

# SYLLABUS

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INTERNATIONAL EUROPEAN  
UNIVERSITY



SCHOOL OF  
MEDICINE

Biological and bioorganic chemistry

2021



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## Discipline

 Biological and bioorganic chemistry

## Lecturer

 Koval Svitlana,  
senior lecturer at the department of Fundamental disciplines

## Lecturer's profile


 <https://medicine.ieu.edu.ua/pro-yemsh/kafedry/kafedra-fundamentalnykh-dystsyplin>

## Consultations:

On-campus consultations

 the second Thursday of the month from 15:00 to 16:00

Online consultations

 the third Friday of the month from 15:00 to 16:00

## Контактний телефон

 +380997338153

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 [svitlanakoval@ieu.edu.ua](mailto:svitlanakoval@ieu.edu.ua)

## Discipline page

 <https://dist.ieu.edu.ua/user/preferences.php?userid=26&course=1>

## Form of final control

final test	диференційований залік	exam
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## 1 Brief discipline annotation

"Biological and bioorganic chemistry" lays the foundation for the further formation of the following program learning outcomes in accordance with the Standard of Higher Education of Ukraine undergraduate training of specialists of the second (master's) level of the specialty "Medicine".

## 2 Background for studying discipline

The discipline is based on previously studied by students in secondary school such subjects as "Chemistry", "General Biology", "Human Biology". "Biological and bioorganic chemistry" lays the foundations for the study of medical biology, biophysics, medical chemistry (bioinorganic, physical chemistry), morphological disciplines and integrates with these disciplines; lays the foundations for students to study molecular biology, genetics, physiology, pathology, general and molecular pharmacology, toxicology and propaedeutics of clinical disciplines.

## 3 Goal and objectives of the discipline

The purpose of teaching the discipline "Biological and Bioorganic Chemistry" is to study biomolecules and molecular organization of cell structures, general patterns of enzymatic catalysis and biochemical dynamics of transformation of major classes of biomolecules (amino acids, carbohydrates, lipids, nucleotides, porphyrins, etc.), molecular biology and genetics of information macromolecules (proteins and nucleic acids), ie molecular mechanisms of heredity and realization of genetic information, hormonal regulation of metabolism and biological functions of cells, biochemistry of special physiological functions.

## 4 Learning outcomes

**As a result of studying the discipline "Biological and Bioorganic Chemistry" the student must:**  
**Know:**

- classification of bioorganic compounds according to the structure of the carbon skeleton and the properties of the functional national groups
- classes of bioorganic compounds according to the properties of their functional groups
- biological role of basic organic compounds
- structure and properties of alcohols, phenols, aldehydes and ketones, carboxylic acids, lipids, aminoacids, peptides and proteins
- basic heterocyclic compounds
- structure of nucleosides, nucleotides and nucleic acids

**Be able:**

- Distinguish classes of bioorganic compounds by their functional groups;
- Write formulas for classes of bioorganic compounds by their functional groups
- laboratory research and detection of certain classes of biological compounds according to their properties functional groups
- to carry out qualitative chemical reactions on separate organic compounds
- to predict the properties of their functional groups according to the formulas of bioorganic compounds;
- Detect the aldehyde group by qualitative reactions of Tromer, Tolens
- Detection of glucose by qualitative reactions
- Carry out a qualitative reaction on starch with iodine
- Carry out qualitative reactions to amino acids and proteins



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## 4 Learning outcomes

### Master the skills:

- Detection of glucose by qualitative reactions
- Carrying out a qualitative reaction on starch
- Qualitative reactions to amino acids and proteins

## 5 ECTS credits

The discipline "Biological and Bioorganic Chemistry" contains 8.0 ECTS credits

## 6 Discipline structure

Topics	Types of classes / hours		
	Lectures	Seminars	Individual practical training/ work laboratory
<b>Section 1. Biologically important classes of bioorganic compounds. Biopolymers and their structural components.</b>			
<b><i>Sub- section 1. Theoretical base of the structure and reactivity of bioorganic compounds</i></b>			
Theme 1. Classification, nomenclature and isomerism of bioorganic compounds. The nature of the chemical bond.	0,5	1,5	4,0
Theme 2. Classification of the chemical reactions. Reactivity of alkanes, alkenes, arenes.	0,25	1,5	3,25
Theme 3. The reactivity of alcohols, phenols, amines.	0,25	1,5	3,75
Theme 4. Structure and chemical properties of aldehydes, ketones.	0,25	1,5	3,75
Theme 5. Structure, properties and biological significance of carboxylic acids and their functional derivatives.	0,25	1,5	5,25
Theme 6. Fatty acids. Lipids. Phospholipids.	0,25	1,5	4,25
Theme 7. Structure, reactivity and biological importance of heterofunctional compounds ( $\alpha$ -, $\beta$ -, $\gamma$ -hydroxy acids, keto acids and phenolic acids).	0,25	3,0	3,75
<i>Total</i>	<i>2,0</i>	<i>12,0</i>	<i>28,0</i>
<b><i>Sub- section 2. Structure and biological functions of carbohydrates.</i></b>			
Theme 8. Carbohydrates. The structure and chemical properties of monosaccharides.	0,5	1,0	2,0



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## Discipline structure

Topics	Types of classes / hours		
	Lectures	Seminars	Individual practical training/ work laboratory
Theme 9. Structure and function disaccharides and polysaccharides.	0,5	1,0	4,0
<i>Total</i>	<i>1,0</i>	<i>2,0</i>	<i>6,0</i>
<b><i>Sub- section 3. Biologically active heterocyclic compounds</i></b>			
Theme 10. Classification, structure and value of biologically important heterocyclic compounds.	0,5	3,0	4,5
Theme 11. Structure and biochemical features of nucleosides and nucleotides.	1,0	3,0	1,0
Theme 12. Structure and biological role of nucleic acids.	0,5	3,0	2,5
<i>Total</i>	<i>2,0</i>	<i>9,0</i>	<i>8,0</i>
<b><i>Sub- section 4. <math>\alpha</math>-Amino acids, peptides, proteins.</i></b>			
Theme 13. Amino acid composition of proteins and peptides. Structural organization of proteins.	1,0	3,0	4,0
Theme 14. Physico-chemical properties of proteins. Precipitation reactions. Denaturation.	1,0	3,0	4,0
<i>Total</i>	<i>2,0</i>	<i>6,0</i>	<i>8,0</i>
<b><i>Total for section 1</i></b>	<b><i>8,0</i></b>	<b><i>32,0</i></b>	<b><i>50,0</i></b>
<b>Section 2. General metabolic patterns. The metabolism of carbohydrates, lipids, proteins, and its regulation</b>			
<b><i>Sub- section 5. The role of enzymes and vitamins in metabolism</i></b>			
Theme 15. Subject and tasks of biochemistry. The study of the structure and physico-chemical properties of proteins. Quantitative protein determination by biuret method. Proof of protein nature of enzymes.		3,0	3,0
Theme 16. Study of the structure and physicochemical properties of enzymes.	1,0	3,0	
Theme 17. Determination of enzyme activity, the study of the kinetics of enzymatic catalysis and the effect of activators and inhibitors.	1,0	3,0	
Theme 18. Investigation of the role of cofactors and coenzyme forms of vitamins in the catalytic activity of enzymes.	1,0	1,5	1,5



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## Discipline structure

Topics	Types of classes / hours		
	Lectures	Seminars	Individual practical training/ work laboratory
Theme 19. Study involved vitamins and coenzyme forms of vitamins in different biochemical processes.	1,0	1,5	0,5
<i>Total</i>	4,0	12,0	5,0
<b><i>Sub- section 6. Metabolism and energy exchange.</i></b>			
Theme 20. Study of oxidative phosphorylation and ATP synthesis; inhibitors and separators of oxidative phosphorylation.	1,0	1,5	2,5
Theme 21. Metabolism and energy exchange. Research of functioning of the citric acid cycle.	1,0	1,5	2,5
<i>Total</i>	2,0	3,0	5,0
<b><i>Sub- section 7. Metabolism of carbohydrates and its regulation</i></b>			
Theme 22. Investigation of the features of carbohydrate digestion. Biosynthesis and catabolism of glycogen. Transformation of other monosaccharides into glucose.	1,0	3,0	2,0
Theme 23. Investigation of the anaerobic oxidation of glucose. Biosynthesis of glucose - gluconeogenesis.	0,5	3,0	2,5
Theme 24. Study of aerobic glucose oxidation. Pentose phosphate pathway of glucose conversion.	0,5	3,0	4,5
<i>Total</i>	2,0	9,0	9,0
<b><i>Sub- section e 8. Lipid metabolism and its regulation</i></b>			
Theme 25. Structure and function of cell membranes.	1,0	1,5	1,5
Theme 26. Investigation of the features of lipid digestion. Violation of digestion of lipids and transport exogenous lipids in the blood.	1,0	1,5	1,5
Theme 27. Study of exchange of fatty acids and ketone bodies. Beta-oxidation of fatty acids. Biosynthesis and biotransformation of cholesterol.	1,0	1,5	4,0
Theme 28. Study of the biosynthesis of fatty acids, triacylglycerols and phosphoglycerides. Disorders of lipid metabolism: obesity and fatty infiltration of liver.	1,0	1,5	4,0
<i>Total</i>	4,0	6,0	11,0



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## Discipline structure

Topics	Types of classes / hours		
	Lectures	Seminars	Individual practical training/ work laboratory
<b><i>Sub- section 9. Metabolism of amino acids. Enzymopathies of amino acid metabolism.</i></b>			
Theme 29. Investigation of chemical composition of gastric juice. Features of protein digestion.	1,0	0,5	2,5
Theme 30. Investigation of amino acid transformations (transamination, deamination, decarboxylation).	1,0	0,5	3,5
Theme 31. Investigation of ammonia detoxification and biosynthesis of urea.	1,0	0,5	2,5
Theme 32. Specialized ways of exchange of individual amino acids. Biosynthesis of creatine. Violation of amino acid metabolism.	1,0	0,5	3,5
<i>Total</i>	4,0	2,0	12,0
<b><i>Total for section 2</i></b>	<b>16,0</b>	<b>32,0</b>	<b>42,0</b>
<b>Section 3. Molecular biology. Biochemistry of intercellular communication. Biochemistry of tissues and physiological functions.</b>			
<b><i>Sub- section 10. Basics of molecular biology.</i></b>			
Theme 33. Study of the biosynthesis and catabolism of purine nucleotides. Determination of the end products of their metabolism.		3,0	2,0
Theme 34. Study of pyrimidine nucleotide metabolism. Study of nucleic acids composition.		3,0	2,0
Theme 35. Study of DNA replication. Analysis of DNA mutations and repair mechanisms.		1,5	2,0
Theme 36. RNA transcription. Protein biosynthesis in ribosomes. Stages and mechanism of translation, the regulation of translation. Antibiotics are inhibitors of transcription and translation.		1,5	2,0
<i>Разом</i>		9,0	8,0
<b><i>Sub- section 11. Molecular mechanisms of action of hormones on target cells and the biochemistry of hormone regulation</i></b>			
Theme 37. Study of molecular-cellular mechanisms of action of hormones on the target cell. The hormones of the pituitary and hypothalamus.		1,5	1,0



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## 6 Discipline structure

Topics	Types of classes / hours		
	Lectures	Seminars	Individual practical training/ work laboratory
Theme 38. Investigation of the effects of pancreatic hormones and hormones of gastrointestinal tract. The mechanism of metabolic disorders in diabetes mellitus.		1,5	1,0
Theme 39. Hormonal regulation of blood glucose levels. Construction of sugar curves. Adrenal hormones.		1,5	1,0
Theme 40. Hormonal regulation of calcium metabolism. Investigation of iodine in the thyroid gland. Physiologically active eicosanoids.		1,5	1,0
Theme 41. Steroid hormones of sex glands. Hormonal regulation of biochemical transformations of substances during nutrition. Regulation of the metabolism during starvation.		1,5	2,0
Theme 42. Relationship of all types of metabolism and its regulation.		1,5	2,0
<i>Total</i>		9,0	8,0

### ***Sub- section 12. Biochemistry and pathobiochemistry of blood.***

Theme 43. Investigation of the chemical composition and acid-base state of the blood. Determination of blood residual nitrogen.		1,5	3,0
Theme 44. Investigation of coagulation, anticoagulant and fibrinolytic blood systems.		1,5	1,0
Theme 45. Investigation of the chemical composition of erythrocytes. Normal and abnormal forms of hemoglobin. Investigation of end products of heme catabolism. Pathobiochemistry of jaundice.		3,0	2,0
<i>Total</i>		6,0	6,0

### ***Sub- section 13. Biochemistry of tissues and organs.***

Theme 46. Biochemistry of liver. Microsomal oxidation, cytochrome P-450.		1,0	0,5
Theme 47. Investigation of types of biological oxidation. The role of fat-soluble vitamins in the functioning of tissues and organs.		1,0	0,5





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6	Discipline structure	Types of classes / hours		
		Lectures	Seminars	Individual practical training/ work laboratory
	Theme 48. Investigation of normal and abnormal urine components.		1,0	1,0
	Theme 49. Biochemistry of connective tissue.		3,0	2,0
	Theme 50. Biochemistry of nervous tissue.		2,0	2,0
	<i>Total</i>		8,0	6,0
	<b><i>Total for section 3</i></b>		32,0	28,0
	<b>Total</b>	24,0	96,0	120,0

7	Obligatory tasks
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## **Section 1. Biologically important classes of bioorganic compounds. Biopolymers and their structural components.**

Classification, nomenclature and isomerism of bioorganic compounds. The nature of the chemical bond. Classification of the chemical reactions. Reactivity of alkanes, alkenes, arenes. The reactivity of alcohols, phenols, amines. Structure and chemical properties of aldehydes, ketones. Structure, properties and biological significance of carboxylic acids and their functional derivatives. Fatty acids. Lipids. Phospholipids. Structure, reactivity and biological importance of heterofunctional compounds ( $\alpha$ -,  $\beta$ -,  $\gamma$ -hydroxy acids, keto acids and phenolic acids). Carbohydrates. The structure and chemical properties of monosaccharides. Structure and function disaccharides and polysaccharides. Classification, structure and value of biologically important heterocyclic compounds. Structure and biochemical features of nucleosides and nucleotides. Structure and biological role of nucleic acids. Amino acid composition of proteins and peptides. Structural organization of proteins. Physico-chemical properties of proteins. Precipitation reactions. Denaturation.

## **Section 2. General metabolic patterns. The metabolism of carbohydrates, lipids, proteins, and its regulation**

Subject and tasks of biochemistry. The study of the structure and physico-chemical properties of proteins. Quantitative protein determination by biuret method. Proof of protein nature of enzymes. Study of the structure and physicochemical properties of enzymes. Determination of enzyme activity, the study of the kinetics of enzymatic catalysis and the effect of activators and inhibitors. Investigation of the role of cofactors and coenzyme forms of vitamins in the catalytic activity of enzymes. Study involved vitamins and coenzyme forms of vitamins in different biochemical processes. Study of oxidative phosphorylation and ATP synthesis; inhibitors and separators of oxidative phosphorylation. Metabolism and energy exchange. Research of functioning of the citric acid cycle. Investigation of the features of carbohydrate digestion. Biosynthesis and catabolism of glycogen. Transformation of other monosaccharides into glucose. Investigation of the anaerobic oxidation of glucose. Biosynthesis of glucose - gluconeogenesis. Study of aerobic glucose oxidation. Pentose phosphate pathway of glucose conversion.



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## Obligatory tasks

Structure and function of cell membranes. Investigation of the features of lipid digestion. Violation of digestion of lipids and transport exogenous lipids in the blood.

Study of exchange of fatty acids and ketone bodies. Beta-oxidation of fatty acids. Biosynthesis and biotransformation of cholesterol. Study of the biosynthesis of fatty acids, triacylglycerols and phosphoglycerides. Disorders of lipid metabolism: obesity and fatty infiltration of liver.

Investigation of chemical composition of gastric juice. Features of protein digestion. Investigation of amino acid transformations (transamination, deamination, decarboxylation). Investigation of ammonia detoxification and biosynthesis of urea. Specialized ways of exchange of individual amino acids.

Biosynthesis of creatine. Violation of amino acid metabolism.

### **Section 3. Molecular biology. Biochemistry of intercellular communication. Biochemistry of tissues and physiological functions.**

Study of the biosynthesis and catabolism of purine nucleotides. Determination of the end products of their metabolism.

Study of pyrimidine nucleotide metabolism. Study of nucleic acids composition.

Study of DNA replication. Analysis of DNA mutations and repair mechanisms.

RNA transcription. Protein biosynthesis in ribosomes. Stages and mechanism of translation, the regulation of translation. Antibiotics are inhibitors of transcription and translation.

Study of molecular-cellular mechanisms of action of hormones on the target cell. The hormones of the pituitary and hypothalamus. Investigation of the effects of pancreatic hormones and hormones of gastrointestinal tract. The mechanism of metabolic disorders in diabetes mellitus.

Hormonal regulation of blood glucose levels. Construction of sugar curves. Adrenal hormones. Hormonal regulation of blood glucose levels. Construction of sugar curves. Adrenal hormones. Hormonal regulation of calcium metabolism. Investigation of iodine in the thyroid gland. Physiologically active eicosanoids.

Steroid hormones of sex glands. Hormonal regulation of biochemical transformations of substances during nutrition. Regulation of the metabolism during starvation. Relationship of all types of metabolism and its regulation.

Investigation of the chemical composition and acid-base state of the blood. Determination of blood residual nitrogen. Investigation of coagulation, anticoagulant and fibrinolytic blood systems.

Investigation of the chemical composition of erythrocytes. Normal and abnormal forms of hemoglobin.

Investigation of end products of heme catabolism. Pathobiochemistry of jaundice.

Biochemistry of liver. Microsomal oxidation, cytochrome P-450. Investigation of types of biological oxidation. The role of fat-soluble vitamins in the functioning of tissues and organs. Investigation of normal and abnormal urine components.

Biochemistry of connective tissue.

Biochemistry of nervous tissue.

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## Selective tasks

Creating multimedia presentations on the topics of practical classes

Creating chemical crossword puzzles on the topics of practical classes

Making tables

Participation in the work of the student scientific circle

Participation in the student olympiad in the discipline

Participation in student scientific - practical conferences

Organization and visiting of thematic museums

Publication of abstracts of scientific conference reports in co-authorship with the teacher

In addition to the student's academic rating, 12 points are added for the performance of selective tasks



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## 9 Discipline features

Period of teaching	Semester	International discipline integration	Year of study	Courses: general training/ professional training/ elective
1,5 year	4	available	1 and 2 course	vocational training

## 10 Assessment system and requirements

Current student performance is assessed according to the 4-point scale (2; 3; 4; 5) during every practical class given the approved assessment criteria for a corresponding discipline. Students should obtain a grade in each topic for further conversion of grades into scores due to the multi-point (200-point) scale.

Assessment criteria of current learning activities:

Excellent (5) – students answer correctly to 90-100% of A-format tests (from the Krok-2 database); solve case problems and can generalize the material.

Good (4) – students answer correctly to 70-89% of A-format tests; have necessary practical skills and techniques of their performance in the volume exceeding the required minimum.

Satisfactory (3) – students answer correctly to 50-69% of A-format tests; have an obligatory minimum of research methods.

Failure (2) – students answer correctly to 50% of A-format tests, make significant, serious mistakes while answering and showing practical skills.

Students' individual work related to preparations for practical classroom activities is assessed during current control of a topic during a corresponding class.

A semester test is assessed due to the two-point scale (pass/fail) and 200-point scale by defining the arithmetic average of current grades for each practical class due to the 4-point scale and by its further conversion into scores of the 200-point scale. Minimum amount of scores that should be obtained by students: 120.

The final control of knowledge in the ophthalmology discipline is conducted in the form of grading test.

The grading test is conducted in the form of oral questioning according to grading test questions.

<https://ieu.edu.ua/docs/rate-of-study.pdf>

## 11 Admission to final control

Students who accomplish all types of works, tasks prescribed by the curriculum for the semester according to the academic discipline, answer during all classes stipulated by the curriculum, prepare a medical report and have the average grade of at least 3 (72 scores according to the 120-point scale) for current learning activities are admitted to the semester final control.

<https://ieu.edu.ua/docs/rate-of-study.pdf>

## 12 Discipline policy

To achieve the goals of training and successfully complete the course, it is necessary from the first day to be actively involved in work, regularly attend lectures, prepare for practical classes, do not be late and do not miss classes, come to class dressed in a medical gown, perform all necessary tasks and work daily over self-improvement, be able to work with a partner or in a group, seek help and receive it when you need it.

### For students:

- exclude the possibility of using a mobile phone, tablet or other mobile devices during classes, copying and plagiarism;



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## 12 Discipline policy

- when studying the discipline to adhere to the cooperation and solidarity of teachers and students;
- apply to the teacher for help in organizing and consulting on scientific, exploratory and research work;
- take part in scientific circles;
- topics of the discipline are considered in terms of their practical application and bioethical capacity;
- to be in medical gowns during classes.

For teachers:

- implementation of the curriculum is mandatory;
- delays in lectures, practical (seminar) classes are not allowed;
- discipline policy provides for an objective assessment of knowledge and skills;
- any manifestations of corruption are prohibited;
- the teacher must follow the chemical classrooms;
- pay special attention to students in practical classes when working with chemical equipment and reagents;
- prejudice and discrimination regardless of race, ethnicity and religion are not allowed.

## 13 Policy of absence and late task performance

Students who miss current control for valid reasons confirmed by documents have the right to take current control within two weeks after returning to studying.

Students who have missed classes without valid reasons, have not participated in current control activities, have not liquidated academic failure are not admitted to final semester control of this discipline. In this case, an academic staff member puts a mark 'non-admission' in the exam record.

Repeated taking of the grading exam of the discipline is appointed in case of accomplishing all types of educational, individual work stipulated by the working program of the academic discipline and is carried out according to the approved schedule of academic failure liquidation.

<https://ie.u.edu.ua/docs/050.pdf>

## 14 Academic integrity policy

Participants of the educational process rely on the academic integrity principles

<https://ie.u.edu.ua/docs/011.pdf>

## 15 Recommended sources of information

### Basic literature

1. Biological and bioorganic chemistry: in 2 books: textbook. Book 1. Biological chemistry / BS Zimenkovsky, VA Музиченко, I.B. Nizhenkovskaya, G.O. Raw; for order. B.S. Zimenkovsky, IV Nizhenkovskaya. - 2nd ed., Ed. - K.: ВСВ «Медицина», 2017. - 272с.
2. Biological and bioorganic chemistry: in 2 books: textbook. Book 2. Biological chemistry / YI Gubsky, IV Nizhenkovskaya, MM Korda and others; for order. Yu.I. Gubsky, IV Nizhenkovskaya - 3rd ed. - K.: VSV "Medicine", 2021. - 544p.
3. Bioorganic Chemistry: textbook / Yu. Gubskiy. - 2nd ed. - Vinnytsia: Nova Knyha, 2019 / - 224p.
4. Biological chemistry = Biological chemistry: textbook / edited by Yu. Gubsky. - 3rd edition. - Vinnytsia: Nova Knyha, 2020. - 488p.

### Supporting literature

1. Biochemistry: a textbook / edited by prof. AL Zagayka, prof. KV Alexandrova - H.: Publishing House "Fort". - 2014. - 728 p.



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## Recommended sources of information

2. Biological and bioorganic chemistry: in 2 books: textbook. Book 1. Bioorganic chemistry (university IV year) / ed. B.S. Zimenkovsky, IV Nizhenkovskaya. - Ed. : WWII "Medicine". - 2014. - 272 p.
3. Gonsky YI, Maksimchuk TP, Kalinsky MI Human biochemistry. Textbook. - Ternopil: Ukrmedknyha. - 2013. - 744 p.
4. Biological and bioorganic chemistry [Text]: textbook. way. for students. higher textbook lock / O.O. Mardashko, LM Mironovich, GF Stepanov. - O. : Odessa Medical University. - 2011. - 235 p.
5. Functional biochemistry: a textbook for students. higher farm. textbook lock IV level of accreditation / AL Zagayko [etc.]. - Kharkiv. : НФаУ. - 2010. - 219 p.
6. Role of science and education for sustainable development: Collective monograph / Edited by Magdalena Wierzbik-Strońska and Iryna Ostopolets / Publishing House of University of Technology. - Katowice, 2021 –p.168-176
7. Bobrova MS, Kholodaieva OA, Koval S.Yu., Tsviakh OO, Kucher OO. The effect of hypothermia on the state of the prooxidant-antioxidant system of plants // REVISTA DE LA UNIVERSIDAD DEL ZULIA. 3rd epoch. Año 12 N ° 33, 2021. DOI: <http://dx.doi.org/10.46925//rdluz.33.07> (Web of Science, Italy, article in English)

### Information resources:

1. <http://guides.lib.vt.edu/oer/chemistry> - Books on chemistry.
2. [www.ncbi.nlm.nih.gov/PubMed](http://www.ncbi.nlm.nih.gov/PubMed) - free access to the database of scientific data in the field of biomedical sciences.
3. <https://pubchem.ncbi.nlm.nih.gov/> - free access to the database of scientific data in the field of biomedical sciences.
4. [www.biochemistry.org.ua](http://www.biochemistry.org.ua) - the official site of the Institute of Biochemistry. O.B. Palladin of the National Academy of Sciences of Ukraine.
5. [www.bpci.kiev.ua](http://www.bpci.kiev.ua) - the official website of the Institute of Bioorganic Chemistry and Petrochemistry of the National Academy of Sciences of Ukraine.
6. [www.xumuk.ru](http://www.xumuk.ru) - articles on biochemistry in free access.
7. [www.pereplet.ru/cgi/soros/readdb.cgi](http://www.pereplet.ru/cgi/soros/readdb.cgi) - Soros Educational Journal - free access to popular science articles in biochemistry, biology and chemistry.
8. <https://ojs.tdmu.edu.ua/index.php/ijmr> - International Journal of Medicine and Medical Research
9. <https://ojs.tdmu.edu.ua/index.php/bmb> - Bulletin of medical and biological research

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## Tips on successful study during the course

To be successful in learning and self-study, prepare yourself for this by forming the following habits:

- Be responsible for yourself. Responsibility is the realization that in order to be successful, you have to set your own priorities, allocate time and resources.
- Focus on your values and principles. Don't let friends and acquaintances tell you what's important to you.
- Put the first things first. Do not allow others to distract from the goal. Determine the time and place of your greatest productivity. Prioritize according to the degree of complexity of the material.
- Show yourself from the best side.
- Understand others first, and then make them understand you.
- Find the best solution.
- Be demanding of yourself.