BIOCHEMISTRY CURRICULUM

The curriculum has been adopted at the meeting of the Faculty Council № 41/08.07.2020

Annotation of the academic discipline

The Medical Biochemistry course for pharmacy students provides the opportunity of acquiring knowledge and expertise in the molecular organization of the living matter. The structure and function of biopolymers, enzymology, bioenergetics, metabolism, molecular biology and genetics, molecular pathology, the specifics of exchange and disruptions in the various tissues and organs are studied in detail so students are prepared to perform professional capabilities in different pharmaceutical areas.

Main objectives of the study programme

The Medical Biochemistry course is a compulsory fundamental module of the Master's degree in Pharmacy. Students are required to accomplish the following tasks:

1. Students should gain detailed knowledge of important facts, principles and theories in the field of Medical Biochemistry;

1.1. Students should learn the content, structure and functions of cellular components, the chemical reactions and processes taking place in the cells and their regulation. Students should understand the significance of cells for the organism under normal and pathological conditions and they should find out examples of putting theory into clinical practice;

1.2. Students should know the rational fundamentals of nutrition during the various stages of growth and development;

1.3. Students should learn the basic principles of chemotherapy in terms of destroying pathological cells of choice, neutralizing toxins and replacement of missing components;

1.4. Students should be able to apply laboratory biochemical methods and to use technical facilities which enable diagnosis and screening of diseases on the basis of chemical content alterations in blood, urine and other body fluids. Students should also succeed in interpreting experimental and clinical results.

1.5. Students should acquire skills needed for the application of information and communication technology in the field of biomedical sciences. They should be able to search information via specialized literature resources.

2. Students are provided with the possibility of self-assessment and assessment of the theoretical knowledge through interactive tests.

3. Students are expected to pass from a passive to an active form of critically oriented learning – i.e. the knowledge acquired is used to solve interactive web-based computer-simulated cases.

Lectures Vth semester

Lecture №1

Introduction to Medical Biochemistry. Objectives and scope of the Medical Biochemistry. Contribution of biochemical studies to diagnosis, prognosis and treatment of a disease. Examples: galactosemia and myocardial infarction. General characteristics of biopolymers. Role and importance of proteins. Classification of amino acids. Characteristics of the peptide bond.

Lecture №2

Levels of organization of protein molecules. Charge properties of the amino acids. Methods for protein

analysis. Principles of electrophoresis and chromatography. Nucleic acids. Types and biological role. Chemical composition and bonds. Free nucleotides. Importance. Polynucleotide chains of DNA and RNA. Conformation. Methods for DNA and RNA analysis. Electrophoresis. Clinical cases.

Lecture №3

Chemical nature of enzymes. Co-enzymes and prosthetic groups. Enzyme classification. Mechanism of enzyme catalysis. Enzyme-substrate complex. Active site. Specificity of enzyme action. Enzyme kinetics. Michaelis-Menten equation. Enzyme units. Determination of V_{max} and K_m constants using Lineweaver-Burk equation. Kinetic characteristics of phosphoribosyl pyrophosphate synthetase in some cases of gout. Increased sensitivity to ethanol as a result of increased K_m of alcohol dehydrogenase. Effect of pH and temperature on the velocity of the enzyme catalyzed reactions. Changes in the pH optimum of alcohol dehydrogenase. Competitive and non-competitive inhibitors. Activators. Transformation of pre-enzymes into active enzymes. Antimetabolites.

Lecture №4

Allosteric regulation. Cases of gout as a result of a lost allosteric sensitivity. Orotic aciduria. Enzyme regulation through covalent modifications. Signaling cascade regulation of glycogen phosphorylase and glycogen synthase. Clinical significance of enzymes. Isoenzymes. Restrictases. Enzymes as therapeutics in treating myocardial infarction.

Metabolism. Characteristics of living organisms as an open system. Compartmentalization of metabolic processes, types and biological role.

Lecture №5

Principals of bioenergetics. Coupling of exergonic and endergonic reactions in living cells. Macroergic compounds. Central role of ATP/ADP system. Substrates of biological oxidation and final acceptors of hydrogen atoms. Oxido-reductases. Important redox systems. Oxidative phosphorylation at substrate level. Beri beri.

Respiratory chain – localization, function and molecular organization. Places of proton translocation. Co-efficient of oxidative phosphorylation. Respiratory control, phosphate potential. Inhibitors of the electron transport and the oxidative phospholylation. Chemiosmotic theory of Mitchel. ATP synthase. Uncoupling agents. Free oxidation. Thermogenesis. Role of thermogenin in the brown adipose tissue. Short electon transport chains in the ER. Generation and removal of ROS.

Lecture №6

Citric acid cycle – biological role, chemistry, regulation. Energy balance. Pyruvate dehydrogenase deficiency.

Carbohydrates metabolism. Glycolysis – importance, chemical reactions, energy balance in aerobic and anaerobic conditions, tissue specificity. Functional connections between glycolysis and respiration – shuttle mechanisms for hydrogen transfer from the cytoplasm to the mitochondria. Pasteur effect. Shuttle systems for transfer of hydrogen from cytosol into mitochondria. Lactic acidosis. Gluconeogenesis. Importance. Regulation. Deficiency in fructose 1,6-bisphosphatase activity.

Lecture №7

Pentose phosphate pathway. Importance. The oxidative reactions of the pathway. Transferase steps. Deficiency in glucose 6-phosphate dehydrogenase activity. Metabolism of galactose. Galactosemia. Metabolism of fructose. Fructose intolerance. Synthesis and degradation of glycogen. Clinical cases.

Lecture №8

Oxidation of fatty acids with an even and odd number of carbon atoms. Energy balance. Biosynthesis of fatty acids. Acyl synthase complex. Synthesis and degradation of triacylglycerols. Metabolism of glycerol. Types and metabolism of phosphoglycerides and sphingolipids. Sphingolipidoses. Metabolism of phospholipids. Ketone bodies, types, ketogenesis, ketolysis. Biological role and pathologies in Diabetes Mellitus.

Lecture №9

Metabolism of cholesterol. Biosynthesis and excretion from the body. Regulation. Derivatives of cholesterol: steroid hormones, vitamin D, bile acids. Transport of lipids. Composition, origin and function of lipoprotein complexes and their receptors. Atherosclerosis. Hypercholesterolemia.

Lecture №10

Metabolism of amino acid; oxidative deamination, transamination, transdeamination, decarboxylation. Biological amines. Detoxification of ammonia – urea cycle, synthesis of glutamine, and ammoniagenesis. Catabolism of the carbon skeletons of amino acids. Glycogenic and ketogenic amino acids. Essential and nonessential amino acids. One-carbon units. Role of S-adenosyl-L-methionine and derivatives of tetrahydrofolic acid in metabolism. Therapeutic application of folate analogs. Enzymopathies, related to the metabolism of aromatic and other amino acids. Parkinson's disease.

Lecture №11

Biosynthesis and degradation of purine and pyrimidine nucleotides. Regulation. Antimetabolites. Porphyrins. Biosynthesis of porphyrins and heme. Porphyrias. Degradation of hemoglobin. Bile pigments. Jaundice. Integration of metabolism. Links between metabolic pathways of carbohydrates, lipids, amino acids and nucleotides. Role of common metabolites and key enzymes.

Lecture №12

Information molecules. Biosynthesis of DNA. Mechanisms of replication. Chemical and physical agents influencing replication. Reparation, reparation systems, defects in reparation. Changes in genetic information. Mutations. Biosynthesis of different types of RNA – enzymatic mechanism. Processing of RNA. Defects in the processing of RNA, role. Genetic code – characteristics. Biosynthesis of proteins – initiation, elongation, termination. Regulation of gene expression in prokaryotes and in eukaryotes. Operon model. Inhibitors of protein biosynthesis.

Lecture №13

Recombinant DNA technologies. Identification of DNA sequences. Sanger sequencing method. Amplification of DNA – cloning and PCR. Application of recombinant DNA technologies in Medicine.

Lecture №14

Signal transduction through membranes. Molecular mechanisms of action of steroid hormones. Transduction systems for peptide hormones, growth factors and cytokines: second messengers, cAMP, protein kinase A, regulation of Glycogen phosphorylase and glycogen synthase. Kinase cascades as second messengers.

Lecture №15

Molecular mechanisms of diabetes mellitus. Prognosis in type I and type II diabetes mellitus. Pathobiochemistry of diabetes mellitus and its complications.

Biochemistry of digestion. Chemical composition and enzymes of the digestive fluids. Degradation of food and uptake of the digested food.

Exercises Vth semester - 45 academic hours (15 exercises in 3 academic hours)

Practical exercise № 1

Proteins – importance, amino acid composition, classification of amino acids. Primary, secondary, tertiary and quaternary structure of proteins. Denaturation and renaturation. Prion diseases.

Practical exercise № 2

Charge properties of amino acids and proteins. Electrophoresis. Electrophoretic profiles of serum proteins. Structure and function of nucleic acids. Sickle-cell anemia and phenylketonuria – examples of molecular diseases.

Practice - Web-based simulation of a clinical case "Sandra".

Practical exercise № 3

Enzymes – structure, specificity and mechanism of action. Coenzymes and prosthetic groups. Nomenclature and classification of the enzymes. Michaelis-Menten equation. Michaelis constant. Units for enzyme activity. Lineweaver-Burk equation.

Practical exercise № 4
Effect of pH and temperature on the velocity of the enzyme-catalyzed reaction. Inhibitors and activators. Regulation of enzyme activity. Importance of enzymes for the clinical practice. Isoenzymes.
Practice - Web-based simulation of a clinical case "Vassil".

Practical exercise № 5
BIOPOLYMERS (PROTEINS AND NUCLEIC ACIDS) AND ENZYMES: SEMINAR WITH FINAL MARK (written problems and oral discussion)

Practical exercise № 6
Principles and characteristics of biological oxidation. High-energy compounds. Central role of ATP-ADP system. Important redox-systems. Respiratory chain – localization, function and molecular organization. Inhibitors of electron transfer. Uncoupling agents. Heat production. Electron transfer in the endoplasmic reticulum.
Practice - Web-based simulation of a clinical case "Ivo and Stanoy".

Practical exercise № 7
Glycolysis – importance, chemical reactions, energy balance at anaerobic and aerobic conditions, tissue specificity. Malate and glycerol phosphate shuttles for transfer of hydrogen. Regulation of glycolysis. Citric acid cycle - chemical reactions, metabolic and energy balance. Pyruvate dehydrogenase complex. The pentose phosphate pathway – importance, chemical reactions . Glucose-6-phospate dehydrogenase deficiency.
Practice - Quantitative determination of glucose with test strip on Reflotron**.**

Practical exercise № 8
Gluconeogenesis – importance, chemical reactions, energy balance, regulation. The Cori cycle. Glycogen – structure, hydrolytic and phosphorolytic degradation, synthesis. Regulation of glycogenolysis and glycogen synthesis. Glycogen storage diseases. Metabolism of fructose and galactose. Diseases connected with the galactose and fructose metabolism.
Practice - Web-based simulations of clinical cases "Charley"and **"**Rumen"**.**

Practical exercise № 9
CARBOHYDRATE METABOLISM and BIOENERGETICS: SEMINAR WITH FINAL MARK (written problems and oral discussion)

Practical exercise № 10
Lipids – classification. Carnitine shuttle. Oxidation of fatty acids with even and odd number of carbon atoms. Fatty acid synthesis. Degradation and synthesis of triacylglycerols. Ketogenesis and ketolysis.
Practice - Quantitative determination of triglycerides with test strip on Reflotron**.**

Practical exercise № 11
Metabolism of cholesterol and the derivatives of cholesterol. Transport of lipids in the organism.
Practice - Quantitative determination of total cholesterol with test strip on Reflotron.
Web-based simulations of a clinical case "Vassil 2".

Practical exercise № 12

LIPID METABOLISM AND ITS LINKS WITH CARBOHYDRATE METABOLISM: SEMINAR WITH FINAL MARK (written problems and oral discussion)

Practical exercise № 13

General reactions of amino acid catabolism – oxidative deamination, transamination, transdeamination, decarboxylation. Biogenic amines. Urea cycle – importance, chemical reactions, links with the citric acid cycle. Glucose-alanine cycle. Metabolism of the carbon skeleton of the amino acids. One-carbon unit fragments. Role of folate derivatives in metabolism. Disorders in the amino acid metabolism.

Practice - Quantitative determination of GOT, GPT and urea with test strips on Reflotron. Web-based simulations of clinical cases "Marina".

Practical exercise № 14

Biosynthesis and degradation of purine and pyrimidine nucleotides. Regulatory enzymes. Gout. Orotic aciduria.

Practice - Quantitative determination of uric acid with test strip on Reflotron. Web-based simulation of a clinical case "Emil".

Practical exercise № 15

Hormones, growth factors, cytokines. Types of receptors. Signaling transduction systems – adenylate cyclase system, phosphoinositide system, mitogen activated protein kinase cascade, insulin transduction pathway, JAK-STAT signalling pathway, mechanisms of action of steroid hormones. Oncogenesis. Targeted therapy.

Evaluation of the average annual mark.

Legalization of the semester.

Syllabus for theoretical semester exam

1. Contemporary Biochemistry – basis for understanding of metabolism in health and disease. Subject, objectives and scope of Biochemistry. Relations between Biochemistry and other medical disciplines stimulates mutual advances. Contribution of biochemical studies to diagnosis, prognosis and treatment. Examples: galactosemia and myocardial infarction.
2. Proteins – biomedical importance, amino acid composition, classification of amino acids based on their chemical structure and polarity of the side chains. Covalent bonds and noncovalent interactions in protein molecules. Characteristics of polypeptide chains. Primary structure. Differences in the primary structure of hemoglobin A and S. Insulin and diabetes mellitus. Primary structure of insulin in different species.
3. Charge properties of amino acids and proteins. Electrophoretic techniques. Electrophoresis and densitometry of serum proteins - role for diagnosis. Chromatographic techniques. Methods for determination of the amino acid composition and primary structure. Phenylketonuria.
4. Secondary, tertiary and quaternary structure of proteins. Globular and fibrous proteins. Structure of hemoglobin (Hb). Glycated hemoglobin. Denaturation and renaturation. Sickle cell anemia. Prion diseases.
5. Relations between protein structure and function. Similarities in the structure of myoglobin and hemoglobin subunit, important for oxygen binding. Differences in oxygen dissociation curves for myoglobin and hemoglobin. Differences between HbA and HbF. Composition and structure of collagen type I. Changes in the structure of collagen in vitamin C deficiency.
6. Nucleic acids – types and biomedical importance. Chemical composition, chemical bonds in and between the nucleotides. Free nucleotides with important biological action. Characteristics of the polynucleotide chains. Purine and pyrimidine analogs as anticancer and antimicrobial agents.
7. Primary structure of RNA and DNA. Conformation of DNA. Sickle cell anemia and phenylketonuria – examples for molecular diseases. Conformation of different types of RNA. Electophoretic methods of analysis of DNA and RNA.

8. Chemical nature of enzymes. Co-enzymes and prosthetic groups. Nomenclature and classification. Mechanism of enzyme action. Concept for enzyme-substrate complex. Active cite. Enzyme specificity.
9. Enzyme kinetics. Michaelis-Menten equation (effect of the substrate concentration and enzyme concentration on the reaction rate). Units for enzyme activity. Evaluation of the kinetic parameters V_{max} and K_m via Lineweaver-Burk equation. Changes in V_{max} and K_m for phosphoribosyl pyrophosphate synthetase in cases of gout. Increased sensitivity to ethanol due to increased K_m of acetaldehyde dehydrogenase.
10. Effect of pH and temperature on the velocity of the enzyme-catalyzed reaction. Changes in the pH optimum of alcohol dehydrogenase. Regulation of enzyme activity. Competitive and noncompetitive inhibitors. Activators. Conversion of proenzymes into active enzymes.
11. Antimetabolites – competitive inhibitors towards substrates and cofactors. Examples: puromycin, acylguanosine (acyclovir), 3'-azido,3'-deoxytimidine (AZT), sulfonamide; methotrexate (ametopterin), allopurinol.
12. Allosteric regulation. Case of gout resulting from mutation in an allosteric site. Orotic aciduria. Phosphorylation and dephosphorylation – main regulatory mechanism in the cell. Protein kinases and protein phosphatases. Cascade for regulation of glycogen phosphorylase and glycogen synthase.
13. Importance of enzymes for the clinical practice. Isoenzymes. Electrophoresis of lactate dehydrogenase isoenzymes. Changes in non-functional plasma enzymes (in myocardial infarction and hepatitis). Changes in functional plasma enzymes. Genetically determined enzymopathies (cases of gout, Lesch-Nyhan syndrome). Restriction endonucleases. Enzymes in therapy (in myocardial infarction).
14. Structure of the animal cell – short overview. Compartmentalization of metabolic processes. Metabolic pathways – types and biomedical importance.

15. Living organisms as open chemical systems. Coupling of endergonic and exergonic processes via high-energy compounds. Definition and types of high-energy compounds. Central role of ATP/ADP system in energy transfer.

16. Characteristics of biological oxidation. Substrates of biological oxidation. Ultimate acceptors of hydrogen. Oxido-reductases. Important redoxsystems: $NAD^+/NADH+H^+$, $NADP^+/NADPH+H^+$, $FMN/FMN.H_2$, $FAD/FAD.H_2$, $CoQ/CoQ.H_2$, hemes of the cytochromes, lipoic acid, ascorbate.

17. Oxidative phosphorylation at substrate level. Synthesis of ATP coupled to oxidation of glyceraldehyde 3-phosphate, enolase reaction, oxidative decarboxylation of □-keto acids (pyruvate dehydrogenase complex, role of the cofactors TPP, lipoic acid, CoA, FAD and NAD^+). Beri-beri.

18. Respiratory chain – localization, function and molecular organization. Sites for proton translocation. Coefficient of oxidative phosphorylation (P/O). Respiratory control, phosphate potential. Inhibitors of electron transfer (barbiturates, antimycin A, KCN). Dangerous combination of barbiturates and alcohol.

19. Chemiosmotic theory for coupling of oxidation and phosphorylation in the respiratory chain. ATP synthase. Effect of uncouplers (2,4-dinitrophenol). Natural uncouplers. Inhibitors of the oxidative phosphorylation (oligomycin).

20. Free oxidation. Heat production. Role of thermogenin in mitochondria of brown adipose tissue. Electron transfer in the endoplasmic reticulum. Formation and detoxification of reactive oxygen intermediates (superoxide, H_2O_2 and free hydroxyl radical). Mitochondrial diseases.

21. Citric acid cycle - biomedical importance for catabolism and anabolism, chemical reactions, metabolic and energy balance. Mechanisms of regulation. Pyruvate dehydrogenase deficiency.

22. Glycolysis – biomedical importance, chemical reactions, energy balance at anaerobic and aerobic conditions. Metabolic fates of $NADH+H^+$, lactate and pyruvate. Tissue specificity of glycolysis. Relations between glycolysis and respiratory chains. Shuttle mechanisms for transfer of hydrogen from the cytosol into mitochondria: malate and glycerol phosphate shuttles. Links between glycolysis and citric acid cycle. Pasteur effect. Pyruvate kinase deficiency and hemolytic anemia. Lactic acidosis.

23. Gluconeogenesis - importance. Circumventing the irreversible steps in glycolysis. Regulation. Fructose 1,6-bisphosphatase deficiency.

24. The pentose phosphate pathway for catabolism of glucose (direct oxidative degradation). Biomedical importance. Chemical reactions – oxidative steps and transferase reactions. Glucose-6-phospate dehydrogenase deficiency.

25. Metabolism of fructose and galactose. Essential fructosuria. Fructose intolerance. Galactosemia.

26. Glycogenolysis. Role of cAMP. Glycogenesis. Regulation. Glycogen storage diseases. Regulation of blood glucose level. Role of different tissues and organs. The Cori cycle. Regulatory enzymes and hormones for carbohydrate metabolism.

27. Oxidation of fatty acids with even and odd number of carbon atoms. Energy balance.

28. Biosynthesis of fatty acids. Structure and function of multifunctional fatty acyl synthase.

29. Catabolism of fats. Metabolism of glycerol. Biosynthesis of triacylglycerols.

30. Metabolism of phosphoglycerols – catabolism and biosynthesis. Sphingolipids – types, structure and importance. Prostaglandins - types and biological role.

31. Ketogenesis. Utilization and oxidation of ketone bodies in extrahepatal tissues. Ketonemia and ketonuria. Ketoacidosis (in diabetes mellitus and in starvation).

32. Metabolism of cholesterol. Chemical reactions in the synthesis of cholesterol. Excretion of cholesterol. Regulation. Atherosclerosis.

33. Derivatives of cholesterol (steroid hormones, vitamin D, bile acids) – structure and biological role.

34. Transport of lipids in the organism. Lipoproteins - composition, origin and functions of chylomicrons and lipoprotein complexes (VLDL, LDL, HDL). Receptors for the lipoprotein complexes. Familial hypercholesterolemia.

35. General reactions of amino acid catabolism: oxidative deamination, transamination, transdeamination, decarboxilation. Biological amines. Parkison disease.

36. Detoxification of ammonia. Glutamine synthesis. Ammoniagenesis. Urea cycle.

37. Metabolism of the carbon skeleton of the amino acids. Glucogenic and ketogenic amino acids. Essential and nonessential amino acids.

38. One-carbon units – types, sources, importance. S-adenosyl-L-methionine. Role of folate derivatives in metabolism. Therapeutic application of folate analogs.

39. Metabolic disorders of aromatic amino acids catabolism (phenylketonuria, alkaptonuria, tyrosinemia, methylmalonic aciduria).

40. Biosynthesis and catabolism of purine nucleotides. Hyperuricemia due to enzyme defects (gout, Lesch-Nyhan syndrome).

41. Biosynthesis and catabolism of pyrimidine nucleotides. Orotic aciduria.

42. Biosynthesis of porphyrins. Types of porphyrias. Degradation of hemoglobin. Bile pigments. Types of Jaundice.

43. Integration of metabolism of carbohydrates, lipids, amino acids and nucleotides at molecular level. Role of common metabolites and key enzymes.

44. Biosynthesis of DNA. Replication and repair. Drugs that affect replication. Biosynthesis of RNA. Processing of RNA.

45. Structure and organization of prokaryotic and eukaryotic genes.

46. Genetic code. Biosynthesis of proteins. Inhibitors of protein synthesis.

47. Regulation of gene expression in prokaryotes and eukaryotes.

48. Molecular mechanisms of action of antibiotics, toxins and other chemicals on the synthesis of DNA, RNA and proteins.

49. Application of recombinant DNA technology in medicine.

50. Signal transduction through membranes. Types of molecular signals. Classification of hormones. Receptors.

51. Molecular mechanisms of hormone action. Hormones that bind to intracellular receptors.

52. Molecular mechanisms of hormone action. Hormones that bind to receptors on the cell surface. Example – effect on glycogen phosphorylase and glycogen synthase. Role of cyclic AMP and other second messengers. Kinase cascades as second messengers.

53. Diabetes mellitus – changes in metabolism in diabetes type I and type II. Diabetes type I as autoimmune disease. Mechanism of insulin action. Complications in type I and type II diabetes mellitus.

54. Biochemistry of nutrition. Chemical composition and enzymes in the digestive fluids - saliva, gastric, pancreatic, and intestinal fluid. Degradation of food and uptake of the digested food.

Academic literature:

Title, authors, publisher, ISBN, year of publication

1. Rodwell VW., Bender DA,. Botham KM., Kennely, PJ, Weil PA. Harper's Illustrated Biochemistry. McGraw-Hill Medical, 31sth ed., New York, US, 2018.

2. Ferrier D, Lippincott's Illustrated Reviews. Biochemistry, 7th ed., Lippincott Williams and Wilkins, Philadelhia, US, 2017.

3. Devlin, T. M. (ed.), Textbook of Biochemistry with Clinical Correlations, Wiley-Liss, 7th ed., New York, 2010.

List of schemes to be prepared

1. Formulas of the 20 amino acids of the proteins – end of first week
2. Part of polypeptide chain containing all the amino-acid residues – end of first week
3. Formulas of the AMP, GMP, TMP, UMP, CMP – end of second week
4. Part of DNA chain, containing AMP, GMP, TMP, CMP and part of RNA chain, containing AMP, GMP, TMP, CMP – end of second week

At the week, corresponding with the lecture:

5. Oxidative decarboxylation of pyruvate end enolase reaction
6. Oxidative phosphorylation of glyceraldehyde-3-P
7. Citric acid cycle
8. Respiratory chain with components, substrates and effectors;
9. Respiratory chain – asymmetric location of complexes I-IV and ATPase
10. Glycolysis
11. Malate and glycerophosphate shuttle systems for transport of hydrogen
12. Gluconeogenesis
13. Pentose phosphate pathway
14. Glycogenolysis
15. Synthesis of glycogen
16. Metabolism of galactose
17. Metabolism of fructose
18. Oxidation of fatty acid with even number of C-atoms
19. Oxidation of fatty acid with odd number of C-atoms
20. Synthesis of fatty acids
21. Ketogenesis in liver and oxidation of ketone bodies in extrahepatal tissues
22. Cholesterol synthesis
23. Atherosclerosis – 3 stages
24. Metabolism of acylglycerols
25. Metabolism of phosphoglycerols
26. Metabolism of sphingolipids
27. Metabolism of amino acids – deamination, transamination, transdeamination
28. Metabolism of amino acids – decarboxylation and formulas of biogenic amines
29. Detoxification of ammonia – synthesis of glutamate and glutamine
30. Degradation of the carbon skeletons of the amino acids - ketogenic and glucogenic aminoacids
31. Urea cycle
32. Conversion of amino acids to specialized products according to q. 36
33. One-carbon units
34. Water soluble vitamins – formulas and roles: B_1, B_2, PP, pantothenic acid, B_6, B_{12}, C, biotin, folate
35. Lipid-soluble vitamins – formulas and roles: A, D, E, K.
36. Signalling transduction systems - adenylate cyclase system, phosphoinositide system, mitogen activated protein kinase cascade, insulin transduction pathway, JAK-STAT signalling pathway.