



**INTEGRATED ACADEMIC
STUDIES OF PHARMACY**

SECOND YEAR OF STUDIES

The academic year 2023/2024

Fundamentals of human biochemistry

Course: 19.BE001

FUNDAMENTALS OF HUMAN BIOCHEMISTRY

The course is evaluated with 5 ECTS. The course consists of 4 classes of active teaching per week (2 classes of lectures and 2 classes of small groups activities).

TEACHERS AND ASSOCIATES:

No		E-mail address	Title
1.	Milan Zarić	zaricmilan@gmail.com	Associate professor
2.	Marina Mitrović	mitrovicmarina34@gmail.com	Full professor
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COURSE STRUCTURE:

Modul number	Name of the module	N° of weeks	Lectures	Work in a small group	Teacher - head of the module
1	Enzymology. Energy metabolism 1.	6	2	2	prof. dr Marina Mitrović
2	Energy metabolism 2 - lipids, nucleic acids and proteins.	5	2	2	prof. dr Ivanka Zelen
3	Biochemistry of hormones, organs, tissues, integrative metabolism and mechanism of drug action	4	2	2	prof. dr Milan Zarić
					$\Sigma 30+30=60$

ASSESSMENT:

The student masters the subject by modules. The grade is equivalent to the number of points earned (see tables). Points are earned in two ways:

1. ACTIVITY DURING THE LESSON: In this way, the student may earn up to 61 points:

A. In a special part of the class, he answers two questions from that week of lectures and receives 0-2 points. In this way, every student can earn up to 30 points.

B. FINAL WRITTEN TESTS BY MODULES: In this way, the student can gain up to 31 points. The test consists of closed type (abcd) questions. Each correct answer adds 0.5 points to the final grade.

2. FINAL ORAL EXAMINATION: In this way, a student can gain up to 39 points by answering three question from three different modules, for which he/she is evaluated from 0-13 points for each question. A score of 0 on any question represents the end of the exam. A student has the right to take the final oral exam if he/she has achieved more than 50% of the points for the activity and the final test in all modules.

MODULE		MAXIMUM POINTS			Σ
		activity during classes	module test	final oral examination	
1	Enzymology. Energy metabolism 1 – ROS and carbohydrates.	12	12	39	
2	Energy metabolism 2 - lipids, nucleic acids and proteins.	10	11		
3	Biochemistry of hormones, organs, tissues and integrative metabolism.	8	8		
Σ		30	31	39	100

The final grade is formed as follows:

In order to complete the course, the student must acquire at least 51 point in summary, has sufficient number of points for each module and pass oral examination.

In order to pass the module the student must:

1. acquire more than 50% of summary points of the module
2. acquire more than 50% of points for activity during classes in each module
3. acquire more than 50% of points for module test in each module

number of acquired points	grade
0 - 50	5
51 - 60	6
61 - 70	7
71 - 80	8
81 - 90	9
91 - 100	10

TESTS BY MODULES

MODULE 1 .

FINAL TEST
0-12 POINTS

FINAL MODULE TEST

The test has 24 questions
Every correct answer equals 0.5 points

MODULE 2.

FINAL TEST
0-11 POINTS

FINAL MODULE TEST

The test has 22 questions
Every correct answer equals 0.5 points

MODULE 3.

FINAL TEST
0-8 POINTS

FINAL MODULE TEST

The test has 16 questions
Every correct answer equals 0.5 points

LITERATURE:

the name of the textbook	authors	publisher	the library
Biochemistry for the Pharmaceutical Sciences 1st Edition	Charles P. Woodbury Jr.	Jones and Bartlett Publishers, Inc	does not have
Marx's fundamentals of medical biochemistry - a clinical approach	M. Lieberman, AD Marks, C. Marks	<i>Lippincott Williams & Wilkins</i>	does not have
Biochemistry	Garrett RH, Grisham CM.	Cengage Learning	does not have

PROGRAM:

FIRST MODULE: ENZYMOLOGY. ENERGY METABOLISM 1 – ROS AND CARBOHYDRATES

TEACHING UNIT 1 (FIRST WEEK):

INTRODUCTION TO BIOCHEMISTRY. ENZYMOLOGY

lectures - 2 classes	small groups activities - 2 classes
Introduction to Biochemistry. Introductory lecture, introduction in biochemistry, biochemical organization cell- and sub-cellular organelles. Water and types of bonds, hydrogen bond, concept of hydrophilicity and hydrophobicity. Enzymology. The nature of enzymes, general principles of enzymes' reactions, kinetics and enzymatic activities.	Introduction to Biochemistry. Introductory lecture, introduction in biochemistry, biochemical organization cell- and sub-cellular organelles. Water and types of bonds, hydrogen bond, concept of hydrophilicity and hydrophobicity. Enzymology. The nature of enzymes, general principles of enzymes' reactions, kinetics and enzymatic activities.

TEACHING UNIT 2 (SECOND WEEK):

REGULATION OF ENZYME ACTIVITY. CLINICAL ENZYMOLOGY

lectures - 2 classes	small groups activities - 2 classes
Enzymology. Regulation of enzyme activity, mechanisms of activation and inhibition. Allosteric enzymes, clinically important enzymes, nomenclature and classification of enzymes.	Enzymology. Regulation of enzyme activity, mechanisms of activation and inhibition. Allosteric enzymes, clinically important enzymes, nomenclature and classification of enzymes.

TEACHING UNIT 3 (THIRD WEEK):

VITAMINS AND COENZYMES

lectures - 2 classes	small groups activities - 2 classes
Enzymology. Biochemistry of vitamins, hydrosoluble and liposoluble vitamins, enzyme cofactors, cosubstrates, prosthetic groups.	Enzymology. Biochemistry of vitamins, hydrosoluble and liposoluble vitamins, enzyme cofactors, cosubstrates, prosthetic groups.

UNIT 4 (FOURTH WEEK):

GLYCOLYSIS, HMP PATHWAY AND PDH COMPLEX.

lectures - 2 classes	small groups activities - 2 classes
Glycolysis. HMP pathway and PDH complex. Digestion and absorption of carbohydrates. Glycolysis and the hexose-monophosphate pathway. Oxidative decarboxylation of pyruvate.	Glycolysis. HMP pathway and PDH complex. Digestion and absorption of carbohydrates. Glycolysis and the hexose-monophosphate pathway. Oxidative decarboxylation of pyruvate.

UNIT 5 (FIFTH WEEK):

KREBS CYCLE AND OXIDATIVE PHOSPHORYLATION

lectures - 2 classes	small groups activities - 2 classes
Krebs cycle. Oxidative phosphorylation. Metabolism, anabolic and catabolic processes. Sources and fate of acetyl - CoA and the Krebs cycle. Oxidoreduction processes, energy-rich compounds, respiratory chain.	Krebs cycle. Oxidative phosphorylation. Metabolism, anabolic and catabolic processes. Sources and fate of acetyl - CoA and the Krebs cycle. Oxidoreduction processes, energy-rich compounds, respiratory chain.

UNIT 6 (SIXTH WEEK):

GLYCOGEN AND GLUCONEOGENESIS

lectures - 2 classes	small groups activities - 2 classes
Carbohydrate metabolism. Glycogen metabolism – glycogenolysis, glycogenesis. Gluconeogenesis.	Carbohydrate metabolism. Glycogen metabolism – glycogenolysis, glycogenesis. Gluconeogenesis.

**SECOND MODULE: ENERGY METABOLISM 2 - LIPIDS.
ENERGY METABOLISM 3 – NUCLEIC ACIDS AND PROTEINS**

UNIT 7 (SEVENTH WEEK):

ROS AND ANTIOXIDATIVE PROTECTION

lectures - 2 classes	small groups activities - 2 classes
ROS and antioxidant protection. The mechanism of formation of reactive oxygen species. Damage to biomacromolecules mediated by the action of ROS. Antioxidants and antioxidant protection.	ROS and antioxidant protection. The mechanism of formation of reactive oxygen species. Damage to biomacromolecules mediated by the action of ROS. Antioxidants and antioxidant protection.

UNIT 8 (EIGHTH WEEK):

LIPID METABOLISM

lectures - 2 classes	small groups activities - 2 classes
Lipid metabolism. Digestion and absorption of lipids. β - oxidation of fatty acids, ketone bodies. Oxidation of fatty acids with an odd number of carbon atoms. Oxidation of fatty acids with unsaturated bonds. ω -oxidation. α - oxidation. Synthesis of fatty acids and triacylglycerol.	Lipid metabolism. Digestion and absorption of lipids. β - oxidation of fatty acids, ketone bodies. Oxidation of fatty acids with an odd number of carbon atoms. Oxidation of fatty acids with unsaturated bonds. ω -oxidation. α - oxidation. Synthesis of fatty acids and triacylglycerol.

UNIT 9 (NINTH WEEK):

CHOLESTEROL, BILE ACIDS AND LIPOPROTEINS

lectures - 2 classes	small groups activities - 2 classes
Cholesterol, bile acids and lipoproteins. Synthesis of cholesterol, bile acids and complex phospholipids. Transport of lipids - lipoproteins of blood plasma.	Cholesterol, bile acids and lipoproteins. Synthesis of cholesterol, bile acids and complex phospholipids. Transport of lipids - lipoproteins of blood plasma.

UNIT 10 (TENTH WEEK):

NUCLEIC ACIDS

lectures - 2 classes	small groups activities - 2 classes
Nucleic acids. Catabolism and anabolism of nucleotides and nucleic acids, metabolism of purines and pyrimidines.	Nucleic acids. Catabolism and anabolism of nucleotides and nucleic acids, metabolism of purines and pyrimidines.

UNIT 11 (ELEVENTH WEEK):

AMINO ACIDS AND PROTEINS, PROTEIN SYNTHESIS

lectures - 2 classes	small groups activities - 2 classes
Amino acids and proteins, protein synthesis. Digestion and absorption of proteins. Catabolism of amino acids(transamination, oxidative deamination, ammonia metabolism). Urea synthesis, glutamine synthesis. Non-protein nitrogenous compounds. Protein synthesis, regulation of protein synthesis.	Amino acids and proteins, protein synthesis. Digestion and absorption of proteins. Catabolism of amino acids (transamination, oxidative deamination, ammonia metabolism). Urea synthesis, glutamine synthesis. Non-protein nitrogenous compounds. Protein synthesis, regulation of protein synthesis.

THIRD MODULE: BIOCHEMISTRY OF HORMONES, ORGANS, TISSUES. INTEGRATIVE METABOLISM AND MECHANISM OF DRUG ACTION

UNIT 12 (TWELFTH WEEK):

BIOCHEMISTRY OF HORMONES

lectures - 2 classes	small groups activities - 2 classes
Biochemistry of hormones. Chemical structure, synthesis, transport, mechanism of action.	Biochemistry of hormones. Chemical structure, synthesis, transport, mechanism of action.

UNIT 13 (THIRTEENTH WEEK):

METABOLISM OF WATER AND BIOELEMENTS. TISSUES

lectures - 2 classes	small groups activities - 2 classes
Metabolism of water and bioelements. Metabolism of water and bioelements, inorganic substances - minerals. Tissues. Liver.	Metabolism of water and bioelements. Metabolism of water and bioelements, inorganic substances - minerals. Tissues. Liver.

TEACHING UNIT 14 (FOURTEENTH WEEK):

INTEGRATIVE METABOLISM

lectures - 2 classes	small groups activities - 2 classes
Integrative metabolism. The relationship between the metabolism of carbohydrates, lipids and amino acids.	Integrative metabolism. The relationship between the metabolism of carbohydrates, lipids and amino acids.

UNIT 15 (FIFTEENTH WEEK):

MECHANISM OF DRUG ACTION

lectures - 2 classes	small groups activities - 2 classes
Mechanism of drug action. Competitive inhibitors, regulatory enzyme metabolic roads: respiratory chain, HMG-(CoA)-reductase, ACE-inhibitors, xanthine oxidase inhibitors, antibiotics, antimetabolites and cytostatics.	Mechanism of drug action. Competitive inhibitors, regulatory enzyme metabolic roads: respiratory chain, HMG-(CoA)-reductase, ACE-inhibitors, xanthine oxidase inhibitors, antibiotics, antimetabolites and cytostatics.

LESSON SCHEDULE FOR THE SUBJECT FUNDAMENTALS OF HUMAN BIOCHEMISTRY

module	Sunday	type	method unit name	a teacher
1	1	L	Introduction to biochemistry. Enzymology	prof. dr Marina Mitrovic
		SGA	Introduction to biochemistry. Enzymology	prof. dr Marina Mitrovic
	2	L	Regulation of enzyme activity. Clinical enzymology	prof. dr Marija Anđelković
		SGA	Regulation of enzyme activity. Clinical enzymology	prof. dr Marija Anđelković
	3	L	Vitamins and coenzymes	prof. dr Marina Mitrovic
		SGA	Vitamins and coenzymes	prof. dr Marina Mitrovic
	4	L	Glycolysis, Hexose-moniphosphate pathway and oxidative decarboxylation.	prof. dr Ivana Nikolić
		SGA	Glycolysis, Hexose-moniphosphate pathway and oxidative decarboxylation.	prof. dr Ivana Nikolić
1	5	L	Krebs cycle and oxidative phosphorylation.	prof. dr Ivana Nikolić

LESSON SCHEDULE FOR THE SUBJECT FUNDAMENTALS OF HUMAN BIOCHEMISTRY

module	Sunday	type	method unit name	a teacher
		SGA	Krebs cycle and oxidative phosphorylation.	prof. dr Ivana Nikolić
	6	L	Glycogen - glycogenesis and glycogenolysis. Gluconeogenesis.	prof. dr Milan Zarić
		SGA	Glycogen - glycogenesis and glycogenolysis. Gluconeogenesis.	prof. dr Milan Zarić
2	7	L	ROS and antioxidants.	prof. dr Ivanka Zelen
		SGA	ROS and antioxidants.	prof. dr Ivanka Zelen
	8	L	Fat metabolism.	prof. dr Ivanka Zelen
		SGA	Fat metabolism.	prof. dr Ivanka Zelen
		FTM	FINAL TEST OF MODULE 1	
2	9	L	Cholesterol and lipoproteins. Bile metabolism.	prof. dr Milan Zarić

LESSON SCHEDULE FOR THE SUBJECT FUNDAMENTALS OF HUMAN BIOCHEMISTRY

module	Sunday	type	method unit name	a teacher
		SGA	Cholesterol and lipoproteins. Bile metabolism.	prof. dr Milan Zarić
	10	L	Nucleic acid metabolism.	prof. dr Sanja Stanković
		SGA	Nucleic acid metabolism.	prof. dr Sanja Stanković
	11	L	Metabolism of amino acids and proteins. Protein synthesis.	prof. dr Petar Čanović
		SGA	Metabolism of amino acids and proteins. Protein synthesis.	prof. dr Petar Čanović
3	12	L	Biochemistry of hormones.	prof. dr Marija Anđelković
		SGA	Biochemistry of hormones.	prof. dr Marija Anđelković
3	13	L	Metabolism of water and bioelements; Tissues.	prof. dr Petar Čanović
		SGA	Metabolism of water and bioelements; Tissues.	prof. dr Petar Čanović

LESSON SCHEDULE FOR THE SUBJECT FUNDAMENTALS OF HUMAN BIOCHEMISTRY

module	Sunday	type	method unit name	a teacher
		FTM	FINAL TEST OF MODULE 2	
3	14	L	Integrative metabolism.	prof. dr Marijana Stanojević Pirković
		SGA	Integrative metabolism.	prof. dr Marijana Stanojević Pirković
	15	L	Mechanism of drug action.	prof. dr Marijana Stanojević Pirković
		SGA	Mechanism of drug action.	prof. dr Marijana Stanojević Pirković
		FTM	FINAL TEST OF MODULE 3	
		I	EXAM (JANUARY-FEBRUARY TERM)	

Oral exam questions

A (one question is drawn)

1. Water and connection types. Hydrophilicity and hydrophobicity.
2. Chemical nature of enzymes. General principles of enzyme activity. Kinetics of enzymatic activity.
3. Main classes of biomolecules and their basic properties
4. Types of enzyme inhibition
5. Regulation of enzyme activity. Postsynthetic regulation
6. Classification and nomenclature of enzymes
7. Oxidoreductases and transferases
8. Hydrolases and lyases
9. Isomerases and ligases
10. Functional and non-functional blood plasma enzymes
11. Transaminases (AST and ALT)
12. γ -glutamyl transferase
13. Lactate dehydrogenase
14. Alkaline and acid phosphatase
15. Liposoluble vitamins
16. B complex vitamins as cofactors in enzymatic reactions: niacin and riboflavin
17. The role of coenzymes for the transfer of phosphate groups in enzymatic reactions. Vitamin V12 and folic acid.
18. Complexes of the respiratory chain.
19. ATR synthase and the release of newly synthesized ATR from mitochondria. R/O ratio in the respiratory chain.
20. Free radicals. Oxygen free radicals.
21. Places of production of oxygen free radicals. Tissue damage caused by radicals.
22. Nitrosative stress
23. Superoxide dismutase , catalase and glutathione peroxidase
24. Non-enzymatic antioxidants
25. Digestion and absorption of carbohydrates
26. Glycolysis: phases, regulation, energy balance
27. Pentozophosphate pathway

28. Glycogenesis
29. Glycogenolysis
30. Gluconeogenesis
31. Oxidative decarboxylation of pyruvate
32. Krebs cycle

B (one question is drawn)

1. Beta oxidation of fatty acids
2. Fatty acids and lipid digestion
3. Ketone bodies
4. Synthesis of fatty acids
5. Cholesterol
6. Bile acids
7. Phospholipids
8. Lipoproteins. Chylomicrons
9. VLDL, LDL and HDL lipoproteins
10. Breakdown of nucleic acids and nucleotides. Breakdown of AMP and GMP
11. Breakdown of nucleic acids and nucleotides. Decomposition of pyrimidines
12. De novo synthesis of purine nucleotides
13. Biosynthesis of pyrimidine nucleotides
14. Digestion and absorption of proteins
15. Gamma-glutamyl cycle
16. Transamination and oxidative deamination
17. Glutamate-dehydrogenase
18. Urea synthesis
19. Regulation of the urea cycle. Glutamine. Creatine and creatinine.
20. Amino acids. Division of amino acids.
21. Eukaryotic translation
22. Protein structure. Properties of peptide bonds.

V (one question is drawn)

1. Basic characteristics and divisions of hormones
2. Secondary messengers
3. Steroid hormones
4. Control of hormone secretion
5. Hormones of the adrenal medulla
6. Thyroid hormones
7. Insulin
8. Glucagon
9. Macroelements
10. Copper, zinc and selenium
11. Liver functions
12. Metabolism of ethanol in the liver
13. Hemoprotein metabolism
14. The state of satiety
15. State of starvation
16. Diabetes mellitus. Hypoglycemia
17. Branched-chain amino acids
18. Respiratory chain inhibitors
19. HMG-CoA-reductase inhibitors - statins
20. ACE – inhibitors
21. Xanthine oxidase inhibitors