Universidad Zaragoza

Academic Year/course: 2021/22

68450 - Introduction to Structural, Molecular and Cell Biology

Syllabus Information

Academic Year: 2021/22
Subject: 68450 - Introduction to Structural, Molecular and Cell Biology
Faculty / School: 100 - Facultad de Ciencias
Degree: 626 -
ECTS: 6.0
Year: 01
Semester: First semester
Subject Type: Compulsory
Module:

1. General information

1.1. Aims of the course

This course is intended to provide to the students who have not yet a solid basis on the general field of Biology with the basic knowledge so that they can follow other courses of the Master.

The course will begin with an introduction on the origin, organization and classification of living beings, focusing on unicellular organisms.

Next there will be a section on biomolecules, dedicated to the structure, function and interaction of carbohydrates, lipids, nucleic acids and, with special emphasis, on proteins, particularly on enzymes.

We will then present the major techniques used in research in the fields of biophysics, biochemistry and molecular and cellular biology.

Later we will approach the cellular structure, differentiating eukaryotic cells from prokaryotic cells, and commenting on the main cellular functions, as well as the organelles and structures involved: cellular membranes and transport across them, endoplasmic reticulum, Golgi, nucleus and cytoskeleton.

We will continue with cellular metabolism, giving some general notions of bioenergetics and metabolic pathways and the organelles involved, particularly mitochondria, chloroplasts and peroxisomes.

We will finish with a section dedicated to the transmission of genetic information: DNA, RNA, proteins, cell cycle and cell death.

The general objective of this course will be for students to acquire essential knowledge about the functioning of living organisms at the cellular and molecular level.

1.2. Context and importance of this course in the degree

This course is part of the complementary module of the Master in Biotechnology, Bio-Big-Data and Drug Discovery and is essential for those students who have not taken biology courses before enrolling in the Master or for those who want to update their knowledge in the field.

1.3. Recommendations to take this course

Continuous work on the contents of the subject is recommended, consulting the recommended bibliography and resolving possible doubts with the teachers, during the development of the classes, through the use of tutorials, through the ADD or through e-mail.

2. Learning goals

2.1. Competences

On passing the subject, the student will be more competent to:

- Develop work habits in a laboratory with biological material.

- Dominate the basic terminology of biology and correctly express biological concepts and principles.

- Understand the general, structural, functional and evolutionary principles of life molecules, as well as the basis for their utilization as biotechnological tools.

- Acquire a general integrated vision of cellular function and relate the activity of different cellular compartments.

- Become familiar with basic instrumental techniques of molecular biophysics and cell biology.

- Understand how the structural organization of the major biological macromoleculas determines their interaction with other molecules and their biological functions.

2.2. Learning goals

In order to pass this subject, the student must demonstrate the following results:

1. To observe and discriminate different cell types: bacteria, animal cells, plant cells and protists.

2. To recognize the structure and to know the function of the major groups of biological macromolecules.

3. To understand the principles for protein structure-stability-interaction-function

4. To work with protein databases and visualization programs

5. To discriminate the differences between the different forms of cellular organization.

6. To identify the different cellular organelles and know their functions.

7. To discriminate the different forms of water/solute transport of water and solutes between cell compartments.

8. To know the main metabolic pathways and cellular mechanisms of energy/matter, exchange of energy and matter.

9. To know cellular models used in research, their advantages and disadvantages.

10. To manage simple computer tools of structural and functional genomics.

11. Display and analysis of macromolecule structures.

12. Knowledge and application of the basic principles of structural resolution.

13. Preparation and oral exposition of reports.

2.3. Importance of learning goals

This subject is important to provide to the Master?s student without previous training in Structural, Molecular and Cell Biology, or to those who want to update their knowledge, with an overview of the functioning of living beings at the molecular and cellular level, as well as the chemical reactions that define life. These reactions are based on physical parameters that are not unique to biological systems, but are particularly interesting in these systems. Due to the trend towards the multidisciplinary nature of science today, interrelating knowledge from different disciplines, this subject will contribute to facilitate the assimilation of more advanced concepts in other subjects of this Master.

3. Assessment (1st and 2nd call)

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

The evaluation of the subject will be based on a final exam that will account for 80% of the final grade, homeworks presented by the students that will account for 10% of the final grade and laboratory practical classes that will account for 10% of the final grade. The student may opt for a single final theoretical-practical examination in the event of not being able to be adequately evaluated in the previous way, in which they will be able to obtain the maximum grade of the subject (10). Classes are given with PowerPoint presentations, which are available to the student through the teaching digital ring, as well as any other necessary information related to the subject.

Homework

This will account for up to 10% of the final grade of the subject (up to 1 point out of 10). It will consist on the preparation of a seminar related to the contents of the subject and will be presented by the student in the class.

If a student cannot impart the seminar and wants to opt for the maximum grade, he or she must take the only final theoretical-practical test.

Practical classes

Practical classes will take place at the lab and/or computer room. Each student will be given a practical problem to solve using the computer tools explained at the beginning of the practical session. The student will need to prepare an oral presentation about the DNA sequence that has been provided, explaining what protein codes for, an explanation of the structural group of the protein, its properties and peculiarities, where it is located in the cell, and what it is its function, The oral presentation will account for 10% of the final grade.

If a student is unable to complete practical classes and wants to opt for the maximum grade, he or she must take the only final theoretical-practical test.

The final grade of the course is divided into the following sections:

- Theoretical examination: up to 8 points

The theoretical examination will consist of two parts, one test and the other with short-answer questions. It is necessary to pass both parts of the theoretical examination in order to pass the subject, that is, to obtain at least 5 out of 10 points in each part (at least 4 points in each part, out of the total 8 points of the theoretical examination). If one of the two parts of the final theoretical examination (test or short-answer questions) is not passed, the mark appearing in the minutes will be that of the

part which has not been passed. If both are not passed, the highest grade will appear. The multiple-choice questions consist of four possible answers, each question is scored with 1 point and each wrongly answered question discounts 0.25 points . The total is then prorated over 4 points. Wrongly answered short answer questions do not count negatively. Each is scored with one point and then prorated over 4 points.

- Practical classes plus seminar: up to 1 point.

- Homework : up to 1 point.

4. Methodology, learning tasks, syllabus and resources

4.1. Methodological overview

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

The teaching-learning methodologies offered to achieve the stated objectives and acquire the competences are the following:

* Theory classes: 45 hours of theory, encouraging student participation through continuous questions and group discussions and not just presentation of information by the teacher.

* Practical classes: 4 hours of practical classes on a central theme of the subject.

* Tutorials: teacher responsible for the subject permanently available by email or through the Digital Teaching Ring. Face-to-face tutorials with teachers to be scheduled.

4.2. Learning tasks

The teaching-learning methodologies offered to achieve the stated objectives and acquire the competences are the following:

- Theoretical classes (45 hours)

- Practical classes (4 hours)

- Resolution of problems and practical cases (6 hours)

- Public exposition of work (2 hours)

- Workshops and debates through the ?digital teaching ring? (3 hours)

- Tutorials: teacher responsible for the subject permanently available by email or through the Digital Teaching Ring. Face-to-face tutorials with teachers to be scheduled.

4.3. Syllabus

Theoretical classes (45 hours)

I. Introduction

Topic 1. Origin, organization and classification of living beings (2 hours)

Characteristics of living beings. Information flow in the cells. Cellular Theory. Origin of the cells. Chemical evolution and cellular evolution. Miller's experiments. Catalytic RNA. Cell membranes. Obtaining energy. Basic properties and classification of living organisms. Prokaryotes and eukaryotes. Viruses.

II. Biomolecules

Topic 2. Chemical composition of cells (1 hour)

Structural levels in the cell. Bioelements. Types of biomolecules. Main functional groups in biomolecules. Stereoisomery. Biological importance of water and weak bonds. Hydrogen bridges, electrostatic interactions, Van de Waals forces, hydrophobic interactions. Acid-base balance. Osmosis.

Topic 3. Nucleic acids (2 hours)

Nucleotides: chemical composition, structure and functions. Absorption spectra. Functions as energy exchangers. Functions as enzymatic cofactors: coenzyme A. Functions as signal transducers: the cyclic AMP. Nucleic acids. Structure and function of DNA. The double helix. Denaturalization and hybridization. Types of RNAs and their functions.

Topic 4. Carbohydrates (1 hour)

Chemical composition and functions. Monosaccharides. Stereoisomers. Aldoses and ketoses. Monosaccharide derivatives. Reducing sugars. Disaccharides and glycosidic bond. Polysaccharides: glycogen and starch. Homo and heteropolysaccharides, peptides and glycoproteins.

Topic 5. Lipids (1 hour)

Chemical composition and functions. Saturated and unsaturated fatty acids. Triacylglycerides. Sterification and saponification. Biodiesel. Membrane lipids: phospholipids, sphingolipids and glycolipids. Cholesterol and steroids. Other lipids: icosanoids, fat-soluble vitamins and electron transporters.

Topic 6. Proteins: Structure (2 hours)

Amino acids. The peptide bond. Acid-base properties of amino acids. The isoelectric point. Structural levels of proteins. Forces determining the stability of proteins. The structure-function relationship of proteins. Simple and conjugated, fibrous and globular proteins. Structural determination. Intrinsically disordered proteins.

Topic 7. Proteins: Folding (2 hours)

The paradigm of protein folding. Anfinsen experiment. Levinthal paradox. Folding stages. The "novel view" of folding.

Conformational equilibrium. Asisted folding. Induced folding. Denaturation. Incorrect folding, aggregation and pathologies.

Topic 8. Enzymes (2 hours)

Functioning. Characteristics: catalytic capacity, specificity and regulation. Classification and nomenclature. Enzymatic co-factors: metals and coenzymes. The active site. Enzymatic kinetics; Km, Vmax and Michaelis Menten equation. Regulation, pH and temperature. Reversible inhibition, competitive and non-competitive, and irreversible.

Topic 9. Interactions among macromolecules (1 hour)

Nature of interaction surfaces. Forces involved in the interaction. Protein-protein interactions. Protein-nucleic acid interactions. Protein-lipid interactions. Protein-carbohydrate interactions. Examples.

III. Basic techniques in Biophysics, Biochemistry and Molecular and Cellular Biology.

Topic 10. Basic techniques in Biopphysics and Biochemistry (2 hours)

Basic knowledge of absorption and emission spectroscopy. Optical properties of biomolecules. Beer-Lambert law. Separation methods: centrifugation, chromatography, electrophoresis.

Topic 11. Basic techniques in Molecular and Cellular Biology (2 hours)

Molecular Biology tenchiques: enzymes, PCR, cloning, recombinant protein production. Optical microscopy. Resolution and enhancement. Fixation, staining and assembly. Fluorescence microscopy and fluorochromes. Immunofluorescence. Transmission and scanning electron microscopy. Cell culture. Homogenization and cell fractionation. Centrifugation. Probes for the study of cells: radioisotopes, fluorescent probes. Affinity chromatography. Antibody preparation. Immunoprecipitation. Electrophoresis. Western blot.

IV. Cell Organization and Dynamics

Topic 12. The prokaryotic cell (3 hours)

Domains of living beings. Eubacteria and archaeobacteria. General characteristics of prokaryotes. Morphology and structure of prokaryotic cells. Plasma membrane and cell wall: gram-positive and gram-negative bacteria. Peptidoglycan and penicillin. Membrane transporters. Pilli and flagella. Bacterial division and sporulation. Bacterial DNA. Conjugation. Structure and gene expression. Plasmids. The lambda phage. Main bacterial lineages. Halophilic, thermophilic and methanogenic bacteria. Archaeobacteria. The bacteriorrodopsin. Replication. Archaeobacteria and eubacteria. Metabolism and ways of life of bacteria. Types of prokaryotes: autotrophs, heterotrophs; aerobes, anaerobes. The nitrogen cycle and its fixation. Annamox bacteria. Biolixiviation.

Topic 13. The eukaryotic cell (2 hours)

Differences between prokaryotes and eukaryotes. Evolution of eukaryotes. Unicellular and pluricellular eukaryotes. Protozoa, animal cell and plant cell. General characteristics of eukaryotic cells. General organization of eukaryotic cells. Cellular organs: nucleus and chromosomes, mitochondria and their origin, chloroplasts and their origin, endoplasmic reticulum, Golgi apparatus, cytosol. Membranes, endocytosis and exocytosis. Cells and organisms as experimental models: bacteria, yeasts, Arabidopsis thaliana, Drosophila melanogaster, Caenorhabditis elegans, zebrafish, mouse. The amount of DNA and the complexity.

Topic 14. Cell membranes (2 hours)

Functions of cell membranes. Selective permeability. Chemical composition. Structure of the membranes: lipid bilayer and model of the fluidic mosaic. Dynamics and asymmetry of membrane lipids. Membrane proteins and their functions. Isolation of membrane proteins. Dynamics and compartmentalization of membranes.

Topic 15. Transport through membranes (2 hours)

Simple diffusion and facilitated diffusion. Passive and active transport. The electrochemical gradient. Types of membrane transport proteins. Ionic channels and their regulation. Uniport, symport and antiport. The sodium glucose symport. The sodium-potassium pump. Osmosis. F and V-ATPases, ATP synthesis and proton pumping. Cystic fibrosis.

Topic 16. The endoplasmic reticulum (1 hour)

Cytoplasmic organelles. Import of proteins to different organelles, localization signals. The endoplasmic reticulum and its functions, smooth and rough. Import of proteins into the endoplasmic reticulum. The secretion route. The response to unfolded proteins (UPR) and chaperones. Biosynthesis of phospholipids in the ER and redistribution between monolayers, scramblases and flippases.

Topic 17. Golgi Apparatus and Vesicular Traffic (2 hours)

Structure, organization and biogenesis. Vesicular transport. Endocytosis and exocytosis, phagocytosis and pinocytosis, transcytosis. Modification and distribution of proteins in the Golgi apparatus. Constitutive and regulated secretion. Receptor-mediated endocytosis, cholesterol and clathrine. The lysosomes. Autophagy. Membrane fusion and responsible proteins.

Topic 18. The nucleus (2 hours)

Location and functions. The interphase nucleus. Overview of gene expression in eukaryotes. The nuclear envelope and the nuclear lamina. The nuclear pore complex and the trafficking of proteins and RNA. The nuclear envelope during cell division. Types of chromatin. DNA organization in the nucleus. The nucleolus. The packaging of DNA and nucleosomes. Chromosomal segregation during mitosis. Phases of mitosis. The karyotype.

Topic 19. The cytoskeleton (1 hour)

Structure, organization and functions. Microtubules and dynamic instability. Microtubules during mitosis. Motor proteins. Cilia and flagella. Microfilaments and associated proteins. Myosin and muscle contraction. Intermediate filaments, types, intercellular junctions.

V. Cellular metabolism

Topic 20. Introduction to metabolism and cellular bioenergetics (1 hour)

Universe and systems. Matter and energy. Thermodynamics. Free energy, enthalpy and entropy. Bioenergetics. Metabolic routes, anabolism and catabolism. Importance of ATP as an energy exchange molecule. Biological transporters of electrons. Role of energy transporters in cells.

Topic 21. Overview of major metabolic pathways (2 hours)

Main catabolic routes. Carbohydrate metabolism. Glycolysis as a producer of energy and molecules for other routes. Gluconeogenesis. Alcoholic and lactic fermentations. Oxidative decarboxylation of pyruvate. Lipid metabolism. Absorption of lipids from the diet. Beta oxidation of fatty acids. The biosynthesis of fatty acids. The metabolism of amino acids, transaminases. The nitrogen cycle. Nitrogen fixation in leguminous symbiotic bacteria. The citric acid cycle. The glyoxylate cycle.

Topic 22. Mitochondria, chloroplasts and peroxisomes (2 hours)

Origin, structure and function of mitochondria. Mitochondrial fission and fusion. Synthesis of mitochondrial proteins. Oxidative metabolism in mitochondria: the citric acid cycle, the electron transport chain and oxidative phosphorylation. Mitochondrial ATPase. Origin, structure and function of chloroplasts. Types of plastids. Photosynthesis, light phase and dark phase. The transport of electrons in the chloroplast. The cyclic electron flow. The chemiosmotic generation of ATP in mitochondria and chloroplasts. Biogenesis, structure and function of peroxisomes. Oxidation of long chain fatty acids and detoxification. X-linked adrenoleukodystrophy. The glyoxysomes. The photorespiration. The metabolic interaction between chloroplasts, mitochondria and peroxisomes.

VI. Transmission of genetic information

Topic 23. Introduction to molecular genetics (3 classes)

Genetic variability. Concept of gene. Organization of genetic material. Structure of the chromosomes. Basic concepts of genetics. Genotype and phenotype, locus and allele, dominant and recessive. Sexual and asexual reproduction. Mitosis and meiosis. Recombination. Mutations, duplications and translocations. Horizontal gene transfer. Mobile genetic elements, transposons and viruses. Genetic homology and evolution. Biotechnology, transgenic plants and animals, food and health applications. Cloning.

Topic 24. From DNA to proteins (3 hours)

The central dogma of molecular biology and retroviruses. Semi-conservative DNA replication. Leading and lagging strands, the Okazaki fragments. Protein DNA replication machinery: helicases, topoisomerases, DNA binding proteins, primases, DNA polymerases and DNA ligases. DNA replication in prokaryotes and eukaryotes. Mutations: types and causes. The transcription of RNA in prokaryotes and eukaryotes. Protein synthesis in prokaryotes and eukaryotes. The polysomes. The genetic code. Posttranslational modifications of proteins. Regulation of gene expression. The lactose operon. Differential gene expression in superior eukaryotic tissues. Microarrays and two-dimensional electrophoresis. The alternative splicing. Methylation and genomic imprinting.

Topic 25. The Cell Cycle and Cell Death (1 hour)

Division, survival, differentiation and cell death. The cell cycle. Cell cycle check points. DNA damage detection. Mitosis and meiosis. Apoptosis and necrosis.

Total, 45 hours

Practical classes (4 hours)

Online DNA and protein servers and programs. Structural data bases. Programs for macromolecule structure visualization. Explanation and practical case in class.

Resolution of problems and practical cases (6 hours)

Aqueous solutions. Concentrations based on volume or weight. Equilibrium constants. Acids and bases. What is a buffer? (2 h). Explanation, one example in class, 3-4 problems to home.

1. Enzymatic activity. Experimental design and determination of enzymatic parameters (2 h) Explanation, one example in class, 3-4 problems to home.
2. Biochemical energetics. Laws of thermodynamics. Coupled reactions. Calculation of equilibrium constants (2 h). Explanation, one example in class, 3-4 problems to home.

Public exposition of work (2 hours)

Exposition of a mini-project elaborated by the student.

Workshops and debates through the ?digital teaching ring? (3 hours)

4.4. Course planning and calendar

Theoretical classes and seminars will be given in the classroom and timetable established by the Deanery of the Faculty and published on its website.

The global examinations are also determined by the Dean of the Faculty and published on the website.

Practice sessions will be announced during the course. The workbooks must be submitted in any form at least two weeks before the theoretical examination.

4.5. Bibliography and recommended resources

http://psfunizar10.unizar.es/br13/egAsignaturas.php?codigo=68450