SYLLABUS

1. General information on the course

Full course name	Biological and Bioorganic Chemistry
Full official name of a higher education institution	Sumy State University
Full name of a structural unit	Faculty of Technical Systems and Energy Efficient Technologies. Department of Theoretical and Applied Chemistry
Author(s)	Yanovska Hanna Oleksandrivna, Litsman Yuliia Volodymyrivna, Dychenko Tetiana Vasylivna
Cycle/higher education level	The Second Level Of Higher Education, National Qualifications Framework Of Ukraine – The 7th Level, QF-LLL – The 7th Level, FQ-EHEA – The Second Cycle
Semester	18 weeks across 2 semester
Workload	The volume of the discipline is 3 credits ECTS, 90 hours, including 40 hours of work with lecturer (8 hours of lectures, 32 hours of practical classes), 50 hours of self-study.
Language(s)	English

2. Place in the study programme

Relation to curriculum	Compulsory course available for study programme "Medicine"
Prerequisites	Study of disciplines of natural-mathematical cycle according to the program of secondary school
Additional requirements	There are no specific requirements
Restrictions	There are no specific restrictions

3. Aims of the course

The purpose of the discipline is to achieve by students a system of knowledge on the basic classes of biomolecules (amino acids, carbohydrates, lipids, nucleotides, porphyrins, etc.).

4. Contents

Module 1. Biologically important classes of bioorganic compounds. Biopolymers and their structural components.

Topic 1 Theoretical bases of structure and reactivity of bioorganic compounds.

Bioorganic chemistry as a science: definition, subject and tasks, sections, research methods. Significance in the system of higher medical education. Classification of organic compounds by the structure of the carbon chain and the nature of functional groups. Nomenclature of organic compounds: trivial, rational, international. Principles of formation of names of organic compounds according to the IUPAC nomenclature: substituents, radical-functional. The nature of chemical bonding in organic compounds: hybridization of orbitals, electronic structure of carbon compounds. The structure of the most important classes of bioorganic compounds by the nature of functional groups: alcohols, phenols, thiols, aldehydes, ketones, carboxylic acids, esters, amides, nitro compounds, amines.

Topic 2 Carbonyl compounds: aldehydes and ketones. Carboxylic acids and their functional derivatives

Carbonyl compounds: aldehydes and ketones. Carboxylic acids in bioorganic chemistry: structure and chemical properties; functional derivatives of carboxylic acids (anhydrides, amides, esters). Decarboxylation reactions. Structure and properties of dicarboxylic acids: oxalic, malonic, succinic, glutaric, fumaric.

Topic 3 Heterofunctional compounds

Amino alcohols: structure, properties. Biomedical value of ethanolamine (colamine), choline, acetylcholine. Amines: nomenclature, properties. Biomedical value of biogenic amines (adrenaline, noradrenaline, dopamine, tryptamine, serotonin, histamine) and polyamines (putrescine, cadaverine). Hydroxy acids in bioorganic chemistry: structure and properties.

Topic 4 L-Amino acids, peptides, proteins.

Definition, of amino acids, general formula. classification, formula of 20 proteinogenic amino acids; bipolar ion, isoelectric point. Chemical properties of amino acids: reactions by carboxyl group, reactions by amino group, formation of peptides, deamination reactions, oxidative deamination, transamination. Peptides: dipeptides, tripeptides, protein polypeptides, alkaline and acid hydrolysis reactions of dipeptides. Protein structures and types of chemical bonds in them. Denaturation and hydrolysis of proteins. Color reactions of proteins.

Topic 5 Situational tasks. Control of knowledge acquisition of content modules

1 "Theoretical bases of the structure and reactivity of bioorganic compounds. Carboxylic acids and their functional derivatives. Heterofunctional compounds" and 2 "Amino acids, peptides, proteins".

Topic 6 Carbohydrates.

Carbohydrates: definition, classification. Monosaccharides (aldose and ketosis; triose, tetrose, pentose, hexose, heptose), biomedical significance of individual representatives. Monosaccharides: pentoses (ribose, 2-deoxyribose, xylose), hexoses (glucose, galactose, mannose, fructose). Structure, properties. Qualitative reactions to glucose. Structure and properties of monosaccharide derivatives. Amino derivatives: glucosamine, galactosamine. L-Ascorbic acid (vitamin C). Products of reduction of monosaccharides: sorbitol, mannitol.

Topic 7 Biologically active heterocyclic compounds. Five-membered heterocyclic compounds with one heteroatom (pyrrole, furan, thiophene). Biomedical significance of tetrapyrrole compounds: porphyrins, heme. Indole and its derivatives: tryptophan and tryptamine and serotonin formation reactions; indoxyl, skatol - importance in the processes of putrefaction of proteins in the intestine. Five-membered heterocycles with two nitrogen heteroatoms: thiazole, oxazole. Thiazole as a structural component of the thiamine molecule (vitamin B1). Six-membered heterocycles with one Nitrogen heteroatom: pyridine. Nicotinamide (vitamin PP) as a component of redox pyridine coenzymes. Pyridoxine and molecular forms of B6.
Topic 8 Nucleosides, nucleotides, nucleic acids. Nucleosides, nucleotides. Nitrogen bases of purine and pyrimidine series, which are part of natural nucleotides. Minor nitrogenous bases. Nucleosides. Nucleotides as phosphorylated derivatives of nucleosides (nucleoside mono-, di- and triphosphates). Nomenclature of nucleosides and nucleotides as components of RNA and DNA. Structure and biochemical functions of free nucleotides.
Topic 9 Fatty acids. Lipids. Lipids: definition, classification. Components of saponified lipids (glycerin, sphingosine, colamine, choline, serine, orthophosphate acid, FA - palmitic, stearic, arachidonic, palmitoleic, oleic, linoleic, linolenic, arachidonic). Conditional notation of the composition of FA: the number of C atoms, the presence or absence of multiple bonds in the carbon chain, the location of multiple bonds.
Topic 10 Situational tasks. Generalization and systematization of knowledge about bioorganic compounds. Final control of mastering of the course. Situational tasks. Generalization and systematization of knowledge about bioorganic compounds. Final control of mastering of the course.

5. Intended learning outcomes of the course

After successful study of the course, the student will be able to:

LO1	Classify organic compounds and types of chemical reactions with their participation, apply the rules of chemical nomenclature to compile the names of organic compounds.
LO2	Predict and explain the typical chemical properties of bioorganic compounds in connection with their belonging to a certain class, recognize typical bioorganic compounds.
LO3	Analyze the reactivity of carbohydrates, lipids, amino acids, which provides their functional properties and metabolic transformations in the body.
LO4	Interpret: features of the structure and transformations in the body of bioorganic compounds as the basis of their pharmacological action as drugs

6. Role of the course in the achievement of programme learning outcomes

Programme learning outcomes achieved by the course.

For 222 Medicine:

PO1	To detect and identify the leading clinical symptoms and syndromes (according to the List 1); to establish the most probable nosological or syndromic preliminary clinical diagnosis of diseases (according to the List 2) using standard methods, preliminary data of the patient's anamnesis, patient's examination data, and knowledge about a human, his organs and systems.
PO2	To collect information about the patient's general condition; to assess the patient's psychomotor and physical development and the state of organs and systems of the body; to assess information on the diagnosis (according to the List 4) based on laboratory and instrumental findings.
PO3	To order and analyze additional (mandatory and optional) examinations (laboratory, radiological, functional and/or instrumental) (according to the List 4) in order to perform a differential diagnosis of diseases (according to the List 2).
PO4	To establish a final clinical diagnosis at a medical institution under control of a supervising doctor by means of informed decision and logical analysis of the obtained subjective and objective data of clinical and additional examinations, and differential diagnosis, following the relevant ethical and legal norms (according to the List 2).
PO5	To detect the key clinical syndrome or the reason for patient's condition severity (according to the List 3) via informed decision and evaluation of the person's state under any circumstances (at home, in the street, at a healthcare facility), including under emergency and military operation conditions, in the field, with a lack of information and limited time.
PO18	To search for the necessary information in the professional literature and databases; to analyze, evaluate, and apply this information. To apply modern digital technologies, specialized software, statistical methods of data analysis to solve complex health problems.

7. Teaching and learning activities

7.1 Types of training

Topic 1. Theoretical bases of structure and reactivity of bioorganic compounds.
pr.tr.1 "Theoretical bases of structure and reactivity of bioorganic compounds." (full-time course) Bioorganic chemistry as a science: definition, subject and tasks, sections, research methods. Significance in the system of higher medical education. Classification of organic compounds by the structure of the carbon chain and the nature of functional groups. Nomenclature of organic compounds: trivial, rational, international. Principles of formation of names of organic compounds according to the IUPAC nomenclature: substituents, radical-functional.

pr.tr.2 "The nature of the chemical bond. Reactivity of bioorganic compounds. Laboratory experiments №1." (full-time course)

The nature of chemical bonding in organic compounds: hybridization of orbitals, electronic structure of carbon compounds. The structure of the most important classes of bioorganic compounds by the nature of functional groups: alcohols, phenols, thiols, aldehydes, ketones, carboxylic acids, esters, amides, nitro compounds, amines. Space structure of bioorganic compounds: stereochemical formulas; configuration and conformation. Stereoisomers: geometric, optical, rotational (conformers). Optical isomerism. Chirality of molecules of organic compounds of D- and L-stereochemical series. Enantiomers and diastereoisomerism of bioorganic compounds. Relationship of spatial structure with physiological activity. Types of reactions of bioorganic chemistry: classification by result (direction) and reaction mechanism.

Topic 2. Carbonyl compounds: aldehydes and ketones. Carboxylic acids and their functional derivatives

pr.tr.3 ""Carbonyl compounds. Carboxylic acids and their functional derivatives."" (full-time course)

Carbonyl compounds: aldehydes and ketones. Carboxylic acids in bioorganic chemistry: structure and chemical properties; functional derivatives of carboxylic acids (anhydrides, amides, esters). Decarboxylation reactions. Structure and properties of dicarboxylic acids: oxalic, malonic, succinic, glutaric, fumaric

Topic 3. Heterofunctional compounds

lect.1 "Heterofunctional compounds." (full-time course)

Amino alcohols: structure, properties. Biomedical value of ethanolamine (colamine), choline, acetylcholine. Amines: nomenclature, properties. Biomedical value of biogenic amines (adrenaline, noradrenaline, dopamine, tryptamine, serotonin, histamine) and polyamines (putrescine, cadaverine). Hydroxy acids in bioorganic chemistry: structure and properties of mono carboxylic acids.

pr.tr.4 "Heterofunctional compounds. Hydroxy acids." (full-time course)

Hydroxy acids in bioorganic chemistry: structure and properties.

pr.tr.5 "Oxoacids. Laboratory experiments №2." (full-time course)

Oxoacids. Laboratory experiments №2. Oxoacids: structure, properties. Keto-enol tautomerism. Representatives (pyruvic, acetoacetic, oxaloacetic, D-ketoglutaric). The concept of ketone bodies. Phenolic acids. Salicylic acid and its derivatives as anti-inflammatory agents (acetylsalicylic acid, methyl salicylate, sodium salicylate).

Topic 4. L-Amino acids, peptides, proteins.

lect.2 "L-Amino acids, peptides, proteins." (full-time course)

L-Amino acids: definition, of amino acids, general formula. classification, formula of 20 proteinogenic amino acids; bipolar ion, isoelectric point. Chemical properties of amino acids: reactions by carboxyl group, reactions by amino group, formation of peptides, deamination reactions, oxidative deamination, transamination. Peptides: dipeptides, tripeptides, protein polypeptides, alkaline and acid hydrolysis reactions of dipeptides. Protein structures and types of chemical bonds in them. Denaturation and hydrolysis of proteins. Color reactions of proteins.

pr.tr.6 ""Amino acid composition of proteins and peptides. Deamination, decarboxylation, transamination"" (full-time course)

Definition, of amino acids, general formula. classification, formula of 20 proteinogenic amino acids; bipolar ion, isoelectric point. Chemical properties of amino acid.

pr.tr.7 "Structural organization of proteins. Physico-chemical properties of proteins. Solubility, precipitation, dialysis, protein electrophoresis. Denaturation." (full-time course)

Laboratory experiments № 3. Structural organization of proteins. Physico-chemical properties of proteins. Solubility, precipitation, dialysis, protein electrophoresis. Denaturation.

Topic 5. Situational tasks. Control of knowledge acquisition of content modules

pr.tr.8 "Control of practical learning skills with topics 1-4" (full-time course)

Control of practical learning skills on topics 1-4. Theoretical bases of structure and reactivity of bioorganic compounds. Carboxylic acids and their functional derivatives. Heterofunctional compounds and Amino acids, peptides, proteins.

Topic 6. Carbohydrates.

lect.3 "Classification, structure and chemical properties of carbohydrates: monosaccharides, disaccharides, polysaccharides" (full-time course)

Carbohydrates: definition, classification. Monosaccharides (aldose and ketosis; triose, tetrose, pentose, hexose, heptose), biomedical significance of individual representatives. Monosaccharides: pentoses (ribose, 2-deoxyribose, xylose), hexoses (glucose, galactose, mannose, fructose). Structure, properties. Qualitative reactions to glucose. Structure and properties of monosaccharide derivatives. Amino derivatives: glucosamine, galactosamine. L-Ascorbic acid (vitamin C). Products of reduction of monosaccharides: sorbitol, mannitol.

pr.tr.9 "Carbohydrates. Monosaccharides structure and chemical properties and biological impact of carbohydrates: будова, хімічні властивості та біологічне значення." (full-time course)

Monosaccharides: pentoses (ribose, 2-deoxyribose, xylose), hexoses (glucose, galactose, mannose, fructose). Structure, properties. Qualitative reactions to glucose. Structure and properties of monosaccharide derivatives. Amino derivatives: glucosamine, galactosamine. L-Ascorbic acid (vitamin C). Products of reduction of monosaccharides: sorbitol, mannitol.

pr.tr.10 "Structure, properties and biological role of di- and polysaccharides. Laboratory experiment №4." (full-time course)

Oligosaccharides: structure, properties. Disaccharides (sucrose, lactose, maltose), their biomedical value. Polysaccharides. Homopolysaccharides: starch, glycogen, cellulose, dextrins - structure, hydrolysis, biomedical value. Qualitative reaction for starch. Heteropolysaccharides: definition, structure. Structure and biomedical significance of glycosaminoglycans (mucopolysaccharides) - hyaluronic acid, chondroitin sulfates, heparin.

Topic 7. Biologically active heterocyclic compounds.

pr.tr.11 "Classification, structure and significance of the biologically important five-membered heterocyclic compounds." (full-time course)

Five-membered heterocyclic compounds with one heteroatom (pyrrole, furan, thiophene). Biomedical significance of tetrapyrrole compounds: porphyrins, heme. Indole and its derivatives: tryptophan and tryptamine and serotonin formation reactions; indoxyl, skatol - importance in the processes of putrefaction of proteins in the intestine. Five-membered heterocycles with two nitrogen heteroatoms: thiazole, oxazole. Thiazole as a structural component of the thiamine molecule (vitamin B1). Six-membered heterocycles with one nitrogen heteroatom: pyridine. Nicotinamide (vitamin PP) as a component of redox pyridine coenzymes. Pyridoxine and molecular forms of B6.

pr.tr.12 "Classification, structure and significance of biologically important six-membered heterocyclic compounds" (full-time course)

Six-membered heterocycles with two nitrogen atoms. Diazines: pyrimidine, pyrazine, pyridazine. Nitrogen bases are pyrimidine derivatives (uracil, cytosine, thymine). Pyrimidine derivatives as drugs: 5-fluorouracil, potassium orotate. Barbituric acid; barbiturates as hypnotics and antiepileptics (phenobarbital, veronal). Purine and its derivatives. Amino derivatives of purine (adenine, guanine). Their tautomeric forms; biochemical significance in the formation of nucleotides and coenzymes. Hydroxy derivatives of purine: hypoxanthine, uric acid, methylated derivatives of xanthine (caffeine, theophylline, theobromine) as physiologically active compounds with action on the central nervous and cardiovascular systems.

Topic 8. Nucleosides, nucleotides, nucleic acids.

lect.4 "Heterocyclic compounds. Structure, properties and biological significance of nucleic acids. "" (full-time course)

Nucleosides, nucleotides. Nitrogen bases of purine and pyrimidine series, which are part of natural nucleotides. Minor nitrogenous bases. Nucleosides. Nucleotides as phosphorylated derivatives of nucleosides (nucleoside mono-, di- and triphosphates). Nomenclature of nucleosides and nucleotides as components of RNA and DNA. Structure and biochemical functions of free nucleotides: nucleotides-coenzymes; cyclic nucleotides 3 ', 5'-cAMP and 3', 5'-cGMP. Nucleic acids (deoxyribonucleic, ribonucleic) as polynucleotides. Polarity of DNA and RNA polynucleotide chains. Structure and properties of DNA; nucleotide composition, complementarity of nitrogenous bases. Primary, secondary and tertiary structures of DNA.RNA: structure, types of RNA and their role in protein biosynthesis. Vitamins: general characteristics; the concept of the coenzyme action of vitamins. Structure and properties of vitamins B1, B2, B6, PP.

pr.tr.13 "Structure and biochemical functions of nucleosides, nucleotides and nucleic acids. Laboratory experiments № 5 "" (full-time course)

Structure and biochemical functions of nucleosides, nucleotides and nucleic acids. Laboratory experiments № 5 Nucleosides, nucleotides. Nitrogen bases of purine and pyrimidine series, which are part of natural nucleotides. Minor nitrogenous bases. Nucleosides. Nucleotides as phosphorylated derivatives of nucleosides (nucleoside mono-, di- and triphosphates). Nomenclature of nucleosides and nucleotides as components of RNA and DNA. Structure and biochemical functions of free nucleotides: nucleotides-coenzymes; cyclic nucleotides 3 ', 5'-cAMP and 3', 5'-cGMP.

Topic 9. Fatty acids. Lipids.

pr.tr.14 "Fatty acids. Saponified simple lipids. Laboratory experiments № 6. "" (full-time course) Lipids: definition, classification. Components of saponified lipids (glycerin, sphingosine, colamine, choline, serine, orthophosphate acid, FFA - palmitic, stearic, arachidonic, palmitoleic, oleic, linoleic, linolenic, arachidonic). Conditional record of the composition of FFA: the number of C atoms, the presence or absence of multiple bonds in the carbon chain, the location of multiple bonds.
pr.tr.15 "Saponifiable compound lipids. Nonsaponifiable lipids. "" (full-time course) Reactions of formation and formulas of triglycerides, equations of hydrolysis (acid and alkaline (saponification), difference of products (fatty acids, salts of FA - soap), addition (hydrogenation, halogenation). Compound lipids: phospholipids. Njnsaponifiable lipids.
Topic 10. Situational tasks. Generalization and systematization of knowledge about bioorganic compounds. Final control of mastering of the course.
pr.tr.16 "Final control of knowledge acquisition from the module" (full-time course) Final control of knowledge acquisition from the module

7.2 Learning activities

LA1	Work during the lecture (listening, taking notes, participating in the discussion, etc.)
LA2	Discussion of theoretical issues
LA3	Performing chemical experiments
LA4	Execution of practical tasks
LA5	Processing of educational information on the basis of available educational and methodical materials
LA6	Preparation for a practical class
LA7	Execution of control work
LA8	Interactive testing
LA9	E-learning in systems (Google Classroom, MIX and in the format of a YouTube

8. Teaching methods

Course involves learning through:

TM1	Visualization lectures, interactive lectures, problem lectures, mini-lectures
TM2	Problem-searching method
TM3	Method of demonstrations
TM4	Practice-oriented learning
TM5	Searching laboratory work

Lectures provide students with educational information on the theoretical foundations of a holistic physico-chemical approach to study the processes of life and the ability to evaluate chemical properties and transformations of substances in the body, which is the basis for self-study of higher

education. Lectures are complemented by practical classes that allow students to confirm the theoretical provisions of chemistry, which are used to explain the essence of the processes occurring in the body. Independent learning will be facilitated by preparation for lectures and practical classes, work in small groups during a chemical experiment, performing of test tasks, performing of individual tasks of control works, processing of educational information, etc.

. GC 1. Ability to abstract thinking, analysis, and synthesis. GC 2.Ability to learn, master modern knowledge, and apply the knowledge in practice. GC 3. Knowledge and understanding of the subject area and professional activity comprehension. GC 5. Ability to make reasoned decisions; teamwork ability; interpersonal skills. GC 7. Ability to use information and communication technologies.

9. Methods and criteria for assessment

9.1. Assessment criteria

ECTS	Definition	National scale	Rating scale
	Outstanding performance without errors	5 (Excellent)	170 ≤ RD ≤ 200
	Above the average standard but with minor errors	4 (Good)	140 ≤ RD < 169
	Fair but with significant shortcomings	3 (Satisfactory)	120 ≤ RD < 139
	Fail – some more work required before the credit can be awarded	2 (Fail)	0 ≤ RD < 119

9.2 Formative assessment

FA1	questionnaires and oral comments of the lecturer on his results
FA2	instructions by the teacher in the course of performance of laboratory works
FA3	self-assessment
FA4	discussion and mutual evaluation of completed tasks by students

9.3 Summative assessment

SA1	interactive testing to check the assimilation of lecture material
SA2	work in practical classes
SA3	performing and research of laboratory experiments
SA4	multimedia presentation
SA5	performing of control works
SA6	final control

Form of assessment:

2 semester		**200 scores**
SA1. interactive testing to check the assimilation of lecture material		**30**
	3x10	30

SA2. work in practical classes		**20**
	4x5	20
SA3. performing and research of laboratory experiments		**25**
	5x5	25
SA4. multimedia presentation		**5**
		5
SA5. performing of control works		**40**
	2x20	40
SA6. final control		**80**
		80

Form of assessment (special cases):

2 semester		**200 scores**
SA1. interactive testing to check the assimilation of lecture material		**30**
	3x10	30
SA2. work in practical classes		**20**
	4x5	20
SA3. performing and research of laboratory experiments		**25**
	5x5	25
SA4. multimedia presentation		**5**
		5
SA5. performing of control works		**40**
	2x20	40
SA6. final control		**80**
		80

Assessment during the semester is conducted in the form of oral and written surveys, interactive testing, tests. All work must be performed independently. The form of final control is a differentiated test, which is conducted in written form.

10. Learning resources

10.1 Material and technical support

MTS1	multimedia equipment
MTS2	specialized training chemical laboratory
MTS3	means of communication with access to the Internet
MTS4	chemical laboratory equipment, utensils and reagents

MTS5	video recording of chemical experiments
MTS6	software to support distance learning
MTS7	Library funds

10.2 Information and methodical support

Essential Reading	
1	Biological chemistry/ Yu. I. Gubskyi. - 3-nd. ed. - Vinnitsa : Nova Knyha, 2020. - 488 p
Supplemental Reading	
2	«Біологічна та біоорганічна хімія» (в таблицях і схемах) (+Авторизований доступ) / укладачі :Ю. В. Ліцман, О. П. Манжос. – Суми : Сумський державний університет, 2015. – 112 с.
3	Біоорганічна хімія (тестові завдання) / Л. М. Миронович, О.П. Манжос (+Авторизований доступ) – Суми: СумДУ, 2015. – 191 с.
Web-based and electronic resources	
4	Офіційний сайт кафедри загальної хімії СумДУ http://chem.teset.sumdu.edu.ua/