structure of agricultural land in Ukraine, a situation with the following ratio of land is considered ideal: 1 – arable land: 1.6 – natural fodder land: 3.6 – forests. But the real ratio is as follows: 1 – arable land: 0.23 – hayfields and pastures: 0.3 – forests. Such a ratio is evidence that the state of agricultural landscapes is extremely unbalanced. According to these data, it is possible to assess the ecological state of agrolandscapes: Polissya is moderately degraded, Forest-Steppe is severely degraded approaching catastrophic, and Steppe is catastrophic; in general, for Ukraine, it is much worse.

The way out of the difficult ecological situation that has developed in Ukraine is expressed in the gradual transition from existing agrolandscapes with low forest cover to the formation of new agroforestry landscapes as highly productive, biologically stable, and self-regulating systems. They are capable of resisting the destruction of soils, reducing their fertility, optimizing the structure of the land, and rationalizing land use. It should be added that forest-agrarian landscapes can become migration routes, and shelters for biodiversity components. According to the calculations of experts, for this purpose, the forest protection area must be brought up to 30–40% in the next 10–15 years; as of 1996, according to the calculations of V.D. Baitali does not exceed 2.6%.

S. Yu. Bulygin, in the process of ecological conversion of agriculture in Ukraine, proposes to transfer a certain part of currently plowed, but not very productive lands (salted, eroded, etc.) to use as fodder lands (hayfields and pastures) and to afforestation. According to his calculations, the degree of plowing will thus decrease in the Steppe zone from 81.3 to 60%, in the Forest-Steppe – from 82.0 to 60.8%, in the Polissia – from 66 to 49%; on average in Ukraine – from 78.5 to 57.9%.

Ukraine has 32 million hectares of arable land, more than 71% of which are fertile black soils. However, in the process of agricultural use, soils are subjected to various types of degradation. The processes of degradation of Ukraine's soil cover have reached such a scale that they threaten its integrity and diversity. For example, certain types and subtypes of soils are already disappearing within some landscapes, which in general threatens not only the efficiency of agricultural production, and the food security of the state, but also, of course, negatively affects both the natural environment and biodiversity.

Therefore, the agricultural landscapes of Ukraine, despite the significant anthropogenic transformation, remain an important condition for preserving biodiversity.

BIODIVERSITY OF INSECTS IN BIOCENOSES, SYSTEMATICS, AND ECOLOGY

Despite the united front, ecologists still cannot agree among themselves regarding the level of biodiversity and the depth of the planetary crisis. Thus, E. Wilson (1993) believes that it is impossible to determine the exact number of species that may disappear, but their number is very significant. For the first time, the total number of species on Earth, as well as the actual rates of extinction, were calculated in 1992 from the data available at that time. It was substantiated that 3.63 million species live on the planet, and the rate of their disappearance is 3–5 species per year.

Depending on the scientific and government institutions of developed countries that performed similar calculations, the gap between extinction rates was between 17,000 and 100,000 species per year, while some experts believe that the rate of extinction of biota is even higher. Entomologists estimate that the entomological diversity of the British Isles has decreased by 7–20% over the past 100 years. This problem ultimately stems from a lack of sufficient published scientific data – biologists admit that they know very little about most organisms on our planet.

The simplest approach to calculating total biodiversity is to compare the ratio of the known and unknown number of species. Such an assessment was carried out for birds, mammals, and other well-known animals of the temperate zone, with subsequent extrapolation of the data to the tropics. Assuming that there are twice as many species in the tropics and this approach is valid for all classes of living beings, the calculations showed a level of world biodiversity of 3 million species. It is now recognized that insects are the most numerous group of species. One of the estimates of the total number of their species ranges from 4.9 to 30 million. If we assume that beetles make up 40% of all species of arthropods, which are twice as abundant in the forest canopy than under the canopy, with rounding, we get approximately 30 million species of insects in the world.

After analyzing all the available materials, the scientific commission under the auspices of the UN came to a consensus that the number of insect species on the planet is 13.6 million. Many ecological researchers do not recognize this document as a "working hypothesis", considering it a speculative product of "office biology".

Thus, by any available scientific estimate, insects represent the majority of life forms on the planet.

Insects are the most famous of all invertebrates. They are easily identified: they have 3 pairs of legs and 3 main body parts – head, chest, and abdomen. Insects are protected by a hard chitinous coating. Most insects have large faceted eyes and antennae (antennae).

Most insects reproduce sexually, although some insects, such as aphids, can reproduce asexually. All insects lay eggs. In the more primitive species of insects, the offspring, which has just been born from the egg, resembles the parents in miniature. However, the majority of insects are characterized by metamorphosis, when individuals that are born from the egg are very different from their parents, and to reach the adult stage, they must go through significant changes.

Paleontology shows that insects lived 400 million years ago. They are the first animals to master flight. Shortly after the development of wings, about 330 million years ago, there was an explosion of insect speciation recorded in the paleontological record, which also witnessed the spread of insects to new habitats. Today, insects, except the ocean, inhabit almost all major ecosystems on the planet (including Antarctica).

Research by other authors on other species of insects in the temperate climatic zones of the planet confirmed this conclusion. However, such evolutionary conservatism is not always observed, so it was concluded that increased speciation occurs mainly in tropical zones. In addition, evolutionary changes are characteristic of endemic species.

The class of insects includes at least 32 orders, but only 4 of them are dominant. These include: 1) Coleoptera – 370,000 known species, or 40% of all insects and 10% of all animals; 2). Lepidoptera – more than 130,000 known species, the second largest group; 3) Diptera (Diptera) – 120,000 known species; and 4) Hymenoptera – according to various estimates, there are 15,000–25,000 species. All these four orders include more than 80% of all known species of insects, and the other 28 orders – only about 20% of species.

Ecologists have long recognized butterflies as the best group of insects for studying the structure of total biological diversity. Butterflies are an excellent "indicator" of insect diversity, as they are distinguished by their size and bright color. They were among the first to be thoroughly studied and cataloged, with most species discovered as early as the late Victorian era; even according to conservative estimates, it is accepted that nowadays 90% of the world's butterfly fauna has been described. The use of such an indicator makes it possible to estimate the level of global biodiversity based on knowledge of the ratio of the share of butterfly species among all other insects, as well as the share of insect species in the global number of species. Today, the world's known butterfly fauna includes, according to various estimates, from 14,750 to 17,500 species. Calculations allow us to reach the figure of 3,627,695 species, which make up the total biological diversity of the planet.

The extremely high level of global insect diversity is indirectly confirmed by the results of classic studies of individual regions of the planet. So, the Argentine Monte desert has an area of 38 million hectares. Studies of entomological biodiversity made it possible to identify 17,958 species of insects belonging to 16 families.

The northern region is the largest forest biome after the rainforest. Its area is about 16.6 million km^2. Although the boreal forest is structurally much less diverse than the rainforest, the boreal insect biodiversity is also impressive. For example, at least 4,000 species of insects that feed on dead wood have been described to date in northern Finland alone.

According to estimates available in the scientific literature, the insect fauna of Ukraine in the 20th century numbered 25,000 to 35,000 species. The range of estimates of the indicator shows that, under the conditions of a powerful entomological school, a thorough systematization of the species diversity of insects of Ukraine has not yet been carried out, which makes it difficult to determine the state of agrobiodiversity. The question arises, how to assess the state of the entomofauna of agrolandscapes if theoretically, it counts tens of thousands of species that inhabit various components of agrolandscapes? In our opinion, such an assessment is possible on the example of a representative sample of insects, which, according to literature, is represented by constant and dominant species. These species are listed in many entomological reviews, monographs, and reference books, which were published over decades of faunal research conducted in the 20th century by teams of domestic entomologists.

To obtain representative samples in the process of faunal research, the known entomofauna of agrolandscapes were grouped according to the main life forms, each of which requires adequate methods of counting the number, which is due to the peculiarities of the ecology of each grouping. According to the results of the analytical research conducted according to the literary sources of the 20th century, lists of dominant and constant types of agrolandscapes of the Forest-Steppe of Ukraine were compiled by life forms. Long-term faunal studies of different stations of agrolandscapes allowed us to establish the presence or absence of certain species in entomological collections and to compare the existing types of biodiversity with literature information.

The set of morphological, biological, and physiological properties of an insect species constitutes its life form, which reflects the most important features of its ecological niche, as well as biotic relationships with other organisms. According to the existing classification by life forms, insects of terrestrial ecosystems are divided into "geophilous" and "phytophiles". The first includes life forms of geobionts and herpetobionts, and the second – is hortobionts and dendrobionts.

Life forms and ecological group of insects

An important feature of all terrestrial animal groups is the large number and variety of arthropods, primarily insects. Each type of ecosystem is characterized by its own set of species, among which the dominant species stand out – the most numerous species in biocenosis.

A *life form* is a historically formed complex of biological, physiological, and morphological properties of a species that determine a certain reaction to the influence of the environment.

The term "*life form*" was introduced into science by A. Humboldt in 1806. During the 19th century, the term was used in botany, and then it became more widespread. Raunkier's works on the life forms of plants are very popular, and among Soviet researchers – V. V. Alekhin, B. A. Keller, A. P. Shennikov, I. G. Serebryakov, and many others. Botanists Warming and Gamory suggested that ecological groups similar to plant life forms can also be distinguished in animals.

An important step forward in the development of the problem of life forms was made by A. N. Formozov, who substantiated their characteristics according to certain quantitative indicators – morphological, physiological, etc. In his writings, A. N. Formozov assumed that the species largely bears the imprint of the environment in which it lived and lives and to which it is, as a rule, well adapted. Hence the emergence of certain landscapes of life or biological forms specific to them, and similar landscapes of different continents there may be their own sets of forms, moreover, outwardly and in their habits, they are quite similar to the first ones, although they are very distant in systematic terms. In the formation of biological forms, a greater role is played by convergent evolution – the process of convergence of morphological, physiological, and other features. This process can apply not only to individual species but also to some extent to entire faunas or even biota. Within the boundaries of one landscape zone, such as deserts, several specific life forms of animals solve the task of adapting to desert landscapes in their way, as was shown by A.N. Formozov, A.K. Rustamomov and N.N. Thrush Convergent and parallel development is usually observed in family forms. This was explained, in particular, by I.I. Schmalhausen, who wrote: "for dissimilar organisms, the environment can never be the same, because different organisms occupy a different position in it, that is, they treat it differently," therefore, one cannot expect a deep similarity in the adaptive reactions of such organisms.

In animals, *life forms* are groups of taxa, usually within the same order or close orders, which have similar morpho-ecological adaptations for living in the same environment. A typical example of life forms can be adaptive ecological groups of mammals: swimming, burrowing, running, jumping, flying, etc. Similar groups have been repeatedly described in birds, insects, fish, reptiles, ticks, and other animals, so we can talk about the universality of the phenomenon of adaptive parallelism of animals, about a kind of "fourth rule" of adaptive evolution in animal ecology, along with the well-known rules of Bergman, Allen, and Gloger.

Other transformation strategies are also possible, for example, the relationship of animals with the "microbial link" of the trophic chain, the development of "internal trophic chains" in ruminants, mollusks, coral polyps, and many other animals, which at the initial stage of trophic divergence is associated with the formation of life forms.

These and other changes observed during the separation of life forms not only allow organisms to master new food resources, avoid adverse abiotic influences, and occupy an ecological space free from enemies and competitors but also lead to a complication of the structuring of biogeocenoses and the biosphere as a whole.

The ecological importance of insects is reflected in the structure of their life forms. Therefore, the life form is a complex of biological, physiological, and morphological properties of a species, which cause a certain reaction to the action of the environment. Externally, the life form is characterized by general features of adaptation to the specifics of the place of residence, the similarity of the main morphological signs, and signs of behavior.

Land dwellers have the following categories of life forms.

Geobionts are soil inhabitants, which are divided into:

rhizobionts – animals associated with roots;

saprobionts – inhabitants of decomposing organic substances;

coprobionts – invertebrates – dung dwellers;

botrobionts – inhabitants of burrows;

planophiles are animals characterized by frequent movement.

Epigeobionts are invertebrate animals that live on more or less open areas of the soil surface.

In turn, depending on the soil on which animals live, they are divided into:

psamobionts – animals adapted to life on a sandy substrate;

petrobionts – inhabitants of rocky areas;

halobionts are inhabitants of saline areas of the soil.

Herpetobionts are invertebrate animal inhabitants of plants and other organic remains on the soil surface. Inhabitants of the forest floor are usually called stratobionts.

Hortobionts are inhabitants of the grass cover. Depending on their place of residence, they are divided into:

ectobionts – animals living on the surface of plants;

endobionts – inhabitants of the thickness of leaves, stems, buds, and galls.

Tamnobionts are inhabitants of shrubs.

Dendrobionts are tree dwellers.

Dark and dendrobionts are often combined into one life form, dendrobionts.

Xylobionts are inhabitants of dead wood.

The study of the life form is of great importance for solving several theoretical and practical questions, in particular about the peculiarities of the influence of the environment and the directions of adaptive changes of organisms during introduction and acclimatization.

Biodiversity of geobiont insects

Among the diversity of entomofauna, soil insects (*geobionts*) play a significant role. Geobionts are organisms that live in the earth, soil, and subsoil permanently or for a certain period of their life cycle. A large number of insect species live in the soil. Some groups of insects are so closely associated with the soil that they hardly appear on its surface. Many types of insects live in the soil only in certain periods of ontogenesis, or in certain seasons. In the insects of some species, only embryonic development takes place in the soil: for example, in locusts (Acridoidea), crickets (Gryllodea), and grasshoppers (Tettigoniidae).

Insects of many species spend larval periods in the soil, and insects with complete transformation and pupal periods. Among the insects with incomplete transformation, we can mention as an example the cabbage moth (*Gryllotalpa gryllotalpa* L.), a cicada of the Cicadidae family. From insects with a complete transformation, there are many species of carabidae, Staphylinidae, Elateridae, Tenebrionidae, Scarabaeidae, leaf beetles (Crysomelidae) of the *Sagrinae* group, some species of weevils (Cerambycidae), weevils (Curculionidae), from Diptera – species of the families Bibionidae, Tipulidae, Stratiomyidae, Tabanidae, Asilidae, Therevidae; from butterflies – species of the Agrotinae subfamily; from Hymenoptera, bee-eaters from the genera *Apodea, Sphecodea*, etc. develop in soil buds. Among these insects, some species lay eggs on the surface of the soil or plants, and their larvae move into the soil either immediately after hatching from the eggs (before feeding), as in bulbous weevils (Sitona sp.), or first feed on the aerial parts of plants, and then after the first and second molt, they go into the soil, like the caterpillars of the winter weevil (*Agrotis segetum* Schiff.).

Larvae and caterpillars of many insects burrow into the soil, already after finishing feeding on the surface of the soil and spend there only the pre-pupal phase and the pupal phase; such are many Diptera from the families Cecydomyidae, Muscidae, Larvivoridae, Phasiidae, etc.

The number of insects in the soil is very significant, as evidenced by scientific studies of soil fauna. So, for example, according to M.S. Hylyarova, on average, 1 m2 of soil contains from several dozen to several hundred invertebrates.

Insects living in the soil are significantly affected by the structure of the soil, which depends on its thermal, air, and water regimes, chemical composition, and relief. The influence of soil on insects as a habitat is closely related to its three-phase nature: the presence of structural granules of different sizes, air filling the spaces between these granules, and water.

The influence of insects on the soil is very significant, it is determined by their nutrition and digging ability. Moving in the soil, insects influence its aeration, structure, etc. Insects can stir the soil, carry its particles from deeper layers to the upper horizons, and vice versa, carry them deep.

As mentioned above, many soil insects are exclusively saprophagous or caprophagous, and most others are also characterized by partial feeding on organic remains. Saprophagous, caprophagous, and necrophagous insects accelerate the destruction of organic remains and have a positive effect on soil humification processes, enriching it with easily digestible substances for plants.

Research results of A.V. Zrazhevskii show that in the forest-steppe and steppe, the fallen leaves of trees are turned into a humified mass almost exclusively by the larvae of dipterous insects – species of the genera *Bibio Geoffr., Neosciaria Pett., Scatopse* Geoffr. etc. Larvae of *N. modesta* Staeg. in trees of 8 species, the leaves are completely converted into a dust-like humified substance, and in trees of 10 species, the leaves are half eaten. The excrement of larvae that fed on fallen leaves of a sharp-leaved maple contains about 10 mg of ammonia and 8 mg of nitrates per 100 g of dry matter. In the humified mass, into which the larvae turn fallen leaves, a significant increase of nitrogen was noted in comparison with its content in fallen leaves.

The results of the observations of several scientists, as well as special laboratory studies, confirm that in the absence of soil invertebrates, the accumulation of humic substances does not occur.

The biodiversity of insects-geobionts according to the analysis of literary sources is 107 species from 6 orders and 13 families. The ecological analysis of the entomofauna proves (Table 4) that the largest number of families has some Soleoptera (8), which is 93.38% of the total, where the species of the Carabidae family are dominant*: Pterostichus vernalis* Panzer, *Harpalus distinguendus* Duft., *Broscus cephalotes* L., *Amara similata* Gyllenhal, *A. aenea* Degeer, *A. familiaris*

Duft., *Calathus erratus* Sahlb., *Bembidion properans* Steph., *Harpalus luteicornis* Duft., which is 31.48% of the total, and the Curculionidae family: *Otiorrhynchus ligustici* L., *Sitona crinitus* Hrbst., *S. humeralis* Steph., *S. lineatus* L., *S. longulus* Gyll., *S. puncticollis* Steph., which is 27.77%. The orders Dermatoptera and Homoptera have 2 families each, which is 5.6%, and Isoptera and Orthoptera have 1 family each. The families Curculionidae, Carabidae, and Scarabaeidae are the most numerous by species: 32, 27, and 18 species, respectively. This is explained by the fact that the habitat of the larvae of these species is the soil, where they spend a fairly significant period of their life cycle – from 2 to 4.5 years, until the emergence of the imago. The families Termitidae, Gryllotalpidae, Alleculidae, and Tipulidae are represented by 1 species (see Table 4).

Table 4

Taxonomic structure of biodiversity of geobiont insects

№	Infraorder	Family	Kinds	
			number	(%)
1	Isoptera	Termitidae	1	0,93
2	Orthoptera	Gryllotalpidae	1	0,93
3	Dermatoptera	Forficulidae	2	1,87
4	Homoptera	Cixiidae	2	1,87
5	Coleoptera	Carabidae	27	25,23
		Scarabaeidae	18	16,82
		Elateridae	11	10,21
		Alleculidae	1	0,93
		Tenebrionidae	7	6,54
		Chrysomelidae	2	1,87
		Curculionidae	32	29,91
		Silphidae	2	1,87
6	Diptera	Tipulidae	1	0,93
In total	**6**	**13**	**107**	**100**

Biodiversity of herpetobiont insects

At the beginning of the 21st century, the species biodiversity of herpetobiont insects amounted to 470 species.

The taxonomic analysis of the results of analytical studies is given in the table. 5. As can be seen from the given data, the diversity of insects consists of 5 orders, which include 30 families. The largest number of families in the ranks: Coleoptera – 17 and Hemiptera – 7.

Table 5

Taxonomic structure of biodiversity of herpetobiont insects

№	Infraorder	Family	Kinds	
			number	(%)
1	Coleoptera	Carabidae	126	26,8
		Scarabaeidae)	9	1,9
		Elateridae	15	3,1
		Chrysomelidae	15	3,1
		Curculionidae	231	49,1
		Lathridiidae	1	0,2
		Silphidae	11	2,3
		Mordellidae	2	0,4
		Apionidae	1	0,2
		Cicindelidae	4	0,8
		Staphylinidae	18	3,8
		Leptinidae	1	0,2
		Anthicidae	2	0,4
2	Hemiptera	Histeridae	3	0,6
		Tenebrionidae	8	1,7
		Dermestidae	1	0,2
		Cerambicidae	1	0,2
		Miridae	2	0,4
		Rhopalidae	1	0,2
		Pyrrhocoridae	1	0,2
		Coreidae	3	0,6
		Cydnidae	1	0,2
		Nabidae	1	0,2
		Lygaeidae	1	0,2
3	Orthoptera	Tettigonidae	2	0,4
		Acrididae	1	0,2

Continued table 5

		Gryllidae	3	0,6
4	Hymenoptera	Sphecidae	1	0,2
		Formicidae	2	0,4
5	Dermatoptera	Forficulidae	2	0,4
In total	**5**	**30**	**470**	**100**

Regarding the quantitative distribution of insects by families, the largest number of species in the Curculionidae families is 231; Carabidae – 126, Staphylinidae – 18, Elateridae, and Chrysomelidae – 15 each. These families account for 85.9% of all types of entomological diversity of herpetobionts.

The structure of the species saturation of various series of herpetobiont insects is shown in fig. 9.

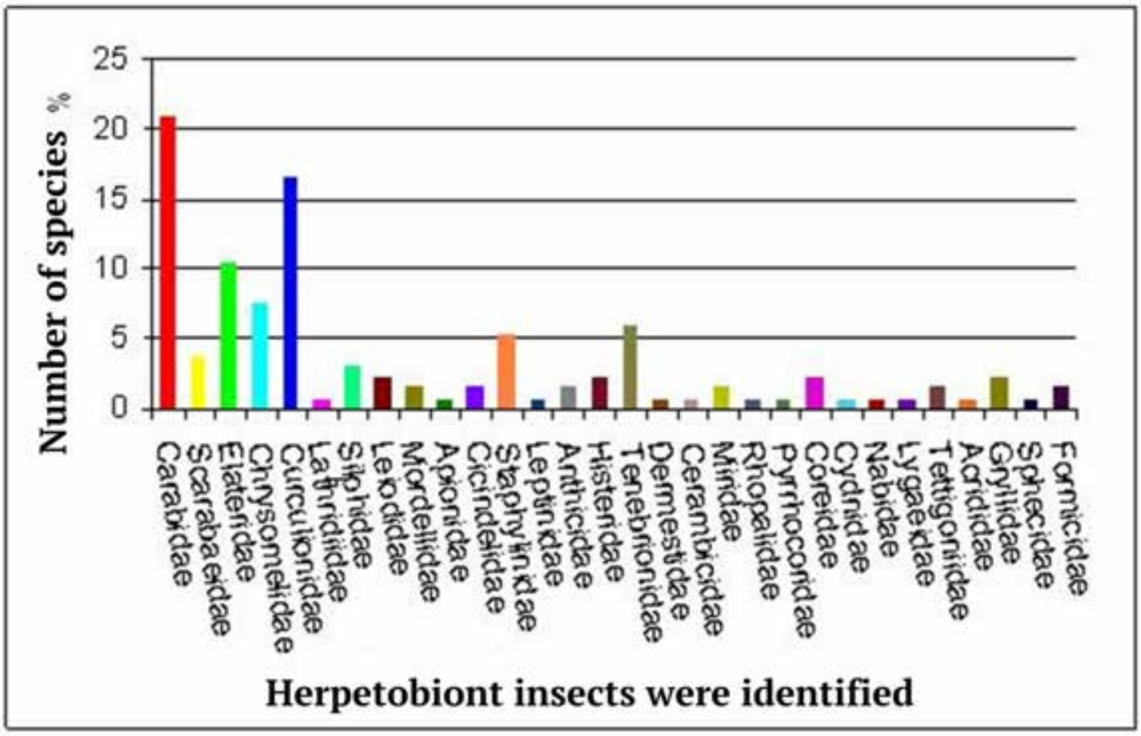

Fig. 9 **Species richness of herpetobiont insect series**

Biodiversity phytophagous insects of the herbiont life form

The known number of entomological biodiversity of hortobionts – inhabitants of the stratum of the herbaceous cover, which is formed by cereals, is 173 species (Table 6), consisting of 7 series, which include 42 families. The number of families in the series is dominated by the Homoptera series (11 families). The least abundant order in terms of families is Thysanoptera (2 families). It should also be noted the abundance of families of Lepidoptera (10 families). According to the abundance of species, the level of dominance of different series differs significantly.

Thus, the order of Lepidoptera includes 47 species, and Homoptera – 39 species. The least abundant is the order of Hymenoptera – only 7 species of insects from 2 families. The order of Thysanoptera includes only 2 families, but they include 30 species (see table 6).

Table 6

Taxonomic analysis of insect hortobiont biodiversity

Infraorder	**Family**	**Kinds**	
		number	**(%)**
Homoptera	Cixidae	2	1,2
	Delphacidae	5	2,8
	Tettigometridae	1	0,6
	Cercopidae	1	0,6
	Cicadellidae	14	8,1
	Pemphigidae	2	1,2
	Anoeciidae	1	0,6
	Chaitophoridae	2	1,2
	Aphididae	6	3,5
	Pseudococcidae	4	2,3
	Coccidae	1	0,6
Hemiptera	Miridae	5	2,8
	Rhopalidae	1	0,6
	Pyrrhocoridae	1	0,6
	Scutelleridae	4	2,3
	Pentatomidae	3	1,7
Thysanoptera	Thripidae	28	16,2
	Phloeothripidae	2	1,2
Coleoptera	Chrysomelidae	6	3,5
	Curculionidae	4	2,3

Continued table 6

	Alleculidae	5	2,8
	Mordellidae	1	0,6
	Meloidae	2	1,2
Lepidoptera	Psychidae	3	1,7
	Ochsenheimetiidae	3	1,7
	Tortricidae	2	1,2
	Glyphipterigidae	1	0,6
	Elachistidae	9	5,2
	Pyralidae	2	1,2
	Phycitidae	1	0,6
	Pyraustidae	3	1,7
	Crambidae	8	4,6
	Noctuidae	15	8,7
Hymenoptera	Cephidae	1	0,6
	Tentredinidae	3	1,7
	Eurytomidae	3	1,7
Diptera	Cecidomyiidae	3	1,7
	Agromyzidae	4	2,3
	Opomyzidae	2	1,2
	Ephydridae	1	0,6
	Chloropidae	5	2,8
	Anthomyidae	3	1,7
In total	**42**	173	**≈100**

Biodiversity of dendrobiont insects

According to the results of analytical studies, it was established that the dominant and constant entomofauna of tree and shrub plantations of agro-landscapes at the beginning of the 21st century is 854 species (Table 7).

Taxonomically, the diversity of entomofauna consists of 13 orders, which include 136 families. The following orders have the largest number of families: Lepidoptera – 39, Coleoptera – 31, Hymenoptera – 15, and Homoptera – 14.

Table 7

Taxonomic structure of entomological biodiversity of dendrobionts

Infraorder	Family		Kinds	
	number	(%)	number	(%)
Orthoptera	2	1,5	3	0,4
Homoptera	14	10,3	88	10,3
Hemiptera	12	8,8	44	5,2
Thysanoptera	1	0,7	7	0,8
Coleoptera	31	22,8	368	43,1
Lepidoptera	39	28,7	205	24,0
Hymenoptera	15	11,0	78	9,1
Diptera	17	12,5	56	6,6
Mecoptera	1	0,7	1	0,1
Blattodea	1	0,7	1	0,1
Neuroptera	1	0,7	1	0,1
Dermaptera	1	0,7	1	0,1
Raphidioptera	1	0,7	1	0,1
In total	**136**	**≈ 100**	**854**	**≈ 100**

As for the species richness of families, the following families have the largest number of species: Ipidae – 65, Curculionidae – 63, Cerambycidae – 51, Tenthredinidae – 40, Chrysomelidae – 39, Buprestidae – 38. These families account for 34.8% of all species of entomological diversity (table 8).

Table 8

Species richness of dendrobiont insect families

Infraorder	Family	Kinds	
		number	(%)
Orthoptera	Gryllotalpidae	1	0,1
	Acrididae	2	0,2
Homoptera	Cicadidae	1	0,1
	Cicadellidae	7	0,8
	Membracidae	2	0,2
	Aphrophoridae	4	0,5
	Aleyrodidae	2	0,2
	Adelgidae	13	1,5
	Aphididae	27	3,2

Continued table 8

	Lachnidae	6	0,7
	Coccidae	9	1,1
	Eriococcidae	4	0,5
	Kermesidae	2	0,2
	Asterolecaniidae	2	0,2
	Diaspididae	8	0,9
	Psyllidae	1	0,1
Hemiptera	Tingidae	2	0,2
	Pyrrhocoridae	1	0,1
	Miridae	10	1,2
	Coreidae	3	0,3
	Aradidae	1	0,2
	Cydnidae	3	0,3
	Pentatomidae	16	1,9
	Rhopalidae	2	0,2
	Coptosomidae	1	0,1
	Scutellaridae	2	0,2
	Lygaeidae	2	0,2
	Reduviidae	2	0,2
Thysanoptera	Thripidae	7	0,8
Coleoptera	Scarabaeidae	17	2,0
	Lymexylidae	3	0,3
	Coccinellidae	13	1,5
	Anobiidae	4	0,4
	Cantharidae	5	0,5
	Bostrichidae	3	0,3
	Mordellidae	3	0,3
	Lyctidae	1	0,1
	Malachiidae	3	0,3
	Elateridae	19	2,2
	Buprestidae	38	4,4
	Byturidae	1	0,1
	Oedemeridae	4	0,5
	Meloidae	1	0,1
	Cerambycidae	51	6,0
	Chrysomelidae	39	4,7
	Attelabidae	9	1,1
	Curculionidae	63	7,4
	Ipidae	65	7,6
	Platypodidae	1	0,1
	Nitidulidae	1	0,1

Continued table 8

Coleoptera	Silphidae	1	0,1
	Ptinidae	1	0,1
	Cleridae	1	0,1
	Carabidae	13	1,5
	Lagriidae	1	0,1
	Tenebrionidae	2	0,2
	Phalacridae	2	0,2
	Byrrhidae	1	0,1
	Bruchidae	1	0,1
	Anthicidae	1	0,1
Lepidoptera	Incurvariidae	3	0,3
	Hesperiidae	2	0,2
	Eriocraniidae	1	0,1
	Tischeriidae	1	0,1
	Adelidae	4	0,5
	Cossidae	1	0,1
	Plutellidae	6	0,7
	Pterophoridae	2	0,2
	Chimabachidae	1	0,1
	Oecophoridae	2	0,2
	Argyresthiidae	4	0,4
	Cemiostomidae	1	0,1
Lepidoptera	Hyponomeutidae	1	0,1
	Gracillariidae	9	1,1
	Yponomeutidae	7	0,8
	Sesiidae	10	1,2
	Tortricidae	26	3,0
	Lycaenidae	1	0,1
	Carposinidae	1	0,1
	Phycitidae	9	1,1
	Pieridae	2	0,2
	Notodontidae	10	1,2
	Eupterotidae	1	0,1
	Geometridae	36	4,2
	Drepanidae	2	0,2
	Lasiocampidae	3	0,3
	Lymantriidae	8	0,9
	Zygaenidae	2	0,2
	Nymphalidae	3	0,3
	Noctuidae	28	3,3
	Arctiidae	1	0,1

Continued table 8

Lepidoptera	Gelechiidae	5	0,6
	Hepialidae	1	0,1
	Satyridae	1	0,1
	Crambidae	2	0,2
	Pyralidae	3	0,3
	Syntomiidae	1	0,1
	Glyphipterygidae	1	0,1
	Ethmiidae	1	0,1
Hymenoptera	Siricidae	4	0,5
	Xiphydriidae	3	0,3
	Cephidae	2	0,2
	Sphecidae	1	0,1
	Pamphilidae	4	0,5
	Cimbicidae	3	0,3
	Megachilidae	1	0,1
	Formicidae	1	0,1
	Argidae	3	0,3
	Diprionidae	4	0,5
	Tenthredinidae	40	4,7
	Cynipidae	7	0,8
	Anthophoridae	3	0,3
	Chalcididae	1	0,1
Hymenoptera	Apidae	1	0,1
Diptera	Cecidomyidae	24	2,8
	Lonchaeidae	2	0,2
	Agromyzidae	8	0,9
	Syrphydae	4	0,5
	Asilidae	3	0,3
	Bombyliidae	1	0,1
	Tabanidae	1	0,1
	Tachinidae	1	0,1
	Phoridae	1	0,1
	Anthomyidae	1	0,1
	Ulidiidae	1	0,1
	Tephritidae	4	0,5
	Tanypezidae	1	0,1
	Scatophagidae	1	0,1
	Opomyzidae	1	0,1
	Xylophagidae	1	0,1
	Bibionidae	1	0,1
Mecoptera	Panorpidae	1	0,1

Continued table 8

Blattodea	Blattellidae	1	0,1
Neuroptera	Chrysopidae	1	0,1
Dermaptera	Forficulidae	1	0,1
Raphidioptera	Raphidiidae	1	0,1
In total	**136**	**854**	**≈ 100**

As a result of research on the biodiversity of the entomofauna of Ukraine, the state was determined and analyzed, and calculations were made for various life forms of insects. It was determined that there are 1,604 species of insects from 31 orders and 221 families in the agricultural landscapes of Ukraine.

Insects are divided by life forms as follows: geobionts – 107 from 5 orders and 13 families. Herpetobionts – 470 from 6 orders and 30 families. Hortobionts – 173 species from 7 orders and 42 families. Dendrobionts – 854 from 13 orders and 136 families (Table 9).

Table 9

Quantitative analysis of entomological biodiversity by order, family, species by life forms

Life forms of entomological biodiversity	Infraorder	Family	Kinds
Geobionts	5	13	107
Herpetobionts	6	30	470
Hortobionts	7	42	173
Dendrobionts	13	136	854
In total	**31**	**221**	**1604**

FOOD AND ECOLOGICAL NICHES OF ENTOMOLOGICAL BIODIVERSITY

Dimensions of ecological niches of insects

Of the abiotic factors, temperature, humidity and precipitation, light, and wind are of great importance for insects – the main elements of the climate of this or that area or the microclimate of those or other places of stay. In addition to the physical elements of the environment, soil conditions are important factors affecting insects, especially those directly related to the soil. Among the biotic factors, food is very important in the life of insects. In addition, the most important factors of the biotic environment of insects include symbiosis, commensalism, parasitism, predation, competition, and relationships with plants.

Anthropogenic factors are extremely powerful, especially since this activity can be deliberately aimed at destroying species harmful to humans, or at creating conditions favorable for the development and reproduction of useful species.

Trophic relationships of insects. The trophic relationships of animals with the environment were assessed as the most important environmental factor even by Forbes. He wrote that "...without a doubt, of all the properties of the environment surrounding an individual, none affects him so strongly, variously, and so deeply as the elements of his food. Even the climate, the season, the soil, and the inorganic environment usually affect the animal through food directly." Food is necessary for insects to increase body size during ontogenesis, for the development and maturation of sexual products, and to replenish energy costs during life.

Insects that feed only on plants are called phytophages, that feed only on animals – *zoophagous*, that feed on decomposing plant substances – *saprophages*, that feed on animal corpses – *necrophages*, and those that feed on manure – *caprophages*.

There is no clear distinction between autophagy, phytophagy, saprophagy, and necrophagy in some insects. Yes, some grasshoppers (*Decticus albifrons* F. and *Tettigonia caudata* Charp.) are usually herbivores, but sometimes willingly feed on various insects. *Oreasobia fedtschenkova* Sauss. they feed on both living plants and decomposing plant remains, and also eat dead insects and worms. Many herbivorous butterfly caterpillars are capable of cannibalism. Therefore, the division of insects by the nature of nutrition into the above-mentioned groups is more or less relative, and the degree of specificity of nutrition in different types of insects is different. A significant role in the nutrition of insects is played by the protein substances of food, since the composition of various proteins and the nutritional value of the constituent amino acids are quite diverse, therefore, first of all, the features of growth and reproduction depend on protein nutrition. The degree of completeness of food is also highly dependent on the energy resources of food substances.

According to the nature of nutrition, insects are divided into monophagous, which feed on homogeneous food, oligophages – a wider source of food, and polyphages, capable of feeding on heterogeneous food.

Zweigelt was one of the first to substantiate the course of the evolution of insect nutrition, which goes from polyphagy, through oligophagy to monophagy.

Several ways of the evolution of the insect feeding spectrum are theoretically substantiated:

1. Oligo- or polyphages acquire a narrower specialization due to the narrowing of food plants.

2. Insects move to new food sources with the loss of ties with traditional host plants.

3. Expansion of food plants due to the inclusion of new objects and the preservation of old ones. This is one of the ways of survival of the species in changing environmental conditions. Before the spread of sugar beet culture in Ukraine, the common beet weevil fed on weeds from the quinoa and buckwheat families. The harmful turtle bug was an aborigine of the virgin Steppe of Ukraine, with the development of agricultural production, which was accompanied by an increase in the level of plowing of the steppe, the phytophagous switched to feeding on grain spikes.

In most cases, the polyphagy of insects is limited. However, there are insects capable of absorbing all kinds of organic substances, up to their excrement (some termites, in particular *Acanthotermes turkestanicus* Jakob.), such insects are called omnivores. Many locusts (Acridodea), caterpillars of winter caterpillars, which eat various plants, the egg-eating parasite Trichogramma evanescens Westw., which infects the eggs of various butterflies, and many predatory beetles (Carabidae), which eat various insects, worms, and mollusks, are distinguished by their omnivorousness.

Food that is not characteristic of one or another type of insect can sometimes be eaten forcibly, in the absence or lack of optimal food. So, for example, the larvae of the Asian locust (*Locusta migratoria* L.) eat peas only in the absence of other food. The parasitic fly (*Ernestia consobrina* Mgn.), which infects the caterpillars of various caterpillars (Noctuidae), can also infect butterflies of some other families in their absence. An example of the influence of food quality on fertility can be given to the caradrina scoop (*Laphygma exigua* Hb.).

In many dipterans, mosquitoes (*Sulicidae*), mosquitoes (genus *Phlebotomus* Rd.), and midges (Simuliidae), a special phenomenon was found, which was named the gonotrophic cycle, the essence of which is that the development of eggs is in strict accordance with the nutrition of females.

The dependence of the duration of insect development on the quantity and quality of food has been established for many species. At the same time, it is known that not every change in the chemical composition of food necessarily affects the rate of ontogenesis of any kind of insect.

The search for the necessary or most suitable food plants forces insects to be distributed on the territory following the distribution of food resources and to occupy different ecological niches in biotopes. The patchy distribution of insect species over the territory is very significantly related to the nature of food chains and cycles. Certain plants attract certain types of insects that feed on them, and the latter, in turn, attract their parasites and predators. Manure, in which plant substances, animal corpses, etc. decompose. has its specific insect fauna. In some cases, migrations of insects related to food needs have a regular seasonal character, this is especially clearly expressed in many aphids.

In some cases, the feeding of insect larvae can affect the sex of the future adult phase.

In many insects, the phenomenon of geographical variability like food is known. Geographic variability like nutrition allows insects to spread more widely, which is an adaptation to the conditions of different environments. Of course, geographic variability can occur only in euribiont species.

In some species of insects, the forms of providing offspring with food take on a complex nature. The creation of food reserves ensures the larvae from starvation and death and from expending energy in search of food.

Dependence of insects on temperature. Insects belong to poikilothermic animals – their body temperature depends on the temperature of the environment, and their ability to thermoregulate is limited. Therefore, among the abiotic factors of the ecological niche of insects, the temperature is one of the main factors. Regulation of body temperature in insects is carried out mainly by changes in the intensity of oxygen absorption and water evaporation. The intensity of breathing increases with increasing temperature. According to A. Krogh, pupae of the large mealybug (*Tenebrio molitor* L.) per 1 g of mass consume 45 mm^3 of oxygen in 1 hour at 100°C, 199 at 20°C, 495 at 30°C, and 495 at 32.5°C – 592 mm^3. According to G.A. Pantyukhova, the eggs of the ringed silkworm (*Malacosoma neustria* L.) at a temperature of 3°C per 1 g of weight consume 2.7 mm^3 of oxygen, at 5°C – 1.4 and at 11°C – 0.53 mm^3; pupae of the elm foot tail (*Exaereta ulmi* Schiff.) at the same temperatures consume 3.8, 2.2 and 0.73 mm^3 of oxygen per 1 g of their weight, respectively. According to the work of M. Necheles, changes in oxygen absorption and water evaporation in the black cockroach (*Blatta orientalis* L.) inhibit the decrease in body temperature at an ambient temperature below 13°C and its increase at an ambient temperature above 25°C.

Black beetles (Tenebrionidae) of the genus *Adesmia* Fisch.-Wald. in the sun, their body temperature is 2–9°C lower in their living state than when they are dead.

Due to evaporation from the surface of the body and through the stigmas during breathing in the caterpillar of the cotton bollworm (*Chloridea obsoleta* F.), the body temperature under the influence of solar radiation of 1–1.2 calories per 1 dm^2 of surface rises by no more than 5–8°C.

According to Bakhmetyev's observation, the rapid wing movement of the pine sparrow (*Sphinx pinastri* L.) increased its body temperature by 10.7°C. According to V.V. Nikolskoi, N.P. According to Naumova, the body temperature of the Asian locust (*Locusta migratoria* L.) at an air temperature of 17–20°C at rest is approximately equal to the air temperature, while in flight it rises to the level of 30–37°C.

The intensity of heat exchange between insects and the environment is also related to the size, shape, structure, and coloring of their bodies. Undoubtedly, these features have developed in them to some extent depending on the temperature conditions of the environment in which they live.

It is common knowledge that dark colors have a greater ability to absorb solar heat than light colors. In this regard, black body color prevails in insects living in high mountain and arctic regions. As experimentally proven, the Central Asian light form of the winter weevil (*Agrotis segetum var. pallida* Stgr.) can be obtained during the development of this insect in conditions of high temperature and low humidity; on the contrary, the large dark Siberian form of this butterfly (*A. segetum var. glaucina* Kozh.) is revived when the insect is kept at a low temperature. The light-winged form of the butterfly (*Acronicta lutea var. leucoptera* Btl.) is common in the northern borders of the area.

In the entomological literature, there is a lot of information about the effect of temperature on the coloration of insects, especially on the pigmentation of butterflies that emerged from pupae and were kept at different temperatures. Ch. Elton thoroughly investigated the conditions for the development of dark pigments in the bed bug (*Pyrrhocoris apterus* L.) and showed that the effect of temperature on the insect's color is due to changes in metabolism.

The peculiarities of the environment to which the life of dimorphic insects are adapted in different seasons are by no means limited only to temperature. As it was established, even at the same temperature of 26°C, caterpillars reared 24 hours a day under light given only in the summer form, and under lighting for 9 hours. per day – only spring uniform. When rearing caterpillars in the dark, 77.6% of pupae enter diapause and produce red butterflies, and 22.4% develop without diapause and produce black butterflies. Thus, abiotic factors affect the development of insects collectively.

There is evidence that different temperatures can cause changes in the size of individual parts of the body, for example, the relative length of wings in bees, the fly *Drosophila virilis* Sturt., and the large flour beetle *(Tenebrio molitor* L.). Development under dramatically different temperature conditions can affect developmental biology in some insects, such as Melanoplus mexicanus Sauss. molt 6 times at a temperature of 22–27°C, and 5 times at a temperature of 33–37°C.

Adaptation of insects to the temperature of the environment is often due to their adaptive behavior, which significantly increases the adaptive potential of the organism. Excessive metamorphosis with the presence of a false pupa stage here can easily be explained as an adaptive phenomenon to winter low temperatures.

At ambient temperatures exceeding the optimum, many insects move to cooler places, for example, at high temperatures, beetles (*Hylobius abietis* L.) go from the illuminated part of forest clearings to a cooler, unlit area, hide in the moss and switch to active life after lowering daytime heat

According to Williams' proposal, the temperature that is adaptive for the majority of individuals in the population was named thermal preference. The study of this issue showed that thermal preference is highly dependent on environmental conditions. It is not the same in different seasons, at different hours of the day, and also depends on the temperature at which this species developed earlier, therefore, on the climate in different parts of the range.

According to Wellington, caterpillars of the spruce leafroller (*Choristoneura fumiferana* Clem.) in Canada are active when their body temperature does not exceed 38°C, and this temperature is usually 11–12°C higher than the ambient temperature.

The temperature has a very large (direct and indirect) impact on all aspects of insect life. It largely determines the speed of ontogenesis of insects, life span, fecundity, gluttony, mobility, and rates of their mortality. Thus, the number of insect populations and their behavior greatly depends on the ambient temperature.

Embryonic and post-embryonic development of insects and the rate of development of their reproductive products (eggs and sperm) tend to accelerate at higher temperatures.

The development of insects occurs within known temperature limits; there are temperatures below which and above which development stops. These temperature limits are usually called the lower and upper thresholds of development.

Small temperature fluctuations, in most cases, in a small amount accelerate the course of ontogenesis in insects; this was established, for example, for locust eggs *(Melanoplus atlanis* Rly.), for different stages of development of the apple borer (*Laspeyresia pomonella* L.). In Shelford's experiments, the acceleration, in comparison with the terms of development at constant temperatures, reached 7% for fruit-eater eggs, 8% for caterpillars, and 7% for pupae. In Cook's experiments with scoop caterpillars (*Chorizagrotis auxiliaris* Grt.), it was found that the acceleration of development also depends on the duration of exposure to certain temperatures.

The experiments of Ludwig and Kabel revealed that the effect of temperature fluctuations is not the same for different physiological states of the insect, and also depends on whether the temperature decreases or increases during development. The development of insects usually slows down when the temperature fluctuates to the limits above the optimum for development. According to Kozhanchikov, in the caterpillars of the unpaired (*Porthetria dispar* L.) and oak (*Aniherea pernyi* Guer.) silkworms, changes in the temperature regime become a depressing factor in development only if they lead to a reduction in the food eaten by them.

Different populations of many insect species react differently to the same environmental factors, so diapause can interrupt the development of some of them, while other populations under the same conditions do not enter diapause. Such a diapause was called facultative. In the complex environmental conditions that prevent the manifestation of facultative diapause, temperature plays a leading role.

Egg-laying rates and fecundity of insects, as a rule, increase when the temperature rises to a certain limit. Sometimes this temperature limit can be close to the limit of the insect's activity, after which heat stress already occurs. So, for example, in Schubert's experiments, 20 female bedbugs (*Piesma quadratutn* Fieb.) laid 136 eggs in 10 days at a temperature of 10–12°C, 352 eggs at 18–20°C, and 764 eggs at 37–40°C. Similar data were obtained in other experiments.

The temperature optimum of vitality for different stages of insect development, and even more so for different types of insects, is very different. Thus, the temperature optimum of viability for eggs of the winter weevil (*Agrotis segetum* Schiff.) is 25.3°C, for caterpillars – 22.0°C, for pupae – 19.0°C. Some orthoptera (Orthoptera) in the deserts of Palestine are most active at noon, when the temperature rises to 60°C, while some aphids (Aphidodea) are mobile and reproduce already at a temperature of 7.2°C.

Insects living in more northerly places are more resistant to low temperatures than insects in the south, and insects that hibernate in the open tolerate lower temperatures compared to those that hibernate in more frost-protected places.

Different phases of insect development differ in cold resistance. Much greater cold resistance is characteristic of those phases that go into winter. Preparation for wintering is accompanied, first of all, by a decrease in the total amount of water in body tissues, which leads to the concentration of solutions of substances in them, and especially to a decrease in the content of free moisture not bound by colloids. In hibernating insects, the respiratory rate decreases.

The rate of their cooling is also very important for the cold resistance of insects. The lower the cooling rate, the higher the cold resistance.

The temperature zone that lies between the critical temperature of activity and the temperature of death of the insect is called the anabiosis zone. The state of anabiosis is characterized by the slowing down of metabolism, but not its complete cessation. Studies of the cold resistance of insects have shown that most insects die at the very beginning of ice crystals in the insect's body. On the other hand, among insects, there were also cases of revival after almost complete freezing of their body juices, and therefore, almost complete cessation of metabolism. However, very few such insects are known so far.

Adaptation of insects to humidity and precipitation

The body of insects, like all living organisms, contains a large amount of water, which serves as a solvent for digestion, circulation of nutrients, and removal of excrement, to regulate osmotic pressure. Water is also necessary to regulate heat exchange. The percentage of water in the body of insects varies from 46–48% (in adults of the collared weevil (*Calandra granaria* L.) to 90–92% (in caterpillars of *Telea polyphemus* Cram.), to the total body weight.

In conditions of moisture deficit, which enters the body of insects from the outside, to ensure water exchange with the environment in some insects, the use of metabolic water, which is formed as a result of the oxidation of fats and some other substances, is important. Water, which enters with food, is retained in the insect's body, the more its deficiency in the insect's body. In insects, where the percentage of water is equal to 80–92% of the body weight and which feed on wet food, only 3–9% of water is bound by colloids.

The behavior and mobility of insects are largely determined by the humidity conditions of the environment and precipitation. Hygrotaxis forces insects living on the surface of the soil to move to places with more favorable humidity.

Air humidity in burrows is always higher than on the soil surface. According to Shelford's research, the larvae of Cicindelidae in dry areas burrow deeper than in areas with higher humidity. In the desert and semi-desert areas, a fairly rich insect fauna is noted in the burrows of rodents. Red forest ant (*Formica rufa* L.) adapts to the amount of precipitation, arranging anthills of different heights.

Precipitation and humidity affect mortality rates, fecundity, terms ontogeny of insects, their mobility, distribution by biotopes, community formation, and geographical distribution. A very large number of insects often die during torrential rains. Winter precipitation in the form of rain, as a rule, in cold and temperate climates increases the mortality of many insects. On the contrary, precipitation in the form of snow increases the survival of many species of insects.

Air humidity and precipitation significantly affect the development of fungal and bacterial diseases of insects, which causes an indirect effect on the number of the latter. For many insects, the effect of environmental humidity on fecundity is known. In *Psophus stridulus* L. and some other species of *Siberian locust*, environmental humidity increases fecundity. Bean grain (*Acanthoscelides obtectus* Say.) at a relative humidity below 26% does not reproduce at all.

For each phase of each type of insect, there is a more or less certain optimal humidity of the environment, which largely depends on the percentage of water in their body, which provides the best conditions for metabolism. If the water content in the insect's body under certain conditions is higher than the optimum, dry air, increasing evaporation, contributes to the vitality of insects, while moist air, on the contrary, depresses it.

The effect of humidity on insects is closely related to other factors, especially temperature. Thus, when the temperature deviates from the optimum for a given species and a given phase of insect development, humidity usually has a negative effect. Many small, flat-bodied insects, such as the flea *Xenopsylla cheopsis* Rothsch. or adults of the bug *Oxycarenus hyalinipennis* Costa., at high temperatures almost do not react to changes in humidity, while large insects react more sharply.

Adaptation of insects to abiotuc environmental factors

It is known that all factors of the external environment act on insects collectively. Yes, the evening flight of the marbled roach begins at a certain temperature. Poplar glaze (*Sesia apiformis* Cler.) is distributed in poplar plantations at different times of the day at different distances from the surroundings, according to the intensity of illumination of the trees.

In addition, it was found that the temperature preferred by the insect can differ by several degrees in the light and the dark. Thus, in the caterpillars of the Chinese oak silkworm, the activity of catalase is higher under short daylight hours, and the activity of cytochrome oxidase, as well as succinoxidase, on the contrary, increases under long daylight hours.

In addition to different daily activities, for many insects with complete transformation, a strictly defined time of rebirth from pupae is established, which is also largely explained by lighting conditions.

Light can affect fertility, reproductive development, egg fertilization, and insect oviposition.

The photoperiodic reaction of insects is manifested even with very weak illumination of 1–3 lux. The range of temperatures at which the effect of daylight length on insect diapause is manifested is different in different types of insects. Lighting conditions play an even greater role, the wider this range is.

In addition to influencing diapause, the length of daylight can influence the rate of larval development, the color features and body size of some insect species, and the migration of many species of aphids.

Wind plays a significant role in the life of insects. There are much data in the literature about the influence of wind on the distribution of insects. A mass arrival of aphid *Brachycauda helichrysi* Kltnb. was noted. and aphids of several other species during one day from a distance of 20 km from the mainland to Memmert Island in the North Sea, where these aphids were completely absent the day before. Strong winds can carry not only small and light insects but also large and heavy ones over long distances.

The wind in many cases determines the direction of insect flight. Some insects have positive anemotaxis (that is, they often fly against the wind), while others have negative anemotaxis (they fly in the direction of the wind). The plum weevil (*Contrachelus nenupar* Hbst.) flies against the wind, and the meadow butterfly

(*Loxostege sticticalis* L.) flies against the wind; downwind, the desert locust (*Schistocerca gregaria* Forsk.) makes long migrations in the direction of the monsoon winds.

BIODIVERSITY OF ENTOMOPHFGES (PREDATORS AND PARASITES)
(on the example of insects of biocenoses)

The entomophagy of agroecosystems makes up the dominant part of consumers of higher levels. Phytophagous insects, including pests of agricultural crops, perform a regulatory function. Knowing the relationships between insects makes it possible to describe the interaction between various components of agroecosystems, to ecologically justify measures to preserve the biodiversity of entomophagous, which will contribute to reducing the pesticide load on the surrounding natural environment, and to maintain the ecological sustainability of agroecosystems.

Among insects, the types of nutrition acquired naturally in the process of evolution are common: predation and parasitism.

Predation is characterized by the fact that one organism – the predator – feeds on another – the victim and often kills it immediately. During their lifetime, predators eat a large number of prey individuals. Compared to parasitism, predation is considered to be an earlier form of feeding.

Parasitism is a more specialized form of relationship, when one organism – the parasite lives at the expense of another organism – the host and is closely connected with it ecologically and biologically for a greater or lesser extent of its life cycle. Parasitic insects usually lead the host to death or severe exhaustion. Unlike a predatory larva, the development of a parasitic larva takes place at the expense of only one individual of the host.

Biodiversity of insects predators and their specialization

Predatory insect species, known in Ukraine in 15 orders both among insects with incomplete (dragonflies (Odonata), praying mantises (Mantoptera), freckles (Plecoptera), Orthoptera (Orthoptera), pinchers (Dermaptera), thrips (Thysanoptera), and with complete (beetles (Coleoptera), reticulata (Neuroptera), camelids (Raphidioptera), wasps (Megaloptera), scorpionflies (Mecoptera), hairflies (Trichoptera), lepidoptera (Lepidoptera), Hymenoptera (Hymenoptera), Diptera) by transformation. Predatory insects are often represented by large systematic groups at the same level, such as dragonflies, praying mantises, reticulata, and families – anthocoridae bugs (Anthocoridae), midges (Asilidae) and many families from the order of beetles (Coleoptera). The most common in the biocenoses of the Forest Steppe are predatory bugs, thrips, beetles, reticulata, hymenoptera, and diptera. Representatives of almost all orders of insects serve as prey (food) for predators.

During feeding, predatory insects crush their prey with the help of gnawing oral organs (dragonflies, praying mantises, ants (Formicidae), wasps (Pompilidae), most ground beetles (Carabidae), coccinellidae, etc.). Some of them suck the contents of insects with the help of a sucking mouth apparatus adapted for this (bugs (Hemiptera), thrips, gizzards (Gasterophilidae)), or highly developed hollow mandibles (some species of beetles and coccinellids) or a groove formed between the masticator and the lower jaw (larvae of goldfish (Chrysopidae). For species that suck food, extraintestinal digestion is typical, in which the insect predator lets the digestive juice into the victim through a wound inflicted by it, and then sucks out the already partially hydrolyzed liquid.

Predatory insects are too voracious. The need for a large amount of food is related to the fact that food provides the processes of growth, development, and sexual maturation for insects. In addition, food constantly replenishes the energy resources in the predator's body due to its intensive expenditure of energy to search for prey, overcome its resistance, and other vital processes.

According to the type of adaptation of the active stages of insects to predation, the following groups are distinguished: 1) species that are predators only in the adult phase; 2) species that are predators only in the larval stage; 3) predatory species in the larval and imaginal stages.

The first group is mostly omnivorous species. Most of them lay their eggs outside the victim. This group includes scorpion flies and staphylinid beetles (genus *Aleochara*), for which protein food is necessary for puberty. This also includes ants and wasps, which have complex instincts to care for their offspring. Adult ants feed on insects and the sweet secretions of aphids (Aphidoidea), while wasps feed on the nectar of flowers and absorb some of the crumbling insects.

The second group consists mainly of predatory syrphid flies (Syrphidae), galliformes (Cecidomyidae), and some reticulata – common goldeneye (*Chrisopa carnea Steph.*), beautiful (*Ch. formosa Br.*) and others. Adult syrphids and gold flies feed on the nectar and pollen of plants. Aphagia is typical for Galicians. Flies lay their eggs in places where the victim is gathered – future food for their larvae. Goldeneyes lay their eggs outside the prey's colonies, and their larvae forage for themselves.

The third group is the most numerous and diverse in terms of food specialization and lifestyle. Some of them differ in food regimes and stations of stay in the larval and imaginal stages. Thus, dragonfly larvae live in water bodies and feed on the larvae of mosquitoes (Diptera), dayflies (Ephemeroptera), and other organisms. Adult dragonflies are aerial hunters and catch their prey on the fly. Adult camelids feed on insects on plants, and their larvae in the passages of tree trunks eat the larvae of beetles that live there.

The most numerous predatory insects, in which adults and larvae have similar food relationships. Although they feed on a wide range of arthropods, many of them have clearly defined food relationships with certain taxonomic groups of insects. So, most of the insects of the Reticulate family (Neuroptera) prefer sucking insects.

Most coccinellids (Coccinellidae) feed on aphids. These are mainly ecologically plastic species of ladybugs: 7–spotted (Coccinella septempunctata L.), variable (Coccinella divarigata Aol.), 2–spotted (Adalia bipunctata L.), propylaea (Propilaea quatuordecimpunctata L.) and many others. They lay eggs in groups on plants outside the host. Their larvae can migrate long distances in search of food.

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Beetles are characterized by great complexity in the trophic relationship – they are obligate predators. Calosoma and Carabus species – prefer insects and mainly caterpillars and pupae of butterflies, Vembidion, Agonum, Salathus, feed on aphids, small caterpillars of butterflies, larvae and eggs of various insects. Species of the Pterostichus family are mainly carnivorous beetles and feed on insects from various families. Wider polyphagy is characteristic of ground beetles of the Orhonus and Narpalus families, which feed on animal and plant food. Among them, many species are inhabitants of field stations, and species such as green and small carabidae (Carabidae) are typical for forest biocenoses. The life of adults and especially larvae in most species of these insects is connected with the soil.

Biodiversity of parasitic insects in biogeocenoses and their ecological function

In the Insecta class, parasitic insects are represented by 5 orders: Coleoptera, Strepsiptera, Lepidoptera, Hymenoptera, and Diptera, that is, insects with a complete transformation.

Parasitic insects are characterized by larval parasitism, and in the adult state, they lead a free lifestyle. It is known that adaptive changes in the process of formation and development of parasitism in insects occurred both in the adult insect and in the larval stage. Adaptations of adult insects are related to the performance of the function of reproduction. This was accompanied by the formation in them of the ability to identify and choose a certain host and ways of placing their offspring, as well as the development of instincts to care for them. The larva had to adapt to development at the expense of the living, developing host. At the same time, to overcome the defensive reactions of the host, the larva must acquire the ability to preserve its fullness as a food substrate until the end of its development.

In the relationship with the hosts, parasitic insects have their specific features:

- relatively small differences in the size of the body of the host and the parasite;
- the absence of significant differences in the duration of ontogenesis;

- the death of the host after the completion of the development of the parasite (lethal parasitism) and less often the sexual sterilization of the host.

Hymenoptera are quite numerous in terms of the number of species (about 250,000). It includes species that are unique in their way of life, with highly developed, complex, and diverse instincts. Parasitic insects are represented by four superfamilies: Ichneumonoidea, Chalcidoidea, Proctotrupoidea, and Cynipoidea.

Parasitism is also characteristic of many stinging Hymenoptera – Scolioidea, Vespoidea, and Sphecoidea.

Trophic relationships and types of parasitism

The representatives of most families and subfamilies have quite clearly expressed food specialization about certain taxonomic groups of insects and phases of their development. In ichneumonids (Ichneumonidae) and braconids (Braconidae), parasitism on caterpillars of butterflies (Lepidoptera) and larvae of sawflies (Tenthredinidae) and beetles (Coleoptera) is widespread. Typical specificity is also expressed about the hosts and in the representatives of the families: Aphidiidae – these are mainly parasites of aphids; Encyrtidae and Aphelinidae are coccid parasites; Mymaridae, Trichogrammatidae, and Scelionidae are egg parasites. Food specialization is characteristic of many other groups of chalcids (Chalcidoidae) and cynipids (Cynipoidae).

Adaptations to parasitism on different groups of insects and stages of their development determined the diversity of types of parasitism. Depending on the location of the parasite's larvae relative to the host – outside or inside it – ecto- and endoparasites are distinguished. The way of life of the larva caused significant differences in the biological (anatomical-morphological, behavioral, etc.) features of these parasites.

In ectoparasites, in connection with the development of eggs outside the host, embryogenesis is carried out only at the expense of nutrients contained in the egg of the parasite, which usually contains a large amount of yolk. To obtain food, the larva pierces the host's integuments with highly developed jaws and sucks its contents through the cavities in them.

The larvae of endoparasites, developing in the middle of the host, feed on its cavity fluid with the help of the oral apparatus, and young larvae – often diffusely through the thin coverings of their bodies. They, like ectoparasitic larvae, are characterized by extraintestinal digestion. The larvae of endoparasites in the process of evolution have developed mechanisms that ensure the preservation of the host's completeness for nutrition until the end of their development.

For endoparasites, the host is not only a source of food but also a place of residence. Endoparasites have a wider range of hosts. They infect cryptic and open-living insects and other arthropods. Their hosts are known in many orders of insects with complete and incomplete transformation. They are also adapted to parasitizing different phases of insects, which determined their ontogenetic specialization. Among them are parasites of eggs, larvae, pupae, and adults.

Parasitic Hymenoptera is characterized by single parasitism – development at the expense of one host individual of one parasite larva.

Imago behavior. In parasitic Hymenoptera, females play an active role in infecting the host. In females, the incentive to meet the host is their physiological preparation for laying eggs. The process of establishing contact between the female and the host is divided into stages: searching for the location of the host, and searching and choosing the host.

The search for the location of the host is related to the search by females for stations occupied by the host's food plant. Historically, the parasite's unequivocal host reactions to its fodder plants contribute to their concentration in the same stations. Phytophages cannot independently synthesize pheromones and some hormones and receive them in ready form from plants.

Parasites search for a host by a direct and thorough examination of plants where the host may be present. Chemical means of intraspecific communication of their hosts and primarily sexual attractants secreted by them, as well as excrement and substances produced by phytophages to facilitate their retention and movement on plants, serve as a reference point when identifying a host.

The place and process of egg laying, as well as the effect on the host, differ significantly in different groups of parasites. To lay eggs, ectoparasitic females, infecting cryptic larvae, pierce or drill with the ovipositor the substrate or the wall of the cocoon where the host is and lay eggs on or near the host. Before laying an egg, the female paralyzes the host.

Methods of reproduction. Reproduction of parasitic Hymenoptera is carried out with the participation of both sexes. They are also characterized by parthenogenesis - the development of an organism from an unfertilized egg. The following types of parthenogenesis are known among riders:

Arrhenotokia – is the development of males from unfertilized eggs, and females from fertilized ones. At the same time, males are haploid, and females are diploid. Arrhenotic parthenogenesis occurs most often;

Thelytokya – the formation of females from unfertilized eggs - is a less common phenomenon. In the same species, parthenogenesis can be of different types in different geographical zones of its range;

Deuterotoky – formation during arrhenotic reproduction in unfertilized eggs of males and a certain number of females (spanondria), during telitokny – the appearance of males among females (spanogyny).

Polyembryony is the development of a large number of embryos from one parasite egg. Their number can be from 2 to 3000 normally developing individuals.

Females usually predominate in the bisexual offspring of parasites. Their number often reaches 60–80%. Less often, the gender ratio is 1:1. Males usually fly 1–2 days earlier than females. Their mating can take place immediately after a flight or during the first two days of their life. Females usually mate once, and a male can impregnate several females. The meeting of sexes can take place in the places of their development on plants and nectaries during their additional feeding.

Relationships of parasites with hosts in ontogenesis

The relationships with the hosts differ especially significantly in species that parasitize at different phases of the development of host insects. When parasitizing in non-feeding phases – eggs and pupae, when the food resources of the parasite are limited to a certain supply, parasites have been shown to have the ability to stop the development of the host. Females of such parasites prefer to infect the host at the initial stages of development: eggs – at the beginning of embryogenesis; pupa – at the beginning of histolysis.

In some species, the first instar larvae mechanically destroy the host. They shake the contents of the egg with highly developed oral hooks and setae on their body and tail appendage. This is characteristic of telenomine larvae – parasites of bugs and silkworms, trichogrammatids, in which the larva of the first instar is sac-like. The larvae of such parasites are considered internal predators. Trichogrammatid larvae can cause lysis of the host, turning the contents of the egg into a homogeneous mass. The development of the larvae that destroy the host is fast: 3–4 days for trigrams, and 5–6 days for telecoms, while the total duration of parasite development is 10 and 15 days, respectively.

Parasites of pupae can inhibit the development of the host. Thus, an inhibitory effect on the development of the wax moth pupa was detected when the egg of the ichneumonid Pimpla turionella L was introduced into its body. A more complex mechanism of inhibition of the development of the same host is found in another parasite species – *Pimpla aquilonia* Cres. The reborn larva of this parasite, regardless of the place of laying the egg in the body of the host, immediately penetrates the head of the pupa, destroys its brain, and then moves to the abdomen, where it develops.

Parasites of larvae and adults, on the contrary, in the initial stages of development, treat their host sparingly. At these stages of the host, thanks to the continuous replenishment of its body with nutrients, the parasite larvae have acquired the opportunity to use them in sufficient quantities throughout their development. In larval parasites, ontogenetic development is connected with the development of the host. For endoparasites of the caterpillars of the cabbage whitefly, the grain borer, the unpaired silkworm, and the ectoparasite of the grape leafroller (*Lobesia botrana* Den et Schiff.), it was established that the larvae of the first age feed on the hemolymph of the host, without worsening its physiological state.

On the contrary, the intensity of feeding increases in infected caterpillars. This is accompanied by an increase in their mass, a large accumulation of fat reserves, and better survival compared to healthy ones.

Exhaustion of the host's body and reduction in the intensity of its nutrition occur at the end of the parasite's development. At this time, the larvae feed mainly on the adipose tissue of the host and accumulate a large number of fat reserves. Along with this, an increase in enzymatic activity in larvae causes the so-called canning of the host. This helps to preserve the contents of the host in a state suitable for feeding the parasite. A stimulating effect on the growth, development, and survival of the host at the initial stages of the parasite's ontogenesis was also noted for encyrtids, parasites of the larvae of pseudo scythes. Activation of the growth and development of the host with a weak influence of the parasite on it has important biological significance. Otherwise, the possibility of functioning of the "parasite-host" biological system between insects would be limited.

The death of the host occurs only after the parasite has completed its development. In most riders, an adult larva causes complete lysis of the internal organs of the larva of the host.

Parasites of insect adults usually do not destroy the host's vital organs. Their larvae feed mainly on hemolymph, the losses of which are replenished in the process of additional nutrition of the host. However, the presence of the parasite weakens the supply of nutrients to the gonads and limits egg maturation.

Parasitic hymenoptera, like other insects, hibernate in a state of diapause, the formation of which is strongly influenced by photoperiodism and temperature regime during their development. Along with this, the physiological state of the host becomes important for many parasites. In monocyclic species – hosts and parasites – diapause is hereditarily fixed, it occurs in them relatedly and often even during the period of favorable temperatures for their development in nature. This is typical for parasites of the eggs of the ringed silkworm (*Telenomus laeviuculus* Ratz.), unpaired silkworm (*Anastatus bifasciatus* Fansk.), which are in a state of diapause for about 10 months, as well as the parasite of grain scoop caterpillars (*Lissonota nitida* Grav.) and other monocyclic species.

Wintering of young parasite larvae is usually associated with hibernating insect larvae, and the onset of diapause in them is due to its formation in the host.

Larval and imaginal nutrition in the life of insects

When studying the factors that determine the reproductive and general viability of entomophagous insects, studies of the feeding physiology of larvae and adult insects become important. Knowledge of this is necessary when studying the behavior and relationships of insects in biocenoses.

The ontogenetic development of insects is a rather complex process with sharp differences in functions at the larval and imaginal stages. Larvae spend the nutrients they receive during feeding for their growth and development, as well as for the accumulation of reserves and the laying of the organs of an adult insect. In the imaginal stage, which performs the functions of reproduction and settlement, the reserves accumulated by the larva are consumed. The feeding of the imago by the amount of food consumed is often insignificant and considered as additional.

The physiological fullness of insects is determined by the quantity and quality of accumulated reserves in the larval stage. Imaginal nutrition is characteristic of insects, in which oogenesis continues throughout their life, and is species-specific.

Feeding predatory insects

Most species of predatory insects require protein food in the larval and adult stages. Some of them are reborn sexually immature. Their viability and fecundity depend on the degree of satisfaction with the nutritional needs of the larva and adult.

In long-lived (2–4 years) adult beetles, the mechanism of accumulation of fat resources changes during the season depending on their physiological needs. In the spring-summer period, nutrition mainly ensures the maturation of eggs in females and related metabolic processes. By autumn, after the end of laying eggs, they have a period associated with the accumulation of nutrient reserves in the body to support their life during the winter.

In coccinelids, nutrients are stored at a fairly high level throughout their life. In adult insects, an inviolable or peculiar "metabolic reserve" of food resources is created, characteristic of the species, which ensures the support of their life. A decrease in this reserve below a critical level causes exhaustion of the body and death in insects.

In syrphids and gallica, as a result of laying eggs by females in a colony of aphids, the larvae are provided with a sufficient amount of food. Galits fly out sexually mature. Female syrphids in the process of puberty feed on nectaries and the sweet secretions of aphids. Up to 3–6 mg of pollen containing sugars, a large amount of amino acids, and vitamins accumulates in their intestines. The fertility of syrphids also depends on the type of fodder plant.

Feeding of parasitic insects

Parasitic larvae, unlike predators, have food options limited to only one individual of the host. For adult insects, hydrocarbon nutrition is more typical.

For larvae that feed inside the host with its cavity fluid, the quantity and quality of food reserves accumulated in the host's body are important. It is known that the physiological state of the host, which is determined by the conditions of its development, affects the physiological state of the parasite developing in it.

The imago's need for food depends on the nature of the female's puberty. In parasitic flies, females fly out sexually immaturely. Their ripening in different species can last from 4–6 to 30 days. Fat-protein deposits accumulated in the adipose tissue by the larva contribute to the ripening of the ovaries in tachins. However, their transition into the hemolymph and consumption for the development of sexual products becomes possible with additional protein nutrition of females in combination with hydrocarbon. They get the necessary food by feeding on nectar, flower pollen, and the sweet secretions of sucking insects. Obtaining protein feed is especially important for viviparous species, the embryo of which uses the nutrients contained in the hemolymph of the female mother.

Puberty in parasitic Hymenoptera is more diverse. According to the type of maturation, females are divided into three main groups: 1) prooviogenic – egg maturation mainly occurs at the pupal stage and does not need additional nutrition; 2) synovigenic – fly out with a certain number of mature eggs, live a long time and need additional nutrition; 3) epiovigenic – fly out with immature gonads and additional protein nutrition is mandatory. Parasites from the last two groups are characterized by two types of female maturation. In some species, females leave with a relatively large number of mature eggs. With additional nutrition, their number increases several times. Ripe eggs are stored in the ovaries for a long time. This can be one of the important adaptations that ensure the meeting of females ready to lay eggs with an asynchronously developing host, for example, in the woodworm, a parasite of grain scoop caterpillars.

Adult riders feed on the nectar of various cultivated and wild nectariferous plants, and their flight coincides with the flowering period. Some of them also feed on the sweet secretions of sucking insects. Along with this, it is typical for many types of riders to feed on the juice of the host – hemolymph, rich in nitrogenous substances and free amino acids. Attacking a host to feed on hemolymph is considered one of the forms of predation.

According to the nature of hemolymph nutrition, three groups are distinguished among riders:

1 – are limited to a single intake of protein food (ichneumonid *Hemiteles* graculus Grav.);

2 – facultative hemolymph feeding (ectoparasite *Aphytis proclia* W.);

3 – systematic feeding is necessary (ectoparasite *Habrobracon hebetor* Wesm.).

In the latter, without the use of protein feed, there is no accumulation of yolk in the eggs. The need for feeding with hemolymph is more common for ectoparasites and some braconids and ichneumonids – endoparasites that are at lower stages of evolutionary development.

Feeding the host's hemolymph is associated with the need to accumulate the necessary amount of yolk in the eggs of the parasites, which ensures the development of the embryo. This can explain the greater need for protein food of ecto- and endoparasites, the eggs of which contain a large amount of yolk.

Literature data show that additional nutrition significantly increases the fecundity of female parasitic insects. The carbohydrates they receive provide metabolic processes that contribute to more complete use of the nutrients accumulated in the larval phase for the formation of eggs. Supplemental nutrition also significantly extends the life of adult insects. It is important for species that develop asynchronously with their hosts, and especially for species that hibernate in the imago stage.

In the period of preparation for wintering, hydrocarbon nutrition ensures the accumulation of necessary food reserves in the body of insects. Under the influence of external factors, the carbohydrates received by insects undergo a corresponding restructuring in their body, which helps to increase the cold resistance of parasites.

Types of food specialization of insects

According to the degree of host specialization, parasitic and predatory insects are divided into 3 main biological groups: 1) highly specialized, i.e. adapted to one or two host species (monophagous); 2) omnivores (polyphages), capable of living at the expense of a wide range of hosts, even representatives of different orders of insects; 3) relatively specialized (oligophages) that infect insects belonging to different genera within families and parasitize or prey on several host species. This group is intermediate and more numerous. It includes species of varying degrees of specialization from narrow to broad oligophagy.

Specialization in insects is determined by the degree of attachment of the development cycle of the entomophagous to the development cycle of the main host, the similarity of the requirements of the entomophagous and the host to the environmental conditions, the attachment of the active period of the adult stage of the entomophagous to the period of development of the adult stage of the host, the attachment of the physiological features of the entomophagous to life at the expense of the host's organism.

Greater correspondence in life cycles and requirements for physical environmental factors with hosts is noted in highly specialized entomophagous, or monophages. However, monophagy in its narrow sense is relatively rare among entomophagous.

Polyphages are characterized by wide ecological plasticity and lack of synchronicity in development with their hosts.

In oligophages, the life cycle and ecological requirements do not sufficiently correspond to their hosts. Despite the wide range of hosts, they appear to be more closely related to two or three types of insects. Such insects are called primary hosts. Insects that live in the places of the main host, but are rarely infected by the parasite, are called secondary hosts.

Among entomophagous, oligophagy and polyphagy are distinguished in space and time. In the first case, parasites can develop on different types of insects that occur simultaneously in a given area. This gives an idea of the breadth of their food specialization. For such parasites, many insects are alternative hosts, the choice of which may depend on their presence or availability in the stations where the parasite resides. The change of hosts over time is caused in parasites by the need to replace disappearing species with others. This is usually observed in polycyclic parasites biologically related to monocyclic hosts.

Features of the formation of the host-parasite biological system

The formation of the host-parasite biological system, partners standing in biocenoses at different trophic levels, has its specificity. In the process of overcoming the protective reactions manifested by both the host and the parasite, they developed mutual adaptations to coexist.

In adult parasitic insects, adaptations were formed to the location of the host, to the microconditions of its life, or ecological specialization was formed. Females acquired the ability to find a host and lay eggs in it or on it in those stations and on those types of plants on which they developed themselves. As a result, the circle of hosts narrowed.

In specialized species, the maintenance of specificity became part of the function of the female. In the process of evolution, it developed instincts to choose for laying eggs in certain groups or species of insects at certain phases of their development, which are in the ecological conditions to which the parasite has adapted. Thus, among entomophagous, there are species – inhabitants of open field stations or tree plantations, which infect open- or hidden-living insects in certain coenoses.

Thus, in the imaginal stage, biocenosis interspecies relationships between phyto- and entomophagous were formed.

The larva's living conditions are determined mainly by the female, which places her offspring by her specific specialization. However, when the circle of hosts expands or accidentally infects a new species of insect, the larva can adjust the possibility of switching to another host. This is determined by the physiological specialization of the parasite larva to the host. Changing the host is especially complicated due to the ontogenetic specialization characteristic of larvae – differences like their influence on the host during parasitism at different stages of its development.

MICROBIAL BIODIVERSITY

Microorganisms are one of the most numerous and diverse groups of living organisms. Their classification and diversity is based on morphological, physiological, biochemical and cultural differences.

Morphological differences are based on the variety of cell shapes, their arrangement, the presence of endospores, capsules, jutes, their arrangement, and Gram staining.

Physiological and biochemical differences – differences in the ratio of cells to oxygen, the way they produce energy, the dependence of growth on temperature, pH, nutrient assimilation (sources of carbon, nitrogen, etc.), the need for additional growth factors, the relationship to antibiotics, etc.

The cultural differences lie in the different growth patterns on agarized (colony characteristics) and liquid nutrient media.

The development of molecular genetic methods has allowed for a more detailed study of the diversity of microorganisms and has led to the rapid development of phylogenetic classification, which reflects the evolutionary relationships between organisms. Today, it is more accurate to determine the diversity of microorganisms based on molecular genetic markers, amino acid sequences of proteins, nucleotide sequences of genes, etc. However, the phenotypic approach to their classification remains the basis for determining the biodiversity of microorganisms.

Diversity of microorganisms according to the Bergi classification

According to Bergey's Manual of Systematic Bacteriology, all bacteria are grouped into the kingdom Procaryotae and divided into four phyla:

I. Gracilicutes (from Latin gracilus – thin, slender; cutes – skin): gram-negative eubacteria that have a cell wall);

II. Firmicutes (from Latin firmus – strong; cutes – skin): gram-positive eubacteria that have a cell wall);

III. Tenericutes (from Latin tener – soft, tender; cutes – skin): eubacteria that do not have a cell wall);

IV. Mendosicutes (from Latin mendosus – false; cutes – skin): archaebacteria).

Among these four divisions are classes, among classes – parts, among parts – orders, tribes, families, genera.

Gracillicutes phylum

This phylum includes prokaryotic microorganisms that have a complex cell wall of the gram-negative type. Such a cell wall consists of an outer membrane, a thin inner layer of peptidoglycan, and additional other components outside or between the two layers. Cells are spherical or oval, in the form of straight or curved rods, spirals, filamentous; some of these shapes can be surrounded by a cover or capsule. Such microorganisms reproduce by binary fission, but some groups are characterized by budding and some organisms (Plesiosariales) by multiple fission. Myxobacteria can form fruitbodies and myxospores. They do not form endospores. Many representatives are motile (movement by flagella or sliding). Among the representatives there are phototrophs and non-phototrophs (both lithotrophs and heterotrophs), aerobes, anaerobes, facultative anaerobes and microaerophiles.

The phylum includes three classes (Table 10): Scotobacteria (consists of 14 parts – №. 1–14); Anoxyphotobacteria (consists of one part – № 15); Oxyphotobacteria (consists of one part – № 16).

Class Scotobacteria

Part 1: *Spirochetes*. Gram-negative spiral-shaped cells, extremely flexible, mobile due to the periplasmic flagellum, not the flagellum that protrudes from the cell into the external environment. Anaerobes, microaerophiles, facultative anaerobes or aerobes. Spirochetes reproduce by transverse cell division; they do not form spores. Among them are aerobes (*Leptospira interrogans*), facultative anaerobes (*Spirochaeta aurantia*) and anaerobes (*S. litoralis*). They are chemo-organotrophs by the type of feeding. Cell sizes vary widely. Large cells (up to 250 µm long) have spirochetes belonging to the genera *Spirochaeta* and *Cristispira*. Spirochetes of the genera *Treponema* (5.020.0 µm), *Borrelia* (3.0 – 0.0 µm) and *Leptospira* (4.0 – 8.0 µm) have short cells. Among the representatives of spirochetes, there are both free-ranging and in associations with animals, mollusks, arthropods or humans, some species are pathogenic.

The free-ranging species are bacteria of the genus *Spirochaeta*, which inhabit wastewater and polluted waters, freshwater and marine waters containing hydrogen sulfate. These microorganisms ferment glucose to produce acetic, lactic, oxalic, formic acids, ethanol, carbon dioxide, and hydrogen.

Associate bacteria include members of the genus *Cristispira*, which inhabit the digestive tract of freshwater and marine mollusks. The parasites of humans and vertebrates are representatives of the genera *Treponema*, *Borrelia*, *Leptospira*, in particular, the pathogenic species are *Treponema pallidum* (syphilis agent), *T. pertenuae* (frambesia agent), *Leptospira interrogans* (leptospirosis agent), *Borrelia recurrentis* (human relapsing fever (typhus) agent).

Table 10

Microorganisms of the phylum Gracilicutes

Class Scotobacteria	
Part 1. Spirochetes	Order Spirochaetales*:* 1) family Spirochaetaceae (genera *Spirochaeta, Cristispira, Treponema i Borrelia*); 2) family Leptospiraceae (genus *Leptospira*)
Part 2. Aerobic, microaerophilic, motile, spirally curved Gram-negative bacteria	Family Spirillaceae (genera *Spirillum, Azospirillum, Oceanospirillum, Aquaspirillum, Campylobacter, Helicobacter, Vampirovibrio, Bdellovibrio, Cellvibrio*)
Part 3. Non-motile (or rarely motile) gram-negative curved bacteria	Family Spirosomaceae (genera *Spirosoma, Microcyclus. Brachyarcus, Pelosigma, Runnela, Flectobacillus, Meniscus*)

Continued table 10

Part 4. Gram-negative aerobic bacilli and cocci	Families 1) Pseudomonadaceae (genera *Pseudomonas, Xanthomonas, Xanthobacter*); 2) Azotobacteriaceae; 3) Rhizobiaceae (genera *Rhizobium, Agrobacterium*); 4) Methylococcaceae (genera *Methylomonas, Methylococcus*); 5) Halobacteriaceae (рід *Halomonas*) 6) Acetobacteriaceae (роди *Acetobacter, Gluconobacter*) 7) Legionellaceae; 8) Neieseriaceae (genera *Neisseria, Moraxella, Kingella, Acinetobacter*)
Part 5. Facultative anaerobic gram-negative bacilli	Families: 1) Enterobacteriaceae (genera *Eachetiehia, Salmonella, Shigella, Klebsiella, Proteus, Morganella, Citrobacter, Erwinia, Enterobacter*); 2) Vibrionaceae (genera *Aeromonas, Plesiomonas, Vibrio, Photobacterium*); 3) Pasteurellaceae (genera *Haemophilus, Pasteurella, Actinobacillus*)
Part 6. Gram-negative anaerobic straight, curved and spiral rods	Family Bactercidacese (genera *Butyrovibrio, Succinovibrdo, Bacteroides. Fusobacterium. Leptotrhichia. Wotlnella, Anaerovtbrto. Acetlvlbrio*)
Part 7. Sulfate-assimilating or sulfite-reducing bacteria	genera *Desulfovibrio, Desulfomonas, Delfusarcina, Variabilis*
Part 8. Anaerobic gram-negative cocci	Family Veillonceceae (genera *Veillonella, Acidarmnococcus, Megaaphaera*)
Part 9. Rickettsia and chlamydia	Order Rickettsiales (families Rickettsiaceae, Bartonellaceae, Anaplnasmataceae); order Chlamydiales (family Chlamidiaceae, genus *Chlamydia*)

Continuation of Table 10

Part 10. Sliding bacteria	Order Myxobacteriales (familyMyxobacteriaceac. genera *Myxoccccus, Cyatobacter, Hannocystis*); order Cytophagalea (family Cytophagaceae. genus *Cytophuga*, family Beggialoecenc, genus *Beggiatoa*)
Part 11. Bacteria that have coatings	genera *Leptothrix, Crenothrix, Streptotrix, Sphaerolilus*
Part 12. Bacteria that are budding and/or stem-forming	genera *Caulobacter, Prosthecormicrobium, Nevskia, Ancalomicrobium, Pedomicrobium, Hyphomicrobium, Hyphomonas*
Part 13. Gram-negative chemolithotrophic bacteria	Family Nitrobacteraceae (genera *Nitrosococcus. Nitrospira. Nitrobactee*; genera *Thiobacillus, Thiobacterum, Thiocolum, Thiospira*)
Part 14. Endosymbionts	Bacteria are endosymbionts of protozoa and insects
Class Anoxyphotobacteria	
Part 15. Phototrophic bacteria	Order Rhodospirilleles (families Rhodospirillaceae, Chromatiaceae); order Chlorobiales (families Chlorobiaceae, Chloroflexaceae)
Class Oxyphotobacteria	
Part 16. Cyanobacteria	Orders Cyanobacteriales, Prochlorales

Part 2. Aerobic microaerophilic, motile, spiral-curved gram-negative bacteria. This group of microorganisms is represented by Gram-negative bacteria of spiral (with one or more complete turns of the spiral) or vibrio (having less than one complete turn of the spiral) shape. They are mobile due to polarly arranged flagella, moving in a straight line with a characteristic helical motion. By the nature of their oxygen consumption, they are aerobes or microaerophiles, using oxygen as an electron acceptor. At the same time, these bacteria are capable of anaerobic respiration, using nitrate or fumarate as electron acceptors. Therefore, these microorganisms are chemo-

organotrophs, but some can grow as autotrophs using H_2 as an electrons donor. They can be found in soil, fresh and seawater, plant roots, reproductive organs, the digestive tract and oral cavity of humans and animals. Some are pathogenic to animals and humans. Some are predators of other microorganisms.

Representatives of the genus *Azospirillum* are free-living microaerophilic nitrogen-fixing organisms found on the roots of grasses and legumes, and bacteria of the genus *Vampirovibrio* are found in chlorellas. *Spirillum*, mostly saprophytes, live in stagnant and polluted waters, seawater (*Oseanosrillum*), on rotting plant and animal residues, and in rice fields. Among the parasites are bacteria of the genus *Bdellovibrio*, in particular *B. bacterlovorrus*, an intracellular bacterial parasite (Fig. 10). It is a non-spore-forming small (0.25–0.4 to 0.8–1.2 μm), slightly curved rod with one polar flagellum. The cells are very mobile. They can exist both inside a bacterial cell and saprophytic on a complex nutrient medium with yeast extract. *B. bacterlovorrus* attaches to host cells, loses its flagellum, penetrates the cell wall (with the help of enzymes that dissolve the membrane) into the periplasmic space and multiplies there. The cycle of intracellular development lasts 3–5 hours, after which the parasitic cells leave the dead cell and repeat the parasitic phase or go into a dormant state, forming cysts. In an environment with a large number of host cells, the cysts germinate and repeat the parasitic phase of development again. Bacteria of this genus are inhabitants of soil, sea and fresh water, and are used to combat epidemiological pathogens (e.g., cholera).

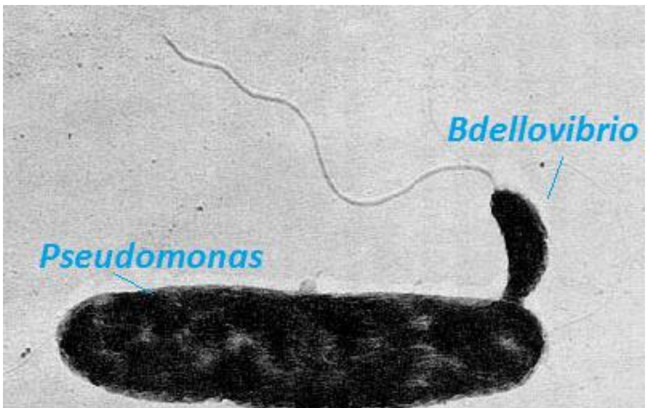

Fig. 10 ***B. bacteriovorus*****, which parasitizes bacteria of the genus** ***Pseudomonas*** (http://microgen.ouhsc.edu/b_bacter/b_bacter_home.htm)

<u>Part 3.</u> *Non-motile (or rarely motile) gram-negative, curved bacteria.* These microorganisms are chemoorganotrophs and saprophytes. They can exhibit respiratory (genus *Runella*) or fermentative (genus *Meniscus*) metabolism. Obligate aerobes (*Branchyarcus thiophilus*), aerotolerant anaerobes (*Meniscus glaucopis*). They are found in soils, fresh and salt water bodies. They form pigments of white-beige (*Microcyclus aquaticus*), yellow (*Spirosoma linguale*), pink colour (*Flectobacillus major*). The group includes four types of microorganisms:

1) curved or C-shaped bacteria capable of forming rings by overlapping cell ends. Cells in the form of curls and spirals can be found. The presence of gas vacuoles is possible. Aerobes that are found in soil and water; These include bacteria of the genus *Spirosoma*.

2) vibroids or straight (or curved) sticks. Form gas vacuoles. Aerotolerant anaerobes with a strictly fermentative type of metabolism;

3) arched cells with gas vacuoles are arranged in the form of a clover leaf. There are pretzel-shaped cells. They exist in lakes and ponds where sulfide is present and oxygen is absent; These include bacteria of the genus *Branchyarcus*;

4) thin S-shaped cells, which form flattened sigmoidal aggregates by placing them close to each other (the number of cells is 4 or a multiple of 4), then are mobile. They exist in fresh and brackish waters where sulfide is present and oxygen is absent; These include bacteria of the genus *Pelosigma.*

<u>Part 4.</u> *Gram-negative aerobic bacilli and cocci.* Chemoorganotrophs, but some can grow autotrophically, using H_2 as an electrons donor. They do not form prostheke, stalks, covers or gas vacuoles. Incapable of sliding movement. They do not reproduce by budding. They grow in the air. Respiratory metabolism using oxygen as an electron acceptor. Some are capable of anaerobic respiration with electron acceptors other than oxygen. They are found in soil, fresh and seawater, plant roots or reproductive organs, the intestinal tract and oral cavity of humans and animals. Some are pathogenic to animals or humans.

This group of bacteria includes eight families (see Table 10).

1. **Family Pseudomonaceae** – obligate aerobes, some species are optionally anaerobic, do not fix molecular nitrogen, motile (polar flagella) single straight or curved rods. This family includes bacteria of the genus *Pseudomonas*, are able to use a wide range of organic compounds as a carbon source, including heterocyclic and aromatic compounds that are not assimilated by other microorganisms (*Pseudomonas fluoresce*, *P. putida*). Among them are pathogenic species, in particular, *P. aeruginosa* – is a pathogenic bacterium that can cause otitis media, pneumonia, meningoencephalitis, and wound suppuration. Strains that are pathogenic to plants are grouped into a species *P. syringae*. The Pseudomonaceae family also includes bacteria of the genus *Xanthomonas*, which are phytopathogens. A representative of this genus is also *Xanthomonas campestris* – is a producer of the world's most famous microbial exopolysaccharide xanthan.

2. **Family Azotobacteriareae** includes rod-shaped bacteria that can change their shape depending on their age and cultivation conditions. They are also capable of forming cysts. They are arranged in pairs or form short chains surrounded by a common capsule. With aging, cysts are formed (resting form). Representatives of the genus *Azomonas* (*A. agilis*) do not form cysts. The main feature of this family is the ability to fix molecular nitrogen. Among them is the bacterium *Azotobater chroococcum* – is the first aerobic nitrogen fixer that exists freely (10 mg or more of nitrogen is fixed per 1 g of carbon consumed). Azotobacterin, made on the basis of live nitrogen fixer cultures, is designed to enrich soil with nitrogen and increase crop yields. No less well-known are *Azotobater vinelandii* – is a producer of the polysaccharide alginate, which is similar in composition to plant polysaccharides isolated from seaweed.

3. **Family Rhizobiaceae** is represented by two genera *Rhizobium* and *Agrobacterium*, but recently new genera of nodule bacteria have been described and officially recognized (*Azorhizobium, Bradyrhizobium* etc.). Genus *Rhizobium* unites gram-negative, chemoorganotrophic, motile (having one polar or subpolar flagellum or peritrichal flagellation) rod-shaped bacteria, whose peculiarity is the ability to cause the growth of root tissue with the formation of nodules and fix atmospheric nitrogen

in symbiotic relationships with a legume plant (Fig. 11). Based on these features, the species names of these bacteria are determined mainly by the host plant: *R. leguminosarum* b. *viceae* (pea, vetch, fodder bean bacteria), *R. leguminosarum* b. *trifolii* (clover bacteria), *R. leguminosarum* b. *phaseoli* (beans bacteria), *R. loti* (lupine bacteria), *R. meliloti* (alfalfa bacteria), *R. galegae* (goatfold bacteria). Representatives of the genus are found in tropical and subtropical latitudes *Bradyrhizobium* (*B. japonicum*). Bacteria of the genus *Agrobacterium* – intracellular parasites that penetrate the cells of host plants and cause tumor formation (except for *A. radiobacter*). They cause overgrowth of plant tissues in the form of galls on the root system and stems of plants - crown gall (bacterial), hair root, bacterial stem cancer. Tumor induction correlates with the presence of a large tumor-inducing plasmid (Ti-plasmid) in bacterial cells. A typical representative of this genus is *A. tumefaciens*. Bacteria of the genus *Agrobacterium* (*Agrobacterium tumefaciens*) are intracellular parasites that penetrate the tissue of a host plant through damage and cause tumors on the roots, stems, or leaves of plants.

4. **Family Methylococcaceae** is represented by bacteria for which the only source of carbon is organic compounds methane or methanol. This family includes the genera *Methylomonas* and *Methylococcus*, that differ in morphology and ability to move. In particular, for example, *Methylomonas methanica* is motile bacteria, but *Methylococcus capsulatus* – unmotile.

5. **Family Halobacteriaceae** includes members of the genus *Halomonas* (*H. elongata*), which are halotolerant bacteria that can grow in the presence of 0.052% NaCl in the medium. These microorganisms were first isolated from salt extraction equipment. Representatives of this genus mainly have a respiratory metabolism, but some are able to exist in anaerobic conditions and use nitrate as the final electron acceptor.

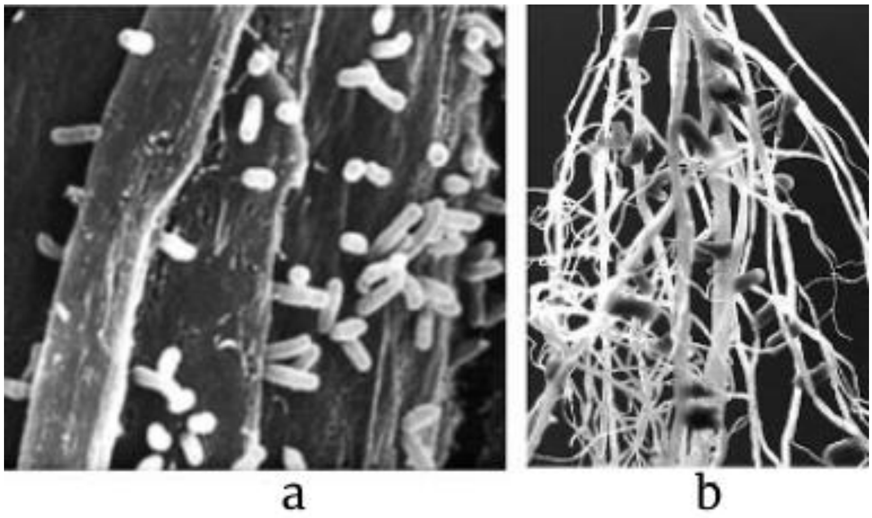

Fig. 11 **Nodule bacteria of the genus Rhizobium:** *a – cells of Rhizobium, penetrating into the plant tissue; b – nodules formed on the legume plant (Serhiychuk M.G., 2008)*

6. **Family Acetobacteriaceae** are bacteria that can oxidize ethanol to acetic acid in a neutral or acidic environment (pH 4.5). Morphologically, these microorganisms are rods, sometimes the cells are ellipsoidal, arranged singly, in pairs or in chains. Representatives of this family are obligate aerobes, motile or non-motile. Motile forms have peritrichial or lateral flagellation. These bacteria are chemoorganotrophs that can be isolated from wine, cider, yoghurt, etc. Family Acetobacteriaceae includes two genera – *Acetobacter* (typical member is *A. aceti*) and *Gluconobacter* (typical member is *G. oxydans*).

7. **Family Legionellaceae** is represented by aerobic gram-negative bacilli that use amino acid residues as their main source of energy. This family includes the genus *Legionella*, which includes several species that cause legionellosis (for example, *L. pneumophila*).

8. **Family Neisseriaceae** includes such genera as *Neisseria, Moraxella, Kingella, Acinetobacter.* Members of the first three genera are parasites of mucous membranes: *Neisseria gonorrhoeae* – causative agent of gonorrhea, *N. meningitidis* – causative agent of meningitis, *Moraxella lacunata* and *Kingella kingae* – parasites of the mucous membranes of humans and warm-blooded animals. These bacteria require complex nutrient environments for their development. Genus *Acinetobacter* is

represented by saprophytic forms that are widespread in nature.

Part 5. Facultatively anaerobic gram-negative bacilli. Bacteria belonging to this group are chemoorganotrophs, but some can grow autotrophically, using H_2 as an electron donor. Representatives of this group do not form prostellates (thin outgrowths consisting of a cell wall, membrane, and cytoplasm), stalks, sheaths, or gas vacuoles. They are not capable of slithering. They do not reproduce by budding. Able to grow in the air, respiratory metabolism, can also grow heterotrophically through fermentation. Occur as freely existing forms and in associations with animals, humans, or plants. Some are pathogenic.

This group of microorganisms includes three families: Enterobacteriaceae, Vibrionaceae i Pasteurellaceae.

Family Enterobacteriaceae is represented by motile (peritrichs), asporogenic, chemoorganotrophic, saprophytic and pathogenic microorganisms. Metabolism is respiratory or fermentative. They are common in soil, water, and can be found on vegetables, plants, and in human and animal organisms. Typical genus is *Escherichia*, typical member is *E. coli*. This genus also includes *E. blattae*. Certain serotypes *E. coli*, members of genera *Klebsiella, Enterobacter, Proteus, Providencia* may cause hospital-acquired infections. Bacteria of genus *Escherichia* grow well on conventional nutrient media at 37°C with the formation of two types of colonies: S-colonies (smooth) – slightly convex, moist with a shiny surface and smooth edges, grayish, well emulsified in saline; R-colonies (rough) – dry, not emulsified in saline. To differentiate, use Endo medium, on which E. coli forms pink colonies with a metallic sheen, and serological reactions. *E. coli* is conditionally pathogenic. In the intestines of vertebrates, it is a commensal (commensalism is a form of symbiosis between microorganisms and a macroorganism, in which the microorganism feeds on the macroorganism, causing neither benefit nor harm). But under certain conditions (weakening of the macroorganism), it causes intestinal diseases. Pathogenic species of *E. coli* cause coli enteritis in humans. Together with the secretions from the digestive tract, E. coli enters the environment – water, soil, and food. It is considered an indicator of fecal contamination of the environment.

Pathogenic species include members of the genera *Salmonella* (typhoid causative agent), *Shigella* (dysentery causative agent), and *Klebsiella*. Phytopathogenic species are found among bacteria of the genera *Erwinia, Enterobacter, Serratia, Hafnia.*

Related to *E. coli* are coliform bacteria of the genera *Salmonella*, *Shigella* and *Citrobacter*. The genus *Salmonella* includes species that can be the causative agents of typhoid fever (*S. typhi*), paratyphoid fever (*S. paratyphi*) and hospital-acquired salmonellosis (*S. typhimurium*). Shigellae are the causative agents of bacterial dysentery: *S. dysenteriae, S. flexneri, S. sonnei*.

Some species of the genus *Proteus* can cause postoperative complications. Bacteria of the genus *Yersinia* have oval or rod-shaped cells, motile, but their motility depends on the temperature of cultivation. The pathogen *Y. pestis* is the causative agent of plague.

Family Vibrionaceae includes bacteria whose cells are shaped like straight or curved motile rods. Habitats include water bodies, surfaces, and aquatic animals. The genera *Aeromonas* and *Photobacterium* belong to this family. Bacteria of the genus *Aeromonas* are inhabitants of freshwater bodies, they can cause diseases in frogs and fish or infect the human body, which is accompanied by diarrhea and bacteremia. *Vibrio cholerae* is a pathogen that causes cholera, an acute infectious disease with a strong tendency to spread epidemically. Most strains of bacteria of the genus *Photobacterium* grow in a mineral medium made on the basis of seawater in the presence of D-glucose and NH_4Cl. Two species of this genus (*P. leiognathi, P. phosphoreum*) are capable of bioluminescence.

Family Pasteurellaceae includes pleiomorphic, non-motile, aerobic, or optionally anaerobic bacteria. The shape of the cells varies from coccoid to straight rods, which can swell or form filamentous structures. Members of this family are chemoorganotrophs with respiratory and fermentative metabolism. They are parasites of vertebrates, mainly mammals and birds. *Pasteurella multocida* – is the causative agent of hemorrhagic septicemia in cattle, avian cholera and pneumonia in farm animals. *Haemophilus influenzae* – the main causative agent of meningitis in children, can also cause inflammation of the middle ear, chronic bronchitis, and pneumonia. *H. ducreyi* – causative agent of soft chancre or chancroid.

Part 6. *Gram-negative anaerobic straight, curved and spiral rods.* Microorganisms belonging to this group are chemoorganotrophs, obligate anaerobes, non-spore-forming, non-motile or motile rods, prone to pleomorphism. They obtain energy through anaerobic respiration or fermentation. Anaerobic respiration does not use sulfate, other oxidized sulfur compounds, or elemental sulfur as a terminal electron acceptor.

Bacteria are united in one family Bacteroidaceae, which has 13 genera (*Butyriovibrio, Succinivibrio, Bacteroides, Fusobacterium, Leptothrichia, Wolinella, Anaerovibrio, Acetivibrio* etc.). Bacteria of this group live in the oral cavity, digestive tract of humans, animals and insects. Some species are pathogenic (some Fusobacterium species are found in purulent and gangrenous infections). Bacteria of different genera differ in the end products of fermentation: members of genus *Butyriovibrio* form butyrate from glucose, *Succinivibrio* – succinate, *Acetivibrio* – acetate. *Fusobacterium* accumulate butyric acid as the main fermentation product, *Leptotrichia* – lactic acid, *Bacteroides* – a mixture of acids (succinic, acetic, formic, etc.).

Part 7. *Sulfate-assimilating or sulfate-reducing bacteria.* Among the members of the bacteria group are chemolithotrophic obligate anaerobes, which obtain energy by oxidizing molecular hydrogen under anaerobic conditions using sulfate as a terminal electron acceptor. They are chemo-organotrophs that use organic acids (lactate, pyruvate, formate, acetate), alcohols (ethanol, butanol), and carbohydrates as a source of carbon and energy. They do not form endospores and are mostly non-motile.

The group of bacteria is represented by the genera *Desulfovibrio, Desulfomonas, Desulfobulbus, Desulfobacter, Desulfococcus, Denulfosarcina. Desulfosarcina variabilis* is capable of autotrophic growth, using CO_2 as the only source of carbon, H_2S as energy, and SO_4^{2-} as the terminal electron acceptor.

Part 8. Anaerobic gram-negative cocci. Chemoorganotrophs. Anaerobes. Non-spore-forming, non-motile cells that are arranged singly, in pairs, in chains or clusters. Metabolism is exclusively fermentative. The group is represented by one family Veillonellaceae, which consists of three genera: *VeillonelLa, Acidaminococcus, Megasphaera.* They are parasites of warm-blooded animals, found in the digestive tract of humans, ruminants, rodents, and pigs.

Part 9. Rickettsia and chlamydia. Obligate intracellular parasites of eukaryotic hosts (vertebrates and arthropods). Cells are rod-shaped, coccoid and pleomorphic. Many species are pathogenic.

Rickettsiae are pathogenic to humans (cause typhoid fever), while Ehrlichieae are non-pathogenic. The bacteria of the Wolbachieae tribe are symbionts of arthropods, non-pathogenic, except for the genus *Rickettsiella*, which is a pathogen for insect larvae and some other invertebrates. Rickettsiae of the Bartonellaceae family are found in human and vertebrate erythrocytes. Small rickettsial forms of the Anaplasmataceae family are obligate parasites of plasma and red blood cells of many wild and domestic animals.

Chlamydia are obligate intracellular parasites of humans and vertebrates that reproduce only in the blood cytoplasm.

Part 10. Slithering bacteria. Chemoorganotrophic, obligate aerobic bacteria lacking flagella but able to slide on hard surfaces. In the absence of nutrients, the cells aggregate to form fruiting bodies, which consist of mucus and cells, often brightly colored and visible to the naked eye. Fruiting bodies vary from simple lumps to complex structures that have sporangia of characteristic shapes and sizes, arranged singly or in groups on simple stems or on branching stems. The cells inside the fruiting bodies are resting forms (myxospores or microcysts).

Fruiting bodies can be formed by representatives of the order Muhobacteriales. Myxobacteria are characterized by high activity of lytic enzymes that cause hydrolysis of protein, nucleic acids, polysaccharides, etc. Due to this, they actively destroy dead plant residues, lysing prokaryotic and eukaryotic cells. They exist in the soil, on decaying plant material, and in the bark of living trees.

Part 11. Bacteria that have covers. Chemoorganoheterotrophs. Aerobes. Unable to move by sliding. Growth in the form of filaments with cells surrounded by membranes (tube or extracellular substance) is characteristic. When observed in a wet preparation using phase-contrast microscopy, the tube looks transparent, resembling a plastic microtubule or a pipe. Sometimes the sheath is so thin and fits so tightly to the cell that it is impossible to distinguish it under phase-contrast microscopy. When 95% ethanol is added to the preparation, the envelope becomes visible. The coverslips can have a color from yellow to dark brown due to deposits of iron and manganese oxides. Single cells can be motile due to polar or subpolar flagella or immobile.

Bacteria are free-floating or attached to plants, stones, and other objects submerged in water. They can be found in wastewater, activated sludge, and in marine and freshwater bodies. The most common bacteria are those of the genera *Sphaerotilus*, which inhabit sewage, and *Leptothrix*, which develop in places rich in organic material and iron.

Part 12. Bacteria that are budding and/or stalked. Дsome have prostheses - thin outgrowths consisting of a cell wall, membrane and cytoplasm. Buds are formed at the end of a pore or on the surface of the cell. They help bacteria attach to the surface. Prostheses are formed by bacteria of the genera *Caullobocter, Prosthecomicrobium*. Members of the genus *Hyphomicrobium* reproduce by budding. Some reproduce by binary fission. Prostheses are formed by bacteria of the genera *Caulobacter, Prosthecomicrobium*. Bacteria of the genus *Pedomicrobium* accumulate iron and manganese.

Part 13. Gram-negative chemolithotrophic bacteria. Depending on the chemical nature of the inorganic compounds that serve as a source of energy for bacteria, they are divided into the following groups:

1) Nitrifiers (use ammonia and nitrite) *Nitrosomonas, Nitrososprira, Nitrosococcus, Nitrobacter*;

2) Bacteria that oxidize sulfur (inorganic sulfur compounds) *Thiobacillus, Thiobacterium, Thiovulum, Thiospira*;

3) Obligated hydrogen oxidizers;

4) Bacteria that form or accumulate manganese and/or manganese oxides on the surface or inside the cell;

5) Magnetotactic bacteria whose cells have magnetosomes.

Nitrifiers exist in soil, freshwater, and seawater. Sulfur-oxidizing bacteria live in soil, water, sulfuric vents, and sulfur deposits, where hydrogen sulfide is produced and sulfur is deposited. Bacteria of the Siderocapsaceae family are found in waters containing iron.

Part 14. Endosymbionts. According to the host type, they are divided into three groups: endosymbionts of protozoa (infusoria, flagellates, amoebae), insects, fungi, and other invertebrates (except arthropods). All endosymbionts are adapted to intracellular existence, most of them are unable to grow outside the cell. Five genera of protozoan endosymbiont bacteria are known (*Halospora, Tectibacter, Lyticum, Caedibacter, Pseudocaedibacter*) and one genus of insect endosymbionts (*Blattabacterium*).

Class Anoxyphotobacteria

Part 15. Phototrophic bacteria. Bacteria that contain bacteriochlorophyll, carotenoids and are able to use light as an energy source. They grow in the light under anaerobic conditions and do not release oxygen during photosynthesis. Some are able to grow in the dark due to oxygen respiration. They can exist photoautotrophically, photoheterotrophically, and chemoheterotrophically. They cannot use water as a hydrogen donor; they need donors with a higher degree of oxidation (hydrogen sulfide, hydrogen, organic compounds). Therefore, photosynthesis in them takes place without the release of oxygen (anoxygenic photosynthesis). They do not contain phycobiliproteins. According to their ability to use elemental sulfur as an electron donor, they are divided into sulfur and non-sulfur bacteria. Morphologically diverse group - cocci, rods, curved forms (spirillum, vibrio), motile and non-motile.

Bacteria belong to two orders. The first order Rhodospirilleles (purple bacteria) includes the families Rhodospirillaceae (non-sulfur purple bacteria) and Chromatiaceae (sulfur purple bacteria), and the second order Chlorobiales (green bacteria) includes the families Chlorobiaceae (green sulfur bacteria) and

Chloroflexaceae.

A common feature of the Rhodospirillales order is that their photosynthetic apparatus is located on the inner membranes (thylakoids), which are formed from invaginations of the plasma membrane. Representatives of the order Chlorobiales are characterized by the presence of chlorosomes, organelles that contain pigment and are adjacent to the plasma membrane. Chlorosomes contain bacteriochlorophyll.

Purple and green bacteria exist in water bodies with a hydrogen sulfide content of 20-100 mg/l and above, which provides them with anaerobic conditions. Non-sulfur bacteria develop in water bodies rich in organic matter. They live in salt and fresh water bodies. They are probably the oldest bacteria on Earth.

Class Oxyphotobacteria

Part 16. *Cyanobacteria.* Bacteria that contain chlorophyll and use light as an energy source and release oxygen (like green plants). They are divided into two groups:

1) organisms that contain chlorophyll a and phycobiliproteins (allophycocyanin, phycocyanin, sometimes phycoerythrin). They are called cyanobacteria;

2) organisms that contain chlorophylls a and b (which is characteristic of green algae and higher plants), but not phycobiliproteins. They are called prochlorophytes.

They are divided into two orders – Cyanobacteriales i Prochlorales. Morphologically, cyanobacteria are divided into five groups:

1) chroococcal cyanobacteria – unicellular rods and cocci, located singly or in aggregates in which they are united by capsules or mucus. They reproduce by binary fission or budding. genera: *Synechococcusy, Gloebacter* etc;

2) pleurocapsular cyanobacteria are also unicellular forms, but only those that can reproduce by multiple division. In this case, many small cells, called biocytes, appear inside the dividing cell. genera: *Pleurocapsar, Dermocapsa, Myxosarcina* etc.;

3) filamentous cyanobacteria without heterocysts – trichomes consist only of vegetative cells. genera: *Oscillatoria, Spirulinay Plectonema* etc.;

4) filamentous cyanobacteria with heterocysts – genera *Anabena, Nostoc* etc.

In addition to heterocysts, they can form akinetes, which are dormant cells that differentiate from vegetative cells by forming a thick outer membrane, increasing in volume, and accumulating cyanophycin, glycogen, lipids, and carotenoids. The cells divide in the same plane;

5) filamentous cyanobacteria with heterocysts – differ from group 4 in that the cells divide in more than one plane. Genus *Fischerella*.

The photosynthetic apparatus is represented by thylakoids. A distinctive feature of cyanobacteria is the presence of phycobilisomes, disk-shaped formations that are externally adjacent to thylakoids and consist of phycobiliproteins. Phycobilisomes are light-harvesting pigments. Only one cyanobacterium, *Gloeobacter violaceus*, does not have thylakoids and phycobilisomes.

Cyanobacteria are common in various water bodies, in soil, and in rice fields. Due to their ability to fix molecular nitrogen, they exist in places that are poor in nutrients (sea sand, rocks in deserts). They are not afraid of extreme conditions. Some of the cyanobacteria are so resistant to acids and thermophilic that they grow in acidic hot springs (70 °C, pH 4.0).

Prochlorophytes are exosymbionts, living on the bodies of marine animals.

Phullum Firmicutes

The Firmicutes order (Table 11) includes gram-positive prokaryotes that are spherical, rod-shaped, and filamentous. The rods and filaments may be branching. Reproduction by binary fission. Some species form spores (endospores or spores on hyphae or in sporangia). Most species are non-motile. The motile ones have flagella. Members of the division are chemoheterotrophs, including aerobes, anaerobes, facultative anaerobes, and microaerophiles. This group includes simple asporogenic and spore-forming bacteria, as well as actinomycetes and related organisms. They are divided into two classes: Firmibacteria (consisting of three parts, Nos. 17–19); Thallobacteria (consisting of one part, No. 20).

Table 11

Microorganisms of the Firmicutes order

Class Firmibacteria	
Part 17. Gram-positive cocci	1) familyMicrococcacese (genera: *Micrococcus, Staphylococcus, Planococcus*); 2) family Streptococcacese (genera: *Streptococcus, Pediococcus, Aerococcus, Gemella, Leuconostoc*); 3) family Peptococcaceae (genera: *Peptococcus, Ruminoccus Peptostreptococcus. Sarcina*).
Part 18. Bacilli and cocci that form endospores	Family Bacillaceae, which consists of five genera (*Bacillus, Sporolactobacillus, Clostridium. Sporosarcina, Desuifotomaculum*)
Part 19. Gram-positive rod-shaped bacteria that do not form endospores	Family Lactobacillaceae (genus *Lactobacillus*)
Clas Thallobacteria	
Part 20. Actinomycetes and related organisms	Order Actinomycetales (family Actinomycet aceae, genera *Actinomyces, Arachnia, Bifidobacterium*), family Propionobacteriaceae (genera *Propionibacterium, Eubacterium*), family Mycobacteriaceae (genus *Mycobacterium*), family Frankiaceae (genus *Frankia*), family Actinoplanaceae (genera *Actinopianes Streptonporangium*), family Nocardiaceae (genus *Nokardia*), family Streptomycetaceae (genera *Streptomyces, Streptoverticillum*), family Micromonoeporaceae (genera *Micromonospora, Thermoactinomyces, Thermomonospora, Microbispora, Micropolyspora*), genera *Corynebacterium, Arthrobacter, Cellumonas, Kurihia*

Class Firmibacteria

Part 17. Gram-positive cocci. Chemoorganotrophic, mesophilic, gram-positive cocci that do not form spores and are divided as follows:

1) aerobic cocci, arranged in pairs, in clusters, tetrads. Catalase-positive. Contain cytochromes. There are no teichoic acids in the cell walls. Acid formation from carbohydrates is often absent or weakly expressed (family Misrossaceae);

2) facultatively anaerobic or microaerophilic cocci arranged in pairs, in chains, clusters or tetrads. The presence of catalase, cytochromes, and teichoic acids in the cell wall are variable features (family Streptococcacea);

3) Strictly anaerobic cocci, arranged in pairs, in chains, tetrads or cubic packets. Cytochromes are not detected. Catalase test results are usually negative, although in some cases weak or pseudocatalase activity is observed (family Peptococcaceae).

The bacteria of the **family Mycobacteriaceae** are aerobes. These are cocci that divide more than water. Chemoorganoheterotrophs. Mobile or non-motile. They exist in soils, fresh waters, on human and animal skin (genus *Micrococcus*), skin glands, mucous membranes of warm-blooded animals and humans (genus *Staphylococcus*), and in sea water (genus *Planococcus*). They are mostly saprophytes, but there are pathogenic species (*Staphylococcus aureus* – causes boils, purulent processes and even sepsis).

The diversity of the genera of the **family Streptococcaceae** is based on morphological characteristics and fermentation products: bacteria of the genera *Streptococcus, Pediococcus, Aerococcus* ferment glucose to form lactic acid, i.e. they are homofermentative. Bacteria of the genus *Leuconostoc* are heterofermentative, since in the process of glucose fermentation not only lactic acid is formed, but also ethanol, acetic acid, and CO_2. They are found in soils, air, water, milk and dairy products (*Streptococcus lactis, Streptococcus cremoris*), sauerkraut, and food. They can cause food spoilage (sugar syrup – *Leuconostoc mesenteroides*). They are parasites of mammals (*Gemella, Streptococcus*). Streptococci are particularly pathogenic, causing a number of diseases in humans (lymphadenitis, abscesses, lung and kidney infections, etc.).

The **Peptococcaceae family** includes anaerobic non-motile cocci. During fermentation, they produce CO_2, H_2, lower fatty acids, succinate, and ethanol. Lactic acid is not the main product of fermentation. Saprophytes are mainly inhabit the soil (*Sarcina*), the surface of grain crops, the mouth and respiratory tract of humans and animals (*Peptococcus*), and the rumen of ruminants (*Ruminoccus*). There are pathogenic species (*Peptostreptococcus*).

Part 18. Bacilli and cocci that form endospores. Bacteria that form heat-resistant endospores. Most often, they are motile rods or filaments, but one genus is represented by motile cocci (placed in tetrads or cubic packets). Mostly gram-positive, particularly in young cultures, but representatives of one genus are gram-negative. Obligate aerobes, facultative anaerobes, microaerophiles or strict anaerobes. Chemoorganotrophs. In one genus of anaerobic bacteria, anaerobic respiration occurs using sulfate as a terminal electron acceptor.

This group of bacteria is characterized by a wide variety of properties. Among them are butyric acid bacteria (*Clostridium butyricum*), acetobutyric bacteria (*Clostridium acetobutyricum*), urolithic bacteria (*Sporosarcina ureae*), atmospheric nitrogen fixers (*Clostridium pasteurianum*), producers of antibiotics, enzymes, amino acids, and toxins. All these biologically active compounds are produced by representatives of the genus *Bacillus*. The most productive species is *Bacillus subtilis*, for which more than 70 different antibiotics have been described. About 30 antibiotics are produced by *Bacillus brevis* strains. It has been established that *Bacillus subtilis* induces the formation of interferon of the second type. The interferonogenicity of bacilli is associated with the production of extracellular lectins.

Bacteria of this group exist in soils, bottom sediments, silt, fresh and salt water bodies. They are saprophytes, but there are also parasites, even particularly pathogenic ones: *Clostridium* species cause gas gangrene and botulism.

Part 19. Gram-positive rod-shaped bacteria that do not form endospores. Straight or curved rods, non-motile (few motile), facultative or obligate anaerobes. Inhabitants of plants, milk and dairy products, beer, pickles, marinades, the human digestive tract, and warm-blooded animals. Saprophytes, except for those that play a role in dental caries. The main product of fermentation is lactic acid, so these bacteria are called "lactic acid bacteria".

Class Thallobacteria

Part 20. Actinomycetes and related organisms.

Order Actinomycetales (family Actinomycetaceae, genera *Actinomyces, Arachnia, Bifidobacterium*). Actinomycetes are Gram-positive bacteria that form branched filaments or hyphae in the form of mycelium, i.e., they form a mycelium – like structure (air and substrate) (Fig. 12). Mycelium can be stable or break down into rod-like and coccoid elements. If the mycelium is stable, spores are formed, which are used for reproduction. Spores can be formed directly on aerial hyphae (sporophores), from which conidia are untied, or in sporangia. Some representatives form spores with flagella (motile). Motility in actinomycetes (if any) is due to flagella. Almost all aerobes.

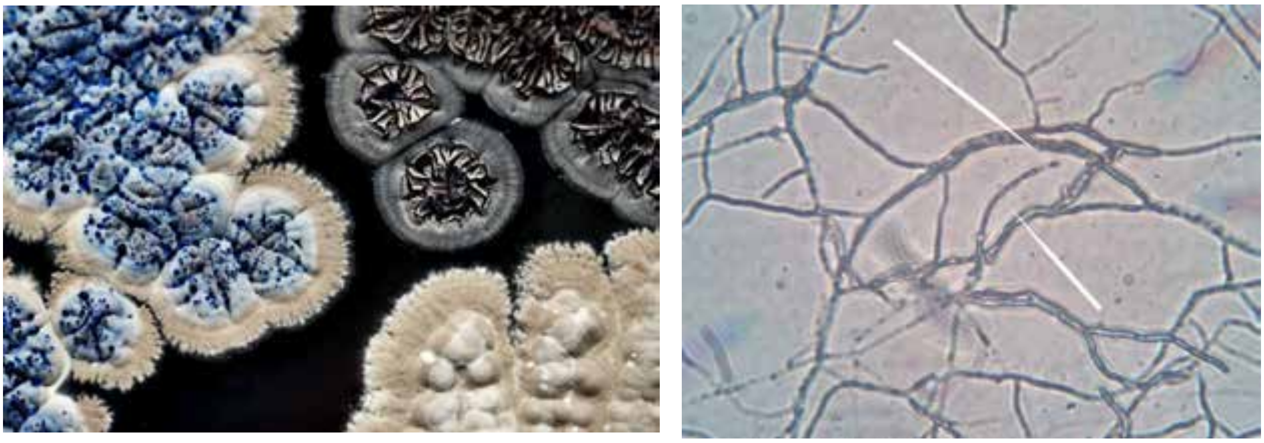

Fig. 12 **Morphology of representatives of the family Actinomycetales** (https://taxateca.com/ordenactinomycetales.html)

Actinomycetes got their name from the first of the described species, *Actinomyces bovis*, a "radiant fungus" that causes actinomycosis, a disease of cattle. Chemoheterotrophs use a variety of energy sources, including complex polymers. The genera are distinguished by morphological features, as well as by the presence or absence of marker chemical components of the cell wall.

Related organisms are root-forming and propionate bacteria.

Coryneform bacteria are Gram-positive rod-shaped bacteria prone to morphological variability with the formation of club-shaped, weakly branched cells, which are often angled in the form of the letters V, Y. They also look like irregular sticks that turn into coccoid shapes (the coccus-coccus cycle is inherent). Most are non-motile, non-acid-resistant, chemo-organotrophs, mainly obligate aerobes, but there are facultative anaerobes. Bacteria of the genus *Corynebacterium* are aerobic organotrophs. They exist in soil, water, and air, and a number of species are pathogens of plants, animals, and humans (for example, the causative agent of diphtheria – *Corynebacterium diphtheriae*). Arthrobacteria live in the soil, carry out ammonification, nitrification, and molecular nitrogen fixation processes, and decompose plastics, herbicides, fungicides, and mercury-containing compounds. Bacteria of the genus *Cellulomonas* decompose cellulose, their cell walls contain neither blade-diaminopimelic acid nor arabinose.

Anaerobic microorganisms in this group are represented by organotrophic non-spore bacteria: oil-acid bacteria *Eubacterium, Butyriovibrio*, homoacetate bacteria *Acetobacterium*, lactic acid bacteria *Bifidobacterium*, propionic acid bacteria *Propionibacterium*, thermophilic bacteria *Thermoanaerobacter*, which carry out various types of fermentation with the release of H_2 to produce various fatty acids.

Family Mycobacteriaceae *(*genus *Mycobacterium).* Mycobacteria are acid-resistant aerobic non-motile organotrophic *Mycobacterium* bacilli that do not form spores. They are characterized by slow growth (from 2 to 40 days) and acid resistance (after staining, they do not discolor when treated with acidified alcohol or strong inorganic acids). Acid resistance is due to the presence of mycolic acids in the cell walls, which contain 78–95 carbon atoms. Only long-chain mycolic acids confer acid resistance to cells. It should be noted that mycolic acids are present in the cell walls of *Corynebacterium* and *Nocardia*, but their chains are shorter (mycolic acids of *Corynebacterium* contain 32–36 carbon atoms, and those of *Nocardia* contain 48-58 carbon atoms), and therefore these bacteria are not acid-resistant. They have a weak Gram stain. Sometimes they form branching filaments. They do not form air mycelium. Most are saprophytes, but some are pathogenic to humans (tuberculosis pathogen). They live in soil, water, and animal tissues.

Family Nocardiaceae *(*genera *Nocardia).* Nocardiaforms are Gram-positive bacteria prone to forming branched forms and poorly developed mycelium. The typical genus of the group is *Nocardia*. Organotrophic bacteria of the genus *Rhodococcus*, despite their name, have nothing to do with purple non-sulfur bacteria.

Aerobes, which are relatively slow-growing, are able to efficiently utilize hydrocarbon oils.

Family Actinoplanaceae *(*genera *Actinopianes Streptonporangium)*. Actinoplans are aquatic actinomycetes that form well-developed both substrate and aerial mycelium. Spores are formed in bag-like sporangia, which can withstand drying. But when moistened, the spores are released as motile flagellated cells. genera: *Actinoplanes, Dactylosporangium*.

Family Streptomycetaceae *(*genera *Streptomyces, Streptoverticillum).* Streptomycetes form a well-developed mycelium and reproduce by conidia. They have a structure similar to that of fungi, but with thinner prokaryotic hyphae that contain many nucleoids and are not always divided into separate cells. These are primarily soil organisms adapted to exist in relatively arid conditions. They are characterized by high hydrolytic activity towards various polymers. Many streptomycetes assimilate cellulose, chitin, and other natural substances that are difficult to decompose. The mycelium is divided into substrate and aerial mycelium, which serves for reproduction. Conidiospores are both reproductive and dormant organs. Streptomycetes are producers of antibiotics (streptomycin, chloromycetin, aureomycin, tetracyclines). genera: *Streptomyces* (over 500 species). *Streploverticillium, Intrasporangium, Kineosporia, Sporichthya*.

Geodermatophiles and frankia are actinomycetes that do not form mycelium. genera: *Dermatophilus. Geodermatophilus, Frankia*. Aerobic organogrophs. *Frankia* is a nitrogen-fixing symbiont of alder that forms nodules on its roots (similar to rhizobia). They are characterized by a typical aerial mycelium with a sporangium divided into many spores.

Maduromycetes or oligosporous actinomycetes have the same mycelial structure as other actinomycetes, but unlike them, they form a small number of conidia. The genera differ primarily in the shape of the conidia. genera: *Actinomadura, Microspora, Pianomonospora, Microtetraspora, Spirillospora, Streptoeporangium*.

Thermoactinomycetes are distinguished by their ability to moderate thermophilia. genera: *Thermoactinomyces. Thermomonospora, Actinosynnema, Nocardiopsis, Streptoalloteichus*.

Phyllum Tenericutes

Members of the phylum Tenericutes are prokaryotes that lack a cell wall (called *mycoplasmas*) and are incapable of synthesizing peptidoglycan precursors (Fig. 13). Cells are surrounded by an elementary plasma membrane, pleomorphic, vary in size (the smallest size is 0.15–0.20, the largest is 10 microns). Branching filamentous forms are characteristic. Reproduction can occur by budding, fragmentation and/or binary fission. Immobile, some species are characterized by motility (slithering). They do not stain according to Gram's method. Growth requires complex nutrient media (media with high osmotic pressure). These organisms sometimes resemble L-forms of bacteria that do not have a cell wall (especially common in Gram-positive eubacteria), but differ from these eubacteria in that they are unable to reverse to the normal type and form a cell wall. Many species additionally require cholesterol and long-chain fatty acids for growth.

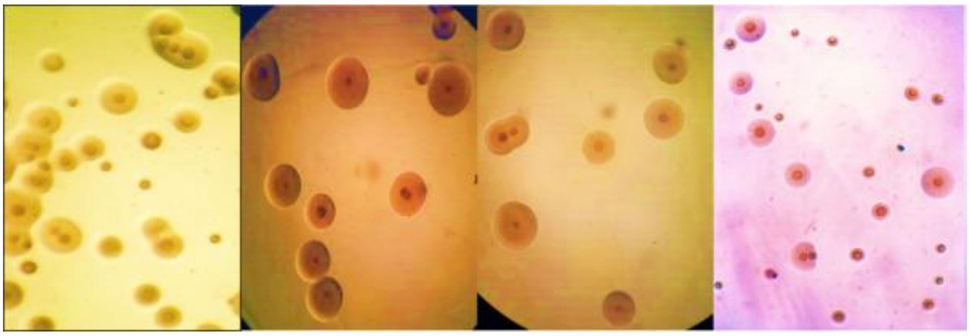

Fig. 13 **Member of the mycoplasmas *Mycoplasma gallisepticum*** (S. Marouf et al., 2022, https://doi.org/10.1016/j.psj.2021.101658)

The absence of a cell wall caused the peculiarity of the structure of bacteria of this group: 1) polymorphism of cells – spherical, elliptical, disc-shaped, rod-shaped, filamentous, branching; 2) resistance to antibiotics that specifically act on the cell wall (e.g., penicillin and its analogues); 3) presence of a well-developed stable elastic plasma membrane.

Representatives of the division form the class Mollientes (consisting of one part – № 21). Species belonging to this class are the smallest prokaryotes capable of self-propagation. They are united in the order Mycoplasmetales and three families Mycoplasmataceae, Acholrplamataceae, Spiroplasmataceae. Mycoplasmas are divided into families according to their relationship to sterols: sterol-dependent mycoplasmas of the Mycoplasmataceae family require exogenous cholesterol (and other sterols), which is the main component of membrane lipids of parasitic mycoplasmas; mycoplasmas of the Acholeplasmataceae family are sterol-independent.

Energy is obtained through the oxidation or fermentation of organic compounds (mono- and polysaccharides) and inorganic compounds (iron, manganese). The absence of quinones and cytochromes indicates that their respiratory chain is limited. Most of them are aerobes, and there are obligate anaerobes. There are acidophiles that can grow only in conditions of high acidity of the environment – *Thermoplasma acidophilum*, pH 1–4. Members of the genus *Thermoplasma* are thermophiles, some mycoplasmas are able to hydrolyze urea (genus *Ureaplasma*).

Among mycoplasmas, saprophytic, parasitic, and pathogenic forms have been identified. The latter cause diseases of animals, plants and tissue cultures. In plants, mycoplasmas are the causative agents of etiolation diseases. They are mainly localized in the phloem and, due to their external similarity to spirillum, are grouped into the genus *Spiroplasma*. *Spiroplasma citri* – the causative agent of citrus etiolation disease. Similar forms have been found in other plants (corn, Bermuda grass, rice). *Spiroplasma* was also found in bees and grasshoppers. It is likely that insects not only transmit mycoplasmas, but are also their hosts.

Phyllum Mendosicutes

Archaebacteria are mainly soil or water microorganisms, and are also symbionts of animals. Aerobes, anaerobes. Chemoorganotrophs, heterotrophs or facultative heterotrophs. Some can exist at t over 100°C. Their esters include glycerol isoprenyl esters. The nucleotide sequences of 5S-, 16S-, 23S-rRNA are very different from those of eubacteria and eukaryotes. There is no muren in the cell walls. In gram-positive representatives, cell walls consist of pseudomorphin, methanochondroitin, and heteropolysaccharide. Gram-negative cells have surface layers consisting of glycoprotein. The shape of the cell is diverse: Spherical, spiral, lamellar, rod-shaped. There are multicellular forms in the form of filaments or aggregates. Reproduction – by binary division, budding, tethering, fragmentation. They can be colored red, purple, pink, orange-brown, yellow, green, gray and white.

They are divided into 5 main groups:

1. ***Methanogens*** *(Methanobacterium, Methanococcus, Methanosarcina, Methanospirillum, Methanobreviobacterium, Methanogenium, Methanotrix* etc.*)*. Obligate anaerobes whose final metabolic product is methane. Substrates are H_2+CO_2, formate, acetate, methanol, methylamines, H_2+methanol. Sulfur can be reduced to H_2S. Mesophilic and thermophilic, neutrophilic (pH=7), halophilic species are found.

2. ***Sulfate-reducing archaea.*** Genus *Archaeoglobus (A. fulgidus* and *A. Profundus*). Cells are coccoid irregular in shape, often triangular, arranged singly or in pairs. Gram stain is negative. They form greenish-black colonies 1–2 mm in diameter. Obligate anaerobes capable of producing H_2S from sulfates. Form small amounts of methane. Extreme thermophiles, pH 4.5–7.5. Chemolithotrophs, chemoorganotrophs, chemomixotrophs. Autotrophic growth requires thiosulfate and H_2. Heterotrophs consume formate, lactate, glucose, starch and proteins.

3. ***Halobacteria.*** Gram-negative or gram-positive, aerobes or facultative anaerobes, chemoorganotrophs. Cells are rod-shaped, with a shape from regular to very irregular. Chemoorganotrophs. They require a high concentration of NaCl. Some can use light to synthesize ATP (contain the photoactive red-purple pigment bacteriorhodopsin). Neutrophils or alkalophils. Mesophiles or to some extent thermophiles (up to 55ºC) genera *Halococcus, Halobacterium, Haloarcula. Haloferox, Natronobacterium, Natronococcus*

4. ***Archaebacteria that have no cell wall.*** Thermoacidophiles, aerobes (genus *Thermoplasma*). The optimum temperature is about 60°C, the optimum pH is 1-2. The cells are coccoid, without a cell wall. They can be called thermoacidophilic "mycoplasmas". The cytoplasmic membrane contains mannose-rich glycoprotein and

lipoglycan.

5. ***Extreme thermophiles and hyperthermophiles that metabolize sulfur.*** Extreme thermophiles and hyperthermophiles that metabolize S. Obligate thermophiles, aerobes, facultative anaerobes, or strict anaerobes. Gram-negative rods, filaments or cocci. The optimal temperature for growth is in the range of 70–105°C. Acidophiles and neutrophils. Autotrophs or heterotrophs. Most species metabolize sulfur. Belong to 14 genera (*Acidianus, Desulfurolobus, SulfolobuS Pyrobaculum, Pyrococcus, Desulfurococcus* etc.).

Phylogenetic classification of microorganisms

Until 1977, the existence of two kingdoms of living organisms – prokaryotes and eukaryotes – was generally recognized among microbiologists. In 1977, C.R. Wesley and G.E. Fox compared the nucleotide sequences of 16S rRNA (and similar eukaryotic 18S rRNA) in a wide range of living organisms. The genes that encode rRNAs are highly conserved, and therefore rRNAs change very little in the course of evolution. These informational molecules are considered as molecular chronometers reflecting the origin and development of microorganisms. The results of the comparison showed that there are three kingdoms of living organisms: archaebacteria, eubacteria, and eukaryotes. Archaeobacteria and eubacteria differ from each other as much as they differ from eukaryotes.

The results of studies conducted by C.R. Weese and E. Steckebrandt in the first half of the 1980s showed that eubacteria are divided into 11 main groups when analyzing 16S rRNA nucleotide sequences (Fig. 14).

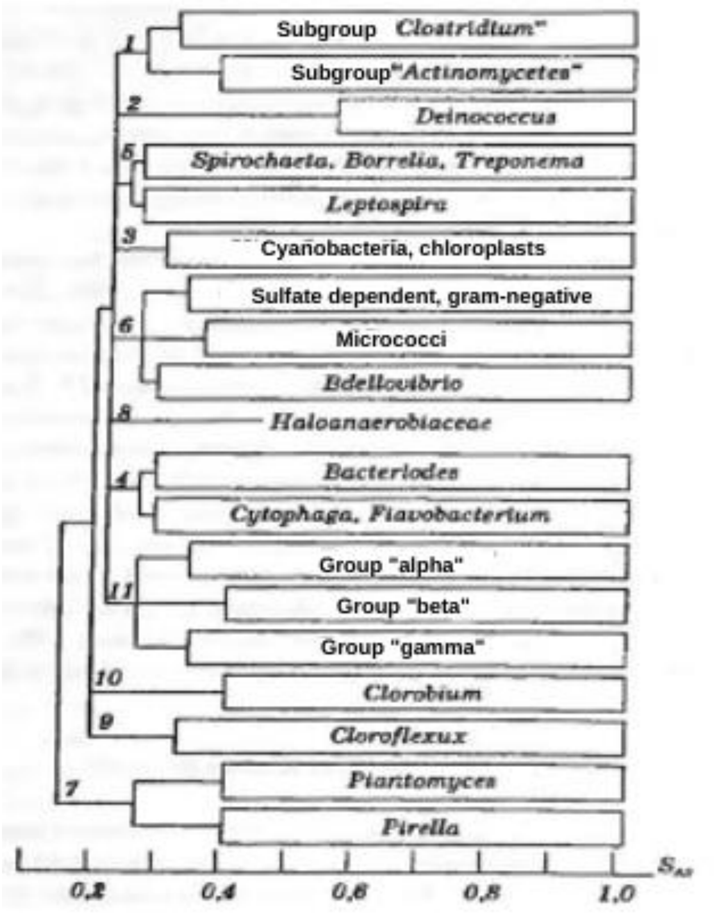

Fig. 14 **Dendrogram of the formation of the main lines of evolution in the kingdom of eubacteria**

Groups of microorganisms according to phylogenetic classification:

1. Gram-positive bacteria form one group (*Deinococcus* is an exception), which consists of two subgroups: clostridia (with a low content of GCs in DNA) and actinomycetes (with a high content of GCs in DNA). This group also includes some mycoplasmas.

The “Clostridium” subgroup includes the following genera: *Acetobacterium, Clostridium, Eubacterium, Acetogenium, Acholeplasma, Mycoplasma, Spiroplasma, Bacillus, Brochothrix. Listeria, Gamella, Enterococcus, Streptococcus, Kurthia, Lactobacillus, Leuconostoc, Pediococcus, Peptococcus, Planococcus, Staphylococcus, Ruminococcus, Sarcina, Sporolacfobacillus, Sporosarcina, Thermoactinomyces, Erysipelothrix, Aerococcus*.

The subgroup "Actinomycetes" includes genera: *Actinomadura, Nocardiopsis, Actinomyces, Bifidobacterium, Propionibacterium, Actinoplanes Ampullariellay*

Arthrobacter, Micrococcus, Aureobacterium, Brevibacterium, Cellulomonas, Curtobacterium, Microbacterium, Nocardioides, Kitasatosporia, Microellobosporia, Promicromonosporay Streptosporangium, Streptoverticillium, Thermomonospora, Corynebacteriumy Dactylosporangium, Micromonospora, Microbacterium, Rhodococcus, Nocardia, Streptomyces, Dermatophilus, Geodermatophilus, Stomatococcus, Frankia.

2. Deinococcus and closely related cocci are characterized by an atypical cell wall.

3. Cyanobacteria and chloroplasts of higher plants and algae; no heterotrophic representative of this group has been found.

4. One of the main groups of eubacteria, which consists of subgroups Bacteroides, Flavobacterium, Cytophaga. The last subgroup is divided into two lineages, each of which contains flavobacteria.

5. Spirochaetes form a group of three subgroups that combine Spirochaeta, Borrelia. Treponema; the peripheral member of this branch is Leptospira.

6. The group unites Bdellovibrio, myxococci, dissimilatory sulfur- and sulfate-reducing bacteria, which have almost no common taxonomic features. The presence of sulfate-reducing bacteria among archaebacteria, gram-negative and gram-positive bacteria indicates that their evolution could have taken different paths.

7. The Plantomyces and Pirella groups are budding organisms with a protein cell wall (no muramic and diaminopimelic acids). The very low SAB (0.15) value with other bacteria indicates that members of this group are descendants of the oldest group of eubacteria.

8. Haloanaerobiaceae – are anaerobic, moderately halophilic bacteria with a low content of GCs in DNA.

9 i 10. Green sulfur bacteria – a separate line of evolution *Chlorobium vibrioforme*.

11. The most difficult group to understand and interpret is represented by purple and related gram-negative bacteria. It includes phenotypically different organisms. The composition of group 11 is practically inconsistent with the existing classification

of bacteria given in the Berghi definition. The group unites three main subgroups (alpha, beta, gamma), each of which contains phototrophic bacteria. This grouping was based on both the results of DNA-DNA hybridization and the determination of 16S rRNA nucleotide sequences. It is assumed that the common ancestor of this group of bacteria was a phototroph.

Comparison of the phylogenetic structure of bacteria with the traditional phenotypic taxonomy (especially group 11) immediately shows significant differences. A different picture is observed for archaebacteria, whose classification was originally based on 16S rRNA analysis. The phylogenetic structure of archaebacteria is fully consistent with the phenotypic classification (Fig. 15).

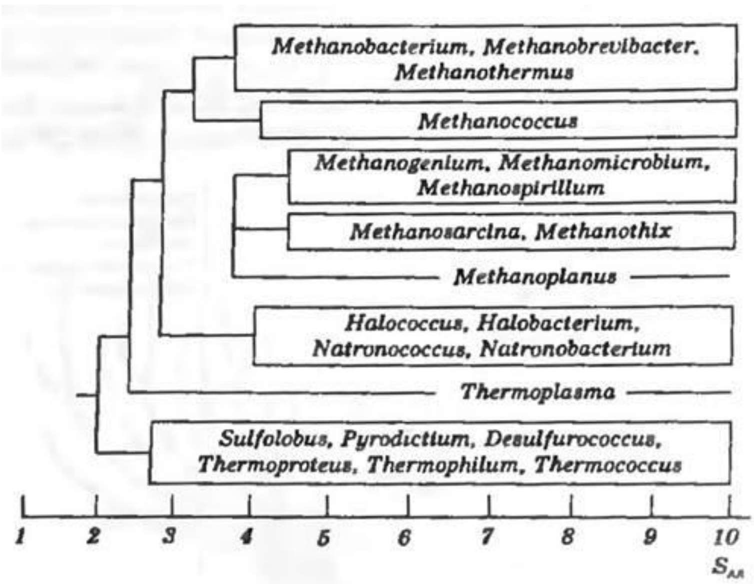

Fig.15 **Dendrogram of the formation of the main lines of evolution in the kingdom of archaeobacteria**

Archaea

Combines three orders (Thermoproteales, Sulfolobales, Thermococcales), one family (Halobacteriaceae), two genera (*Archaeoglobus i Thermoplasma*), methanogenic bacteria (taxon of uncertain rank).

Bacteria

1. ***Phyllum A.*** Firmicutes includes nine families (Streptomycetaceae, Pseudonocardiaceae, Frankiaceae, Thermomonoaporaceae, Streptosporangiaceae,

Nocardiaceae, Cellulomonadaceae, Dermatophilaceae, Heliobacteriaceae), 67 genera, and taxa of uncertain rank (Lactobacillus, Carnobacterium, anaerobic gram-positive cocci).

2. ***Phyllum B.*** Cyanobacteria – one order (Prochlorales).

3. ***Phyllum C***. Proteobacteria – seven families (Enterobacteriaceae, Vibrionaceae, Pseudomonaceae, Azotobacteriaceae, Halomonadaceae, Chromatiaceae, Ectothiorhodospiraceae), 78 genera, as well as taxa of uncertain rank (Rhizobiai, Moraxella; Myxobacteria; manganese oxidizing bacteria; lithotrophic ammonium oxidizing bacteria; unusually curved bacteria; gram-negative mesophilic sulfate-reducing bacteria).

4. Spirochetes – four genera (*Spirochaeta, Treponema, Borrelia, Leptospira*).

5. Chlorobiaceae – order Cytophagales, family Chlorobiaceae, seven genera.

6. Chlamydia – genus *Chlamydia*.

7. Plantomycetes and related bacteria – order Plantomycetales and four genera.

8. Family Deinococcaceae, genus *Thermus*, and related microorganisms.

9. Chloroflexaceae and related bacteria – family Chloroflexaceae and four genera.

10. Genus *Verrucomicrobium.*

11. Order Thermotogales.

Some taxa are not phylogenetically delineated. These include most forms that grow in symbiosis with other organisms; thermophilic aerobic hydrogen bacteria; morphologically different sulfur-oxidizing bacteria; large symbiotic spirochetes; mycoplasma-like organisms (pathogenic to plants); 12 genera of bacteria (including *Zooglea, Leptotrichia, Gallionella, Caulococcus, Kuznezovia, Siderocapsa, Fusobacterium*) and some others.

VIRUS BIODIVERSITY, MORPHOLOGY AND ECOLOGY

The world of viruses and the world of microbes are diametrically opposed to each other, and these organisms are not similar at all: their physiology, structure, and methods of reproduction are different. It took a long time for this to become an axiom. So what is a virus?

A **virus** is a biological non-cellular form of existence characterized by obligate, intracellular parasitism and antigenicity for all known animals, plants, bacteria, fungi, protozoa and other living things. At the same time, they have their own, often unique genome and are capable of reproduction only in living host cells. It (the genome) is represented by only one type of nucleic acid and is reproduced in living cells using their synthetic apparatus, causing the synthesis of specialized structures that can transfer the virus genome to other cells. This reflects two essential qualities of viruses: first, the presence of their own genetic material, which uses the biochemical apparatus of the host cell, and second, the existence of an extracellular infectious phase, which is represented by specialized particles or virions that reproduce under the genetic control of the virus and serve to introduce the virus genome into other cells.

The first clear description of a viral disease was made in ancient times by the Greek physician Hippocrates, an idol of Olympic athletes of that time. Medical historians, studying his works, have shown that he developed a clear description of mumps with all the symptoms of the disease, the stages of the disease's development, and an explanation of its etiology, especially for young children.

A lot of doctors and microbiologists based their thoughts on the analogy between microbial and viral diseases, because it was microbiologists who started to study virology.

It was in the last two decades of the 19th century that information about bacteria and their role as pathogens was substantiated. This was due to the proposal of the immersion microscopy method and other inventions associated with the name of Robert Koch and other scientists. Tobacco mosaic disease played a special role.

The actual science of viruses is a little over 100 years old, when in 1892 our compatriot Dmytro Ivanovsky defended his dissertation at Kyiv University (now

Taras Shevchenko National University of Kyiv) and for the first time spoke about a strange disease agent passing through a bacterial filter. A little later, in 1898–99, the Dutch scientist Martin Beyerink showed that this agent was not a bacterium, as Ivanovsky said, but an infectious liquid germ – *contagium vivum fluidum*.

Subsequently, it was shown that viruses, unlike other biological forms, cause infectious diseases and reproduce only in living cells of autotrophic, heterotrophic, and other organisms. It should be noted that viruses, unlike bacteria, cannot be cultivated *in vitro* on artificial nutrient media. They are submicroscopic in size, have a unique morphology, relatively simple biochemical composition, physical structure, and are characterized by various manifestations of external symptoms on infected plants. In 1962, virologist Andre Lwoff described in detail and defined the role of viruses in biogeocenosis.

The question arises as to why virology, which originated in the bowels of microbiology, has made such a powerful step over the past 25–30 years? What prompted it?

■ Firstly, as the role of bacteria, protozoa and fungi in human, animal and plant infectious virology has been reduced, and many biological and chemotherapeutic drugs are already available for the prevention and treatment of these diseases, the relative mass of viruses in infectious pathology has increased significantly. For many viral diseases, science has not yet invented such drugs, and chemotherapy of viral diseases is a delicate phenomenon and is still taking its first steps.

■ Secondly, it is well known that viruses are an independent category of lower-level existence. Due to their relative simplicity, they are widely used as biological models in molecular biology, genetics, genetic engineering, biochemistry, immunology, etc.

■ Thirdly, viruses are a model system for studying many biological patterns for the benefit of humanity. The role of viruses as components of biogeocenosis is unsurpassed. The relationship of these pathogens is reflected in many areas of science - medicine, light and food industries, etc.

It was only in the 40s of the last century that it became known that almost 80% of all infectious diseases are caused by viruses, not germs, as previously thought.

The list of described viral diseases of living things is growing every day. Currently, more than 1000 plant viruses are known. And so it is in every section of virology. Unfortunately, this is a sad statistic.

As for plants, almost every plant has its own virus, which leads to significant changes in physiology and loss of inherent functions of the organism, and as a result, for agricultural crops of yields and technological quality in quite large percentages.

History and modern principles of virus nomenclature and classification

After the discovery of viruses, the only known physicochemical feature of viruses was their ability to pass through bacterial filters. In fact, it was an estimate of the size of virus virions that distinguished them from microorganisms. At that time, it was impossible to determine other properties of viruses, so research was aimed at studying the infectious process and the body's response to infection. For this reason, the first attempts at classification were based on the similarity of the pathogenic properties of the virus, for example, "hepatitis viruses" were identified, or on their organotropy, for example, "respiratory viruses". As the nature of viruses became better understood, various attempts have been made since the 1950s to classify them on the basis of different properties. A number of classifications, often mutually exclusive, have been proposed.

There are three main hypotheses about the origin of viruses:

1) from pre-cellular life forms (authors: virologists A.O. Smorodintsev, A.S. Krivitsky, 1953; V.M. Zhdanov, 1953);

2) from bacteria (authors: French microbiologist, Nobel laureate J. Nicoll, 1925; American virologist R. Green, 1935; Australian virologist and immunologist, Nobel laureate F.M. Burnett, 1943);

3) from cellular components (authors: American virologists, Nobel Laureate S. Luria and J. Darnell, 1967).

The modern classification of viruses is based on the following main criteria:

1) type of nucleic acid (DNA or RNA), its structure (number of strands);

2) the presence of an outer lipoprotein membrane;

3) strategy of the viral genome (replication mechanism);

4) size and morphology of the virion, type of symmetry, number of capsomeres;

5) forms of genetic interactions;

6) the range of susceptible hosts;

7) pathogenicity, including cytopathic changes and formation of inclusion bodies in cells;

8) geographical distribution

9) mode of transmission;

10) antigenic properties.

In 1966, the Committee on Virus Nomenclature was established. In 1973, it was renamed the International Committee on Taxonomy of Viruses ICTV (International Committee on Taxonomy of Viruses ICTV). The task of this committee is to prepare and publish works on improving the taxonomy and nomenclature of viruses. The rules set by this organization are mandatory for all scientific publications in international journals.

There have been many variants of virus classifications in general, for example, classifications by Brown, Matthews, and Baltimore. Currently, one of the newest is the classification by Frankie (1991).

Currently, more than 3,600 species of viruses of vertebrates, invertebrates, plants, fungi, protozoa, and bacteria are known. Of these, 1550 are classified into 3 orders, 56 families, 9 subfamilies, and 233 genera. Taking into account strains and serotypes, there are more than 30,000 viruses. Vertebrate viruses are included in 2 orders, 28 families, of which 10 are DNA-containing and 18 are RNA-containing, 7 subfamilies and 85 genera.

All viruses belong to the kingdom Vira. This kingdom is divided into RNA- and DNA-containing viruses. Further, viruses are divided into single- and double-stranded viruses according to the structure of the nucleic acid or the charge of the nucleic acid - negative or positive. There is also a division by morphology: filamentous, elongated, or isometric. Most viruses are known to consist of a nucleic acid and a protein capsid that covers it, but there is also a division into those with a supercapsid.

Some viruses have their genome in a single lobe (monogenomic), but there are also those that have their genome in many virus lobes (multigenomic). It is divided into two, three, or rarely four lobes.

Other characteristics in the classification of viruses include the symmetry of the helix in isometric viruses, the size of viruses, as well as other physical, chemical, and biological properties.

An **order** is a collection of families with common characteristics that differ from other orders and families. It is denoted by the name with the suffix – **virales**. Plant viruses are grouped into three orders: Caudovirales, which includes the families Myoviridae, Siphoviridae, Podoviridae; the order Mononegavirales includes Paramyxoviridae, Phabdoviridae, Bornaviridae and Filoviridae; the order Nidovirales, which includes the families Coronaviridae and Alteriviridae.

Families and subfamilies unite virus genera with common characteristics that differ from those of other families. They are designated by the suffix **viridae**. Most families differ from others in virion morphology, genome structure, or replication strategy.

Virus genera are a group of viruses that have common characteristics that are distinct from those of other genera. They are designated by the suffix **virus**.

Virus **species**. The species taxon is the most important unit in the classification system. Definition of a virus species "A virus species is a polypygous category that has a similar replication lineage and occupies a specific ecological niche. Members of this class are defined by more than one characteristic.

Phytovirologists believe that the concept of species for phytoviruses is not sufficiently perfect. Mainly because of the mechanism of reproduction – unlike many other groups of organisms.

Almost every week, the world learns about new viruses, among which phytoviruses occupy a significant place. Such viruses must be classified and assigned to a specific viral group. For some time, the viruses under study have not been classified and thoroughly studied. We should not forget about the high level of strain specificity among viruses. Often, new viruses are a separate isolate of an already known virus.

Currently, many characteristics of viruses are used for taxonomic purposes: morphology (size, shape of the virion, presence of a shell, capsid structure), physicochemical properties (molecular weight, sedimentation coefficient, solvent resistance), type of genomic NC, genome size in thousands of base pairs, number of NC strands, linearity or ringing, nucleotide sequence, G+C ratio, protein properties (number, size and functional activity of structural proteins, presence of enzymes, amino acid sequence).

Most phytoviruses have a name derived from the external symptoms of the disease they cause. Plant viruses are organized into groups, unlike other viruses. The name of the virological groups is usually derived from the first host where they were discovered. For example, the virus that causes tobacco mosaic disease is called *tobacco mosaic virus* (TMV), and the virological group of such viruses is called Tobamovirus. The virus that causes tomato bronzing is called *tomato spotted wilt virus* (Tospovirus group), etc.

The International Congress Taxonomy of Viruses (ICTV) decided to prohibit giving phytoviruses official names, but viruses are still called by different names, often in local languages, mostly in English. Such names often include the name or main plant on which it was first discovered.

Phytoviral families and groups:

Single-stranded RNA, no supercoiled, single-fragment

1) Potyvirus group – Y-virus of potato.

The size is 680 – 900 x 12 nm.

2) 2) Potexvirus group – X-virus of potato.

The size is 470 – 580 x 11 – 13 nm.

3) 3) Closterovirus group – sugar beet jaundice virus.

The size is 1100 – 2000 x 12 nm.

4) Carlavirus group – clover mottled mosaic virus.

The size is 610 – 700 x 12 – 13 nm, RNA 7.4 – 7.7 kb. (There are also groups of Capillovirus and Trichovirus, which has a huge similarity, but also a difference – in the sequence of the capsid protein).

5) Tobamovirus group – tobacco mosaic virus.

The size is the virus is 300 x 18, the virus molecule weight is 39 mDa.

6) Carmovirus group – clove mottle virus.

7) Luteovirus group – western sugar beet mosaic virus.

Isometric, 25 – 30 nm.

8) Corn chlorosis virus group.

9) Necrovirus group – tobacco necrosis virus.

10) Parsnip yellow mottle virus group.

11) Sobemovirus group – mosaic virus of cowpea.

12) Tombusvirus group – tomato bushy dwarf virus.

13) Thymovirus group – yellow mosaic virus of turnip.

Single-stranded RNA, no supercoiled, double-stranded

1) Bimovirus group – barley yellow mosaic virus.

The size of the first particle is 550 – 700 x 12 nm, the second 275 – 300 x 12 nm.

2) Furovirus group – millet golden streak virus.

The size is 65 – 390 x 18 – 24 nm in diameter.

3) Tobavirus group – tobacco rust virus.

The size of the first particle is 190 x 22, the size of the second is 100 x 22 nm.

4) Dianthovirus group – clover necrotic mosaic virus.

5) The Comovirus group is a mosaic virus of cowpea.

The diameter is 30 nm.

6) Nepovirus group – arabis mosaic virus.

The diameter is 30 nm.

7) The Fabavirus group is a virus of severe bean suppression.

The size is 30 nm.

8) A group of pea mosaic enantiomosaic viruses.

Single-stranded RNA, no supercoiled, three-fragmented

1) Chordeovirus group – barley streak virus.

The particles are 100 – 150 x 20 nm.

2) Cucumovirus group – cucumber mosaic virus.

The size is 29 nm in diameter.

3) Bromovirus group – brome mosaic virus.

The dimensions are 26 – 35 nm.

4) The Ilarvirus group is a virus of necrotic plum flammability.

The dimensions are 20 – 32 nm.

5) Alfalfa mosaic virus group.

The dimensions are 30 – 57 x 18 nm.

Single-stranded RNA, no supercapsid, four-fragmented

1) Tenuivirus group – maize stripe virus.

The dimensions are 290 – 2100 nm.

Double-stranded DNA, no supercapsid

1) Group Badnavirus – coconut stem tumor virus.

The dimensions are 30 – 100 x 300 nm.

2) Cauliflower mosaic virus group.

The dimensions are 50 nm.

Single-stranded DNA, no supercapsid

Group Geminivirus – maize streak virus.

The dimensions are 20 nm in diameter.

Double-stranded RNA, without supercoiling

1) Cryptovirus group – beet cryptovirus.

The dimensions are 50 – 75 nm.

2) Reovirus group – millet sterility virus.

The dimensions are 65 – 70 nm.

Single-stranded RNA, with a supercoiled end

1) Tospovirus group – tomato bronze virus.

The dimensions are 80 – 110 nm.

2) Rabdovirus group – maize mosaic virus.

The dimensions are 200 – 500 x 50 – 95 nm.

General characteristics and information about plant viruses

A virus is a nucleoprotein that can cause disease. It multiplies only in living cells and is so small that it cannot be seen with a light microscope.

The total number of viruses in 2015 was 6000, and new viruses are described every month. About a third of the described viruses infect plants, causing diseases. Thus, a single virus can infect one or a number of different plant species, and each species is affected by many other viruses. Another interesting fact is that a plant can be affected by several viruses at the same time.

Yes, a virus is a disease-causing agent, just like microorganisms, consisting of a nucleic acid and a protein. At the same time, the protein forms a protective outer shell - the capsid.

In a single virus, the genetic material is only one type of nucleic acid – DNA or RNA – and most phytoviruses have only one type of protein. But there are also those that have two or more different proteins.

Viruses, unlike other biological forms of existence and life, do not divide and do not form special reproductive structures, such as spores in bacteria. They reproduce themselves using the host cell and all its necessary cycles and substances.

Viruses cause diseases by eating cells or intoxicating them, using various cellular substances for their own needs – replication, etc., deplete cells, disrupting their inherent physiological functions, and negatively affecting the entire body.

Because they are so small, they cannot be as well identified and studied methodically as other pathogens. Nevertheless, cellular inclusions formed during certain viral infections, which are viral particles, can be observed in a light microscope.

Viruses are not cells and are not made up of them.

Virus morphology

Phytoviruses come in various shapes, with sizes ranging from 16 to 2200 nm. About half of viral pathogens have an elongated shape – filamentous or rod-shaped, while others are spherical (isometric or polyhedral) or bacilliform particles. The morphology of any virus can be studied only with an electron microscope. Some elongated viruses are structures averaging 15 x 300 nm. For example, rhabdoviruses are small, bacilliform, cylindrical, 3–5 times longer than wide (52–75 by 300–380 nm).

Most spherical viruses are from 17 nm across (satellite tobacco necrosis virus) to 60 nm across (wound tumor virus).

The tomato bronze virus is covered with an outer membrane and has a flexible, spherical shape of about 100 in diameter.

Biochemical structure of phytoviruses

A virus is a composition of one type of nucleic acid (DNA, RNA) and a protein (one type or more). However, some phytoviruses, such as rhabdoviruses, contain lipids, enzymes or inorganic components in their structure.

The vast majority of plant viruses have a fragmented genome, consisting of two or more nucleic acid fragments that are packaged in the same protein, but in different ways. It is also interesting to note that some isometric viruses have two or three different components of the same shape, but containing nucleic acid fragments of different lengths.

For such multicomponent viruses, all of these nucleic acid regions must be present in the plant in order for the virus to be able to reproduce in its normal way. The viral surface or capsid consists of a different number of protein components that are arranged spirally on elongated viruses and packed on the sides of spherical viruses.

Virus structure

Every phytovirus consists of at least a nucleic acid and a protein. Some viruses are composed of more than one form of nucleic acid and proteins, and some contain lipids and membrane lipids.

Nucleic acid occupies from 5 to 40% of the virus, protein – 60–95%. The smallest amount of nucleic acid is found in rod-shaped, elongated viruses, and the largest amount of nucleic acid is found in spherical viruses.

The total nucleoprotein mass of viral particles varies from 4.6 to 73 mDa, and the mass of purified NC is on average 1–3 mDa per viral particle for most viruses, but some have 6 mDa, and the 12-component nucleic acid of one virus that infects tobacco (wound tumor virus) is 16 mDa.

It is interesting to note that all nucleic acids of viruses in their native form are quite small in size because they are specifically packaged.

Structure and functions of viral proteins

Viral proteins, like all proteins, are composed of amino acids, of which there are 20 known, just like for other creatures. The sequence of amino acids in a viral protein depends on the sequence of nucleotides in the genetic material and determines the nature of the protein.

For example, the viral capsid of phytoviruses consists of repeating capsomeres. The amino acid content and sequence of capsomeres of the same virus is constant, but differs for other viruses, even for a different strain of the same virus.

It should also be noted that the amino acid composition and sequence of different viral proteins of a single viral particle will be different, not to mention other viral particles.

The composition and sequence of amino acids is already known for many viral proteins. For example, the VTM protein subunit consists of 158 amino acids with a molecular weight of 17.6 kDa.

In rhabdoviruses, the helical nucleoprotein is covered with a membrane.

In polyhedral phytoviruses, the protein subunits are carefully packed into groupings consisting of 20 or sometimes more facets, forming a capsid that covers the nucleic acid.

If we compare the number of proteins inherent in different organisms and forms of life, we find very interesting facts.

Almost all viruses encode a protein or proteins necessary for the replication of the viral genome. Some viruses also contain enzymes. One or more virus-coding proteins make up the capsid, which covers the genomic nucleic acid. However, viruses can also encode proteins with other functions, for example:

- Movement or transport – the ability of a viral virus to move from cell to cell.
- Transmission – the ability to be transmitted by invertebrate or fungal vectors.

- Protein processing – the activity of a protease that breaks down a polyprotein into functional products.

Composition and structure of viral nucleic acids

Almost all plant viruses include ribonucleic acid in their genome, but about 80 viruses include DNA.

Both nucleic acids are long, spiralized, and contain hundreds, and often thousands, of their subunits, the nucleotides. Each nucleotide consists of a ring structure called a base, a nitrogenous base that is bonded to a five-carbon sugar, ribose, in RNA, and deoxyribose in DNA, which is in turn bonded to a phosphoric acid.

The sugar residue of one nucleotide reacts with the phosphate of the second nucleotide, and this is repeated many times to form an RNA or DNA strand.

Other components of viruses

In addition to water, a plant cell contains a large number of different small-mass constituent substances. All of them are involved in such cellular processes as metabolism, synthesis of amino acids, nucleic acid bases, sugars, fatty acids, etc., which are used in the synthesis of macromolecules for the construction of cellular structures. Many cells also contain small substances that are involved in specialized cellular processes. For example, viruses contain very few such substances.

Such viruses that have a supercapsid, a capsid made of protein and lipids, contain the same proportion of water as cells – about 3 to 4 g/g dry weight. Viruses that do not have such a lipoprotein contain about 0.7–1.5 g, the same as soluble cellular proteins.

Some plant viruses contain divalent metal ions, often Ca^{2+}, in specific parts of their structure, which has a positive effect on the formation of a stable viral capsid structure.

Pathogenesis and mechanism of transmission of viral infections

Phytoviruses enter cells only through damage caused mechanically or by vectors, or through penetration of plant pollen.

In the process of viral infection of a plant, the virus moves from one cell to another, and its reproduction occurs.

Viruses are transported from cell to cell mainly through plasmodesmata - specific bridges between contacting cells.

Viruses multiply in the parenchyma of each cell they infect. Thus, in the parenchymal tissues of the leaf, the virus moves about 1 mm or 8–10 cells per day.

It is important to note how viruses utilize the systemic complexes of the plant they infect. In the case of transportation, they need to reach the phloem, which is where they spread very quickly over long distances in the plant. However, most viruses require 2-5 days to spread in the plant from the site of inoculation (leaf).

If the virus penetrates the phloem, it quickly gets into all vegetative parts (apical meristem, for example) and plant organs – tubers, rhizomes.

From the phloem, the virus spreads systemically throughout the plant and penetrates into parenchymal cells through plasmodesmata in a new way.

Further, the development of localized damage – viral symptoms – is a manifestation of the localization of the virus in a given place in the plant.

A certain number of viral diseases are characterized by further development of the infection and its spread beyond local necrotic lesions (for example, on leaves).

In systemic viral infections, some viruses are limited to the phloem and several layers of parenchymal cells.

For example, viruses that cause mosaic diseases in plants affect tissues in the form of streaks, i.e. with a diverse but structured localization. It is known that virus-infected cells are mosaic-like, containing from 100 thousand to 10 million viral particles per cell. It is also known that viral particles can infect up to 100% of plant cells. Some of them fill only certain parts of tissues, while others are virus-free. As for the apical meristems of plants, they can also be infected by some viruses, but in most cases they are virus-free.

Virus-induced symptoms on plants

Almost all plant viruses cause some form of curling, dwarfism, and other symptoms that affect the physiology of the entire plant. Viruses significantly reduce the life span of plants, although they rarely lead to plant death. Such effects are widely known and well observed.

The most common symptoms on virus-infected plants are on the leaves, but some viruses cause changes in the morphology and anatomy of the stem, fruit and roots, even sometimes independently of their manifestation on the leaves.

In almost all plant virus infections that occur in fields (agrocenoses), viruses are present in the entire plant organism, this is a systemic infection, and such symptoms are called *systemic*.

In many plants that have been artificially infected with viruses, the virus causes the development of small, chlorotic or necrotic lesions only at the sites of penetration (localized infection). Such symptoms are called *localized*.

On the other hand, it should be noted that sometimes viruses infect different plants without showing any external symptoms. Such viruses are called latent viruses, and the affected plants are called *asymptomatic* vectors.

In other cases, there are cases when plants that show external viral symptoms sometimes (under the influence of various environmental factors – temperature difference, humidity) do not show symptoms of damage at all. In this case, such symptoms are called *masked*.

Viral symptoms can often manifest themselves in different forms after the virus has entered the plant. They can progress rapidly, leading to significant metabolic disorders and rapid plant death.

The most well-known viral systemic symptoms are *mosaics and ring spotting*.

Mosaics are characterized by light green, yellow, or white stripes alternating with normal green on leaves or fruits, or simply lighter areas compared to the normal colors of flowers or fruits. Depending on the intensity or stippling of these areas, mosaic symptoms can be categorized as *stippled, annular, interveinal, or chlorotic.*

Ring spot is characterized by the appearance of chlorotic or ring-like lesions on leaves, sometimes on stems or fruits. Often with such diseases, the plant may lose these specific symptoms over time, but not the virus that causes the disease.

Other viral symptoms can be characterized very broadly. These include dwarfism, yellowing, enation, tumors, and stem drying. Such symptoms can occur at the same time in combination with other symptoms on different plant organs (leaves, stems, roots).

Transmission of phytoviruses

Phytoviruses are transmitted from one plant to another in many ways – vegetatively, mechanically through plant sap, seeds, mistletoe, sucking insects and mites, nematodes, fungi, etc.

Vegetative transmission

In any of the variants of vegetative propagation of agricultural and other crops widely used in the national economy, namely, propagation by budding, cuttings or cuts, or in the variant of using tubers, bulbs, rhizomes, it should be said that in the case of primary infection of these mother plant forms, the presence of the virus in subsequent generations will be observed 100 percent.

Noting the fact of infection during vegetative propagation, it should be noted that this way of propagation (e.g., potatoes – tubers) is widespread in farms, and it is important to be aware that this way does not guarantee the production of high-quality plants. Even when using a growth point or apical meristem from a virus-infected plant for further propagation, it may not be effective enough to obtain virus-free plants.

Virus transmission can also occur through root contacts between different plants, especially among trees. For some tree viruses, this is the only pathway that has been described to date.

Mechanical virus transmission through juice

The mechanical transmission of phytoviruses in natural conditions by direct contact through sap from one plant to another is not very common and not very relevant. Such transmission of viruses can be observed when exposed to strong winds, when there is severe damage to plants and their organs. In this case, we can talk about virus transmission through direct contact between infected and healthy plants. It should also be noted that viruses can be transmitted through garden tools (shovels, rakes, cultivators), by hands when animals feed, when the juice gets on healthy plants, thereby affecting them.

Viruses such as potato X virus, tobacco mosaic virus (TMV), and cucumber mosaic virus (CMV) are transmitted through plant sap in the fields and cause large yield losses.

Mechanical transmission is of great importance when studying viruses under artificial infection.

Virus transmission through seeds

More than 100 phytoviruses are transmitted through seeds. And only a small number (1-30%) of plant seeds are capable of carrying the virus. Seed infection is highly dependent on the infection of the plant at a certain stage of ontogeny. Seeds are most affected when the plant was infected at the time of ovule formation, but there are cases when the same occurs at the stage of seed formation and flower formation or at the flowering stage.

Pollen transmission

The virus infects plant pollen. This results in the infection of the seed and the subsequent plant germinating from it. Such a transmission route is known, for example, for necrotic spot virus in cherries.

Insect transmission

This type of virus transmission is undoubtedly one of the most common for agrocenoses. Some groups of insects are capable of transmitting viruses.

The Homoptera group includes aphids (Aphididae), leafhoppers (Cicadellidae) and other major representatives of virus vectors. Other representatives of this group should also be noted - whiteflies (Aleurodidae), which usually transmit geminiviruses, worms (scale insects) (Coccoidae) and representatives of Membracidae.

A certain number of vectors belong to another group – Hemiptera, Thysanoptera, Coleoptera. Interestingly, even grasshoppers are capable of transmitting some viruses.

The most strategic vectors of viruses are, first of all, aphids, leafhoppers, whiteflies and thrips. They should also be distinguished by the structure of their mouthparts. There are insect vectors with chewing and sucking mouthparts.

Insects with sucking mouthparts carry viruses in their stylet – *stylet-borne viruses* – and are able to transmit the virus for a short period of time during feeding, from a few seconds to several minutes. The viruses can remain in the vector for several hours. They are also known as *non-persistent viruses*.

In the case of other viruses, sometimes an insect has to accumulate a certain sufficient amount of virus in itself to transmit it further (minutes, hours, days). Such insects that have accumulated the virus are able to transmit it for several minutes or hours. Such viruses that persist in the vector for 1–4 days are called *semi-permanent.*

There are viruses that, after the insect transfers it to another plant, recirculate back to the mouthparts and can remain for a long time. Such viruses are called *circulating or persistent.* Some viruses are able to reproduce directly in the vector – these are *virulent* viruses

Viruses transmitted by insects with chewing mouthparts (Coleoptera, beetles) can also circulate on the mouthparts.

Aphids carry the largest number of stiletto viruses (more than 250). Sometimes one aphid can carry several viruses at the same time.

More than 50 phytoviruses are transmitted by leafhoppers, including complex viruses from the Rabdovirus and Heminivirus groups. Such insects mainly penetrate the vascular systems of the phloem with their mouthparts, transmitting viruses. All these viruses are circulating.

Transmission by mites

Scientific studies have shown that only one family of mites – Eriophyidae – transmits at least 6 viruses, including wheat streak mosaic virus and some others that affect cereal crops. These ticks have a specific mouthparts – spiny-sucking.

Tick-borne transmission of phytoviruses is very specific and sometimes ticks are the only carrier of a particular virus.

Transmission by nematodes

Currently, 20 phytoviruses are known to be transmitted by a single species of three generations of soil-dwelling, ectoparasitic nematodes.

Nematodes of different generations – *Longidorus, Paralongidorus, Xiphinema* – transmit several polyhedral phytoviruses known as the Nepovirus group. These include grape leaf curl virus, tobacco ringspot virus and some other viruses.

Nematodes transmit viruses from an infected plant to a healthy one by eating the roots.

Transmission by fungi

Fungal organisms such as *Olpidium, Polymyxa, and Spongospora* are known to transmit about 15 phytoviruses. Some of the viruses are transmitted internally (internally), and some are transmitted externally (externally) through spores or zoospores of fungi. When a virus is transmitted by fungi to healthy plants, symptoms characteristic of the virus they carry are observed.

Transmission by mistletoe

Some phytoviruses are transmitted from one plant to another by the formation of bridges by a parasitic plant *Cuscuta sp.*

BIODIVERSITY AND ECOLOGY OF BLUE-GREEN AND GREEN ALGAE

Algae represent an ecological group of organisms united by their aquatic lifestyle, oxygenic photosynthesis, undifferentiated body into multicellular organs, and a number of other features. In systematic terms, they are divided into numerous divisions that differ in cell structure and pigment set. In the general taxonomy of the organic world, algae belong to different kingdoms

The great diversity of the algae's external shape correlates with several types of morphological differentiation of thalli belonging to different systematic groups.

Algae are characterized by the following structures:

amoeboid – cells lack a hard shell, do not have flagella and move by pseudopodia;

coccoid – immobile cells, separate or combined into colonies of various shapes;

monadic – characterized by active mobility of unicellular and colonial representatives with the help of flagella in the vegetative state. Peculiar organelles characteristic of monadic cells are contractile vacuoles and ocelli;

filamentous (trichal) – simple or branched filaments;

palmyloid – several cells are united by common mucus but are interconnected;

lamellar – a plate consisting of cells that form one or more layers. When cells divide in three planes, parenchymal structures are formed;

multifilamentous (heterotrichous) – characterized by two systems of filaments: creeping on the substrate, which perform the function of attachment and vertical, which perform the assimilation function;

pseudoparenchymatous – occurs in algae that form large volumetric creepers as a result of filament growth;

s**iphonal** – unicellular algae with a bulky protoplast and a large number of nuclei;

siphoning – occurs in algae capable of forming complex slates from the primary siphonal thallus, consisting of primary multinucleated segments;

tissue (parenchymatous) – characterized by the fact that cells are able to divide in three mutually perpendicular directions, resulting in the formation of volumetric slates with tissues that perform different functions.

Algae are characterized by vegetative, sporeless, and stomatous reproduction.

In some unicellular algae (*Euglena*), vegetative reproduction occurs by dividing the cell in half, in some colonial representatives – by sections of colonies (*Microcystis*), in filamentous algae – by fragments of filaments (*Ulothrix, Spirogyra*).

The brown algae of the order Sphacelariales have specialized branchlets. In green algae of the order Charales, nodules on rhizoids are used for vegetative reproduction.

Asexual reproduction in algae is carried out with the help of motile (zoospores) and immobile (aplanospores) spores. The cells in which spores of asexual reproduction are formed are called sporangia, and the individual on which the sporangia are formed is called a sporophyte.

During sexual reproduction in algae, a diploid zygote appears as a result of pairwise fusion of haploid cells. The sexual process in algae can occur with or without the participation of gametes. The types of sexual process involving gametes in algae are as follows: isogamy – fusion of motile gametes of the same size and shape; heterogamy – fusion of motile gametes of the same shape but different sizes; oogamy – fusion of a large, immobile female gamete of an egg with small, motile sperm.

The cells in which iso- and heterogametes are formed are called gametangia, and the individual on which they are formed is called a gametophyte. The cell in which sperm are formed is called antheridium, and the cell containing the egg (one or more) is called oogonia. The types of sexual reproduction in algae without gamete formation are as follows: cholagamy – fusion of two motile unicellular individuals; conjugation – fusion of protoplasts of two haploid vegetative cells to form a diploid zygote.

Blue-green algae are unicellular, colonial, and multicellular organisms with a prokaryotic cell structure and oxygenic photosynthesis.

The cell is surrounded by a wall, the structural component of which is peptidoglycan (murein). The membrane often becomes mucous. The protoplast lacks a formed nucleus, chloroplasts, mitochondria, Golgi apparatus, endoplasmic reticulum, vacuole with cell sap, and a number of other organelles. It is divided into a peripheral colored part, the chromatoplasm, and a central non-colored part, the centriole.

In many representatives, it is impossible to establish a clear boundary between chromatoplasm and centroplasm. The chromatoplasm contains thylakoids, which contain pigments: chlorophylls a, b (in prochlorophytes), carotenoids and phycobiliproteins (blue allophycocyanin and phycocyanin, red phycoerythrin). The different ratio of pigments causes the color of blue-green algae to vary from blue-green to yellow and even reddish.

DNA is located in the cytoplasm, but unlike eukaryotes, it is not limited to the nuclear envelope. Storage substances are represented by cyanophycin starch, cyanophycin granules, and polyhedral bodies. The cells of many blue-green algae contain pseudo-vaults – gas vacuoles whose membrane consists only of protein.

Sexual reproduction is not known for blue-greens (*Cyanophyta*). Many filamentous forms are characterized by heterocysts, special light-colored cells with thick membranes and clogged pores. Algae reproduce vegetatively. In filamentous forms, reproduction is by hormonogonia – short sections of several cells, which often break off from the mother filament along the heterocysts.

In green algae, the cell usually has a rigid wall. Most of them are cellulose, but many have a different composition, such as peptidoglucan. Chloroplasts are found in different numbers (from one to many per cell) and have different shapes. This coloration is due to chlorophylls a and b, which prevail over carotenoids: α- and β-carotene, lutein, neoxanthin, violaxanthin, zeaxanthin, and antheraxanthin. The pyrenoid is immersed in the chloroplast stroma and permeated by thylakoids. The reserve product is most often starch. It is deposited inside the chloroplast – around the pyrenoid and in the stroma.

In most species, a large part of the cell is occupied by a large vacuole with cell sap. In motile cells, there are most often 2 flagella, less often 1, 4, or many (up to 120). In all cases, they are of the same size and structure. Three-filament mastigonemes are not found in flagellates. Vegetative reproduction usually occurs by the division of individual cells, by fragmentation of colonies, or by breaking filaments. Asexual (spore) reproduction usually occurs by motile zoospores, in some species by immobile aplanospores. The sexual process is isogamy, heterogamy, oogamy (most often), and conjugation. Primitive forms may have cholagamy – fusion of whole vegetative individuals as gametes.

Anabaena and *Nostoc* are blue-green algae that perform an important function of water purification in natural reservoirs. They are widely used in biotanks for wastewater treatment.

Chlorella is a green algae belonging to the order Chlorococcales. It includes up to 100 genera and 700 species. It has high photosynthetic activity (up to 10%). It produces organic substances and the antibiotic chlorellin. Causes water blooms. It reproduces by autospores, which are formed by sequential cell division. Sexual reproduction is rarely found in bivalve gametes.

Spirogyra is an algae from the order Zygnematales. It is characterized by a special sexual process – pellet conjugation.

FUNGAL BIODIVERSITY, MORPHOLOGY AND ECOLOGY

Fungi are a vast group of organisms that includes 100 thousand species.

Fungi differ from animal organisms in having a well-defined cell wall, immobility at the vegetative stage of the life cycle, unlimited growth, osmotrophic (sucking) type of nutrition, and reproduction through various types of spores. Fungi differ from plants in the presence of chitin, chitosan, and glucan in the cell wall matrix, and in the absence of photosynthetic pigments; their reserve foods are glycogen and volutin, not starch, as in plants.

In the vast majority of fungi, the vegetative body is the mycelium (mycelium), formed by a system of branched hyphae that densely penetrate the substrate. Mycelial hyphae actively colonize the substrate and come into close contact with it. In some fungi, the vegetative body (thallus) is represented by single cells that bud or divide.

Non-cellular mycelium is one huge, highly branched cell with many nuclei. The cellular mycelium is formed by thin, colorless hyphae divided by transverse septa into separate cells (Fig. 16).

Fungi are heterotrophs by the way they feed. They get organic matter from other organisms. Saprotrophs, symbionts, and parasites are distinguished by the way they feed. The latter are divided into obligate and facultative. There are also necrotrophs, balanced and destructive biotrophs.

Among them are xylotrophs (wood-destroying) – false tinder fungus, autumn mushroom and root sponge, oyster mushroom.

Soil saprotrophs are a numerous group: forest soil saprotrophs – wrinkle, rain, star, rainbow, and row. Their habitat is leaf litter and litter. The second group includes soil saprotrophic mushrooms of open spaces – agaric mushrooms: common champignon, umbrella mushrooms, etc.

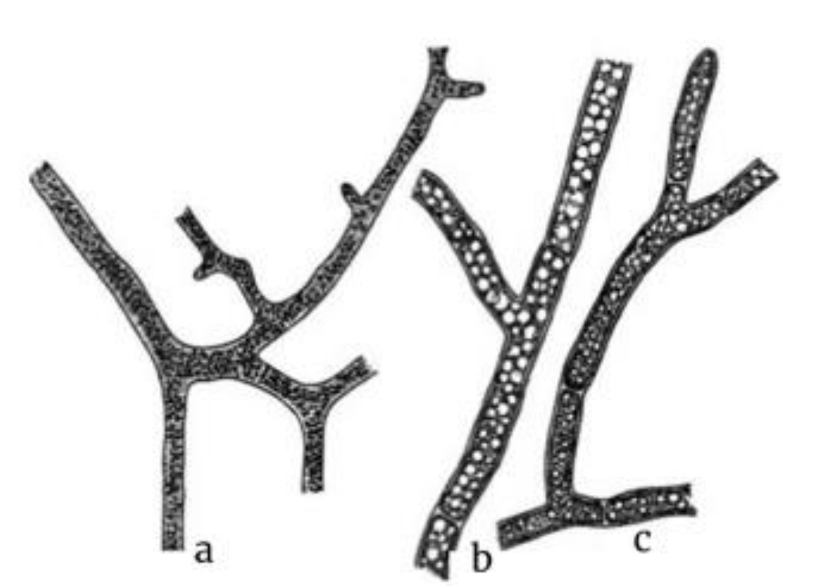

Fig. 16 **Fungal mycelium**

A – part of non-cellular mycelium, B, C – cellular mycelium

Fungi reproduce vegetatively, asexually, and sexually. Vegetative reproduction occurs by fragments of mycelium, which, when placed on a new suitable substrate, give rise to new mycelium.

Asexual reproduction can be carried out by motile zoospores or immobile sporangiospores, as well as conidia. Zoospores and sporangiospores are formed endogenously, i.e. inside the mother cell – sporangia, and conidia are formed exogenously – on the top or side of specialized mycelial hyphae, the so-called conidiogenes.

During sexual reproduction in fungi, as in other organisms, two germ cells (plasmogamy) and their nuclei (karyogamy) fuse. In this case, these two processes can be separated in time and space: the respective nuclei may not fuse at first, but coordinate in pairs, then synchronously divide; a pair of such non-sister nuclei is called a dicarion. As a result of the sexual process, primitive representatives form dormant spores – zygotes, and more developed ones form special sexual meiospora. In marsupial fungi, endogenous ascospores are formed, and in basidiomycetes, exogenous basidiospores are formed.

Methods of sexual reproduction: gametogamy – oogamy, heterogamy, zygogamy, somatogamy; gametangiogamy (ascomycetes).

Based on the type of sexual process, the main classes are distinguished:

Chytridiomycetes – mycelium is poorly developed or absent. Zoospores and gametes with one flagellum;

Hyphochytridiomycetes – mycelium is poorly developed or absent. Zoospores and gametes with one anterior pinnate flagellum;

Oomycetes – mycelium is developed, non-cellular. Zoospores with two flagella – pinnate and batiform. The sexual process is oogamy;

Zygomycetes are non-cellular mycelium. Zoospores were not found. Asexual reproduction by sporangiospores. Sexual process is zygogamy;

Ascomycetes are well-developed, cellular mycelium. There are no mobile stages. Asexual reproduction by conidia. The sexual process is gametangiogamy. Spores are formed endogenously, in bags (asci);

Basidiomycetes – well-developed, cellular mycelium. There are no mobile stages. Asexual reproduction by conidia. The sexual process is somatogamy. Spores are formed exogenously, on the base;

Deuteromycetes have well-developed, cellular mycelium. Reproduction is only asexual, by conidia. The group is at the stage of formation.

Fungi are divided into micro- and macro-mycetes by size.

LICHEN BIODIVERSITY

Lichens represent a peculiar group of symbiotic organisms formed by an autotrophic phycobiont (algae) and a heterotrophic mycobiont (fungi). Both components make up a single symbiotic organism that differs morphologically, anatomically, and physiologically and biochemically from free-living fungi and algae. In the vast majority of lichens, the mycobionts belong to ascomycetes (discomycetes and perithecal fungi). In a small number of species, mycobionts belong to basidiomycetes. Lichen mycobionts are species-specific. Algae of one species can be the phycobiont of different lichen species. Lichen phycobionts mainly belong to green algae, to a lesser extent to cyanobacteria and very rarely to yellow-green algae. Among green algae, coccoid forms are more common, and there may also be representatives of genera with multicellular thalli.

Lichens are symbiotic organisms; unlike mosses, they do not have a characteristic green color, and their vegetative body is undifferentiated into organs – leaves, stem, and root. The lichen thallus (lichenicolous tissue) is quite diverse in appearance. There are three main morphological types of thallus: scaling (corky), leafy, and bushy, but there are also transitional forms (Fig. 17).

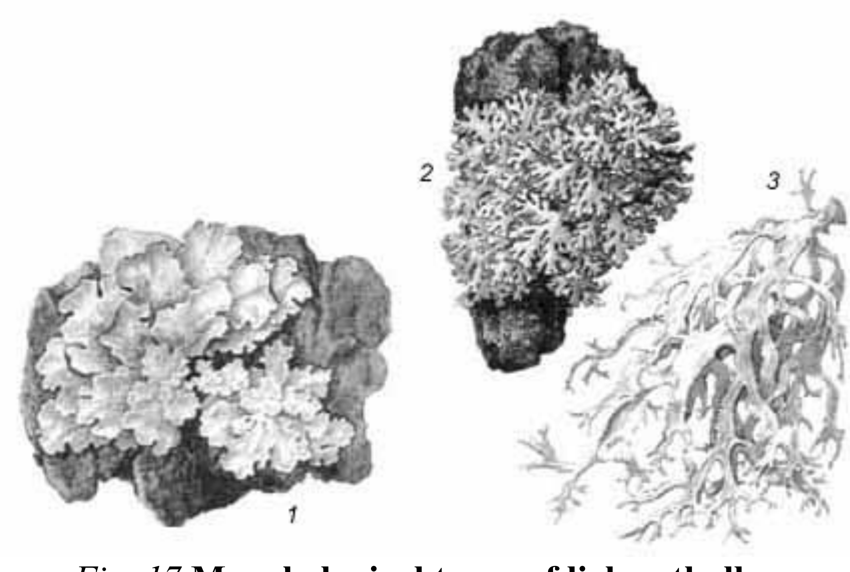

Fig. 17 **Morphological types of lichen thallus**

1 – crustose lichen, 2 – foliose lichen, 3 – fruticose lichen

According to the anatomical structure, lichen thallus is divided into two types: homeomeric – with a uniform distribution of mycobionts and phycobionts in the thickness of the thallus and heteromeric, in which separate layers are distinguished, which are clearly visible in transverse sections (Fig. 18): the upper cortex, represented by mycobiont hyphae, below it a layer of phycobiont – the algal zone or gonidial layer (mainly green algae), then a layer of mycobiont – the core or cuticle, and below it the lower cortex, which is also represented by mycobiont hyphae (in some species it is absent).

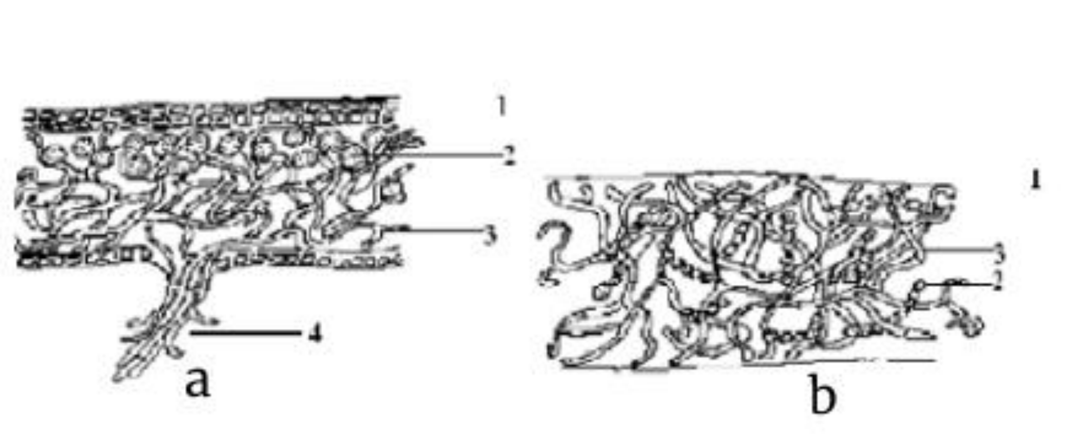

Fig. 18 **Anatomical structure of lichen thallus**

A – *Heteromeric thallus: 1 – upper cortical layer, 2 – algal layer, 3 – core layer, 4 – hyphae.*
B – *Homeomeric thallus: 1 – cortical layer, 2 – phycobiont layer, 3 – fungal hyphae*

Lichens have different ways of reproduction. The most effective is vegetative reproduction, which is carried out by parts of thalli (fragmentation) and with the help of special structures – soredia and isidia. Soredia are algal cells wrapped in fungal hyphae. They develop in large numbers under the upper bark. Under the pressure of the mass of soredia, in places of their accumulation, the bark breaks and the soredia come to the surface of the thallus. Asexual reproduction occurs with the help of niknoconidia, stylospora, and less often conidia; sexual reproduction with the formation of spores in bags (ascospores) or on basidia (basidiospores).

BIODIVERSITY OF MOSSES AND FERNS

The bryophytes (Bryophyta) (about 25 thousand species) belong to the higher spore plants, which are characterized by the division of the body into organs. They are known from the Carboniferous period. Mosses are found everywhere (except for deserts), but mainly in temperate and cold climates.

Bryophytes, or mosses, are the most primitive of the higher land plants. Their cells are differentiated. They combine to form specialized tissues. The body is either slate (anthocerotids, some liverworts) or divided into stem and leaves. In the center of the stem, in the form of bundles, there is a conducting system through which solutions of mineral salts and organic substances pass.

Leaves are represented by linear-lanceolate green blades consisting of several layers of cells. They contain special cells – assimilators. There is no real root system. The function of the roots is performed by colorless transparent outgrowths of the epidermis - rhizoids located in the lower part of the stem

Bryophytes reproduce asexually (by spores), sexually and vegetatively. They are characterized by the alternation of sexual and asexual generations.

The life cycle is dominated by the haploid gametophyte (Fig. 19). The gametophyte of mosses can be monoecious or dioecious and bears female genitalia - archegonia and male genitalia - antheridia. A prerequisite for fertilization is the presence of water. After fertilization, a sporophyte is formed, which looks like a box, where a sporangium develops on the leg, connecting it to the gametophyte. After maturation, the spores fall out and germinate into the gametophyte, the protoneme, which resembles a filamentous green algae. The cells of the protonema give rise to the gametophyte.

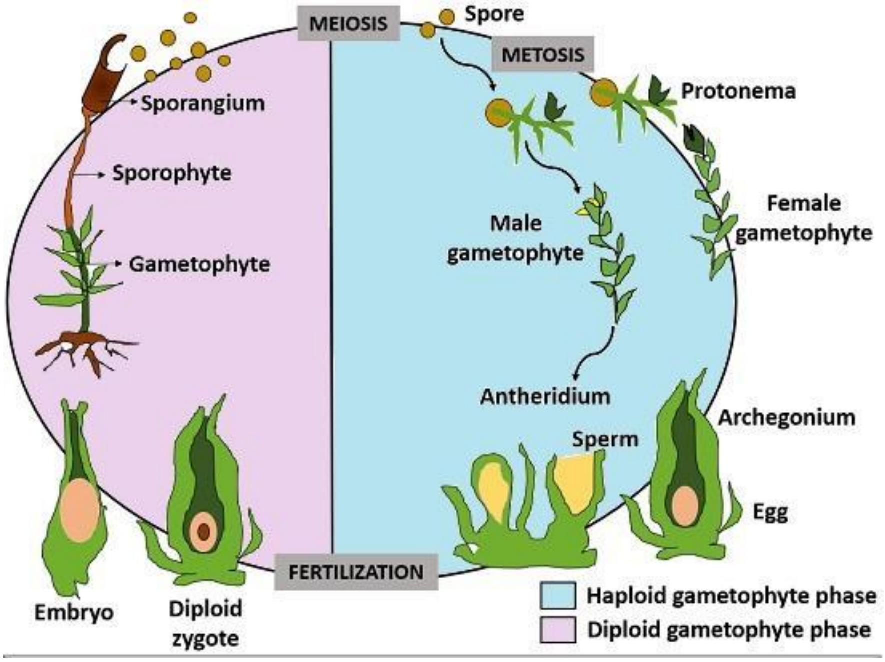

Fig 19 **Reproduction cycle of bryophytes**

Ferns (Polypodiophyta) – a phylum of vascular plants that occupy an intermediate position between rhyniophytes and gymnosperms. The main difference between ferns and rhyniophytes is the presence of leaves and a root system, and the absence of seeds.

The Phylum Ferns includes one class Polypodiopsida, which is divided into 8 subclasses, three of which became extinct in the Devonian. There are 300 known genera of ferns, uniting about 10,000 species. This is the largest group of spore plants. Ferns are widespread due to their ecological plasticity. The greatest diversity of ferns is found in the humid regions of the tropical and subtropical zones. Some species are xerophytes or hygrophytes (salvinia, azolla).

Ferns differ in size, life forms, and cycles. A sporophyte consists of leaf blades, a petiole, a modified shoot, and a root system that includes a vegetative and adventitious root. Ferns do not have true leaves. They are a system of branches lying in the same plane. The botanical name for this is a flat branch, or vaya, or pre-branch. On the underside of the fern leaves are the saplings (Fig. 20).

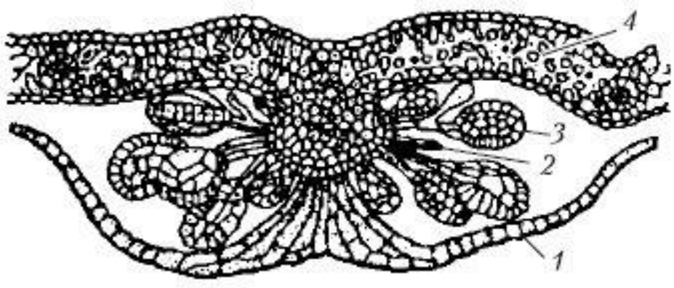

Fig. 20 **The structure of the saurus**

1 – indusium, 2 – placenta, 3 – sporangium, 4 – vaya

Ferns reproduce by spores and vegetatively (rhizomes, flat branches, buds).

The life cycle of a fern (Fig. 21) is divided into two phases: sporophyte (asexual generation) and gametophyte (sexual generation), the sporophyte phase being longer.

There are sporangia on the lower surface of the vayas. The spores germinate as a nodule with gametes. After fertilization, a young sporophyte is formed. In unisexual ferns, gametophytes are bisexual. In dicotyledonous ferns, the male gametophyte is highly reduced, while the female gametophyte is well developed and contains nutrients for the development of the sporophyte embryo.

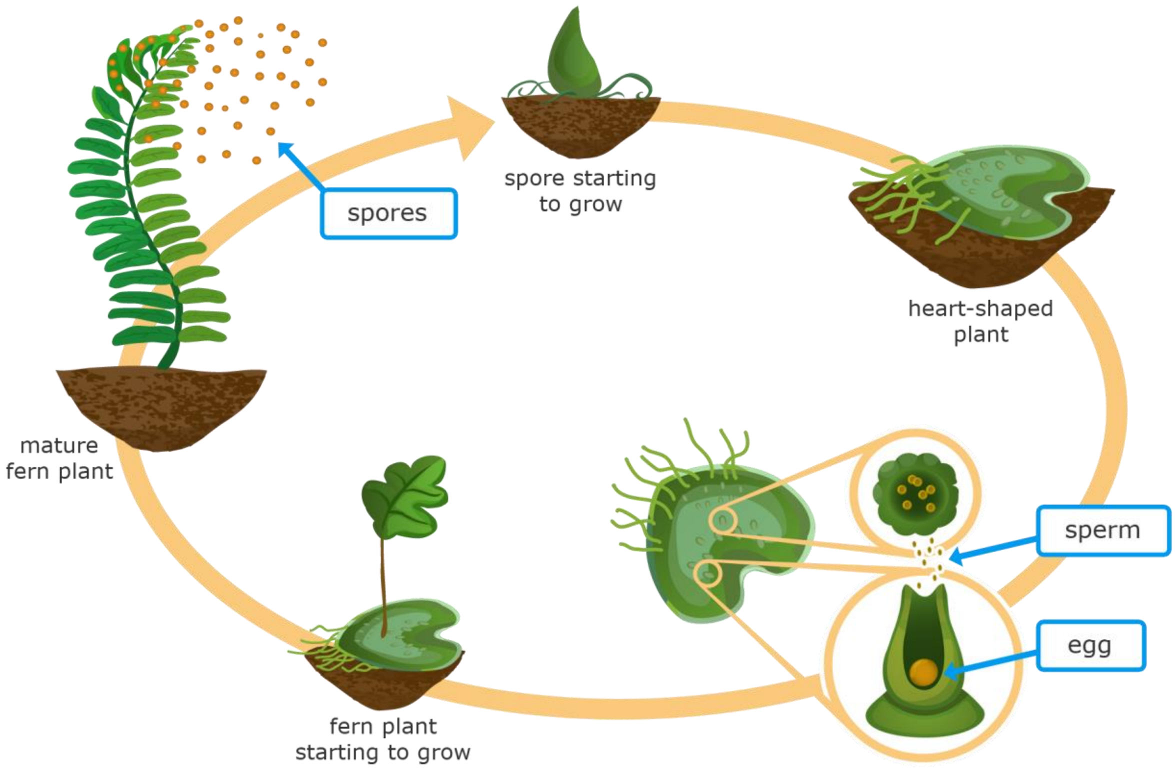

Fig. 21 **The life cycle of ferns**

MEASURES TO PRESERVE BIODIVERSITY

The best strategy for the long-term protection of biodiversity is to preserve natural communities and populations in the wild, i.e. in situ conservation. Only in the wild are species able to continue the process of evolutionary adaptation to a changing environment within their natural communities. However, for many rare species, in situ conservation does not save them from increasing anthropogenic disturbances. In such circumstances, the only way to prevent species extinction is to maintain the species in artificial conditions under human supervision. This strategy is called ex situ. There are already a number of animals that have become extinct in the wild but have survived in captivity, such as the Davidian deer (Elaphurus davidianus). The Franklin mahogany tree grows only in nurseries and is no longer found in the wild.

The long-term goal of many ex situ conservation programs is to establish new populations in the wild, if there are sufficiently large numbers of individuals and suitable habitat. Ex situ conservation of animals is carried out in zoos, special farms, and aquariums. Plants are preserved in botanical gardens, arboretums and seed banks.

Zoos have made considerable efforts to develop technologies for breeding populations of rare and endangered species, such as snow leopards and orangutans, as well as to develop new methods and programs for reintroducing species into the wild.

Currently, aquariums contain approximately 600 thousand fish caught in the wild. The main efforts today are aimed at developing technologies for breeding and keeping rare fish species in aquariums in order to release them into their natural habitats or reduce the need to catch wild species. The role of aquariums in the conservation of endangered cetaceans is especially important. Aquarium staff often respond to requests from the public to help whales that have been stranded or lost their bearings in shallow waters.

The world's 1,600 botanical gardens house the largest collections of plants, which are the main resource for implementing plant conservation measures. Today, botanical gardens around the world are home to 4 million plants representing 80 thousand species, or approximately 30% of the world's flora. The world's largest botanical garden, the Royal Botanic Gardens (England), cultivates 25 thousand species of plants, which is about 10% of all species in the world, 2700 of which are endangered. In California, a specialized pine arboretum grows 72 out of 110 pine species in the world, and the largest botanical garden in South Africa cultivates 25% of the plant species growing in the country. In addition, botanical gardens are important for public outreach in the field of nature conservation, as they are visited by about 150 million people every year.

There are also genetic seed banks that contain seeds from wild and cultivated plants. In such banks, seeds of most plant species can be stored for a long time in dry, cold conditions, maintaining germination. The ability of seeds to remain dormant at low temperatures is extremely important for *ex situ* species conservation, as it allows for the storage of a large number of rare species in a small space with minimal maintenance and at low financial cost. There are about 50 genetic seed banks in the world. Although seed banks have great potential for preserving rare and endangered species, they also face certain difficulties. If equipment breaks down or the power supply drops, the entire frozen collection can be ruined. Even when stored cold, seeds gradually lose their germination capacity due to the depletion of energy reserves and the accumulation of harmful mutations. To overcome this gradual deterioration of seed quality, it is necessary to periodically germinate seed lots, bring adult plants to a mature state and collect new seed samples from them for storage. For seed banks with large collections, this testing and updating of seed samples can be a difficult task.

Seed banks are recognized as an effective way to preserve the genetic diversity of crops. Often, genes responsible for resistance to a particular disease or pest are found in only one variety of a crop, so-called local varieties, which grow only in a certain area of the world. This genetic variability is often extremely important for agriculture to maintain and increase crop yields and their ability to withstand changing environmental conditions, such as acid rain, droughts and soil salinity.

Protecting habitats containing intact biological communities is the most effective way to conserve biodiversity. One might even argue that this is the only way to conserve species, because the resources and knowledge we have are only sufficient to save a small fraction of the world's flora and fauna in captivity.

There are four ways to preserve biological communities: the organization of protected areas, effective management of these areas, conservation outside protected areas, and restoration of biological communities in destroyed habitats.

Biological communities vary greatly in the degree of damage caused by human activity. Very few communities are unaltered, and can be found on the ocean floor or in remote parts of the Amazon rainforest. Communities heavily disturbed by human activity are found in agricultural areas, cities, and artificial reservoirs.

When organizing a nature reserve, it is important to find a reasonable compromise between the requirements for protecting biodiversity and the normal functioning of ecosystems and solving medium- and long-term tasks of providing resources to the local population.

The International Union for Conservation of Nature has developed a classification for protected areas that reflects the full range of intensity of human use of the areas:

I. Nature reserves preserve species and natural processes in an intact state. These areas provide representative samples of biological diversity;

II. National parks are large areas of scenic and rich natural beauty that are designated to protect one or more ecosystems for scientific and educational purposes, as well as for recreation. These areas are usually not used for commercial exploitation of resources;

III. National natural reserves are somewhat smaller and are intended to preserve unique biological, geological and cultural sites of special interest;

IV. Managed nature reserves are similar to protected areas, but some human activity is allowed in them. The latter may include the removal of exotic species, which is sometimes necessary to maintain community characteristics. Harvesting is sometimes allowed within certain limits;

V. Protected landscapes and sea views allow local people to use the environment in a traditional way without destroying it, especially in places that have specific cultural, aesthetic and ecological characteristics. These areas may include fishing villages, orchards and pastures. These places provide a special opportunity for tourism and recreation;

VI. Protected areas with controlled use of resources, including water, wildlife, grazing, logging, tourism and fishing in a manner that guarantees the conservation of biological diversity. These areas are often large and allow for both modern and traditional use of natural resources.

Of these categories, only the first five can be considered truly protected areas, as habitat management is carried out exclusively from the perspective of biodiversity conservation.

Ecologocal principles of biodiversity conservation

The species richness of both animals and plants is rapidly decreasing as a result of negative processes occurring in the environment and human activity itself. To live and survive in nature, man has learned to use the useful properties of the components of biodiversity to obtain food, raw materials for the manufacture of clothing, work tools, housing construction, and energy sources. Anthropogenic activity, primarily associated with agriculture, mining, the expansion of settlements, and the transport and communication sphere, leads to the transformation and degradation of ecosystems and their components, the fragmentation and reduction of areas occupied by natural complexes, the appearance of desertification, dehumidification, strengthening of erosion processes. Reduction of areas occupied by natural ecosystems, loss of primary plant groups and faunal complexes, changes in the structural and functional characteristics of ecosystems, landscapes, and biomes and is connected, ultimately, with the loss of biotic and landscape diversity, "natural capital", "eco fund".

Biodiversity loss is one of those global problems of our time, the solution of which cannot be postponed. Biodiversity is not only the foundation of a significant part of natural resources that provide people with food, various raw materials, medical drugs, etc., but it is also intrinsically valuable regardless of the material value determined by socio-economic relations. Such self-worth is embedded in the very evolutionary history of living things and the unique ecological functions performed by each of the species in the global ecosystem.

The highest threat to biodiversity is primarily associated with the risk of extinction of rare species. The decline in biodiversity is caused by several reasons. The most important of them.

1. *The loss of the habitat* is caused by the results of human intervention in the habitat on a global scale. Analysis of statistical materials testifies to the significant impact of human activity on world ecosystems.

Untouched areas: characterized by the largest amount of primary vegetation, and very low population density.

Partially disturbed areas: characterized by a change in the structure under the influence of extensive agriculture; the presence of naturally regenerating secondary vegetation (secondary succession); increased density of domestic animals; other signs of human intervention.

Areas and dense human settlements are characterized by the presence of permanent agriculture or a high level of urbanization; primary vegetation is removed; current vegetation differs from potential vegetation; high levels of desertification or other permanent degradation.

2. *Distribution of an exotic variety*. Sometimes this happens by accident, as happened with noxious weeds and pests. But in most cases, it's the other way around. For example, foxes, rabbits, and cats arrived in Australia from Europe and replaced local species. The use of exotic fish for sport or food purposes has caused the disappearance of 18 species of fish in North American rivers.

3. *Illegal hunting and systematic cutting* of forests for energy or charcoal production are also causes of biodiversity loss. The use of medicinal plants can to some extent illustrate this statement.

4. *Cases of "interdependent" effects are less studied.* A species that co-evolves with another (for example, plants that spread with the help of special insect pollinators) will die out if the other species of the pair is threatened with extinction.

When the last homing pigeon died in the early 1990s, two of its parasites – varieties of lice – disappeared.

5. *Pollution and global environmental* change also threaten global biodiversity.

All these reasons have one thing in common – they are caused by human activity. This makes human activity one of the most serious causes of the current deterioration of biodiversity. Therefore, many aspects of human impact on biodiversity, together with the direct causes of its deterioration, are important for determining priorities and countering existing negative trends.

6. *Population growth (anthropogenic factor).* The relationship between the loss of biodiversity and the number of the population, its growth rates, and density is quite complex. Population growth affects the growth of resource consumption and their degradation, and the expansion and intensification of land use cause the growth of poverty and the disruption of traditional systems of nature management. At the local level, population growth is often the result of urbanization, resettlement, and migration. Local population growth also directly affects resource use and degradation, often leading to habitat transformation in areas important for biodiversity conservation.

7. *Structure of production and excessive consumption*. An increase in the production and consumption of energy leads to the transformation of the habitat and excessive use of ecosystems. Reducing resource and energy consumption at various levels will reduce pollution and resource extraction that degrade biodiversity. There is a correlation between the decrease in biodiversity and the level of environmental culture, education, and well-being of the population.

Nature is an interdependent hierarchy of ecosystems. Preservation of biological diversity is inextricably linked to the preservation of landscape diversity (diversity of biotopes, econiches, and trophic chains). The creation of protected areas, natural and biosphere reserves, national natural parks, and forest plantations (forest reclamation) is among the most effective biodiversity conservation measures. These measures provide the conditions necessary to reduce the harmful anthropogenic impact on biological objects, and contribute to the preservation of the integrity of ecological systems, in which the natural mechanisms of relations between biological species, which are necessary for the existence of the system, can be maintained.

Today, it is generally accepted that forests play a decisive role in maintaining the stability of the biosphere due to the preservation of biodiversity and the global impact on the planet's climate. Forests play an important role at the regional and local levels – as key elements of landscapes that ensure their stability and as sources of biodiversity. In addition, the forest landscape is a defining element in the concept of preservation and development of biodiversity.

The nature reserve network of Ukraine includes 6,939 such territories and objects, which make up more than 4% of the country's area. Four biosphere and 16 nature reserves, 12 national natural parks belong to the higher categories of bequests. 2,507 nature reserves, 3,016 natural monuments, 35 dendrological parks, 527 parks-monuments of horticultural art, 22 botanical gardens, 12 zoological parks, 35 regional landscape parks, and 754 protected tracts correspond to the status of natural national property. It should be noted that, unlike the national one, in the international classification, the functions of national and natural parks are demarcated. Nature parks are primarily created for recreation, i.e. rest. The main task of national parks is the preservation of natural diversity, while recreation and tourism have a subordinate and limited role.

Forest plantations are one of the main types of vegetation, which consist of a combination of woody plants, shrubs, herbaceous plants, mosses, and lichens, including animals and microorganisms that are biologically related in their development and influence each other and the environment. Forests are one of the leading components of the living shell. They have a positive effect on many other components of natural complexes, and ensure their preservation as a whole. The stability of natural territorial complexes and the nature and intensity of the processes occurring in them mostly depends on the state of forest plantations. All this determines the enormous environmental protection role of forest plantations.

Forest strips are strip forest plantations of artificial origin (forest crops), which are located in flat conditions and on slopes, on agricultural lands along the borders of fields to increase the yield of crops to improve the microclimate in adjacent fields, snow retention, combating deflation, and preservation and improvement soil fertility. They also play a major environmental role.

Field forest strips are a kind of "oases" for many groups and species of biota in agricultural landscapes. A large number of organisms live here due to a greater variety of food objects, a milder and more stable climate, etc. Species that do not tolerate plowing of the soil find shelter in forest strips and their multi-grass plumes. They contain a large number of dendrobium and euribiont species.

Along with this, many concepts have recently emerged regarding the principles of biodiversity management, including the integrity, health, resilience, and resilience (ability to withstand the stress and shock) of an ecosystem.

One of the most productive ideas of modern ecology is the idea of an eco-network. It is integral in the organization of the preservation of bio- and landscape diversity, on the one hand, and the perspective of tireless nature management - on the other. The general trend in the approach to the eco-network is an effort to create a universal socio-natural structure that would solve not only the problems of preserving animals, plants, fungi, and their habitats, but also constantly provide the population with social and economic benefits and, improving the conditions of its existence, thereby laid the foundations of ecologically balanced development of the territory, as one of its basic elements. Aspects and problematic moments of the practical implementation of the idea of an eco-network are considered in the scientific literature.

Measures to preserve biodiversity have become an important component of state environmental policy, concretizing and developing the ideology of traditional nature protection. The formation of the eco-network will contribute to the improvement of the ecological state of the environment by regulating the hydrological regime, reducing soil erosion, softening the microclimate, stabilizing the small cycle of substances, preserving renewable resources, and maintaining the natural balance. The eco-network is the first active form of nature protection, the main goal of which is to restore the natural territorial and functional integrity of ecosystems in combination with their balanced use.

Creation and state of implementation of the eco-network in Ukraine

The eco-network model as a specific measure for nature protection has been developed in Europe for more than 10 years. The basis was the need to solve problems related to the restoration of species of large herbivores within their historical ranges in Europe, namely, to ensure the paths of their movement and migrations over fairly long distances by creating a network of connected areas of natural territories.

Further development in this direction showed that the eco-network is a key element of the practical implementation of the ecological paradigm of nature management and preservation of the natural framework of national territories and the most effective mechanism for fulfilling the tasks of the Convention on the Protection of Biodiversity.

Every sufficiently large territory on which ecosystems with all their components have been preserved in their natural state is a natural ecosystem, that is, a continuum of natural ecosystems exists in such a territory and all living organisms have the necessary conditions for existence, reproduction, and migration. The higher the degree of fragmentation of the ecosystems of a certain territory, the more difficult it is to restore their natural continuum. The territory of Ukraine is very heterogeneous in terms of the disturbance of natural complexes. The Carpathians are characterized by the least fragmentation. Considerable in terms of area, intact natural massifs have been preserved on the territory of Ukrainian Polissia. The territory of the Forest Steppe is more fragmented and the Steppe of Ukraine is the most disturbed.

The basic structural elements of the eco-network of Ukraine are defined in the Law of Ukraine "On the ecological network of Ukraine" by the principles of territorial structuring of the All-European eco-network. They differ in their functions and are divided into key (cores), connecting (eco-corridors), buffer, and renewable territories.

Key territories ensure the preservation of the most valuable and typical for this region component of landscape and biological diversity. Connecting areas (eco-corridors) connect key areas and ensure animal migration, plant and animal settlement, and genetic material exchange. Buffer territories include natural and artificially altered areas, and protect key and connecting territories from external influences. Restorative territories, represented by anpropogenically changed landscapes, ensure the formation of the spatial integrity of the ecosystem.

There are biosphere, continental, national, regional (regional), and local (local) levels of eco-networks. The key is the regional level, as it ensures the formation of a real territorial ecosystem system.

According to the Law "On the Ecological Network of Ukraine", the design of the eco-network at the regional level is carried out by developing regional schemes of the eco-network of the regions of Ukraine and the city of Kyiv, as well as local schemes of the eco-network of administrative districts. Regional eco-network schemes can also be developed for natural regions, the boundaries of which are determined by natural factors – river basins, mountain systems, coastal strips of seas, etc. The following are the main principles that the territorial structure of the regional eco-network must comply with:

• adequacy (the total area of the territories and objects of the eco-network is sufficient to preserve biodiversity);

• spatial integrity (territories and objects of the eco-network are connected in a coherent spatial system);

• representativeness (both typical and rare for a certain region species of plants and animals, plant groups, ecosystems, and landscapes are represented in the territories of the eco-network).

The project territorial structure of the regional eco-network is developed based on the characteristics of its constituent structural elements.

According to international standards, there are 3 stages of the formation of national eco-networks:

• the first (pioneer) network, as a prospective list of specific territories and their cartographic display;

• the second – the network as the basis of the national environmental protection plan;

• the third is a network as part of an integration national or regional (local) plan.

Ukraine is at the first stage of forming a national eco-network. It is the only state in the entire post-Soviet space, and possibly in Europe as well, that has a legislative basis for the creation of an eco-network. These are the Laws of Ukraine "On the Nationwide Program for the Formation of the National Ecological Network of Ukraine for 2000–2015." (No. 1989 – III dated September 21, 2000) and "On the ecological network of Ukraine" (No. 1864 – IV dated June 24, 2004). The scientific and methodological foundations of creating an eco-network and perspective plans of varying degrees of detail have already been developed. However, there is still no complete perspective list of specific areas of the eco-network.

Therefore, the creation of an ecological system (eco-network) is the formation of an interdependent complex of nature conservation areas that ensure ecological balance, biodiversity of landscapes, and purity of the biosphere. The creation of a scientifically based eco-network involves the provision of favorable environmental conditions for the life of the organic world; reproduction and preservation of rare natural objects, resources, or territorial complexes; meeting scientific and cultural needs of society, creating prerequisites for balanced use of land, water, forest resources and sustainable development of the territory; preservation of biodiversity, protection of vital ecological processes, ecosystems, and landscapes.

Preservationt of species diversity of insects in agrobiocenoses

With the existing system of intra-farm land management, which combines areas with quite different soil and microclimate conditions, between the fields of crop rotation and even within the same field, there are inevitable significant differences in providing plants with heat, moisture, and elements of mineral nutrition, the periods of the passage of plants in phenological phases, the degree of damage to crops by pests, diseases, and weeds and as a result – high variability of crop yield. In other words, the system of compensatory large-scale land management, which does not adequately take into account the unevenness of the distribution of soil and microclimatic factors, does not allow to realize the most important agrobiological tasks of crop rotation – to ensure the most rational use of local natural resources, the adaptive potential of plant varieties and man-made factors of agricultural intensification.

It is obvious that the practice of "equalizing" land use, formed throughout the country, requires, first of all, a fundamental revision of the intra-household land management system. It should be based on an economically justified, but more differentiated use of natural and man-made resources due to the allocation of ecologically similar territories (EOTs), combining relatively homogeneous basic surfaces (morpho-elements), soil characteristics, microclimate, and natural processes.

Man has come to understand the need to preserve the diversity of the surrounding environment with the help of a will or other types of protection of natural territories. But when carrying out environmental protection measures, it is necessary to remember, especially at the economic level, about nuts, dykes, borders, beams, glades, bushes, and so on, because these are precisely those fountains from which there is a constant supply of both natural and artificial types of "nutrition" biocenoses. Such semi-natural stations of agrolandscapes in ecological literature were called "entomological refugium". The term "refugium" refers to an ecological storage area – an area of the earth's surface where one or many species of fauna experience unfavorable periods, during which these life forms disappeared over large areas.

If the diversity of biotopes in agrolandscapes is preserved, there will be significantly fewer problems in preserving biodiversity in them. Human non-interference in these small centers of functioning of biotic complexes will contribute to their close to natural successional processes, i.e. self-regulation of internal relationships will prevail there. So, for example, it is not necessary to treat forest strips (and all other "islands") with pesticides, including their edges (against weeds), not to burn them. There will be no practical benefit from the use of chemical plant protection in such conditions, but very great damage will be done to successful processes. It is advisable to fight weeds and phytophages directly in cultural phytocenoses but under the condition of scientifically based protective systems that provide for a minimized impact on beneficial entomofauna (poisoning of the seeds of cultivated plants, especially row crops, night chemical treatments, etc.).

At the same time, as well as when conducting economic activities in agricultural landscapes in general, it is necessary to pay close attention to the preservation of useful entomofauna. As for wild plant pollinators, the preservation of their species diversity (up to 700 species in Ukraine) also depends on the preservation of their habitats (woodlands, meadows, roadsides, slopes of streams, ravines, fallows, etc.). Moreover, all these biotopes must be given the status of micro-reserves. It does not require a lot of expenses, but it brings a lot of benefits. Therefore, the same attention should be paid to the preservation of the species diversity of wild pollinators as to red-listed insect species.

Nowadays, little attention is paid to the fact that the biodiversity of faunal complexes of insects can be a guarantee against the degradation of entomofauna in natural, partially changed ecosystems. Long-term studies show that the species diversity and numerical abundance of beetles of different families living in the soil of virgin areas are 1.5–5.0 times more than in agrocenoses, depending on the type of soil and agriculture. The biodiversity of Lepidoptera (butterflies), whose caterpillars lead a mostly open lifestyle on plants, and are more vulnerable to physical and chemical influences, differs even more. Therefore, it can be said that entomological shelters or refugia have now become the last stronghold of insect biodiversity in agricultural landscapes. For example, as a result of studies of the peculiarities of the formation of entomocomplexes in the agrobiocenoses of the Central Forest Steppe of Ukraine, it was established that the species diversity varied from the field of sugar beets ($H=2.45\pm0.10$ bits/individual), field peas ($H=2.52\pm0.17$ bit/individual), winter wheat ($H=2.97\pm0.13$ bit/individual) to corn ($H=3.01\pm0.13$ bit/individual) and forest strip ($H=3.65\pm0.17$ bit /person). Semi-natural biotopes, grain, and legume fields were characterized by a greater variety and number of beetles and grasshoppers, compared to row crops, because the conditions in these biotopes are favorable for most species of local fauna.

The dominant species in crops were *Pterostichus cupreus* L.*, P. melanarius* L.*, Bembidion properans* Steph.*, Ophonus rufipes* Deg. In winter wheat fields bordering field protection tree plantations, roadsides of transport routes, and sown areas of other crops, the number of species of beetles (especially zoophagous), their diversity, and population density increased in places of contact with forest strips. Larger areas of meadow biotopes, field protection plantations, and ecotones in the field system contributed to the accumulation of epigenetic entomophagous, and therefore to the natural regulation of the number of phytophages. The impact of field protection forest strips on the entomocomplex in a separate agrocenosis was manifested in a decrease in the overall diversity of hortobiont insects and the number of entomophagous as the distance from tree plantations increased. semi-natural ecosystems (hay, recreational, pasture, and hydro melioration) were characterized by the greatest species diversity of insects. Various complexes of arthropods were formed on the fallows, but with a numerical predominance of harmful phytophagous – orthopterans, bugs, and leafhoppers. Agrocenoses were characterized by a lower diversity of insects, but a higher population density of individual representatives.

Entomological refugia in wastelands are a natural component of agricultural landscapes. Therefore, it is necessary to treat them in the same way as arable land. Excessive livestock grazing, steppe fires, dumping of household waste, barbaric collection of medicinal herbs, unreasonable plowing of areas with poor soils, which as a result turn into littered deposits – all this impoverishes the biodiversity of insects within the boundaries of each specific farm. But the most dangerous pesticides are those that, as a result of being washed off or washed off from the fields, poison natural ecosystems, gradually impoverishing the species composition of insects.

Agricultural lands directly bordering entomological refugia should be used for alfalfa and other fodder leguminous grasses, regularly placing the output fields of grain rotations on them. In addition, in these fields it is desirable to use insecticides with the shortest half-life in the soil, practicing the use of only ground spraying equipment. It is impossible to use aerosol generators of insecticide dust near entomological refugia, as well as to break up intensive fruit orchards since all existing systems of chemical protection of orchards assume the use of larger volumes of insecticides, which are several times higher than their costs in field crops.

Scientific criteria for the selection of territories for inclusion in the structural elements of the eco-network and lists of territories and objects of the eco-network

According to the methodological recommendations for the development of regional and local eco-network schemes as the main measure for the preservation of agro-biodiversity, the use of the landscape principle in the planning of the eco-network of an administrative unit allows presenting the floristic and coenotic diversity of the region in the most complete way within its boundaries. The composition of each high-ranking key territory should include various landscapes and natural population complexes, this is a necessary condition for the self-regulation of the biota of this key territory, and therefore the creation of conditions for the restoration of the potential flora, vegetation, and biota in general, which existed on this territory in the pre-agricultural period. It is desirable to analyze the territory of an agricultural enterprise using land management maps. This makes it possible to distinguish landscape elements of different groups according to the degree of landscape changes within meadow or steppe territories. In territories with a predominance of anthropogenic landscapes, the role of small areas of natural vegetation is increasing, provided that they are connected in a coherent network. Such a network should be considered as the territory of a structural element of a local-scale eco-network.

Ecocorridors are spatial structures with an elongated configuration that connect key territories (cores) and include existing biodiversity of varying degrees of naturalness and its habitat. Their main function is to ensure the maintenance of reproduction processes, exchange of gene pool, migration of species, the spread of species to adjacent territories, survival of adverse conditions, hiding, and maintenance of ecological balance. The functional designation of eco-corridors as paths of migration, colonization, and gene exchange due to adverse conditions is carried out at different geographical distances – from local to global, and for small and sedentary species – from local to regional, which determines the territorial status of eco-corridors.

The shape of the corridors can be different, both straight and winding. According to territorial integrity, continuous and island eco-corridors are distinguished. The first is a continuous strip with natural or semi-natural vegetation, and the second is an elongated contour, within which there are natural areas between which the exchange of genetic information exists or is potentially possible. They must include the maximum number of natural features characteristic of the key areas they connect and be broad enough to create suitable conditions for biodiversity. In general, the narrower the corridor, the worse it fulfills its purpose, and the wider, the better.

Most of the indicators by which eco-corridors are distinguished coincide with the indicators for establishing key territories. They must have optimal conditions for the survival of organisms, opportunities for their movement and migrations, places suitable for resting and feeding migratory animals, and opportunities for integration into a single continental system.

The basic criteria for the selection of connecting territories (eco-corridors) are the naturalness of the borders, the sufficient width, and length to ensure the migration of species, their reproduction, and the survival of adverse conditions. This is because the main function of eco-corridors is to provide spatial connections between key territories. The main criterion for their selection is migration. An eco corridor is such a territory or a combination of them, along which the exchange of genetic material and migration between key territories can take place. The main conditions for this are:

• the length of the eco-corridor does not exceed the distance over which the majority of species that exist in the key territories connecting the eco corridor migrate;

• the width of the eco-corridor allows populations to effectively use it as a migration and settlement channel;

• the edaphic conditions of the eco-corridor are similar or close to the edaphic conditions of the key areas it connects;

• within the eco-corridor there are no migration barriers or other factors that could hinder the migration and dispersal of species.

The components of the restoration territories of the eco-network include territories: long-plowed, low-productivity; salted for the second time due to excessive irrigation; pasture failures, areas of cattle drive and places of its permanent concentration; infested with quarantine weed species, including harmful to human health; quarries, rock dumps, etc.; arable land on slopes, which are set aside under soil protection strips, or permanent areas intended for the breeding of wild pollinating insects; embankment slopes and exclusion strips along highways, railways, oil and gas pipelines, power lines and other communications; areas of open soil where landslides and landslides occur or may develop; places of permanent rest and other recreational areas; areas that are subject to long-term conservation due to radiation, chemical or other contamination that poses a threat to human and animal health; residential areas subject to

Red book species of entomological biodiversity of Ukraine

Among the entomofauna, there are 10 species of insects (!), which are listed in the Red Book of Ukraine: Sacred scarab (*Scarabaeus sacer (*Linnaeus, 1758) (Scopoli, 1763), Hairy Staphylin (*Emus hirtus (*Linnaeus, 1758), Fragrant bumblebee (*Bombus fragrans (*Pallas, 1771), Periphanes delphinii (*Periphanes delphinii* (*Linnaeus*, 1758), Lygaena laeta (*Lygaena laeta* (Hubner, 1790), Hungarian weevil (*Carabus hungaricus* (Fabricius, 1792), The giant beetle (*Satanas gigas* (Eversmann, 1855), the steppe beetle (*Saga pedo* (Pallas, 1771) (Figs. 21–30). These insects are still found in the biocenoses of Ukraine, but in rather small numbers (!).

Fig. 21 ***Saga pedo*** **(Pallas, 1771)**

Order – Orthoptera

Family – Tettigoniidae

Fig. 22 ***Satanas gigas*** **(Eversmann, 1855)**

Order – Diptera

Family – Asilidae

Fig. 23 ***Calosoma sycophanta*** **(Linnaeus, 1758)**

Order – Coleoptera

Family – Carabidae

Fig. 24 ***Carabus hungaricus*** **(Fabricius, 1792)**

Order – Coleoptera

Family – Carabidae

Fig. 25 ***Scarabaeus sacer*** **(Linnaeus, 1758)**

Order – Coleoptera

Family – Scarabaeidae

Fig. 26 ***Osmoderma eremita*** **(Scopoli, 1763)**

Order – Coleoptera

Family – Scarabaeidae

Fig. 27 ***Emus hirtus*** **(Linnaeus, 1758)**

Order – Coleoptera

Family – Staphilinidae

Fig. 28 ***Lygaena laeta*** **(Hubner, 1790)**

Order – Lepidoptera

Family – Zygaenidae

F*ig.* *29* ***Periphanes delphinii*** **(Linnaeus, 1758)**

Order – Lepidoptera

Family – Noctuidae

F*ig.* 30 ***Bombus fragrans*** **(Pallas, 1771)**

Order – Hymenoptera

Family – Apidae

BIODIVERSITY ASSESSMENT METHODS

The problem of preserving biodiversity as a necessary component of sustainable development of our planet and preservation of life on Earth is one of the most pressing issues of our time. This is because destabilization of biota can lead to a loss of the biosphere's ability to maintain the required environmental quality and, ultimately, the sustainable development of civilization.

The solution to the problem of its conservation is currently being considered on the basis of the population-species and ecosystem approaches, which are to some extent interrelated. The population-species approach involves the conservation or restoration of the genetic potential of the biosphere, the number and ranges of species on a scale sufficient for their sustainable existence and use, as well as the conservation of populations and intraspecific forms, monitoring and management of their conservation.

The ecosystem approach focuses on studying the status and developing a set of measures to preserve their most vulnerable species, maintain their natural processes, and ultimately preserve their functions.

In any approach, biodiversity is assessed (described) for different territorial communities of the biosphere. This is the so-called territorial or biochorological approach. The lowest level of biochorological (territorial) diversity in ecology is considered to be biogeocenosis and elementary regional biota. Higher levels of biogeographical zoning are considered to be a district, province, region, the contours of which may not coincide in different Earth zoning systems (depending on the criteria used).

Depending on the biochorological level (the size of the territory), the taxonomic level of the units used to assess biodiversity can also change significantly. The most universal and obligatory unit for all biochorological levels is the species. When assessing the biodiversity of territorial communities of higher rank (district, province, oblast), as well as when assessing changes in diversity over time, taxa such as genus, family, order, etc. are becoming increasingly important. At the same time, at the community level, along with species associations, smaller groups (parcells, sinusia, etc.) are also considered.

Controlling biodiversity requires its measurement, and measurement is only possible when qualitative traits can be described quantitatively, in terms of comparable values.

Biodiversity assessment is of great practical importance because:

1) allows to control the preservation of genetic potential;

2) gives an idea of the state of ecosystems in a certain area;

3) serves as a basis for developing a management system for certain species.

Biodiversity is usually assessed either by counting species, measuring their relative abundance, or by measures that combine the two. However, assessing diversity by simply counting species is not very informative, as no community is composed of species of equal abundance. Of the total number of species in a trophic level or community as a whole, usually only a few are dominant (i.e., have high biomass, productivity, or other indicators), while the vast majority are rare (i.e., have low "importance" indicators). Thus, most species in the community are few in number, others are moderately abundant, and only a few are widespread.

Biodiversity is commonly understood as the species richness of flora or fauna, but in fact such assessments reflect not diversity but richness, which is a fundamentally different category. Diversity is an integral assessment of wealth and the distribution of wealth elements in terms of their abundance. A number of indicators are used to assess diversity. The most famous among them are the Shannon-Weaver entropy index (H') and the Simpson diversity index (D). These and similar indicators are used to calculate community complexity, species and taxonomic diversity, etc.

Assessment of species biodiversity (α-diversity)

When assessing alpha diversity, two factors are taken into account: species richness and species diversity equilibrium.

Species richness is the number of species of the entire biota or some part of it (plants, mosses, lichens, algae, fungi, nematodes, insects, birds, etc.) in a certain area.

Evenness is the uniformity of distribution of species by their abundance in the community.

To estimate alpha diversity, you can use species diversity graphs or methods of finding species richness indices - the ratio between the number of species and an indicator of significance: abundance, biomass, or productivity.

Currently, more than 40 indices have been proposed to assess biodiversity.

Indices used in the analysis of community diversity should meet the following requirements:

1) the higher the diversity of a community, the greater the number of species in it;

2) the higher the diversity of a community, the higher its level of evenness.

Most of the differences between indices measuring biodiversity lie in the importance they place on evenness and species richness.

Species richness indexes

An important measure of diversity for a spatially and temporally limited community, for which the number of its constituent species and individuals is known, is species richness. However, in most cases, only a sample is used, without taking into account the full list of species in the community. In this case, it is necessary to use "numerical species richness", i.e. the number of species with a ratio per strictly defined number of individuals or per a certain biomass, and species density.

Species density (e.g., per 1 m2) is the most common indicator of species richness. Numerical species richness is less commonly used, although it is more popular in water body studies. For example, when studying environmental impacts on fish communities, the number of species per 1000 fish can be used.

Different combinations of S (number of species identified) and N (total number of individuals of all S species) are the basis for simple indicators of species diversity:

Margalef species richness index:

$$D_{\mathrm{Mg}} = \frac{S-1}{\ln N}$$

Menhinik species richness index:

$$D_{\mathrm{Mn}} = \frac{S}{\sqrt{N}}$$

The advantage of these indices is the ease of calculation. A larger index value corresponds to greater diversity.

Indices based on the relative abundance of species

This group of indices is called heterogeneity indices, as they take into account both levelness and species richness. Indices based on the relative abundance of species are non-parametric because they do not require any assumptions about distributions. Their use deepens the assessment of biodiversity compared to species richness indices that rely on only one parameter.

There are two categories of nonparametric indices:

1) indices derived from the theory of information (information and statistical);
2) dominance indexes.

In 1949, Shannon derived a function that became known as the Shannon Diversity Index. The calculation of the Shannon Diversity Index assumes that individuals are drawn randomly from an "indefinitely large" (i.e., virtually infinite) population, with all types of the population represented in the sample. The uncertainty is maximized when all events (N) have the same probability of occurrence (pi = ni/N). It decreases as the frequency of some events increases compared to others, until it reaches a minimum value (zero), when there is only one event and there is certainty of its occurrence.

The Shannon index is calculated using the formula:

$$H = -\sum p_i \ln p_i$$

where p_i is the proportion of individuals of the i-th species.

In the sample, the true value of pi is unknown, but is estimated as n_i/N.

The reasons for the errors in assessing diversity using this index are that it is impossible to include all types of real community in the sample.

When calculating the Shannon index, the binary logarithm is often used, but other types of logarithm (decimal, natural) are also acceptable.

The Shannon index usually ranges from 1.5 to 3.5, very rarely exceeding 4.5.

The Shannon index proved to be the most popular in assessing data on diversity and is used more often than others.

Measures of dominance focus on the abundance of common species rather than species richness. The best dominance index is the Simpson index.

The Simpson index describes the probability of any two individuals randomly selected from an indefinitely large community belonging to different species using a formula:

$$D = \sum {p_i}^2$$

where p_i is the proportion of individuals of the i-th species.

To calculate the index, a formula is used that is specific to the end community:

$$D = \sum \left(\frac{n_i(n_i - 1)}{N(N - 1)} \right)$$

where n_i is the number of individuals of the i-th species, and N is the total number of individuals.

As D increases, diversity decreases. Therefore, the Simpson index is often used in the form (1-D). This value is called the "probability of interspecies encounters" and varies from 0 to 1. It is very sensitive to the presence of the most abundant species in the sample, but is not strongly dependent on species richness. A high or low value of the index is determined by the type of species diversity distribution for cases where the number of species exceeds 10.

Mackintosh diversity measure. In 1967, Mackintosh proposed to consider a community as a point in an S-dimensional hyperspace with coordinates (n1, n2, ..., ns). Then the distance of such a community from the origin can be used as a measure of its diversity:

$$U = \sqrt{\sum {n_i}^2}$$

The Mackintosh index U is not a dominance index by itself, but using it, you can calculate a measure of diversity D, or dominance, which is independent of the sample size:

$$D = \frac{N - U}{N - \sqrt{N}}$$

Later, you can solve the equations:

$$E = \frac{N - U}{N - N\sqrt{S}}$$

The Berger-Parker index is one of the measures of dominance. Its advantage is its simplicity of calculation. The Berger-Parker index expresses the relative importance of the most abundant species:

$$d = \frac{N_{\max}}{N}$$

where N_{max} – is the number of individuals of the most abundant species.

An increase in the value of the Berger-Parker index, like the Simpson index, means a decrease in diversity and an increase in the degree of dominance of one species. Therefore, the inverse of the Berger-Parker index 1/d is usually used.

This index is independent of the number of species, but it is affected by the sample size. Some scientists consider this index to be a better measure of diversity.

Graphs and models of α-diversity

A number of patterns in the distribution of species in communities due to abundance (number of species) and evenness (number of individuals) are well revealed when graphing. Usually, several types are used, reflecting either general trends or details of the phenomenon under study.

1. The rank/abundance graph displays data on the number of species. Its construction is preceded by ranking by number, on the basis of which the ordinal numbers of species are plotted on the abscissa (horizontal) axis in the direction of decreasing number, and the number of each species is plotted on the ordinate axis. The line connecting the points is called the curve of significance (dominance) of the species distribution. Such a graph corresponds to a geometric distribution model that is typical for species-poor types of disturbed communities (habitats), when each species occupies a free ecological niche without overlapping the niche of other species

(with a certain share of resources). Of course, the steeper the curve, the less diversity and the stronger the dominance of one or more species.

2. The frequency distribution establishes the relationship between the number of individuals and the number of species. It shows that most species in the community are relatively few in number, some species are of medium abundance, and numerous species are essentially "solitary" (in the "tail" of the distribution).

3. A logarithmic distribution, in which the number of individuals is plotted on a logarithmic scale on the abscissa axis. There are 2 possible options here:

- logarithmic simple distribution, which corresponds to the distribution of a small number of numerous species and a significant number of rare ones. It is characterized by a steeply falling curve;

- logarithmic normal distribution reflects the ratio of species in many communities, the existence of which is determined by a large number of factors. The ratio of the number of species and the number of their individuals is well reflected by the S curve, which indicates that most species exist in conditions of competition rather than direct competition for resources.

4. A graph that corresponds to the "broken rod" model, when a large number of species are plotted on a linear scale on the ordinate axis and the abscissa axis is the rank in logarithmic frequency from most abundant to least abundant. This model well reflects the ratio of species with distinct territorial behavior and interspecific competition.

5. You can also use a graph that plots the accumulated species abundance as a percentage on the ordinate axis and the logarithm of the rank (species number) on the abscissa axis.

In addition to the above, zeta, hyperbolic, exponential and other models are also used to reflect the distribution of species in some communities, taking into account the density of organisms.

Analysis of β-diversity of communities

Beta diversity (proposed by Whittaker in 1960) characterizes the degree of difference or similarity between a number of habitats or samples in terms of their species composition, and sometimes the number of species. One common approach to establishing beta diversity is to assess changes in species diversity along a gradient of the environment. Another way to determine it is to compare the species composition of different communities. The fewer common species in communities or at different points along the gradient, the higher the beta diversity. This approach is used in any study that considers the degree of difference in species composition between samples, habitats, or communities.

It is also used to compare the seasonal dynamics of community composition, changes in the degree of food specialization of species, assessing pollution of water bodies and terrestrial communities, etc.

In conjunction with measures of internal habitat diversity, beta diversity can be used to provide an indication of the overall diversity of conditions in a given area.

When evaluating data on the presence or absence of species in communities, different measures or criteria for measuring β-diversity are usually used, but the Whittaker measure is the most commonly used. Data on similarity/differences are usually set in absolute or relative values.

The following indicators are taken into account when comparing communities:

- a – number of species common to both communities;
- b – number of species present only in one community;
- c – the number of species found only in the other community.

They are used to calculate the values a + b, a + c, a + b + c, as well as negative coincidences (mismatches).

Similarity scores are based on measures of diversity. There are 6 measures of beta diversity based on the presence or absence of species.

The Whittaker measure is described by the formula:

$$\beta_W = \frac{S}{\alpha} - 1$$

where S is the total number of species registered in the system: α – is the average diversity of standard-sized samples, measured as species richness.

The Cody measure is designed to investigate changes in the bird community along an environmental gradient:

$$\beta_C = \frac{g(H)=l(H)}{2}$$

where g(H) is the number of species added along the habitat gradient, and l(H) is the number of species lost along the same transect.

Rutledge's activities. The measure β_R takes into account the total species richness and the degree of species overlap:

$$\beta_R = \frac{S^2}{2r + S} - 1$$

where S is the total number of species in all samples, and r is the number of pairs of species with overlapping distributions.

The measure β_I is based on information theory and has been simplified for qualitative data and equal sample sizes:

$$\beta_I = \log(T) - (1/T)\sum e_i \log(e_i) - (1/T)\sum \alpha_j \log$$

where e_i is the number of samples along the transect in which the i-th species is represented, α_j is the species richness of the j-th sample, and $T = \sum e_i = \sum \alpha_j$.

The measure β_E is an exponential form of β_I:

$$\beta_E = exp\ (\beta_I) - 1.$$

Wilson and Schmidt's measure β_T includes the same elements of species loss (l) and addition (g) as the Cody measure, but is standardized to the average species richness of the samples α, which is included in the Whittaker measure:

$$\beta_T = [g\ (H) + l(H)]/2\alpha$$

More than 10 indices have been proposed for biocenotic, faunal, and biogeographic studies, but the most commonly used are the indices:

Jaccard's measure J = a/(a+b+c), calculates the ratio of the number of common species to the total number;

Chekanovsky-Serensen`s measure, the ratio of species to the arithmetic mean number of species in the two communities.

Among the indexes that take into account negative coincidences (mismatches), the simplest are the indexes:

Kulchinsky`s index Ik = a/(b+c);

Sokal-Maychener`s index (a+d)/(a+b+c+d).

When calculating commonality indices for quantitative data, the most appropriate use of the Serensen coefficient is:

$$Cn = \frac{2jN}{aN+bN},$$

where the divisor is the sum of the smallest quantities; the divisor is the total number of individuals in plots a and b.

When calculating certain indicators, they are usually grouped and classified. These procedures are performed by converting the obtained calculation data (matrix) into various graphs or diagrams.

Biodiversity assessment of large territorial communities

To characterize biodiversity at the level of landscapes, the γ-diversity indicator is usually used, at the level of biogeographic regions – epsilon diversity, and at the level of natural zones – γ-diversity.

However, since these territories are spatially heterogeneous and their ecosystems are not the same, the characteristics require taking into account many factors and ultimately result in generalized indicators that do not have an absolute value. Most often, indicators of simple, conditional, and complex entropy are calculated, which show the conditional scale of the study.

A number of studies characterizing γ-diversity take into account the diversity of communities and ecosystems in terms of spatial indicators, including the degree of community fragmentation, landscape heterogeneity coefficient, complexity of territorial community boundaries, and others, but they are not strictly described in informational terms, formulas, and ultimately do not provide absolute values.

If gamma diversity is defined as the total diversity of a group of sites, then epsilon diversity, or regional diversity, is the total diversity of a group of gamma-diverse areas that belong to large biogeographic regions.

To study the diversity of a phytocoenochorus (phytocoenochorus – (from phytocoenosis and Greek chora – place, space), a unit of territorial combination of phytocoenoses within a geochora of different ranks), it is considered effective to use the calculation of complex entropy to study gamma diversity:

$$H'' = -\sum_{j=1}^{N} P_j \sum_{j=1}^{N} P_{ij} \log P_{ij}$$

where Pj is the a priori probability of occurrence of class j; Ij is the probability of assigning a sample of class i to class j.

In the multilateral study of complex units, it is recommended to calculate the conditional entropy Hn (Yaglom, 1972) of the form:

$$H_n = -\sum_{i=1}^{N} P(A_i) H(A_i)$$

where P (Ai) is the conditional probability of occurrence of the i-th class according to the j-th spatial (or other conditional) characteristic:

$$P(A_i) = -\sum_{i=1}^{N} P_j p_{ij}$$

and *H(Ai)* are separate conditional entropies for each class:

$$H(A_i) = -\sum_{j=1}^{N} P_{A_i(j)} \log P_{A_i(j)}$$

The use of this apparatus in different directions can describe different properties of gamma diversity. It should be remembered that all these indicators do not have an absolute value and are used only for their comparison, which gives an increase in information (ΔIi), depending on the change in the conditions of experience, and is determined by the difference in intermediate entropies:

$$(H_i): \Delta I_i = H_i - H_{i-1}$$

Many works at the landscape level consider biodiversity as the diversity of communities and ecosystems in terms of spatial indicators, including the degree of fragmentation, patch shape, boundary complexity, patch contiguity, and other indicators related to the measurement of landscape structure. However, such indicators of spatial heterogeneity are not strictly described in information terms.

Diagnostics of the ontogenetic state of woody plants

The period of time from the emergence of a plant from a fertilized egg or vegetative bud to its natural death is called the life cycle or ontogeny.

Plant ontogeny consists of a series of successive age periods. The sequence of these periods and their duration are determined by the genotype of a particular species.

Embryonic period – begins on the mother plant with the formation of a zygote. As a result of the processes of division, growth and differentiation of zygotic cells, a seed embryo is formed.

Seedlings (rl) are plants formed from a seed in the year of its germination, with a primordial root and a shoot with cotyledons.

Juvenile trees (j) – do not have cotyledons, but have some infaltic structures. The primary shoot has no branches. The root system consists only of the primary root and a small number of lateral roots.

Imature trees (im) – occupy an intermediate position between juvenile and adult trees. The shoot system consists of branches of 2–4 orders, the crown is not yet formed. The diameter of the trunk does not exceed the diameter of large branches by more than twice. The leaves have an adult structure. Imitation trees are part of the shrub layer.

Verginal trees (v) – have almost fully formed features of an adult tree that has not yet begun to bear fruit. The plants have well-developed trunk and crown, and the height growth is maximum for the entire period. The diameter of the trunk exceeds the diameter of the skeletal branches by 3 or more times. The shoot system consists of branches of 4–7 orders.

Young generative trees (g1) – first start bearing fruit. Reproductive organs are located in the upper part of the crown. The branching order is 7–9 or more. A bark begins to form in the lower part of the trunk.

Medieval generative trees (g2) have a typical crown. The growth of trees in height is slowing down. Dormant buds awaken. The number of flowers is maximum for this species. Fruits and seeds are formed in the upper and middle part of the crown.

Old generative trees (g3) – the plant's height growth stops. Dormant buds on the trunk awaken. In some cases, the secondary crown can completely replace the primary crown. The number of flowers and fruits is irregular. The number of seeds is small.

Sine trees (s) – have passed the stages of generative development (full ontogeny), have a dry top, low-lying living part of the crown. The tree is not capable of producing seeds and fruits.

Most woody plants can flower and bear fruit repeatedly - polycarpic species. In contrast, monocarpic species are able to bloom and bear fruit only once in their lives, after which the above-ground shoots die off.

In polycarpic tree species, the aging stage is often very long, because along with the aging and death of individual shoots in the crown, new shoots are formed due to the awakening of dormant buds. The development of stump, root and trunk shoots also contributes to life extension.

According to their life expectancy, woody plants are divided into:

- - quite durable – oak (up to 1500 years), European cedar (up to 1000 years), larch (up to 800 years);
- - long-lived – common juniper (up to 500 years), forest beech (400-500 years), pine (up to 350 years), pear (200-300 years);
- - medium-long-lived – hanging birch (up to 150 years), apple tree (100–150 years), black alder (100–150 years);
- - short-lived – poplar (100 years), aspen (80–100 years), rowan (up to 60 years).

The ontogeny of any woody plant is associated with such phenomena as growth and development. Both of these processes occur simultaneously and are inseparably interconnected. Growth refers to the age-related increase in height, volume and mass of woody plants. Development is a qualitative change that takes place in the plant organism.

According to the intensity of growth, trees are divided into:

- fairly fast-growing - annual growth up to 2 m and more (poplar, hanging birch, common ash);
- fast-growing – growth of up to 1 m per year (elm, oak, scots pine);
- moderately growing – growth up to 0.5–0.6 m (linden, spruce, Virginia juniper);
- slow-growing – growth up to 0.25–0.3 m (pear, apple);
- rather slow-growing – growth up to 0.15 m or less (common juniper).

Perennial woody plants repeat the same cycles every year – vegetation and dormancy, budding and budding, shoot growth and cessation, etc. Within these cycles, there is a sequential onset and progression of phenological phases (phenophases) of growth and development of woody plants. The phenological phase is understood as a separate time stage of the annual cycle of plant growth and development, which is characterized by clearly expressed external morphological features. The calendar time of the phenological phase is called the phenodate. The time between individual phenodates is the interphase period, or phenological cycle. Cyclicity and periodicity of physiological processes determines the onset of phenological phases, but the dynamics of their onset, start and end dates, duration are influenced by climatic conditions, adapting to which, plants significantly change the rhythm of growth and development processes and their phenological state.

Methods for estimating absolute density and spatial structure of the population

The absolute density (D) of organisms in a homogeneous area under study is defined as the arithmetic mean of the number of organisms (of a given species) recorded within each sample plot (x_i):

$$D = \frac{\Sigma x_i}{n}$$

where n is the number of test plots studied (i ([1, n]).

An indicator that characterizes the accuracy of the results obtained is the error of density estimation (SE_D), which is determined by the variant (S^2):

$$SE_D = \sqrt{\frac{S^2}{n}}$$

$$S^2 = \sum x_i^2 -$$

where Σx_i^2 is the sum of the squares of the number of organisms in each of the n sample plots, $(\Sigma x_i)^2$ is the square of the sum of these values.

The results are considered reliable when the D/SE_D ratio is greater than or equal to 5, i.e. the error is no more than 20% of the value of the indicator itself.

Based on this approach, the required number of test sites is determined so that the data obtained is reliable. This number (n*) is determined by the Elliot formula:

$$n \ = \frac{25 \times S^2}{D^2}$$

Spatial structure of the population

The simplest method for determining the nature of the spatial distribution of objects is to use the Odum index I_0

$$I_0 = \frac{S^2}{D}$$

If it is statistically proven that $I_0 < 1$, then individuals are distributed evenly in the population, $I_0 > 1$ – in groups, if $I_0 = 1$, then individuals are distributed randomly.

The Odum index characterizes the type of spatial distribution of organisms at each time of collection, and thus can be used to analyze the variability of the spatial structure of a population over time.

Determination of species diversity, richness and level of dominance of individual species in the biocenosis

The numerical characterization of the ratio between the number of different species is given by the Simpson's dominance index (S):

$$S = \sum (n_i / N)^2,$$

where n_i is the number of individuals of each species, and N is the total number of individuals of all analyzed species.

The Berger-Parker dominance index takes into account only the share of the dominant species:

$$D_{BP} = n_{max} / N,$$

where n_{max} is number of the most common species.

Both indices take on a smaller numerical value the more equalized the dominance structure is, i.e., the closer the population estimates for all species are. At the same time, the Simpson's index gives more weight to common species, since squaring small ratios (n_i/N) results in very small values.

Species diversity, or the measure of species heterogeneity of a community, is determined by the Shannon formula:

$$H_{Sh} = - \sum [(n_i/N) * \ln (n_i/N)],$$

aor Simpson's formula:

$$H_S = 1 - \sum (n_i/N)^2.$$

both indicators take the maximum value when the number of all species in the community is equal. In this case, the Shannon diversity index tends to the value $H_{Sh} \rightarrow \ln s$, and Simpson's diversity index – $H_S \rightarrow (s-1)/s$, where s is the total number of species.

The Margaleff Index is used to quantify the species richness of a community:

$$D_M = \frac{s-1}{lnN}$$

The more species, the higher the value of this index. An increase in the number of individuals with a constant number of species leads to a decrease in the index value.

The uniformity of species distribution, which also reflects the degree of diversity of the community, is determined by the Peel's index of evenness:

$$E = H_{Sh}/\ln s,$$

where H_{Sh} is the value of Shannon's diversity index for this grouping. The Pieloux equalization index takes values from 0 to 1.

For real groups, this figure rarely exceeds 0.80.

Assessment of the spatial distribution of individuals

An important ecological characteristic of the studied population is the nature of the spatial distribution of individuals (Fig. 32).

When individuals are not subject to any stable interactions, they are distributed randomly (A). When the relations between individuals are basically antagonistic, repulsive forces act between them, so if the environment is sufficiently homogeneous, the distribution of individuals will be close to uniform (B). And finally, if the behavior of individuals is dominated by a tendency to positive interactions, their placement in a homogeneous environment can be group (C). In addition, the group type of distribution of individuals in space can be caused by the unevenness (heterogeneity) of the environment itself where they are located.

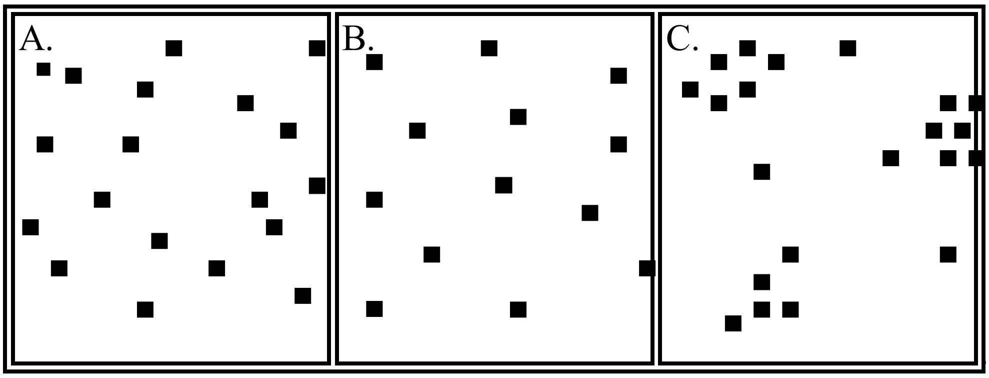

Fig. 32 **Nature of spatial distribution of individuals**

A – no stable interactions between individuals, B – antagonistic interactions between individuals, C – positive interactions between individuals

A significant drawback of many methods of assessing the nature of the spatial distribution of individuals is the assumption that the sample can be much smaller than the spots formed by clusters of individuals. The obvious way to eliminate this assumption is to use a large number of small samples (test plots).

The method of determining the nature of the spatial distribution of individuals, which was proposed by Morisita (1959), does not make the above assumption. The results of this method are not affected at all by the size of the test plot and the size of the sample (provided that it is not too large).

A systematic approach to studying the movement of individuals in space

All living organisms actively move in the course of their life. A whole group of factors can cause the movement of individuals in space:

- nutritional activity;
- search for a sexual partner;
- reducing excessive crowding in a particular place;
- range expansion.

Dispersal or dispersal can be active and passive.

Passive dispersal is characteristic of plants and many groups of attached animals.

Active dispersal is often associated with the organism's response to environmental factors.

Movements that have an ecological and physiological basis are called **taxa**. The movement of individuals along an elevation gradient is called geotaxis; movement along the direction of air flow (wind) or water flow is called rheotaxis; from a lighted to a more shaded habitat is called scototaxis; along a temperature gradient is called thermotaxis, etc.

The value of the dispersion of an organism is considered as the distance of movement of an individual over a certain period of time. The distance of movement is defined as the length of a straight line between the positions of an individual during two consecutive observations.

Methods of migration activity analysis

When processing the results, the following aspects of migration activity are analyzed:

- intensity of movements;
- directionality;
- distance of movement;
- straightforwardness;

- territoriality.

The intensity of movement (dispersal) of organisms is defined as the proportion of labeled individuals that have moved during a given period of time, out of the total number of released individuals at the beginning of the experiment.

Direction of movement. The choice of movement direction is determined by environmental factors (habitat heterogeneity) or by the peculiarities of social relations between individuals. To analyze the directionality of movement, we use Pearson's Chi-square criterion (χ^2), which allows us to assess the probability of the directionality of movement of organisms from the uniform one.

The distance of movement of organisms is characterized by the distance (in a straight line) from the release site. It is assumed that:

- first, the probability of detecting a marked individual does not depend on the distance of its removal;
- secondly, an individual moves in an almost straight line during a unit period of time.

Straightness of movements. In long-term studies, the efficiency of movement is determined using the **Hamilton Straightness Index** (It). This index is calculated as the ratio of the distance from the starting point to the total length of the path (i.e., the sum of the movement distances at each stage of the individual's position registration). If the monitored individual is within the same zone, the straightness index will be close to zero, and if the individual moves in an almost straight line, it will be close to one.

Territoriality. The concept of an "individual plot" characterizes the space used by an individual leading a sedentary lifestyle. The main quantitative characteristic of an individual plot is its area.

Resettlement can be defined as the movement of animals from the place of birth to the place where they breed.

There are two types of settlement: ***natural and forced.*** **Natural dispersal** refers to spontaneous movements that are caused not by external conditions, but by the genetic characteristics of the individuals being dispersed. **Forced dispersal** is a behavioral response of animals to unfavorable external conditions, such as lack of food or living space. In this case, natural dispersal is similar to diffusion, while forced dispersal is similar to processes that occur under the influence of selection.

Flora and fauna similarity indexes

To compare communities in different habitats and to analyze their changes along the studied gradient, a number of indices of similarity of flora and fauna based on the proportions of common and different species in the compared pair of taxonomic sets are used. The analysis is carried out in the following steps.

1. The first step is comparison. Lists of all species found in both ecosystems under study are compiled, and it is noted whether each species is found in a given community. Then a table is built where the following values are entered:

a	b
c	d

where a is the number of species that occur in both compared communities;
b is the number of species that are present only in the first community and not in the second;
c – the number of species that are present only in the second grouping and not in the first;
d – the number of species that are absent in both groups but are present in other lists from all the data.

The first two of the indices proposed below do not take into account the value of d and use only data on the presence or absence of each species considered in the comparative lists, while the calculation of the other two requires information on the number of each species in both groups.

2. The second step is to determine the similarity indices.

The Chekanovsky-Serensen`s index determines the ratio of the total number of species to the arithmetic mean of the number of species in the two lists:

$$I_{CS} = \frac{2a}{(a+b)+(a+c)} \times 100$$

This index expresses the percentage of similarity in species composition of biocenoses, for example, at two test sites; $I_{CS} = 0$ if there is no common species, $I_{CS} = 100$ if all species are common to the two sites (communities).

The degree of dominance of each species is not taken into account, as it is when using the **Jaccard`s index**, which determines the ratio of the total number of species to the number of species in the combined list:

$$I_j = \frac{a}{a+b+c} \times 100$$

The Renkonen`s index takes into account the level of relative dominance of individual species, but is quite sensitive to the presence of clear dominants in the community, which, however, may not fully characterize the cenoses under consideration:

$$I_D = \Sigma\ d_i^{min},$$

where d_i^{min} is lower (of the two sets) value of the index of relative species dominance i, where $i \in [1; s]$.

Almost identical to the Renkonen`s index, **the Rogers-Schöner overlap index**:

$$C_{jk} = 1 - 1/2 * \Sigma\ |p_{ij} - p_{ik}|,$$

where p_{ij}, p_{ik} is the share of the *i-th species* in the total number of individuals in samples j and k (i.e., the same indicators di, but only in fractions of one).

If the Rankine and Rogers-Schöner indices are equal to zero, the groupings being compared are completely different; if $I_D = 100$ and $C_{jk} = 1$, they are identical.

Assessment of the age diversity of individuals in the population

The level of age diversity reflects the population's response to selection pressure, the different direction and intensity of which largely determines the age structure. High diversity contributes to population stability, as different life cycle stages have different resilience to environmental factors. In extremely unstable, marginal habitats (as well as under severe anthropogenic stress), the age distribution can be greatly simplified.

The nature of the age diversity of the population can be characterized mathematically using the **age heterogeneity index** (∇):

$$\nabla =(\Sigma P_i^2)^{-1},$$

where P_i is the proportion of individuals of the i-th age group.

Methods of growth process analysis

Growth of an organism can be defined as an irreversible increase in the dry mass of protoplasm.

Growth processes of organisms can be studied from several angles:

chronological growth – features of growth of linear dimensions of an organism (or its weight) over time;

r*elative or allometric growth* – the ratio of growth of individual parts of the organism to the whole.

The biological meaning of the equations used to describe linear (or weight) growth is that after a certain point in time, the value of the parameter reaches the maximum possible (for a given population or species), but never exceeds it. Asymptotic equations (Bertalanffy equation) or logistic equation are better for functional description of growth patterns.

The Bertalanffy equation (for linear growth) (Fig. 33) is as follows:

$$L_t = L_{max} (1 – e^{a+b*t}),$$

where L_{max} is is the theoretically maximum possible value of the size of a given organism in a given population, L_t is the size of the organism at time t.

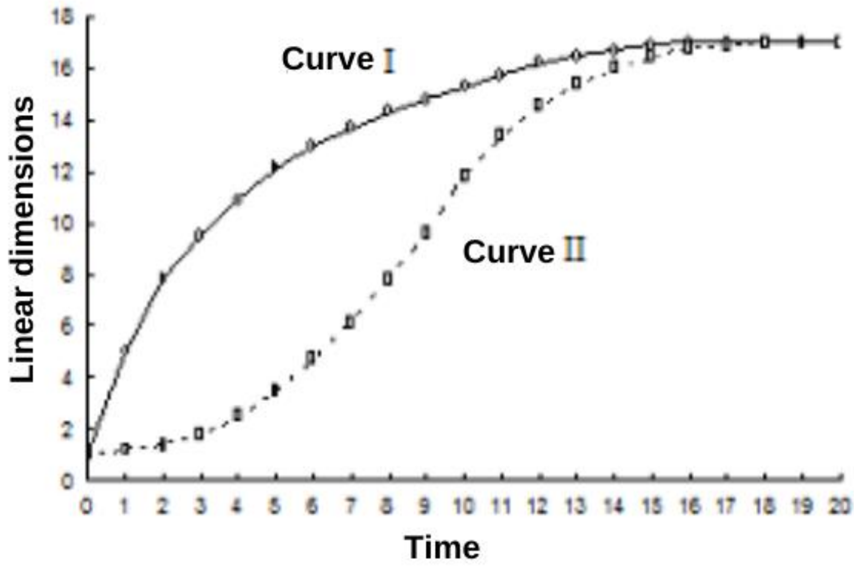

Fig. 33 ***The Bertalanffy equation*** (for linear growth)

The L_{max} value can be determined by **the Ford-Walford method**. This method assumes that the L_{max} value corresponds to the solution of the system of equations:

$$L_{t+1} = a + b * L_t,$$

$$L_{t+1} = L_t.$$

In addition, the L_{max} value can be determined by the formula:

$L_{max} = L_{max}/0,95$, where $L`_{max}$ is the maximum possible empirical value of a given trait in a given population.

After the transformation, the Bertalanffy`s equation can be represented in a linear form, for which the values of the parameters "a" and "b" are found by the least squares method:

$$\ln [1 - (L_t / L_{max})] = a + b * t.$$

The logistic equation is:

$$L_t = L_{max}/(1 + e^{a+b*t}),$$

For the Bertalanffy`s equation, the logistic equation is transformed to a linear form:

$$\ln [(L_{max}/L_t) - 1] = a + b * t.$$

Equations are used to describe the weight growth of organisms:

$$W_t = W_{max} (1 - e^{a+b*t})^3 ,$$

where parameters W_{max} and W_t have the same meaning as in linear growth equations.

After transformation, this equation can be represented in linear form:

$$\ln [1-(W_t/W_{max})^{1/3}]=a+b*t.$$

Entomological biodiversity assessment methods

Methods of researching the current state of entomological biodiversity

It is convenient to study the state of entomological biodiversity of agro-landscapes based on the life forms of insects of constant and dominant species. For faunal studies, representative samples from populations are obtained, they are compared with registers of known species, and the real state of biodiversity of agro-landscapes is determined. The next stage is the compilation of lists of species biodiversity known in Ukraine of constant and dominant species of the main ecological groups of insects by life forms: geophilous (gabions, herpetobionts) and phytophiles (hortobionts, dendrobiums), which is the basis for determining the real state of the entomofauna of agricultural landscapes.

According to the results of remote sensing of the earth (DZZ), the structure of the agrolandscapes of Ukraine is analyzed (by natural zones: Steppe, Forest-Steppe, Polyssia). To analyze the components of the agricultural Entomological biodiversity assessment methods.

Methods of researching the current state of entomological biodiversity

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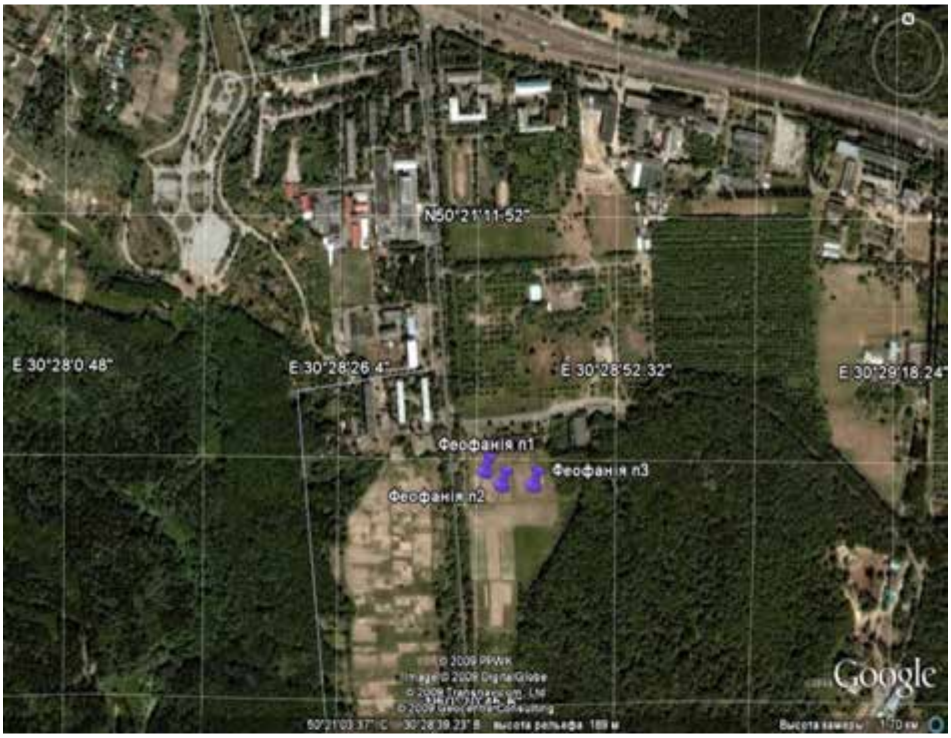
According to the results of remote sensing of the earth (DZZ), the structure of the agro-landscapes of Ukraine is analyzed (by natural zones: Steppe, Forest-Steppe, Polyssia). To analyze the components of the agricultural landscape, Google Earth photos are used (Figs. 34–37). Areas of ecosystems of various natures are selected as sites of record: biocenoses, agrocenoses, trees and shrubs, herbaceous vegetation in semi-natural ecotones, and soil environment.

Analytical-synthetic, ecological-statistical, and experimental methods are used, tested, and recommended for field and laboratory research in entomology, plant protection, and ecology.

Collection of entomofauna is carried out according to generally accepted methods once every 7–10 days at stationary sites. The taxonomic affiliation of biological collections is determined using entomological determinants.

Indicators of entomological biodiversity are evaluated by species richness and the Shannon-Weaver index, which are calculated according to M. Bigon



Pic. 34 Placement of Barber's traps in the Feofania tract (data from DZZ Google Earth)

Pic. 35 Placement of Barber's traps in the agrocenoses of the village of Tarasivka (data from DZZ Google Earth)

Pic. 36 Permanent sites for the study of entomological biodiversity in the agrocenoses of the village of Danylivka (data from DZZ Google Earth)

Pic.37 Permanent research sites of entomological biodiversity in the agrocenoses of the village of Muzychi (data from DZZ Google Earth)

Collection of hortobiont insects is carried out by mowing with an entomological net during the growing season according to standard methods in the accounting plots, which are located according to the matrix scheme (4 × 10) at a distance of 25 m from each other, and with the help of catching on yellow glue traps.

Methods of accounting for insect herpetobionts

Barber's traps (jars with a volume of 0.3–0.5 l, glass or plastic) are buried in the soil in such a way that their throat is at the same level as the soil surface. Alcohol, formalin, etc. are used to fix caught insects).

Catching grooves 3–4 m long are dug to a depth of 7–10 cm from the soil surface. The walls are vertical and smooth. It is advisable to use fishing grooves together with Barber's traps, placing the latter at the ends or intersections of two grooves.

Barber's traps and fishing grooves are used to record insects that actively move along the soil surface. For the completeness of the characteristics of the entomofauna of herpetobionts, an additional examination is carried out under stones, clods of soil, tree trunks, etc.

Methods of accounting for insect hortobionts

The entomofauna of any type of grass cover is recorded by mowing with a net, with the help of an exhauster, a biocenometer, or visually observed.

During the research, the method of mowing with an entomological net was used. To do this, choose a typical area for this area, and mow it in the direction of the sun. Grab the net in your hands at a distance of 1 m from the ring. Energetic movements are carried out on the surface of the plants to the right and the left with an amplitude of about 180 degrees. With each new wave, they take a step forward. 25–50 such double sweeps are made (50 and 100 single sweeps, respectively), after the last sweep the net is moved closer to itself, and the collected insects are quickly shaken in the air to the bottom of the net and poured into a prepared jar (stain) with ether or alcohol and closed. In the laboratory, the contents of the stain are poured onto a sheet of paper, and plant parts are selected, and carefully examining them. The insects are preliminarily sorted into systematic groups and counted, the results are entered into a table and the insects are placed on a mattress with a label.

An exhauster is used to collect small insects. This is a test tube or a wide-mouthed jar with a stopper. 2 thin (0.5 cm) glass tubes are inserted into the cork, and a rubber tube is pulled over one of them. The opening of the free tube is brought closer to the insect and air is drawn through the rubber tube. In this way, the insect is drawn in and transferred to a test tube (jar).

Methods of accounting for phyllophage insect

1. Survey of trees: small specimens of trees (shrubs) are selected for accounting. Identified insects are counted, and data are entered in a diary. Determine the percentage of trees inhabited by one or another species, the average

number of individuals found on a tree in the visible part. Note the height at which the inspection was carried out.

2. Tree dusting: dusting is carried out early in the morning or cloudy weather, when insects are less active. Insects are shaken on a tarpaulin placed under a tree or shrub.

3. Mowing with a net on the branches of a tree or bushes: shake the insects into the net.

4. Accounting for damaged leaves: several categories of damage are distinguished: solid – the insect eats the entire leaf, the petiole remains; marginal – the leaf is eaten away from the edge; perforated – insects eat through holes in the leaves; window-shaped – more or less small areas are eaten away on the plane of the leaf, the upper or lower skin remains intact; skeletonization – the pulp and skin of the leaf are eaten, the veins remain intact; mining – arthropods that have penetrated through the epidermis in one place, eat the parenchyma, leaving traces in the form of spots of various sizes and shapes, winding lines; speckled – spots of brown, yellow, white, black color formed from leaf sucking; galls – tumors of different sizes, often collected in the form of a flower from leaves on willows; tubular – a leaf (leaves) rolled into a tube of various configurations; web nests – insects fasten leaves with webs when feeding. Leaf counts are carried out on 5–10 model branches, the branches are not cut.

5. Accounting for damage according to the degree of eating leaves. A method is used for direct determination of the extraction area of the leaf surface (weight method, pallet method), and determination of the relative degree of extraction. In this case, the nature of the damage is established as follows: there are traces of damage, the leaves are eaten by 5% – 1 point; 2 points – weak damage, leaves eaten by 5–25%; 3 points – medium damage – leaves eaten by 25–50%, 4 points – severe damage, leaves eaten by 50–75%; 5 points – complete damage – leaves are eaten by 75–100%.

When characterizing damage to plants by aphids, the degree of colonization of plants by these insects is taken into account on a 4 – point scale: 0 – aphids are absent, 1 – individual aphids, 2 – single specimens occupy up to 50% of leaves (branches), 3 – colonies occupy more than 50% of leaves (branches).

Accounting for soil insect (geobionts)

It is carried out in different ways, depending on whether they live in the soil or the soil litter on the surface of the soil.

Determining the number and condition of insects in the soil is carried out by excavation. Samples during excavation will be taken in three types: small, ordinary, and deep. Small samples (up to 10 cm deep) are used to record a relatively limited group of insects (cocoons of the meadow butterfly, pea fruit-eater, young caterpillars, scoops, pupae of the transient moth, etc.). Conventional samples (up to 45 cm deep, more often 30–35 cm) were used when recording most insects living in the soil. Deep soil samples (up to 65 cm, sometimes up to 1 m) are used to record some lamellar beetles (especially beetle larvae), gray beet weevil larvae, some thrips, and other phytophages living in deep soil layers.

Fields are placed evenly on the plot to survey the edges and the middle of the plot. Samples are placed on the examined area diagonally or evenly across the entire area (in a checkerboard pattern).

The sizes of soil samples depend on the method of extraction of insects. Thus, when manually sampling insects from the soil, square samples of 0.25 m^2 (50X50 cm) are most often laid. From each sample, the soil is removed layer by layer: the first layer is 5 cm deep, and each subsequent layer is 10 cm deep. When using the washing method, all layers must be taken 5 cm apart. Insects are selected, counted, and determined separately for each layer.

On narrow long areas (road edges, irrigation canals) placement of samples with a "snake" is used. On homogeneous areas of a small area, soil samples are placed along two mutually intersecting diagonals.

The manual sampling method is also used. On the surface of the soil, with the help of divisions applied to the shovel, a site of the required size is measured, and the edges of the site are dug up. The soil taken from the sample is placed on a substrate (plywood, tarpaulin, film), and then insects are removed from it by hand. All live and dead insects are picked from the soil and placed in a jar with a strong solution of table salt. If the excavation is layered, then as many jars are used for each area as there are layers.

The sieving method is suitable for dry and slightly moist soil. This method uses a set of soil sieves with holes of different sizes. The soil sieves are stacked in such a way that the sieve with the holes of the largest diameter is on top, and the sieve with the gradually decreasing diameters of the holes is below. The soil from the sample is passed through a set of these sieves in small portions. Large insects remain on the upper sieve, smaller ones on the intermediate one, and the smallest ones on the lower sieve.

The washing method is the most accurate method of extracting insects from the soil. With this method, it is possible to extract almost all, even the smallest, objects from the soil sample. Three metal basins are half-filled with water, a soil sample is dipped into the first basin and thoroughly stirred with a stick. Then the second sample is immersed in the second basin and also stirred. The third sample is placed in the third basin and also mixed. Most of the insects in the basins float up. They are collected from the surface of the water in a test tube and the sample is mixed again.

GLOSSARY

A

Abiotics – the whole complex of physical and chemical characteristics of the inorganic environment that influences organism. The temperature, light, water, in salt, oxygen, magnetic field of earth, physical and chemical properties of soil and others like that belong to the basic factors of AE.

Abundance – the total number of individuals of a taxon or taxa in an area, population, or community.

Aerobic, aerobic organisms – organisms that need for their lives presence of oxygen. To A. belong the majority of animals, all plants, as well as a significant part microorganism. Among the latter obligate distinction (unconditioned) A. (aerofily) and facultative (conditional) A, can survive with small amounts of free oxygen and even without it (due to oxygen nitrates, sulfates and other compounds). The first group includes, (for ex., Acetic acid bacteria, the second – yeast, denitrifying bacteria and others.

Aquatic life – organisms that lives in aquatic habitat.

Artificial parthenogenesis – artificial induction of virgin (without fertilization) of eggs using any chemical or physical factors. (for ex., AP was obtained by B. Astaurov at silkworm using effects on insect eggs increased temperature, it leaded to the birth from these eggs only of females that are genetically identical to their mothers.

Arboretum – a plot of land on which many different trees or shrubs are grown for study or display.

Assimilation – one of processes of metabolism which consists in mastering of matters an organism. These substances are converted into compounds that are constituents of the body. In large quantities part of the protein of animals and plants play an important role in the reactions of the urea cycle and transamination is involved in the biosynthesis of purine and pyrimidine precursor in the synthesis of some essential amino acids (see essential amino acids) in plants and microorganisms.

Autotrophs – organisms which synthesize from inorganics all organic matters, that are needed for life, using energy of photosynthesis (green plants, algae, phototrophic bacteria) or chemosynthesis (see *Chemosynthetic bacteria*).

Autoinhibitors of adaptation – organisms cproduce or generate these substances and ensure to safe of population within balance, supported the environment.

Auxotrophs – microorganisms (bacteria, fungi or algae), which lost as a result of mutation ability to synthesize substances from simpler precursors one of the substances needed for their growth (base, vitamin, etc.), so that they can grow on depleted environment; to ensure normal growth in medium A. should add appropriate nutrients (for ex.,amino acids, vitamins, nitrogenous bases, etc.).

Adaptation – adjustment in natural or human systems to a new or changing environment.

Alien species – a species, subspecies or lower taxon, introduced outside its natural past or present distribution; includes any part, gametes, seeds, eggs, or propagules of such species that might survive and subsequently reproduce.

Alternative energy – energy produced from sources other than fossil fuels (solar, wind, hydroelectric,geothermal, and biomass).

Alternative agriculture – agriculture based on reduced use of chemical fertilizers and pesticides, increased use of crop rotation, and reduced tillage of the soil.

Amensalism – an interaction where an organism inflicts harm to another organism without any costs or benefits received by the other.

Suspended animation – the slowing or stopping of life processes by exogenous or endogenous means without termination.

Antagonism – the result of the interaction between organisms in which one benefits at the expense of the other.

Anthropogenic – based on human activities; often used to refer to environmental changes caused by human activity.

Apoptosis is important for regulating the differentiation, homeostasis and the transformation of organs and tissues. With apoptosis internal or external factors, activating the genetic program that leads to cell death and its efficient removal of tissue; including apoptosis plant cells infected infecting agent, prevents the spread of infection. Apoptosis is characterized by activation of endogenous nelizosomnyh endonucleases that cleave the nuclear DNA into small fragments. Regulation of apoptosis by using different molecular mechanisms.

Species area of distribution – the area contained within the shortest continuous imaginary boundary which can be drawn to encompass all the known, inferred or projected sites of occurrence, excluding cases of vagrancy and introductions outside its natural range. The area within the imaginary boundary should, however, exclude significant areas where the species does not occur, and so, in defining an area of distribution, account should be taken of discontinuities or disjunctions in the spatial distribution of species.

B

Benthos – organisms living at the bottom of an aquatic environment.

Bacteria – a large group of mostly single-celled or combined in groups prokaryotic microorganisms with the cell membrane, cytoplasmic membrane, cytoplasm and cell amorphous nucleus without membrane. The sizes of bacteria are on average 0.5–5 microns. According to the modern classification of all prokaryotes clearly divided into two categories: small group of archaebacteria (*Archaebacteria* – «ancient bacteria"), and others called eubacteria (*Eubacteria* – «true bacteria"). There are following group of B. relatively to peculiarities of the morphology: cocci (more or less spherical), bacilli (rods or cylinders with rounded ends), spirillum (rigid helix forms) and spirochetes (thin and flexible form) that reproduce by simple division.

Biocenosis, biocenose, biocoen – a complex of living organisms (animals, plants and microorganisms) inhabitates of the area with environmental homogeneous conditions, is located in the close depending on the environmental factors. B. There are resistant (stored for several decades or more) and cyclical (rapidly changing). B. is the part of the biogeocoenose (see *Biogeocoenosis*).

Biochemical luminescence – shine of the living organisms or their individual organs and tissues (including those not visible to the naked eye) that occurs due to the energy of biochemical reactions that occur in them; B. phenomenon uses to assess the damaging action of many unfavorable and toxic factors, assess the suitability preserved organs and tissues, etc.

Biological Safety – the collection of handling and containment procedures, guidelines, and precautions that protect humans and the environment from exposure to biohazardous agents or materials.

Biogeocoenosis – the homogeneus ground or water surface area with a definite composition of living (biocoenosis) and inert (lower layers og the atmosphere, soil, water, solar energy) components and the dynamic interaction between them (exchange of matter and energy).

Biodégradation – the process of decomposing organic matter and substances as a result of the action of microorganisms.

Bioethics – a field of study concerned with the ethics and philosophical implications of certain biological and medical procedures, technologies, and treatments, as organ transplants, genetic engineering, and care of the terminally ill.

Biocommunication – communication within or between species of plants, animals, fungi and bacteria, by such means as vocalizations or chemical signals (Chemical, mechanical, optical, electrical, etc.) or nonspecific signals (related life). B. helps find food and favorable conditions of stay, facilitates protection from enemies and harmful influences, helps the interaction of parents and offspring, regulates relations between individuals of different groups etc. The most common channel of communication –

chemical; (for ex., using of pheromone (see *Pheromones*) males of some fish accelerate maturation of females, synchronizing of breeding population.

Bioaccumulation [Greek *bios* – life and lat. *accumulatio* – accumulation] –1) is the process of accumulation of any harmful substances in the organism with appropriate food chain. At each new level of the chain dose received from food hazardous substances is significantly increased. For ex., in the food chain (plankton – fish – people) is increasing the dose to two orders of magnitude. Other chains dose can be increased to thousands and thousands of times; 2) the process of accumulation in soil or water chemical elements and inorganic compounds in animal decomposition of plant residues. B. increases the amount of humus in the soil.

Biodiversity – the variability among living organisms from all sources, including, inter alia, terrestrial, marine and other ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems. Synonyms: biological diversity, ecological diversity.

Bioindicators – are a species that can be used to monitor the health of an environment or ecosystem. They are any biological species or group of species whose function, population, or status can reveal the qualitative status of the environment. One example of a group of bio-indicators is the copepods and other small water crustaceans that are present in many water bodies. Presence, abundance, structure and features of these organisms serve as an indicator of natural processes, conditions or anthropogenic changes in habitat. Application of B. for evaluation of various processes and environmental conditions (bioindication) base on a narrow adaptability of organisms and their communities to certain biotic and abiotic factors. For ex., piscivorous birds cluster indicates those areas of the reservoir, where the fish; microflora composition of water - its purity and quality of drinking; composition of soil organisms (microorganisms and invertebrates) – its fertility. B. is also the so-called Indicator plants (see *Indicator line, indicator species*).

Biological control, biocontrol – the practice of using of useful natural organisms for regulation of harmful plants (weeds), agents of plant diseases, insect pests and parasites of animals; can be an alternative or complement to other (for ex.,chemical) methods of control; 2) control the size of some organisms as a result of predation of others; 3) systematic sampling in humans and other biological objects in order to analyze the concentration of environmental pollutants, food metabolism and biotransformation (for ex.,B. control is an effective method of sterilization).

Biological diversity, biodiversity, biovariety – the variety of all living organisms from all sources on Earth, up to and including terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; This concept includes diversity within species, between species and of ecosystems. The definition of "B.d." was adopted at the UN Summit in Rio de Janeiro in 1992

Biological monitoring – periodic monitoring of biological objects to estimate and forecast their susceptibility to the effects of toxic chemical agents environment (analysis of toxic substances and their metabolites in body fluids and organisms).

Biological restoration, bioremediation – The using of organisms (e.g., plants, bacteria, fungi, etc.) to consume or otherwise help remove (e.g., biorecovery) materials (e.g., toxic chemical wastes, metals, etc.) from a contaminated site (e.g., remove toluene from the land and ponds on site of an old refinery, etc.).

Biological resurces – are the complex of genetic resources (see *Genetic resources*), organisms, populations and any other biotic component of ecosystems with actual or potential utility (value) for humanity. B.r. include industrial facilities, crops, livestock, forests, scenic landscapes, etc.

Biomass – total mass of individuals in a population of one species, groups of species or populations or groups of organisms, usually expressed in units of mass of dry or wet substance per unit area or volume of any seat (kg/ha g / m^2, etc.). B. of plants called phytomass, B. of animals – zoomass, B. of microorganisms – a mass of microorganisms. Annual production of the plants is around 170 billion tons of dry B., and annual production of animals – 909 million tons on land and 3025 million tons in the ocean. There is B. of consuments, producers; decomposers, etc. (See also *Bacterial mass, biomass of bacteria*).

Biome – a major portion of the living environment of a particular region (such as a fir forest or grassland), characterised by its distinctive vegetation and maintained largely by local climatic conditions.

Bionanotechnology [Greek *bios* – life, *nanos* – one billionth part, *techne* – art, skill and *logos* – teaching] – technology, combining methods and techniques of biotechnology (see *Biotechnology*) with nanotechnology (see *Nanotechnology*). For example, it can be creating of nanoparticles containers for directed drug delivery, nano-robots that destroy cancer cells and aging and so on.

Bioremediation – The use of organisms (e.g., plants, bacteria, fungi, etc.) to consume or otherwise help remove (e.g., biorecovery) materials (e.g., toxic chemical wastes, metals, etc.) from a contaminated site (e.g., remove toluene from the land and ponds on site of an old refinery, etc.). It is removal of foreign or harmful agents from the air, water and soil using living organisms (microbes, plants, algae, etc.) to facilitate filtering and / or degradation of these impurities and restores the original properties of the elements of the environment. (for ex.,for B. of wastewater widely used "omnivorous" Gram-negative bacteria genus Pseudomonas, which can dispose of naphthalene, toluene, alkanes, camphor, phenol compounds specific components of oil and insecticides, herbicides and others xenobiotics (see *Xenobiotics*).

Biosensor – specialized analytical device is based on certain *types* of organisms, complex organisms, cells or isolated from their enzyme systems and specific biological substances that are sensitive to certain chemicals (for ex.,to toxins or complex). So, *Neurospora europea* is used to determine NH_3, *Trichosporon brassiacae* – to determine of the acetic acid. B. usually consist of two components: the biochemical nature of the recognition system (receptor) and physico-chemical converter (transducer). In the first stage of B. action, bioelements "recognition" of the specific substances from multicomponent mixtures and, on the second stage, information about the biochemical reactions transformate in the form of electrochemical signal; on the last stage, the electrical signal from the transducer is converted into a suitable form for processing. There are electrochemical, optical and other proteins of B. Nanosensors are created from gold nanotubes with a conical shape inside the mechanically and chemically resistant polymer membrane. B. are used in engineering, medicine, food industry and environmental protection.

Biosphere – shell of the Earth, the composition, structure and energy of B. are determined by the overall activity of living organisms. The constant movement (migration) of the molecules goes in B. as a result of living life; they move from the atmosphere in hydrosphere, in the Earth's crust and close its circulation, returning to the original environment. B. coveres part of the atmosphere (by the ozone screen), part of the lithosphere, especially weathering crust, and all hydrosphere.

Biota – all living organisms, that exist within a given area or period.

Biotechnosphere – transition from the biosphere to the noosphere. A characteristic feature of this period is a combination of natural and conscious, negative and positive impact of human activity on the environment. The term "B." was proposed by A. Sidorenko in 1980.

Biotic environment – is the complex of organisms, whose livelihood affects on the other organisms. Some of them may serve as food for others, be habitat, promote reproduction and others. Effect of B.en. factors evidents in the mutual influence of different kinds of organisms on each other unlike the abiotic factors of environment (see *Abiotic environment*).

Biotic factors – factors of the living environment, that effect on the livelihoods of organisms. Effect of B.f. appears in the form of mutual influence of one organism on the livelihoods of others and in their entirety on the habitat. There are direct and indirect relationships between organisms (See also *Biotic environment*).

Biotic potential, reproductive potential – are species-specific characteristics of the internal potential ability of some population to grow at a stable age structure and optimal environmental conditions; B.p. expresses as dimension of population increase per unit time in computation per individual.

Biotope – a small geographical unit occupied by a community of plants and/or animals and characterized by a high degreee of uniformity in its main climatic, soil and biotic conditions.

Botanical garden – A place where plants are cultivated for scientific, educational, and ornamental purposes, often including a library, a herbarium, andgreenhouses; an arboretum.

Buffer zone – a designated land or water area along the edge of some land (often nature or other reserves) use, whose own use is regulated so as to absorb, or otherwise preclude unwanted development or other intrusions into areas beyond the buffer.

Buffer – solution that preserves the pH (see pH) at a constant level; a mixture of weak acid and its salts (for ex.,CH_3COOH and CH_3COONa) or a weak base and its salts (for ex., NH_3 and NH_4C1). The pH buffer does not change when you add a small amount of free acid or alkali, dilution or concentration. B. is widely used in most molecular genetic, microbiological and cytohistology methods based on chemical reactions that occur in solution (liquid media).

Buffer capacity – is the ability of the buffer (See *Buffer, Buffer solution*) to maintain of the buffer pH due to the elements number, from which it consists. For ex., B.c. of natural water – its ability to maintain an active reaction medium (pH) in acids and alkalis; ability to cleanse water of pollutants. Bicarbonate acid-base buffer system has the largest buffer B.c. among all B. systems.

C

Camouflage – structural adaptation that enables species to blend with their surroundings; allows a species to avoid detection by predators.
Carrying capacity – the maximum number of organisms of a given species that can be supported in a given habitat or geographic area.

Catabolism – a complex of biochemical reactions in the body, aimed at splitting of complex compounds that are the part of the organs and tissues as their building blocks (proteins, nucleic acids, phospholipids, etc.) or are deposited in them as spare material (fat, glycogen, etc.). As a result of C complex of compounds lose their inherent specific features, becoming a substance partly used for a new biosynthesis or partially removed from the body (intermediate and end products of metabolism). The main process in C. - biological oxidation (a complex of oxidation - breathing and oxidative phosphorylation), there is a continuous release of energy at the cellular level. C is a process opposite to anabolism (See *Anabolism)* and is closely associated with him. C is a dissimilation (See *Dissimilation*) at the cellular level.

Catabolite repression – is the slowing or stopping of the synthesis of enzymes involved in the catabolism (See *Catabolism*). (for ex., at the bacteria the lactose operon, encoding enzymes of metabolism of lactose, is repressed in the presence of glucose.

Chemosynthesis – is type of autotrophic nutrient, synthesis of organic compounds by chemosyntetic bacteria (see *Chemosyntetic bacteria*) from carbon dioxide using the energy, released during the oxidation of chemical compounds. For ex., ferrobacteria oxidate of ferrous iron to ferric; sulfur bacteria oxidate of hydrogen sulfide to molecular sulfur or sulfuric acid salts.

Chemosynthetic bacteria – bacteria that perform chemosynthesis (see *Chemosynthesis*). CB are not only one taxonomic group and systematized depending on oxidate of inorganic substrate. Aerobic CB (Hydrogen, nitrifying, tion, etc.) absorb CO_2 also in photosynthesis; anaerobic CB reduce of sulfur compounds and CO_2. CB have an important for the agryculture. Nitrifying soil bacteria (see Nitrifying bacteria) form of ammonium nitrate (see *Nitrification*), sulfur bacteria (see *Sulfur bacteria*) are involved in the formation in the soil available to plants sulfates, methane-producing bacteria (see methane-producing bacteria) are used to produce of biogas from organic waste; play an important role in biogeochemical cycles in the biosphere.

Chemostat – the device that is used for growing bacteria and cell cultures, which automatically adjusts the removal of culture and revenues fresh culture medium; C design provides the ability to change individual parameters cultivation to assess their effects on bacterial culture. One component of the culture medium in C is limited, providing constant exponential population and allows adjusting its speed (substrate delimitation). The lack of a nutrient leads to slower growth rate. The vehicles (turbistaty) (see *Turbistat*) are used to deal with this shortcoming, in which the flow of fresh culture medium is regulated by phototurbidimetric way.

Chemotaxis – the movement of an organism in response to a chemical stimulus.

Coefficient of variation – at statistics is a measure of the relative dispersion of random variable; the percentage of standard deviation to the arithmetic mean of the data values.

Compensation – 1) organism reaction on the violation of it life, during which intact bodies or their parts assume the function of damaged structures; 2) recovery of normal organism develop after the interruption at previous stages; 3) substitution in the evolution of one system or another system or organ of the organism; 4) replacement of missing features, or present a small amount by another; 5) C. of gene dose is the gene inactivation of one of the two X chromosomes in women (See *Lyonization*).

Cultivar (cultivated variety) – diversity of culture, a complex of cultivated plants that are significantly different in certain morphological, cytological, physiological or other grounds and keep these differences in various types of sexual or asexual reproduction.

Cultivated species, domesticated species – species, that is used in human practice. CS usually are called plants and to designate of CS of animal notion – "domesticated species".

Cytoplasmic membrane – a thin surface layer of cytoplasm adjacent to the cell membrane and has a high density; it contains numerous folds, crinkles and pores that allow you to adjust the passage through it of various substances. CM is high selective filter, it is support the ion concentration from differences on both sides of the cell and allows nutrients to penetrate cells, and the product of selection – to go outside. CM consist of a double layer of phospholipid molecules and built-in or with related protein and non-protein complexes origin, including steroids, prostaglandins, metal ions, etc.

Climax – the final stage of biotic succession attainable by a plant community in an area under the environmental conditions present at a particular time.

Climax community – a stable mature community in a successive series which has reached equilibrium after having evolved through stages and adapted to its environment

Coevolution – type of evolution where two or more species having a close ecological relationship evolve together such that one species adapt to the changes of the other, thereby affecting each other's evolution.

Colicin – a protein antibiotic (See *Antibiotics*), produced by some strains of *E. coli* and exhibits of the bactericidal effect; plays an important role in the regulation of intestinal microbiome. Colicinogenic bacteria are resistant to their own C. C usually form under the action of ultraviolet radiation or chemical mutagens. Mechanisms of C bactericidal action depends on its type (some C destroy of DNA and other split of the ribosomal RNA, to inhibit the synthesis of peptidoglycan cell wall, etc.); (See also *Bacteriocins*).

Colon bacillus, coli bacteria, *Escherichia coli, E.coli* – is Gram-negative bacterium, belonging to the *Enterobacteriaceae* family, which lives in the intestines of animals and humans. *E.coli* are mobile, do not form spores, facultative anaerobes. It is widely used in genetic engineering to clone genes and as producer of biologically active compounds. It was first described by Theodor Escherich in 1885 (lat. name on its behalf). *E.coli* is studied better than all other microorganisms. It short reproduction time and ease of cultivation makes it possible to quickly accumulate a large amount of material. Iits genetics and molecular biology are well studied. *E.coli*, like other gram-negative bacteria, has a complex structure of the cell wall, including of the external lipopolysaccharides membrane, protein and cell wall glycans and the inner plasma membrane. The latter is a typical phospholipid bilayer, containing of embedded in it proteins. *E.coli* in large quantities is part of the normal microflora of the large intestine. It synthesizes vitamin K and provides the protection against other bacteria. *E. coli* causes of disease, sometimes severe in the case of its penetration through the mucous membrane of the intestine in those tissues and organs that normally sterile (for ex., in the abdominal cavity at violation of the integrity of the intestinal wall into the bladder or blood).

Colloidal solution – is a liquid, containing particles in suspension, which can not penetrate through biological barriers. CS of different metals is used in medicine. CS includes blood products and synthetic substitutes. R. Zsigmondy was awarded the Nobel Prize in 1925 for establishing the heterogeneous nature of CS and the development of methods that are fundamental in modern colloid chemistry.

Commaless genetic code – Successive codons that are contiguous and not separated by noncoding bases or groups of bases. Bacterial genes do not have introns (q.v.), and therefore the sequences of amino acids in polypeptides and of codons in the gene are colinear. Most of eukaryotic genes contain coding regions called exons (specifying amino acids) interrupted by noncoding regions called introns, and in these situations the code is said to contain commas. It is lack of coding nucleotide sequences of the bacterial genome (ie between triplets) one or more non-coding nucleotides (ie no "com" between columns – «commaless»), which is shown in full collinearity gene and the encoded polypeptide.

Commensalism – a type of relationship between two species in which one lives with, on, or in another without damage to either.
Competition – an interaction between organisms or species in which the fitness of one is lowered by the presence of another.
Community (biological) – an assemblage of organisms characterised by a distinctive combination of species occupying a common environment and interfacing with one another.

Concentration – is the value, expressing of the relative number of component definition (independent component part) in a physical-chemical system (mixture, solution, alloy). The following methods of C expression are most often used: partial C by weight – ratio of the component weight to the mass of the entire system, atomic (molar) partial C – the ratio of gram atoms (moles) of the component to the total gram atoms (moles) of the system; partial C volume - ratio of the component volume to the total system volume. C of the liquid systems often express the weight of a substance dissolved in 100 g (sometimes 1 L) of the solvent or the number of moles dissolving the substance in 1 liter of solution. In volumetric analysis C is expressed by normality (number of gram-equivalents of the active part of the solution to 1 liter) and titles (number of grams of active ingredient in 1 ml).

Consortium – a group of interspecific semiosic links in biocoenosis.

Consumer – a organism that generally obtains food by feeding on other organisms or organic matter due to lack of the ability to manufacture own food from inorganic sources; a heterotroph.

Correlation – a relationship or connection between two things based on co-ccurrence or pattern of change.

Cosmopolitan – species, family or other taxonomic groups which growing or occurring in many parts of the world; widely distributed.

Cotransfection – the method of genetic engineering (See *Genetic engineering*), the simultaneous transfection host cells with two recombinant DNA of different types: one is usually plasmid vector, carrying a selective marker and another - a vector plasmid without selective marker. Selection of transfectants is carried on the first vector, because transferring of both recombinant DNA occurs in a cell at the C with very likely (> 80%) at the same time. C also is called of double transfection; it is advisable to use in experiments in which there is a problem of selection of cells transfected with the gene without encoder selective marker.

Crypsis – the ability of an organism to avoid observation or detection by other organisms.

Cryophyte – a organism, that grows on snow or ice.

Cytoplasmic membrane – a thin surface layer of cytoplasm adjacent to the cell membrane and has a high density; it contains numerous folds, crinkles and pores that allow you to adjust the passage through it of various substances. CM is high selective filter, it is support the ion concentration from differences on both sides of the cell and allows nutrients to penetrate cells, and the product of selection – to go outside. CM consist of a double layer of phospholipid molecules and built-in or with related protein and non-protein complexes origin, including steroids, prostaglandins, metal ions, etc.

D

Decant – isolating of solid phase system from a liquid system by mechanical draining of the liquid from the settled sludge; used for the extraction of soluble substances from solid powdered materials.

Degradation – the act or process of damaging or ruining something.

Degeneration – 1) degeneration, deterioration from generation to generation of the biological or economic properties of the organism as a result of unfavorable living conditions; (for ex.,in microbiology – the weakening of the vitality of culture of unicellular organisms under adverse growing conditions; 2) the same as biological reduction, ie simplifying the structure or almost complete disappearance of the process of ontogeny that have evolutionary value (for ex.,the disappearance of the rudiments of gills in terrestrial animals); 3) degeneration, deep structural changes in the tissues of the body that often accompanied by the appearance in these matters, far from this tissue.

Depopulation – removing or reducing the population by destruction or expulsion.

Destruction – the act or process of damaging something so badly that it no longer exists or cannot be repaired; the act or process of destroying something.

Desertification – the gradual destruction or reduction of the capacity of Drylands (low rainfall with high evaporation) for plant and animal production due to the inherent vulnerability of the land and the pressure of human activities.

Detergents – generic name of surfactant, usually synthetic, which reduces the value of surface tension of liquids, so have soluble, detergent, disinfectant, antiseptic solution and action, they also have emulsifying and foaming properties. For certain types of E are inherent of the nonspecific bactericidal action (for ex., for certain ammonium compounds). Depending on the charged groups such D are distinguished: anionic (soaps, sodium dodecyl sulfate, sulfates, alkyl etc.), cationic (invert soaps, amines, quaternary ammonium salts, etc.) and nonionic (Triton X–100, Sulfanol et al.). D are used in microbiology for washing and disinfecting of the glassware and contaminated materials in the case of "soft" degradation by microorganisms and obtaining of individual structures and molecules of microbial cells; in molecular biology – to solubilize of the hydrophobic macromolecules (proteins, lipids); are used for the manufacture of some cosmetics and pharmaceuticals, food processing and others.

Detoxification – 1) metabolic process by which toxins are transformed into less toxic substances 2) the artificial process of cleaning the blood from pathogens, viruses and/or toxins.

Detritus – matter composed of leaves and other plant parts, animal remains, waste products, and other organic debris that falls onto the soil or into bodies of water from surrounding terrestrial communities.

Detritivore – an organism, that feeds on dead plant or animal matter.

Dissociation – 1) chemical substances collapse on ions in a solution (when the temperature, when dissolved electrolytes and others.) 2) spontaneous or induced fission nuclear components of the heterokaryon, in which may form the mosaic mycelium; 3) division of the acentric chromosome into two acrocentric (as one of the areas of *Robertsonian* translocations).

Divergence – a break up into two communities, that was caused internal or external changes.

Dominant species – the species that predominates in an ecological community, particularly when they are most numerous or form the bulk of the biomass.

Drag-design – directed design of new drugs. Basic concepts, used in the DD, are target and medications. The target serves the macromolecular biological structure, associated with a particular feature, the violation of which leads to disease. The certain chemicals (usually low-molecular) that specifically interacts with it synthesize (or selected from existing) on this target using DD, leading to a positive therapeutic effect. Cell receptors and enzymes mainly use as targets. Drugs are often ligand or its equivalent, if they serve as a target receptor. Search of targets are usually performed, using of the methods of comparative and functional genomics and computer modeling. Several limitations impose on the possible structure of the ligands that significantly narrows of conducted search. A combinatorial library of compounds typically use as a starter set of ligands for research on the ability to bind to a target.

Dysplasia – deviations in the development of tissues and organs, regardless of time and their causes D. often due to congenital developmental disabilities.

Dysploidy – a significant variation in the number of chromosomes of individuals of a species not associated with polyploidy (abnormal ploidy) and not accompanied by significant phenotypic differences between individuals (ex., the occurrence of triploids in diploid populations of organisms).

E

Eurybiont – an organism that can live under different environmental conditions.

Eutrophication – the process by which a body of water becomes enriched in dissolved nutrients (as phosphates) that stimulate the growth of aquatic plant life usually resulting in the depletion of dissolved oxygen.

Ecosystem engineer – an organism that modifies, creates or destroys habitat and directly or indirectly modulates the availability of resources to other species, causing physical state changes in biotic or abiotic materials.

Ecosystem – a dynamic complex of plant, animal and microorganism communities and their non-living environment interacting as a functional unit.

Ecotone – the transition zone between two different plant communities.

Ecotope – the smallest ecologically-distinct features in a landscape mapping and classification system.

Ecotourism – travel undertaken to witness sites or regions of unique natural or ecological quality, or the provision of services to facilitate such travel.

Elective culture – cells of microorganisms that were grown on selective nutrient media. The conditions are created due to specially selected composition of elective media, which are favorable for the vast growth of microorganisms with certain physiological properties. For ex., nitrogen-assimilating microorganisms begin to grow at inoculation of soil, water or water ground samples on the nutrient media which contain of glucose and several minerals without nitrogen. EC of bacteria that decompose of cellulose are obtained on a nutrient medium containing cellulose as the singular carbon source. The obtaining of EC these microbes always proceeds of allocation of pure cultures in the presence of growth factor (vitamins, amino acids, etc.). EC can be obtained by inoculation of fewer bacterial cells, it can detect in soil and water in 4–10 times more microorganisms than at the inoculation on medium without growth factors.

Endemic – those that are unique to a specific geographic region.

Environment – the air, water, minerals, organisms, and all other external factors surrounding and affecting a given organism at any time.

Eukaryote – any of the single-celled or multicellular organisms whose cell contains a distinct, membrane-bound nucleus.

Ecosystem capacity – the overall ability of an ecosystem to maintain its natural, original, or current condition and to produce goods and services.

Environmental protection – measures and controls to prevent damage and degradation of the environment, including the sustainability of its living resources.

Environmental protection – any activity to maintain or restore the quality of environmental media through preventing the emission of pollutants or reducing the presence of polluting substances in environmental media.

***Ex-situ* conservation** – keeping components of biological diversity alive outside of their original habitat or natural environment.

Exteine – the amino acid sequence of the protein that is stored in it after posttranslational protein splicing, leading to the removal of intein. The interior partof the polypeptide is removed as a result of protein splicing, it was called intein and external N – and C-terminal parts-exteine.

Extremophiles – organisms which require extreme physico-chemical conditions for their optimum growth and proliferation. Extremophilic microorganisms are e.g., thermophiles or psychrophiles, halophiles, alkalophiles or acidophiles, osmophiles and barophiles, based on their growth at extremes of temperature, salt concentration, pH, osmolarity, or pressure, respectively.

F

Facultative – is optional, not present in all cases (for ex., F microorganisms have a choice (switching) of alternative metabolic pathways, resulting in the ability to acquire live in different environments: F of anaerobes (see *Facultative anaerobes*) can develop not only in anoxic conditions, but in the presence of oxygen. See also *Facultative nucleotide codon*.

Facultative anaerobes – microorganisms able to extract energy from substrates aerobic (oxidative) and anaerobic (fermentative) routes of biological oxidation (growing in both anaerobic and aerobic conditions). Metabolism of facultative anaerobes can be carried out under full oxygen in the environment (oxygen acceptor is molecular oxygen) and under conditions of relative anaerobiosis (metabolites that are easily restored, are performed the role of electron acceptors). FA can contain more or fewer respiratory chain enzymes (cytochromes, catalase, peroxidase, flavin enzymes) in the absence usually oxidase used for their identification. Most pathogenic and syngenic microorganisms of the human body belongs to this group. Cultivation of FA usually carried out with free access of oxygen in the environment.

Fauna – all the animals that live in a particular area, time period, or environment.

Feeder, feeder cells – processed by antymitogen (mitomycin C) or UV irradiated are incapable of cell division, but retained the ability to metabolize. They are produced in the culture medium (see *Cultural environment*) metabolites and growth factors needed to maintain normal growth of cultured cells (nourishing layer of cultured cells). For ex., as F. for cultivating and maintaining totypotentnosti of embryonic stem cells embryonic fibroblasts are used, which not only provide better the cell growth, but also support them in the undifferentiated state by secretion into the culture of growth factors and prevent direct contact with the substrate, adhesion of which serves as a signal to start the synthesis of proteins of the cytoskeleton and spontaneous differentiation.

Fermentation – is the process of biochemical processing of organic material by microorganisms, certain enzymes or their complexes. F represents a set of successive operations by entering into a pre-prepared and thermostatted environment inoculum to complete the process of growth, biosynthesis or biotransformation. The special bioreactors are used for the F. Special case of F is zymosis. X. von Euler-Helpin and Alexander Garden were received Nobel Prize for 1929 for the study of the mechanism of F.

Ferric-reducing bacteria, ferric iron-reducing bacteria – various bacteria that reduced of iron, are able to oxidize a large complex of organic substrates, that including of sugars, amino acids and aromatic compounds by transferring of electrons to an insoluble iron oxide (for ex.,*Geobacter metallireducens, Acidobacterium capsulatum* and *Shewanells* spp.).

Flora – the plants of a particular region or period, listed by species and considered as a whole.

Fluorochrome, fluorophore – fluorescent dye, natural or synthetic compound that after irradiation of UV rays or blue begins to emit (fluoresce) of characteristic glow. On chemical structure F it is usually aromatic and heterocyclic compounds with electron and/or electron substitutes.

Free radicals – are kinetically independent particles (atoms, molecules) in the presence of unpaired electrons. F.r. form in the organisms at the biochemical reactions, as well as ionizing radiation or UV. The important biochemical processes take the place with the participation of F.r. in the organisms, for example, the enzymatic oxidation. F.r. involve in the lipid peroxidation reactions and perform the alarm functions in the organism. Nitric oxide (NO) form under the action of the enzyme NO-synthase, penetrating through the cell membrane of smooth muscles of the human organism, acts as a relaxing factor (increases the lumen of blood vessels). Meanwhile superoxide anion oxygen, on the contrary, acts as a vasoconstrictor factor, because it links of the NO-radical. F.r. is a high-energy substances and at the accumulation in biological systems can have damaging effects. (for ex., F.r. serve as the main factor damage nerves and blood vessels in the tissues of patients with diabetes at the later stages of the pathology. Controlled formation of free radicals by enzymes occurs in the process of normal life in living organisms, (for ex., at the biosynthesis of prostaglandins, electron transport in the mitochondria, the removal of individual bacteria cells (phagocytes) of multicellular organisms. Formation of F.r. in the organism causes of aging process. The antioxidants use as protection against free radicals (See *Antioxidants*).

Fumigation – gassing, the effect of smoke or gas for the purpose of disinfection, for ex., the destruction of insect pests, plant pathogens, and others.

Fungi – one of the living organisms' kingdoms, lower eukaryotes, which combine features of animals and plants. F include true fungi, oomycete and mold. There are over 100 species of F, which are mastered the different environments in the biosphere, part of which a human is also. F variety is quite large: from microscopic unicellular to multicellular. All F are heterotrophs and aerobes (see *Aerobic, Aerobic organisms*). F cell wall, unlike bacteria, contains of muramyl peptides but has the marker structure as chitin (rarely – chitosan or cellulose). F reproduction is implemented in three ways: a) vegetative (by hyphas seedlings, substrate mycelium, budding, modifications filamentous elements); b) sex (spores or conidia) and c) asexual. Some F is cosmopolitan (*Aureobasidium pullulans*), many are aspergillus, penicillins, endemic (*Coccidioides immitis*, etc.). The main function of F (as others microorganisms) is participation in the processes of mineralization of organic substrates. Some F is widely used in various biotechnological processes. Yeast (see *Yeast*) used in baking and winemaking, in the production of alcohol, xylitol, enzymes, food additives, for treatment of oil pollution and others. Certain types of mold produce the antibiotics.

G

Galactose – milk and french. – ose – suffix meaning belonging to sugars] – monosaccharide that forms milk sugar (lactose) in combined with glucose. The process of converting glucose to G takes place in the liver. G. is used as a contrast agent to improve of diagnostic image at ultrasound during diagnostic tests. The galactosemia disease develops with a lack of enzymes involved in the metabolism of G, in which galactose–1–phosphate accumulates, G that have toxic action on the nervous system, liver, kidneys, intestines, organs of vision.

Gametogenesis – the development and formation of reproductive cells. It includes meiosis and gamete formation of haploid cells. In plants G completes the formation of mature pollen grains and embryo sac, in animals – sperms and ovocytes.

Gene – the functional unit of heredity; the part of the DNA molecule that encodes a single enzyme or structural protein unit.

Genetic diversity – the variation in the amount of genetic information within and among individuals of a population, a species, an assemblage, or a community.

Genetic load – the aggregate of deleterious genes that are carried, mostly hidden, in the genomes of a population and may be transmitted to descendants.

Gene mutation – any mutation of normal nucleotide sequence that leads to changes in any gene. GM are divided into two groups by its mechanisms and consequences: without reading frame shift mutations and to shift reading frame mutations. The first take place as result of nucleotide pairs replacing. At that the total length of the DNA does not change, as a result of amino acids can be replaced, but because of the genetic code degeneracy the preserve of the protein structure is possible. The second group GM take place as result of insertion loss or nucleotide pairs, with the total length of DNA changes and as a result there is a complete change in the structure of the protein.

Gene network – group of coordinated functioning of genes, providing of perform certain vital functions of organisms, regulating of physiological processes, respond to the impact of the environment, etc. The mathematical modeling of the GN functioning dynamics currently is actively developed.

Gene of drug resistanse – is a gene that encodes an enzyme which provides of drug resistance cell. Typically, the enzyme that encoded of drug

Genetically modified organism – any organism, with the exception of human beings, in which the genetic material has been altered in a way that does not occur naturally by mating and / or natural recombination.

Gene pool – total genetic material possessed by a given reproducing population or species.

Gene therapy – treatment of hereditary diseases and viral infections of human through putting into tissues or organs of cloned individual genes, the products of which demonstrate the therapeutic effect on the organism.

Genealogy – is family tree, based on reliable documents and others sources, evidence of relationship that exists between individuals who have a common ancestor, regardless of the social status of these persons. In clinical practice method of G. is genetic kinship analysis to determine patterns of transmission of hereditary of pathological pathological trait to offspring. Sources of information usually serve direct clinical examination, medical history, the results of family member's interrogation; careful genetic analysis helps to distinguish hereditary diseases from other disorders, non-hereditary nature.

Generative mutation – a mutation that occurs in germ cells or zygote; GM is transmitted to offspring during sexual reproduction if it does not cause of infertility.

Genesis – origin origin; in a broader sense - the birth and subsequent development process that leads to a certain condition, phenomenon.

Genetic bank – 1) storing of collections of seeds, deep frozen tissues or cells of plants and animals that are suitable for subsequent reproduction of members of vanishing or extinct species; 2) special refrigerated room for long-term storage of samples of living cells (for ex.,the mucous tissue, sperm, peripheral and cord blood et al.) or DNA, obtained from different modern organisms. The necessity of GB formation is premised on he unique preservation of genetic material, and for people – using of material for identification and detection of predisposition to a particular disease and its treatment, or therapeutic cloning.

Genetic drift – chance changes in allele frequencies that result from small population size.

Genetic structure of populations – characteristics of the population (see *Population*), which is based on the distribution of frequencies of genetic markers (often enzymes which are tested by electrophoresis) or genetically coded signs; the term "GSP" is virtually supplanted at present by the term "gene pool".

Genetic system – is complex of structures and mechanisms of genetic information (genetic material) transmission, typical for this type of organisms.

Gram-negative bacteria, G^- – bacteria belonging to one of the two main groups, separated on base of their differential staining by X. Gram method. GNB dont stain at blue at standard procedure of staining (methylene blue, gentian violet et al.), it indicates on the differences in the structure of cell walls of bacteria compared with gram positive bacteria. GNB includes of *Gracilicutes* bacteria species, which are characterized by: the presence of the outer membrane, a thin layer of peptidoglycan (2–3 nm) in cell walls, resistance to certain antibiotics, some features of the composition and structure of the membrane system, the ability to phototrophy, intracellular symbiosis or parasitism in the cells of animals, plants and others.

Gram-positive bacteria, G^+ – bacteria that belong to one of the two main groups, separated on bas of their differential staining X. Gram method. GPB zare stained by blue coloring with standard methods (methylene blue, gentian violet et al.), it indicates on the differences in the structure of cell walls of bacteria compared to Gram-negative. The cell wall of GPB in several times thicker than at Gram-negative; mainly consist from peptidoglycan and teichoic acids (20-80 nm thickness); some GPB contain of large amounts of lipids and mycolic acid, which make them resistant to acids (for ex.,at *Mycobacterium tuberculosis*). In contrast to Gram-negative bacteria GPB are resistant to other spectrum antibiotics, have some features of the composition and structure of the membrane system, can form endospores and others. GPB include *Firmicutes.* bacteria.

Gram stain – the method of pstaining of microbiological simples, based on biochemical differences of membranes, which allows identifying of two groups of bacteria: Gram-positive and Gram GS is made by basic dyes – gentian or methyl violet, and after the dye is fixed by solution of iodine. The method was proposed by C. Gram in 1884.

Green zones – areas along river– and streambanks, wetlands, lakes, and ponds where there is high productivity and diversity.

Growing stock – volume of all living trees in a given area of forest or wooded land.

H

Habitat fragmentation – the "breaking apart" of continuous habitat into distinct pieces

Halophyte – a plant that can grow in salty or alkaline soil.

Heat resistance – is the ability of plants to preserve the viability of soil and air overheating. The highest heat resistance characteristic for some xerophytes (for ex., cactus, certain types of wormwood are stable at + 60 °C and above). Cultural plants (mesophytes) can not withstand temperatures above + 45–48 °C.

Heliotropism – a form of tropism, is the diurnal motion or seasonal motion of plant parts (flowers or leaves) in response to the direction of the sun.

Herbivore – an animal that feeds chiefly on plants.

Heterotroph – an organism requiring organic compounds for its principal source of food.

Heterotrophic bacteria – bacteria that use as an energy source and carbon organic compounds unlike from the photosynthetic bacteria that assimilate CO_2 as a carbon source. The greater the number of known species of bacteria refers to HB, which include both aerobes and anaerobes. HB divide into two groups - copiotrophic and oligotrophic bacteria, depending on the capacity for growth of rich or poor in organic matter media. Many of HB utilize the sugars, alcohols and organic acids, but there are specialized HB, able to decompose ofcellulose, lignin, chitin, keratin, hydrocarbons, phenol and others substances. The most of HB are common in soil and ground water reservoirs in food and so on.

Hygroscopy – the ability of a substance to absorb and retain water. (for ex., soil H. is the ability of the soil, due to his characteristic surface energy absorbing particles to the surface of its water vapor contained in the air. High possess of H. certain to chemicals, for example, dimethyl, sulfuric acid, sodium carbonate and others. H. material is important in the calculation process of drying and moistening it count during prolonged storage and transportation of products and materials. Some substances with high H. (for ex., *Concentrated sulfuric acid*) is used for dehumidification.

Hygrophyte – any plant that grows in wet or waterlogged soil.

Homeostasis – the tendency of an organism or a cell to regulate its internal conditions, usually by a system of feedback controls, so as to stabilize health and functioning, regardless of the outside changing conditions.

Heredity – property of organisms to repeat the similar types of metabolism and individual development as a whole at number of generations; provided by reproduce of material carriers of H – genes, localized in the chromosomes of the cell nucleus (nuclear chromosomal heredity) and DNA structures cytoplasm (extra-nuclear, cytoplasmic H). H with variability ensures the sustainability features in several generations and diversity of life and the basis for the evolution of nature.

Homologous series – 1) groups of related (with the same functions and the same type of chemical structure) organic compounds characterized by one or more methylene group (CH_2) 2) HS of genetic variability are the law formulated by N.I. Vavilov in 1920. This law is based on that: genetically close to each other species and genera are characterized by identical rows of genetic variability.

Hormonal system of plants – regulatory complex, including plant hormones, their receptors and secondary intermediaries. HSR ensure the growth and development of plants sensitive to environmental changes. For ex., the drought is significant adjustment in HSR, that impressed in a decrease of hormones triggers growth – auxin, cytokinins, gibberellins, phenolic growth promoters and growth of abscisic acid and ethylene. Change of HSR using genetic engineering techniques allows obtaining of economically valuable genotypes of plants.

Host – 1) organism that contains another organism (for ex., a cell is infected with a virus); 2) the body that acts as a recipient at transplantation; 3) cell, in which foreign genetic material is introduced.

Host range – is a set of organisms species, cells of which can be infected with a particular microorganism that is largely determined by the last tropism (see *Tropism*). (for ex., there is a wide of HR for tobacco mosaic virus (over 350 species), chlamydia; while many of retroviruses have narrow of HR. Viruses with a wide HR are called amphotropic virus and ecotropic viruses (see *Ecotropic viruses*) are viruses with narrow HR. There are three main of strategies of HR artificial changes (*Tropism*) of viruses: direct change of nucleotide sequence of the coat protein gene of retroviruses, a combination of the protein shell of the new ligands and pseudotyping.

Hydrogen ion concentration, pH – quantitative characterization of active reaction medium, is numerically equal to the negative decimal logarithm of the hydrogen ion concentration. HC (pH) of the neutral medium is 7.0; pH <7.0 – acidic, $14.0 > pH > 7.0$ – alkaline; buffers use for pH stabilize.

I

Idiomatic variability – variability, caused by different genetic factors (genes), which is identical or mostly appears in various organisms; interspecific IV is the basis of the law of homologous ranks, it was formulated by N.I. Vavilov.

Immobilization – is the fixing of low ligands, macromolecules, cellular organelles or cells in certain carrier. I is carried out by various methods: crosslinks to form covalent bonds, inclusion of polymeric material (for ex., to gel), adsorption on the porous carrier, etc.

Immobilization of bacteria – immobilization of motile bacteria with specific immune sera or phages. It is used, (for ex., as a test for accelerated identification of the causative agent of cholera and as serological diagnosis of syphilis.

Immune response – is highly specific form of organism response to genetically agents and foreign substances. IR is carried out by the immune system, morphologically represented lymphoid system. There are humoral and cellular IR.

Immunological tolerance – status of the immune system, that hasn't of immune response to an antigen or a sharp weakening is happened; IT can be induced in various (often early) stages of ontogeny.

Implantation – 1) injection of experimental or therapeutic purposes non-biological material to the organism; 2) the attachment of the embryo to the uterine wall in a mammalian fetal development (eg., at human – on the 5–7 th day of pregnancy); 3) injection of embryo in the uterus after fertilization *in vitro.*

***In-situ* conservation –** the conservation of ecosystems and natural habitats and the maintenance and recovery of viable populations of species in their natural surroundings and, in the case of domesticated or cultivated species, in the surroundings where they have developed their distinctive properties.

Invasion (infestation) – introducing into the human body, animals, plants or animal nature parasites (protozoa, helminths, arthropods) and their distribution in organs and tissues, accompanied by the subsequent development of pathological adaptation and compensatory and reparatory reactions. I has some forms: parasitosis, asymptomatic and parasitic diseases. According to agent I. is divided into protozoozy, worm infestations, entomonosis, acariasis, and miasis; to localization – the blood, skin, intestinal, visceral; by type of owner – in anthroponoses and zoonoses; the duration-acute, chronic and hostrohronichni. I characterize by larger, more complex chemical and antigenic composition, slow reproduction, development cycles, complex relationship with the owner and other factors pathogenicity compared with viruses and bacteria pathogens. The penetration of microorganisms into the cell associate with the production of certain enzymes, as well as factors that inhibit of cells protection. Thus, the hyaluronidase enzyme breaks down hyaluronic acid (see *Hyaluronic acid*), which is part of the intercellular substance, and so on, increases the permeability of mucous membranes and connective tissue; neuraminidase cleaves the neuraminic acid – a component of the cell surface receptors of the mucous membranes, which promotes the penetration of the pathogen in tissues.

Introduction – a species living outside its native distributional range, which has arrived there by human activity, either deliberate or accidental.

Involution – 1) reduction or loss in the evolution of the individual; 2) regression of organs, tissues or cells; 3) atrophy of the pathology and aging (for ex., the loss of the thymus ontogeny); 4) formation of pleomorphic microbial cells under the influence of various external factors (toxins, radiation, lack of nutrients, etc.).

J

J-value – is the effective concentration of one of the ends of DNA molecules that participates in the ligation reaction.

Juvenile phase genesis – an early phase of development in which the organisms is not capable to sexual reproduction. For ex., JPG of plants is the period from emergence of seedling to early flowering, at which plants capable to enhanced formation and growth of vegetative organs but do not yet ready for generative development.

K

Karyotype – complex of chromosomes of an organism, with its specific number, size and shape; K has a high degree of sustainability and serves as an important taxonomic feature (for karyotaxonomy) allows to describe of the new types of organisms.

Karyotype ortoselektion – the same repeating type of complex chromosome rearrangements within a phyletic line, and simultaneously in close phylogenetic lines (in species of the same genus and even less related forms).

Kilobase, kb – a unit of measurement, used to express of the length of nucleic acids. 1 kb = 1000 nucleotides in RNA and single-stranded DNA or nucleotide pair (bp) in double-stranded DNA.

L

Landscape – an area of land that contains a mosaic of ecosystems, including human-dominated ecosystems.

Layering – the multiple vertical layers of a terrestrial biome. Usually includes the upper canopy, low tree layer, shrub understory, the ground layer, forest floor layer (litter layer), and a root layer.

Lipophobic – the property of matter, weakly interacting with the lipids. The passive penetration into the bloodstream and tissues by its passage through the water in the membrane tubules or dissolution in the membrane that is not accompanied by energy costs is characterized for L. chemicals (for ex., ethylene glycol and glycerin).

Lithotrophic microorganisms – microorganisms that are used as an energy source inorganic substances. LM include: hydrogen, that oxidize of hydrogen to water form (most species are represented by Gram-negative genus *Pseudomonas, Alcaligenes, Aquaspirillum, Paracoccus* and *Xantobacter*, some species – Gram-positive genus *Nocardia, Mycobacterium* and *Bacillus*); nitrifying, that oxidize ammonia to nitric acid (*Nitrosomonas, Nitrosolobus, Nitrosococcus, Nitrosospira* and *Nilrobacter*); tion, that oxidize of hydrogen sulfide to elemental sulfur, which is deposited inside the cells, or elemental sulfur to sulfuric acid (*Thiobacillus thiooxidans*), ferrous sulfate or iron to oxidation in acidic medium (*Thiobacillus ferrooxidans*); ferrobacteria that oxidize ferrous iron to oxidation (*Gallionella* and *Leptothrix*) in neutral environments; methane-producing bacteria, stimulating the natural synthesis of methane from carbon dioxide and hydrogen in anaerobic conditions (*Methanobacterium, Methanococcus, Methanosarcina* and *Methanospirillum*); sulfate, existence of which is due to the recovery process of sulfate to hydrogen sulfide (*Desulfovibrio, Desulfotomaculum, Desulfobacter, Desulfococcus, Desulfosarcina, Desulfonema*); nitrate-reducing bacteria that cause of soil denitrification process – restoration of oxidized forms of nitrogen at the scheme: nitrate-nitrite-nitrogen, ammonia (*Thiobacillus denilrificans*). There are photo- and hemylitotrophic microorganisms. LM make a significant contribution to the transformation of substances in the ecological system and take direct part in the formation of minerals (native sulfur, saltpeter, pyrite, natural gas). They participate in the destruction of hardware, stimulating processes of transition and the destruction of polymeric and inorganic materials, creating a harsh environment. Oxidation of metal sulfides by LM to form of sulfuric acid and dissolved metal has been used for leaching (See *Bacterial leaching*) of poor metal ores.

Living matter – the aggregate of living bodies of biosphere organisms, which are expressed numerically by elementary chemical composition, mass, and energy.

Living system – open self-organizing living thing that interact with their environment.

Life form – the characteristic overall form and structure of a mature organism on the basis of which it can be classified.

Life cycle – the phases, changes, or stages through which an organism passes throughout its lifetime.

Limiting factor – a condition or factor whose absence, short supply, or excessive concentration exerts some restraining or negative influence upon a population which is incompatible with a given species requirements or tolerance.

Lithosphere – the rigid outer layer of the earth, and comprising the earth's crust and the solid part of the mantle above the asthenosphere.

Lithophyte – a plant that grows on rocky or stony ground.

Lytic bacteriophage – bacteriophage that quickly destroys of bacteria, after infection and bacterial cell reproduction, releasing own offspring.

Lytic cycle – the process of reproduction phage in a host cell, including its adsorption on the surface of bacterial cells, the penetration of this cell replication of phage DNA (RNA) synthesis of viral proteins and the formation of mature virus particles, then lysis of infected cells and output phage outside.

Lytic virus – virus, the reproduction of which in the cell occurs on litical cycle and leads to its lysis (See *Lytic bacteriophage*).

M

Macroelement – chemical elements that are required in large quantities to supply the body (carbon, hydrogen, oxygen and nitrogen). The mass of living matter is 96% of the M.

Macroevolution – evolution at levels above species (ie development of new species, genera, families, orders) when there is no interbreeding individuals and exchange of genetic material between individuals, but clearly appear the trends of adaptation of animals and plants to biotic and abiotic environmental factors

Mesophytes – land plants that are adapted to the moderate water and temperature conditions.

Mesophilic microorganisms, mesophillous – are a group of microbes, whose growth temperature boundaries are within 20 – 45 °C (optimum temperature 35 – 37 °C). The lower temperature boundary of dormancy and death, depending on plant species and forms of existence begins to +20 °C and extends to deep subzero temperatures. The upper border zone of peace begins with 40 – 45 °C, and the temperature in the death of vegetative forms of most types of MM is 60 – 70 °C at hour exposure, the spores in moist environment – 100 – 130° C at a half-hour exposure, in a wet environment – + 180 °C and at half-hour exposure. MM exist in the body of warm-blooded animals, in soil and others environments with sufficient moisture and nutrients within their temperatrnoyi growth zone. MM are used in various biotechnological processes: traditional sourdough for dairy products, for biological wastewater treatment, etc.

Metabolism – is 1) in the broadest sense – metabolism that occurs in the body and includes assimilation of nutrients and the construction of which the body (anabolism) and the disintegration of chemical compounds in it (catabolism). The intensity and direction of M are provided by complex regulation of chemical synthesis and chemical disintegration activity of enzymes and changing the permeability of biological membranes. There are constructive, energy and basic structural M. M is using of matter and energy in the growth and development of, the main M is using of matter and energy to maintain physiological shipments body at rest, energy M is using of matter and energy in the active living organism; 2) in the narrow sense – transformation within the cells of certain substances from the date of their receipt and in final products, covering the entire set of reactions (mainly enzymic).

Metabolomics – a scientific field in molecular biology and genetics, which deals with the study of metabolic reactions specific to the type of organisms (for ex., the image of its metabolic pathways, measuring of metabolites in different cell types, etc.) and take place in a normal state, controlled environment or genetic modifications, at different kinds of pathologies.

Methanogenesis – methanogenic fermentation process of converting biomass into energy to form methane. M is carried out in three stages: dissolution and hydrolysis of organic compounds, acidogenesis and directly methanogenesis. Only half organic material (1800 kcal / kg of dry matter compared with 4000 kcal in the thermochemical processes) are involved in energy conversion, but residues or wastes of methane "fermentation" are used in agryculture as fertilizer. Three groups of bacteria are involved in M. The first transform of complex organic substrates in oil, propionic and lactic acid (stage of dissolution and hydrolysis of organic compounds); second transform these organic acids into acetic acid, hydrogen and carbon dioxide (amidogenesis stage) and then methane-producing bacteria reduce of carbon dioxide to methane absorption of hydrogen that otherwise may inhibit acetic bacteria (methanogenesis stage). *In vivo* methane-producing bacteria are closely associated with hydrogen-reducing bacteria: this trophic association is beneficial for both types of bacteria. The first use hydrogen gas, produced by the latter, its concentration decreases and becomes safe for hydrogen-reducing bacteria. Biogas that is produced during M, is a mixture that contains 65% methane, 30% carbon, 1% hydrogen sulphide (H_2S) and minor amounts of nitrogen, oxygen, hydrogen and carbon oxide. The energy contained in 28 m^3 of biogas energy equivalent to 16.8 m^3 of natural gas or 20.8 liters of oil. M was discovered by A. Volta in 1776, which established the presence of methane in marsh gas.

Methano-producing bacteria – anaerobic bacteria (see *Anaerobes, anaerobic organisms*) can produce energy by CO_2 recovery to methane (CH_4); some of them are able to ferment of methanol or acetic acid, as result methane form from carbon methyl group. MPB do not form spores, it is difficult to stand out in pure culture. They are used to produce biogas from organic waste of agryculture production (recycling of waste prevents of contamination of the environment). See *Methanogenesis*.

Microbial contamination – 1) entering of potentially dangerous microorganisms for human health (animals) to inanimate objects in the environment (for ex., food, drugs) that can serve as a factor in the transmission of human diseases (animal); sterilization and disinfection of objects leads to decontamination; 2) entering the microorganisms of environment in pure cultures of bacteria, culture media, research material.

Microbial count, bacterial count – sanitary quantitative indicator of bacterial contamination of the environment, which is the number of colonies, grown on MPA, contained in 1 ml of liquid, 1 m of solid or 1 cm^2 surface of the studied or substrate.

Microbiocide – chemical or biological antimicrobial and /or antiviral agent of local action, in the form of a gel, cream foam of sponges and others forms, used for sexual intercourse (vaginal or rectal) to prevent of infections, sexually transmitted. It is considered that small interfering RNA can serve the effective M.

Microbiological diagnostics – identification of the pathogen in the patient or detect immune response to it. The initial stage MD is a selection of biological material and transportation of samples to the laboratory. The microscopic, bacteriological and serological methods, and method-allergic skin tests are used for MD. The initial phase of MD is inoculation of material on nutrient media, separation of pure cultures (microbial population of one species), identification and differentiation of selected cultures, determine of the sensitivity of isolated microorganisms to antibiotics and antiseptics. The systematic group is determined at the studying of the properties of microorganisms' culture; received pure culture of the pathogen belongs to it, it is important to identify the pathogen. Often genus and species of isolated pathogen culture is determined by biochemical parameters. A staining of microorganisms is used for MD. Thus, bacteria are divided into two groups by Gram-method: Gram-positive and Gram-negative. Ziehl Neelsen staining method is used for detection of *Mycobacterium tuberculosis* and some phylon bacteria, actinomycetes and some bacteria and spores. The typing by means of standard sera, bacteriophages and bacteriocins (colicine, piocine et al.), determine of antibiogram (indicators of the sensitivity of microorganisms to antibiotics) are carried out to identify the level of individual strains in addition to research of biochemical characteristics of strain. The testing of microbial antigens in serum is also carried out in the early stages of the disease.

Migration – sustained directional movement by an animal that takes it out of one habitat and into another.

Mimicry – the resemblance of one organism to another or to an object in its surroundings for concealment and protection from predators.

Monitoring – the continuous or frequent standardized measurement and observation of the environment (air, water, land/soil, biota), often used for warning and control.

Mutation – the natural or artificial process of change in the genetic material that determines or alters the characteristics of a species.

Mutualism – a symbiotic relationship between individuals of different species in which both individuals benefit from the association.

N

Nature reserve – a protected area of importance for wildlife, flora, fauna or features of geological or other special interest, which is reserved and managed for conservation and to provide special opportunities for study or research.

Natural system hierarchy – hierarchy is an arrangement of systems in which the systems are represented as being «above», «below» or «at the same level as» one another.

Naturalisation – any process by which a non-native organism spreads into the wild and its reproduction is sufficient to maintain its population.

National park – relatively large land or water areas which contain representative samples and sites of major natural regions, features, scenery, and/or plant and animal species of national or international significance and are of special scientific, educational, and recreational interest.

Nature park – a landscape protected by means of long-term planning, use and agriculture.

Neuston – organisms, similar to plankton, that float on the surface film of open water.

Neutralism – the relationship between two species that interact but do not affect each other.

Nekton – the aggregate of actively swimming aquatic organisms in a body of water, able to move independently of water currents.

Neophyte – a plant species which is non-native to a geographical region, and was introduced in recent history.

Niche – the particular area within a habitat occupied by a plant or animal; the role or function of an organism or species in an ecosystem.

Nonpathogenic bacteria – bacteria of normal microflora that do not cause the development of diseases, and often help the body (lactobacilli, bifidobacteria, enterococci, *E. coli* and others). For ex., some NB that live on the skin and in the intestines of humans, benefit to animal body because of their ability to displace any infection from their occupied surface. Biological preparations from living NB are used for the prevention and treatment of dysbiosis. However, under certain conditions, some bacteria that are considered avirulent may become pathogenic (see *Pathogenic bacteria*); for ex., urinary tract inflammation caused by bacteria that are normally found in the colon.

Noosphere – sphere of interrelations between society and nature within the limits of which the wise human activities become the main factor of development.

Non-renewable natural resources – resources not capable of perpetuating themselves e.g., coal, oil, and other minerals. A nonliving resource of finite supply which cannot be replaced.

Normal flora – some qualitative and quantitative ratio of different populations of microbes and certain organs of the gastrointestinal tract and others mucous tissue, which supports of the biochemical, metabolic and immune microorganism balance, needed to maintain its normal state.

Nutrients – any nourishing substance assimilated by an organism, and required for growth, repair, and normal metabolism.

Nutrient medium – liquid, semi-liquid or solid mixtures of substances, used for the *in vitro* cultivation of microorganisms, cell cultures, tissues, organs and embryos; they contain of compounds that serve as sources of carbon, nitrogen, phosphorus, vitamins and others components that are necessary for life. All these substances are in NM in the form of salts, exceptions are environments where nitrogen and phosphorus can be assimilated by growing cultures from organic sources, for example, autolysate or hydrolysates by microbial or animal origin. The agar serves as basis of many NM (including media for bacteria, bacteriophages, *Drosophila* larvae cultivation, etc.). NM divide into minimal, selective and others for a set of specific components. NM are widely used for staging of laboratory diagnosis of infectious diseases in microbiological practice. There are many standard biological NM (Medium-Murasihe Skuha, Hamborha, White, etc.).

Nutrient substances – are organic and inorganic substances used by living organisms for energy and construction materials that ensure their livelihoods. There are dozens of species of this year, the organisms can not synthesize itself. NS include proteins, fats, carbohydrates, vitamins and others.

O

Obligate organism – organism which capable of functioning or surviving only in a particular condition or by assuming a particular behavior.

Oligosaprobe – an organism that inhabits clean water or water that is only slightly polluted by organic matter.

Oligotroph – an organism that can live in an environment that offers very low levels of nutrients.

Oligophage – organism which eating of only a few specific foods.

Ontogeny – the origination and development of an organism, usually from the time of fertilization of the egg to the organism's mature form.

Ontogenesis – is the process of individual development of the organism, which begins with the birth (fertilization, the zygote distribution, etc.) and ends with death or a new division. The various transformations are occurred at the development of organism (growth, differentiation and integration of parts) during of O. The term "O" was introduced by E.Haeckel in 1866.

Orphan drug – a drug, used to treat of rare diseases, whose production cann't be profitable because of the limited market and therefore is subsidized by government organizations. An example of orphan drugs can serve as drug Zolintsa (Vorinostat), is used to treat – cutaneous T-cell lymphoma, which occurs annually only at 3 people per million.

Oxidative stress – physiological stress / damage caused by excessive levels of free radicals that arise as a result of leaking oxidation reactions in the body. Violation of the formation and transformation of free radicals that occur as a result of OS may act detrimental to the cell if the antioxidant defense system does not perform its function. For ex., OS of the brain often leads to neurodegenerative deceases (Alzheimer's disease, Parkinson's disease). One from indicator of OS is peroxydation of lipid membranes with the formation of mono- and bifunctional aldehydes; oxidation of nucleic acids can lead to mutations.

Oxigenases – enzymes of oxidoreductases class (see Oxidoreductases) that catalyze the joining of two atoms of oxygen molecules to the substrate; with the formation of water or hydrogen peroxide. O play an important role in detoxification and catabolism of various compounds (for ex., monoamine oxidase destroys the biogenic amines).

Oxytocin – octapeptide cyclic hormone (see *Peptide hormone*) of posterior pituitary, consisting of pentapeptide cycle and side chain with three amino acid residues. O stimulates the contraction of smooth muscles of the uterus and less muscle bowel, bladder and several others.

P

Panmixia – random mating of individuals within a population, the breeding individuals showing no tendency to choose partners with particular traits.

Paradigm – a set of assumptions, concepts, values, and practices that constitutes a way of viewing reality for the community that shares them.

Parasitism – a relation between organisms in which one lives as a parasite on another.

Paraclimax – biotic community that occurred as a result of external influences on climax with next degradation and to form a sustainable community.

Pathogen – a biological agent that causes disease.

Pathogenic bacteria – bacteria, parasites and other organisms can cause the infectious diseases of humans, animals and plants, for ex., a large number of human diseases such as plague (*Yersinia pestis*), anthrax (*Bacillus anthracis*), leprosy (*Mycobacterium lepreae*), diphtheria (*Corynebacterium diphtheriae*), syphilis (*Treponema pallidum*), cholera (*Vibriol cholerae*), tuberculosis (*Mycobacterium tuberculosis*), legionnaires disease (*Legionella pneumophila*). It was proved that *Helicobacter pylori* causes the peptic ulcer disease and gastric cancer and chronic gastritis. Plants and animals are also exposed of bacterial infections. At certain conditions (violation of immunity, the general weakening of the body) bacteria that are considered nonpathogenic can become PB.

Periphyton – organisms that live attached to underwater surfaces.

Petrophyt – a plant that grows on rocky or stony ground.

Pheromone – any chemical substance released by an animal that serves to influence the physiology or behavior of other members of the same species.

Phenotype – a visible, or otherwise measurable, physical or biochemical characteristic of an organism, resulting from the interaction between the genotype and the environment.

Photosynthesis – the process in green plants and certain other organisms by which carbohydrates are synthesized from carbon dioxide and a source of hydrogen (usually water), using light as an energy source.

Phototaxis – a locomotory movement, that occurs when a whole organism moves towards or away from stimulus of light.

Phylogenesis – the sequence of events involved in the evolutionary development of a species or taxonomic group of organisms.

Phytoncide – a biologically active substance of plant origin that kills or inhibits the growth and development of bacteria, microscopic fungi, and protozoa.

Phytocoenosis – any group of plants belonging to a number of different species that co-occur in the same habitat or area and interact through trophic and spatial relationships; typically characterized by reference to one or more dominant species.

Pioneer – an organism that successfully establishes itself in a barren area, thus starting an ecological cycle of life.

Plankton – the small or microscopic organisms that drift or swim weakly in a body of water.

Pollution – the presence of matter or energy whose nature, location, or quantity produces undesirable environmental effects.

Polymorphism – 1) the existence of two or more genetically and morphologically different groups in the same population in which individuals continually interbreed with each other. P can be: a) transition (transient), where the replacement of a gene allele, formed as a result of mutation breeding and has greater value; b) balanced when setting optimal ratio of permanent polymorphic forms (forms) where any deviation from it appears unfavorable to population or species in general and is automatically reverse polymorphic regulation system to optimal balance classes; c) geographical – in the case of genetically different classes at different points habitat of the population: 2) local changes in the nucleotide sequence of DNA within the genome (polymorphism DNA) caused by point mutations, division, inversions, insertions, duplications or some other changes in the genome leading to the formation of different alleles at a given locus. P is associated with the appearance of some allelic forms of genes, often manifested in the existence of different protein molecules (protein P). In the case of recurring DNA variation in the number of repeats can lead to P of restriction fragment length, for example, to a different number of tandem repeats in a particular locus. P can be detected by the method fingerprint of DNA (see *Fingerprint*). P of DNA is used at searching for candidate genes of different human diseases, for forensic paternity and maternity, and others.

Polyphage – an organism which can eat a variety of food, but not omnivore.

Pollutant – any substance, as certain chemicals or waste products, that renders the air, soil, water, or other natural resource harmful or unsuitable for a specific purpose.

Population – a group of individuals of the same species, occupying a defined area, and usually isolated to some degree from other similar groups.

Pollution (biological) – constant increase in number of some animal or plant populations, as well as of pathogen microorganisms that damage the agriculture, forestry, fishery, etc., and human health.

Population density – a measurement of population per unit area or unit volume.

Predation – a form of symbiotic relationship between two organisms of unlike species in which one of them acts as predator that captures and feeds on the other organism that serves as the prey.

Protected area – a geographically defined area which is designated or regulated and managed to achieve specific conservation objectives.

Provirus – form existence of the virus in which the genome is integrated with the genome of the host cell and delivered in an integrated form in daughter cells, replicating with host DNA. P can form cells in lesions some moderate viruses. In the state of P can move not only DNA-containing and some RNA-containing viruses (for ex., Retroviruses); process of reverse transcription precedes the formation of P. Induction of P is observed under certain conditions, which leads to the release of the virus genome and its autonomous reproduction.

Primary producer – any green plant or any of various microorganisms that can convert light energy or chemical energy into organic matter.

Psammophyte – any plant which thrives in sandy conditions.

Q

Quantitative – activity relationship, QSAR [lat. *structura* – structure, device] – description of the chemical compound that is derived by analyzing data of organic chemistry, mathematical modeling and computer chemistry that allows to find the quantitative relationship between the structure and properties in the form of mathematical equations, and allows to predict the physiological activity of this compound.

Quantitative character – signs, that are encoded by a large number of genes (polygenes), which is characteristic of quantitative inheritance and continuous range of values; QC include all dimensional characteristics, a number of signs of biological productivity, resistance to various toxic agents, etc.

Quantitative inheritance – inheritance of the quantitative (polygenic) signs, characterized by the lack of a clear (Mendel) splitting; assessment of QI patterns requires the use of the apparatus of mathematical statistics.

Quantitative variation – variability of quantitative (polygenic) signs, characterized by usually continuous complex of values of these attributes.

Quarantine regulations – system or local public health measures that alerts: a) spread of infectious diseases of humans and animals by isolating sick people and animals and ban their entry, removal or departure from the zone affected by infection, and al. events; b) infiltration unwanted.

R

Red data book – a book listing threatened and endangered species and subspecies of animals and plants, including information on their status and measures for protection.

Rehabilitation – the return of a degraded ecosystem to an undegraded condition but which may also be different from its original condition.

Renewable resources – natural resources that, after exploitation, can return to their previous stock levels by natural processes of growth or replenishment.

Readaptation – the ability of a species to survive in a particular ecological niche, especially because of alterations of form or behavior brought about through natural selection.

Regeneration – the natural renewal of a structure, as of a lost tissue or part.

Recultivation – the act of cultivating anew, or the state of being cultivated anew.

Relict – a population or taxon of organisms that was more widespread or more diverse in the past.

Rheotaxis – a form of taxis turn to face into an oncoming current.

Repellent – a substance of natural or artificial origin which deters or repels insects, mites, rodents and animals.

Reproduction - the natural process among organisms by which new individuals are generated and the species perpetuated.

Resistance – ability of cells or the organisms to remain the nonsuscepted to external influences; resistance to the action of physical, chemical, biological objects (agents) that cause a pathological condition. However, R sometimes is cause of diseases; for ex., R to hormone serves the cause of some endocrine diseases (Seypa syndrome, Lawrence et al.).

Resource – any physical or virtual entity of limited availability that provides a benefit.

Ruderal plants – a species, especially a plant, that colonizes or thrives in disturbed areas.

S

Saprobiont – aquatic organisms (plants or animals) that live in the pond, heavily polluted with organic substances, with a low content of dissolved oxygen. Depending on the degree of contamination polisaprobe, mezosaprobe and oligosaprobe are distinguished. The ability of S to mineralize of pollution organic matter is used to enhance the processes of self-purification of water, especially waste. The composition and amount saprobionts are used for biological indication of water quality.

Saprophyte – any organism that lives on dead organic matter.

Sensitization – an organism with acquisition of a specific increased sensitivity to heterologous substances, or allergens.

Habitat – the place or type of site where an organism or population naturally occurs.

Symbiosis – a close, prolonged association between two or more different organisms of different species that may, but does not necessarily, benefit each member.

Synergism – interaction of discrete agencies, agents, or conditions such that the total effect is greater than the sum of the individual effects.

Synusia – a structural unit of a major ecological community characterized by relative uniformity of life-form or of height and usually constituting a particular stratum of that community.

Spectrophotometry – analytical method for qualitative and quantitative determination of substances based on measuring their absorption spectrum or radiation; is widely used in laboratory practice, by using a spectrophotometer. In practice S is often identified with optical spectroscopy. By types of studied systems, S is divided into the molecular and atomic; S at the infrared, visible and ultraviolet parts of the spectrum are distinguished.

Sporophyte – asexual generation or phase of the life cycle of plants from zygote to the formation of spores; usually contains a double (diploid) set of chromosomes, produces spores; S in lower plants can be haploid. In the cycle of development S alternates with gametophyte, all cells of which are haploid.

Stagnation – a lack of motion in a mass of water that tends to hold pollutants in place

Symbiotic viruses – viruses that simultaneously and independently reproduce in the same organ or tissue

Sustainable development – development that meets the needs of the present without compromising the ability of future generations to meet their own needs.

Stenobiont – an organism that can live only under relatively constant environmental conditions.

Succession – unidirectional change in the composition of an ecosystem as the available competing organisms and especially the plants respond to and modify the environment.

Scavenger – organism that feeds on dead animal and plant material present in its habitat.

Skototaxis – the orientation of an organism towards darkness.

Species (biological concept) – groups of actually or potentially interbreeding natural populations, which are reproductively isolated from other such groups.

T

Target – 1) the site of biological objects, in which ionizing radiation causes the chain processes, the final result of which can be genetic mutations or chromosome break, leading to macrovariation of organism as a whole; 2) an individual protein, cell or tissue against which antibodies are formed or on which particular chemical compound acts; 3) the cells or tissues specifically respond to certain hormones or drugs; 4) gene, which is subjected to modification, using of homologous recombination; 5) place of insertion of a mobile genetic element (see *Mobile genetic element, dispersed cell gene, MDCG*).

Taxon – a unit of any rank (i.e. kingdom, phylum, class, order, family, genus, species) designating an organism or a group of organisms. Plural: taxa. Also known as taxonomic unit.

Telotaxis – orientation or movement, by an organism with sensory receptors, toward or away from a particular source of stimulation.

Thermotaxis – a behavior in which an organism directs its locomotion up or down a gradient of temperature.

Thermophilic microorganisms, thermophils – bacteria that normally exist and multiply at temperatures above 45 °C (harmful to most living creatures). TM are also some invertebrates (worms, insects, mollusks) and plants. There are 4 groups of TM: a) termotolerant species that grow in the range of +10 to + 55–60 °C, the optimum temperature is within + 35–40 °C; their main difference from mesophillous is the ability to grow at elevated temperatures, although the optimal temperature of growth for both groups are on the same level; b) facultative TM, with a maximum temperature of growth between +50 and + 65 °C, but also able to reproduce at room temperature (20 °C); optimum temperature occurs in the region close to the upper limit of growth; c) obligate TM, capable of growth at temperatures of about + 70 °C and do not grow below 40 °C (*Bacillus acidocaldarius*, *Synechococcus lividus, archaea Methanobacterium thermoautotrophicum, Thermoplasma acidophilum* et al.); optimal temperature limit of these microorganisms is adjacent to their upper temperature limits of growth; d) extreme TM, which are characterized by the following temperature settings: optimum in + 80–105 °C, the minimum limit growth of + 60 °C and above, the maximum – to + 110 °C (archaea of families *Thermoproteus, Pyrococcus, Pyrodictium* etc.). The upper temperature limit at which growth recorded in the form of pure bacterial culture in the laboratory, is + 110 °C; it was found in archaea *Pyrodictium occultum*, that growes at range of +82 to + 110 °C with an optimum – 105 °C. Among TM, relating to these subgroups, are found photosynthetic, and hemolitotrofni hemoheterotrofni bacteria. Among them are obligate aerobes and anaerobes (see *Anaerobes, anaerobic organisms*). They live in geothermal springs, the upper layers of soil that warm sun on substrates that are self-heating (manure, peat, grains). Some TM are used to produce thermophilic enzymes used in genetic engineering (for ex., Taq-polymerase, ligase, alkaline phosphatases).

Thermostable – organism or substance, resistant to temperature and they do no change at the heat action.

Thermostable DNA polymerases – DNA polymerase (see *DNA polymerase)* that retain their enzymatic activity at high temperatures (100 °C); heat-synthesized microorganisms used in various ways PCR (see *Polymerase chain reaction, PCR*). The thermostable DNA polymerase with 3'-5 'exonucleases (corrections) activity are characterized by most high accuracy of DNA synthesis, for example, such as thermostable DNA polymerase Pfu (from *Pyrococcus furiosis*) and Deep Vent (from *Pyrococcus* species GB – D); Taq P is the most commonly used ofT DNA P.

Thermotolerant microorganisms – microorganisms that have a high temperature of maximum or low minimum and relatively indifferent to the heat. TM are particular important for industrial production, as have high growth rate and resistance to changes in temperature cultivation; they are often more competitive compared to mesophilic producers regarding infection microorganisms (for ex., actinomycetes – producers of lytic enzymes).

Thionic bacteria, thiobacteria – microorganisms that oxidize hydrogen sulfide and others inorganic sulfur compounds and molecular sulfur. TB include many purple and green phototrophic bacteria, some cyanobacteria, a number unphotosynthetic bacteria. TB live in fresh and salt waters, sulfur springs with low content of H_2S. TB actively participate in the circulation of sulfur in nature, most of them – strict aerobes that carry of bacterial leaching of metals from ores, concentrates and rocks, aerobic cause corrosion of metals and destruction of concrete buildings, etc. In biogeotehnology *Thiobacillus ferrooxidans* are widely used. These bacteria are recovered the required energy for the growth of in the oxidation of sulfur and ferrous iron in the presence of free oxygen. TB are leached iron, copper, zinc, uranium and other metals, oxic of sulfuric acid, which is formed by these bacteria with sulphide. The ability of phototrophic TB convert H_2S in the anoxic photosynthesis can use them for biological purification of this toxic compound.

Tolerance – the relative capacity of an organism to endure an unfavorable environmental factor or change.

Total bacterial number, **TBC** – criterion of bacterial contamination, based on the total count of bacteria colonies formed in unit of volume.

Toxins – toxic substances of microbial, animal or vegetable origin. Most T are peptides and proteins, sometimes with non-protein T origin (for ex., aflatoxins – coumarin derivatives). T are divided into endotoxins (complex proteins) and exotoxins (simple proteins). T have different mechanisms of action: neurotoxins (for ex., tipotoxin), block the transmission of signals in the nervous system, cytotoxin (for ex., T of snake poisons) cause lysis of different cells, T – inhibitors (for ex., Diphtheria T.) inhibit synthesis of protein in the cell and the activity of certain enzymes in the cell, T enzymes (for ex., phospholipase, protease) hydrolyze of organic compounds, the important for normal functioning.

Transgenic organism – an organism whose genetic characteristics have been altered by the insertion of a modified gene or a gene from another organism using the techniques of genetic engineering.

Transgenic plant – genetically modified plant, genome of which contains a transgene (see *Transgene*). TP are obtained by transgenesis (see *Transgenesis*). To create a flowering TP usually agrobacterial transformation is used (see *Agrobacterial transformation, agrobacterial gene, transfer*). For monocotyledons (mainly cereals) other ways of transferring genetic structures are developed, which often use ballistic method. TP are established at present, with useful properties and characteristics (for ex., with high resistance to herbicides, insects, pathogenic fungi, bacteria, viruses), organisms-producers of a wide spectrum of biologically active substances (hormones, vitamins, cytokinin, factors growth, enzyme subunit and edible vaccines, etc.), with potential applications in medicine. For ex., transgenic rice was obtained, in which gene was expressed, required for the synthesis of β-carotene (provitamin A). The result was the "golden rice" that can help 2 bln people who suffer from vitamin A deficiency, for whom rice is a basic foodstuff. Using ofTP can increase the productivity, reduce of harvest storage losses, and implement the innovative approaches to solving environmental problems of agriculture, in particular significantly (by 2–3 orders of magnitude) reduce the use of chemical protection and regulation of plant growth. There are fears about uncontrolled ingress of TP at the environment and harm of TP as food, which, however, have not found yet, that his confirmation. The first TP (Tobacco plants with integrated genes of microorganisms) was obtained in 1983 using agrobacterial transformation; the first successful field tests of TP (resistant to viral infection tobacco plants) was held in 1986, at the same time TP were received (Tobacco and sunflower), expressing of significant first pharmaceutical protein – a growth hormone. See also *Transplastomic plants*.

Trophic relations – involving the feeding habits or relationships of different organisms in a food chain or food web.

Trophic chain – a linear system of links in a food web starting from «producer» species and ending at apex predator species, detrivores, or decomposer species.

Trophic level – organisms are the position it occupies in a food chain.

Tropism – 1) aims growth movement or bending of the plants caused by the unilateral action of a stimulus (for ex., in response to unilateral light, gravity, etc. of environmental factors); 2) property parasites choose as the habitat of certain organisms (species T) or organs (organ or tissue T). See *Tropism virus.*

Typing – identification and classification of phages, microorganisms, tissues, blood, etc.

U

Urbanization – the process by which towns and cities are formed and become larger as more and more people begin living and working in central areas.

Underdominance – a phenomenon weaker manifestation of symptoms (survival or viability) in homozygotes from heterozygotes comparable.

Unit of biological activity – is standard unit, which is generally used to express the magnitude of the biological activity of antibiotics (see *Antibiotics*). The minimum number of antibiotic takes as UBA that could inhibit the development or delay the growth of the standard test strain of microbes in a culture medium volume. For ex., UBA of penicillin – the minimum amount of drug that retards the growth of golden staphylococcus strain 209 at 50 ml of nutrient broth. UBA is also used to express the activity of toxins, growth factors, and others biologically active substances.

V

Valeology – the study of the mechanisms and methods of health preserving and strengthening. The level, and potential and reserves of physical and mental health, methods, tools and technologies that can contribute to its preservation and strengthening are studied by V.

Variability – ability of organisms to change their morphological organization, which makes a variety of individuals, populations, races, etc. V is specific to all organisms and there is even at genetically closely related individuals with similar or general living conditions and development (for ex., the twins, and members of a family of microorganisms and organisms that vegetatively propagated). V can be hereditary and modified. Modified forms of individuals, populations, races, etc. are called variants. The natural selection and random impacts of environmental are mainly factors that reduce the extent of V.

Variation – 1) modification, deviation from the typical structure, composition, process; 2) phenotypic differences between individuals in a population or species due to the interaction of environmental factors with genotype.

Vector – an organism or object used to transfer genetic material from a donor organism to a recipient organism. This is a natural (plasmid, bacteriophage, virus, etc.) or artificially constructed recombinant DNA molecule. It contains a selective marker and can autonomously replicate in the recipient cell; is used to transfer the cells of a foreign DNA fragment with the aim of cloning and/or expression.

Viral adaptation – 1) adaptation of the virus that occurs at natural conditions of the new organism, virus to multiply in the host cell or acquisition of resistance to drugs; 2) methodological procedure that allows to obtain strains of viruses capable to the reproduction in tissue culture (*in vitro*).

Viroids (viroids) – subvirusni infectious agents which are lack of protein shell, and are agents of certain diseases (primarily in higher plants). There are known 2 major families of V: *Avsunviroidae* and *Pospiviroidae*. The genom of V is exposed by single-circuit ring RNA (from 247 to 401 bp), which is replicated and does not encode of proteins. V are capable to infect independently of the host cells. Distribution of V takes place by mechanical means (including insects), at the vegetative propagation and grafting plants using seeds, spores and pollen. It is believed that V. are "introns, escaped", ie are cutted during pre-mRNA splicing. V. affects plants persistently, causing of systemic infection in the site-migration to other parts of plants; or can transported mechanically through the cell sap, seeds and pollen. Used as vectors in genetic engineering of plants. First V (*Potato Spindle Tuber Viroid (*PSTVd) was found in 1971by T. Diner.

Viruses – it is non-cellular life form. V don't have their own metabolism, lack the typical cellular organelles and structures outside the cell orgnism or they do not exhibit of life signs. V are ultramicroscopic infecting complex (20–400 nm), characterized of cross throw bacterial filters, lack of growth on syntheticl nutrient media, the ability to independently reproduce only within cells of susceptible organism or develop in tissue culture (*in vitro*); intracellular parasite. V have a different shape and size, are composed from nucleic acid (DNA or RNA) and protein shell – capsid. Some elements of the protein shell are called capsomeres. Nucleinic acid someV is included in the protein shell without breaking which can not be released. Nucleic acid others V is included in a capsule, like a box, and can go outside without breaking the shell. There are three main types of interaction V and cells: a productive infection, abortive infection (see *Abortive infection*) and virogeny. Viruses that affect of bacterial cells are called bacteriophages or phages, viruses of fungi – mycophages (see *Mycophages*), actinomycetes – actinophages. V have the different resistance to environmental variables: many of them are inactivated at 60 °C for 30 min., others can withstand temperatures of + 90 °C for 10 minutes. V. easy tolerate of desiccation and low temperature, but have less resistance to ultraviolet rays and radiation. V cause many human diseases – poliyemiolit, measles, smallpox, encephalitis, some forms of cancer, at animals - foot and mouth disease, plague, rabies and at plants – dwarfism, mosaic, leaf curl. First V (*V. tobacco mosaic*) was found by D.I. Ivanovsky in 1892, the term "V" was suggested by M. Beijerinck in 1899.

Visualization – presentation of the physical process or phenomenon in a form suitable for visual perception.

W

Water treatment – a set of ways of natural water processing, is used to bring its quality indicators in compliance with the regulations. W. comprises the following steps: lighting (removal of the water coagulation of colloidal and suspended particles), disinfection (removal of pathogens), softening (removal of insoluble calcium and magnesium), demineralization (removal of soluble salts), degassing (removal of dissolved gas), adding some components (for ex., fluoridation).

Wild type – phenotype that is most common in natural populations, signs of which are determined by "normal" alleles.

Wild type gene – see *Wild-type allele.*

Wild-type allele – allele that encode of phenotypic characteristics inherent in the wild strain (type) of the organism, is most commonly presented in natural populations.

Wilt – wilting plants caused by various reasons. Often W. is called of tracheomycosis disease that occurs when the defeat by fungi *Verticillium dahliae* (*Verticillium* W.) and *Fusarium oxysporum* (*Fusarium* W.). The first is affected about 350 species of flowering plants. Pathogen grows in the soil through root penetrates in the plant and extending through xylem (see *Xylem*), leads to wilting of the aerial. As a result, often the entire plant dies, at least – some of its parts. Cotton, less sesame, flax, tomato, potato, melon, watermelon, peach, apricot are most defeated from W.

X

Xenobiotics – compounds or factors that are alien for organism (industrial pollution, pesticides, household chemical drugs, medicines, etc.); matter of nonendogenous origin, acting as toxins; pharmacologically and endocrinology active X are divided into biological (for ex., viruses, bacteria), chemicals (pesticides), physical (manmade radiation). X can affect on the genetic apparatus of organisms, getting into the environment in significant quantities, cause their death, and disrupt the balance of natural processes in the biosphere.

Xenogenic transplantation – transplantation of organs, tissues between individuals belonging to taxonomically very different forms, namely (different families, genera or significantly differentiated species).

Xenologous genes – genes that fall into the genome of different species of organisms in the horizontal (non-hereditary) transfer of genetic material between organisms (for ex., genes that are called xenolog). Horizontal gene transferring occurs at physical contact of cells that exchange of genetic material, ie, parasitic, symbiotic or associative systems with phylogenetically distant but geographically close groups of cells or organisms. Carriers of alien (xenologous) DNA can be retroviruses, and in prokaryotes – plasmids at the conjugation and transduction with bacteriophages.

Xenoplastic transplantation, xenogenic transplantation – transplantation of the organs, tissues between individuals, belonging to taxonomically very different forms, namely to different families, general or significantly differentiated species.

Xerophyte – a plant adapted for growth under dry conditions.

Y

Yeast – out of the taxones group of unicellular fungi that lost of filamentous structure in the transition to function of liquid and semiliquid substrates, rich in organic matter; brings together about 1500 species, which belong to ascomycetes and basidiomycetes. Yeast reproduce by budding, at least – spores or simple cell division; sexual process is recorded in some species. In anaerobic conditions yeast can be used as energy source: only carbohydrates, mostly hexoses and oligosaccharides formed on their basis. The true (spore-forming) yeasts basically use in practical biotechnological processes that have sexually reproduce way (for ex., *Saccharomyces*) and usually are not pathogenic for humans. So, baker and brewer's yeast (*Saccharomyces cerevisiae*) is widely used in the baking and brewing industries, *Kluyveromyces fragilis* makes of lactose digestion, *Saccharomycopsis lipolytica* decomposes of hydrocarbons and is used for protein mass. Some Deuteromycetes (imperfect fungi) are used: *Candida utilis* grows in sulfite waste water (waste paper industry); *Trichosporon cutaneum* oxidize many of organic and some toxic compounds (for ex., Phenol), plays an important role in the aerobic wastewater recycling; *Trichosporon cutaneum* synthesize of astaxanthin - the carotenoid that gives the orange or pink color to salmon and trout flesh at growing on farms. Industrial yeasts are usually not reproduce sexually, do not form spores and are polyploid. It explaines their active ability of fast adaptation to changes of cultivation.

Yeast two-hybrid system – the first of systems, was created on base of the analysis of gene expression in yeast for experimental detection of protein-protein interactions.

Z

Zoological Park (zoo) – a facility in which animals are confined within enclosures, displayed to the public, and in which they may also be bred.

Zygote – is a eukaryotic cell formed by a fertilization between two gametes. The zygote's genome is a combination of the DNA in each gamete, and contains all of the genetic information necessary to form a new individual. In multicellular organisms, the zygote is the earliest developmental stage. In single-celled organisms, the zygote can divide asexually by mitosis to produce identical offspring. Fertilized ovicell, which give the start of the development of a new organism with diploid (2n) chromosomes, formed by the fusion of haploid gametes of different sexes.

Zygotic induction – induction of reproduction of prophage in lysogenic not f-cells after a conjugation transfer in these cells of genetic material with included prophage.

Zygotic lethal – is the lethal mutation (See *Lethal mutation*), which comes through the stage of development embryos after formation of zygote (See *Zygote*), but does not influence on livelihoods gametes. ZL divides into: the embryonic, juvenile and postembryonic depending on the phase of specificity exercitation.

Zymosis (fernentation) **–** it is a metabolic process of conversion of organic matter (carbohydrates, alcohols, organic acids, amino acids), in which the organisms gets the energy, which is required for their life (see *Adenosine triphosphate, ATP*). The alcohols, organic acids, acetone, CO_2 and others compound produce. There are many types of F.: alcohol (formation of the alcohol and carbon dioxide), which is caused by yeast organisms and some molds; butyric (accompanied by the formation of butyric acid), which is in most cases the obligate anaerobes (see *Anaerobes, Anaerobic organisms*) and cause the spoilage of canned products; methanogenic (formation of the methane), which is mainly made by microorganisms that break down of the cellulose (for ex., the wastewater treatment); lactic (accompanied by the formation of lactic acid), which occurs by microorganisms and is widely used in the manufacture of dairy and other food products. F. is evolutionarily older and less energetically favorable form of extraction of energy from nutrients. Many species of F. are used in food and microbiological industry for obtaining of alcohols, organic acids and others substances. Microbial nature of F. was opened by Louis Pasteur in 1857.

MAIN REGULATORY DOCUMENTS

International agreements

Konventsiia pro okhoronu biolohichnoho riznomanittia – Rio-de-Zhaneiro, 1992 r.

Videnska konventsiia pro okhoronu ozonovoho sharu – Viden, 1985 r.

Vseievropeiska stratehiia zberezhennia biolohichnoho ta landshaftnoho riznomanittia – Sofiia, 1995 r.

Heteborhskyi protokol 1999 roku pro borotbu z pidkyslenniam, evtrofikatsiieiu i pryzemnym ozonom do Konventsii pro transkordonne zabrudnennia povitria na velyki vidstani, vid 1979 r.

Yevropeiska landshaftna Konventsiia – Florentsiia, 2000 r.

Kartakhenskyi protokol pro biobezpeku do Konventsii pro biolohichne riznomanittia – Monreal, 2000 r.

Kiotskyi protokol do Ramkovoi konventsii OON pro zminu klimatu – Kioto, 1997 r.

Konventsiia OON pro borotbu z opusteliuvanniam u tykh krainakh, shcho poterpaiut vid serioznoi zasukhy ta/abo opusteliuvannia, osoblyvo v Afrytsi, 1994 r.

Konventsiia pro zakhyst Chornoho moria vid zabrudnennia, 1992 r.

Konventsiia pro zberezhennia mihruiuchykh vydiv dykykh tvaryn – Bonn, 1979 r.

Konventsiia pro mizhnarodnu torhivliu vydamy dykoi fauny i flory, shcho perebuvaiut pid zahrozoiu znyknennia (CITES), 1963 r.

Konventsiia pro okhoronu vsesvitnoi kulturnoi ta pryrodnoi spadshchyny – Paryzh, 1972 r.

Konventsiia pro okhoronu dykoi flory i fauny ta pryrodnykh seredovyshch isnuvannia v Yevropi (Bernska konventsiia) – Bern, 1979 r.

Konventsiia pro okhoronu riky Dunai – Sofiia, 1994 r.

Memorandum pro vzaiemorozuminnia shchodo zberezhennia mihruiuchykh khyzhykh ptakhiv Afryky ta Yevrazii (potrebuie rozghliadu pytannia shchodo zdiisnennia na natsionalnomu rivni vidpovidnykh protsedur dlia pidpysannia Memorandumu vid imeni Ukrainy).

Memorandum pro vzaiemorozuminnia shchodo zakhodiv zberezhennia prudkoi ocheretianky (Acrocephalus paludicola).

Memorandum pro vzaiemorozuminnia shchodo zberezhennia ta menedzhmentu serednoievropeiskoi populiatsii drokhvy (Otis tarda).

Memorandum pro vzaiemorozuminnia shchodo zakhodiv zberezhennia tonkodzoboho kronshnepa (Numenius tenuirostris).

Nahoiskyi protokol pro dostup do henetychnykh resursiv ta rozpodil na spravedlyvii i rivnii osnovi vyhod vid yikh vykorystannia do Konventsii pro biolohichne riznomanittia, 2010 r.

Prohrama robit po pyrodno-zapovidnym terytoriiam Konventsii pro biolohichne riznomanittia.

Protokol pro zberezhennia i stale i landshaftnoho vykorystannia biolohichnoho riznomanittia do Ramkovoi konventsii pro okhoronu ta stalyi rozvytok Karpat.

Ramkova konventsiia OON pro zminu klimatu – Rio-de-Zhaneiro, 1992 r.

Ramkova konventsiia pro okhoronu ta stalyi rozvytok Karpat – Kyiv, 2003 r.

Ramsarska Konventsiia pro zakhyst ta zberezhennia vodno-bolotnykh uhid – Redzhaina, 1987 r.

Uhoda pro zberezhennia afro-yevraziiskykh mihruiuchykh vodno-bolotnykh ptakhiv.

Uhoda pro zberezhennia kazhaniv v Yevropi.

Uhoda pro zberezhennia kytopodibnykh Chornoho moria, Seredzemnoho moria ta prylehloi akvatorii Atlantychnoho okeanu.

Laws of Ukraine

Zakon Ukrainy «Pro okhoronu navkolyshnoho seredovyshcha» vid 25 chervnia 1991 roku.

Zakon Ukrainy «Pro pryrodno-zapovidnyi fond» vid 16 chervnia 1992 roku.

Zakon Ukrainy «Pro okhoronu atmosfernoho povitria» vid 16 zhovtnia 1992 roku.

Zakon Ukrainy «Pro pestytsydy ta ahrokhimikaty» vid 2 bereznia 1995 roku.

Zakon Ukrainy «Pro roslynnyi svit» vid 9 kvitnia 1999 roku.

Zakon Ukrainy «Pro moratorii na provedennia sutsilnykh rubok na hirskykh skhylakh v yalytsevo-bukovykh lisakh Karpatskoho rehionu» vid 10 liutoho 2000 roku.

Zakon Ukrainy «Pro myslyvske hospodarstvo ta poliuvannia» vid 22 liutoho 2000 roku.

Zakon Ukrainy «Pro pryiednannia Ukrainy do Kartakhenskoho protokolu pro biobezpeku do Konventsii pro biolohichne riznomanittia» vid 12 veresnia 2000 roku.

Zakon Ukrainy «Pro tvarynnyi svit» vid 13 hrudnia 2001 roku.

Zakon Ukrainy «Pro Chervonu knyhu Ukrainy» vid 7 liutoho 2002 roku.

Zakon Ukrainy «Pro okhoronu zemel»» vid 19 chervnia 2003 roku.

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Zakon Ukrainy «Pro Osnovni zasady (stratehiiu) derzhavnoi ekolohichnoi polityky Ukrainy na period do 2020 roku» vid 21 hrudnia 2010 roku.

Zakon Ukrainy «Pro rybne hospodarstvo, promyslove rybalstvo ta okhoronu vodnykh bioresursiv» vid 8 lypnia 2011 roku.

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FOR NOTES

Scientific edition

Klyachenko O.L., Lisovyy M.M., Kvasko O.Yu.

FUNDAMENTALS OF BIODIVERSITY

Textbook

Editor
Layout and cover design by O.M. Vyuntsova

Signed for printing on 00.00.2023.
Format 60x84/16. Times New Roman font.
Conditions - print. sheet. 19.0.
Edition of 300 approx. Deputy No. 492

Subject's certificate of state registration
DK no