

**MINISTRY OF SCIENCE AND HIGHER EDUCATION
RUSSIAN FEDERATION**

**FEDERAL STATE AUTONOMOUS EDUCATIONAL INSTITUTION OF
HIGHER EDUCATION
NORTH-CAUCASUS FEDERAL UNIVERSITY**

Methodological Guidelines
for Students on arranging and performing independent work
in the Discipline of Biochemistry
for Students majoring (Specialty) in 31.05.01 General Medicine

Methodological Recommendations for Studying Theoretical Material

When performing the independent study of theoretical material, the student must follow the rules as set below. The working curriculum of the respective academic discipline shall be recommended to be used as the basis for such activity. According to the schedule of classroom lessons and independent work, a different number of hours is to be allocated for studying individual topics. A significant portion of the student's independent work should be allocated to mastering the material on the covered topic, writing a summary (notes) on the specified theoretical blocks, and searching for additional literature based on the NCFU library and via the Internet system. The lecture material shall not cover all theoretical material; the greater part of it must be mastered through independent work. Given the above, working with the recommended literature is mandatory. Special attention must be paid to the content of the main provisions and conclusions, the explanation of phenomena and facts, and the understanding of the practical application of the theoretical issues under consideration. In the process of this work, the student should strive to understand and memorize the main provisions of the material being considered, the examples illustrating it, as well as to understand the illustrative material. Preparation should be completed by drawing up a plan (summary/notes) on the material (issue) being studied. This allows for the creation of a concentrated, concise representation of the issues being studied. First, studying the recommended literature is to be done. Special attention must be paid to the content of the main provisions and conclusions, the explanation of phenomena and facts, and the understanding of the practical application of the theoretical issues under consideration.

During this work, the student should strive to understand and memorize the main provisions of the material being considered, the examples illustrating it, as well as to understand the illustrative material. Preparation should be completed by drawing up a plan (summary/notes) on the material (issue) being studied. This allows for the creation of a concentrated, concise representation of the issues being studied. If necessary, one should seek (advice) consultation from the instructor. When going to a consultation, it is necessary to thoroughly think through the questions that require clarification. Keeping records contributes to turning reading into an active process, mobilizing motor memory along with visual memory. The following should be born in mind: a student who systematically keeps records creates their own individual stock of auxiliary materials for a quick review of what has been read and for the mobilization of accumulated knowledge. Records are especially important and useful when they reflect the thoughts that arose during independent work.

It is important to develop the students' capacity to compare sources and to think through the material being studied.

Improving note-taking skills among students is of great importance.

The instructor may recommend the following main forms of recording to students: a plan (simple and detailed), excerpts, and theses (abstracts).

The results of note-taking can be presented in various forms.

- A plan is an outline of the read material, a brief (or detailed) list of questions reflecting the structure and sequence of the material.
- A detailed plan fully replaces a summary.
- A summary (notes) is a systematized, logical presentation of the source material. Four types of summaries are distinguished:
 - Outline-summary (Plan-notes) – this is an expanded, detailed plan in which sufficiently detailed records are provided for those points of the plan that need explanation.
 - Textual summary – this is the reproduction of the most important provisions and facts of the source.
 - Free summary – these are clearly and briefly formulated (stated) main provisions resulting from a deep understanding of the material. It may contain excerpts, quotations, and theses; part of the material may be represented by a plan.

- Theme-based summary – this is compiled on the basis of studying a number of sources and gives a more or less exhaustive answer according to a certain scheme (issue).

Methodological Guidelines for the Preparation for Practical Activities

When preparing for practical activities, the recommendation implies studying the control questions for the given lesson and the theoretical material from one's own notes.

The main form of work during the lessons is an interview (discussion). Each student must be ready to speak on all issues raised in the plan and demonstrate maximum activity during their consideration.

The speech must be constructed freely, convincingly, and with arguments. The instructor ensures that the speech is not reduced to a reproductive level (simple reproduction of the text); simple reading of the summary is also not allowed.

It is necessary for the speaker to show their own attitude towards what they are talking about, express their personal opinion and understanding, substantiate it, and be able to draw the correct conclusions from what has been said. In doing so, the student may refer to the entries in the summary, directly to the primary sources, use knowledge of previously studied disciplines, etc. In addition, to obtain a grade at an advanced level, students solve situational tasks based on the results of the mastered topics.

During the execution of practical works, a defense of practical skills is provided, the full list of which is specified in the fund of assessment tools.

Methodological Recommendations for the Preparation of Presentations and Reports

The report must contain elements of novelty; along with the fundamental aspect, an analysis of the current state of the problem under study must be carried out, as well as inclusion in regional issues. The report must include an introduction, a theoretical part, a conclusion, a list of literature, and a presentation that reveals the essence of the topic in graphs, pictures, diagrams, and formulas.

The report is recommended to be submitted on 1 printed sheet. The text of the work must be printed with 1.5 line spacing on one side of a standard sheet (A4) of white paper.

The text and other printed elements of the work must be black, and the contours of letters and signs must be clear, without halos and shading. The font must be Times New Roman, size 14. The titles of chapters and paragraphs are highlighted in bold. The sheet with text must have margins: left – 30 mm, right – 10 mm, top – 20 mm, bottom – 20 mm.

Page numbering of the text is done in the lower right corner of the sheet. It is necessary to number pages starting from the page where the Introduction is printed, on which the number 3 is placed. After that, all pages, including appendices, are numbered.

A space equal to two intervals is placed between the title of the chapter and the title of the paragraph of this chapter, and the title of the paragraph must not be separated from the text of this paragraph by a space. The titles of paragraphs shall be separated from the text of the previous paragraph by a space equal to two intervals. Each chapter, as well as the introduction, conclusions, appendices, and the list of used literature, begin on a new page. The word Chapter is not to be written. Chapters have ordinal numbers within the entire work, designated by Arabic numerals (for example: 1, 2, 3), followed by a period.

The word **PARAGRAPH** or the paragraph symbol (§) is not placed in the title. Paragraphs have ordinal numbers within the chapters, designated by Arabic numerals (for example: 1.1. and 1.2.).

Headings of chapters and paragraphs in the text must be centered; a period shall not be placed at the end of the title of the chapter and paragraph. It is not allowed to hyphenate (transfer) a part of a word in a heading. 4.5. The numbering of tables and figures can be running (continuous) or relate to the number of the chapter and paragraph. For example, if a table or a figure is included in the text of the first paragraph of the second chapter, the numbering is as follows: Table 2.1.1., Fig. 2.1.1.

The last digit means the ordinal number of the table (or figure) in this paragraph.
The table is to be placed as the next page after the first mention of it in the text.

Educational, Methodological, and Informational Support for the Discipline

1. List of Main and Additional Literature Required for Mastering the Discipline (Module)

1.1. List of Main Literature:

1. Davidov V.V., Vavilova T.P., Shestopalov A.V. Medical biochemistry, SPb: Eco-vector, 2018. – 392 p. – ISBN 978-5-906648-57-0
2. Glukhov A.I., Garin V.V. Biochemistry with exercises and tasks : textbook . – Moscow: GEOTAR-Media, 2022. – 296 c. – ISBN 978-5-9704-7069-5.

1.2. List of Additional Literature:

1. Koolman J. Roehm K.-H., Color Atlas of Biochemistry, Germany: Thieme, 2nd edition 2005. – 476 p.

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Methodological Guidelines
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for Students majoring (Specialty) in 31.05.01 General Medicine

The purpose of mastering the discipline "Biochemistry" is to obtain the necessary amount of knowledge, skills and abilities in the field of biological chemistry, the formation of competencies in accordance with the requirements of the Federal State Educational Standard.

- acquiring of theoretical knowledge of the basics of general and clinical biochemistry;
- training in modern methods of assessing human biochemical status;
- learning the main patterns of biochemical processes in healthy person
- learning the main patterns of biochemical processes in typical disorders;
- formation of mentions about the interrelationships of the biochemical process with the functions of the body, as a whole, in order to form a clinical mindset, a doctor's worldview;
- acquiring of knowledge about the importance of biochemical disorders prevention for improving the health of children and adults.

1. Introduction to biochemistry. The structure and functions of amino acids, peptides, simple and complex proteins. Biological significance. The subject of biochemistry. A brief history of biochemistry. The role of Russian scientists in the development of biochemistry. Modern trends and the use of biochemistry achievements in the economy and medicine. The relationship of biochemistry with biophysics, genetics, immunology, pharmacology. Protein. The role of proteins in the body. Physico-chemical properties of amino acids and proteins. Amino acids. Classification. Chemical and physical properties of amino acids. Levels of protein structure organization. Protein primary structure. Characteristics of the peptide bond. The secondary structure of the protein. Characteristics of the α -helix, β -folded layer. Protein tertiary structure. Prediction of secondary and tertiary structure based on primary amino acid sequence. The quaternary structure of the protein. Protein folding. Post-translational modification. Conjugated proteins. Characteristics of immunoglobulins, hemoglobin, myoglobin, phosphoproteins, and insulin. Proteomics is a field in the study of the protein composition of the body in norm and pathology.

2. Vitamins. Mechanisms of water- and fat-soluble vitamins action.

The chemical structure of vitamins. Classification of vitamins. The concept of vitamin deficiency, hypovitaminosis and hypervitaminosis. Characteristics of the structure and function of water-soluble vitamins. Characteristics of the structure of fat-soluble vitamins. Vitamin-like substances. Coenzymes. Antivitamins.

3. Enzymes. General characteristics, classification and nomenclature of enzymes. Enzymatic catalysis in comparison with other types of catalysis. Physical and chemical base of enzymatic catalysis. Enzyme activity. Enzyme kinetics in stationary mode. The Michaelis-Menten equation. Factors affecting the rate of the enzymatic reaction. General ideas about the structure of the active center of enzymes. The mechanism of enzymatic catalysis. Allosteric enzymes and their features. Isozymes. The functional significance of regulatory enzymes. Methods of regulation of enzymatic activity. Enzyme activators and inhibitors. Enzyme usage in pharmacology and therapy.

4. Nucleic Acids: Structure, Properties, and Matrix Biosyntheses

Structure and Functions of Nucleic Acids (DNA and RNA): chemical composition and nucleotide structure; primary and secondary structures of nucleic acids; base complementarity and its biological significance; classification and characteristics of different RNA types (mRNA, tRNA, rRNA, regulatory RNAs). Physicochemical Properties of Nucleic Acids: solubility, viscosity, and UV absorption; denaturation and renaturation processes; melting temperature (T_m) and factors affecting it; methods for studying the spatial organization of nucleic acids (electrophoresis, spectroscopy, X ray crystallography, PCR based techniques). Transcription: Mechanism and Regulation: structure and function of RNA polymerases; stages of transcription (initiation, elongation, termination); regulation of transcription in prokaryotes and eukaryotes; RNA processing and splicing (including alternative splicing). Translation and Protein Biosynthesis: ribosome structure in prokaryotes and eukaryotes; stages of translation (initiation, elongation, termination) and the role of GTP and protein factors; post translational modifications and protein maturation; inhibitors of matrix biosyntheses and their medical relevance. DNA Replication and

Repair: mechanism of DNA replication and the concept of the replication fork; key enzymes and proteins (DNA polymerases, helicases, primase, ligase); telomeric DNA and telomerase function; types of DNA damage and repair systems (base excision repair, nucleotide excision repair, mismatch repair).

5. Hormonal Regulation and Signal Transduction

General Principles of Hormonal Regulation: concepts of positive and negative feedback, permissive action, and target tissue specificity; stages of hormone metabolism; hormone receptors: membrane (G protein coupled, channel linked, catalytic) and intracellular (cytosolic, nuclear) types. Mechanisms of Hormone Action: signaling pathways of water soluble molecules (peptide hormones, growth factors, cytokines); second messengers: cyclic nucleotides, peptides, fatty acid derivatives, IP₃, DAG, Ca²⁺; mechanisms of action for different hormone classes. Chemical nature of hormones: steroid hormones; proteinaceous hormones; peptide hormones; amino acid derivative hormones. Hypothalamic and Pituitary Hormones: biosynthesis, structure, and functions of hypothalamic hormones; tropic hormones of the pituitary: classification, chemical nature, and role in regulating peripheral glands; growth hormone (GH): metabolism, metabolic and physiological effects. Selected Hormones and Their Effects: neurohormones: oxytocin and vasopressin; adrenal hormones: adrenaline, glucagon, glucocorticoids; insulin: molecular mechanisms and biological effects; thyroid hormones: structure and influence on metabolism; clinical correlation: diabetes mellitus.

6. Bioenergetics

Fundamentals of Bioenergetics: metabolism: anabolism vs. catabolism; ATP as a universal high energy compound; mitochondrial membrane structure and function. Biological Oxidation and Energy Production: respiratory chain components and electron transfer; pyruvate dehydrogenase complex; tricarboxylic acid (TCA) cycle: reactions and metabolic significance; oxidative phosphorylation and coupling mechanisms; proton gradient and energy storage; regulation of the respiratory chain. Inhibitors and Uncouplers: inhibitors of the electron transport chain (rotenone, barbiturates, cyanide, carbon monoxide); uncoupling agents (dicoumarol, gramicidin A); free oxidation and reactive oxygen species (ROS).

7 Carbohydrate Metabolism

Classification, physicochemical properties, and biological roles of carbohydrates. Glycolysis: steps, regulation, and energy yield. Pentose phosphate pathway: reactions and physiological significance. Fermentation (lactic acid, alcoholic) and ethanol metabolism. Aerobic carbohydrate oxidation and pyruvate decarboxylation. Gluconeogenesis: pathways, regulation, and tissue distribution.

8. Carbohydrate Digestion and Metabolism

Digestion and Absorption of Carbohydrates: enzymes involved in carbohydrate digestion in the GI tract and their characteristics; mechanisms of glucose transport across membranes via GLUT receptors; insulin secretion and its role in glucose uptake. Metabolism of Specific Monosaccharides: fructose metabolism; differences between hepatic and muscular fructose metabolism; disorders of fructose metabolism; galactose metabolism; galactosemia and other disorders of galactose metabolism. Glucose Homeostasis and Glycogen Metabolism: mechanisms controlling blood glucose concentration; glycogen synthesis and glycogenolysis; regulation of these processes; Cori cycle; glycogenoses; blood glucose curve; roles of adrenaline, glucagon, and insulin in glucose regulation; hyper and hypoglycemia: causes, acute and long term compensatory mechanisms; metabolic and clinical consequences of acute and chronic hyper and hypoglycemia; diabetes mellitus; glucosuria.

9. Lipid Digestion and Metabolism

Lipid Structure, Classification, and Membrane Biology: general properties and biological roles of lipids; structure and properties of fatty acids; saturated vs. unsaturated fatty acids; isomerism and structure of unsaturated fatty acids; essential fatty acids; eicosanoids: prostaglandins, thromboxanes, prostacyclins, leukotrienes; classification, structure, properties, and distribution of

major lipid representatives; biological membranes: structure and functions; roles of lipids, proteins, and carbohydrate containing compounds; micelles and liposomes; chemical heterogeneity of membrane phospholipids; cholesterol in membranes; glycolipids. Digestion, Absorption, and Mobilization of Lipids: mechanisms of lipid digestion and absorption; enzymes involved; role of various lipases in dietary fat digestion in infants; bile: composition, functions, mechanism of action in digestion; steatorrhea: causes and consequences; mobilization of fats from adipose tissue: reactions, regulatory mechanisms, hormonal control, physiological significance. Fatty Acid and Ketone Body Metabolism: activation and transport of fatty acids into mitochondria; β oxidation of fatty acids: reactions, regulation, energy balance; ketone bodies: biological role, metabolic reactions, regulation; ketonemia, ketonuria: causes, mechanisms, consequences. Lipid Biosynthesis and Cholesterol Metabolism: fatty acid biosynthesis: stages, reactions, structure of fatty acid synthase, regulation; triacylglycerol biosynthesis: mechanism, regulation, tissue specific features; cholesterol: biological significance, sources and utilization; cholesterol synthesis, regulation; mechanisms of cellular cholesterol uptake; bile acid synthesis; cholesterol transport; hypercholesterolemia: causes and consequences. Lipoproteins and Atherosclerosis: blood lipoproteins: classification, diagnostic significance; atherogenic coefficient; dyslipoproteinemias; molecular mechanisms of atherosclerosis.

10. Protein Digestion, Amino Acid Metabolism, and Nitrogen Metabolism

Protein Digestion and Nitrogen Balance: protein digestion in the GI tract; principles of protein requirements in nutrition; nitrogen balance; enzymatic hydrolysis of proteins in the GI tract; mechanisms of amino acid absorption; putrefaction of proteins in the intestine; role of UDP glucuronic acid and PAPS in detoxification and excretion of putrefaction products (phenol, indole, skatole, indoxyl, etc.); impaired protein digestion; protein deficiency: causes, metabolic and clinical consequences, prevention. General Amino Acid Metabolism: formation of the blood amino acid pool and its utilization; common reactions of amino acid metabolism: transamination, direct and indirect deamination, decarboxylation; tissue specific features; utilization of the carbon skeletons of amino acids; formation of biogenic amines (histamine, tyramine, tryptamine, serotonin, GABA); physiological roles.

Specific Amino Acid Pathways: serine and glycine metabolism: pathways and significance; cysteine metabolism: pathways, significance; role of PAPS in biological sulfation; methionine metabolism: pathways, significance; formation of S adenosylmethionine and its role in methylation reactions; methionine resynthesis; roles of THF and vitamin B₁₂; interconnection between methionine and cysteine metabolism; methionine as a lipotropic factor; glutamic and aspartic acid metabolism: pathways, biosynthesis, roles in ammonia detoxification; glutamine as an amino group donor; formation and utilization of GABA and GHB; phenylalanine metabolism: conversion to tyrosine; catecholamine and melanin pathways; homogentisate pathway; phenylketonuria, albinism, alkaptonuria; tryptophan metabolism: main pathways; serotonin biosynthesis and biological significance. Ammonia Detoxification and Urea Cycle: ammonia detoxification and utilization: formation of glutamine, asparagine, urea; tissue specific features; urea (ornithine) cycle: integration with amino acid and energy metabolism; deficiencies of urea cycle enzymes: causes and consequences; acute and chronic ammonia toxicity: metabolic and clinical effects.

11. Nucleic Acid Metabolism

Digestion and absorption of nucleic acid hydrolysis products; tissue nucleotide metabolism; purine ring biosynthesis; degradation of purine nucleotides to uric acid; disorders of purine nucleotide metabolism: hyperuricemia, gout, urolithiasis. Reactions of ammonia use and neutralization: formation of glutamine, asparagine, urea – tissue features. The relationship of the ornithine cycle with amino acid metabolism and energy metabolism. Deficiency of ornithine cycle enzymes, causes and consequences. Mechanisms of acute and chronic ammonia toxicity, metabolic and clinical consequences

12. Organ and Tissue Biochemistry

Acid-base balance. Erythrocyte and Leukocyte Biochemistry: metabolism in erythrocytes; mechanisms of free radical oxidation and antioxidant defense; methemoglobin; hereditary and acquired erythrocyte metabolic disorders; causes and mechanisms of reduced osmotic resistance and erythrocyte aging; oxygen and carbon dioxide transport, acid base balance regulation; leukocytes: functions, chemical composition, metabolic features; biochemical aspects of phagocytosis. Hemostasis System: primary and secondary hemostasis; endothelium and endothelial factors; platelet activation mechanisms; plasma coagulation factors; biochemical mechanisms of clot formation; roles of Ca^{2+} and vitamin K; anticoagulant system; fibrinolysis system; methods for assessing hemostasis; hemostasis disorders. Liver Function and Iron Metabolism: liver's role in maintaining homeostasis (carbohydrate, lipid, and protein metabolism); liver's role in pigment metabolism; hemoglobin biosynthesis and breakdown; iron metabolism: role of iron in the body; intestinal iron absorption mechanisms; iron pools; regulation of iron homeostasis; disorders of iron metabolism; biochemical aspects of anemias; liver detoxification function. Blood Biochemistry: plasma proteins: classification, separation methods; disorders of plasma protein composition; non protein organic components of plasma; types of azotemia; key biochemical markers in blood and urine reflecting the functional state of different muscle tissues. Myocardial and Connective Tissue Biochemistry myocardial biochemistry; ischemic heart disease, myocardial infarction: biochemical causes, metabolic disturbances, consequences; laboratory diagnosis of myocardial infarction; connective tissue: cellular and chemical composition, organization, and functions; structure, functions, and metabolism of collagen, elastin, fibronectin, glycosaminoglycans, proteoglycans; normal and pathological states (wound healing, collagenoses, vitamin C/D/A/K deficiencies); roles of hormones and vitamins in connective tissue metabolism; biochemical diagnosis of degenerative processes. Calcium and Phosphate Homeostasis: regulation of calcium and phosphate metabolism; parathyroid hormone, calcitriol, calcitonin: structure, synthesis, mechanism of action. Kidney Biochemistry: normal and pathological components of urine and their origins; renal glucose threshold, glucosuria; regulation of water and salt balance; renin angiotensin aldosterone system; vasopressin; atrial natriuretic peptides.

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