

Topic 3

Physical and chemical environmental factors in the life of organisms, role and significance

Motivation

The vast majority of all living organisms that make up complex ecological systems are exposed to physical and chemical factors in their life activities. Moreover, these factors often play the role of limiting factors, i.e. factors that limit the development and vital activity of the body due to their deficiency or excess compared to the need (optimal content). For the first time, the importance of limiting factors that were at a minimum was pointed out by the German agrochemist J. Liebig in the middle of the 19th century. He described the importance of even individual chemical deficiencies for plant productivity (for example, insufficient phosphorus in the soil can reduce yields). This phenomenon was called the law of the minimum by Yu. Liebig . R. Mitscherlich showed that the combined effect of all plant life factors, including physical ones: temperature, humidity, light, etc., is important for productivity. Subsequently, in the development of theoretical aspects of the influence of physical and chemical environmental factors on the vital functions of organisms, the law of independence of factors by V. R. Williams and the law of tolerance by V. Shelford played a huge role . It has now been repeatedly confirmed that in natural conditions, organisms depend on critical levels of exposure to physical factors, the content of necessary chemicals, as well as on the range of tolerance of the organisms themselves to various environmental factors. These patterns relate to the fundamental ecological principles and laws, knowledge of which is of great practical professional importance for pharmacists and can be used in developing methods for growing medicinal plants or creating test systems for the selection of plants resistant to oxygen deficiency and other physical and chemical factors, contributing to the formation of environmental thinking.

Purpose of the lesson: to form an idea of the meaning and role of physical and chemical factors in the life of organisms, as a theoretical basis for the implementation of professional labor actions, taking into account the need to ensure environmental safety.

Question for oral questioning:

1. The concept of limiting environmental factors and the range of tolerance of organisms to their effects (stenobionts and eurybionts).
2. Physical environmental factors and their significance in the life of organisms (temperature, humidity, air movement, light, radiation).
3. Poikilothermic and homeothermic animals: concepts, examples. The combined effect of temperature and humidity on the life of organisms.
4. Light and its role in the life of organisms: The concept of photoperiodism, examples of the influence on the life of representatives of the animal and plant world.
6. The importance of oxygen in the life of organisms. Gas exchange in the aquatic environment (adaptation of organisms to living in an environment with low oxygen content, adaptation to fluctuations in oxygen content in the environment).
7. Hypoxia - concept, adaptation mechanisms. Comparative analysis of the quantitative oxygen content in different media (water, air), factors that change the amount of oxygen.
8. The importance of green spaces in changing the chemical composition of the air.
9. Water as the most important environmental factor. Classification of terrestrial organisms depending on their water needs.
10. Nutrients (macro- and microelements): concept, examples, significance in the life of plants and animals. Large cycle of substances in nature.

List of knowledge and practical skills

After mastering the topic, the student must know the general laws of ecology

After mastering the topic, the student must be able to carry out the prevention of environmentally-related diseases among the population, carry out awareness-raising and health education work on environmental education and training.

Independent work of students in class

1. Carrying out practical work to determine physical environmental factors:
 - 1.1. Measuring and recording ambient air temperature
 - 1.2. Determination of relative air humidity using an aspiration psychrometer.
 - 1.3. Determination of air speed with an anemometer.
4. Solving a situational professionally oriented problem, documenting the solution in a protocol.
5. Listening and discussing the essay prepared by the student on the individual instructions of the teacher.
6. Working with control tests.
 - 6.1. Input test to control the level of knowledge on the topic of the lesson.

Exercise. Input control of the level of knowledge in the second lesson on topic No. 3 - give written answers to control test questions and submit the work to the teacher for checking.

Reference material

Limiting environmental factors, or limiting factors , are environmental factors (usually of a physical or chemical nature) that limit the development of organisms due to a deficiency or excess compared to the need (optimal content).

The range of tolerance (or tolerance) of environmental factors in various plant or animal organisms is very diverse. However, in accordance with W. Shelford's law , both a deficiency and an excess of any factor (in a qualitative or quantitative sense) may be close to the limits of what can be tolerated for each specific organism.

Such limits are called *limits of tolerance*.

Organisms whose life requires conditions limited to a narrow range of tolerance are called *stenobionts* (" steno " - narrow), and those adapted to live in conditions with a wide range of tolerance are called *eurybionts* ("eury" - wide). For example, shade-loving plants are stenobionts in relation to the effects of sunlight Sveta; The brown bear is eurybiontic in relation to climatic factors. It is known that organisms that are eurybiont to the main climatic factors are most widespread on planet Earth.

It is worth considering that the body's tolerance range does not remain constant and unchanged throughout life; it can narrow or expand. For example, newborn representatives of mammals are more stenobionts to the effects of physical factors (and above all, temperature) compared to adult individuals.

Physical environmental factors

Ambient temperature is one of the most important limiting factors. Highlight stenothermic And eurythermic organisms (Fig . 1).

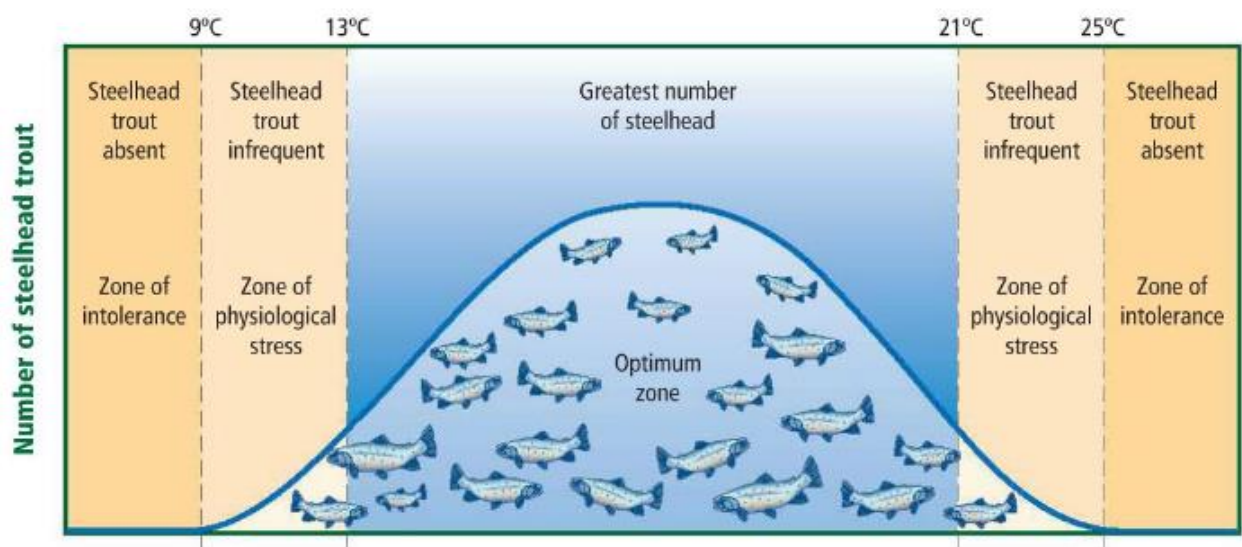


Figure 1. Limits of tolerance of eurythermal and stenothermal organisms.

Homeothermic animals have a higher tolerance limit compared to poikilothermic animals. In general, most living beings are able to live in a temperature range from 0 to 50° C, which is due to the characteristics of cell protoplasm and protein denaturation in animals and the characteristics of photosynthesis in plant organisms. For example, at temperatures above 0° C , metabolic processes are activated in most perennial and annual plants; with an increase in temperature by 10° C, the intensity of photosynthesis increases 2 times, but only to a level of 30-35° C; with a further increase in temperature, the intensity of photosynthesis decreases, and at 50° C stops altogether.

The thermal state of the environment, determined by a complex of physical factors (temperature, humidity, air speed, radiant heat) in a limited space and

influencing the heat exchange of living organisms, is designated by the term *microclimate* .

Monitoring the state of ambient temperature and measuring it is carried out using thermographs and a set of technical, research and meteorological thermometers, most often liquid ones. Together with thermographs, minimum and maximum liquid thermometers are also used to establish specific values for recorded temperature fluctuations.

Ambient relative humidity can be measured using aspiration psychrometers, and wind mobility can be measured using vane or cup anemometers. Wind speed changes under the influence of cyclonic activity of the atmosphere, and the passive movement of air masses is of a convective nature. Air movement promotes the movement of aeroplankton (spores, pollen, seeds, microorganisms and also insects and even small animals) and contributes to their settlement in limited areas. Under the influence of wind loads, the above processes can occur much more intensely and, in addition, the wind has a direct effect not only on living organisms, but also on the environments themselves, causing characteristic adaptations. For example, adaptation to flight as a means of searching for food or changing the terrain, etc.

Light and its role in the life of organisms. Natural light, the source of which is the Sun, is the most important environmental factor without which life on planet Earth is impossible. Sunlight is the most important source of energy; it participates in the processes of photosynthesis, providing plants with the production of oxygen and organic compounds from inorganic ones. It should be remembered that only part of the solar spectrum with a wavelength in the range from 380 to 760 nm is involved in photosynthesis . This area is called *the physiologically active radiation region (PAR)* . Within it, waves with a length of 600-700 nm (red-orange) and 400-500 nm (violet-blue) are of greatest importance for photosynthesis; waves with a length of 500-600 nm correspond to the yellow-green part of the spectrum and have the greatest reflectivity. Outside the PAR are the ultraviolet (UV) and infrared (IR) regions. UV radiation has a photochemical effect, and organisms are very sensitive to its effects. IR radiation has a greater thermal effect, which is important for climate

formation, heating of water masses, and even for a direct increase in body temperature in poikilothermic organisms.

In addition, illumination is also important for the life of plant and animal organisms - a light value equal to the ratio of the luminous flux incident per unit area to its area, measured in lux (lx), as well as illumination intensity, which is also measured in *lx* and in temperate latitudes in the summer at noon in sunny weather it reaches a value of 100,000 lux, and in the afternoon it decreases to 25,000 lux. Depending on the limits of tolerance to light and light intensity, all plant organisms are divided into: *light-loving, or heliophytes* (meadow grasses, cereals, weeds, fruit trees...), *shade-loving, or sciophytes* (plants of forest-steppe oak forests, taiga spruce forests, tropical forests) and those *that are not tolerant* (black elderberry, lily of the valley, golden currant, common mantle, etc.). Shade-tolerant plants have the widest range of light tolerance.

In addition, light has a signaling and regulatory significance, which is manifested, among other things, by *photoperiodism* in plants - the body's reaction to seasonal changes in the length of daylight hours .

Electromagnetic fields, in particular the geomagnetic field of the Earth, are also of great importance in the life of animals and humans. For example, it is known about the influence of changes in the intensity of the geomagnetic field on anthropometric indicators: with a decrease in the intensity of the magnetic field, an increase in the size of the skeleton of animals and humans is recorded. Electromagnetic fields are also universal carriers of information in the biosphere; they are associated with the migration of migratory birds, the migration of fish during the spawning period, etc.

The electrostatic field affects the content of air ions and the ratio of negatively and positively charged air ions) - the predominance of negative (so-called light air ions) leads to an increase in the germination of plant seeds and an increase in the vital activity of animals and humans.

The Earth's natural radioactive field, or field of ionizing radiation, is formed due to cosmic radiation, radionuclides included in rocks (potassium-40, uranium-

238, thallium, thorium-232, radium-226), as well as radioactive gases - radon 222 and radon-220 (thoron). Fixed on the surface and in the near-surface part of the lithosphere. Natural radioactive background varies between 2-20 mSv /year; this level is considered safe. In cases where the above level of radioactivity is exceeded, so-called long-term effects, in particular mutagenic effects, may be observed.

Chemical factors and their significance in the life of organisms

Among the most important environmental factors of a chemical nature, we primarily pay attention to oxygen, nitrogen, carbon and water. The chemical composition of the atmosphere at the present stage of the evolution of planet Earth is quite homogeneous and is represented by: nitrogen and its compounds - 78.8%; oxygen – 20.95%; argon and other inert gases - 0.9%; carbon dioxide, or carbon dioxide – 0.03-0.04% by volume. In the aquatic environment, the amount of oxygen is 20 or more times less (at great depths) than in the atmosphere (Table 1).

Table 1

Oxygen in water and air environments

	Water environment	Air environment
The amount of oxygen in the environment	Sea and fresh waters contain 88.8% (by mass) bound oxygen; in small fast cold rivers the upper threshold reaches 12 mg/l, in lowland rivers, large flowing lakes and reservoirs - 9-7 mg/l, in small closed lakes and ponds - 5 mg/l; 3-6 mg/l in drinking water.	In the atmosphere, the content of free oxygen is 20.95% by volume and 23.12% by mass.
Factors that reduce the amount of oxygen in the	As the water temperature decreases, the amount of dissolved oxygen begins to decrease. With a subsequent decrease in temperature, aquatic plants and algae begin to die off, the intensity of photosynthesis is reduced to zero, and the content of dissolved	Environmental pollution, active and passive smoking. A decrease in the amount of atmospheric oxygen, and therefore

environme nt	oxygen in water depends only on the mechanical effect of air on water. Next comes a critical period in the life of the fish population of the reservoir - the establishment of a dense ice cover, which almost completely blocks the access of oxygen from the air to dissolve in the upper layer of water.	its entry into the body, is largely facilitated by increased air humidity, accompanied by high temperature. Increase in altitude above sea level.
Factors that increase the amount of oxygen in the environme nt	High speed of air movement, as the intensity of mixing water and air increases, which is facilitated by powerful autumn wind-driven disturbances in river flows. In summer, during the intensive growth of algae and submerged aquatic vegetation in lowland rivers and lakes, the amount of oxygen is higher, as plants release oxygen into the water through the process of photosynthesis. The oxygen content of water is affected by the temperature of the water: the colder the water, the more oxygen it contains.	Regular ventilation of enclosed spaces.

Oxygen and carbon dioxide are limiting factors for the distribution of living organisms and life forms in the atmosphere and hydrosphere (Fig. 2).

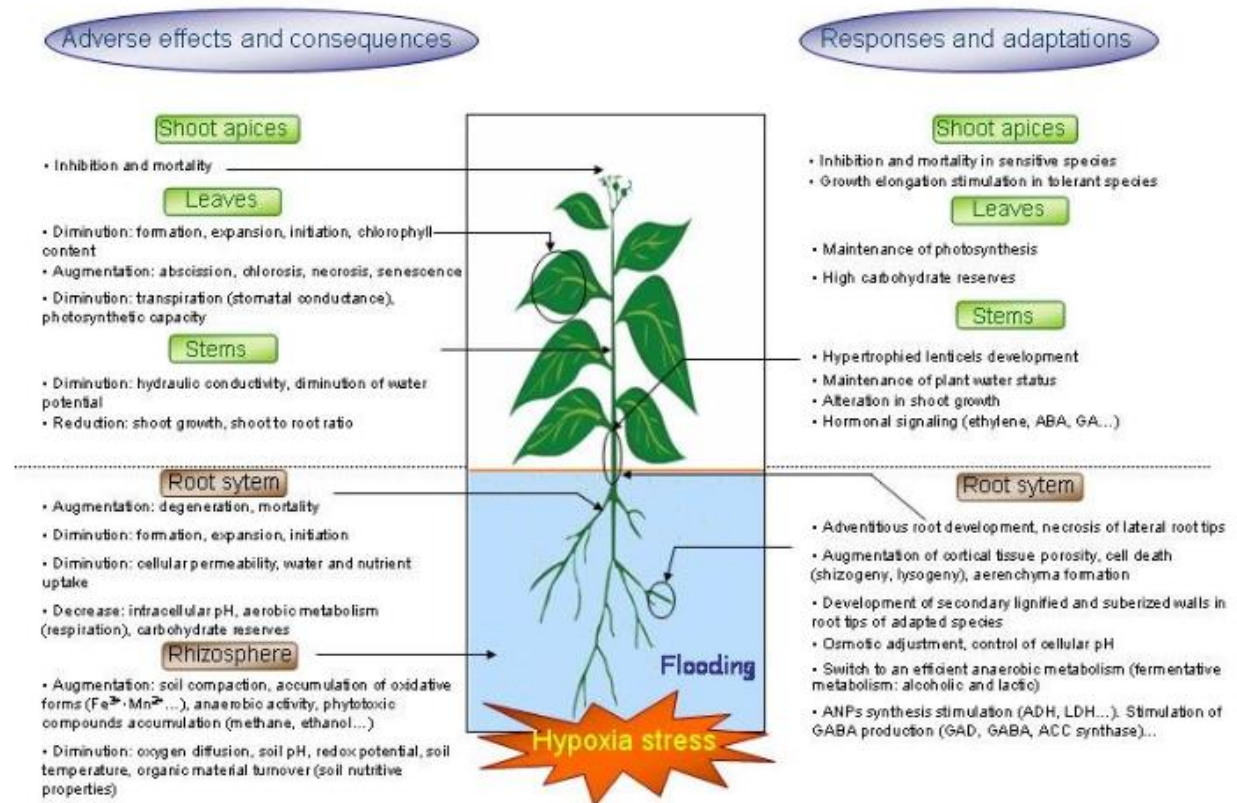


Figure 2. Scheme of ways of plant adaptation to hypo- and anoxia

The carbon dioxide content in the soil reaches about 10%, and oxygen becomes a limiting factor for aerobic organisms. Among the biogenic macroelements, nitrogen and phosphorus act as the most important biogenic macroelements for all spheres of life, because phosphorus is the most important intracellular element, and nitrogen is a component of protein molecules. These elements participate in the biological cycle of substances and are fixed by most plant and heterotrophic animal organisms. The importance of phosphorus for plant productivity was described by J. Liebig in the 19th century and became one of the basic environmental laws. It is known that phosphorus deficiency is second only to water in its effect on the productivity of biota. Potassium, calcium, sulfur and magnesium also play a vital role in the life of organisms: they perform structural, biochemical and regulatory functions. Biogenic microelements: iron, manganese, copper, zinc, boron, silicon, molybdenum, chlorine, vanadium and cobalt are included in enzymes, ensure the transfer and exchange of oxygen, regulate the processes of photosynthesis and

nitrogen metabolism, etc. It is important to consider that not only a deficiency, but excess (due to environmental pollution or as a result of natural endemics) can act as limiting factors.

plays a role *in the life of organisms* the most important role. From a physiological point of view, water is a universal solvent that ensures the occurrence of most redox reactions, the most important structural component of protoplasm; From an environmental point of view, it is a living environment and a limiting factor for both flora and fauna, both in terrestrial and aquatic habitats.

All living organisms, depending on their need for water, and, consequently, on differences in habitat, are divided into a number of ecological groups:

- **aquatic or hydrophilic** - permanently living in water;
- **hygrophilic** - living in very humid habitats;
- **mesophilic** - characterized by a moderate need for water;
- **xerophilous** - living in dry habitats.

Based on the type of habitat and lifestyle, aquatic organisms are grouped into the following ecological groups.

Plankton are organisms that mostly move passively due to currents. There are **phytoplankton** (single-celled algae) and **zooplankton** (single-celled animals, crustaceans, jellyfish, etc.).

Nekton are animals that actively move in water (fish, amphibians, cephalopods, turtles, pinnipeds, cetaceans, etc.).

Benthos are organisms living at the bottom and in the soil. It is divided into **phytobenthos** (attached algae and higher plants) and **zoobenthos** (crustaceans, mollusks, starfish, etc.).

In addition, in some cases, **periphyton and neuston are isolated**. Periphyton are organisms attached to the leaves and stems of aquatic plants or other protrusions above the bottom of a reservoir. Neuston – organisms that live at the surface of water (mosquito larvae, water striders, duckweed, etc.).

For aquatic environments, water temperature, transparency, current, salinity, oxygen concentration, etc. are important. For the land-air environment, the most

important characteristics are: the amount of precipitation, air humidity, available water supply, etc.