COURSE DATA

DATA SUBJECT

Code: 33172
Name: Metabolism and regulation
Cycle: Undergraduate Studies
ECTS Credits: 6
Academic year: 2026-27

STUDY (S)

Degree	Center	Acad. year	Period
1111 - Grado en Biotecnología	Facultat de Ciències Biològiques	2	First quarter, Second quarter

SUBJECT-MATTER

Degree	Subject-matter	Character
1111 - Grado en Biotecnología	Biochemistry	COMPULSORY

COORDINATION

PERETO MAGRANER JULI

GARCIA MURRIA MARIA JESUS

SUMMARY

Metabolism and Regulation is an obligatory four-monthly subject, taught in the second 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 second year, students have knowledge of Chemistry, Biochemistry, Genetics, 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.

COMPETENCES / LEARNING OUTCOMES

1102 -

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

1111 - Grado en Biotecnología

Actuar con autonomía en el aprendizaje, tomando decisiones fundamentadas en diferentes contextos, emitiendo juicios en base a la experimentación y el análisis y transfiriendo el conocimiento a nuevas situaciones

Analizar de forma correcta el coste energético de los procesos celulares

Apply analytical, synthetic and critical thinking skills in the application of the scientific method.

Colaborar eficazmente en equipos de trabajo, asumiendo responsabilidades y funciones de liderazgo y contribuyendo a la mejora y desarrollo colectivo

Conocer las rutas metabólicas y sus mecanismos de regulación

Demostrar razonamiento crítico y autocrítico en el ámbito de la titulación, considerando aspectos tales como la ética profesional, los valores morales y las implicaciones sociales de las diferentes actividades realizadas

Identify the molecules that make up a living organism.

Participate in multidisciplinary teams, engaging in teamwork and collaboration.

Propose creative and innovative solutions to complex situations or problems, typical of the area of ¿¿¿¿connection, to donate responses to the various professional and social needs

Que el estudiantado demuestre su capacidad para calcular correctamente los parámetros relevantes de un

proceso o un experimento mediante la representación de los datos experimentales

Que el estudiantado demuestre su capacidad para utilizar las diferentes fuentes bibliográficas y bases de datos biológicos y usar las herramientas bioinformáticas

Saber comunicarse de manera efectiva, tanto de forma oral como escrita, adaptándose a las características de la situación y de la audiencia

Ser capaz de determinar las concentraciones de metabolitos, los parámetros cinéticos, termodinámicos y coeficientes de control de las reacciones del metabolismo intermediario

Use English to write reports and to interpret information from protocols, manuals and databases.

Work in laboratories, including safety procedures, waste management and accurate activity logging.

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

PRESENCIAL ACTIVITIES

Activity	Hours
Tutorials	2,00
Theory	38,00
Laboratory	16,00
Computer classroom practice	4,00
Total hours	**60,00**

NON PRESENCIAL ACTIVITIES

Activity	Hours
Attendance at other activities	0,00
Individual or group project	0,00
Independent study and work	45,00
Preparation of lessons	10,00

Preparation for assessment activities	30,00
Resolution of case studies	5,00
Total hours	**90,00**

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

English
Learning assessment will be carried out continuously throughout the course. The assessment will combine the evaluation derived from direct contact with students and their active participation in theory classes, practical sessions, tutorials and seminars, with the evaluation obtained from examination tests. In addition, a minimum number of problem sets solved fortnightly will be submitted (PBL).
Theoretical content: The assessment of theoretical content will be carried out through a written examination. The result of the theoretical assessment will account for 6.0 points of the final grade of the course (60% of the final mark). To pass the course, it will be necessary to pass the theoretical component (grade equal to or higher than 5 out of 10). A midterm examination will be held at the end of Part 1 and another at the end of the semester (Part 2). Each midterm will account for 50% of the theoretical grade. A theoretical midterm will be considered passed (and therefore that part of the syllabus eliminated) if the

grade is equal to or higher than 5 out of 10. If the theoretical component is not passed through midterms, the final exam (first or second sitting) will allow students to retake the pending parts during the course. If the theoretical component is not passed in the first sitting, the grades obtained in the passed midterms will be kept only until the second sitting.
Practical content: Attitude and performance in laboratory and computer lab work will be assessed. Pre-lab questionnaires, outlines, as well as the summary and discussion of the results obtained will also be assessed. The result of this assessment will account for up to 4 points out of 10. To pass the course, a minimum grade of 2 points in this section will be required.
Other considerations: To pass the course, a global grade of 5 out of 10 or higher will be required, having passed each part (theory and practicals) under the conditions described above. If the course is not passed in the first and second sittings, and if the practical component is passed (grade equal to or higher than 2 out of 10), the grade will be carried over to the following academic year. Grades obtained in seminars and participation in different activities will only be retained for the second sitting.
/span>

REFERENCES

- Berg, J.M., Tymocczko, J.L., Stryer, L. (2007). Bioquímica (versión catalana y versión castellana de la 6 ed.). Reverté, Barcelona. En 2012 s¿ha publicat la 7ena edició en anglès i en castellà.
- Mathews, C.K., van Holde, K.E., Ahern, K.G. (2002). Bioquímica. 3 ed. Addison Wesley.
- Metzler, D.E. (2001). Biochemistry. The chemical reactions of living cells. 2 ed. Vol.1. Harcourt/Academic Press, San Diego. Metzler, D.E. (2003). Biochemistry. The chemical reactions of living cells. 2 ed. Vol. 2. Academic Press, Amsterdam.
- Nelson, D.L., Cox, M.M. (2009). Lehninger. Principios de bioquímica. 5 ed. Omega, Barcelona.
- Peretó, J., Sendra, R., Pamblanco, M., Bañó, C. (2005). Fonaments de bioquímica. 5 ed. Publicacions de la Universitat de València, València. Edició en castellà 2007 (PUV, València).
- Voet, D., Voet, J.G. (2006). Bioquímica. 3 ed. Panamericana, Buenos Aires.

- Frayn, K.N. (2010). Metabolic regulation. A human perspective. 3 ed. Blackwell Publishing.
- Heldt, H.W, Piechulla, B. (2011). Plant Biochemistry. 4th ed. Academic Press. - Kim, B.H., Gadd, G. M. (2008). Bacterial physiology and metabolism. Cambridge University Press, Cambridge.
- Neidhart, F.C., Ingraham, J.L., Schaechter, M. (1990). Physiology of the bacterial cell. A molecular approach. Sinauer, Sunderland.
- Schwender, J., ed. (2009). Plant metabolic networks. Springer, Dordrecht.
- Stephanopoulos, G.N., Aristidou, A.A., Nielsen, J. (1998). Metabolic engineering. Principles and methodologies. Academic Press, San Diego.
- White, D. (1995). The Physiology and Biochemistry of Prokaryotes. OUP.