MEDICAL BIOCHEMISTRY

METABOLISM AND FUNCTION

SECOND YEAR OF STUDY

The academic year
2023/2024.

Course title:

MEDICAL BIOCHEMISTRY

The course is evaluated with 12 ECTS. There are 11 hours of active teaching classes per week (6 hours of lectures and 5 hours of practice).

TEACHERS:

No		E-mail address	Title
1.	Marina Mitrović	mitrovicmarina34@gmail.com	Full professor
2.	Ivanka Zelen	ivankazelen@gmail.com	Full professor
3.	Marijana Stanojevič Pirković	marijanas14@gmail.com	Associate professor
4.	Ivana Nikolić	angelkg2009@gmail.com	Associate professor
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6.	Marija Andjelković	marijabcd@gmail.com	Associate professor
7.	Petar Čanović	petar.c89@gmail.com	Associate professor
8.	Sanja Stanković	sanjast2013@gmail.com	Assistant professor

COURSE STRUCTURE:

Module	**Module name**	**Weeks**	**Lectures**	**Practice**	**Teacher-module instructor**
1	Enzymology. Energy metabolism 1 – carbohydrates.	6	6	5	Prof. dr Marina Mitrović
2	Energy metabolism 2 – ROS; lipids. Energy metabolism 3 – nucleic acids and proteins.	5	6	5	Prof. dr Ivana Nikolić
3	Biochemistry of hormones, organs, tissues, integrative metabolism, and interpretations of biochemical parameters	4	6	5	Prof. Dr Milan Zarić
					Σ90+75=165

EVALUATION:

The student receives the final grade of the course by passing activities and tests during the course of the modules and taking the final exam. The grade is equivalent to the number of points earned (see tables). Points are earned in two ways:

ACTIVITIES AND FINAL TEST BY MODULE DURING THE TEACHING LESSONS: In this way, the student can gain up to 61 points:

A. ACTIVITIES: During the practice, the student answers two exam questions from that week of teaching classes and can earn 0-2 points. In this way, the student can gain up to 30 points. In order to pass the activity during the lesson, the student must obtain more than 50% of the points.

B. FINAL TESTS BY MODULE: In this way, the student can gain a total of up to 31 points:

- Up to 12 points on the first final test of the module
- Up to 11 points on the second final test of the module, and
- Up to 8 points on the third final test of the module.

In order to pass each of the final tests of the module, the student must obtain more than 50% of the points.

FINAL WRITTEN EXAM:

In this way, the student can gain up to 39 points by answering one question from three different modules, each question evaluated from 0-13 points. In order to pass the final test, the student must obtain more than 50% of the points.

MODULE		**FINAL GRADE**			
		ACTIVITY	**FINAL TEST BY MODULE**	**FINAL EXAM**	**Σ**
1	Enzymology. Energy metabolism 1 – carbohydrates.	12	12	13	37
2	Energy metabolism 2 – ROS; lipids. Energy metabolism 3 – nucleic acids and proteins.	10	11	13	34
3	Biochemistry of hormones, organs, tissues, integrative metabolism, and interpretations of biochemical parameters	8	8	13	29
Σ		**30**	**31**	**39**	**100**

THE FINAL GRADE IS FORMED AS FOLLOWS:

In order to pass the course, the student must obtain a minimum of 51 points; pass activities, pass final tests by module and pass the final exam (test).

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

FINAL TESTS BY MODULE

MODULE 1.

FINAL TEST
0-12 points

EVALUATION OF FINAL TEST
The test contains 24 questions
Each question is worth 0,5 points

MODULE 2.

FINAL TEST
0-11 points

EVALUATION OF FINAL TEST
The test contains 22 questions
Each question is worth 0,5 points

MODULE 3.

FINAL TEST
0-8 points

EVALUATION OF FINAL TEST
The test contains 16 questions
Each question is worth 0,5

LITERATURE:

Name of the textbook	authors	publisher	library
Marks' Basic Medical Biochemistry: A Clinical Approach 2nd Edition	Colleen M. Smith (Author), Allan D. Marks (Author), Michael A. Lieberman (Author), Dawn B. Marks (Author), Matthew Chansky	Lippincott Williams & Wilkins January 1, 2004	Electronic format
Biochemistry, 4th edition	Reginald H. Garrett, Charles M. Grisham	Mary Finch, 2010	Electronic format
Harper's Illustrated Biochemistry, Twenty-Sixth Edition	Robert K. Murray, MD, PhD Daryl K. Granner, MD Peter A. Mayes, PhD, DSc Victor W. Rodwell, PhD	Lange Medical Books/McGraw-Hill Medical Publishing Division, 2003	Electronic format
Medical Biochemistry. 5th edition.	Baynes JW, Dominiczak MH.	Philadelphia: Elsevier; 2018.	Electronic format

The presentations for teaching lectures and accompanying documents in Word can be found on the website of the Faculty of Medical Sciences:www.medf.kg.ac.rs

Course units:

FIRST MODULE: ENZYMOLOGY. ENERGY METABOLISM 1 – CARBOHYDRATES.

TEACHING UNIT 1:

INTRODUCTION TO BIOCHEMISTRY; ENZYMOLOGY

Lecture - 6 classes	Practice -5 classes
Introduction to Biochemistry: **Introductory lecture**: introduction to biochemistry, biochemical organization of cells, and subcellular organelles.Water and bond types, hydrogen bond, concept of hydrophilicity and hydrophobicity. **Enzymology:** Chemical nature of enzymes, general principle and action of enzymes, kinetics of enzyme activity.	**Introduction to Biochemistry:** **Introductory lecture:** introduction to biochemistry, biochemical organization of cells, and subcellular organelles.Water and bond types, hydrogen bond, concept of hydrophilicity and hydrophobicity**.** **Enzymology:** Chemical nature of enzymes, general principle and action of enzymes, kinetics of enzyme activity.

TEACHING UNIT 2:

REGULATION OF ENZYME ACTIVITY; CLINICAL ENZYMOLOGY

Lecture - 6 classes	Practice -5 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:

VITAMINS AND COENZYMES

Lecture - 6 classes	Practice -5 classes
Enzymology: Biochemistry of vitamins, hydrosoluble and liposoluble vitamins, enzyme cofactors, cosubstrates, and prosthetic groups**.**	**Enzymology:** Biochemistry of vitamins, hydrosoluble and liposoluble vitamins, enzyme cofactors, cosubstrates, and prosthetic groups.

TEACHING UNIT 4:

GLYCOLYSIS. HEXO-MONOPHOSPHATE PATHWAY. OXIDATIVE DECARBOXYLATION OF PYRUVATE

Lecture - 6 classes	Practice -5 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

TEACHING UNIT 5:

KREBS CYCLE. OXIDATIVE PHOSPHORYLATION

Lecture - 6 classes	Practice -5 classes
Krebs cycle. Oxidative phosphorylation. Metabolism, anabolic and catabolic processes. Sources and fate of acetyl-CoA and the Krebs cycle. Oxido-reduction processes, energy-rich compounds, respiratory chain, synthesis of ATP.	**Krebs cycle. Oxidative phosphorylation.** Metabolism, anabolic and catabolic processes. Sources and fate of acetyl-CoA and the Krebs cycle. Oxido-reduction processes, energy-rich compounds, respiratory chain, synthesis of ATP**.**

TEACHING UNIT 6:

CARBOHYDRATES: GLUCOSE AND GLYCOGEN

Lecture - 6 classes	Practice -5 classes
Carbohydrate metabolism: Glycogen metabolism - glycogenolysis and glycogenesis. Gluconeogenesis.	**Carbohydrate metabolism:** Glycogen metabolism - glycogenolysis and glycogenesis. Gluconeogenesis**.**

SECOND MODULE: ENERGY METABOLISM 2 – ROS; LIPIDS. ENERGY METABOLISM 3 – NUCLEIC ACIDS AND PROTEINS.

TEACHING UNIT 7:

ROS AND ANTIOXIDANT PROTECTION

Lecture - 6 classes	Practice -5 classes
ROS and antioxidant protection. The mechanism of formation of reactive oxygen species. Biomacromolecule damage mediated by ROS action. Antioxidants and antioxidant protection.	**ROS and antioxidant protection.** The mechanism of formation of reactive oxygen species. Biomacromolecule damage mediated by ROS action. Antioxidants and antioxidant protection.

TEACHING UNIT 8:

LIPID METABOLISM

Lecture - 6 classes	Practice -5 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 triacylglycerols.	**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 triacylglycerols.

TEACHING UNIT 9:

CHOLESTEROL AND LIPOPROTEINS

Lecture - 6 classes	Practice -5 classes
Cholesterol and lipoproteins: Synthesis of cholesterol, bile acids, and complex phospholipids. Transport of lipids - lipoproteins of blood plasma.	**Cholesterol and lipoproteins:** Synthesis of cholesterol, bile acids, and complex phospholipids.Transport of lipids - lipoproteins of blood plasma. .

TEACHING UNIT 10:

NUCLEIC ACIDS METABOLISM

Lecture - 6 classes	Practice -5 classes
Nucleic acids: Catabolism and anabolism of nucleotides and nucleic acids; purine and pyrimidine metabolism.	**Nucleic acids:** Catabolism and anabolism of nucleotides and nucleic acids; purine and pyrimidine metabolism.

TEACHING UNIT 11:

AMINO ACIDS AND PROTEINS METABOLISM

Lecture - 6 classes	Practice -5 classes
Amino acids and proteins: 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:** 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 INTERPRETATIONS OF BIOCHEMICAL PARAMETERS

TEACHING UNIT 12:

BIOCHEMISTRY OF HORMONES

Lecture - 6 classes	Practice -5 classes
Biochemistry of hormones: chemical structure, synthesis, transport, mechanism of action.	**Biochemistry of hormones:** chemical structure, synthesis, transport, mechanism of action

TEACHING UNIT 13:

METABOLISM OF WATER AND ELEMENTS; TISSUES

Lecture - 6 classes	Practice -5 classes
Metabolism of water and elements. Metabolism water and elements, inorganic substances – minerals; Tissues; Liver.	**Metabolism of water and elements.** Metabolism water and elements, inorganic substances – minerals; Tissues; Liver.

TEACHING UNIT 14:

INTEGRATIVE METABOLISM

Lecture - 6 classes	Practice -5 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

TEACHING UNIT 15:

INTERPRETATIONS OF BIOCHEMICAL PARAMETERS.

Lecture - 6 classes	Practice -5 classes
Clinical and laboratory interpretations of biochemical parameters.	Clinical and laboratory interpretations of biochemical parameters.

WEEKLY COURSE SCHEDULE

COURSE	WEDNESDAY	FRIDAY
MEDICAL BIOCHEMISTRY (6+5)	**LECTURES** **13:00 - 16:00** (R9-2) **PRACTICE** **16:15 - 19:15** (R9-2)	**LECTURES** **16:00 - 17:30** (R9-2) **PRACTICE** **17:30 - 18:15** (R9-2)

Module	week	type	Unit name	Teacher
1	1	**L**	INTRODUCTION TO BIOCHEMISTRY. ENZYMOLOGY	Prof. dr Marina Mitrović
1	1	**P**	INTRODUCTION TO BIOCHEMISTRY. ENZYMOLOGY	Prof. dr Marina Mitrović
1	2	**L**	REGULATION OF ENZYME ACTIVITY; CLINICAL ENZYMOLOGY	Prof. dr. Marija Andjelković
1	2	**P**	REGULATION OF ENZYME ACTIVITY; CLINICAL ENZYMOLOGY	Prof. dr. Marija Andjelković
1	3	**L**	VITAMINS AND COENZYMES	Prof. dr Marina Mitrović
1	3	**P**	VITAMINS AND COENZYMES	Prof. dr Marina Mitrović
1	4	**L**	GLYCOLYSIS. HEXO-MONOPHOSPHATE PATHWAY. OXIDATIVE DECARBOXYLATION OF PYRUVATE	Prof. dr Ivana Nikolić
1	4	**P**	GLYCOLYSIS. HEXO-MONOPHOSPHATE PATHWAY. OXIDATIVE DECARBOXYLATION OF PYRUVATE	Prof. dr Ivana Nikolić

module	week	type	Unit name	teacher
1	5	**L**	KREBS CYCLE. OXIDATIVE PHOSPHORYLATION	Prof. dr Ivana Nikolić
1	5	**P**	KREBS CYCLE. OXIDATIVE PHOSPHORYLATION	Prof. dr Ivana Nikolić
1	6	**L**	GLYCOGENESIS. GLYCOGENOLYSIS. GLUCONEOGENESIS	Prof. dr Milan Zarić
1	6	**P**	GLYCOGENESIS. GLYCOGENOLYSIS. GLUCONEOGENESIS	Prof. dr Milan Zarić
2	7	**L**	ROS. ANTIOXIDANTS	Prof. dr Ivanka Zelen
2	7	**P**	ROS. ANTIOXIDANTS	Prof. dr Ivanka Zelen
2	8	**L**	LIPID METABOLISM	Prof. dr Ivanka Zelen
2	8	**P**	LIPID METABOLISM	Prof. dr Ivanka Zelen
2	9	**L**	CHOLESTEROL AND LIPOPROTEINS	Prof. dr Milan Zarić

module	week	type	Unit name	teacher
2	9	**P**	CHOLESTEROL AND LIPOPROTEINS	Prof. dr Milan Zarić
2	10	**L**	NUCLEIC ACIDS METABOLISM	Prof. dr Sanja Stanković
2	10	**P**	NUCLEIC ACIDS METABOLISM	Prof. dr Sanja Stanković
2	11	**L**	AMINO ACIDS AND PROTEINS METABOLISM	Prof. Dr. Petar Čanović
2	11	**P**	AMINO ACIDS AND PROTEINS METABOLISM	Prof. Dr. Petar Čanović
3	12	**L**	BIOCHEMISTRY OF HORMONES	Prof. Dr Marija Andjelković
3	12	**P**	BIOCHEMISTRY OF HORMONES	Prof. Dr Marija Andjelković
3	13	**L**	METABOLISM OF WATER AND ELEMENTS; TISSUES	Prof. Dr. Petar Čanović

module	week	type	Unit name	teacher
3	13	**P**	METABOLISM OF WATER AND ELEMENTS; TISSUES	Prof. Dr. Petar Čanović
3	14	**L**	INTEGRATIVE METABOLISM	Prof. dr Marijana Stanojević Pirković
3	14	**P**	INTEGRATIVE METABOLISM	Prof. dr Marijana Stanojević Pirković
3	15	**L**	CLINICAL AND LABORATORY INTERPRETATIONS OF BIOCHEMICAL PARAMETERS.	Prof. dr Marijana Stanojević Pirković
3	15	**P**	CLINICAL AND LABORATORY INTERPRETATIONS OF BIOCHEMICAL PARAMETERS	Prof. dr Marijana Stanojević Pirković

Questions for the final exam:

A (one question is drawn) – From the first module

1. Water and types of chemical bonds. 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. Polysynthetic 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 B12 and folic acid.
18. Enzyme complexes of the respiratory chain.
19. ATP synthase, synthesis, and the release of newly synthesized ATR from mitochondria. P/O ratio in the respiratory chain.
20. Free radicals. Oxygen free radicals (reactive oxygen species).
21. Places of production of oxygen free radicals. Tissue damage caused by free radicals (ROS).
22. Nitrative stress
23. Enzymatic antioxidants
24. Non-enzymatic antioxidants
25. Digestion and absorption of carbohydrates
26. Glycolysis: phases, reactions, regulation, energy balance
27. Pentose phosphate pathway
28. Glycogenesis
29. Glycogenolysis
30. Gluconeogenesis
31. Oxidative decarboxylation of pyruvate
32. Krebs cycle

B (one question is drawn) – From the second module
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. Catabolism of nucleic acids and nucleotides. Catabolism of AMP and GMP
11. Catabolism of nucleic acids and nucleotides. Catabolism 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.

C (one question is drawn) – From the third module

1. Types of hormones and their basic characteristics
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 fed and absorptive state
15. State of starvation (fasting)
16. Diabetes mellitus. Hypoglycemia
17. Non-protein nitrogen compounds
18. Acute phase reactants
19. Hyperbilirubinemia
20. Proteinuria