

**Metabolic Control**

Code: 100865  
ECTS Credits: 3

Degree	Type	Year	Semester
2500252 Biochemistry	OB	3	2

**Contact**

Name: Emili Itarte Fresquet  
Email: Emili.Itarte@uab.cat

**Use of languages**

Principal working language: catalan (cat)  
Some groups entirely in English: No  
Some groups entirely in Catalan: No  
Some groups entirely in Spanish: No

**Other comments on languages**

The theory classes will be in Catalan, but most of the graphic material and the bibliography will be in English. The seminars and the answers to the questions of the exam can be in Catalan, Spanish or English.

**Prerequisites**

There are no official prerequisites. However, it is assumed that the student has acquired the knowledge taught in previous courses of the degree of Biochemistry, at first and second year's level and in the first semester of the third year, in particular the contents of Biochemistry I, Biochemistry II, Molecular Biology, Biocatalysis, Cell Biology, Animal Physiology and Cell Signalling.

**Objectives and Contextualisation**

Metabolic regulation is a subject in the third year, second semester, and deals with the most important aspects of the metabolic pathways control mechanisms, the strategies followed by their identification, their physiological significance, the interconnections in the integration of the metabolic pathway response to biological signals and the metabolic interrelations between the various organs and tissues in various physiopathological situations.

**Specific objectives:**

- Describe the structural and molecular aspects that govern the cellular metabolic specialization, their response to different extracellular signals and their functional adaptation.
- Know the strategies used in the identification of control points and the quantification of metabolic control.
- Describe the theoretical and practical aspects of the metabolism regulation's study systems, their suitability and ethical considerations.
- Know the mechanisms that regulate the selective transport of substances through the cell membranes.

- Describe the most significant mechanisms in the regulation of glycolytic metabolism, lipid and nitrogen compounds.
- To know in an integrated way the mechanisms of transmission of hormonal signals, neurotransmitters and growth factors in the control of metabolism.
- Explain the metabolic interrelations of the tissues and the integration in the control of the metabolism to satisfy the physiological demands.
- Know how to apply the knowledge studied and the information of the metabolic pathways databases to solve problems related to their alterations in pathological situations, especially to the most prevalent metabolic diseases in our population.
- Know how to design experiments, including the limitations of the experimental approach, interpret the experimental results, apply the computer resources for the search of specialized information, the treatment of the data and the communication of the results to the scientific community.

## **Skills**

- Analyse and explain normal physiological processes and alterations in them on the molecular scale, using the scientific method.
- Collaborate with other work colleagues.
- Demonstrate an integrated vision of the function of hormones, neurotransmitters and growth factors in the control of gene expression and metabolism.
- Describe metabolic routes, their interconnections and their physiological significance, and also understand the mechanisms that regulate their activity to satisfy physiological needs.
- Describe the structural, physiological and biochemical characteristics of the different types of cells and explain how their properties fit in with their biological function.
- Design experiments and understand the limitations of experimental approaches.
- Explain the structure of cell membranes and their role in signal transduction processes, the transport of solubles and the transduction of energy.
- Interpret experimental results and identify consistent and inconsistent elements.
- Make an oral, written and visual presentation of ones work to a professional or non-professional audience in English and understand the language and proposals of other specialists.
- Manage bibliographies and interpret the information in the main biological databases, and also know how to use basic ICT tools.
- Manage information and the organisation and planning of work.
- Process cells and tissues to obtain purified sub-cellular organelle preparations, and characterise them biochemically and structurally.
- Read specialised texts both in English and ones own language.
- Think in an integrated manner and approach problems from different perspectives.
- Use ICT for communication, information searching, data processing and calculations.

## **Learning outcomes**

1. Analyse the strategies used to identify control points and quantify metabolic control.
2. Apply the metabolic interrelationships of tissues, integration in the control of the metabolism, and metabolic adaptations, to physiopathological situations.
3. Collaborate with other work colleagues.
4. Critically analyse the experimental parameters measurable in tissues in a normal or pathological physiological situation, as described in the relevant scientific literature.
5. Describe the functional heterogeneity of tissues, the mechanisms that regulate it and some experimental methods for observing it.
6. Describe the molecular principles of the selective transport of substances through cell membranes, and how it is regulated.

7. Describe the most important mechanisms regulating the metabolism of glucids, lipids and nitrogenated compounds.
8. Describe the structural and metabolic factors that govern cellular metabolic specialisation, their response to different extracellular signals and their functional appropriateness.
9. Describe the theoretical aspects of systems for studying biological response to whole organisms in cell cultures, the suitability of these systems, and methodological and ethical considerations.
10. Describe the theoretical aspects of the methodology of cellular subfractionation and of the parameters used to assess its efficiency.
11. Design experiments and understand the limitations of experimental approaches.
12. Explain the metabolic interrelationships of tissues and integration in the control of the metabolism to satisfy physiological needs.
13. Interpret experimental results and identify consistent and inconsistent elements.
14. Make an oral, written and visual presentation of ones work to a professional or non-professional audience in English and understand the language and proposals of other specialists.
15. Manage information and the organisation and planning of work.
16. Read specialised texts both in English and ones own language.
17. Think in an integrated manner and approach problems from different perspectives.
18. Use ICT for communication, information searching, data processing and calculations.
19. Use databases on metabolic pathways, biological signal transmission and their disorders in pathological situations.

## **Content**

### **Program for theory classes.**

#### **Topic 1 - Introduction to metabolic regulation: metabolic characteristics of the tissues.**

Concept of metabolic regulation. Metabolic specialization and interactions between tissues. Levels of control of enzymatic activity. Identification of control points of metabolism: quantification of control.

#### **Topic 2 - Hormonal control of metabolism.**

General characteristics, metabolic effects and signalling pathways in the response to insulin, glucagon, catecholamines and steroid hormones. Mechanisms involved in the secretion of insulin and glucagon and factors that affect them.

#### **Topic 3 - Transport through cell membranes.**

Glucose transporters: Types and tissue distribution. Regulation of glucose transport: relationship with energy demand and hypoxia. The amino acid carriers: Characteristics, mechanisms of regulation and their relation with the translation. Transport of lipids: Alterations of the transport of glucose and lipids in the pre-diabetic state.

#### **Topic 4 - Regulation of the tricarboxylic acid cycle.**

Interconnections of the tricarboxylic acid cycle to other intermediate metabolic pathways. Importance of -ketoglutarat in hydroxylations and demethylations. Regulation of pyruvate dehydrogenase. Control of the tricarboxylic acid cycle: relationship with respiration. Indicators of the cellular energy state and their relevance in the coordination of the control of the intermediary metabolism.

#### **Topic 5 - Control of glucose metabolism.**

Regulation of the synthesis and use of glucose 6-phosphate. Control of glycolysis in the muscle and liver. Regulation of hepatic gluconeogenesis: Metabolic compartmentation in the liver. Regulation of the pentose-phosphate pathway: Interconnections with lipid and nucleotides metabolism.

## **Topic 6 - Regulation of glycogen metabolism.**

Integration of glycogen metabolism in the general metabolism of glucose: functional relevance in muscle and liver. Regulation of glycogen synthase and glycogen phosphorylase: Coordination in the control of glycogen metabolism. Glycogenesis.

## **Topic 7 - Regulation of lipid metabolism.**

Connections between the metabolism of glucose and lipids in the liver and adipose tissue: Importance of the triacylglycerol / fatty acids cycle. Regulation of the synthesis of fatty acids and triacylglycerols. Regulation of lipolysis. Metabolism of the ketone bodies. Importance of cholesterol in living organisms. Control of the metabolism of cholesterol and lipoproteins.

## **Topic 8- Regulation of the metabolism of nitrogen compounds and Integration in the control of metabolism.**

Control of the metabolism of nucleotides. Mechanisms of control of amino acid metabolism. Integration of the mechanisms involved in the regulation of metabolism.

## **Seminars**

The seminars are designed to consolidate the contents worked on in theory classes and to encourage students to acquire group work abilities, critical reasoning, discussion of scientific topics and communication skills. At the beginning of the theory classes, the teacher will propose a list of subjects for seminars that will be published in Campus Virtual.

## **Methodology**

### **Theory classes:**

The content of the theory program will be taught mainly by the teacher in the form of master classes. The presentations used in class by the teacher will be available to the students in the Virtual Campus of the matter in advance to the beginning of each topic of the course. It is recommended that students consult on a regular basis the bibliographical material recommended in this teaching guide, as well as the review articles referenced in the graphic material of the classes, which are accessible through the UAB network, in order to consolidate or clarify, if necessary, the theory aspects explained in class.

### **Seminars:**

For the seminars the students will be divided into two groups (A and B) whose lists will be made public at the beginning of the year by the Degree Coordination. The student must consult which group they belong to and attend the classes corresponding to their group.

At the beginning of the theory classes, the teacher will propose a list of subjects that will be published in Virtual Campus. The students will organize in work groups of three to four people which will be kept during the sessions of the seminars. The organization of the groups, the distribution of subjects to be dealt with and the programming of the dates of presentations will be carried out during the first week of classes of the course. Each group will work on a specific topic related to the course program for its subsequent oral presentation and collective discussion with the available means in the classroom. Each group will write a brief summary (1 page) of the content of their presentation and send it by e-mail, in pdf format, to the professor responsible for the seminars with a minimum of 48 hours in advance of the presentation of the seminar. The teacher will make this material available to the Virtual Campus of the course prior to the presentation of the seminar. Once the presentation has been made, the students will send the teacher, by e-mail, in pdf format and not later than 24 hours after the seminar, a report that must include the graphic material used in the presentation, the conclusions and the bibliography.

## Tutorials:

Individual or small group tutoring will be carried out at the request of the students. The objective of these tutorials will be to solve doubts, to guide on the sources of information to consult and the preparation of the seminars. In the event that the number of applicants was extremely high, a classroom tutoring could be scheduled to solve doubts or to reconsider some basic concepts, that would be announced through the Virtual Campus in due time. These sessions will neither be used to expose new topics nor to advance in the theory program but they will be sessions of debate and discussion.

## Activities

Title	Hours	ECTS	Learning outcomes
<b>Type: Directed</b>			
Seminars	5	0.2	1, 4, 18, 3, 11, 15, 13, 16, 17, 14, 19
Theory classes	18	0.72	1, 4, 2, 8, 10, 9, 7, 6, 5, 11, 12, 13, 19
Tutorials	3	0.12	1, 4, 2, 8, 10, 9, 7, 6, 5, 11, 12, 15, 13, 17, 19
<b>Type: Supervised</b>			
Preparation of a seminar	4	0.16	1, 4, 18, 2, 8, 10, 9, 7, 6, 5, 11, 12, 15, 13, 16, 17, 14, 19
<b>Type: Autonomous</b>			
Study - autonomous work	37	1.48	1, 4, 18, 2, 3, 8, 10, 9, 7, 6, 5, 11, 12, 15, 13, 16, 17, 14, 19

## Evaluation

The competences on the subject of this course will be evaluated through the preparation and presentation of a seminar and two theory partial exams.

### Theory (80% of the overall grade)

There will be two partial written exams, which will be eliminatory if their rating is equal to or greater than 4 (out of 10). The weight of each exam will be 40% of the overall score.

There will be a **theory retrieval exam**, with characteristics similar to those of the previous one. To be eligible for the retake process, the student should have been previously evaluated in a set of activities equaling at least two thirds of the final score of the course or module. Thus, the student will be graded as "No Avaluable" if the weighthin of all conducted evaluation activities is less than 67% of the final score. Students who have obtained a grade lower than 4.0 (out of 10) in the previous exam of one or both of the partial exams must complete the exam of that corresponding partial (s) (first partial , second partial or both). Any student who wishes to improve the qualification of any of the partials of theory can also present to the theory retrieval exam. In this case, it is understood that the first grade is waived and the one obtained in the recovery exam will be considered as a partial grade of theory. No minimum value is established so that the qualifications of the partials of theory of this second exam can compensate with that of the seminar.

### Seminars (20% of the overall grade)

This section assesses the capacity for analysis and synthesis of the students of each group, as well as the skills of group work and oral presentation. The assessment will consider (1) the initial

summary, (2) the content (degree of depth and knowledge of the subject) of the seminar shown in the oral presentation and the answer to the questions, (3) the conclusions and (4) the bibliography. The qualification of the seminars does not require a minimum grade to compensate for the theory.

In all the assessment components, the acquisition of written communication skills will be taken into account in addition to the knowledge. The sections of Theory and Seminars are inseparable, so that the student must participate and be evaluated in both to pass this subject.

To pass the subject, it is necessary to obtain a final global grade equal to or greater than 5.0 (out of 10).

Any student, who cannot attend an individual assessment test for any justified reason (such as illness, death of a first-degree relative or accident) and brings in the corresponding official documentation to the teacher or the Degree Coordinator, will be entitled to perform the missed test on another date.

## Evaluation activities

Title	Weighting	Hours	ECTS	Learning outcomes
First partial of theory	40%	2	0.08	1, 4, 2, 8, 10, 9, 7, 6, 5, 11, 12, 13, 17
Presentation of a seminar, summary writing and graphical material.	20%	4	0.16	18, 3, 11, 15, 13, 16, 17, 14, 19
Second partial of theory	40%	2	0.08	1, 4, 2, 8, 10, 9, 7, 6, 5, 12

## Bibliography

### a) General

Berg, J.M., Tymoczko, J.L., Gatto, G. J., Stryer, L. "Biochemistry" (2015). 8<sup>a</sup> ed. W.H. Freeman, New York. A translated edition is: "Bioquímica" (2013). 7<sup>a</sup> ed. Ed. Reverté. Translated from the 7<sup>a</sup> ed., 2012. Ed. W.H. Freeman. [www.whfreeman.com/stryer](http://www.whfreeman.com/stryer)

Nelson, D.L., Cox, M.M. "Lehninger-Principios de Bioquímica" (2014) 6th. ed. Ed. Omega. Translated from the 6<sup>a</sup> ed., 2013. Also available is the 7th English edition (2017). Ed. W.H. Freeman. [www.whfreeman.com/lehninger/](http://www.whfreeman.com/lehninger/)

Tymoczko, J.L., Berg, J.M., Stryer, L. "Bioquímica, Curso Básico" (2014) Ed. Reverté, Barcelona. Translated from "Biochemistry: A Short Course" 2nd ed.(2013) W.H. Freeman & Co. New York.

### b) Specialized

Adamafo, N. "Integration and Control of Metabolism". 2005. Ed. iUniverse.com.

Frayn, K.N. "Metabolic Regulation- A Human Perspective". 3rd ed. 2010. Ed. Wiley-Blackwell. Oxford. UK.

Gibson, D.M., Harris, R.A. "Metabolic Regulation in Mammals". 2002. Taylor & Francis. New York. USA.

Kraus, G. "Biochemistry of Signal Transduction and Regulation", 4th ed. 2008, Ed. John Wiley and Sons Ltd.

Marks, F., Klingmüller, U., Müller-Decker, K. "Cellular Signal Processing: An Introduction to the Molecular Mechanisms of Signal Transduction", 2nd ed. 2017, Ed. Garland Science.

Newsholme, E.A. "Functional biochemistry in health & disease: metabolic regulation in health and disease". 2nd ed. 2008 Ed. John Wiley and Sons Ltd.

Storey, K.B. "Functional Metabolism. Regulation and Adaptation". 2004. Ed. John Wiley and Sons Ltd.

**C) Review articles published in scientific journals.**

Full references of the various recommended review articles will be indicated in the graphic material of the classes. These review articles will correspond to journals that are accessible through the UAB network.

**Material available on the Virtual Campus.**

Presentations used by the teacher in theory classes.

List of review articles proposed as seminar topics.