Ministry of Education and Science of Ukraine
V. N. Karazin Kharkiv National University

MICROELEMENTOSES IN THE PRACTICE OF A DOCTOR

Methodological recommendations
for independent work of students of the 2nd year of study of the medical faculty
in the discipline "Human Microelementoses"

Electronic resource

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M 59

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M 59 **Microelementoses** in the practice of a doctor: methodological recommendations for independent work of students of the 2nd year of study of the medical faculty in the discipline "Human Microelementoses" [Electronic resource] / compilers S. O. Sherstyuk, S. A. Nakonechna, A. V. Havrylenko. – Kharkiv : V. N. Karazin KhNU, 2025. – (PDF 70 p.)

Methodological recommendations for independent work of students in the discipline "Human Microelementoses" are developed in accordance with the current programs in this discipline for students of medical faculties of universities. The manual is intended for the work of students in preparation for classes on the course "Human Microelementoses". The topics are illustrated with drawings and diagrams that facilitate the perception of the material and contribute to its better assimilation. The materials allow students to form a correct understanding of the patterns of structure and functions of the human body. For students of the Faculty of Medicine.

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CONTENT

ENTRY

MICROELEMENTOLOGY (from micro..., Latin elementum – element, primordial substance and ... logy) is the study of the composition, biological role and mechanisms of participation of chemical elements of low concentrations (trace elements) in living organisms, as well as states and processes in them associated with impaired intake (lack or excess) or imbalance of trace elements. Trace elements in living organisms began to be detected in the 19th century, although they have been systematically studied since the beginning of the 20th century. A significant contribution to the study of the influence of trace elements on the vital activity of organisms was made by V. Vernadsky and his followers.

At present, biological (physiological) microelementology, medical, veterinary microelementology, nutritionology, agronomy (agrochemical) microelementology, chemical, biogeochemical, etc. are distinguished. However, they can be combined in three main areas – microelementology of plants, animals and humans. The 30 most important trace elements for the life of plants, animals and humans are determined - iron, iodine, manganese, cobalt, copper, selenium, zinc, fluorine, chromium, bromine, molybdenum, vanadium, silicon, etc. The lower the concentration of an element in a living organism, the more difficult it is to find out its biological role and functions. For example, the importance of such elements in living organisms as scandium, zirconium, niobium has not yet been precisely established.

The term "microelementoses" is most often used in medical practice in relation to human microelementoses; It has become widespread in recent decades as a result of the accumulation and deepening of clinical studies of the metabolism of trace elements in the human body, which has become possible, in particular, thanks to the latest diagnostic technologies. Although the first studies on trace elements were carried out on animals in the 1920s, when the composition of trace elements in soils and animal tissues from different geochemical zones was compared. In the 1980s. The norms of the content of most trace elements in the body were established, which made it possible to carry out practical activities in the direction of analysis and correction of the content of minerals in the human body. To determine the elemental composition, certain types of spectrometry (atomic absorption, atomic emission with inductively coupled plasma) and photometric methods (in the infrared spectrum or visible and ultraviolet spectrum) are used. Now it is known that the human body (at the level of all tissues and fluids) consists of 86 chemical elements of the table of D.I. Mendeleev, of which 25 are the most necessary for the normal functioning of the body. All of them are divided into micro and macro elements according to the level of concentration. The concentration of trace elements in the human body ranges from 0.001 to 0.000000000001%, and the daily requirement for them does not exceed 100 mg. The concentration of trace elements is determined by their content in blood, hair, nails, saliva, gastric juice.

According to biological value, trace elements are divided into vital, or essential, and conditionally necessary; There is also a division of trace elements into non-toxic and potentially toxic. The main functions of trace elements in the human body are the regulation of many biochemical processes (in particular, acid-base balance, osmotic pressure of

cellular and intercellular fluids, water-salt metabolism, blood coagulation system, etc.), activation of a number of enzyme systems, hormones, antibodies; promoting the normal functioning of various organs and tissues; participation in the construction of supporting tissues of the body.

Trace elements are not evenly distributed in the body, but depending on their physiological role. So, for example, in the brain, cuprum, manganese, aluminum, silicon, titanium, argentum are actively involved in biochemical processes. In the thyroid gland, iodine is concentrated (although it is present throughout the body), there is also bromine, cobalt, arsenic, mercury, cuprum, plumbum, fluorine, zinc, titanium. In the pancreas - zinc, cobalt, nicol, arsenic, iodine, molybdenum, silicon, manganese, stanum, chromium, plumbum. The liver, on the one hand, is the main repository of minerals for the body, and on the other hand, it is the only organ that removes excess trace elements from it. Trace elements are not synthesized in the body; The source of their supply is food of plant and animal origin and water. The development of microelementology is also facilitated by the latest geochemical research, since the volume of microelements in the body depends not only on the set of food products, but also on the geochemical conditions of the area in which they were obtained, and in general on the state of the environment where a person lives.

Currently, in medicine, many non-communicable diseases are associated with a deficiency, excess or imbalance of micro and macro elements in the body. There are several groups of causes that most often cause health disorders in connection with trace elements (such disorders are also called microelementosis): natural endogenous factors (congenital, hereditary dysfunctions that cause problems with the metabolism of trace elements), natural exogenous factors (geographically different areas have a different natural composition of trace elements in the air, water, soils - from insufficient to excessive for normal human life), man-made factors (man-made environmental pollution leads to a significant excess of trace elements in it), iatrogenic (excess of the concentration of trace elements in connection with the intake of medicines or disturbance of the metabolism of trace elements as their side effect).

The world's most famous example of microelementosis is endemic iodine deficiency, which leads to the development of goiter. The fact that endemic goiter is a consequence of iodine deficiency has been known in science since the 1st half of the 20th century, although it is believed that iodine-deficient goiter was first described in ancient China, where it was treated with extracts from seaweed and thyroid glands of livestock. This disease is most often characteristic of mountainous areas. Iodine deficiency was detected in the western and northern regions of Ukraine, in particular in Polissia, a biogeochemical province characterized by a lack of iodine in soil, water and food. In the Carpathians and Polissia, a biogeochemical province, an increased incidence of thyroid hyperplasia is also recorded.

Left-bank Ukraine, especially the Poltava region, is a natural-endemic zone of another disease - dental fluorosis, associated with a high content of fluoride compounds. Too high content of this element in drinking water is also recorded in some territories of the Odessa region. Iron deficiency anemia is another prime example of a common microelementosis that often occurs in pediatric practice, obstetrics and gynecology. According to some reports, it is recorded in every fifth person in the world.

A number of other diseases that clearly correlate with a lack or excess of trace elements include boric enteritis, endemic silicon nephropathy, molybdenum gout, aluminum disease, antimony urolithiasis, manganese parkinsonism, Kashin-Beck disease associated with an excess of strontium, Keshan's disease caused by selenium deficiency, "itai-itai" disease, which occurs under conditions of high cadmium content in drinking water, "beer drinkers' disease" (enlargement of the thyroid gland due to excess cobalt associated with certain beers), etc. On the territory of Ukraine, due to man-made pollution of the environment, an increased content of some trace elements is recorded, namely: nickel, vanadium, mercury (in areas with a developed energy industry); chromium, manganese, plumbum (in areas with a concentration of machine-building enterprises); plumbum and bromine (where there are a lot of car exhaust gases); zinc and cuprum (in all industrial cities).

The Chornobyl disaster had a particularly negative man-made impact on the composition of trace elements in the environment – uranium decay products, primarily strontium and cesium, which retain radiation activity, are able to displace other trace elements and accumulate in the body. The development of modern microelementology takes place in the direction of active scientific research on the role of trace elements in the pathogenesis of certain diseases. For example, pathological processes that cause diseases of the heart and blood vessels are now studied in connection with such trace elements as cadmium, cobalt, chromium, cuprum, ferrum, plumbum, zinc; diseases associated with bone density (osteoporosis) - with cuprum, manganese, zinc; joint pathology (arthritis) - with cobalt, cuprum, ferrum, lithium, manganese, strontium, zinc; of the body's immune system - with a general imbalance of trace elements, etc. The results of high-quality clinical studies on microelements are published in international professional journals that played an important role in the formation of microelementology as a branch of medicine, among them are "Trace Elements in Medicine" (published in 1984), "Journal of Trace Elements and Electrolytes in Health and Disease" (published in 1987), "Journal of Trace Elements in Experimental Medicine" (published in 1988).

Human microelementoses

Specific goals: to be able to

- To analyze the trace element state in human phylo- and ontogeny.
- Analyze anomalies and variants of human development, painful conditions and pathologies, having an imbalance of trace elements.
- Describe the symptoms of a lack of trace elements in the body.
- Describe the states of excess trace elements in the body.
- Conduct endemic monitoring of trace elements in the area.

Topic 1. Mineral elements. Modern classification. Content in liquid media and structures of the human body. Functions of elements in a living organism. Problems related to the violation of the content of some elements.

Mineral elements. Modern classification. Content in liquid media and structures of the human body. The chemical composition of liquid media of the body. Functions of elements in a living organism. Prerequisites for a lack of trace elements. Diagnostics. Water balance of the body. Biological role and physiological effect of water varieties. Mineral water. Melt water. Tap water. Heavy water. Contaminated water. Hard water. Problems associated with a violation of the content of elements in the liquid media of the body. Accumulation of trace elements and biologically active compounds.

Topic 2. The most important macro- and microelements. Ultratrace elements. Causes and consequences of deficiency. Basic principles of correction. Symptoms of excess and conditions of poisoning.

The most important macro- and microelements. Physiological significance. Daily requirement. Deficiency and hyperstates in the body. Means of adaptation. Ultratrace elements. Causes and consequences of deficiency. Basic principles of correction. Symptoms of excess and conditions of poisoning. Principles of first aid. Mineral composition of an adult. Electrolytes and their importance. Violation of the water-electrolyte balance. Restorative measures. News in the scientific world.

Topic 3. Essential and conditionally essential elements. Classification of bioelements according to the degree of usefulness for humans. Methods for determining trace element deficiency. Causes of deficiency. Principles of correction of deficiency states. Food sources.

Essential and conditionally essential elements. Classification in the evolutionary aspect. Classification of bioelements according to the degree of usefulness for humans. Normal indicators of the content of bioelements in the body depending on various factors. Methods for determining the deficiency of trace elements. Causes of deficiency, signs of demineralization. Principles of correction of deficiency states. Food sources. Daily human need for minerals. Consequences of excess. Causes of endemic diseases.

Topic 4. Toxic and potentially toxic elements. Levels of concentration of elements for the human body. Classification of harmful and dangerous factors of the production environment. The most dangerous pollutants. Symptoms of poisoning. Preventive principles. Endemic diseases.

Toxic and potentially toxic elements. Levels of concentration of elements for the human body: deficient, optimal, tolerable, fatal. Classification of harmful and dangerous factors of the production environment. The most dangerous pollutants. Harmful waste from industrial enterprises. Symptoms of poisoning. Preventive principles. Micronutrient imbalance diseases caused by biogeochemical factors. Classification of microelementoses according to the etiological principle. Man-made microelementoses. Alimentary and household microelementoses. Overdose of bioelements. Endemic diseases.

Topic 5. Microelementoses. Modern classifications. Significance for clinical practice. Research methods in biological substrates. Genetically determined diseases. Symptoms of micronutrient imbalances. Issues of prevention of dysmicroelementosis.

Microelementoses. Diseases caused by a lack of vitamins and minerals in the human body. Significance for clinical practice. Research methods in biological substrates. Atomic absorption spectroscopy and spectrometry. Daily balance of trace elements for an adult. Symptoms of micronutrient imbalance. Signs of disease. Metabolic disorders associated with a lack of trace elements. Genetically determined diseases. Iatrogenic bioelementoses. Natural-endemic zones of Ukraine. Issues of prevention of dysmicroelementosis.

Topic 6. Basic principles of rational nutrition. Healthy eating rules. The optimal ratio of macro- and micronutrients. Medical, vitamin and microelement preparations. Food impurities. Sports nutrition.

Healthy lifestyle. Basic principles of nutrition. Human nutritional and energy needs. Healthy eating rules. Balanced diet. The optimal ratio of macro- and micronutrients. The need for vitamins. Symptoms of vitamin deficiency. Food sources of vitamins and minerals. Medical, vitamin and microelement preparations. Recommendations for admission. Biologically active impurities: probiotics, prebiotics, parapharmaceuticals. Food impurities. Sports nutrition. Vitamins for athletes. World Healthy Eating Day.

Topics of practical classes

№	Topic of the practical lesson	Several. Hours
1	Mineral elements. Modern classification. Content in liquid media and structures of the human body. Functions of elements in a living organism. Problems related to the violation of the content of some elements.	5
2	The most important macro- and microelements. Ultratrace elements. Causes and consequences of deficiency. Basic principles of correction. Symptoms of excess and conditions of poisoning.	5
3	Essential and conditionally essential elements. Classification of bioelements according to the degree of usefulness for humans. Methods for determining trace element deficiency. Causes of deficiency. Principles of correction of deficiency states. Food sources.	5
4	Toxic and potentially toxic elements. Levels of concentration of elements for the human body. Classification of harmful and dangerous factors of the production environment. The most dangerous pollutants. Symptoms of poisoning. Preventive principles. Endemic diseases.	5
5	Microelementoses. Modern classifications. Significance for clinical practice. Research methods in biological substrates. Genetically determined diseases. Symptoms of micronutrient imbalances. Issues of prevention of dysmicroelementosis.	5
6	Basic principles of rational nutrition. Healthy eating rules. The optimal ratio of macro- and micronutrients. Medical, vitamin and microelement preparations. Food impurities. Sports nutrition.	5
	Together	**30**

Tasks for independent work

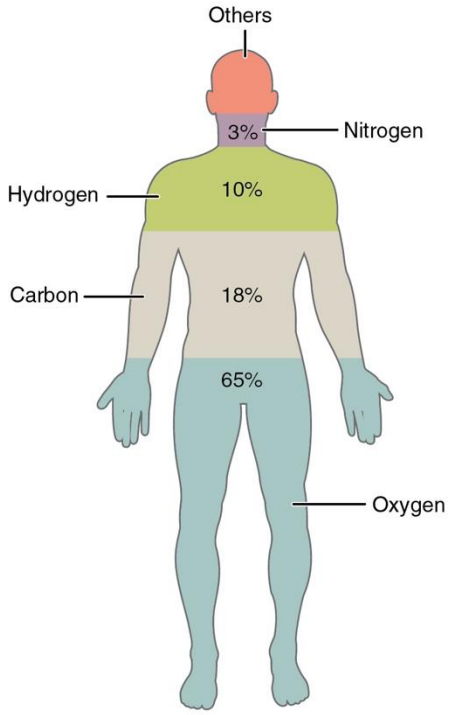
№	Theme	Number of hours
1	Preparation for passing test tasks as components of the USCI and USMLE RX on the topic: "Mineral elements. Modern classification. Content in liquid media and structures of the human	10

	body. Functions of elements in a living organism. Problems associated with the violation of the content of some elements."	
2	Preparation for passing test tasks as components of the USCI and USMLE RX on the topic: "The most important macro- and microelements. Ultratrace elements. Causes and consequences of deficiency. Basic principles of correction. Symptoms of excess and states of poisoning".	10
3	Preparation for passing test tasks as components of the USCE and USMLE RX on the topic: "Essential and conditionally essential elements. Classification of bioelements according to the degree of usefulness for humans. Methods for determining trace element deficiency. Causes of deficiency. Principles of correction of deficiency states. Food Sources".	10
4	Preparation for passing test tasks as components of the USCI and USMLE RX on the topic: "Toxic and potentially toxic elements. Levels of concentration of elements for the human body. Classification of harmful and dangerous factors of the production environment. The most dangerous pollutants. Symptoms of poisoning. Preventive principles. Endemic diseases".	10
5	Preparation for passing test tasks as components of the USCI and USMLE RX on the topic: "Microelementoses. Modern classifications. Significance for clinical practice. Research methods in biological substrates. Genetically determined diseases. Symptoms of micronutrient imbalances. Issues of prevention of dysmicroelementosis".	10
6	Preparation for passing test tasks as components of the USCI and USMLE RX on the topic: "Basic principles of nutrition. Healthy eating rules. The optimal ratio of macro- and micronutrients. Medical, vitamin and microelement preparations. Food impurities. Sports nutrition".	10
	Just	**60**

Topic 1. Mineral elements. Modern classification. Content in liquid media and structures of the human body. Functions of elements in a living organism. Problems related to the violation of the content of some elements.

MICRO- AND MACRO ELEMENTS (from micro... and macro..., lat. elementum – element, primary substance) – chemical elements present in the body in low (from 0.001 to 0.0000000000001%) and high concentrations. This is what determines their names: trace elements – in German and English, oligoelements – in French authors, scattered elements – in the works of V. Vernadsky. The only characteristic feature of trace elements that distinguishes them from macronutrients is their low concentration in living organisms. There are different classifications of chemical elements found in the human body. Some researchers prefer the name "biologically significant elements" (as opposed to "biologically inert elements"), indicating that these are chemical elements necessary for living organisms to ensure normal life.

The elements that ensure the vital activity of the body are classified according to various characteristics - content in the body, degree of need, biological role, tissue specificity, etc. According to the content in the human body, they are divided into macronutrients (more than 0.01% of body weight), trace elements (from 0.009 to 0.00001%), ultratrace elements (less than 0.000001%; see Table 1).



Element	Symbol	Percentage in Body
Oxygen	O	65.0
Carbon	C	18.5
Hydrogen	H	9.5
Nitrogen	N	3.2
Calcium	Ca	1.5
Phosphorus	P	1.0
Potassium	K	0.4
Sulfur	S	0.3
Sodium	Na	0.2
Chlorine	Cl	0.2
Magnesium	Mg	0.1
Trace elements include boron (B), chromium (Cr), cobalt (Co), copper (Cu), fluorine (F), iodine (I), iron (Fe), manganese (Mn), molybdenum (Mo), selenium (Se), silicon (Si), tin (Sn), vanadium (V), and zinc (Zn).		less than 1.0

Some researchers divide these groups according to other concentrations. Sometimes ultratrace elements are not separated from trace elements. Modern classifications divide all trace elements according to the following characteristics: according to vital necessity: 1) essential - Fe, I, Cu, Zn, Co, Cr, Mo, Se, Mn; 2) conditionally essential – As, B, Br, F, Li, Ni, V, Si; 3) toxic – Al, Cd, Pb, Hg, Be, Ba, Vi, Tl; 4) potentially toxic – Ge, Au, In, Rb, Ag, Ti, Ti, U, W, Sn, Zr; by immunomodulatory effect: 1) necessary (essential) for the immune system - Fe, I; 2) Cu, Zn, Co, Cr, Mo, Se, Mn, Li; 3) immunotoxic: Al, As, B, Ni,

Cd, Pb, Hg, Be, Vi, Tl, Ge, Au; 4) Sn, etc. The distribution of trace elements in the organs of the body is based on their physiological significance, as well as the peculiarities of the body's blood supply.

In the brain, half of the iodine present throughout the body is concentrated, in addition, bromine, cobalt, arsenic, mercury, cuprum, plumbum, fluorine, zinc, titanium. In the pancreas - zinc, cobalt, nicol, arsenic, iodine, molybdenum, silicon, manganese, stanum, chromium, plumbum. The liver is the main "storehouse" of minerals for the body; it contributes to their constancy in the blood. At the same time, the liver is the only organ that removes trace elements from the body. Trace elements are part of enzymes (about 200 metalloenzymes are known): Zn - to carbonic anhydrase, Cu - to polyphenol oxidase, Mn - to arginase, Mo - to xanthine oxidase; vitamins: Co – to vitamin B_{12}; hormones: I – to thyroxine, Zn and Co – to insulin; respiratory pigments: Fe – to hemoglobin and other iron-containing pigments, Cu – to hemocyanin.

Some trace elements affect the ability to grow (Mn, Zn, I), reproduction (Mn, Zn), hematopoiesis (Fe, Cu, Co), tissue respiration processes (Cu, Zn), intra-cells. exchange, etc. For a number of trace elements (Sc, Zr, Nb, Au, La, etc.), their amount in tissues, organs is unknown and biol has not been clarified. role. Basic. The source of micronutrients in the body is food. Drinking water covers 1–10% of the daily requirement for I, Cu, Zn, Mn, Co, Mo, and only for F, Sr there is a goal. Source. The content of trace elements in food depends on the geochemistry of the area where it was obtained and the set of products in the diet.

The cause of endemic human diseases is: I, the lack of which contributes to the spread of endemic goiter, and F, with an excess of which fluorosis occurs, and with insufficiency, caries. For F, the determining source of intake in the body is water, for I – milk and vegetables. The main "supplier" to the diet of most of the other most important trace elements are bread products.

With age, the content of many trace elements (Al, Ti, Cl, Pb, F, Sr, Ni) in the body increases, during the period of growth and development, this growth is rapid, and by the age of 15-20 it slows down or stops. The content of Co, Cu, Ni in the blood and Sr in the skeleton at the age of 50-60 becomes lower than at 20-25 years. In clinical medicine, in the fight against some types of anemia, preparations containing Co, Fe, Cu, Mn, as well as Br and I are effectively used. In cases where there is too much F in natural waters, defluorination plants are operated.

Microelementoses are diseases and syndromes, in the genesis of which there is a deficiency or excess of trace elements, their imbalance, an abnormal ratio of macro- and microelements. The development of various microelementoses in modern conditions is facilitated by man-made pollution of the environment. In the immediate vicinity of many industrial enterprises, zones with a high content of Pb, As, Hg, Cd, Ni and other toxic trace elements are formed.

It is possible to determine the state of metabolism of chemical elements in the body and the toxic effect of certain heavy metals on it by the content in blood, hair, saliva, gastric juice, urine. For this purpose, modern analytical methods are used (atomic emission and mass spectrometry, atomic absorption spectrophotometry, etc.). Recently, hair research has been of increasing interest, since the content of trace elements in it reflects the elemental status of the whole organism and is an integral indicator of mineral metabolism. With the

help of plasma spectrometric analysis of hair, it is possible to determine the body's predisposition to certain abnormalities and diseases.

Out of 106 elements of the periodic table of D.I. Mendeleev, 86 are constantly present in the human body, 25 of them are necessary for normal life. If the amount of the element in the body exceeds 2-10%, it is considered a macronutrient. Most of all, the body contains the following macronutrients: oxygen - 65%, carbon - 18%, hydrogen - 10%, nitrogen - 3%. These macronutrients are called organogenic, or macronutrients; Proteins, fats, carbohydrates, nucleic acids, etc., are mainly built from them. Other macronutrients include: potassium – 0.35%, calcium – 2%, magnesium – 0.05%, sodium – 0.15%, sulfur – 0.25%, phosphorus – 1.1%, chlorine – 0.15%. With an average human body weight of 70 kg, his body contains (in grams): calcium - 1700, potassium - 250, sodium - 70, magnesium - 42, ferrum - 5, zinc - 3. H, C, O, N, the share of which is 96% of the mass of living matter, and Ca, P, K, Na, Mg, S, Cl make up 10–20% or more of the body weight. Macronutrients are concentrated, as a rule, in one type of tissues of a living organismI.

The content of macronutrients in the body is quite constant, but even relatively large deviations from the norm are compatible with the vital activity of the body. Macronutrients, as a rule, are part of organic compounds in the body. Hydrogen (H) in nature is found mainly in the form of compounds; it is a component of all biological substances (amino acids, proteins, vitamins, hormones), water. The level of hydrogen ions determines the acidity of the environment. Nitrogen (N) is present in living organisms as part of amino acids, peptides, purines that are part of DNA. Oxygen (O) is part of proteins, fats, carbohydrates, without it it is impossible to breathe, oxidation of amino acids, fats, carbohydrates. In phagocytes, oxygen is reduced to superoxidation, which initiates the oxidation of foreign organic substances captured by phagocytes. The normal oxygen content in the air (≈21 volume%) creates the partial pressure necessary for the saturation of blood and tissues. A decrease in the O2 content to 16–18 volume % is not dangerous. When the O2 content is reduced to 14 volume %, signs of oxygen deficiency appear, and a decrease to 9 volume % is life-threatening. (C) is organogen No. 1 in its importance for living organisms. Sodium bicarbonate is part of one of the body's buffer systems (pH 7.8–8.0), which, for example, creates an alkaline environment in bile that promotes the hydrolysis of fats. K, Na, Ca, P, Mg, S, Cl enter the body with water, food and play a leading role in the regulation of water-salt, protein, carbohydrate and fat metabolism, maintaining acid-base balance, cell membrane function, transmission of nerve impulses, etc.

The content of trace elements in liquid media and structures of the human body.

- Intracellular fluid (55%)
- Extracellular fluid (45%)
- a) interstitial fluid (20%)
- b) plasma (7.5%)
- c) crystallization water of bone, cartilage (15%)
- d) transcellular fluid (2.5%)

Rice. 1. Water content in the human body.

Table. 2. Intracellular fluid content:

Ion, a mineral	Intracellular fluid	Extracellular fluid	Ocean Water	Artesian water
Na+	0,23	3,22	10,7	0,03
K+	5,46	0,156	0,382	0,01
Ca++	0,000004	0,1	0,417	0,07
Mg++	0,72	0,036	1,297	0,014
Cl-	0,142	3,55	19,34	0,021
HCO3-	0,27	1,647	0,097	0,34
PO4-	5,7	0,19	0,00007	0,00005

Interstitial or tissue fluid – It is a fluid that bathes and envelops cellular tissues and is found in the internode, the space between cells, also known as the space between tissues.

The human being has an average of 20 liters of interstitial fluid in his body, which is about 16% of the total body weight, and provides nutrients in the cells of the body, as well as being a means to remove or eliminate waste.

The human body has, on average, between 4.5 and 5.5 liters of blood, which translates into a greater amount of interstitial fluid in the body. This fluid is made up of various elements such as **salts, amino acids, hormones, etc.**

- Interstitial fluid consists of an aqueous solvent, which is mainly water, solutes and proteins. Solutes include: ***sugars, salts, acids, hormones, neurotransmitters, metabolites and electrolytes.***

- The amount of proteins present in the interstitial fluid is less than in plasma. The composition of tissue fluid depends on the exchange between cells in tissue and blood, so interstitial fluid has a different composition in different tissues and parts of the body.
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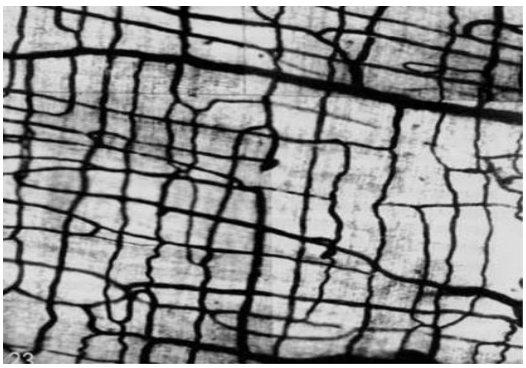
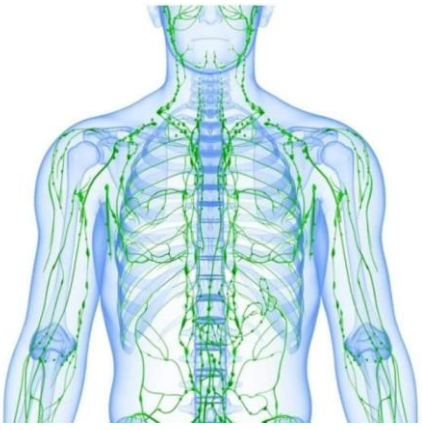


Rice. 2. Interstitial tissue.

The interstitial space is an amorphous component:

- It contains up to 15% of body water (5% in the blood)
- 85-90% structured, i.e. non-flowing (bound)
- The last 10% of "free" water provides directional transport of substances.

Interstitial fluid in the lymphatic system:



Rice. 3. Human lymphatic system.

- The lymphatic system is an anatomical structure that transports lymph unidirectionally to the heart and is part of the circulatory system.
- **Functions:** the lymphatic system controls the concentration of proteins in the interstitium, the volume of interstitial fluid and its pressure.

  Lymph is a clear fluid, somewhat whitish, that passes through the lymphatic vessels. It is formed after the transfusion of fluid leaving the blood capillaries into the interstitial space.

  Thus, **the main function of** lymph is to collect and return interstitial fluid to the bloodstream.

- **Interstitial fluid overflow**
- There are a number of diseases or clinical signs that manifest themselves in the lymphatic system.
- The formation of lymphatic edema or lymphederma is a pathology associated with interstitial fluid.
- Edema is considered a clinical sign, consisting in the accumulation of fluid in the intercellular or interstitial space, as well as in the cavities of the body.
- Edema is formed when fluid is secreted excessively into the interstitial space, or when it is not restored properly, which can be due to resorption problems, as well as problems with lymphatic diseases.

Blood plasma *is* a liquid part of the blood containing the main and additional components. It is a colloidal solution of various substances that are in dynamic equilibrium with tissue and intracellular fluids. Normally, the concentrations of some substances remain constant, while the content of others can fluctuate within narrow limits.

CHEMICAL COMPOSITION OF BLOOD PLASMA.

Main components:

Water (90-92%).
Mineral ions (0.9%).
Plasma proteins (7-8%).
Glucose (0.12%)

Rice. 4. Blood composition.

Additional components:

Nutrients (lipids, amino acids), vitamins, trace elements (Cu, Go, I, Zn, Mη).
Hormones and enzymes.

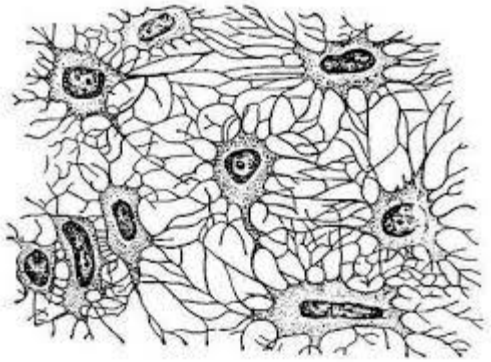
Intermediate metabolic products (lactic, pyruvic acids).
End products of metabolism (CO_2, urea, uric acid, ammonia, bilirubin, creatinine, etc.)

Minerals are found in the blood plasma in the form of cations and anions. Most of all, the plasma contains sodium, potassium, chlorides, bicarbonates. Deviations in the mineral composition of blood plasma can be observed in various diseases and with significant water loss due to sweating during physical work.

Crystallization water of bones and cartilage

Crystallization water —Associated water, contained incrystalline Latticein the form ofMolecules.

Bone chemistry: Contains up to 50% water, 28% organic matter, including 15% fat, and 21% inorganic substances (compounds Ca, Mg, P).



Rice. 5. Cartilage tissue.

Transcellular fluid

Fabric liquid,intercellular fluid— fluid that fills the intercellular and pericellular spaces of tissues and organsAnimalsandHuman; together withbloodYi and Yilymphis the internal environment of the body. In terms of chemical composition, it is close toPlasma Blood. but contains a smaller amountsquirrel. The transcellular fluid from the blood plasma receivesoxygenand nutrients necessary for cells, and from cells — products of theirExchange. The composition and properties of the t. r. have a certain constancy, which is provided by the mechanisms of homeostasis. Flowing from the organs inLymph Vessels, T. r. turns into lymph. The function of tissue fluid is to wash the cells of the body.

Water balance of the body:

It consists of 3 processes:

- 1) intake of water into the body with food and drinks;
- 2) the formation of water during metabolism (endogenous water)

- 3) excretion of water from the body.

Changes or disorders of water metabolism (accumulation of excess water in the body) or water deficiency in the body

How to understand that there is a deficiency of intracellular fluid

- A lack of intracellular fluid can be suspected by a number of signs. In particular, when there is a feeling of tightness of the skin after washing/showering and if the cream is chosen very quickly.

You should also pay attention to the presence of these signs:

- Dry dermatitis
- Dry mouth, thick saliva is an early sign of intracellular dehydration
- Dry lips
- Formation of cracks on the heels, palms
- Peeling and cracked elbows, front surface of the lower legs like a "desert"
- Dryness during sexual intercourse, and the more pronounced the dehydration, the earlier this dryness occurs and causes pain
- Dry and dull hair
- Lack of sparkle in the eyes

How to restore water balance

- The fastest way to replenish intracellular fluid deficiency is with mineral water. Due to its composition, it is attracted to the right places.
- "Mineral water should not be medicinal, in any case, because you can "treat" yourself with a bunch of health problems if you have a habit of abuse. Choose a canteen, read on the label. Study the composition and dosages. You need to drink as soon as you feel thirsty or from 0.5 to 1 liter per day.
- Due to the habit of abusing mineral water, you can get cardiovascular complications, urological and neurological diseases, stones.

Basic rules for drinking mineral water:

- Divide the volume of water into equal parts and drink 15 minutes before eating
- The water must be free of gases, otherwise it will not enter the cage. Water with gases, on the other hand, will increase the pressure and will draw water out of the cell.
- Just open the lid and leave the water bottle for a few hours.

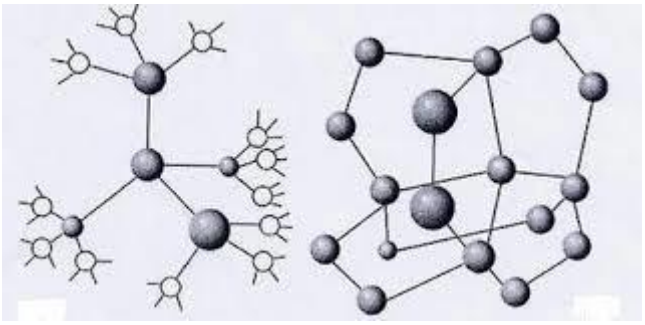
When can you drink soda:

- When weakness appeared

- during the heat, when you want to reduce sweating
- If you want, on the contrary, to increase sweating, drink still water
- if "the pressure dropped"

The following sources can also restore the water regime:

- Structured water. This is a more or less stable formula of water that will enter the cell 100%.



Rice. 6. Structured water.

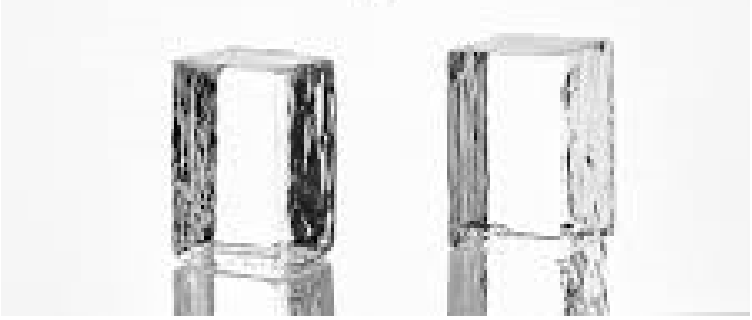
- Green tea of the third brew.
- Spring water. But a study should be carried out on its composition. Such water should not be collected in early spring, when melted snow/ice melts (they are washed off along with the dirt).

Rice. 7. Spring water.

What is the use of melt water:

- Most of the processes that occur in our body are chemical reactions in aqueous solution. FromAs Water, its composition, depends on the health of the whole organism. Water is considered the best, which has a structure similar to the structure of the fluid inside the body. Such water is able to penetrate into cells without obstacles, improve metabolism. This important property is possessed by melt (structured) water, which is considered the best for human health.

- The benefits of melted, "living" water speak for themselves: people who live high in the mountains near a spring that originates from a melting glacier suffer less from various diseases and have a longer life expectancy.
- Melt water can be drunk, used in cooking, brewing tea (without boiling), washing.



Rice. 8. Melt water.

Healing properties of melt water:

- Improves the functioning of all organs;
- Increases immunity;
- Helps to get rid of allergies;
- Treats skin diseases, wounds;
- Improves digestion and metabolism;
- Normalizes heart function;
- Helps fight excess weight;
- Enhances the effect of drugs;
- Normalizes the level of leukocytes in the blood;
- Lowers blood cholesterol levels;
- Accelerates recovery processes;
- Improves brain activity and increases performance.

Ordinary tap water has the following composition:

— Fresh ("living") water, the basis of life. Freezes at a temperature of 0°C;— Deuterium oxide ("heavy" water). 1 liter contains 150 mg of deuterium water. Freezes at a temperature of +3.8°C;

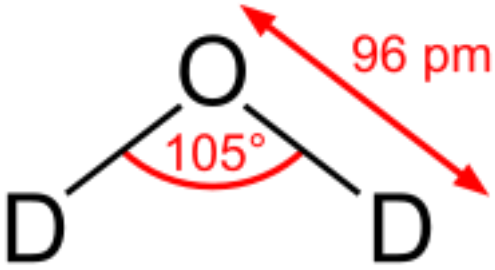
— Dissolved organic compounds, salts, chemicals. Freeze at a temperature of -7°C;— Impurities deposited on the walls of blood vessels and internal organs, as well as mucous membranes.

To purify such water from all unnecessary components, leaving only the "living" component, freezing is used - the most effective method of water purification. As a result of a single freeze-thaw process, melt water is obtained.

To obtain protium water, the process of slow freezing and melting of water is monitored, removing "heavy" water and dissolved salts in a timely manner.

Heavy hydrogen water has the same chemical formula as ordinary water, but instead of two atoms of the usual light isotope of hydrogen (protium), it contains two atoms of the heavy isotope of hydrogen, deuterium, and its isotopic composition of oxygen corresponds to oxygen in the air. At first glance, heavy water is similar to ordinary water - a colorless, odorless liquid with a sweet taste.

Biological role and physiological effects



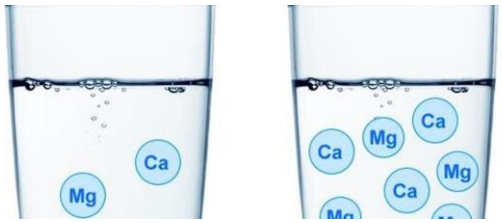
Rice. 9. Heavy water.

Heavy water is toxic only to a small extent, chemical reactions in its environment proceed somewhat slower than in ordinary water, hydrogen bonds involving deuterium are slightly stronger than ordinary ones, but due to the twofold difference in the mass of light and heavy nuclides, the kinetics of the ion exchange processes taking place changes significantly (slows down with deuterium). Experiments on mammals (mice, rats, dogs) have shown that the replacement of 25% of hydrogen in tissues with deuterium leads to infertility, sometimes irreversible. Higher concentrations lead to the rapid death of the animal; For example, mammals that drank heavy water for a week died when half of the water in their body was deutation; Fish and invertebrates die only when 90% of the water in the body is deutered. Protozoa are able to adapt to a 70% solution of heavy water, while algae and bacteria are able to live even in clean, heavy water. A person can drink several glasses of heavy water without visible harm to health, all deuterium will be excreted from the body in a few days. For example, in one of the experiments to study the relationship between the vestibular apparatus and involuntary eye movements (nystagmus), volunteers were asked to drink from 100 to 200 grams of heavy water; As a result of the absorption of denser heavy water by the cupula (gelatinous structure in the semicircular canals), its neutral buoyancy in the endolymph of the canals is disturbed, and minor disturbances in spatial orientation, in particular nystagmus, occur. This effect is similar to that of alcohol (however, in the latter case, the density of cupula decreases, since the density of ethyl alcohol is less than that of water). Thus, heavy water is much less toxic than, for example, table salt. Heavy water has been used to treat hypertension in humans at daily doses of 10 to 675 g of D_{2O} per day.

The human body contains as much deuterium as a natural impurity as 5 grams of heavy water; this deuterium is mainly found in HDO semi-heavy water molecules, as well as in all other biological compounds that contain hydrogen.
Some people notice that heavy water tastes sweet. Scientific confirmation of this fact was published in 2021. It was found that the sweetish taste of heavy water is approximately the same as the taste of 0.05 g of sucrose solution in plain water (17 g/l, or half a teaspoon of sugar per glass of water).

Hard water

Hard water is water that contains excessive amounts of calcium and magnesium. And in some cases, iron salts. Hard water can be temporary or permanent (static).
Temporary stiffness is provoked by calcium and magnesium. And it is easily eliminated by boiling. It is enough to heat the water - calcium and magnesium will break down and settle in the form of scale.
Constant hardness is due to the presence of chlorides, sulfates, calcium and magnesium nitrates in the water. Boiling in this case will not help, water conditioning is required. In 95% of cases, when they talk about "hard water", they mean temporary hardness. This is because permanent ones are extremely rare.



Rice. 10. Hard water.

Signs of hard water:
An increased amount of magnesium and calcium in its composition is indicated by:
- coating of faucets with plaque;
- the appearance of whitish streaks;
- scale formation on the walls of the kettle;
- poor foaming when washing dishes and linen;
- hard water damages the heating system;
- Plumbing breaks faster.

Is hard water dangerous to health?

- Calcium and magnesium themselves are very useful macronutrients for the body.
- But only in the optimal amount.
- There is clearly an excess of them in hard water. However, despite this, no particular harm is done to the body.
- Although there are a number of nuances here.
- First, calcium and magnesium are deposited on the intestinal wall. As a result, gastric motility deteriorates, salts accumulate.
- Secondly, hard water is bad for the skin. After washing or bathing, the skin becomes dry, irritated, and there is a feeling of tightness. This is because hard water clogs pores and

washes away natural defenses. As a result, it is more difficult for the skin to breathe, acne and various rashes appear.

• Thirdly, hair also suffers from hard water. Salt compounds make breathing difficult, brittleness and dandruff appear. In some cases, hair begins to fall out.

How to remove water hardness:

- Use special creams that help minimize the negative effects of hard water.
- Hard water has a particularly negative effect on the skin of newborns. For this reason, they are bathed in boiled water to prevent any health risks.
- Drinking water must be boiled. Purchase filters with a magnetic component for drinking water purification.

Rice. 11. Drinking water purification. 

Topic 2. The most important macro- and microelements. Ultratrace elements. Causes and consequences of deficiency. Basic principles of correction. Symptoms of excess and conditions of poisoning.

About 1.9% of the cell mass is accounted for by eight more macroelements: Sodium (Na), Magnesium (Mg), Potassium (K), Calcium (Ca), Phosphorus (P), Sulfur (S), Chlorine (Cl), Ferrum (Fe).

Other chemical elements are found in the cell in very small quantities: trace elements - those that account for from 0.000001% to 0.001%, - Boron (B), Cobalt (Co), Nickel (Ni), Cuprum (Cu), Zinc (Zn), Molybdenum (Mo), Iodine (I),
Fluorine (F), Manganese (Mn), etc.

Oxygen is a person's daily oxygen requirement of 300-400 liters (280 ml/min).

Participates in all types of exchange. Oxygen is necessary for the most important life process - breathing. All oxidation-reduction reactions in the body occur in the presence of oxygen. Oxygen is part of such biologically important compounds as proteins, amino acids, carbohydrates, lipids, nucleic acids, vitamins, hormones, etc. The phagocytic functions of the body depend on oxygen levels. A decrease in oxygen levels leads to a decrease in the protective functions of the body. Oxygen is necessary for the decomposition of dead animals and plants (the cycle of substances in nature).

Oxygen, together with carbon (IV) oxide, excites the respiratory and vascular-motor centers. Oxygen is used to treat cardiovascular, infectious, tumor diseases (oxygen therapy and oxygen barotherapy).

With a lack of oxygen, asphyxia, hypoxia, death from suffocation occur.
Excess oxygen causes bradycardia, vasoconstrictor effect, increased resistance of peripheral vessels, slowing down blood flow, and increased blood clotting.

Carbon

Carbon content in biological tissues:
In bone – 36%
In muscle tissue – 67%
The daily requirement for carbon fiber in food is 300 g

With a lack of carbon, there is a general depletion of the body, a decrease in brain activity. The basis of all organic compounds due to its unique ability to form strong covalent bonds with each other, as well as with atoms of other chemical elements, for example, hydrogen, oxygen, nitrogen, sulfur, halogens.

Carbon (IV) oxide together with oxygen is used for reflex stimulation of the respiratory center during shock, asphyxia, poisoning, etc. Liquid CO_2 is used for hypothermia, for freezing biomaterial.

Activated charcoal, having a larger surface, adsorbs gases, alkaloids, toxins well. It is prescribed for flatulence, food intoxication, poisoning with alkaloids, salts of heavy metals.

Carbon compounds are toxic to humans: carbon (II) oxide, carbon (IV) oxide, hydrogen cyanide HCN, carbon disulfide (CS2), phosgene (COCl2)

Hydrogen

- Approximately 10% of the mass of living organisms is hydrogen. It is an integral part of important organic and inorganic compounds that play an important biological role in the human body: proteins, nucleic acids, vitamins, hormones, enzymes, etc.

- **HYDROGEN INDEX** (pH) is a number that characterizes the acidity of the medium and is numerically equal to: $pH=-\lg aH_{+}$. Each physiological fluid - gastric juice, blood, pancreatic juice, etc. - is characterized by a certain acidity, which can vary in a narrow pH range.

One of the most important and widespread chemical compounds on Earth is water. The human body contains about 70% (wt.) of water. Water is not only a universal solvent, but also an active participant in various metabolic reactions (hydrolysis, hydration, swelling, etc.). Water plays the role of a transport system - the transfer of nutrients, enzymes, metabolic products, gases, etc. With the help of water, the state of homeostasis (acid-base, osmotic, hemodynamic, thermal equilibrium) is maintained. Water is necessary for the formation of secretions and excretions, ensuring tissue turgor.

The most important properties of water for living organisms are the following:

1. Water is an excellent solvent for polar and non-polar substances that have charged areas.

2. Water is capable of forming aggregate groups of molecules between its molecules and with molecules of other substances. This significantly increases the force of surface tension, which allows water to rise through the capillaries of the soil and the vessels of plants.

3. Due to the presence of hydrogen bonds between water molecules, its evaporation requires a large amount of energy, and in case of its freezing, heat is released. Therefore, the presence of water on our planet in three states of aggregation significantly softens its climate. In addition, many organisms use the evaporation of water at high temperatures to cool their bodies.

4. Water reaches its highest density at 4 ° C. Ice has a lower density than water. Therefore, in winter, it is located on the surface of water bodies and protects the organisms that live in them from hypothermia. Molecules of organic or inorganic substances that are polar or have charged regions easily interact with water molecules and, accordingly, dissolve easily in it. Such substances are called hydrophilic. If the molecules of organic or inorganic substances are not polar and do not have charged areas, then they interact little with water molecules and, accordingly, do not dissolve in it. Such substances are called hydrophobic.

Nitrogen

Nitrogen content in biological tissues: in the blood - 3.1 mg/ml; in muscle tissue – 7.2%; in bone - 4.3%.

The daily requirement for nitrogen is 8-16 g.

An excess of nitrogen in the air leads to caisson sickness, with increased pressure, suffocation develops. All nitrogen oxides and ammonia are toxic.

It is an integral part of most organic compounds of the body: amino acids, proteins, lipids, vitamins, hormones, enzymes, etc. Nitrogen forms fairly strong covalent bonds with hydrogen, carbon. Together with sulfur, oxygen, phosphorus, nitrogen strengthens the "backbone" of carbon chains, due to which a variety of organic compounds are formed. Nitrogen is the main constituent of air. Very well, like oxygen, it dissolves in biological fluids, in particular, in the blood. Its presence in the blood can cause decompression sickness. A sharp drop in pressure (for example, with a rapid rise of a diver) can lead to the release of nitrogen (blood "boils"). This can lead to paralysis and death.

Potassium *is* the main intracellular ion.

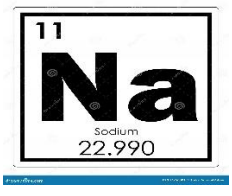
It is involved in protein synthesis, electrical activity of the cell, and glucose utilization. It regulates muscle activity, especially neuromuscular excitability and muscle contraction. The heart is extremely sensitive to changes in potassium levels.

Topography in the body: liver, kidneys, heart, brain, muscles, blood, etc.

Biogenic role: provides osmotic pressure; ensures the emergence of biopotentials, which is associated with the process of nervous and muscular excitability and conduction; maintains an acid-base state; participates in water-salt metabolism; participates in the synthesis of proteins, carbohydrates; affects the activity of enzymes.

An increase in the content of potassium ions reduces the contractile function of the myocardium (bradycardia); A decrease in potassium ions increases the heart rate (tachycardia).

Hypokalemia is one of the causes of the development of heart rhythm disturbances - paroxysm, atrial fibrillation and paroxysmal supraventricular tachycardia.



Sodium is contained in the intercellular space, provides the activity of the nervous, cardiovascular system, and carbon dioxide metabolism.

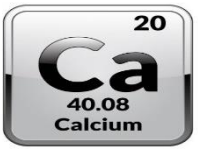
Topography in the body: blood plasma, lymph, digestive juices. The daily requirement of the body for sodium is 4-7 g.

Biogenic role: provides osmotic pressure; maintains the acid-base state of the body; participates in neuromuscular transmission (the occurrence of biopotentials); participates in water-salt metabolism; affects the work of enzymes. When sodium channels are blocked on the cell membrane, depolarization does not occur and no action potential occurs. In addition, sodium ions contribute to the swelling of tissue colloids, which leads to water retention in the body and contributes to its accumulation (formation of edema).

With the loss of salts, *hypotonic dehydration may occur*.

The hypotonicity of plasma and interstitial fluid is due to the predominant loss of sodium. The predominance of protein content in cells compared to interstitial fluid contributes to the osmotic movement of water from the extracellular fluid to the cells. As a result, with hypotonic dehydration, the extracellular space decreases, and the cells swell.

Hypernatremia is accompanied by an increase in the volume of fluid in the extracellular space due to an increase in plasma osmolarity, and, as a result, thirst, tachycardia, and an increase in blood pressure.



Calcium is involved in many vital processes in the body. Unlike monovalent ions, which are mainly ionized in body fluids, calcium circulating in the blood in large quantities forms complex compounds with proteins and other organic substances.

The daily requirement is 0.8-0.9 g. It enters the body with milk, cereals, vegetables. The concentration of calcium ions is regulated by parathyroid hormones. For the absorption of calcium ions, vitamin D and phosphate acid salts are needed.

Calcium is the main component of bone and dental tissue, where it enters in the form of hydroxyapatite $Ca_5(PO4)_{3OH}$ and $Ca5(PO4)_{3F}$ — fluorapatite.

Calcium ions are involved: in the transmission of nerve impulses (calcium reduces the excitability of CNS cells); a decrease in its concentration leads to an increase in excitability (tetany); regulates the work of the heart; participates in blood clotting; enters the composition of enzymes (lecithinase) and affects their activity; affects the acid-base state of the body; It has anti-inflammatory and desensitizing effects. Calcium ions are biological antagonists of sodium, potassium, magnesium ions.

Hypercalcemia may be accompanied by gouty nephropathy complicated by renal failure, osteoarthritis and rheumatoid arthritis, in which the calcium content in the blood correlates with the activity of the pathological process and is associated with an imbalance in the secretion of parathyroid hormone and calcitriol.

Magnesium inhibits the nervous system, helps cells absorb oxygen. Ionized calcium is involved in the work of the heart, skeletal muscles, blood clotting, etc.

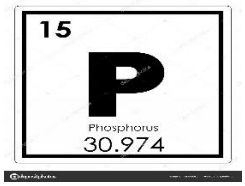
The body's daily requirement for magnesium is 10 mg per 1 kg of human body weight. Topography in the human body: dentin and enamel of teeth, bones of the skeleton, skeletal muscles, kidneys, brain, liver, heart. Intracellular ion. High magnesium content in plants. As a complexing agent, it enters the composition of chlorophyll.

Biogenic role: depending on the concentration, blocks or provides neuromuscular transmission; depresses the center of breathing; depresses the vasculoskeletal center, as a result of which it lowers blood pressure; component and activator of some enzymes; stimulates intestinal motility and bile secretion.

Magnesium is an activator of about 300 enzymes.

Mg^{2+} deficiency in the body is manifested by astheno-neurotic syndrome, depression, migraine, convulsive muscle twitching, tremors of the limbs, tachycardia, intracardiac blockades, people's tendency to thrombosis, bronchospasm, abdominalgia, constipation, the development of coronary heart disease, diabetes mellitus, hyperthyroidism, periodontal disease, choleliary and urolithiasis.

Hypomagnesemia can be the result of insulin resistance, chronic psycho-emotional and physical stress, physical inactivity, intoxication with aluminum and beryllium.



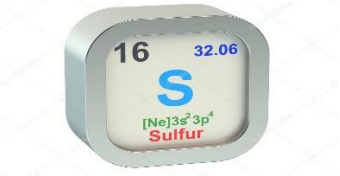
Phosphorus is the main structural component of bone tissue in the form of a calcium phosphate salt called hydroxyapatite. Phospholipids (such as phosphatidylcholine) are the main structural components of cell membranes.

The daily requirement of the body for phosphorus is 1.3 g. It is an integral part of proteins, nucleic acids, ATP and other physiologically active compounds. A large amount of phosphorus is contained in bone and dental tissue. In them it is in the form of hydroxyapatite $3Ca_3(PO4)_2 \cdot Ca(OH)_2$ and $3Ca3(PO4)_2 \cdot CaCO3 \cdot H2O$.

Under conditions of insufficient amount of phosphorus and vitamin D, calcium is not absorbed and rickets occurs. The importance of phosphorus lies in the fact that carbohydrates, fatty acids and other substances must first be phosphorylated in order to perform an energy function. Phosphorus is necessary for the formation of a phosphate buffer system involved in maintaining acid-base balance. In ATP, phosphorus forms macroergic bonds (enriched with energy) with oxygen.

Hypophosphatemia is defined as serum phosphate concentrations below the lower limit of normal, while concentrations above the upper limit of the range indicate

hyperphosphatemia. However, serum and serum phosphate levels do not necessarily reflect the phosphorus content in the body.



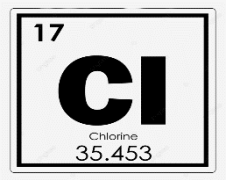
Sulfur is constantly present in all living organisms, being an important biogenic element. Its content in plants is 0.3-1.2%, in animals 0.5-2% (marine organisms contain more sulfur than terrestrial ones). The biological significance of sulfur is determined primarily by the fact that it is part of the amino acids methionine and cysteine and, therefore, in the composition of peptides and proteins. There is no way for protein bodies to exist.

The daily requirement of the body for sulfur is 4-5 g. It is part of enzymes, hormones, vitamins (vitamin B_1 - thiamine). High content of sulfur in hair, bones, nervous tissue. In the body, sulfur is oxidized to sulphuric acid, which neutralizes toxic substances - metabolic products (phenols, cresol, skatole, indole).

Many sulfur compounds are toxic. Hydrogen sulfide deserves special attention, the inhalation of which quickly causes a dull reaction to its unpleasant odor and can lead to severe poisoning, even fatal. The maximum permissible concentration of hydrogen sulfide in the air of working premises is 10 mg/m3, in atmospheric air – 0.008 mg/m3.

Sulfur deficiency:

Tachycardia, high blood pressure, allergies, liver disease, skin disorders, hair loss, constipation, hair becomes dull, nails become brittle, joint pain, hyperglycemia, increased triglycerides in the blood, in severe cases - fatty liver, kidney hemorrhages, impaired carbohydrate metabolism and protein metabolism, overexcitation of the nervous system, irritability and other neurotic reactions.



Chlorine is the most important anion in the extracellular space. It makes up 0.06% of body weight. Most of it is found in gastric juice. It is concentrated in the extracellular fluid along with sodium ions. Participates in maintaining osmotic balance. Activates amylase and peptidase.

A person consumes 5-10 g of NaCl per day. The minimum human need for chlorine is about 800 mg per day. The daily requirement for Cl^- is 4-6 g.

Biological role: regulation of osmotic pressure; promotes the deposition of glycogen in the liver; participates in water-salt metabolism; It is part of enzyme systems, activates saliva amylase. Chlorine atoms are powerful oxidizing agents and therefore have disinfectant properties.

Chlorine toxicity: The toxic range is not always controlled. Symptoms of intoxication. Usually not observed. Large doses can cause nausea, drowsiness, headache, sweating, tachycardia, acute withdrawal syndrome (in drug addicts).

Side effects: Cardiovascular: arterial hypotension, bradycardia, cardiac arrest. Respiratory system disorders: respiratory depression.

- **ULTRATRACE elements** (from the Latin ultra - from above), elements present in living organisms in very small quantities (from 10-6 to 10-12%). These include selenium (Se), uranium (U), mercury (Hg), radium (Ra), helium (He), beryllium (Be), neon (Ne), argon (Ag), scandium (Sc), gallium (Ga), krypton (Kg), stibium (Sb), zirconium (Zr), niobium (Nb), rhodium (Rh), rubidium (Rb), argentum (Ag), cadmium (Cd), indium (In), tellurium (Te), iodine (I), xenon (He), tantalum (Ta), tungsten (W), aurum (Au), thallium (Tl), bismuth (Bi), thorium (Th).

Rice. 12. Ultramicroelements.

Topic 3. Essential and conditionally essential elements. Classification of bioelements according to the degree of usefulness for humans. Methods for determining trace element deficiency. Causes of deficiency. Principles of correction of deficiency states. Food sources.

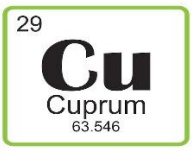
Essential trace elements are vital:

Iron is one of the main vital trace elements for humans. It affects many processes in the body. Iron is present in foods such as apples, pork and beef liver, meat, pomegranates and other "red" foods.

The daily requirement is 15-20 mg. It is localized in erythrocytes, as well as in respiratory enzymes cytochromes. Ferrum is part of the enzymes hemoglobin, cytochromes, catalases, peroxidases, etc. Ferrum takes an active part in the redox processes of the body, in immunobiological reactions necessary for the processes of growth and blood formation. Lack of ferrum leads to the development of anemia.

Iron deficiency anemia is anemia caused by a lack of iron and accompanied by a decrease in the amount of hemoglobin in each red blood cell. It leads to the supply of less

oxygen to the body. Anemia usually occurs in women of all ages who have severe menstruation.



Cuprum is a vital trace element that is part of proteins. The human body contains 150 mg of copper. Half of this amount falls on bones and muscles, 10% on liver tissue, and the rest on other organs.

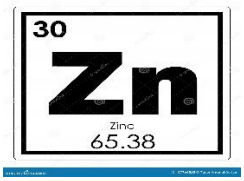
The daily requirement is 2-3 mg. Biotic, the lack of which leads to significant disorders in the body. Biogenic role: enhances the effect of insulin and pituitary hormones; has a positive effect on the growth and development of the body, as it promotes protein synthesis; affects the synthesis of hemoglobin and the formation of red blood cells; has a hypoglycemic effect; affects water and mineral metabolism; enzyme activator.

Cuprum has antioxidant properties, helps to absorb vitamin C, helps to preserve bone structure, and is necessary for the normal functioning of the central nervous system.

People with celiac disease. In its 2009 clinical guidelines for the treatment of celiac disease, the American College of Gastroenterology points out that people with celiac disease appear to have an increased risk of copper deficiency and that copper levels return to normal within a month of consuming a copper supplement while eating a gluten-free diet.

People with Menkes' disease. Menkes disease is a rare, X-related, recessive disorder of copper homeostasis caused by ATP7A mutations that code for copper-transporting ATPase. These individuals have a drastically reduced intestinal absorption of dietary copper, leading to signs of copper deficiency, including low levels of serum copper and ceruloplasmin. Typical manifestations of Menkes' disease include a growth defect, impaired cognitive development, the formation of an aortic aneurysm, seizures and extremely unruly wavy hair. Most people with Menkes disease die at the age of 3 years if left untreated, but subcutaneous copper injections from the first weeks after birth can reduce the risk of mortality and improve the baby's development.

People taking high doses of zinc supplements. High dietary intake of zinc can interfere with copper absorption, and excessive consumption of zinc supplements can lead to copper deficiency. A decrease in erythrocyte copper-zinc superoxide dismutase, a marker of copper condition, has been reported in individuals with even moderately high zinc intake of approximately 60 mg / day for 10 weeks.



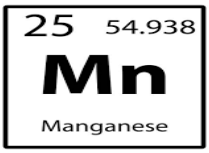
Zinc is a powerful antioxidant and is important for maintaining vision at dusk. The element is also needed for growth and development, improves immunity, maintains the normal condition of bones, hair and skin.

The daily requirement is 10-15 mg. Topography in the body: retinal membrane of the eye, prostate gland, sperm, mammary glands, liver, muscles.

Biological role: affects the processes of reproduction, that is, reproductive function; participates in the metabolism of nucleoproteins, therefore it has a positive effect on growth and reproduction; improves the blood picture during radiation therapy for tumors; is an integral part of the enzymes insulin, carbonic anhydrase, carboxypeptidase, etc.; affects the metabolism of calcium and phosphorus; increases immunogenesis.

With zinc deficiency, the risk of cardiovascular diseases increases, but the ability of tissues to regenerate (restoration, healing), on the contrary, decreases.

Normal production of **serotonin**, the so-called "hormone of happiness", is also impossible in conditions of zinc deficiency. Therefore, zinc-containing supplements are often prescribed for depressive readiness, chronic stress, anxiety, and sometimes chronic fatigue syndrome (CFS).



Manganese is a vital element for humans, it is part of many metal enzymes, and also acts as a nonspecific enzyme activator. Manganese-dependent enzymes include superoxide dismutase (mitochondrial), pyruvate carboxylase, arginase and glycosyltransferase. When some enzymes are activated, Mn^{2+} ions can be replaced by Mg^{2+}, Co2+ or other divalent ions. This element is associated with the formation of connective tissue and bones, growth mechanisms, reproductive functions, carbohydrate and lipid metabolism. Under normal conditions, the intake of manganese into the body with air, food, water is small. Most of the manganese that comes from food is not absorbed, and the predominant way of excretion of absorbed manganese is bile. The excretion of this element in the urine does not respond well to fluctuations in manganese in the diet.

An excess of manganese can lead to serious consequences, after which it is very difficult for even a young body to recover: a deterioration in iron absorption and the development of anemia, a deterioration in the functioning of the nervous system, and impaired calcium absorption.

Manganese deficiency leads to various forms of anemia, impaired reproductive function in both sexes, growth retardation of children, manifestations of body weight deficiency, etc.

Molybdenum is a component of a number of enzymes (aldehyde oxidase, sulfite oxidase, xanthine oxidase, etc.) that perform important physiological functions, in particular, the regulation of uric acid metabolism.

The daily requirement is 0.15-0.3 mg. Topography in the body: liver, kidneys, endocrine glands. Biogenic role: enzyme activator; activates hemoglobin synthesis; affects immunogenesis.

Enzymes containing molybdenum are involved in the metabolism of purines and the absorption of nitrogen, while uric acid is formed. With an increased content of molybdenum, endemic gout develops.

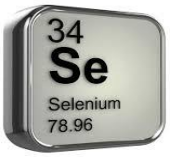
Molybdenum makes antioxidants, including vitamin C, more effective, an important component of the tissue respiration system. It enhances the synthesis of amino acids, improves nitrogen accumulation.

Molybdenum deficiency in the body can appear as a result of a long-term vegetarian diet, artificial nutrition, after injuries and burns. An excess of elements such as tungsten, sulfur, lead and sodium, which inhibit the absorption of molybdenum.

Symptoms that can be used to diagnose a lack of molybdenum in the body are as follows:

1. Increased irritability, as well as excitability;
2. the development of "night blindness", that is, impaired visual adaptation;
3. The development of cardiac arrhythmia (tachycardia).

Lack of molybdenum in the body is accompanied by a decrease in the content of xanthine oxidase in tissues. With a lack of molybdenum, anabolic processes suffer, and a weakening of the immune system is observed.



Selenium was previously considered harmful to the body and thanks to scientific studies it has been found that the question of the harm and benefits of this trace element depends on its quantity. Topography in the body: liver, kidneys, heart, pituitary gland, skeletal muscles. A significant amount of selenium fits in the retina of the eye. Therefore, it is necessary for the process of vision. Selenium is necessary for the function of the gonads, for example, for the normal course of pregnancy. Selenium compounds are toxic. But in microdoses they are used in medicine for the treatment and prevention of diseases of the eye, liver, pancreas, dystrophy, etc. **Selenium** is one of those substances that provide an antioxidant barrier, regulates the functioning of thyroid hormones, and stimulates the immune system.

Iodine is a trace element that is present in nature in small quantities. The bulk of it enters the body with food. Iodine affects brain activity, incl. memory and concentration. The work of the endocrine system and thyroid gland depends on iodine. It contains thyroid hormones T3 (triiodothyronine) and T4 (thyroxine).

The daily requirement is 0.2 mg. In human blood, the concentration of iodide ions has become ($^{10\text{-}6\text{-}10\text{-}5}$ %) and is called the "iodine mirror of blood". The main biological function is involved in the biosynthesis of thyroid hormone - thyroxine.

- ***Diffuse endemic goiter*** (synonym: diffuse non-toxic goiter) is a diffuse enlargement of the thyroid gland without impaired thyroid function, which occurs in the population of more than 5% of children of primary and secondary school age. It occurs in children, adolescents and young adults.

- ***Nodular colloidal proliferating goiter*** is a non-tumor disease of the thyroid gland without impaired thyroid function. In iodine deficiency regions in Russia, its prevalence among the healthy population ranges from 10 to 40%. Nodular colloidal goiter accounts for up to 90% of all thyroid nodules.

An excess of iodine is an ailment in which there is a deviation from the norm in the amount of iodine in the body. This has a detrimental effect on the thyroid gland and the general condition of the body.

Fluoride is necessary for the formation of the hard tissue of the tooth, which is called dentin, as well as for the formation of enamel. It protects teeth from decay, from caries damage, creates a stable compound with phosphorus and calcium. Fluorine also has a very strong anti-caries effect, which is explained by the replacement of the hydroxyl group (OH-)hydroxyapatite of the enamel with fluorine.

Topography in the body: hair, teeth, bones. The daily requirement is 1-2 mg. The composition of tooth enamel and dentin comes in the form of fluorapatite $Ca_5(PO4)_{3F.}$

Insufficient intake of this trace element in the body causes osteoporosis and caries.

When there is too much fluoride in the body, a disease known **as fluorosis** develops. The disease occurs when the concentration of fluoride in drinking water is more than 1 mg/l.

Chromium is a biogenic element found in plant and animal tissues, and is necessary for the normal development and functioning of the body. Its most important biological role is to regulate fat synthesis, carbohydrate metabolism and blood glucose levels. Biological action is based on the ability to complexe.

Biogenic role: affects hematopoiesis; an integral part of the digestive enzyme - trypsin; stabilizes the structure of nucleic acids; chromium compounds have an antitumor effect; Participates in glucose metabolism.

Metallic chromium is part of alloys used in dental prosthetics, as well as for the manufacture of medical instruments.

Soluble chromium compounds in high doses are poisons.

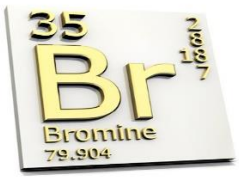
A decrease in the content of chromium in food and in the blood leads to a decrease in the growth rate, an increase in cholesterol in the blood.

Conditionally essential elements are vital, but dangerous in certain doses:

Cobalt is one of the vital trace elements for the body. It is part of vitamin B12 (cobalamin). Cobalt is involved in hematopoiesis, functions of the nervous system and liver, enzymatic reactions.

The daily requirement is 0.05-0.1 mg. Topography in the body: liver, kidneys, pancreas. Biological role: affects all types of metabolism; affects the functions of reproduction and growth; increases the content of red blood cells and hemoglobin (hematopoietic properties); microdoses (1-5 mg) of cobalt lower blood sugar levels; has a positive effect on the absorption of calcium and phosphorus; has a positive effect on immunogenesis.

In the absence of cobalt, acobaltosis develops. However, ***an excess of cobalt*** is harmful to humans: it reduces the immunobiological reactivity of the body. Disorders of cobalt metabolism are characterized by a decrease in its content in whole blood due to a decrease in the amount in the blood serum and erythrocytes. Excretion of cobalt in the urine increases, with feces decreases. These disorders intensify as renal failure develops. deficiency, the content of cobalt in the liver, kidneys, spleen, heart, lungs, pancreas, skeletal muscles is reduced, and in bone tissue is increased.



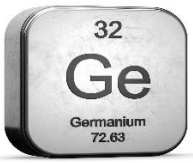
Bromine. Bromine ions inhibit the activity of the thyroid gland, being antagonists of iodides, and when exposed to chronic exposure, they slow down their absorption.

Most bromine is found in the kidneys, thyroid gland, pituitary gland, blood, urine. The daily requirement is 821 mg. Biological role: enhances inhibition processes in the central nervous system; participates in the biosynthesis of testosterone and regulates the function of the gonads.

Bromine is a very poisonous substance. Therefore, in fact, no doctor has yet prescribed pure bromine as a sedative to any patient. What is called bromine in everyday life is actually a solution of one of its salts - sodium bromide NaBr, and even then in a negligible concentration.

Acute poisoning is accompanied by damage to the lymph glands. High concentrations of bromine lead to damage to the ovaries in women and testicles in men. Excitability decreases, drowsiness increases, apathy develops.

The main source of poisonous bromine is emissions from industrial enterprises. Bromine compounds are low-toxic. An overdose of bromine-containing drugs can lead to chronic bromine poisoning. An excess of this element is undesirable for the body.



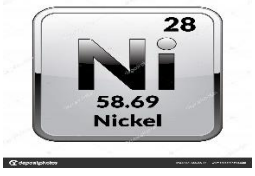
Germanium was discovered in 1868 by the German chemist K. Winkler. It enters the body with food and food, is adsorbed in the intestines, easily penetrates cell barriers. In living organisms, germanium atoms are part of organormanium compounds (GOS) or complexes with low toxicity and high biological activity.

To date, the most studied antitumor activity of Germanium drugs, discovered in 1968 by Dr. K. Asai. The ability to inhibit tumor cell proliferation is associated with post-translational processes of interferonogenesis activation and effects on enzyme processes.

It has been established that Germanium preparations have the ability to inhibit the processes of lipid peroxidation, prevent disruption of the phospholipid layer of membranes, in particular hepatocytes, due to which they have hepatoprotective properties.

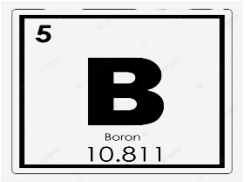
The analgesic effect of organic compounds of germanium is also associated with the ability of the activated germanium atom to intercept free electrons, as well as the participation of endogenous opoids.

Lithium Permanently included in the living Organisms, however, its biological role has not been sufficiently elucidated. Mainly in the body is found in thyroid Gland, lymph nodes, Heart, Liver, Lungs, Intestines, Plasma Blood, adrenal glands. The average person's body (weight 70 kg) contains about 0.7 mg of lithium. Lithium salts normalize water-electrolyte metabolism in the brain; They have an anti-stress effect: they actively suppress pathological emotional lability and disorders, aggressiveness in mental illness.



Normal **nickel** content: when analyzing hair - up to 2 μg/g, nails - up to 3 μg/g.

It is part of the structure of some proteins, DNA, RNA. This biometal activates several enzymatic systems (anhydrase, carboxylase, trypsin, etc.). It stimulates the synthesis of amino acids in the cell, and in low concentrations increases the activity of the enzyme pepsin and improves the activity of hematopoietic enzymes, which normalizes the hemoglobin content in the blood, improves the generation of plasma proteins.

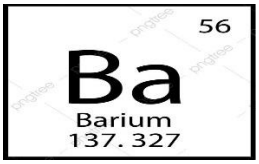


Boron is a mineral that a person consumes almost every day with food. It is found in rice cereal, buckwheat, beets, soybeans.

Topography in the body: lungs, thyroid gland, brain, liver, kidneys, etc.

Biogenic role: participates in carbohydrate-phosphate metabolism; boron compounds have anti-inflammatory and antibacterial effects; Boron preparations have an antiepileptic effect.

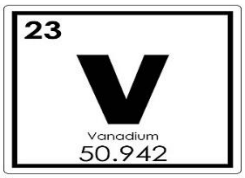
A lack of this trace element can lead to the following anomalies: hormonal imbalance, cancer of the cervix, ovaries and mammary glands, cervical erosion, fibroids, urolithiasis, joint diseases.



Barium is a trace element (10^{-5} %). It is concentrated mainly in the retina, but the biological role has not yet been clarified.

Barium sulfate is used as a radiopaque agent in the diagnosis of diseases of the gastrointestinal tract. This is possible because the substance is insoluble in water, acids, or alkalis and intensively traps X-rays.

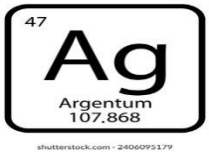
Barium ions are very toxic!



Vanadium is a mineral that plays an important role in the functioning of the cardiovascular system. It is also one of the elements that protect the body from negative external influences.

Vanadium affects the level of hemoglobin, glucose and cholesterol, visual acuity, liver function, kidney function and urinary system. Lack of vanadium can lead to a significant increase in cholesterol levels, diabetes mellitus, atherosclerosis of blood vessels.

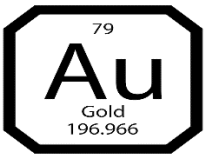
Vanadium compounds, in addition to hypoglycemic effects, also have antihypertensive and anticholesterolemic activity. In addition, vanadium-containing compounds have an antitumor effect.



The biological role of **argentum** is not well understood. Argentum is classified as potentially toxic and potentially carcinogenic.

Topography in the body: liver, kidneys, bones, endocrine glands. Biogenic role has not been established. ***Strong enzyme poison***. Argentum ions have antiseptic, anti-inflammatory and bactericidal effects.

It is known that **argentum** forms compounds with proteins in the body, can block thiol groups of enzyme systems, and inhibit tissue respiration. In blood plasma, argentum binds to globulins, albumins and fibrinogen. With prolonged contact with argentum in industrial conditions, this element can accumulate in the liver, kidneys, skin and mucous membranes. It has been established that leukocytes can phagocytize argentum and deliver it to foci of inflammation.



The biological role of **aurum** is not yet fully understood. It is known that the human body contains about 0.01 g of aurum, almost 50% of which is concentrated in the bones. The rest falls on the liver, kidneys and other organs and tissues. Aurum is part of some metalloproteins, enters into chemical reactions with cuprum compounds, elastase and proteases that hydrolyze collagen, as well as other connective tissue substances. It is involved in the processes of hormone binding in tissues.

In general**, aluminum** is classified as toxic (immunotoxic) elements. Aluminum is part of many biomolecules, forming strong bonds with oxygen or nitrogen atoms. Aluminum is a permanent component of cells, where it is mainly found in the form of Al^{3+}.

Topography in the body: it is found in the blood, lungs, kidneys, liver, bones, enters the membranes of nerve cells of the human brain.

Aluminum plays an important physiological role in the body – it participates in the formation of phosphate and protein complexes; processes of regeneration of bone, connective and epithelial tissue; has an inhibitory or activating effect on digestive enzymes depending on the concentration; It can affect the function of the parathyroid glands.

Silicon plays a great role in the formation and growth of bones, cartilage and connective tissues. This trace element helps prevent osteoporosis, reduces bone fragility, and the strength of skin, hair and nail cells depends on it. Insufficient silicon in the body can lead to weakening of the skin, dryness and brittleness of hair and nails.

It fits in the liver, adrenal glands, hair, lens of the eye.

Due to its antioxidant properties, **silicon** blocks the oxidation reactions of fats. This allows you to preserve not only the beauty and youthfulness of the skin, but also slows down the aging process of the body as a whole. The element fights free radicals, prevents oxygen starvation of cells.

Silicon is involved in tissue regeneration, promotes the renewal of body cells. The element is a component of redox reactions, participates in the synthesis of hormones and enzymes.

The reason for the excessive intake of silicon is industrial poisoning: work with asbestos, quartz, glass, inhalation of silicon particles in mines, during mining operations. Excess silicon leads to silicosis. This is a serious disease of the lung tissue. In addition to pulmonary fibrosis, with an excessive intake of silicon, urolithiasis, malignant tumors in the lungs, gastrointestinal tract are observed.

Organs-depot of trace elements:

- **Fe** - Accumulates in erythrocytes, spleen, liver.
- **K** - Accumulates in the heart, skeletal and smooth muscles, blood plasma, nervous tissue, kidneys.
- **Mn** - Depot organs: bones, liver, pituitary gland.
- **P** - Depot organs: bones, protein substances.
- **Ca** - Depot organs: bones, blood, teeth.
- **Zn** - Depot organs: liver, prostate, retina.
- **I** - Depot organs: thyroid gland.
- **Si** - Depot organs: liver, hair, lens of the eye.
- **Mg** - Depot organs: body fluids, liver.
- **Cu** - Depot organs: bones, liver, gallbladder.
- **S** - Depot organs: connective tissue.
- **Ni** - Depot organs: lungs, liver, kidneys, pancreas, blood plasma.
- **Co** - Tissues in which a trace element usually accumulates: blood, spleen, bone, ovaries, liver, pituitary gland.
- **Si** - Promotes collagen synthesis and the formation of cartilage tissue.

The content of trace elements in food and medicinal plants:

- **Fe** — black currant, corn columns and stigmas, dioecious nettle, dog rose, common shepherd's purse.
- **K** — black currant, corn columns and stigmas , dioecious nettle, common shepherd's purse, dog rosehip, aloe tree.
- **Mn** — black currant, dog rosehip, aloe tree.
- **P** — black currant, corn columns and stigmas, dioecious nettle, dog rose.
- **Ca** — black currant, columns and stigmas of corn, common shepherd's purse, dog rosehip, aloe tree.
- **Co** — black currant, dog rosehip, bean husk.
- **Zn** — black currant, columns and stigmas of corn, dioecious nettle, aloe tree.
- **I** — black currants, seafood, chokeberry, feijoa, beans in pods, tomatoes, strawberries.

- **Si** — black currant, corn columns and stigmas, dioecious nettle
- **Mg** — black currant, dioecious nettle, dog rosehip, aloe tree.
- **Cu** is black currant, dioecious nettle, aloe tree.
- **S** — black currant.
- **Ag** is black currant.
- **Ni** is the husk of beans.

Topic 4. Toxic and potentially toxic elements. Levels of concentration of elements for the human body. Classification of harmful and dangerous factors of the production environment. The most dangerous pollutants. Symptoms of poisoning. Preventive principles. Endemic diseases.

Among toxic elements, trace elements **of the lowest harmless** concentrations are **beryllium, cadmium, mercury, selenium**. Their permissible concentration is characterized by values of 0.1-5 mg/kg.

The range and level **of harmless concentrations** for **arsenic, plumbum, cuprum, boron, nickel, stanum is** about an order of magnitude higher - 2-5-10-20 mg/kg. This indicator **of harmless concentrations** for **vanadium, zinc, fluorine and chromium** is even higher - 10-20-50-200 mg/kg.

It is noteworthy that the so-called "permissible" concentrations for trace elements of the greatest toxicity are 10-20 mg / kg, but for **mercury, cadmium and boron the** permissible concentrations are even lower (not higher than 5 mg / kg).

The range of these data and the wide ranges of "tolerance" indicate the great importance of the general geochemical background (**correlation with other elements**), forms of compounds, plant species and varieties, and weather conditions.

Thus, **selenium** can reduce the toxicity of **arsenic, cadmium, mercury, thallium** and, conversely, the toxicity of **selenium** can be mitigated or increased by the presence of **arsenic, cuprum, germanium.**

Heavy metal poisoning is the effect of a large amount of metal of a certain type on the body. The health consequences can be irreversible.

Heavy metals in low concentrations are quite common in land, water, and household items. But under these conditions, we, as a rule, do not come into contact with heavy metals in such volumes that it causes harm. You can get poisoned by inhaling smoke containing heavy metals, or by ingesting them with food or drink.

In developed countries, where environmental control is carried out, real poisoning with heavy metals is quite rare.

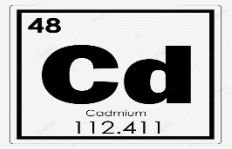
Position of toxic elements in the periodic table of Mendeleev.

Among the heavy metals, those that are most often found in everyday life should be highlighted:

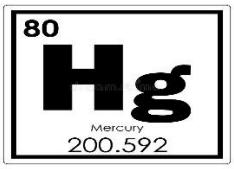
- ferrum (Fe);
- cadmium (Cd);
- cuprum (Cu);
- arsenic (As);
- mercury (Hg);
- plumbum (Pb);
- zinc (Zn).

Beryllium is a toxic chemical element.

The physiological role of **beryllium** is not well understood, but it is known that beryllium can participate in the regulation of phosphorus-calcium metabolism and maintaining the immune status of the body. Basically, beryllium is involved in the metabolism of magnesium (Mg) and phosphorus (P) in bone tissue. It has been established that the activity of beryllium compounds is clearly manifested in various biochemical transformations associated with the participation of inorganic phosphates.



Cadmium is a toxic trace element, being one of the main environmental pollutants. But at the same time, cadmium belongs to the group **of "new" trace elements** (cadmium, vanadium, silicon, tin, fluorine) and in low concentrations can stimulate the growth of some animals. It is concentrated in the kidneys and liver. The biogenic role is not well understood. Zinc antagonist. Unlike zinc, cadmium is an enzyme inhibitor, because it has a great affinity for thiol (-SH) groups. Cadmium is toxic and has cumulative properties.



Mercury (Hg) is a liquid metal that evaporates at 0°C, has high electrical and thermal conductivity, density and chemical resistance. Mercury is used in the manufacture of radio vacuum devices, X-ray tubes, mercury pumps, rectifiers, measuring instruments (thermometers, hydrometers).

It is concentrated in the kidneys and liver. The biogenic role is not fully established. It affects phagocytosis, hematopoiesis. Mercury compounds are enzyme inhibitors, toxic. In medicine, mercury preparations are used as antiseptic, antiparasitic and laxatives.

Mercury dust is easily adsorbed by surrounding objects (walls, fabric) and enters the crevices. It enters the body through the respiratory system. Once in the bloodstream, mercury combines with proteins and circulates in it, blocking protein metabolism. **Chronic**

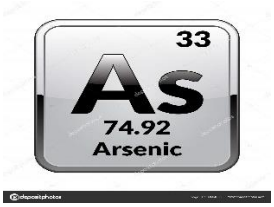
mercury intoxication is manifested by general malaise, sleep disturbances, emotional lability, tremors, bleeding gums.

Eye symptoms of poisoning appear after a longer period in the form of trembling of the eyelids, irritation of the anterior segment of the eye, browning of the cornea and lens, retinal angiopathy; possible cases of retrobulbar neuritis. With chronic mercury intoxication, **intraocular pressure increases**.

In industry, **selenium** is obtained as a by-product of copper processing. It is used in electronic semiconductors, as a discoloring agent for ceramics and glass, as a vulcanizing substance in tire production.

Selenium is used in pharmacology as an anticarcinogenic agent. Selenium salts are easily absorbed by the mucous membranes of the gastrointestinal tract. In the blood, selenium binds to hemoglobin, selenium hemoglobin is formed, resulting in hemic hypoxia.

Selenites as active antioxidants reduce the activity of glutathione peroxidase and glutathione reductase and block glutathione metabolism. Replacement of S-S bonds with selenotrisulfide complexes leads to a change in the tertiary structure of proteins and disrupts their function.

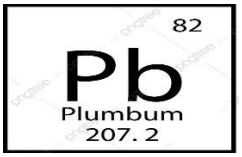


Arsenic is a characteristic coelement of many gold deposits, leading to additional environmental problems in gold-producing countries**.** When ingested in excessive quantities, arsenic leads to mutations in human DNA. The lethal dose when taken orally *is 0.05-0.2 g.*

Topography in the body: kidneys, liver, spleen, lungs. Arsenic persists in hair and bones for many years, which is important for forensic examination. Its highest concentration is observed in the brain and muscles.

Biological role: concentrates in erythrocytes and participates in the synthesis of hemoglobin; participates in redox processes; participates in nucleic acid metabolism. ***In large doses, arsenic compounds are strong poisons.***

Prolonged exposure to arsenic from drinking water and food can cause cancer and skin lesions. It has also been linked to cardiovascular disease and diabetes. In fetal and early childhood, exposure has been associated with negative effects on cognitive development and increased mortality in young adults.



Plumbum and its compounds, especially organic ones, are toxic. Lead compounds cause denaturation of body proteins, are one of the causes of tooth decay. In medical practice, lead compounds are used for external use as astringent antiseptics, for example, lead acetate is used in lotions. Toxic dose of **plumbum** Chronic lead intoxication poses a

serious threat to human life and health, since even in low concentrations this element can accumulate in the human body and cause a number of health problems.

Exceeding the concentration of **cuprum** in the blood serum and skin leads to depigmentation of the latter (vitiligo).

Cuprum compounds cause a sharp irritating effect on the mucous membranes of the upper respiratory tract and gastrointestinal tract.

When cuprum compounds (copper sulfate, etc.) enter the stomach, symptoms such as nausea, vomiting, abdominal pain appear. If cuprum compounds enter the body in the amount of 1-2 g, then with untimely medical care, death from renal failure is possible.

But the most vulnerable contact with cuprum compounds occurs in industry. When cleaning copper products, welding and cutting products made of cuprum and its alloys, the concentration of the latter can reach 14 mg/m^3 with a permissible 1 mg/m^3.

In biogeochemical provinces with an excess **of boron** in the soil, **morphological changes and plant diseases** caused by boron accumulation occur — gigantism, dwarfism, disturbances of growth points, and others. On soils with intensive boron salinity, there are areas devoid of vegetation, "bald spots" — one of the search signs of boron deposits.

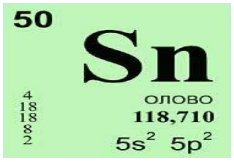
Boron itself, boron oxide, boric acid, borates, and manyorganoboric Compoundsalmost notToxicforHumanandAnimals(toxicity approximately as inKitchen Salt), but at that timeBorani(compounds of boron with hydrogen) are very poisonous, moreover, the full value of boron inBodyanimals, in particular humans, have not yet been clarified too little. IntoMuscle Fabrica person contains 0.33—1× 10^{-4}% boron, inbone Fabric— 1,1—3,3× 10^{-4}%, inBlood— 0.13 mg/l.FoodA person receives 1-3 mg of boron.

Exogenous effects of heavy metals of low intensity, which have the ability to accumulate in the body, lead to the occurrence and development of general nonspecific manifestations of pathology, including long-term effects, **decreased immune reactivity and sensitization.**

Exogenous effects of heavy metals of low intensity, which have the ability to accumulate in the body, lead to the occurrence and development of general nonspecific manifestations of pathology, including long-term effects, **decreased immune reactivity and sensitization.**

The toxic effect of nicol on the body (when it is deposited in tissues) consists in the induction of acute and chronic inflammatory processes, changes in the functional activity of macrophages; vasoconstrictor effect; modification of the metabolism of lipids, proteins (enzymes), glycogen, glucose, DNA, RNA; increased lipid peroxidation; increased permeability of biological membranes; destruction of mitochondria, changes in energy metabolism.

Therefore, despite the fact that heavy metals are elementary chemical structures, they lead to deep and complex processes in the immune system. Such processes include inhibition, nonspecific stimulation, induction of allergic reactions.



Metallic **I'm going to be** is non-toxic, which allows it to be used inFood Industry. Stanum poses a danger to humans in the form of steam or various aerosol particles, dust. Under the influence of vapors or dust of stanum compounds, lung damage may develop. Very toxic are some statesorganocompounds that are used asBactericides(e.g., tributylstanum benzoate) andFungicides(e.g. triphenylstanum acetate), they are part of poisons againstFlea beetles.

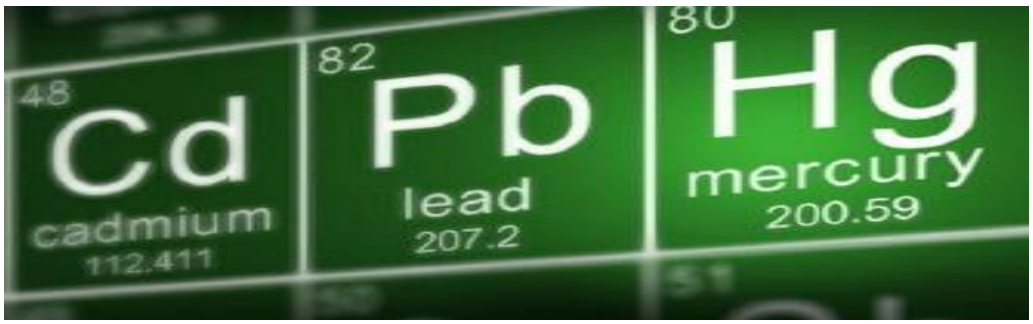
Vanadium can be a relatively toxic element. The toxicity threshold is about 10–20 mg per day or 10–20 mcg per 1 g of diet. Recent reviews have shown that dietary concentrations that are toxic may be caused by dietary composition.

Vanadium inhibits the process of serotonin transformation, which affects the functions of the central nervous system. With vanadium intoxication, respiratory diseases, liver dysfunction, damage to the glomerular and tubular systems of the kidneys occur. Vanadium also negatively affects the cardiovascular and central nervous systems.

An excess **of zinc** in plants occurs in areas of industrial soil pollution, as well as with improper use of zinc-containing fertilizers. Most plant species have a high tolerance to its excess in soils. However, with a very high content of this metal in soils, chlorosis of young leaves is a frequent symptom of zinc toxicosis.

Today, when new industrial enterprises appear everywhere, all living things are simply poisoned **with fluoride**. When fluoride salts accumulate in large quantities in the air, soil, water, getting into the human body, they are concentrated in his bones. **An excess of fluoride** causes osteochondrosis, changes in the color and shape of teeth, directions of their growth, coarsening of joints, their inviolability, bone growths. lungs, muscles.

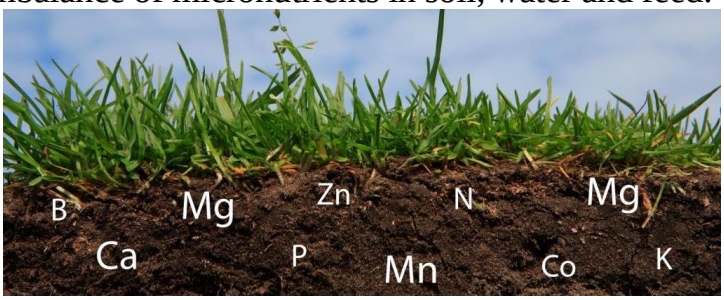
In its pure form, **chromium is quite toxic**, and chromium metal dust irritates lung tissue. Chromium(III) compounds cause dermatitis. Chromium compounds are especially toxic in the oxidation state of **+6.** Almost all chromium ore is processed by converting it to sodium dichromate. Other sources of hexavalent chromium are chromium trioxide and various salts - chromates and dichromates. Hexavalent chromium is transported to the cells of the human body using a sulfate transport mechanism due to its proximity to sulfates in structure and charge. Trivalent chromium, which is more common, is not transported into cells. Hexavalent chromium products are **genotoxic carcinogens.**



Rice. 13. Heavy metals.

1. The most dangerous pollutants (heavy metals): mercury, plumbum, cadmium.
2. Microelementosis is a unifying name for pathological processes caused by a deficiency, excess or imbalance of trace elements. Most diseases of this group are endemic (local) diseases found in certain regions (provinces), called biogeochemical, which are characterized by a deficiency, excess or imbalance of micronutrients in soil, water and plants of vital chemical elements.
3. According to the etiological principle, microelementoses are divided into three main groups:

a) **Natural** (endemic) microelementoses occur in endemic areas or provinces with a deficiency, excess or imbalance of micronutrients in soil, water and feed.



Rice. 14. Endemic microelementoses.

b) **Man-made** microelementoses are found in biogeochemical provinces near industrial enterprises that create an increased content of lead, arsenic, fluorine, mercury, cadmium, manganese, nickel and other elements in the biosphere. The main sources of lead pollution of the biosphere are foundries, automobiles and incineration of industrial waste; copper, molybdenum, mercury, cobalt, chromium and nickel of metallurgical enterprises; amount of arsenic and uranium.


Rice. 15. Man-made microelementoses.

c) **Alimentary** and household microelementoses are associated with unbalanced feeding. The causes of diseases in such cases are the same type of silage-pulp, pulp-bard,

highly concentrated feed, in which it is impossible to satisfy the need of animals for trace elements due to the feed of the diet. With the same type of feeding, conditions are created for the occurrence of a deficiency of some elements in the body and a relative excess of others.

Rice. 16. Alimentary microelementoses.

There are **four biogeochemical zones** and several provinces within their borders.

- ***The taiga-forest non-chernozem zone*** is characterized by high acidity of soils, lack of calcium, phosphorus, potassium, molybdenum, cobalt, copper, iodine, boron, selenium in soil, water and feed with an excess of manganese, zinc and a relative excess of strontium.

Rice. 17. Taigo-forest zone.

- ***The forest-steppe and steppe chernozem zones*** have soils of neutral or slightly alkaline reaction, containing chemical elements in quantities and ratios close to optimal.

Rice. 18. Forest-steppe zone.

- ***Dry steppe, desert and semi-desert zones*** are soils of neutral or alkaline reaction, where there is an increased content of sodium, strontium, zinc, sulfates, boron and molybdenum, lack of iodine, copper and cobalt, manganese, and in some cases an excess of nitrates.

Rice. 19. Desert-semi-desert zone.

- ***The mountainous zone*** is characterized by a great variety of soil and climatic conditions, where there are provinces with a lack of iodine, cobalt and other elements, in which diseases related to the deficiency of these elements are registered.

Rice. 20. Mountainous zone.

An important indicator of the viability of animals, their constitutional strength and resistance to diseases, as well as an indicator of the general physiological state at the moment is proper feeding. Feeding farm animals is one of the main factors that determine their productivity, payment for feed with products and economic efficiency of animal husbandry.

Methods of the science of feeding farm animals: zootechnical (accounting for animal productivity, conducting production experiments), chemical (determination of the content of inorganic compounds and chemical elements in animal feed and body), biochemical (determination of organic compounds), biophysical (spectrometry), statistical.

The territory or zone of feed production is of great importance in feeding. So, in the south, in dry years, the phosphorus content in the feed decreases by 2-3 times with the same calcium content**.** Feeding with such feeds is deficient in relation to phosphorus with a relative excess of calcium. Many feeds in mountainous zones are poor in ***iodine*** and endemic goiter ***is often observed there***. In biogeochemical provinces with an excess ***of copper*** in soils and fodder plants, lambs, and sometimes calves, ***endemic anemia*** caused by an excess of copper in diets is noted. It manifests itself in a decrease in the number of red blood cells, a decrease in the content of hemoglobin in the blood, the transition of

copper from tissues to the blood, the phenomena of hemolysis, jaundice, liver atrophy, and exhaustion of animals. Due to a lack of ***calcium*** and an excess of ***strontium*** in feed in organisms, ***the content of*** calcium, strontium, barium, copper, cobalt, iodine, ***etc.*** ***is disturbed.***

Rice. 21. Viability due to a sufficient amount of trace elements.

Under conditions of unsatisfactory composition and properties of feed, disorders of protein, carbohydrate, water-electrolytic, mineral and vitamin metabolism may occur in farm animals (pathology of several types of metabolism is more often observed: protein-carbohydrate, carbohydrate-fat, vitamin-mineral).

Diseases of insufficiency in cattle are very diverse:

- Infertility caused by improper feeding, in particular hypovitaminosis, occurs much more often than that caused by infections.
- Calves born from cows with a reduced supply of alkalis in the body are not viable, die from dyspepsia, pneumonia, etc.

- Milk from cows that have not been provided with enough carotene in the diet is poor in vitamin A.
- In the milk of animals that consumed insufficient amounts of iodine, cobalt, copper, etc., these elements are not enough, it is poor in some vitamins (for example, B12) and other biologically important compounds.
- It has also been established that animal products (meat, milk) with impaired metabolism pose a threat to health and do not benefit humans.
- If the animal does not receive the substances it needs for a balanced diet, then hunger forces the animal to eat not only feed in general, but also feed containing substances that the body needs most.
- For example, with a lack of calcium and phosphorus, animals often eat bones, chalk, lime, in case of a lack of sodium and chlorine, protein - objects containing salt, fruit shells, etc.

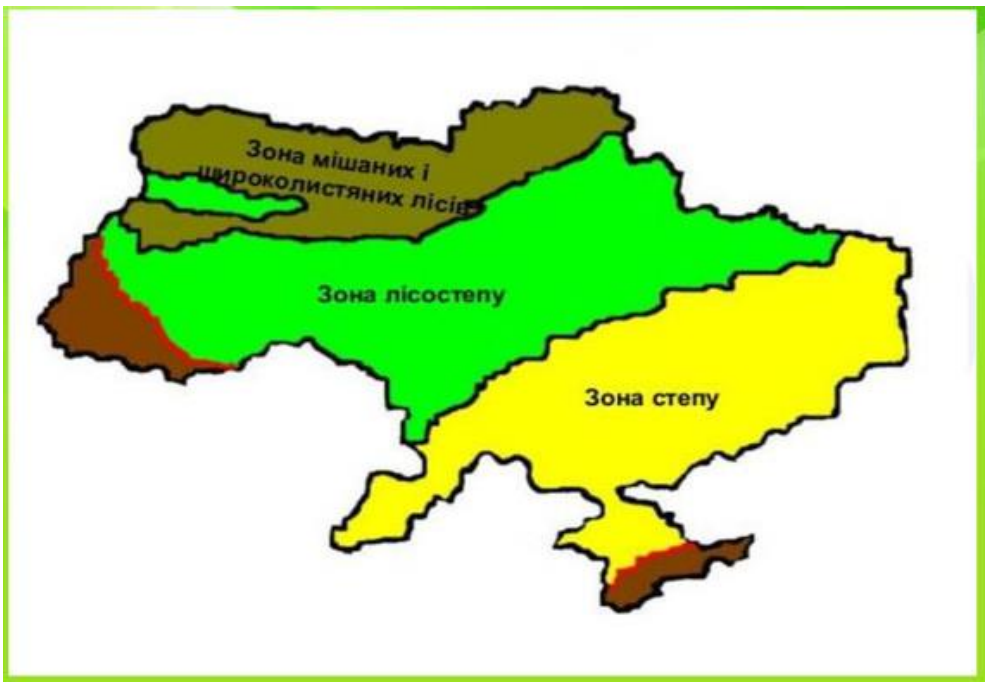


Fig.22. Boundaries of the forest-steppe zone of Ukraine.

Topic 5. Microelementoses. Modern classifications. Significance for clinical practice. Research methods in biological substrates. Genetically determined diseases. Symptoms of micronutrient imbalances. Issues of prevention of dysmicroelementosis.

Microelementoses are diseases and syndromes, in the genesis of which lies insufficiency or excess of microelements, their imbalance, abnormal ratio of macro- and microelements. The development of various microelementoses in modern conditions is facilitated by man-made pollution of the environment. In the immediate vicinity of many industrial enterprises, zones with a high content of Pb, As, Hg, Cd, Ni and other toxic microelements are formed.

Chronic lack of elements leads to:

A) *Imbalance of trace elements* → violation of mineral, protein, fat, carbohydrate metabolism → enzymopathies → endocrinopathies → oncopathies (benign and malignant);

B) *Violation of immune homeostasis* → involution or hyperplasia of the thymus → hypofunction of the thymus → endocrinopathies → inflammatory lesions of organs and tissues.

Significance for clinical practice.

The role of certain trace elements (ME) in the formation of such common diseases and conditions as atherosclerosis and coronary heart disease (CHD), allergic diseases, gastroduodenitis, and certain malignant neoplasms has been emphasized and disclosed in research for a long time.

Trace elements are involved in the formation of endemic and non-endemic diseases of the endocrine system: specific disorders of zinc and chromium metabolism have been identified in diabetes mellitus (zinc is part of and regulates the activity of the insulin molecule, chromium is involved in the binding of the hormone to cell membrane receptors).

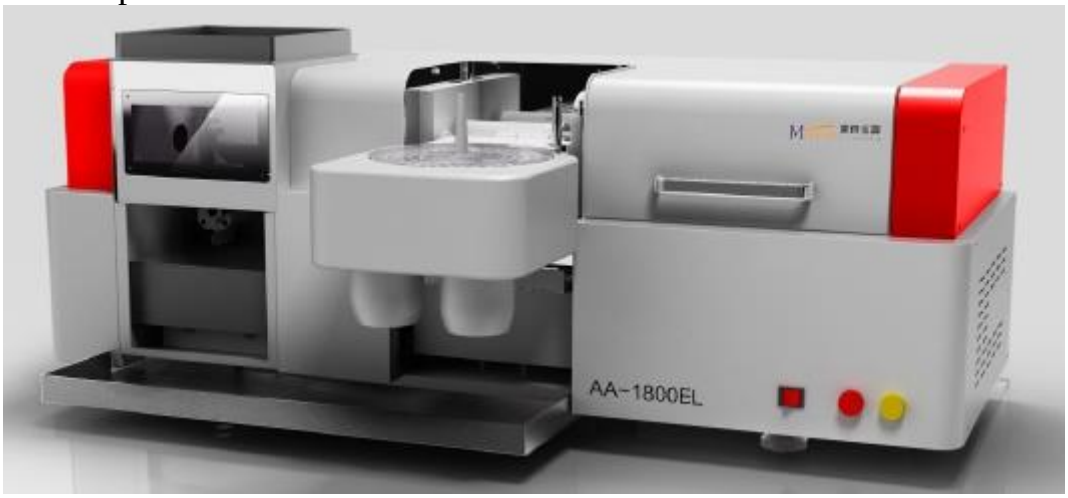
The participation of manganese in egg maturation and zinc in spermatogenesis and the functioning of Leydig cells has been experimentally proven.

Methods for studying the content of trace elements in the body in biological substrates.

Atomic absorption spectrometry (AAS) is a common instrumental method of quantitative elemental analysis in analytical chemistry (modern methods for determining atomic absorption make it possible to determine the content of almost 70 elements of the periodic table).

There are three spectral-analytical methods widely used to determine the composition of matter:

- atomic absorption
- atomic emission
- mass spectral



Rice. 23. Atomic absorption spectrophotometer.

Bioelementosis is a temporary or long-term violation of the bioelemental composition of the body, which inhibits vital processes.

- natural endogenous
- natural exogenous
-Man-made
- iatrogenic

Genetically determined diseases:

- **Wilson-Konovalov disease** (copper toxicosis, hepatolenticular degeneration) – a disease with an autosomal recessive type of inheritance caused by protein synthesis with increased affinity for Cu;

Rice. 24. Copper toxicosis.

- **Menkes' disease** (curly hair disease) is a violation of the absorption and transport of copper, which is accompanied by a deficiency of ceruloplasmin. It develops as a result of a gene defect that has a recessive type of inheritance linked to the X chromosome;

Rice. 25. Curly hair disease.

- **enteropathic acrodermatitis** (Dunbolt-Kloss syndrome, Brandt syndrome) is an autosomal recessive disease caused by impaired absorption processes in the intestine due to zinc deficiency and the absence of an enzyme

Rice. 26. Enteropathic acrodermatitis.

- **hemochromatosis (pigmented** cirrhosis of the liver, bronze diabetes, Troisier-Ano-Chauffard syndrome) is an autosomal dominant enzymopathy, in which an excess amount of iron is absorbed in the small intestine, which is deposited in tissues in the form of hemosiderin granules

Rice. 27. Hemochromatosis.

Symptoms of micronutrient imbalances.

Endemic goiter is a disease characterized by an enlargement of the thyroid gland, more often without impaired function and occurs in certain areas. Endemic goiter is more common in Ukraine in the western regions.

Rice. 28. Endemic goiter.

Fluorosis is a dental disease caused by an excess of fluoride in the body. This trace element is necessary for the body to function normally, but in certain quantities. It enters the tissues with food and, to a greater extent, with water. If it is not enough, bone tissue and tooth enamel are destroyed. But even when there is too much of it, health problems occur. An excess of fluoride leads to an imbalance of elements in the body. which causes softening of hard tissues. When oversaturated with fluoride, fluorosis occurs.

Rice. 29. Fluorosis.

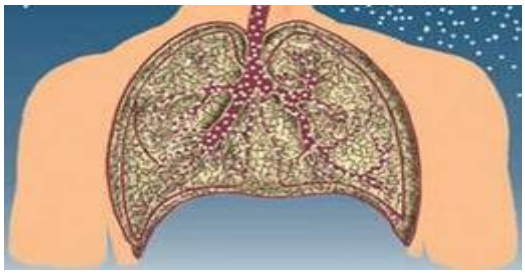
Kashin-Beck disease (Urov's disease) is a rare disease resulting from a deficiency of selenium, excess phosphorus and manganese, which is manifested by impaired growth and maturation of bone epiphyses, which leads to a slowdown in their growth, as well as osteoarthritis.

Rice. 30. Uvarov's disease.

Endemic microelementoses.

Molybdenosis is observed in humans and animals in certain geographical areas with an excess of Mo in the soil. The role of Mo as a bioelement in tissue respiration has been proven.

Miners' pneumoconiosis is a lung lesion that occurs as a result of prolonged inhalation of coal dust and is associated with the occurrence of pulmonary fibrosis.



Rice. 31. Pneumoconiosis.

Minamata disease is a syndrome caused by poisoning with organic mercury compounds, mainly methylmercury. It was first discovered in Japan, in Kumamoto Prefecture in the city of Minamata in 1956. Symptoms include impaired motility, paresthesia in the limbs, impaired speech intelligibility, impaired vision and hearing, and in severe cases, fatal paralysis and impaired consciousness.

Rice. 32. Minamata disease.

Among the industrial and occupational microelementoses, Yokkaic asthma (caused by air pollution by sulfur oxides), chemical Chernivtsi disease (probably due to thallium), thallium alopecia, casting fever (beryllium), allergies of cooks (nickel), bromism, mercurialism, metalloconiosis - lung diseases caused by inhalation of dust of compounds of certain metals - beryllium (berylliosis), iron (siderosis), aluminum (aluminosis), barium (barytosis) and many others are known

Issues of prevention of dysmicroelementosis*:* tests for the content of trace elements and vitamins are an important diagnostic method that allows you to identify the imbalance of these substances in time, and take measures to restore the balance.

Rice. 33. Blood test for trace elements.

Who should be tested for vitamines and trace elements:

- During pregnancy planning, pregnancy and breastfeeding.- After breastfeeding is completed.- Women prone to heavy menstruation.- Children in the active phase of growth.- Adolescents during puberty.
- People who constantly adhere to strict diets.
- Everyone who is engaged in difficult and harmful industries.
- People living in an ecologically unfavorable area.
- Those who are prone to chronic pathologies, stress, after chemotherapy.
- Everyone who experiences symptoms of spring beriberi.
- Elderly people.

Topic 6. Basic principles of rational nutrition. Healthy eating rules. The optimal ratio of macro- and micronutrients. Medical, vitamin and microelement preparations. Food impurities. Sports nutrition.

To achieve these goals, a person needs to be physically active, eat right, follow hygiene rules, give up bad habits, and also follow advice aimed at strengthening the body and human health.

Basic principles of nutrition:

A complete diet should contain proteins, fats and carbohydrates, vitamins and minerals in sufficient quantities and in optimal proportions.

Proteins are used to build body tissues and ensure growth processes. **Fats** are involved in the most important processes of the body's vital functions. **Carbohydrates** are the main source of energy for the body. **Minerals** are involved in the formation and

construction of tissues. **Vitamins** have a positive effect on metabolism, contribute to better digestion of food, increase efficiency, resistance to diseases.

Table. 3. Human nutritional and energy needs:

Age	Male (kJ)	Male (kcal)	Female (kJ)	Female (kcal)
1-2 months*	2,400	574	2,100	502
3-4 months*	2,500	598	2,300	550
5-6 months*	2,600	622	2,400	574
7-12 months*	3,000	718	2,700	646
1 year	3,200	765	3,000	717
2 years	4,200	1004	3,900	932
3 years	4,900	1171	4,500	1076
4 years	5,800	1386	5,400	1291
5 years	6,200	1482	5,700	1362
6 years	6,600	1577	6,200	1482
7 years	6,900	1649	6,400	1530
8 years	7,300	1745	6,800	1625
9 years	7,700	1840	7,200	1721
10 years	8,500	2032	8,100	1936
11 years	8,900	2127	8,500	2032
12 years	9,400	2247	8,800	2103
13 years	10,100	2414	9,300	2223
14 years	11,000	2629	9,800	2342
15 years	11,800	2820	10,000	2390
16 years	12,400	2964	10,100	2414
17 years	12,900	3083	10,300	2462
18 years	13,200	3155	10,300	2462
19-24 years	11,600	2772	9,100	2175
25-34 years	11,500	2749	9,100	2175
35-44 years	11,000	2629	8,800	2103
45-54 years	10,800	2581	8,800	2103
55-64 years	10,800	2581	8,700	2079
65-74 years	9,800	2342	8,000	1912
75+ years	9,600	2294	7,700	1840

*mixed or unknown feeding

Rules by which you should eat:

- Eat protein-rich, low-fat foods three times a day.
- Never consume more than thirty to forty grams of fat in one day;
- Eat two to four fruits a day.
- Eat five times a day
- You can eat at any time when you feel hungry, but only food consisting of complex carbohydrates.
- Do not punish yourself for eating too much high-sodium food, unless it is contraindicated for health reasons (crackers are high in sodium and contain almost no fat).
- If you have a sweet tooth, you can occasionally eat sweets such as jam, jelly, low-calorie caramel. This will help you not feel abandoned and give you the strength to continue with a low-fat diet;
- Try to eat at least three cups of vegetables a day.
- when you lose all the extra pounds, you can eat whatever you want once a week;
- Purchase a guide indicating the fat content of foods and try to avoid fatty foods.

Macronutrients or basic nutrients – **proteins, fats and carbohydrates, which are** needed in tens of grams, during assimilation release energy to perform all body functions. A smaller

number of them is involved in the processes of building cells, tissues, for the synthesis of enzymes and other physiologically active compounds.

Micronutrients, or the so-called minor **physiologically active substances**, are necessary for the body in small quantities; they are involved in the absorption of energy, the regulation of functions and the implementation of the processes of growth and development of the body. Micronutrients include individual **amino acids of food origin**, the participation of which in the regulation of the functions of organs and systems has been proven by numerous studies; **essential fatty acids, vitamins and provitamins, minerals, dietary fiber**, as well as various **organic compounds** characteristic of natural food raw materials of plant and animal origin.

Rules for a balanced diet:

- *Optimal ratio of macronutrients (proteins, fats, carbohydrates) and micronutrients and balance within individual groups of macronutrients;*
- *The share of proteins in the ingested food should be in the range of 10-15% (on average 12%), the share of fats should not exceed 30%, and the share of carbohydrates should be 55-65% (on average 58%).*
- *When translated into grams, the optimal ratio of macronutrients is 1:1.1:4.8*
- *For people engaged in hard work – 1:1,3:5*
- *For young men and women engaged in mental work – 1:1,1:4,1*
- *For the elderly – 1:0.9:3.5*

The need for vitamins:

The daily requirement for vitamins depends on various reasons and factors: age, gender, type of work performed, pregnancy, lactation, climatic and weather conditions, bad habits.

Avitaminosis is a disease that occurs as a result of a long-term insufficient supply of one (monovitaminosis) or several (multivitaminosis) vitamins.
Hypovitaminosis is a disease caused by a lack of vitamins in the body.
Hypervitaminosis is an acute condition that occurs with an overdose of vitamin or with increased sensitivity of the body to its drugs.

Table. 4. Daily requirement of the body for vitamins:

Vitamin	***Daily requirement***	***Functions***
Ascorbic acid (C)	50-100 mg	Increases the body's resistance to stressful situations.
Thiamine (B1)	1.4-2.4 mg	Regulator of fat and hydrocarbon metabolism, activity of the nervous system.
Riboflavin (B2)	1.5-3.0 mg	Participates in the metabolism of proteins, fats, carbohydrates.
Pyridoxine (B6)	2.0-2.2 mg	Protein absorption and nervous system health.

Niacin (PP)	15-20 mg	Participates in OVD in cells. Deficiency causes pellagra.
Folic acid (B3)	200 mcg	Hematopoietic factor, involved in the synthesis of amino acids, nucleic acids, choline.
Retinol (A)	650-950 mcg	It protects against viral diseases, participates in OVD processes, in the synthesis of steroid hormones, and has an antioxidant effect.
Tocopherol (E)	15 mg	Starts the processes of cell regeneration and renewal, has powerful antioxidant properties, smoothes wrinkles.
Vitamin K	1 mg	Hemostatic factor, involved in the body's OVR.

Vitamin A is a group of fat-soluble compounds, which includes substances such as retinoids: retinol (vitamin A1, axerophthol), dehydroretinol (vitamin A2), retinal (retinene, vitamin A1 aldehyde), retinoic acid and several provitamins - carotenoids, among which the most important is β-carotene. It is the latter that is found in large quantities in carrots, giving it a yellow-hot color, from this root crop comes its name (from the Latin "carota" - carrot).

Natural sources of vitamin A

Vegetable origin: green, yellow and orange vegetables (carrots, pumpkin, bell peppers), spinach, broccoli, green onions, , legumes, fruits and berries.

Animal origin: fish oil, caviar, liver (especially beef), dairy products.

B vitamins

Each of the components of the group performs its own function:

Vitamin B1 (thiamine). It releases energy from fats, carbohydrates, proteins. It is found in large quantities in wholemeal bread products, oatmeal, buckwheat, cereal shells, green peas.

Vitamin B2 (riboflavin). The ingredient is essential for the health of the eyes, skin and mucous membranes, while it is involved in all kinds of metabolic reactions. A high content of riboflavin is observed in meat, eggs, mushrooms, nuts, yeast, broccoli, offal (liver, kidneys), white bread, rice, oatmeal.

Vitamin B3 (niacin, vitamin P, vitamin PP). The main function is the synthesis of fats and proteins; It is actively involved in metabolic processes. Niacin is rich in foods such as buckwheat, rye bread, beets, meat, mushrooms, mangoes, pineapple.

Vitamin B5 (pantothenic acid). It takes an active part in the synthesis of antibodies, accelerates tissue regeneration. You can replenish reserves with the help of garlic, buckwheat, oatmeal, chicken, fish caviar, milk, hazelnuts, offal (kidneys, heart). In small quantities, it is synthesized by the body with the help of intestinal microflora.

Vitamin B6 (pyridoxine). It is involved in the formation of hemoglobin and is necessary for carbohydrate metabolism. Pyridoxine regulates the activity of the nervous system,

participates in the production of red blood cells and antibodies. It is produced in the body by healthy intestinal microflora; In addition, nuts, sprouted grains, legumes, meat and dairy products, spinach, cabbage, strawberries, cherries, citrus fruits, potatoes, eggs are rich in vitamin B6.

Vitamin B7 (biotin). It is involved in the release of energy from compounds containing calories. The microflora of a healthy intestine provides the body with a sufficient amount of biotin. The minimum amount of the substance is present in all consumed foods; nuts, peanuts, soybeans, cauliflower, offal (kidneys, liver) are recognized as the record holders for its content.

Vitamin B9 (folic acid). It is responsible for the formation of nucleic acids, leukocytes and erythrocytes, is necessary for growth and immunity. In pregnant women, it promotes the development of the fetus. In the body, folic acid is synthesized with the help of intestinal microflora. You can replenish its supply with the help of green leafy vegetables, citrus fruits, honey, wholemeal bread, liver, yeast.

Vitamin B12 (cobalamin). It is necessary for the formation of red blood cells, is responsible for the development and functioning of the nervous system. Source: Productsanimal origin (yolks of eggs, livers, fermented milk products).

The main signs of vitamin B deficiency

Deficiency of elements from this group can worsen a person's physical and mental health, causing a number of diseases. Itching and dryness of the skin appears, rashes and premature wrinkles, hair loss may appear. But first of all, the lack of B vitamins disrupts the functioning of the nervous system:

This manifests itself in the form of insomnia, irritability, nervous breakdowns, lack of appetite, inability to concentrate.

Vitamin C (L-a scorbic acid) is one of the most important elements,
which brings undeniable benefits to the human body.
It stimulates the immune system, is a powerful antioxidant.
Humans, unlike most animals, are not able to endogenously synthesize vitamin C,
Therefore, it is an important food component.
Sources of vitamin C
The main sources of the nutrient include:

- berries: sea buckthorn, strawberries, currants, rose hips;
- fruits: citrus fruits, pineapples, persimmons, kiwi and apples;
- vegetables: bell peppers, various types of cabbage, potatoes, tomatoes;
- greens: dill, parsley.

Vitamin D is formed in the skin under the influence of UV or enters the body with food, then a chain of metabolic processes occurs with the formation of active metabolites of vitamin D, which, together with parathyroid hormone and calcitonin, ensure the regulation of calcium-phosphate metabolism - the so-called classic action of vitamin D. Life in high latitudes (closer to the polar regions) reduces the synthesis of vitamin D, especially in the winter months. high levels of air pollution, dense cloudiness, clothing coverage, use of sunscreen and dark skin type.

- ***Vitamin D2*** – ergocalciferol is formed in plant cells from ergosterol. The main sources of ergocalciferol are fish, milk, as well as bread and mushrooms. Vitamin D2, which enters the body with food, is absorbed in the small intestine, always in the presence of bile, then it is included in the composition of chylomicrons and transported by the lymphatic system into the venous bloodstream, then passing through metabolic stages similar to cholecalciferol. sufficient amount of fat in food. Impaired bile secretion in diseases of the liver and biliary tract significantly complicates the absorption of the vitamin in the intestines. Ergocalciferol is also available in the form of various drugs, but it shows very little vitamin activity, and therefore is practically not used.
- ***Vitamin D3*** – cholecalciferol is formed in the Malpighian and basal layers of the skin epidermis from 7-dehydrocholesterol (previtamin D) as a result of a non-enzymatic, ultraviolet-dependent photolysis reaction with a wavelength of 290-315 nm. and the other part - in fat cells, where a depot of vitamin D is formed. With age, the content of 7-dehydrocholesterol in the epidermis decreases, respectively, the synthesis of vitamin D3 decreases and after 65 years its level decreases by more than 4 times.

Vitamin D itself is biologically inactive, the implementation of its biological effects is possible only after metabolic transformations in the liver to 25-hydroxyvitamin D (25(OH)D, or calcidiol) and in the kidneys to 1,25-dihydroxyvitamin D (1,25(OH)2D, or calcitriol), which is the final and most active metabolite of vitamin D, and according to the specifics of its action, it is equated to hormones (D-hormone). This is a steroid hormone with endocrine, paracrine and autocrine action. Thus, the main processes of vitamin D biotransformation occur in the skin, liver, and kidneys.

Lack of vitamin D leads to: periodontal disease, asthma, diabetes, rheumatoid arthritis, heart disease, hypertension, breast cancer, prostate, colon, rickets, insomnia, headaches and muscle pains, multiple sclerosis.

Vitamin E (tocopherol) is an important nutrient involved in a number of physiological functions. This fat-soluble vitamin is known for its antioxidant effect. It is used in many fields of medicine, in particular in dermatology. It is part of various cosmetics. It protects the skin from various adverse effects caused by solar radiation by absorbing free radicals.

The main signs of tocopherol deficiency are:

- Muscle weakness.
- Vitamin E deficiency can lead to oxidative stress, which in turn causes noticeable muscle weakness.
- Numbness or tingling sensation in the hands or feet.The cause of discomfort is the same damaged "faulty" neurons.
- Vision problems
- Lack of proper protection can weaken the cells of the organs of vision, which over time leads to a deterioration in visual function.
-Anemia.
- As a result of tocopherol deficiency, red blood cells are destroyed and hemolytic anemia develops.
- Dry skin, brittle nails.

Vitamin K is one of the four fat-soluble vitamins necessary for protein synthesis, ensures the formation of plasma blood coagulation factors, affects bone mineralization and muscle tissue building, regulates the flow of energy in cells due to anabolic action and participates in detoxification processes.
Vitamin K also plays an important role in the formation and repair of bones, ensures the synthesis of osteocalcin, a bone tacna protein on which calcium crystallizes. It helps to prevent osteoporosis, participates in the regulation of redox processes in the body. Vitamin K enters the body mainly with food, partially formed by intestinal microorganisms. The absorption of the vitamin from food occurs with the participation of bile.

In terms of biological activity, the synthetic drug retains the properties of natural vitamin K1.Of the group of related substances, the two main forms of vitamin K that exist in nature are of the greatest interest: vitamin K1 and vitamin K2.Vitamin K1 is a substance that is synthesized in plants and found in leaves.
Vitamin K2 is a substance that is mainly synthesized in the human body by microorganisms (saprophytic bacteria) in the small intestine.

Symptom of vitamin deficiency:

- Increased irritability.
- Low energy levels.
-Drowsiness.
- Muscles do not grow and recover poorly.

Benefits of vitamin balance:

1. Good health;
2. High physical endurance;
3. Sufficient amount of energy for heavy loads and intense training;
4. Fast recovery;
5. Excellent result of participation in competitions.

Table 5

Recommended Daily Allowances for Magnesium

Age range	Males	Females	Pregnancy	Lactation
From birth to 6 mo	30 mg*	30 mg*		
7-12 mo	75 mg*	75 mg*		
1-3 y	80 mg	80 mg		
4-8 y	130 mg	130 mg		
9-13 y	240 mg	240 mg		
14-18 y	410 mg	360 mg	400 mg	360 mg
19- 30 y	400 mg	310 mg	350 mg	310 mg
31-50 y	420 mg	320 mg	360 mg	320 mg
>50 y	420 mg	320 mg		

Biological functions

- **Enzyme cofactor** in > 300 biochemical reactions
- **Energy production**
- **DNA and RNA synthesis**
- **Structural function** of proteins, nucleic acids and mitochondria
- **Muscle contraction/relaxation, vasomotor tone, heart rhythm**

Vitamin and mineral complexes can be narrow, purposeful:

They are used to correct the lack of a certain vitamin or trace element. And there are vitamin complexes that contain active ingredients, based on the need of the average adult for nutrients. There are also special complexes that take into account certain needs and conditions of a person: age (for children, for the elderly); life stages (for pregnant women, women during menopause); lifestyle features (for athletes or persons experiencing increased physical and mental stress); pathological conditions (to maintain immunity, complexes for diabetics).

According to the composition, vitamin complexes are divided into natural and synthetic. Natural vitamins are vitamins obtained exclusively from processed natural raw materials - natural food sources. The advantage of natural complexes is that they already contain enzymes, phytonutrients and minerals. They have a complementary and strengthening effect, so that the main active ingredient is better and more fully absorbed by the body. The main advantages of natural vitamin complexes are due to the following properties: presented in the most active organic forms, which increases their biodigestibility; interact with other trace elements in food, which makes absorption gradual and the effect long-lasting; They are not a foreign substance, have physiological, evolutionarily developed mechanisms of absorption and participation in biochemical reactions of the body, therefore they are less likely to cause allergies.

It is believed that the best vitamin complexes are those that contain all existing vitamins and minerals. All known types of drug interactions are relevant for vitamins: pharmaceutical – components are able to enter into chemical reactions with each other within the dosage form itself before entering the body; pharmacokinetic – interaction of active substances at the stages of absorption, distribution in the environment and tissues of the body, biochemical transformation; Pharmacodynamic – competition between active ingredients for the same receptor at the stage of interaction with the cell membrane. This also happens when one substance displaces another from its connection with the receptor, depriving it of the ability to exert its influence.

When taking ***vitamin-mineral complexes*** , it is recommended to give preference to the following components that mutually reinforce each other: A + zinc (all effects of vitamin A are realized under the influence of Zn-containing enzymes); E + selenium (implementation of antioxidant properties); C + iron (increased absorption of iron from the digestive tract); B_6 + magnesium + zinc (Mg facilitates the entry of B_6 into the cell, and B_6 increases the absorption of Mg, together with zinc B_6 regulates amino acid metabolism); B_{12} + cobalt (cobalt is part of the formula of the active center B_{12}, without which the vitamin does not work); D + calcium + magnesium (the absorption of calcium by bone structures, as well as magnesium, depends on the concentration of vitamin D - its active form in combination with natural easily digestible forms (carbonates) Ca and Mg); biotin + zinc (mutual enhancement of the effect on the structure of the skin, hair, glucose metabolism).

Rice. 34. Vitamin and mineral complex.

Main nutrients:

Macronutrients: proteins, fats, carbohydrates

Micronutrients: prebiotics, probiotics, enzymes, parapharmaceuticals, polypeptides, vitamins, macronutrients, trace elements, amino acids, lipids.

Probiotics are microorganisms taken in sufficient quantities that provide health benefits by improving the gut microbiota (FAO/WHO, 2002).

Rice. 35. Foods containing probiotics.

The main essential properties of probiotics are: 1. Safety for humans 2. Resistance to stomach acid, bile and pancreatic enzymes 3. Ability to colonize in the intestine

Prebiotics are an indigestible ingredient in a product that stimulates the growth and activity of a probiotic culture or a specific type of bacteria in the large intestine (Gibson, 1995).

Rice. 36. Foods containing prebiotics.

Synbiotics are preparations that contain specific bacteria in combination with a prebiotic suitable for them. For example: 1. Bifidobacteria + fructooligosaccharides 2. Lactobacillus rhamnosus + inulin.

Rice. 37. Synbiotics.

Parapharmaceuticals are biologically active compounds that regulate vital processes and are used for prevention, adjuvant therapy and maintaining the functional activity of the body within the physiological norm.


Rice. 38. Parapharmaceuticals.

Sports nutrition is a separate group of food products produced mainly for people leading an active lifestyle and those who are involved in sports and fitness.

Sports nutrition is a separate type of diet that includes the use of natural foods and the correctly calculated amount of supplements in the athlete's diet.

The main principle of sports nutrition is balance and the achievement of a certain sports goal.

The most common drugs for building muscle mass contain chromium, boron, hydroxymethylbutyrate, colostrum, etc.

Rice. 39. Dietary supplements – parapharmaceuticals.

Nutrition for successful training

Athletics, running

It is imperative to eat a sufficient amount of proteins, they will be used as building substances to restore the structure of cells, synthesize hormones and antibodies. If there is too little protein in the diet, this can cause the destruction of muscle tissue cells, impaired hormone production, and a drop in performance.

It is recommended to choose carbohydrates as the main sources of energy, but we must remember: unutilized energy reserves (glycogen) are stored in the liver, and subsequently stored in the form of fat reserves . Fats, being an integral part of cell membranes, also perform a building and energy function.

Before training (a maximum of an hour and a half), you should take a portion of easily digestible carbohydrates (for example, energy bars or a smoothie made from banana and milk). Fibrous carbohydrates (vegetables, grain bread, cereals) are best consumed after a workout, or long before it.

Rice. 40. Sports nutrition.

Strength training

The athlete's nutrition during strength training should be strictly balanced and, if possible, frequent (in moderate portions every four hours). Each serving should contain complete proteins, slow carbohydrates and healthy fats. An hour and a half before the start of training, you can consume a portion of slow carbohydrates (oatmeal, a sandwich made from whole grain bread), after a workout - a protein shake (powdered, from a sports nutrition store, or prepared independently - milk, egg whites).

The diet of a person engaged in weight exercises must strictly comply with the goals:

- If a person is in the "drying" mode - burning subcutaneous fat, then his diet should be dominated by full-fledged high-quality proteins, slow carbohydrates and some unsaturated fats.
- If you aim to gain "mass" (increase the volume of muscle tissue), a small surplus of carbohydrates and proteins is acceptable.

The goal is to lose weight

Regardless of the type of training, if the goal is weight loss , then you must strictly follow the following rules:

- Mandatory calorie deficit

— There are a lot of formulas, online calculators and tables for calculating the daily calorie content of a person based on his physical parameters, frequency and severity of loads. The primary task is to consume the obtained calorie value minus 10-15%, in which case the body will be provided with slow and correct weight loss without negative health consequences;

- It is necessary to choose healthy and high-quality products, to give up unnecessary things: confectionery sweets, cakes and confectionery, sausages, fatty sauces and semi-finished products. Such foods, in addition to their high calorie content, contain a lot of harmful components, dyes and preservatives;

- After a workout (whether it is a long run or a set of exercises with dumbbells), refrain from eating for a couple of hours, at this time the body will consume adipose tissue as an energy source.

TASKS FOR INDEPENDENT WORK:

– The most important carcinogens;
– The most dangerous detergents of our time;
– Hazardous families of trace elements (alkali metals, alkaline-earth metals, rare earth metals);
– Dangerous families of trace elements (semiconductors, pnictogens, chalcogens, halogens);
– Emergency care for poisoning with toxic (heavy) metals;
– Trace element composition of water suitable for drinking;
– Trace element composition of soil suitable for agricultural work;
– Trace element composition of the nutrition of animals that form the human diet;
  - Biogeochemical zones and provinces of Ukraine;
  - Endemic diseases on the territory of Ukraine;
  - Climatic conditions that contribute to trace element deficiency;
  - Imbalance of trace elements that contribute to the occurrence of allergic diseases;
  - Imbalance of trace elements that contribute to the occurrence of malignant neoplasms;

– Food sources of trace elements;
  - Biologically active impurities (dietary supplements);
  - Non-traditional methods of treatment based on knowledge of microelementoses;

– Other classifications of bioelements proposed by great scientists:
  - Classification according to Vernadsky;
  - Classification according to Goldschmidt;
  - Modern knowledge about ultratrace elements.

List of theoretical questions for the final lesson:

Topic 1. Modern classification of mineral elements.

1. The content of mineral elements in liquid media of the human body.
2. The content of mineral elements in the structures of the human body.
3. Functions of mineral elements in a living organism.
4. Problems associated with the violation of the content of organogen elements.
5. Problems associated with a violation of the content of enzyme cofactor elements.

Topic 2. The most important macro- and microelements.

6. Ultratrace elements. Their biological functions.
7. Causes and consequences of trace element deficiency.
8. Basic principles of correction of trace element deficiency.
9. Symptoms of an excess of macro- and micronutrients in the body.
10. States of poisoning with trace elements.

Topic 3. Essential and conditionally essential elements.

11. Classification of bioelements according to the degree of usefulness for humans.
12. Methods for determining trace element deficiency. Causes of deficiency.
13. Principles of correction of deficiency states of essential elements.
14. Food sources of essential trace elements.
15. Food sources of conditionally essential trace elements.

Topic 4. Toxic and potentially toxic elements.

16. Levels of concentration of toxic elements for the human body.
17. Classification of harmful and dangerous factors of the production environment.
18. The most dangerous environmental pollutants. Danger level.
19. Symptoms of poisoning and prophylactic agents for heavy metal poisoning.
20. Endemic diseases in Ukraine, prophylactic agents.

Topic 5. Microelementoses. Modern classifications.

21. The importance of the classification of microelementoses for clinical practice.
22. Methods for the study of microelementoses in biological substrates.
23. Genetically determined diseases.
24. Symptoms of micronutrient imbalances.
25. Issues of prevention of dysmicroelementosis.

Topic 6. Basic principles of rational nutrition.

26. Healthy eating rules.
27. The optimal ratio of macro- and micronutrients.
28. Medical, vitamin and microelement preparations.
29. Food impurities. Their benefits and harms.
30. Sports nutrition issues.

RECOMMENDED READING:

Main:

1. Micro- and macroelements / V. F. Ostashko // Encyclopedia of Modern Ukraine [Electronic resource] / Editors: I. M. Dziuba, A. I. Zhukovsky, M. G. Zheleznyak [et al.]; NAS of Ukraine, NTSh. – Kyiv: Institute of Encyclopedic Studies of the National Academy of Sciences of Ukraine, 2019.

2. Bioactive materials for bone tissue regeneration: study. manual / O. V. Savvova, G. K. Voronov, O. I. Fesenko, Y. O. Smirnova; Kharkiv. National. University of Misk. farm. O. M. Beketova. – Kharkiv: KNUMG. O. M. Beketova, 2021. – 142 p. (in Russian).

3. Fundamentals of toxicological chemistry / M.V. Shevryakov / textbook. – Chemistry, biology and medicine. 2020. – 224 p. (in Russian).

4. Healthy lifestyle. Textbook / Olga Yezhova. Kyiv: "University Book", 2017. - 127 p. (in Russian).

5. Nutrition. Textbook / L.Z. Tel, E.D. Dalenov, A.A. Abduldaeva, I.E. Koman. 2021. – 544 p. (in Russian).

6. Nutrition in family medicine. Part 1: general questions/ ed. "Magnolia". 2022. – 376 p. (in Russian).

7. Vitamins and microelements as specific regulators of physiological and metabolic processes in the body of children and adolescents / A.O. Gorobets; Ukrainian journal Perinatology and Pediatrics 4 (80) 2019. – P. 75-92.

Links to information resources on the Internet, video lectures, other methodological support:

https://empire.org.ua/
https://bcaa.ua/podderzhka/selen_poleznie_svoystva_dlya_organizma_selen_v_produktah
https://cyberleninka.ru/article/n/otruennya-celenom-i-yogo-spolukami-u-promislovosti

https://uk.wikipedia.org/wiki/%D0%99%D0%BE%D0%B4
https://life.pravda.com.ua/health/2019/01/29/235343/
https://www.pharmencyclopedia.com.ua/article/1529/jod

https://agrolait.com.ua/archives/24692

https://dovidka.biz.ua/znachennia-aliuminiiu-v-zhytti-liudyny-biolohichne-znachennia
https://cbo.org.ua/produkti-mistyat-kremnij-dlya-lyudini-rol-i-funkci%D1%97

Additional:

1. Modern Microelementology in Ukraine: Bibliographic Reference for 2005-2016 / Association of Microelementologists of Ukraine; ed. L.M. Shafran. – Dnipro: Accent PP, 2017. – 255 p. (in Russian).

2. The significance of microelementoses and changes in the content of individual microelements for clinical practice // LLC Publishing House: "Health of Ukraine". Medical publications. Specialized medical portal - No alth.ua.com. No. 4/1 March - Pediatrics. 2015.

3. Interaction of microelements: biological, medical and social aspects / I.M. Trakhtenberg, I.S. Chekman, V.O. Linnyk, V.G. Kaplunenko, M.P. Gulich, E.M. Biletskaya, V.F. Shathorna, N.M. Onul // /ISSN 0372-6436. Visn. NAS of Ukraine, 2013, No. 6. Pp. 11-20.

3. Food chemistry. Texts of lectures for students of the direction of training 6.051701 "Food technologies and engineering" / Compiled by: Humeniuk O.L. – Chernihiv: ChSTU, 2013. – 244 p. (in Russian).

4. Heavy metals //Dictionary-handbook with Ecology: Teaching method. / uklad.O.G. Lanovenko, O. O. Ostapishyn. — Kherson: PE Vyshemirskyi V. S., 2013. — P. 30.

5. Chemical elements of the p-block / Biological function of chemical elements. Chapter 5. – Chertko, E. Chertko, D. Budko, A. Taranchuk. Ch. 5 //— Minsk, 2012.

6. Trace elements and health. / Methodical manual for work in the laboratory / [incl. O. O. Konovalova, G. P. Andreyko]. – Kh. – V. N. Karazin Kharkiv National University, 2012. – 40 p. (in Russian).

7. Nanotechnologies of micronutrients: problems, prospects and ways to eliminate the deficiency of macro- and microelements / Serdyuk A.M., Gulich M.P., Kaplunenko V.G., Kosinov M.V. // Zhurn. AMNU. — 2010. — Vol. 16, No. 1. — Pp. 107–114.

8. Fundamentals of physiology and food hygiene: / textbook by N. V. Dudenko [et al.] – Sumy: University Book, 2009. – 555 p. (in Russian).

9. Book about poisons and poisoning / Essays on toxicology // Trakhtenberg I.M.— Ternopil: TDMU, 2008. 364 p. (in Russian).

10. Food hygiene with the basics of nutrition / Ed. Prof. V.I. Cypriyan/. 1 and 2 volumes, Kyiv: Medicine, 2007.- 528 p. and 560 p.

11. Trace elements and their role in human life / Spivakovsky Yu.M., Spivakovska. - Nurse. - 2005. - 468 p. (in Russian).

Електронне навчальне видання комбінованого використання
Можна використовувати в локальному та мережному режимі

Шерстюк Сергій Олексійович
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МІКРОЕЛЕМЕНТОЗИ В ПРАКТИЦІ ЛІКАРЯ

Методичні рекомендації
для самостійної роботи студентів 2-го курсу медичного факультету
з дисципліни «Мікроелементози людини»

(Англ. мовою)

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