Universitat Autònoma de Barcelona

2019/2020

Microbial Physiology and Metabolism

Code: 100772
ECTS Credits: 6

Degree	Type	Year	Semester
2500250 Biology	OT	4	0

Contact

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Use of Languages

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

Prerequisites

The student must have successfully completed Microbiology and Biochemistry from the Microbiology degree, or subjects of equivalent content.

Objectives and Contextualisation

The aim of the course is to provide the student with an overall vision of the operation of the different processes that allow growth of prokaryotic cells as well as their adaptation to a changing environment. In the first part of the course, the main elements of the process of structure building and cell growth are presented hierarchically: biosynthesis, polymerization of macromolecules, formation of structures, transport and secretion processes. Emphasis is made in the quantitative assessment of the impact of thiese processes on global growth expenditure. The subject describes the different mechanisms of energy generation necessary to cover growth expenses. In this part, students learn how to make predictions about the viability of certain metabolic reactions, as well as the tools to determine the energy performance of different types of metabolism. Finally, the student is introduced to some of the elements needed to carry out microbial physiology studies: work with continuous bioreactors, analysis of metabolic budgets and calculation of metabolic rates from steady state data.

Competences

- Be able to analyse and synthesise
- Be able to organise and plan.
- Develop critical thinking and reasoning and communicate ideas effectively, both in the mother tongue and in other languages.
- Develop independent learning strategies.
- Understand the processes that determine the functioning of living beings in each of their levels of organisation.

Learning Outcomes

1. Be able to analyse and synthesise.
2. Be able to organise and plan.
3. Describe the role of microorganisms in important industrial processes and as producers of key compounds for the development of our societies and the improvement of quality of life.

4. Develop critical thinking and reasoning and communicate ideas effectively, both in the mother tongue and in other languages.
5. Develop independent learning strategies.

Content

1.-Composition of the bacterial cell.

Methods of analysis. Cellular volume: factors affecting it. Fresh weight. Dry weight. Cellular density. Elemental composition. Molecular composition. Dynamic aspects of growth.

2.-Diversity and relative abundance of cellular components I

Diversity of macromolecules. PROTEINS: Diversity of proteins in the proteome of *Escherichia coli*. Average protein size. Relative abundance. DNA: Cellular content of DNA. Coding capacity of the prokaryotic genome. Determination of the fraction of the genome being expressed. Coding capacity of different genomes. Genome size and information content. Minimal-genome concept. Gene expression profiling using genomic chips. RNA: Relative abundance of stable RNAs. Calculation of the number of ribosomes. Low molecular weight RNAs: tRNA, sRNA.

3.-Diversity and relative abundance of cellular components II

LIPIDS: Types of lipids in prokaryotes. Structure and composition of membrane phospholipids. Diversity and nomenclature of fatty acids. Analytical techniques. Physiological importance of unsaturated fatty acids. Regulation of the degree of unsaturation as a function of temperature. Other membrane-forming lipids: phytanyl ethers. Diethers vs tetraethers. Lipids without glycerol. LIPOPOLYSACCHARIDE: Intraspecific and interspecific structural variability. PEPTIDOGLYCAN: diversity of peptidoglycan in prokaryotes. Other cell wall-forming macromolecules. Phylogenetic distribution of wall forming polymers.

4.-Cellular Envelopes I

PLASMA MEMBRANE: Functions of the plasma membrane. Protein content of membranes in prokaryotes. Formation of phospholipids: phospholipid assembly pathway, fatty acid biosynthesis. Role of ACP proteins and their relationship to Coenzyme A. Mechanisms of phospholipid transport. LPS: Polymorphisms of the LPS molecule. Disposition in space. LPS stabilizing factors. Selective permeability. LPS formation and assembly. OUTER MEMBRANE: porins. Structural similarity with Siderophore, β-hemolysin and components of secretion systems. PERIPLASM: Dimensions. Composition. Biological function. NUTRIENT TRANSPORT: Primary transporters. Secondary transporters. Comparative structure of different types of transporters. Genomic analysis of transport systems in different microorganisms: Taxonomic distribution of different families of transporters. ABC and MFS: Differential characteristics and relative importance in different microbial groups.

5.-Cellular Envelopes II

PEPTIDOGLYCAN: Structural diversity. Intracellular synthesis of monomers. Extracellular assembly. Role of undecaprenol. Coordination of cleavage and polymerization reactions. EXTRACELLULAR POLYMERIC STRUCTURES: Capsules and slime layers. Function of extracellular polymers. Types of exopolimers according to their composition. Biosynthesis and secretion of alginates. Regulation. Role of exopolimers in biofilm formation. CELLULAR APPENDAGES: Pili: Function in adhesion and colonization of surfaces. Types of pili. Structure. Biogenesis: FLAGELLA: Structure and function of the basal body. Composition and structure of the filament. Biogenesis of the flagellum. Secretion of filament proteins. Stoichiometry of flagellar rotation. S LAYERS: Phylogenetic distribution. Structure and biological function.

6.-Structure and formation of cytoplasm components.

Organization of DNA. Replication speed. Cost of polymerization. Impact of discontinuous synthesis and repair processes on the cost of DNA replication. Composition of the ribosome. Structure of rrn operons. Variability of the number of rrn operons in different groups. 16S rRNA sequence: conserved regions and variable regions. Importance for studies of phylogeny. tRNAs. Low molecular weight RNAs. Cost of stable RNA formation. Stages in the ribosomal polymerization of a peptide chain. Error correction. Cost of the mRNA used. Global

energy expenditure.Problems associated with protein synthesis: depletion of the aa pool and presence of incomplete messengers. Mechanisms of protein folding in prokaryotes. Importance of chaperones. Intracellular proteolysis. Compartmentalized proteases. Degradation tags.

7.-Protein secretion in prokaryotes.

Importance of protein secretion systems. Secretion to the periplasmic space: type II (Sec) secretion systems. Fate of the proteins secreted to the periplasmic space. Self-secreted proteins. Biogenesis of Pili. Main terminal branch (MTB). Direct secretion beyond the external cell membrane: type I, III, IV and V secretion systems.

8.-Energtic cost of cellular construction

Transport and assimilation of nutrients. Biosynthetic pathways. Generation of metabolic precursors. Formation of monomers. Polymerization. Cost of biosynthesis. Integration of growth expenses. Balancing energy and reducing power budgets. Role of transhydrogenases. Calculation of the theoretical yield and comparison with experimental yields. Metabolic efficiency as a function of growth conditions.

9.- Bioenergetics and electron transport chains

Energy yield and electrochemical potential of metabolic reactions. Predicting energy yields: from free energies of formation, from the oxidation-reduction potentials. Components of the respiratory chain. Bacterial respiratory chains. Disposition in the space of the different components. Control of bacterial respiration. Regulation of aerobic / anaerobic metabolism. Facultative and strict anaerobic respirations. Reduction of nitrate. Reduction of sulfate. Methanogenesis. Light-dependent electron transport chains. Photosynthetic pigments. Structure and organization of light-harvesting complexes. Organization of the reaction centers. Oxygenic and anoxigenic photosynthesis. Electron donors and reverse flow of electrons.

10.-Use of organic substrates

Use of organic substrates: glucose catabolism. Degradation of sugars other than glucose. Degradation of polymers. Growth in amino acids. Growth in organic acids. Growthin hydrocarbons. Utilization of aromatic compounds. Assimilation of C1 compounds. Use of inorganic substrates: Problems arising from the use of inorganic substrates. Hydrogen oxidizers. Oxidation of sulfur compounds. Iron Oxidizers. Oxidation of reduced nitrogen compounds

11.-Fermentative metabolism

Characteristics of the fermentative metabolism. Types of fermentation according to the final products: Alcoholic, lactic, butyric, butanol-acetone, mixed acid, butanedioic, propionic. Energy yield. Carbon and carbon and electron budgets.

Methodology

Teaching is carried out through a combination of theory lectures, problem solving sessions, and seminars.

Theory lectures. The theory classes are designed to allow the student to incorporate the elements required to achieve a structured knowledge of the prokaryotic cell function. The contents are taught in the classroom using teaching resources available to the student through moodle.

Problem-solving sessions. These sessions are strictly dedicated to work out, interactively and in small groups, procedures aimed at determining the coherence of experimental data, making metabolic balances and formulating predictions about the viability of different types of metabolism.

Seminars. In the seminars, students carry out a supervised discussion of selected scientific articles related to the content of the subject. The articles are distributed previously together with a questionnaire related to their content. Questionnaires must be completed and delivered before the start of the seminar.

Activities

Title	Hours	ECTS	Learning Outcomes
Type: Directed			
Problem-solving sessions	10	0.4	3, 5, 4, 1, 2
Seminars	5	0.2	3, 5, 4, 1, 2
Theory lectures	30	1.2	3, 5, 4, 1, 2
Type: Supervised			
Tutorial	5	0.2	3, 5, 4, 1, 2
Type: Autonomous			
Literature search	20	0.8	3, 5, 4, 1, 2
Problem solving	25	1	3, 5, 4, 1, 2
Study	31	1.24	3, 5, 4, 1, 2
Text readings	20	0.8	3, 5, 4, 1, 2

Assessment

Assessment will be carried out through two exams each contributing 45% of the final grade. Each of the exams will cover theory (25% of the global grade) and problem-solving (20% of the global grade) contents. The remaining 10% of the grade will complement the exam scores only if both exams have been successfully passed, and will be based on the level of participation in the problem-solving sessions, requiring the completion of the assigned tasks within the established deadlines. To pass the subject the student must obtain 5 or higher in each exam. If the event of failing to pass any of the exams, a reassessment exam is scheduled at the end of the semester. To participate in the reassessment exam, students must have been previously assessed in a set of activities the weight of which equals a minimum of two thirds of the total grade of the subject or module. Students will obtain the "Not Evaluable" qualification when the evaluation activities carried out have a weight lower than 67% of the final grade. Students that, having passed the exams, want to improve their grades may also take the reassessment exam. In the event of taking the reassessment exam, students implicitly renounce to their previously obtained grades.

Assessment Activities

Title	Weighting	Hours	ECTS	Learning Outcomes
Exam 1. Theory (25%) + Seminars (20%)	45%	2	0.08	3, 5, 4, 1, 2
Exam 2. Theory (25%) + Problems (20%)	45%	2	0.08	3, 5, 4, 1, 2
Participation in programmed activities	10%	0	0	3, 5, 4, 1, 2

Bibliography

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Moat AG, Foster JW, Spector MP. 2002. Microbial physiology (4th ed). Wiley-Liss

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Schaechter M., J.L. Ingraham & F.C. Neidhart. 2006. Microbe. ASM Press. Washington D.C.

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