

Ministry of Science and Higher Education of the Russian Federation
Federal State Autonomous Institution of Higher Education
“National Research Nuclear University “MEPhI”

INSTITUTE OF ENGINEERING PHYSICS FOR BIOMEDICINE

APPROVED ИТС ИФИБ

Protocol No. 3.1

dated 30.08.2024

ACADEMIC COURSE OUTLINE

БИОХИМИЯ / BIOCHEMISTRY

Educational program track (speciality) [1] 31.05.01 General Medicine

| Semester | Labour input, credits | Total course academic, hours | Lectures, hrs. | Practical sessions, hrs. | Laboratory sessions, hrs. | In the form of practical studies, hrs. | Independent studies, hrs. | Independent studies monitoring, hrs. | Course progress, Exam/Pass-fail exam/Term |
|-----------------|------------------------------|-------------------------------------|-----------------------|---------------------------------|----------------------------------|---|----------------------------------|---|--|
| 3 | 3 | 108 | 36 | 0 | 54 | | 18 | 0 | PFE |
| 4 | 5 | 180 | 16 | 0 | 48 | | 62 | 0 | Ex |
| Total | 8 | 288 | 52 | 0 | 102 | 0 | 80 | 0 | |

ABSTRACT

The discipline is a fundamental biomedical subject that studies the processes of the human body at the molecular level. Biochemistry lies at the intersection of organic chemistry and biology, representing a dynamic field focused on metabolism and its regulation. It also encompasses key aspects of cell biology, genetics, and epigenetic regulation. The knowledge acquired through this course is essential for developing a future physician's ability to evaluate the morphological, functional, and physiological states of the human body, as well as pathological processes, in order to solve professional tasks.

1. ACADEMIC COURSE GOALS AND OBJECTIVES

Course goal:

To develop systematic knowledge in biological chemistry regarding the fundamental principles of the molecular organization of the cell, tissues, and the organism as a whole.

Course objectives:

- To develop an understanding of the fundamental patterns of metabolic processes, the regulation of metabolism, and its relationship to the functional activity of living systems.
- To develop knowledge of biochemical research methods and the ability to use their results to assess human health.
- To develop the ability to understand pathogenetic mechanisms underlying pathological processes, including those associated with inherited metabolic defects.
- To develop the ability to apply acquired knowledge and skills when studying subsequent fundamental and clinical medical disciplines, and to assess morphological, functional, and physiological states, as well as pathological processes, for solving professional tasks.
- To develop knowledge and skills related to the principles of clinical laboratory technologies and to gain experience working with them.

2. PLACE OF THE ACADEMIC COURSE IN THE MAIN HIGHER EDUCATION CURRICULUM

The study of this discipline builds upon knowledge and skills acquired in courses such as medical and biological physics, chemistry (organic chemistry), biology, anatomy, and histology.

The knowledge and competencies gained from this course are essential for the subsequent successful study of pharmacological disciplines as well as clinical medicine

3. DEVELOPED COMPETENCIES AND INTENDED LEARNING OUTCOMES

Universal and/or general professional competencies:

| Competency code and title | Code and title of competency-based rubrics |
|---|--|
| OIIK-5 [1] – Capable of assessing morphofunctional and physiological states, as well as pathological processes in the human body to solve professional tasks. | 3-OIIK-5 [1] – Know: - basic medical, pharmaceutical, and morphofunctional terminology, including Latin terms; - structure and functions of the human body, age-related, gender-specific, and individual characteristics of the structure and development of a healthy organism; - physical and chemical |

| | | | | | | | |
|---|---|-----------|---------|--------------|----|------|---------------------------------|
| | <i>3 Semester</i> | | | | | | |
| 1 | General biochemistry | 1-6 | 12/0/19 | T-6 (20) | 20 | T-6 | 3-ОПК-5, У-ОПК-5, В-ОПК-5 |
| 2 | Enzymes, Vitamins, Hormones | 7-11 | 12/0/16 | T-11 (20) | 20 | T-11 | 3-ОПК-5, У-ОПК-5, В-ОПК-5 |
| 3 | Catabolism and Anabolism | 12- 15 | 12/0/19 | | 10 | T-15 | 3-ОПК-5, У-ОПК-5 |
| | <i>Totals for 3 Semester</i> | | 36/0/54 | | 50 | | |
| | Assessment events for 3 Semester | | | | 50 | PFE | 3-ОПК-5, У-ОПК-5, В-ОПК-5 |
| | <i>4 Semester</i> | | | | | | |
| 1 | The First Section | 1-6 | 4/0/17 | T-6 (20) | 20 | T-6 | 3-ОПК-5 |
| 2 | The Second Section | 7-11 | 6/0/17 | T-11 (20) | 20 | T-11 | 3-ОПК-5, У-ОПК-5 |
| 3 | The Third Section | 12- 15 | 6/0/14 | T-15 (10) | 10 | T-15 | 3-ОПК-5, В-ОПК-5 |
| | <i>Totals for 4 Semester</i> | | 16/0/48 | | 50 | | |
| | Assessment events for 4 Semester | | | | 50 | Ex | 3-ОПК-5, У-ОПК-5, В-ОПК-5 |

* – abbreviated name of assessment

** – 100 maximum points per semester including a pass/fail exam and (or) an exam

Abbreviated current assessment forms and section assessment

| Abbreviation | Full name |
|--------------|-----------------------|
| T | Testing |
| PFE | Pass/fail examination |
| Ex | Exam |

SYLLABUS

| Weeks | Topics / Content | Lect., hrs. | Pr./sem., hrs. | Lab., hrs. |
|------------|---|----------------|-------------------|---------------|
| | <i>3 Semester</i> | 36 | 0 | 54 |
| 1-6 | General biochemistry | 12 | 0 | 19 |
| 1 - 2 | Protein biochemistry Introductory class. Grading system. Laboratory safety instructions. Review: main classes of compounds, functional groups, heterocycles, types of bonds, polarity/non-polarity, hydrophobicity/hydrophilicity/amphiphilicity. | All | | |
| | | 2 | 0 | 4 |
| | | Online | | |
| | | 0 | 0 | 0 |
| 2 - 3 | Amino acids Structure, classification, formation and properties of the peptide bond. Simple proteins. | All | | |
| | | 2 | 0 | 4 |
| | | Online | | |
| | | 0 | 0 | 0 |
| 3 - 4 | Complex proteins Classification and examples; hemoglobin and | All | | |
| | | 2 | 0 | 4 |

| | | | | |
|--------------|--|--------|---|----|
| | immunoglobulins. | Online | | |
| | | 0 | 0 | 0 |
| 4 - 5 | Nucleotides and Template-Based Biosynthetic Processes Replication, transcription, and translation | All | | |
| | | 2 | 0 | 4 |
| | | Online | | |
| | | 0 | 0 | 0 |
| 5 - 6 | Carbohydrates: Classification and Biological Role Classification of mono-, di-, and polysaccharides. Biological roles of different classes of carbohydrates in the human body | All | | |
| | | 4 | 0 | 3 |
| | | Online | | |
| | | 0 | 0 | 0 |
| 7-11 | Enzymes, Vitamins, Hormones | 12 | 0 | 16 |
| 7 - 8 | Enzymes: Classification and Properties Classification of enzymes by structure and reaction type. Concepts of the active site and allosteric site | All | | |
| | | 3 | 0 | 4 |
| | | Online | | |
| | | 0 | 0 | 0 |
| 8 - 9 | Enzymes: Kinetics and Regulation of Activity Enzymes: Kinetics and Regulation of Activity Factors influencing the rate of enzymatic reactions. Enzyme inhibition and types of enzyme activation | All | | |
| | | 3 | 0 | 4 |
| | | Online | | |
| | | 0 | 0 | 0 |
| 9 - 10 | Vitamins Coenzyme functions of water-soluble vitamins. Fat-soluble vitamins | All | | |
| | | 3 | 0 | 4 |
| | | Online | | |
| | | 0 | 0 | 0 |
| 10 - 11 | Hormones General principles of hormonal regulation. Sites of hormone synthesis and their signaling pathways | All | | |
| | | 3 | 0 | 4 |
| | | Online | | |
| | | 0 | 0 | 0 |
| 12-15 | Catabolism and Anabolism | 12 | 0 | 19 |
| 12 - 13 | ATP Synthesis Pathways in Cells Substrate-level and oxidative phosphorylation | All | | |
| | | 4 | 0 | 6 |
| | | Online | | |
| | | 0 | 0 | 0 |
| 13 - 14 | Oxidative Decarboxylation of Pyruvate and the Krebs Cycle Pyruvate dehydrogenase complex: structure and function. Krebs cycle: chemistry and regulation | All | | |
| | | 4 | 0 | 6 |
| | | Online | | |
| | | 0 | 0 | 0 |
| 14 - 15 | Glycolysis and Gluconeogenesis Chemistry of glucose oxidation reactions, regulation, and biological significance | All | | |
| | | 4 | 0 | 7 |
| | | Online | | |
| | | 0 | 0 | 0 |
| | <i>4 Semester</i> | 16 | 0 | 48 |
| 1-6 | The First Section | 4 | 0 | 17 |
| 1 - 2 | Lipid Digestion Lipid metabolism. Features of emulsification (bile acids), digestion, absorption, resynthesis, and lipid transport. | All | | |
| | | 1 | 0 | 3 |
| | | Online | | |
| | | 0 | 0 | 0 |
| 2 - 3 | Lipolysis Basal and stimulated lipolysis. Glycerol oxidation. β -oxidation of fatty acids in mitochondria. Biosynthesis and utilization of ketone bodies. | All | | |
| | | 1 | 0 | 3 |
| | | Online | | |
| | | 0 | 0 | 0 |

| | | | | |
|--------------|---|--------|---|----|
| 3 - 4 | Fatty Acid Synthesis Biosynthesis of fatty acids. Fatty acid elongation and desaturation. Synthesis of arachidonic acid. Role of cytochrome P450 in xenobiotic detoxification. Reactive oxygen species. COX-1 and COX-2. | All | | |
| | | 1 | 0 | 3 |
| | | Online | | |
| | | 0 | 0 | 0 |
| 4 - 5 | Lipogenesis Biosynthesis of triacylglycerols (TAG). Biosynthesis and degradation of glycerophospholipids and sphingolipids in various tissues. Lipid storage diseases and hepatic steatosis. | All | | |
| | | 1 | 0 | 3 |
| | | Online | | |
| | | 0 | 0 | 0 |
| 5 - 6 | Cholesterol Metabolism Cholesterol biosynthesis. Relationship between lipid and carbohydrate metabolism. Central role of CoA in lipid metabolism. Regulation and pathology of lipid metabolism. Microsomal oxidation of lipids. Lipoproteins. Atherogenesis. | All | | |
| | | 0 | 0 | 5 |
| | | Online | | |
| | | 0 | 0 | 0 |
| 7-11 | The Second Section | 6 | 0 | 17 |
| 7 - 8 | Metabolism of Proteins and Amino Acids Protein digestion. General pathways of amino acid catabolism. | All | | |
| | | 1 | 0 | 5 |
| | | Online | | |
| | | 0 | 0 | 0 |
| 8 - 9 | Ammonia Metabolism Sources of ammonia. Causes of ammonia toxicity. Pathways of ammonia detoxification. Urea synthesis in the liver. Fate of α -keto acids. Synthesis of glutamine and asparagine. Formation of ammonium salts. Concept of hydroxylation and methylation reactions. | All | | |
| | | 1 | 0 | 4 |
| | | Online | | |
| | | 0 | 0 | 0 |
| 9 - 10 | Specific Pathways of Amino Acid Metabolism Specific Pathways of Amino Acid Metabolism Metabolism of individual amino acids: 1. Gly, Ser 2. Phe, Tyr 3. Leu, Val, Ile 4. Arg | All | | |
| | | 2 | 0 | 4 |
| | | Online | | |
| | | 0 | 0 | 0 |
| 10 - 11 | Metabolism of Sulfur-Containing Amino Acids and Tryptophan Biosynthesis of creatine phosphate and its physiological role. Metabolism of Met and Cys. Tryptophan metabolism: serotonin, kynurenine, and indole pathways. Regulation and pathology of amino acid metabolism. | All | | |
| | | 2 | 0 | 4 |
| | | Online | | |
| | | 0 | 0 | 0 |
| 12-15 | The Third Section | 6 | 0 | 14 |
| 12 - 13 | Metabolism of Chromoproteins Synthesis and degradation of hemoglobin. | All | | |
| | | 2 | 0 | 5 |
| | | Online | | |
| | | 0 | 0 | 0 |
| 13 - 14 | Metabolism of Nucleoproteins Synthesis and degradation of purine nucleotides. Role of xanthine oxidase. Synthesis and degradation of pyrimidine nucleotides. Regulation and integration of metabolism of different classes of biomolecules. | All | | |
| | | 2 | 0 | 5 |
| | | Online | | |
| | | 0 | 0 | 0 |
| 14 - 15 | Basics of Blood and Urine Biochemistry Main biochemical aspects of blood and urine. | All | | |
| | | 2 | 0 | 4 |
| | | Online | | |

| | | | | |
|--|--|---|---|---|
| | | 0 | 0 | 0 |
|--|--|---|---|---|

Abbreviated names of online options:

| Abbreviation | Full name |
|--------------|-----------------------|
| EC | E-course |
| FtM | Full-text material |
| FtL | Full-text lectures |
| VM | Video materials |
| AM | Audio materials |
| Prs | Presentations |
| T | Tests |
| ERM | E-reference materials |
| IS | Interactive site |

LABORATORY (LAB) SESSIONS TOPICS

| Weeks | Topics / Content |
|---------|---|
| | <i>3 Semester</i> |
| 2 - 3 | Color reactions for amino acids Biuret, ninhydrin, xanthoproteic, and Folin reactions |
| 3 - 4 | Protein concentration determination Construction of calibration curves and determination of protein concentration in solution |
| 8 - 9 | Enzyme activity determination Determination of alkaline phosphatase activity |
| 9 - 10 | Determination of amylase activity Study of activators and inhibitors of salivary amylase |
| 10 - 11 | Spectrophotometry Determination of NADH concentration in solution |
| 12 - 13 | Study of enzyme specificity toward carbohydrates Study of amylase substrate specificity |
| 14 - 15 | Determination of pyruvate in urine Pyruvate determination by spectrophotometric method |
| 15 - 16 | Effects of hormones on blood glucose levels Determination of glucose concentration by spectrophotometric method |
| | <i>4 Semester</i> |
| 2 - 3 | Determination of lipase activity Kinetics of lipase action |
| 4 - 5 | Study of phospholipids Determination of lecithin concentration in blood serum |
| 5 - 6 | Study of cholesterol Determination of cholesterol concentration in blood serum |
| 7 - 8 | Study of gastric juice Determination of gastric juice acidity |
| 8 - 9 | Transaminase determination Measurement of aspartate and alanine aminotransferase activities in blood serum |
| 10 - 11 | Urea and creatinine Quantitative determination of urea in urine; quantitative determination of creatinine in urine |
| 13 - 14 | Изучение пуринового обмена Determination of uric acid in urine |

6. EDUCATIONAL TECHNOLOGIES

The course employs the research-based learning method, a lecture–seminar credit system, and information and communication technologies.

7. ASSESSMENT TOOLKIT

The assessment toolkit ensures verification of the intended learning outcomes achievement (competency-based rubrics) using current, midterm and interim assessment of the course.

The link between developed competencies and their assessment is presented in the following table:

| Competency | Achievement rubrics | Assessment activity (Syl 1) | Assessment activity (Syl 2) |
|------------|---------------------|-----------------------------|--------------------------------------|
| ОПК-5 | 3-ОПК-5 | PFE, T-6, T-11, T-15, T-6 | Ex, T-6, T-11, T-15, T-6, T-11, T-15 |
| | У-ОПК-5 | PFE, T-6, T-11, T-15, T-11 | Ex, T-11 |
| | В-ОПК-5 | PFE, T-6, T-11 | Ex, T-15, T-11, T-15 |

Educational achievement rubrics scales

The scale of each assessment activity varies from 0 to the maximum established point, inclusive. The final assessment of the course is performed on a 100-point scale and represents the sum of the points earned by the student in the section assessments, framework of current and interim assessment.

Sections and interim assessments are considered passed when the student achieves a minimum score equal to 60% of the maximum. The final grade is assigned only upon passing all sections and the interim assessment.

The final grade is assigned in accordance with the following scale:

| Total score | Rating on a 4-point scale | Pass/fail examination | ECTS assessment |
|-------------|-----------------------------|-----------------------|-----------------|
| 90-100 | 5 – « <i>excellent</i> » | « <i>pass</i> » | A |
| 85-89 | 4 – « <i>good</i> » | | B |
| 75-84 | | | C |
| 70-74 | | | D |
| 65-69 | 3 – « <i>satisfactory</i> » | E | |
| 60-64 | | F | |
| below 60 | 2 – « <i>fail</i> » | « <i>fail</i> » | |

An “excellent” grade indicates a deep and solid mastery of the program material by a student who presents their answers consistently, clearly, and logically, is able to closely link theory with practice, and uses materials from monographic literature in their answers.

A “good” grade corresponds to a student’s solid knowledge of the material, who presents their answers competently and to the point, without any significant inaccuracies.

A “satisfactory” grade corresponds to the basic level of mastery of the material by the student, in which the main material has been mastered, but its details have not been assimilated, the answers contain inaccuracies, insufficiently correct wording and logical inconsistencies.

A grade “pass” corresponds to at least a basic level of mastery of the program material, in which the student possesses the necessary knowledge, skills, and abilities, and is able to apply theoretical principles to solve typical practical problems.

A grade “fail” is given to a student who lacks a significant understanding of the curriculum material, makes significant errors in their answers, or fails all required assignments. These students are generally unable to continue their studies without additional classes.

8. ACADEMIC COURSE EDUCATIONAL, METHODOLOGICAL AND INFORMATIONAL SUPPORT

CORE READING:

1. ЭИ Б63 Biochemistry with exercises and tasks : монография, Garin V.V., Glukhov A.I., Москва: ГЭОТАР-Медиа, 2020
2. ЭИ Е80 Essential Biochemistry for Medical Students with Problem-Solving Exercises : учебник, , Москва: ГЭОТАР-Медиа, 2020
3. ЭИ Б63 Биохимия с упражнениями и задачами : учебник, Глухов А.И., Северин Е.С., Москва: ГЭОТАР-Медиа, 2019
4. ЭИ Ф 76 Органическая химия и основы биохимии. Практикум : учебное пособие для вузов, Тарасенко Е. В., Фоминых В. Л., Денисова О. Н., Москва: Юрайт, 2022

FURTHER READING:

1. ЭИ В60 Biochemistry and Molecular Biology : , , Cham: Springer International Publishing, 2016
2. ЭИ В60 Biochemistry of Oxidative Stress : Physiopathology and Clinical Aspects, , Cham: Springer International Publishing, 2016
3. ЭИ G55 Biochemistry of the connective tissue. Biochemistry of mixed saliva : практическое руководство, Babchenko E.V., Glukhov A.I., Москва: ГЭОТАР-Медиа, 2019
4. ЭИ В 12 Биологическая химия. Биохимия полости рта : Министерство образования и науки РФ Рекомендовано ГБОУ ВПО "Первый Московский государственный медицинский университет имени И.М. Сеченова" в качестве учебника для студентов учреждений высшего профессионального образования, обучающихся по специальностям 060102 "Стоматология" и 060101 "Лечебное дело", Медведев А.Е., Вавилова Т.П., Moscow: ГЭОТАР-Медиа, 2016
5. ЭИ Б 63 Биохимия : Гриф УМО по медицинскому и фармацевтическому образованию вузов России., , Москва: ГЭОТАР-Медиа, 2012

SOFTWARE:

1. Microsoft Office 2016+ ()
2. Microsoft Word (K64-303)

LMS AND ONLINE RESOURCES

1. <https://themedicalbiochemistrypage.org> ()

<https://online.mephi.ru/>

<http://library.mephi.ru/>

9. LOGISTICAL SUPPORT

1. Биноклярные микроскопы "Микромед 2" (64-305)
2. Тринокулярный микроскоп "Микромед 3" (64-305)
3. Видеоокуляр ToprCam 10,0 MP (64-305)
4. Интерактивная доска SMART SBM 685 (64-405)
5. Мебель лабораторная, стулья, шкафы для хранения (64-405)
6. Мышь, клавиатура (64-405)
7. Персональный компьютер: Моноблок Lenovo V540-24IWL All-In-One 23,8" i3-8145U 8Gb 256GB_SSD_M.2 Intel (64-405)
8. Шкаф лабораторный вытяжной "Лабтех" ШВ202 (64-405)
9. Лабораторная посуда, приборы, реактивы (64-405)

10. EDUCATIONAL AND METHODOLOGICAL RECOMMENDATIONS FOR STUDENTS

solving tests, and working through situational problems. Working with academic literature is considered a form of coursework within the discipline and is carried out within the hours allotted for this activity. Each student is provided access to the departmental and university library collections.

Within the course Biochemistry, it is advisable to distinguish 13 sections and ensure a continuous flow of information in which each subsequent topic builds upon the informational foundation formed during the study of the previous topic.

Methodologically, practical classes consist of three interconnected structural components: communication with students, knowledge assessment, and students' independent work.

During interaction with students, the instructor evaluates their basic knowledge through questioning, uses additional teaching tools (films, computer presentations, study guides, etc.), and provides supplementary information. Each practical class involves analysis of theoretical material followed by students' independent work, such as solving situational problems and tests. After this, a current assessment of knowledge acquisition is conducted.

At the end of each section, a "milestone" assessment is carried out in the form of a test (multiple-choice tasks, oral and written assessment). Each semester concludes with a test, and at the

end of the third semester, a final examination is held. The examination consists of three stages: test-based assessment, an oral interview based on theoretical questions from the exam ticket, and evaluation of laboratory skills acquired during the course.

11. EDUCATIONAL AND METHODOLOGICAL RECOMMENDATIONS FOR TEACHERS

Grading scales and criteria for test papers, written assignments requiring extended answers, homework, and the final test:

1. Test papers are graded according to the scheme: 1 point = 1 correct answer. If the student did not attempt the assignment — (-1) point.

2. Written assignments with extended answers are graded according to the scheme: full answer — 2 points; partial answer — 1 point; no answer — 0 points; student did not attempt the assignment — (-2) points.

3. Homework must be completed by all students in order to be admitted to the final assessment. For late submission, points are deducted from the final score (-1 point).

4. Assessment Criteria for the Final Test / Examination

Author(s):

SHatova Olga Petrovna / Шатова Ольга Петровна /