COURSE DATA

Data Subject	
Code	33172
Name	Metabolism and regulation
Cycle	Grade
ECTS Credits	6.0
Academic year	2022 - 2023

Study (s)

Degree	Center	Acad. year	Period
1102 - Degree in Biotechnology	Faculty of Biological Sciences	3	First term

Subject-matter

Degree	Subject-matter	Character
1102 - Degree in Biotechnology	82 - Biochemistry	Obligatory
1102 - Degree in Biotechnology	88 - Biochemistry II	Obligatory

Coordination

Name	Department
PERETO MAGRANER, JULI	30 - Biochemistry and Molecular Biology

SUMMARY

Metabolism and Regulation is an obligatory four-monthly subject, taught in the third year of the University of Valencia's Degree in Biotechnology, within the Biochemistry subject (with a total of 15 ECTS). The course consists of 6 ECTS. When taught in the third year, students have knowledge of Chemistry, Biochemistry, Genetics, Microbiology, Cell Biology and Methods in Biochemistry, suitable for taking the subject. The subject has a mixed theoretical and experimental character, so the theoretical training is complemented with the realization of experiments in the laboratory and computer sessions. A living cell can carry out thousands of reactions simultaneously, catalysed enzymatically and operating in a stationary state. Most enzymes work with great stereochemical selectivity and under non-extreme conditions. The main objective of the course is to understand the functioning of metabolism: the general stoichiometric structure, phylogenetic diversity, regulation, as well as the possibilities of modification for biotechnological purposes. This course intends that the student acquires a knowledge of the metabolic networks and their regulation in an integrated way at a cellular and molecular scale. This basic knowledge will later allow the student to study how these pathways can be altered in a targeted manner for biotechnological use. The aim of the practical sessions is to carry out experiments that allow studies on the regulation and control of central metabolic pathways to be undertaken. Intracellular and extracellular concentrations of metabolites will be analysed; regulatory mechanisms such as allosterism and catabolic

repression in microorganisms will be studied, and the metabolic pathways that allow the prokaryote *Escherichia coli* to synthesize glycogen will be discussed. The computer sessions will allow the participants to become familiar with resources such as databases on enzymes and metabolic pathways, as well as stoichiometric analysis of metabolism.

PREVIOUS KNOWLEDGE

Relationship to other subjects of the same degree

There are no specified enrollment restrictions with other subjects of the curriculum.

Other requirements

To follow succesfully this course, the students must possess previous knowledge in Chemistry, Biochemistry, Cell Biology, Genetics, Microbiology and Analytical Methods in Biochemistry.

OUTCOMES

1102 - Degree in Biotechnology

- Be able to determine metabolite concentrations, kinetic and thermodynamic parameters and control coefficients of intermediate metabolism reactions.

LEARNING OUTCOMES

Skills to achieveKnow the nature of the cellular metabolism.Know the metabolic pathways.Comprehension of the mechanisms of control and regulation of metabolism.Know how look for the suitable bibliography for updating the knowledge on a specific subject.Comprehension of scientific works related with metabolism.Social abilitesCapacity to work in-group. Skill to argue on the base of rational criteria, differentiating clearly what is arguable of what are facts or accepted scientific evidences.Capacity for oral expression in a public auditorium. Capacity of interaction with the teacher and with companions.Capacity to solve problems of biological character, especially related with metabolism and their biotechnological applications.

DESCRIPTION OF CONTENTS

1. Metabolism overview (Item 1)

The cellular chemical factory and its biotechnological applications. Primary and secondary metabolism. Main routes of primary metabolism. Computational and experimental approaches in the study of metabolism. Metabolomics and fluxomics. Metabolic network architecture and Systems Biology. Catalytic and autocatalytic cycles in metabolism. Molecular mechanisms of regulation. Origin and evolution of metabolism.

2. Central carbon metabolism (Items 2 and 3)

2. Acetyl CoA and the citric acid cycle (CAC). Origin and fate of acetyl CoA. Enzymatic steps and regulation of CAC. Anaplerotic and cataplerotic reactions. Glyoxylate cycle. Reductive CAC.
3. Diversity of glycolytic pathways and fermentations. Gluconeogenesis. Glycogen synthesis and degradation. Pentose phosphate pathway: introduction to stoichiometric combinatorics. Carbon dioxide fixation pathways.

3. Metabolism of lipids and nitrogen compounds (Items 4-5)

4. Oxidation and biosynthesis of fatty acids. Lipogenesis. Synthesis of membrane lipids Secondary metabolism derived from acetyl CoA: polyketides and isoprenoids.
5. Nitrogen and amino acid metabolism. Dinitrogen fixation and nitrogen cycling. Amino acid biosynthesis and degradation. Forms of nitrogen excretion. Secondary metabolism derived from amino acids. Metabolism of aromatic amino acids. Biosynthesis and catabolism of purine and pyrimidine nucleotides.

4. Metabolic integration and biotechnology (Items 6-7)

6. Metabolic integration and metabolic engineering. Specialization of animal organs and hormonal control of metabolism. Examples of metabolic adaptations and stress responses. Regulation of the metabolism and fermentation industries.
7. Metabolic engineering and synthetic biology. Strategies for modifying metabolic flows and successful examples of metabolic engineering in biotechnology. Systems biology, Synthetic biology and Biotechnology.

5. Metabolism and Regulation Laboratory

Yeast isocitrate dehydrogenase. Kinetic study of the NAD+-dependent isocitrate dehydrogenase activity of baker's yeast in the absence and presence of an allosteric effector (AMP).
Quantification of intracellular and extracellular metabolites in animal tissues. Measurement of intracellular and extracellular metabolite concentrations (glucose, pyruvate, lactate).
Glycogen biosynthesis in prokaryotes. Quantification of glycogen in Escherichia coli cells cultured in poor or nitrogen-rich media with glucose or acetate as a carbon source.
Production of amylases by fermentation. Secretion of amylases by the fungus Aspergillus niger depending on the composition and conditions of the culture medium.

6. Introduction to stoichiometric analysis of metabolism

Metabolism-related databases. Familiarization with enzyme and metabolic pathways databases: BRENDA (htpp: //www.brenda-enzymes.info/), KEGG (http://www.genome.jp/ KEGG /) and BioCyc (htpp: // biocyc.org).
Introduction to stoichiometric analysis of metabolic networks. Use of the program METATOOL (http://pinguin.biologie.unijena.de/ bioinformatik / networks /) with simple metabolic networks.

WORKLOAD

ACTIVITY	Hours	% To be attended
Theory classes	38,00	100
Laboratory practices	16,00	100
Computer classroom practice	4,00	100
Tutorials	2,00	100
Study and independent work	40,00	0
Readings supplementary material	5,00	0
Preparation of evaluation activities	30,00	0
Preparing lectures	5,00	0
Preparation of practical classes and problem	5,00	0
Resolution of case studies	5,00	0
TOTAL	**150,00**	

TEACHING METHODOLOGY

Theory classes. One-hour sessions will be given depending on the course schedule. Basically, the model of a master class will be used, as it offers the possibility for the teacher to focus on the most relevant concepts for the understanding of the topic and the most appropriate resources will be indicated for the subsequent in-depth preparation of the topic. The necessary audio-visual means will be used for the agile and coherent development of the classes. Teachers will leave the necessary material for the correct monitoring of the classes in the Aula Virtual support platform. In some subjects, a participative model will be used. The concepts presented in the classes will be reinforced through the resolution of questions that will arise throughout the course, stimulating the active participation of the students. Problem-based learning (PBL) will reinforce the acquisition of the fundamental concepts.

Practical laboratory classes. They are of obligatory attendance and will be developed in an intensive way. Four 4-hour sessions will be held. A detailed script of each session will be available to students beforehand. Before the realization of the practices, and in order that every student knows the objectives and the experiments to realize in the laboratory, a previous questionnaire will be provided that will have to be delivered solved at the beginning of the practices.

Computer sessions. Attendance is compulsory. There will be two sessions of 2 hours each. The student will be introduced to the use of databases containing information on enzymes and metabolic pathways and programs for stoichiometric analysis of metabolic networks. A deadline will be established for submitting written proposals.

Group tutoring. Attendance is mandatory. Two 1-hour sessions will be held to discuss the results obtained in the experiments carried out in the laboratory and in the computer room. A deadline will be established to deliver the results questionnaires.

Seminars. If seminars are scheduled during the course, the student must attend them. Seminars may involve reading texts, preparing summaries or solving questions.

EVALUATION

The evaluation of learning will be done continuously throughout the course. The assessment resulting from direct contact with the student and his/her active participation in the theory classes, practices, tutorials and seminars will be combined with the assessment coming from the examination tests. In addition, students will submit a stipulated minimum of fortnightly solved problems (PBL).

Theoretical contents: The contents of the theoretical classes will be evaluated by means of a written exam. The result of the theoretical evaluation will represent 6.0 points of the final grade of the course (60% of the final grade). In order to pass the course, it will be necessary to have passed the theory (at least 5 points out of 10). An eliminatory partial exam will be taken at the end of Part 1, and another one at the end of the four-month period (Part 2). Each partial exam represents 50% of the theoretical grade. A partial theory exam will be considered passed (and, therefore, eliminated from the program) if the grade is equal to or higher than 5 out of 10. In case the theory has not been passed by partial exams, in the final exam (first or second call) the partial exams that have been left pending during the course can be recovered. In the event of not passing the theory in the first call, the grades of the partial exams passed will be kept only until the second call.

Practical contents: The attitude and use of the work in the laboratory and in the computer room will be evaluated. The presentation of the previous questionnaire and the summary and discussion of the results obtained will also be evaluated. The result of this evaluation will represent up to 4 points out of 10. In order to pass the course, it will be necessary to obtain a grade of 2 points or more in this section.

Participation in different activities and evaluation of problem-based learning (PBL): The active participation of the student in the classroom sessions will also be valued, as well as the fortnightly submission of solved problems. This qualification will contribute to the final grade of the course with a maximum of 1 additional point to the global grade.

Other considerations: To pass the course it will be necessary to have obtained a global grade equal or superior to 5 out of 10, having passed each of the parts (theory and practices) with the requirements mentioned above. In the case of failing the course in the first and second calls, if the practices are passed (grade equal to or higher than 2 out of 10), the grade will be kept for the following year. Grades obtained in seminars and participation in different activities will be saved only for the second call.

REFERENCES

Basic

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Additional

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