Universidad Zaragoza

Academic Year/course: 2022/23

26703 - Human biochemistry

Syllabus Information

Academic Year: 2022/23
Subject: 26703 - Human biochemistry
Faculty / School: 104 - Facultad de Medicina
229 - Facultad de Ciencias de la Salud y del Deporte
Degree: 304 - Degree in Medicine
305 - Degree in Medicine
ECTS: 6.0
Year: 1
Semester: First semester
Subject Type: Basic Education
Module:

1. General information

2. Learning goals

3. Assessment (1st and 2nd call)

4. Methodology, learning tasks, syllabus and resources

4.1. Methodological overview

The learning process designed for this subject is based on the following:

- The activities programmed for the course are the same in the different groups at the School of Medicine in Zaragoza and the School for Health and Sport Sciences in Huesca.
- The course is composed of one-hour lectures, laboratory sessions, and seminars. Students will also have to carry out and present tutored reports.
- With regard to the lectures, the materials for each chapter will be available through the webpage dedicated to this subject in the ADD (University?s teaching website) (also at the Photocopying Service, depending on the professor) at least one week before the beginning of that chapter lectures, so that students can peruse it in advance.
- Seminars will be organized around 2 hour sessions and will be used to discuss the functional-structural properties of biomolecules.
- Laboratory sessions of two hours are taught in small groups of 15 students each. Student performance will be assessed through specific questionaires at the end of each session or to be included in the final test exam (10 questions).
- Students will write a brief essay on a question related to the main contents of Human Biochemistry. The activity will be carried out individually and under supervision of the teacher who selects the question. Competence on information synthesis, use of quality scientific repositories and of graphs to present information, will be evaluated.

4.2. Learning tasks

The course includes the following learning tasks:

- 1. Lectures (30 hours)

- 2. Seminars and clinical cases (4 hours)
- 3. Laboratory sessions (8 hours)
    - Students will be informed about the risks and hazards they may become exposed to in the laboratories, and about actions to be taken in case of an accident. Students will be asked to sign a consenting form binding them to follow security rules before they can take part in the laboratory sessions. Students can request more information from the Unit for Prevention of Labor Risks at http/uprl.unizar.es/estudiantes.html
- 4. Tutored reports (5 hours)
- 5. Tutorial sessions with professors of the subject (9 hours)
- 6. Evaluation (4 hours)
- 7. Autonomous students work (90 hours)

4.3. Syllabus

The course will address the following topics:

CHAPTER I: AMINO ACIDS AND PROTEINS

- Lecture 1. Amino acids, Structure, properties, and classification of proteinogenic amino acids. Stereochemistry. Acid-base properties of amino acids.
- Lecture 2. Proteins. Composition of proteins. Classification. Functional diversity of proteins. Primary structure. Peptide bond. Acid-Base properties of peptides. Peptides of biological interest.
- Lecture 3. Spatial conformation of proteins. Regular conformations of polypeptide chain: a-helix and b-sheet secondary structures. Collagen helix. Non-covalent forces determining and stabilizing the secondary structure.
- Lecture 4. Conformation of globular proteins: tertiary and quaternary structures. Myoglobin: structure. Heme group binding to protein and oxygen. Quaternary structure: hemoglobin. Types of hemoglobin. The tertiary structure of globins. Oxygen saturation curves for myoglobin and hemoglobin. Regulation of hemoglobin oxygenation. Bohr effect. Fetal and S hemoglobin. Thalassemias.
- Lecture 5. Enzymes. General properties of enzymes. Specificity. Classification and nomenclature. Distribution of enzymes. Isoenzymes. Enzymes in clinical diagnostics. Enzyme quantification.
- Lecture 6. Enzyme kinetics. Catalysis and enzyme mechanism of action. Enzyme kinetics: Michaelis-Menten equation and its transformations. Effects of pH, temperature and enzyme concentration in enzymatic reaction speed. Enzyme inhibitors.
- Lecture 7. Regulation of enzyme activity. Metabolic regulation. Induction, repression, and derepression. Proenzymes. Antienzymes. Feedback and covalent modification.
- Lecture 8. Vitamins. Hydrophilic vitamins and their roles as coenzymes. Structure and function. Lipophilic vitamins. Structure and function.

CHAPTER II: STORAGE AND USE OF GENETIC INFORMATION

- Lecture 9. Nucleic acids. Structure and properties of nucleosides and nucleotides. DNA structure: a double helix. DNA supercoiling. Topoisomerases. Chromatin structure. RNA: structure and types. Degradation of nucleic acids.
- Lecture 10. DNA replication. General characteristics of replication: semiconservative, bidirectional. Mechanisms for DNA replication in prokaryotes. Primosome and replisome. DNA reparation. Replication origin.
- Lecture 11. DNA transcription: RNA synthesis. Prokaryote transcription. Post-transcriptional modifications of rRNAs and tRNAs. Ribozymes.
- Lecture 12. Translation of genetic message: protein biosynthesis. The genetic code. Translation machinery: involved molecules. Activation and binding of amino acids to tRNA: aminoacyl tRNA synthetases. Prokaryote protein synthesis. Post-translational modifications. Differential characteristics os eukaryote protein synthesis. Inhibitors of protein synthesis.
- Lecture 13. Mitochondrial genetic system. Gene organization. Replication and transcription of mammal DNA. RNAs processing. Regulation of expression.

CHAPTER III: INTRODUCTION TO INTERMEDIARY METABOLISM

- Lecture 14. Intermediary metabolism. Concept. Catabolic, anabolic and amphibolic routes. Bioenergetics: exergonic and endergonic processes. Energetic coupling. Energy-rich compounds: chemical characteristics. Transferred chemical groups. Types of energy-rich bonds. Enzymes and coenzymes involved in biological oxydoreduction processes.

CHAPTER IV: METABOLISM OF CARBOHYDRATES

- Lecture 15. Glycolysis. Glucose uptake by tissues. Stages of glycolysis. Pyruvate metabolic fates. Metabolic and hormonal regulation of glycolysis. Stoichiometry and energy balance. Cori's cycle. Other hexoses incorporation of glycolytic pathway. Pyruvate oxidation to acetyl-CoA.
- Lecture 16. Citric acid cycle. Cycle's role within intermediary metabolism. Cellular localization. Metabolic reactions and their regulation. Cycle's energy balance. Anaplerotic reactions.
- Lecture 17. Biological oxidation and respiratory chain. Components of the respiratory chain. The sequence of respiratory chain components. Oxidative phosphorylation. Structure and function of ATP synthetase. Chemiosmotic hypothesis. Specific transport systems in the mitochondria's inner membrane: translocases. System of mitochondrial shuttles. ATP balance in glucose total oxidation. Reactive oxygen species, antioxidant defenses, and human disease.
- Lecture 18. Gluconeogenesis. Specific reactions. Metabolic and hormonal reactions. Stoichiometry and energy balance. Enzymatic differences between glycolysis and gluconeogenesis. Alterations in gluconeogenesis in humans.
- Lecture 19. Glycogen metabolism and its regulation. Glycogen stores and their physiological role. Glycogenolysis. Synthesis of Glycogen. Hormonal regulation of glycogen metabolism in muscle and liver. Glycogen phosphorylase system. Glycogen synthetase system. Dephosphorylation of enzymes: phosphatases. Glycogenosis.
- Lecture 20. Pentose phosphate pathway. Reactions of the oxidative phase. Reactions of non-oxidative phase. Regulatory mechanisms. Enzymatic defects. Glucuronic acid pathway.
- Lecture 21. Heteroside metabolism. General properties. Biosynthesis of glycoproteins: N-glycans and O-glycans. Control of glycoprotein biosynthesis. Glycoprotein catabolism. Biosynthesis and degradation of proteoglycans. Mucopolysaccharides.

CHAPTER V: LIPID METABOLISM

- Lecture 22. Adipose tissue metabolism and fat mobilization. Lipolysis. Hormonal regulation of lipolysis. Lipolysis products fate.
- Lecture 23. Fatty actid oxidation. Fatty acid activation in cytosol and transport inside mitochondria. Carnitine as shuttling molecule. Mitochondrial beta-oxidation of even-and odd-chain saturated fatty acids. Energy balance.
- Lecture 24. Ketonic bodies metabolism. Ketogenesis. Use of ketonic bodies by extrahepatic tissues: cetolysis. Regulation of fatty acid beta-oxidation and ketogenesis.
- Lecture 25. Biosynthesis of fatty acids: lipogenesis. Biosynthesis of even-and odd-chain saturated fatty acids. Sources of acetyl-CoA and NADPH for lipogenesis. Malonil-CoA formation. Enzymatic and co-enzymatic components of fatty acid synthase. Metabolic reactions. Regulation of synthesis of fatty acid. Fatty acid chain elongation. Biosynthesis of mono-and polyunsaturated fatty acids.
- Lecture 26. Eicosanoid biosynthesis. Eicosanoid precursors. Metabolism of arachidonic acid. Biosynthesis of eicosanoids: cyclooxygenase pathway and lipoxygenase pathway. Catabolism of eicosanoids. Mechanism of action of eicosanoids and its clinical significance.
- Lecture 27. Metabolism of complex lipids. Biosynthesis of triacylglycerides. Biosynthesis of phosphoacylglycerides: de novo pathway and saving pathway. Phosphoacylglycerides degradation. Biosynthesis and degradation of sphingolipids.
- Lecture 28. Metabolism of cholesterol. Whole-body cholesterol balance. Biosynthesis of cholesterol. Mevalonate formation. Mevalonate transformation into squalene. Squalene transformation into cholesterol. Control of cholesterol synthesis.: HMG-CoA reductase. Cholesterol transport. Diseased caused by alterations in cholesterol metabolism.
- Lecture 29. Cholesterol derivatives with physiological significance in the human body. Biliary acids. Biosynthesis of primary and secondary biliary acids. Regulation of biliary acid synthesis. Enterohepatic circulation. Cholesterol excretion. Steroid hormones from adrenal cortex and gonads: biosynthesis and degradation. Biosynthesis of 1,25-dihydroxycholecalciferol.
- Lecture 30. Integration of lipid metabolism. Exogenous and endogenous lipid transport. Liver metabolic control. Fatty liver degeneration. Reverse cholesterol transport.

CHAPTER VI: METABOLISM OF NITROGEN COMPOUNDS

- Lecture 31. The general reaction in amino acid catabolism. Transamination reactions. Oxidative deamination. Decarboxylation. Ammonia fate. Glutamine formation and ammonium excretion. Urea cycle and its regulation. Enzymatic defects in the urea cycle.
- Lecture 32. The fate of carbon skeleton from amino acids. Routes for amino acid carbon skeleton incorporation into different metabolic intermediates. Glycogenic and ketogenic amino acids.
- Lecture 33. Conversion of amino acids into specialized products. Creatine and creatinine formation. Creatinine excretion rate as muscle mass index. Tryptophan: serotonin precursor. Malignant carcinoid syndrome (argentaffin

cell tumors). Metabolism of g-aminobutyrate.
- Lecture 34. Metabolism of purines and pyrimidines.
- Lecture 35. Metabolism of Hemoglobin. Biosynthesis and regulation of porphyrins and heme group. Porphyrias: definition and classification. Biosynthesis of hemoglobin. Catabolism of hemoglobin: metabolism of bilirubin, and biliary pigment formation. Jaundice.

Laboratory Sessions at School of Medicine

- Laboratory 1: Quantifiying total serum proteins
- Laboratory 2: Plasmatic protein electrophoresis
- Laboratory 3: Clinical case: Clinical enzimology
- Laboratory 4: Clinical case: vitamin B12 deficiency and vitamin D toxicity
- Laboratory 5: DNA extraction and isolation
- Laboratory 6: Characterizing reducing sugars
- Laboratory 7: Clinical case: carbohidrate metabolism

- Seminar 1: mitochondrial DNA and mitochondrial diseases
- Seminar 2: Clasification and structural and functional properties of glucids
- Seminar 3: Structure and function of lipids

- Supervised Essay 1: From Genome to Metabolome
- Supervised Essay 2: Carbohydrate usage in a person with hypercaloric, fat rich, diet.
- Supervised Essay 3: Choose your favorite lipidic molecule, describe its characteristic in 2 pages (name, structure, biosynthesis, location, biological role, implications for pathology, pharmacology, etc, with references in Vancouver format). There cannot be duplicates.
- Supervised Essay 4: Urea cycle. Links to the citric acid cycle.

Laboratory Sessions at School of Sciences for Health and Sports

- Laboratory 1: Introduction to working in the biochemistry laboratory
- Laboratory 2: Handling a pH-meter. Titration Curve of an amino acid
- Laboratory 3: Protein Quantitative Determination
- Laboratory 4: Isolation and hydrolysis of Starch
- Laboratory 5: Protein Electrophoresis
- Laboratory 6: Determining the enzymatic activity

- Seminar 1: Formulation of carbohydrates
- Seminar 2: Formulation of lipids
- Seminar 3: Formulation of nucleic acids
- Seminar 4: Metabolic interrelationships

- Supervised essay

4.4. Course planning and calendar

Calendario de sesiones presenciales y presentación de trabajos

Official timetables and calendars are available at the School website:

Zaragoza's School of Medicine: https://medicina.unizar.es/primer-curso

Huesca's School of Health and Sport Sciences: https://fccsyd.unizar.es/horarios-y-calendarios-medicina

Orientative Schedule for subject's activities

This schedule will be adapted to the real availability in the official calendar.

Week	Lecture	Laboratory	Seminars/Cases	Guided Reports	Evalu
1	Chapter I	Section assignment		Theme assignment	
2	Chapter I		Seminar on proteins		
3	Chapter I		Seminar on carbohydrates		
4	Chapter I Chapter II		Seminar on carbohydrates		
5	Chapter II		Seminar on lipids		
6	Chapter II Chapter III		Seminar on lipids		Partial Eval
7	Chapter III Chapter IV	Laboratory sessions			
8	Chapter IV	Laboratory sessions			
9	Chapter IV	Laboratory sessions			
10	Chapter IV Chapter V	Laboratory sessions			
11	Chapter V	Laboratory sessions			
12	Chapter V Chapter VI	Laboratory sessions			
13	Chapter VI	Laboratory sessions		Correction of Tutored Reports	
14	Chapter VI	Laboratory sessions			Final evalua

4.5. Bibliography and recommended resources

Updated bibliography for this subject can be consulted through the University Library webpage:

http://psfunizar10.unizar.es/br13/egAsignaturas.php?codigo=26703