27108 - Biochemistry

Información del Plan Docente

Academic Year	2018/19
Subject	27108 - Biochemistry
Faculty / School	100 - Facultad de Ciencias
Degree	446 - Degree in Biotechnology
ECTS	12.0
Year	2
Semester	Annual
Subject Type	Compulsory
Module	---

1.General information

1.1.Aims of the course

1.2.Context and importance of this course in the degree

1.3.Recommendations to take this course

2.Learning goals

2.1.Competences

2.2.Learning goals

2.3.Importance of learning goals

3.Assessment (1st and 2nd call)

3.1.Assessment tasks (description of tasks, marking system and assessment criteria)

4.Methodology, learning tasks, syllabus and resources

4.1.Methodological overview

4.2.Learning tasks

4.3.Syllabus

The course will address the following topics:

ENZIMOLOGY:

- 1.- Historical introduction: Concept of enzyme and characteristics. Classification and nomenclature. Determination of

enzymatic activity. Units
- 2.- Enzymatic cofactors. Organic cofactors Characteristics of organic cofactors. Metallic cofactors.
- 3.- Enzymatic kinetics. Monosubstrate reactions: Michaelis Menten equation. Bisubstrate reactions.
- 4.- Enzymatic inhibition. Reversible and irreversible inhibition. Competitive inhibition, and non-competitive inhibition. Determination of Ki.
- 5. - Effect of pH and temperature on enzymatic activity.
- 6.- Regulation of enzymatic activity. Allosteric enzymes. Reversible covalent modification. Other mechanisms of regulation of enzymatic activity
- 7.- Catalytic strategies of enzymes. Principles of catalysis. Stabilization of the electric charge. Covalent catalysis. Orientation and proximity effects. Utilization of the binding energy.
- 8.- Mechanisms of action of enzymes: Interest in knowing the mechanisms of enzymatic action. Methods to dissect the mechanism of action of an enzyme. The lysozyme: mechanism from the structure. Serine proteases: example of covalent catalysis. Tyrosyl-tRNA synthetase: Protein engineering to deduce the mechanism. Catalytic antibodies: the confirmation of a hypothesis.
- 9.- Enzymatic technology. Enzymes of industrial interest. Stabilization of enzymes. Immobilization of enzymes and other biocatalytic systems. Biocatalysis: Oxide-reduction reactions; Hydroxylation reactions; Hydrolysis reactions. Use of enzymes in the food industry. Bio-elimination.

METABOLISM

- **10. Introduction of the study of metabolism.** The cycle of matter and flow of energy in the biosphere. Origin of biological energy. Organization of the metabolic pathways. Oxidation of food compounds as the source of biological energy: redox cofactors. ATP as energy exchange molecule. Coenzyme-A: thioester bond function. Metabolic regulation: general mechanisms and hormonal action. Techniques for the study of metabolism.

Carbohydrate metabolism

- **11. Anaerobic metabolism of carbohydrate.** The utilisation of dietary carbohydrates: digestion and intestinal absorption. Glucose transporters. Glycolysis: biological significance, reactions and enzymes involved. 2,3 bisphosphoglicerate role in erythrocytes. Anaerobic fate of pyruvate: fermentation. Mitochondrial oxidation of cytosolic NADH: mitochondrial shuttles. Degradation of other monosaccharides by glycolysis. Metabolic defects in digestion and adsorption of carbohydrates.
- **12. Aerobic metabolism of carbohydrate.** Aerobic fate of pyruvate: respiration. Cellular localization. Oxidation of pyruvate by the pyruvate dehydrogenase complex. Regulation. The citric acid cycle (Krebs cycle)**:** a) reactions and enzymes involved, b) stoichiometry and overall energy balance, c) regulation and d) the intermediates of the cycle as substrates for biosynthetic reactions and anaplerotic reactions.
- **13. Electron transfer and oxidative phosphorylation.** The electron transport chain: multiprotein complexes and electron carriers. The generation of a proton gradient as a form of conserving the energy. Electron transport inhibitors. ATP synthesis: oxidative phosphorylation Coupling of electron transport, proton transfer and ATP synthesis: chemiosmotic theory. Uncouplers. The ATP synthase complex: structure and action mechanism.
- **14. Others pathways for glucose oxidation. The pentose phosphate pathway** Biological role in different tissues. Anabolic and catabolic role of the pathway. Oxidative and non-oxidative phases: reaction and enzymes involved. Regulation. Interconnection between glycolysis and the pentose phosphate pathway. Metabolic defects: Glucose-6 phosphate dehydrogenase, oxidative stress, erytrocytes and malaria.
- **15. Gluconeogenesis.** Glucose synthesis from non glucidic precursors. Common and specific enzymes in glycolysis and gluconeogenesis. Thermodynamically irreversible reactions. Origin of reducing power. Gluconeogenesis from Acetil-CoA in plants: the glyoxylate cycle. Disaccharides synthesis: sucrose and lactose. a-lactoalbumin in lactose synthesis.
- **16. Glycogen metabolism.** The role of glycogen in animals. Glycogen degradation and synthesis: reactions and enzymes involved. Glycogenin in glycogen synthesis. Futile or substrate cycles. Diseases due to defects in the glycogen metabolism.
- **17. Regulation of carbohydrate metabolism. Glycolysis regulation**: hormonal and allosteric mechanisms. Coordinated regulation of glycolysis and **gluconeogenesis**: Fructose 2,6 bisphosphate and Phosphofructokinase II. **Cell energy level and oxidative phosphorylation regulation. Glycogen metabolism regulation**: the role of metabolic cascades, glycogen phosphorylase kinase, glycogen phosphorylase and glycogen synthase. A) muscle and liver differences, B) hormonal and allosteric regulation: insulin, glucagon, adrenaline and blood glucose, C) role of the phospho protein phosphatase-1 (PP1) and others regulatory proteins.

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Lipid metabolism

- **18. Origin and transport of lipids in animals.** Digestion and absorption of dietary fats in the small intestine. Mobilization of stored triacylglycerols: hormones involved and role of perilipin protein and adipocyte lipases. Lypolisis inhibition: insuline action and retroinhibition mechanisms. Transport of lipids in animals: albumin and plasmatic lipoproteins.
- **19. Fatty acids catabolism.** Activation and transport of fatty acids into the mitochondria. Carnitine role. b-oxidation mitochondrial and perixosomal of fatty acids. Energy balance. Fatty acid degradation functions: thermogenesis and uncouple proteins (UCPs). Oxidation of fatty acids with an odd number of carbons: fate of propionate. Oxidation of unsaturated fatty acids: additional reactions. w- and a-oxidation of fatty acids. **Ketonic bodies**: synthesis and degradation. The use of ketone bodies as a source of energy.
- **20. Biosynthesis of fatty acids.** Similarities and differences between the biosynthetic ad degradative pathways. **Biosynthesis of saturated fatty acids**: origin of carbon and reducing power (NADPH). Acetyl-Co and bicarbonate as precursors of fatty acid synthesis: the Acetil-CoA carboxilase and the formation of malonyl-CoA. Fatty acid synthase complex. Origin of cytosolic NADPH and Acetyl-CoA. **Biosynthesis of unsaturated fatty acid**: desaturation and elongation of fatty acids. Peroxisomes role in polyunsaturated fatty acid synthesis. **Fatty acid metabolism regulation**: a) role of hormones insulin, glucagon and adrenaline, b) transcription factors: CHREBP, SREBP and PPARs.
- **21. Biosynthesis of complex lipids.** Biosynthesis of triacylglycerols: origin of glycerol and main reactions. Triacylglicerols cycle: regulation. Biosynthesis of phosphoacylglycerols and sphingolipids. Icosanoids: therapeutics effects and main reactions of synthesis. Ciclooxygenases (COX).
- **22. Biosynthesis of cholesterol.** Acetil-CoA as cholesterol precursor. General steps in cholesterol biosynthesis**.** Transport and cellular internalization of cholesterol: action mechanism of transport by lipoproteins. Regulation of cholesterol synthesis: Hidroxymethylglutaryl-CoA reductase and LDL receptors: a) covalent modification and b) transcription factors: SREBP and the regulatory proteins SCAP and INSIG. Cholesterol as precursor of active biological molecules.

Nitrogen compounds metabolism

- **23. General features of the nitrogen metabolism:** metabolic value, new reactions and coenzymes, interconnect pathways and regulation. The incorporation of ammonia into carbon skeletons: glutamate dehydrogenase, glutamate synthase and glutamine synthetase. Regulation of nitrogen metabolism: glutamine synthetase regulation. **Degradation of the proteins and amino acids I.** Digestion of dietary proteins. Continuous replacement of proteins in living organisms. General reactions: nitrogen elimination and carbon skeleton degradation.
- **24. Amino acid degradation II**. Transamination and oxidative degradation. Main coenzymes: piridoxal phosphate. Special role of glutamate, glutamine and alanine amino acids in nitrogen transfers. Glucose-alanine cycle. Glutamine synthetase and glutaminase in muscle and liver. **Urea cycle:** reactions, enzymes involved, regulation and genetic defects. Relation with the citric acid cycle. Role of the liver glutamine synthetase in the blood pH regulation.
- **25. Amino acid degradation III.** Metabolic degradation of carbon skeletons from amino acids. Glycogenic and ketogenic amino acids. Main reactions: oxidations and carbon transfers. **Main coenzymes: tetrahydrobiopterin, tetrahydrofolate (folic acid vitamin) and S-adenosylmethionine. Activated-methyl cycle.** Genetic disorders in the amino acids metabolism.
- **26. Biosynthesis of amino acids and related compounds.** Precursors and general features of the synthesis pathways (carbon and nitrogen transfers). General principles of the regulation of the synthesis of amino acids. Amino acids as precursors to other important molecules.
- **27. Nucleotide metabolism. Biosynthesis of nucleotides**: the *de novo* and the salvage pathways. **De novo pathway** of the purine and pyrimidine ribonucleotides: precursors, main steps and regulation. Function and synthesis of 5-phosphoribosyl 1-pyrophosphate PRPP). Deoxyribonucleotide synthesis: ribonucleotide reductase, substrata and mechanism. Activity and substrate specificity regulation of ribonucleotide reductase. Synthesis of thymidylate: thymidylate synthase and dihydrofolatereductase. Inhibitors of the nucleotides synthesis: fluorouracil and methotrexate. **Salvage pathways**: a) acid nucleic degradation, b) PRPP-transferase and specific kinases. Nucleotide catabolism: urea, uric acid production. Genetic disorders in the nucleotide metabolism.
- **28. Integration of metabolism. A)** Reciprocal relationships between different organs in animals. The main metabolic pathways in the different organs: liver, adipocyte, brain, muscle and kidney. B) Main mechanisms of hormonal regulation. C) Metabolic adaptations to different physiological and pathological situations: fasting,

prolonged exercise, obesity and diabetes.

SEMINARS

- Biotechnology: a new area of knowledge and industrial activity.
- Enzymes optimization for industry.
- Glucolisis and cancer. Warburg effect. Hypoxia: hypoxia inducible factors (HIF).
- OXPHOS system: organizational models and functional genetics.
- New strategies in diabetes type II treatment. Incretines.
- Adipoquines: leptine y adiponectine., etc.

4.4.Course planning and calendar

Further information concerning the timetable, classroom, office hours, assessment dates and other details regarding this course, will be provided on the first day of class or please refer to the Facultad de Ciencias website https://ciencias.unizar.es/grado-en-biotecnologia

4.5.Bibliography and recommended resources

BB	Berg, Jeremy M.. Biochemistry / Jeremy M. Berg, John L. Tymoczko, Lubert Stryer ; with Gregory J. Gatto . Interantio ed., 3rd. print. New York : W.H. Freeman and Co., cop. 201
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BB	Devlin, T. M. Textbook of Biochemistry with Clinical Correla 7th ed. Wiley and Sons, 2010
BB	Lehninger, A.. Principles of Biochemistry. 6th W. H. Freema Company. 2013
BB	McKee, Trudy. Bioquímica : las bases moleculares de la vi Trudy McKee, James R. McKee ; traducción, Martha Elena Martínez, Anahí Hurtado Chong . - 5ª ed. Madrid [etc.] : McGraw-Hill Interamericana, cop. 2014
BB	Nelson, David L.. Lehninger Principios de bioquímica / Dav Nelson, Michael M. Cox ; coordinador de la traducción, Cla Cuchillo. 6ª ed. Barcelona : Omega, D.L. 2014
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BB	Voet, D.. Biochemistry / Voet, D and, Voet, J.G.. - 4th. ed. 2010
BB	Voet, Donald. Bioquímica / Donald Voet, Judith G. Voet ; [traducido por Pablo Baldi ... (et al.)] . - 3ª ed. Barcelona : M Panamericana, cop. 2006
BC	Biochemistry / Laurence A. Moran, J. David Rawn... [et al] ed. Englewood Cliffs, New Jersey : Prentice Hall, cop.1994
BC	Dixon, M. y Webb, E. C. Enzymes. - 3a ed 1979
BC	Fersht, A. Enzyme structure and mechanism. 2a Ed. 1985

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BC	Macarulla, José M.. Bioquímica cuantitativa. Volumen II, Cuestiones sobre metabolismo / José M. Macarulla, Aída M Alberto Macarulla. - 2ª reimp. Barcelona [etc.] : Reverté, 20
BC	Mathews, Christopher K.. Bioquímica / Christopher K. Math K. E. Van Holde, Kevin G. Ahern ; traducción, José Manue González de Buitrago . - 3ª ed., reimpr. Madrid [etc.] : Pear Addison Wesley, 2004
BC	Problemas de Bioquímica / J. Cárdenas [et al.] Madrid : Alhambra, 1988
BC	Serrano Salom, Ramón. Introducción a las aplicaciones de enzimas / Ramón Serrano Salom . - 1ª ed. Madrid : Alhamb 1985