COURSE IN BIOCHEMISTRY FOR STUDENTS OF FACULTY OF MEDICINE
DEPARTMENT OF BIOCHEMISTRY

The name of Unit in which the subject is realized:
Department of Biochemistry

Head:
Prof. Dariusz Chlubek M.D., Ph.D.

Total hours:
190 hours include:
40 h of lectures
150 h of classes

ECTS:

FORMS OF ACTIVITIES

Written knowledge tests are carried out regularly during the lessons. Students who are unprepared for the theoretical part of the lesson are not admitted to the written test.

The written tests consist of 6 questions. The time granted for answering the questions depends on the type of the questions. 5 minutes are given for essay questions and 2 minutes for choice questions (single-choice tests). A written test cannot last longer than 30 minutes. The credits for a lesson depend on the number of points obtained. For an answer to an essay question, students can obtain 0, 0.5 or 1 point, for a choice question 0 or 1 point. In order to pass a lesson, students have to obtain over 50% of the total achievable points. The points are converted into grades, half points (0.5 points) are not added up. Failing grades obtained during the current lessons are not included in the average semester and year grades, since it is possible to improve failing grades during the re-sits at the end of each semester. In order to receive the credits for a semester it is necessary to achieve an average grade of at least 3.0. The final assessment period is the academic year. The average yearly grade is the sum of all the grades obtained in the lessons in both semesters divided into the number of these grades.

Re-sits are held at the end of each semester, but they are not compulsory. Only fail grades received during the regular lessons can be improved. The grades received during the re-sits, also fail grades, are included in the average grade for the semester and the year. The last possibility to compensate missing credits is to take voluntary credit tests in order to qualify for the final examination. These credit tests take place in the form of written essays including the material from all the lessons in the semester, for which the student did not receive an average grade of at least 3.0. In order to qualify for the final examination, the student has to achieve over 50% of correct answers.

The first examination in biochemistry is a single-choice test. The second takes place in the form of an essay. The third is an oral examination conducted by the director of the department. On request of the director of the department or of the students taking the third examination, the examination can be taken before a board. In order to pass the first and second examination in biochemistry, the students have to achieve at least 60% of correct answers.

Students who receive the minimum result in the first and second examination can take an additional oral examination with the director of the department within 1-2 days from

the date of the examination, on condition they have an average yearly grade of at least 3.5 or average semester grades of at least 3.0.

PROGRAM OF BIOCHEMISTRY

Winter semester

1. **Introduction.**
   Rules and regulations in the biochemistry department. Significance of biochemistry in medical sciences.

2. **Proteins: molecular structure, functions.**
   Biomedical significance of amino acids and peptides. Classification and nomenclature of peptides. Biomedical significance of proteins. Classification of proteins. The orders of protein structure. Forces stabilizing protein structures: weak and strong bonds. Properties of proteins. Isoelectric point of protein. Methods of protein separation. Protein functions in the body.

3. **Nucleic acids and protein biosynthesis.**
   Structure, function and replication of informational macromolecules. Significance of phosphorylated nucleosides. Metabolism of purine and pyrimidine nucleotides. Organization and replication of DNA. Classes of RNA. Synthesis, processing and modification of RNA. Features of the genetic code. Genetic mutations and their consequences. Protein biosynthesis: initiation, elongation and termination. Posttranslational modifications.

4. **Enzymes – general properties, kinetics.**
   Biomedical importance of enzymes. Classification and nomenclature of enzymes. Coenzymes and prosthetic groups. Biochemical catalysis. The concept of transition state. Specificity of enzymes. Isoenzymes: properties and clinical significance. Functional and nonfunctional plasma enzymes. The rate of enzymatic reaction. The kinetics of enzymatic catalysis. Active site and allosteric site: structure and significance. Inhibition of enzymatic reaction: competitive and noncompetitive inhibitors. Enzyme poisons.

5. **Enzymes – mechanism of action, regulation of activities.**
   Significance of metal ions in substrate binding and in catalysis. Metalloenzymes and metal-activated enzymes. Regulation of enzyme quantity. Compartmentation of enzymes. Constitutive and induced enzymes. Allosteric efectors. Feedback inhibition and feedback regulation. Covalent modifications of enzymatic activity.

6. **Dietary proteins. Protein digestion and absorption.**
   Biological value of protein. Nitrogen balance. Digestion of dietary proteins. Production and secretion of HCl. Proteolytic enzymes: endopeptidases and exopeptidases. Zymogens – mechanism of activation. Absorption of amino acids.

7. **Plasma proteins. Immunoglobulins.**

Biomedical importance of plasma proteins. Classification and functions of plasma proteins. Specific and nonspecific transporters. Oncotic pressure in physiology and pathology. Acute phase proteins. Immunoglobulins: classification, structure, properties and functions.

8. **Biosynthesis of the nutritionally nonessential amino acids. Conversion of amino acids to specialized products.**
   Nutritionally essential and nonessential amino acids. Biomedical importance of nonessential amino acids. Biosynthetic pathways of nonessential amino acids. Specialized products of amino acid metabolism.

9. **Catabolism of the carbon skeletons of amino acids.**
   Biochemical pathways of catabolism of particular amino acids. Conversion of amino acids to substrates of carbohydrate and lipid metabolism. Metabolic disorders of amino acid catabolism.

10. **Catabolism of amino acid nitrogen.**
    Deaminations, deamidations and transaminations. Formation of ammonia in the body: reactions and tissue localization. Cellular mechanisms of ammonia detoxification. The urea cycle. Metabolic disorders of the urea cycle. The alanine-glucose cycle.

11. **Biologic oxidation. The citric acid cycle. The respiratory chain.**
    Biomedical importance of the energy production and storage in the cell. Reactions of the citric acid cycle. Regulation and energy balance of the citric acid cycle. Characterization of oxidoreductases. Free radical reactions. Reactive oxygen species. The respiratory chain members. Inhibitors of the respiratory chain. Uncouplers. Oxidative phosphorylation.

12. **Biochemistry of the kidney. Creatinine in plasma and urine –** practice
13. **Glucose tolerance test** – practice
14. **Re-sits:** No 7, 8, 9, 10, 11
15. **Re-sits:** No 2, 3, 4, 5, 6

Summer semestr

16. **Acid – base balance. Part 1.**
    Henderson-Hasselbalch equation. Buffers of physiologic significance. Partial pressure of carbon dioxide. Respiratory regulation of acid-base balance.

17. **Acid – base balance. Part 2.**
    Renal regulation of acid-base balance. Recovery of filtered bicarbonate. Generation of new bicarbonate. Ammoniagenesis in the kidney. Quantitation of acid excretion. Plasma potassium concentration. Acid-base disturbances.

18. **Carbohydrates of physiologic significance. Metabolism of glycogen.**
    Classification of dietary carbohydrates. Glucose as the most important monosaccharide. Digestion of dietary saccharides. Absorption of monosaccharides. Synthesis of glycogen: glycogenesis. Degradation of glycogen: glycogenolysis.

Metabolic and hormonal regulation of glycogen metabolism in the liver and muscle. Glycogen storage diseases.

19. Metabolism of glucose.

Synthesis of glucose: gluconeogenesis. Gluconeogenic substrates. The Cori cycle. The alanine-glucose cycle. Metabolic and hormonal regulation of gluconeogenesis. Control of blood glucose in well-fed state and in starvation. Glucose oxidation: glycolysis. Metabolic and hormonal regulation of glycolysis. Significance of glycolysis in aerobic and anaerobic conditions. Decarboxylation of pyruvate and its regulation.

20. The pentose phosphate pathway. Other pathways of hexose metabolism.

Physiologic significance of the pentose phosphate pathway. Reactions of the pentose phosphate pathway and their regulation. NADPH generation in the pentose phosphate pathway. The uronic acid pathway and its significance. Metabolism of fructose. Metabolism of galactose.

21. Overview of glucose metabolism.

Absorptive and postabsorptive state. Transport of glucose to the cell. Insulin-dependent and insulin-independent tissues. Role of the liver, adipose tissue, erythrocytes, muscle and kidney in glucose metabolism. Hyperglycemia, hypoglycemia and glucosuria. Biochemical symptoms of diabetes mellitus.

22. Lipids of physiologic significance. Lipid digestion and absorption.

Classification of lipids. Dietary lipids and their physiologic significance. Lipid digestion. Pancreatic lipase and other lipases. Emulsification and formation of mixed micelles. Role of bile salts in lipid digestion and absorption. Monoacylglycerol pathway.

23. Lipid transport and storage. Lipoproteins.

Classification and structure of lipoproteins. Metabolism of chylomicrons and VLDLs. Role of the liver and the adipose tissue in lipoprotein metabolism. Intravascular and intracellular lipolysis. Hepatic conversion of glucose to lipds. Down-regulation of LDL-receptor. Reverse cholesterol transport.

24. Metabolism of fatty acids.

Synthesis of fatty acids: lipogenesis. Regulation of lipogenesis. Oxidation of fatty acids: β-oxidation and its regulation. Ketogenesis. Ketonemia and ketonuria. Ketoacidosis.

25. Overview of fatty acid metabolism.

Role of the adipose tissue in lipid metabolism. The synthesis of triacylglycerols and its regulation. Metabolism of fatty acids in the well-fed state and in starvation. Metabolism of acylglycerols and phospholipids.

26. Hormonal regulation of carbohydrate and lipid metabolism. Insulin and glucagon.

Insulin: molecular structure, synthesis, secretion and biodegradation. Metabolic and hormonal regulation of insulin secretion. Glucagon: structure, synthesis and secretion. Physiologic activity of insulin and glucagon.

27. Metabolism of cholesterol and bile acids.

Dietary sources of cholesterol. Regulation of cholesterol absorption. Biosynthesis of cholesterol and its regulation. Role of the liver in cholesterol metabolism. Catabolism of cholesterol. Primary and secondary bile acids. Enterohepatic circulation of bile acids.

28. Steroid hormones.

Choletserol as a precursor of steroid hormones. Classification of steroid hormones. Synthesis of steroid hormones in adrenal cortex and in gonads. Metabolic activity of steroid hormones.

29. Porphyrins and bile pigments. Metabolism of iron.

Biosynthesis of prophyrins. Hemoproteins. Synthesis of heme. Degradation of heme – bilirubin. Hepatic and intestinal metabolism of bilirubin. Stercobilinogen and urobilinogen. Hyperbilirubinemias. Dietary sources of iron. Iron absorption and its transport in plasma. Transferrin, ferritin and total iron binding capacity.

30. Bichemistry of the liver.

Central role of the liver in protein, carbohydrate and lipid metabolism. Hepatic detoxifications. Metabolism of xenobiotics in the liver.

31. The vitamins.

Classification of vitamins. Water-soluble and lipid-soluble vitamins. Metabolism of vitamins. Metabolic disorders caused by vitamin deficiency. Toxic effects of vitamins.

32. Metabolism of calcium and osseous tissue – practice
33. Indicators of cholestasis – practice
34. Re-sits: No 27, 28, 29, 30, 31
35. Re-sits: No 22, 23, 24, 25, 26
36. Re-sits: No 16/17, 18, 19, 20, 21
37. The final re-sit (qualification to the exam)

Textbook:

Murray R.K., Granner D.K., Rodwell V.W.:
Harper's illustrated biochemistry, 27th edition. Lange