DANYLO HALYTSKY LVIV NATIONAL MEDICAL UNIVERSITY

Biophysics Department

APPROVED
First Vice Rector on
Scientific and Pedagogical Work
Assoc. Prof. Iryna SOLONYNKO
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DISCIPLINE PROGRAM

MODERN PROBLEMS OF BIOPHYSICS

elective course, ВБ 1.27
Second (master's degree) level of higher education
Field of Knowledge 22 "Healthcare"
specialty 221 "Dentistry"

Discussed and approved
at the educational-methodical meeting
of the Biophysics department
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Head of the Biophysics department
Prof. Roman FAFULA

Approved
by the Profile Methodical Board
of the Faculty of Foreign Students
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Head of the Methodical Board
of the Faculty of Foreing Students
Assoc. Prof. Tetyana YESHCHENKO

AUTHORS OF THE ACADEMIC PROGRAM OF THE DISCIPLINE:

Fafula R.	Professor, Doctor of Biological Science, head of the Biophysics department of Danylo Halytsky Lviv National Medical University
Fedorovych Z.	PhD in Biology, Associate Professor of the Biophysics department of Danylo Halytsky Lviv National Medical University

REVIEWERS:

Vorobets Z.	Professor, Doctor of Biological Science, head of the Medical biology, parasitology and genetic department of Danylo Halytsky Lviv National Medical University
Boyko O.	Professor, Doctor of Technical Science, head of the Medical Informatics FPGE department of Danylo Halytsky Lviv National Medical University

INTRODUCTION

The academic program of the discipline
"Modern problems of biophysics"
according to the Higher Education Academic Standard of the second (Master's) level education sector 22 "Healthcare"
speciality 221 "Dentistry"
Education Program Master of Dentistry

The description of the discipline "Modern problems of biophysics"

The study of the discipline "Modern problems of biophysics" provides knowledge about the structure and physical properties of living systems at the molecular level, and modern research methods in medical science and practice. Thus, the main focus is on the study of the physical bases of the structural organization and functioning of biomolecules, which determines their biological functions, as well as modern diagnostic methods used in dentistry.

According to the curriculum, the discipline "Modern problems of biophysics" is studied in the first year of study. The discipline program is structured into 2 content modules as follows:

The content module 1. Fundamentals of molecular biophysics of cells and tissues.

In content module 1, the role of the water environment, intramolecular relationships, the physical basis of the structural organization and functioning of proteins, nucleic acids, membrane lipids, and methods of biopolymer research are studied.

The content module 2. Application of biophysical technologies in dental research.

In content module 2, biophysicists consider the basics of X-ray and magnetic resonance diagnostics and the application of laser technologies in dentistry.

Structure of the discipline	**Quantity of credits, hours, from them**				**Year of study**	**Form of the control**
	Total	**Auditory**		**ISW**		
		Lectures	Practical classes			
Name of the discipline: "Modern problems of biophysics" Content modules *2*	**3,5 credits / 105 hours**	**10**	**30**	**65**	**I course**	**Semester credit**

The subject of study of the discipline "Modern problems of biophysics" learns the physical properties of macromolecules, biophysical methods of cell research, the physical basis of methods of biomacromolecule research, and modern technologies

and systems that are based on the properties of X-rays, nuclear magnetic resonance, and induced radiation, on which image acquisition is based, which are applied in dental practice.

Interdisciplinary links:

integrates with the following disciplines:

- Medical and biological physics;
- Medical biology, parasitology, genetics;
- Medical chemistry;

lays the foundations for students to study such disciplines:

- Biological chemistry;
- Bioorganic chemistry;
- Physiology, including physiology of the masticatory apparatus;
- Hygiene and ecology;
- Radiology;
- Propaedeutics of therapeutic dentistry;
- Therapeutic dentistry.

1. Aim and objectives of the academic discipline.

1.1. The purpose of teaching the educational discipline "Modern problems of biophysics" is to acquaint students with modern problems of biophysics in the section of molecular biophysics and the latest achievements in the field of medical and biological physics, and prospects for its application in dentistry.

1.2. The main tasks of studying the discipline "Modern problems of biophysics" are study:

- elucidation of the physical mechanisms underlying the biological functions of biomacromolecules;
- determination of the main methods used to study the structure and activity of biomacromolecules;
- physical phenomena that are the basis of diagnostic and physiotherapeutic (treatment) methods used in dentistry.

1.3 **Competence and learning outcomes**, the formation of which is facilitated by discipline (the relationship with the normative content of higher education graduates' training, formulated in terms of learning outcomes of Higher Education Standard).

In accordance with the requirements of Higher Education Standard, discipline ensures students' acquisition of ***competences:***

– *general:*

GC 1 The ability for abstract thinking, analysis and synthesis.

GC 2 Knowledge and understanding of the subject area and understanding of the professional activities.

GC 3 The ability to apply knowledge in practical situations.

GC 4 The ability to communicate in the official language both orally and in writing.

GC 5 Ability to communicate in English.
GC 6 Skills of information and communication technologies application.
GC 7 The ability to search, work out and analyze information from various sources.
GC 9 Ability to identify, pose and solve problems.
GC 11 The ability to work as a team member.
GC 12 The desire to protect the environment.

- *special (professional):*

PC 2 Ability to interpret the results of laboratory and instrumental research.
PC 13 Ability to assess the impact of the environment on the health of the population (individual, family, population).

Details of the competencies are set out below in the competency matrix table.

The competency matrix

№	Competence	Knowledge	Skills	Communication	Autonomy and responsibility
1	2	3	4	5	6
General competence					
1	GC 1 Ability to abstract thinking, analysis and synthesis	Know methods of analysis, synthesis and further modern learning.	Be able to analyze information, make informed decisions, be able to acquire modern knowledge.	Establish appropriate links to achieve goals.	Be responsible for the timely acquisition of modern knowledge.
2	GC 2 Knowledge and understanding of the subject area and understanding of the profession.	Know structure of professional activity.	Be able carry out professional activities that require updating and integration of knowledge.	Ability to effectively form a communication strategy in professional activities.	Be responsible for professional development, the ability to further professional training with a high level of autonomy.
3	GC 3 Ability to apply knowledge in practical situations.	Know specialized conceptual knowledge.	Be able to solve complex problems and problems that arise in professional activities.	Clear and unambiguous communication of one's own conclusions, knowledge and explanations that substantiate them to specialists and nonspecialists.	Responsible for making decisions in difficult circumstances.

4	GC 4 Ability to communicate in the state language both orally and in writing	Have a perfect knowledge of the state language	Be able to apply knowledge of the state language, both orally and in writing.	Use the state language in professional and business communication and in the preparation of documents the state language.	Be responsible for the preparation of documents in the state language.
5	GC 5 Ability to communicate in English.	Have a basic knowledge of English.	Be able to apply knowledge of English.	Use English in professional activities.	Be responsible for the use of English in professional activities.
6	GC 6 Skills in the use of information and communication technologies;	Know: information and communication technologies used in professional activities.	Be able to: apply informa-tion and communication technologies in the professional field, which requires upda-ting and integration of knowledge.	Apply information and communi-cation technologies in professional activities.	Be responsible for the development of professional knowledge and skills.
7	GC 7 ability to search, process and analyze information from various sources.	Know the methods of information retrieval, processing and analysis	Be able to search, process and analyze information	Use different methods of information processing.	Be responsible for information management.
8	GC 9 Ability to identify, pose and solve problems.	Know the responsibilities and ways to accomplish the tasks.	Be able to set goals and objectives to be persistent and conscientious in the performance of duties.	Establish interpersonal relationships to effectively perform tasks and responsibilities.	Be responsible for the results of solving problems and scientific problems.
9	GC 11 Ability to work in a team	Know the tactics and strategies of communication, laws and ways of communicative behavior.	Be able to make informed decisions, choose ways and strategies of communication to ensure effective teamwork.	Use communication strategies and skills of interpersonal interaction.	Be responsible for effective teamwork

10	GC 12 The desire to preserve the environment.	Be able to form requirements for themselves and others to preserve the environment.	Know the problems of environmental conservation and ways to preserve it.	Make proposals to the relevant authorities and institutions on measures to preserve and protect the environment.	Be responsible for preserving the environment.
Special (professional) competence					
1	PC 2 Ability to interpret the results of laboratory and instrumental research.	To know the influence of physical factors on the human body, standard methods of laboratory and instrumental research.	Be able to analyze research results.	It is reasonable to choose and evaluate research results.	Be responsible for deciding on the evaluation of research results.
2	PC13 Assessment of the impact of the environment on the health of the population (individual, family, population).	Know: environmental factors that adversely affect public health.	Be able: assess the state of the environment and adverse health effects.	Set conclusions about the state of health of the population, based on data on the relationship with environmental factors.	Be responsible for correct conclusions about the negative impact of environmental factors.

Integrative program results outcomes for the formation of which contributes to the academic discipline.

PRO 14 Analyze and evaluate state, social and medical information using standard approaches and computer information technologies.

PRO 15 Assess the impact of the environment on the health of the population in a medical institution by standard methods.

PRO 17 Adhere to a healthy lifestyle, use the techniques of self-regulation and self-control.

PRO 20 Organize the necessary level of individual safety (own and persons cared for) in case of typical dangerous situations in the individual field of activity.

Learning outcomes for the discipline. As a result of studying “Modern problems of biophysics” the student has to

Know:

- general physical and biophysical regularities underlying the processes that occur in a biological object;
- the physical basis of biomacromolecule research methods;

- the essence of modern achievements, problems, and main trends in the field of modern biophysics and the possibilities of using these achievements in dentistry.

Be able to:
- to explain the physical foundations of modern methods of researching biological systems and visualization methods in medical diagnostics;
- analyze the informativeness of the considered methods and conduct a comparative analysis of their effectiveness;
- interpret experimental data of methods of analysis of biological objects, if they are obtained for known compounds;
- explain the principle of operation of medical equipment.

2. Informational content of the discipline

For discipline studying is given 3,5 credits ECTS 105 hours.

The program is structured in content modules:

The content module 1. Fundamentals of molecular biophysics of cells and tissues.

Topic.1 Biomacromolecules in solution.

The role of the water environment. Biological macromolecules in solution. Conformation of macromolecules. Intramolecular interactions in biological macromolecules. Hydrophobic interactions and water structure. The viscosity of solutions of biomacromolecules. Diffusion of macromolecules. Quasi-elastic scattering of light. Interaction between macromolecules in saline solution.

Topic 2. The main types of biomacromolecules.

Biophysics of proteins. The concept of enzyme catalysis. Effect of temperature on the rate of biochemical reactions. Biophysics of nucleic acids, their main purpose and biophysical function. Biophysics of lipids.

Topic 3. Biophysical methods of studying biopolymers.

Biophysical methods of biopolymer research. Electrophoresis of macromolecules. Sedimentation of macromolecules. Centrifugation. Chromatographic method: gel filtration. Dispersion of optical rotation and circular dichroism. Differential scanning microcalorimetry.

Biophysical methods of studying the structure of macroparticles. X-ray structural analysis. Molecular spectroscopy of macromolecules. Rheometry of nucleic acids and proteins.

The content module 2. Application of biophysical technologies in dental research.

Topic 4. Imaging methods in diagnostics and research of substances and biological tissues.

Biophysical bases of X-ray diagnostics. X-ray computed tomography (CT). Image reproduction in CT. The spatial resolution of CT. Three-dimensional image. A side effect of a CT scan.

Biophysical bases of magnetic resonance diagnostics. The phenomenon of nuclear magnetic resonance. Relaxation. Biophysical bases of magnetic resonance diagnostics. The concept of NMR spectroscopy. Magnetic resonance imaging: scanning and image reconstruction; MR image parameters. Diagnostic capabilities of NMR tomography.

Biophysical basis of laser diagnostics. Basic properties of laser radiation. High-power lasers and their interaction with biological tissues. Interaction of powerful lasers with biological tissues. The thermal effect of laser irradiation on biological tissues. Low power lasers. Cellular mechanisms of photobiomodulation. The reaction of cells to irradiation. Classification of lasers and safety requirements. Types of damage to biological tissues. Laser technologies in dentistry: laser-induced fluorescence; laser profilometry.

Other methods of radiation diagnostics (ionizing and non-ionizing) in dentistry.

3. Structure of the discipline

Topic	Lectures	Practical (seminar) classes	ISW	Personal tasks
The content module 1. Fundamentals of molecular biophysics of cells and tissues				
Topic.1 Biomacromolecules in solution.	2	3	26	–
Topic 2. The main types of biomacromolecules.	2	9	–	
Topic 3. Biophysical methods of studying biopolymers.	2	9	22	
Total content module 1	***6***	***21***	***48***	
The content module 2. Application of biophysical technologies in dental research.				
Topic 4. Imaging methods in diagnostics and research of substances and biological tissues.	4	9	17	–
Total content module 2	***4***	***9***	***17***	
Total hours 105 / 3.5 credits ECTS	**10**	**30**	**65**	
Final control				**Semester credit**

4. Thematic plan of lectures

№	TOPIC	Hours
1	Biological macromolecules in solutions.	2
2	Features of the main biological macromolecules structure.	2
3	Modern research methods for determining the structure of biomacromolecules.	2
4	Tomographic methods of radiation diagnostics.	2
5	Biophysical basis of application of laser technologies in dentistry.	2
	Total	**10**

5. Thematic plan of practical classes

№	TOPIC	Hours
1.	Fundamentals of molecular biophysics.	3
2.	Biophysics of proteins.	3
3.	Biophysics of nucleic acids.	3
4.	Biophysics of lipids.	3
5.	Sedimentation and electrophoresis of biological macromolecules.	3
6.	X-ray structural analysis of biological macromolecules.	3
7.	Molecular spectroscopy of macromolecules.	3
8.	Biophysical bases of X-ray diagnostics.	3
9.	Biophysical bases of magnetic resonance diagnostics.	3
10.	Biophysical basis of laser diagnostics in dentistry. Credit class.	3
	Total	30

6. Thematic plan of individual student's work

№	**TOPIC**	**Hours**	**Type of control**
1.	Objects of research in molecular biophysics.	7	Current control in practical classes
2.	Intermolecular interactions and forces stabilizing the structure of biological macromolecules.	7	
3.	Viscosity of solutions of biomacromolecules.	6	
4.	The main types of interactions form biological membranes.	6	
5.	The general theory of dispersion of optical rotation and circular dichroism.	7	
6.	Chromatographic method of biomacropolymers research.	8	
7.	The differential scanning microcalorimetry method	7	

	to study of biological polymers.		
8.	Physical principles of X-ray transmission computed tomography.	6	
9.	Laser microspectral analysis	6	
10.	Radiodiagnosis methods in dentistry.	5	
	Total	**65**	

7. Individual tasks are not implied by the academic program.

8. Teaching methods:

- verbal methods (lecture, conversation);
- visual methods (illustration, demonstration, frontal experiment);
- practical methods (laboratory work and solving problems with professional content);
- individual work of students on comprehension and mastering of material;
- using of computer control and educational programs in the discipline;
- using of the project method to ensure interdisciplinary integration.

9 Control methods

Types of control:

Current control is based on the control of theoretical knowledge, skills and abilities in practical classes. The student's independent work is assessed in practical classes and it is a part of the final assessment of the student.

Final control - semester credit - is a form of final control, which consists in evaluating the student's learning of the educational material solely on the basis of the results of his/her performance of certain types of work in practical, seminar, or laboratory classes.

Assessment of current student performance is carried out at each practical (laboratory) lesson on a 4-point scale and is entered in the journal of academic performance. Students' knowledge is assessed from both theoretical and practical training according to the following **criteria**:

- 5 / “excellent” - the student has mastered the theoretical material, demonstrates deep and comprehensive knowledge of the topic or discipline, the main provisions of scientific sources and recommended literature, logically thinks and builds the answer, freely uses the acquired theoretical knowledge in analyzing practical material, expresses his/her attitude to certain problems, demonstrates a high level of mastery of practical skills;

- 4 / “good” - the student has mastered the theoretical material, has the basic aspects of primary sources and recommended literature, studied it; has practical skills, expresses his/her views on certain issues, but assumes certain inaccuracies and errors in the logic of the presentation of theoretical content or in the implementation of practical skills;

- 3 / "satisfactory" - the student has mainly mastered the theoretical knowledge of the subject or discipline, it is guided by primary sources and recommended

literature, but unconvincingly answers, confuses concepts, additional questions cause the student uncertainty or lack of stable knowledge; answering questions of a practical nature, reveals inaccuracies in knowledge, is unable to assess facts and phenomena, relate them to future activities, makes mistakes in the implementation of practical skills;

- 2 / "unsatisfactory" - the student has not mastered the study material of the topic (discipline), does not know the scientific facts, definitions, almost does not navigate in the original sources and recommended literature, no scientific thinking, practical skills are not formed.

10. Current control is carried out during training sessions and aims to verify the assimilation of students' learning material.

The form of current control during training sessions is determined by the academic program of the discipline.

Forms of current control are:

1) oral examination (frontal, individual, combined).
2) practical verification of the formed professional skills.
3) test control (open and closed test tasks).

10.1. Evaluation of current educational activities. During the assessment of mastering each topic for the current educational activity of the student grades are set on a 4-point (national) scale. This considers all types of work provided by the discipline program. The current control of the results of the tasks of independent work is carried out during the current control of the topic in the relevant lesson. The student must receive a grade from each topic for further conversion of grades into points on a multi-point (200-point) scale.

11. Form of final control of learning success according to the curriculum is a semester credit.

Semester credit for the discipline is carried out after the end of its study, before the beginning of the examination session. The credit is given to teachers who conducted practicals, seminars, and other classes in the study group. Semester assessment does not require students to be present.

12. The scheme of calculation and distribution of points that are received by students:

The maximum number of points that a student can score for the current educational activity while studying the discipline is 200 points.

The minimum number of points that a student must score for the current educational activity in order to enroll in the discipline is 120 points.

The calculation of the number of points is made on the basis of the collected student’s marks on the traditional scale during the discipline study, by calculating the arithmetic mean (AM or average), rounded to two decimal places. The obtained value is converted into points according to the scoring scale as follows:

$$x = \frac{CA \times 20_0}{5}$$

Recalculation of the average score for the current activity in multipoint scale for disciplines ending in credit

4-point scale	200-point scale	4-point scale	200-point scale	4-point scale	200-point scale	4-point scale	200-point scale
5	200	4.45	178	3.92	157	3.37	135
4.97	199	4.42	177	3.89	156	3.35	134
4.95	198	4.4	176	3.87	155	3.32	133
4.92	197	4.37	175	3.84	154	3.3	132
4.9	196	4.35	174	3.82	153	3.27	131
4.87	195	4.32	173	3.79	152	3.25	130
4.85	194	4.3	172	3.77	151	3.22	129
4.82	193	4.27	171	3.74	150	3.2	128
4.8	192	4.24	170	3.72	149	3.17	127
4.77	191	4.22	169	3.7	148	3.15	126
4.75	190	4.19	168	3.67	147	3.12	125
4.72	189	4.17	167	3.65	146	3.1	124
4.7	188	4.14	166	3.62	145	3.07	123
4.67	187	4.12	165	3.57	143	3.02	121
4.65	186	4.09	164	3.55	142	3	120
4.62	185	4.07	163	3.52	141	Less than 3	Insuffi-ciently
4.6	184	4.04	162	3.5	140		
4.57	183	4.02	161	3.47	139		
4.52	181	3.99	160	3.45	138		
4.5	180	3.97	159	3.42	137		
4.47	179	3.94	158	3.4	136		

Students' independent work is assessed during the current control of the topic in the relevant lesson. Assimilation of topics that are submitted only for the independent work is controlled during the final control (the control task).

Students receive a semester credit if the average grade for the current academic performance during the semester is at least “3” (120 points on a 200-point scale).

The scores from discipline are converted to the ECTS scale and to the 4-point scale independently. The ECTS scale points are not converted to the 4-point scale and vice versa. Amount of points which is charged to students, from the discipline is converted in scale ECTS thus:

Estimation ECTS	Statistics
A	The best 10 % of students
B	The following 25 % of students
C	The following 30 % of students
D	The following 25 % of students
E	The last10 % of students

"A", "B", "C", "D", "E" ranking is made for students studying at one of the specialties and who have successfully completed study course.

Students who receive grades FX, F ("2") are not included in the list of students ranked. Students with an FX grade automatically receive an "E" score after retaking.

Points of discipline for students who have successfully completed the program are converted into traditional 4-point scale by absolute criteria, which are listed in the following table:

Points from discipline Estimation on 4-point scale	Points from discipline Estimation on 4-point scale
From170 to 200 points	5
From140 to 169 points	4
From 139 points to the minimum number of points that student must scores	3
Less than minimal quantity of points, which student must collect	2

The ECTS score is not converted to the traditional scale, as the ECTS scale and the four-point scale are independent. The objectivity of the assessment of students' learning activities is checked by statistical methods (correlation coefficient between ECTS assessment and assessment on a national scale).

13. Methodological support

- Academic program from the discipline.
- Lecture thesis from the discipline.
- Lecture presentations.
- Methodical recommendations for teachers.
- Methodical recommendations for practical classes for students.
- Methodical manual for student's independent work.
- Test and control tasks for practical classes.

14. Recommended literature

1. Basic:

1. Chalyi A.V., Tsekhmister Ya.V., Agapov B.T. Medical and Biological Physics: textbook for the students of higher medical institutions of the IV accreditation level. / A.V. Chalyi, Ya.V. Tsekhmister, B.T. Agapov – Vinnytsia, Nova Knyha, 2010. – 480 p.
2. Hobie R.K., Roth B.J. Intermediate Physics for Medicine and Biology. / R.K. Hobie, B.J. Roth. – Springer, 2007. – 616 p.
3. Medical and Biological Physics: Laboratory Manual for students of higher medical institutions of the IV accreditation level // Lychkovsky E., Fafula R., Fedorovych Z., Makar N., Odnorih L. – Lviv, Danylo Halytsky Lviv National Medical University, 2014. – 300 p.
4. Cotterill R. Biophysics. An introduction. J. Wiley & Sons, 2002. – 396 p.
5. Davidovits P. Physics in biology and medicine. 5-th ed. – Amsterdam: Elsevier Academic Press, 2019. – 377 p.

2. Additional:

1. Medical and biological physics. Practicum for students studying the subject in English / V. M. Trusova et al. - Kharkiv: V. N. Karazin Kharkiv nat. univ., 2018. - 123 p.
2. Newman J. Physics of the Life Sciences. – Springer, 2008. – 718 p.
3. Herman I.P. Physics of the Human Body. – Springer, 2008. – 860 p.
4. Glaser R. Biophysics an introduction. 2-nd ed. – Berlin: Springer, 2012. - 407 p.
5. Hille B. Ionic Channels of Excitable Membranes. Sinauer Associates inc. Sunderland, 2004 - 816 p.

15. Informational resources:

1. http://misa.meduniv.lviv.ua/
2. https://pubmed.ncbi.nlm.nih.gov/ (Electronic database of medical and biological publications in English)
3. http://iomp.org/ (International Organization of Medical Physics)
4. http://aapm.org/default.asp (Website of the American Association of Physicists in Medicine)
5. http://scitation.aip.org/content/aapm/journal/medphys (Medical Physics Journal)