COURSE DATA

DATA SUBJECT

Code: 33153
Name: Microbial pathogenesis
Cycle: Undergraduate Studies
ECTS Credits: 6
Academic year: 2026-27

STUDY (S)

Degree	Center	Acad. year	Period
1109 - Degree in Biochemistry and Biomedical Sciences	Facultat de Ciències Biològiques	4	Second quarter

SUBJECT-MATTER

Degree	Subject-matter	Character
1109 - Degree in Biochemistry and Biomedical Sciences	Materia de asignaturas optativas	ELECTIVES

COORDINATION

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SUMMARY

Microbial Pathogenesis is a 6 ECTS optional course in the Degree in Biochemistry and Biomedical Sciences. It belongs to the optional subjects module and is taught in the fourth year. The course builds on previous knowledge of Microbiology, Genetics, Biochemistry, Cell Biology and Immunology.

The course studies the mechanisms by which pathogenic microorganisms, especially bacteria, interact with the host and cause infectious diseases. It covers processes such as adhesion, colonization, invasion, biofilm formation, toxin production, secretion systems, immune evasion, nutrient acquisition, inflammation, tissue damage and transmission.

A central focus is the regulation of virulence: how pathogens detect signals from the host and the environment and coordinate the expression of adhesins, toxins, secretion systems and other virulence factors. Pathogenesis is also analysed from an evolutionary and One Health perspective, considering horizontal gene transfer, mobile genetic elements, the emergence of new pathogens, climate change and the relationship between the environment, hosts and disease.

The course also includes strategies for diagnosis, treatment, prevention and control, with special attention to vaccines, passive immunization, adjuvants, new generations of vaccines and alternative therapeutic approaches.

Teaching combines lectures, laboratory practicals, analysis of scientific articles, seminars, case solving, cooperative activities, critical use of digital tools and artificial intelligence, bacterial genome analysis and identification of virulence genes. Practical and applied activities include pathogen isolation and identification, molecular diagnosis, assessment of virulence factors, antimicrobial resistance, interaction with the immune system, genomic analysis and a scientific escape room aimed at integrating microbiological, experimental and clinical reasoning.

PREVIOUS KNOWLEDGE

RELATIONSHIP TO OTHER SUBJECTS OF THE SAME DEGREE

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

OTHER REQUIREMENTS

No enrolment restrictions involving other subjects in the curriculum have been specified.

Recommendations
For an adequate follow-up of the course, students are recommended to have previously acquired basic knowledge of Microbiology, Genetics, Biochemistry, Cell Biology and Immunology. This knowledge will facilitate the understanding of microorganism-host interaction mechanisms, regulation of virulence, the immune response to infection, pathogen evolution and the experimental techniques used in the study of infectious diseases.

COMPETENCES / LEARNING OUTCOMES

1101 -

Conocer los mecanismos de interacción hospedador-patógeno para entender factores de virulencia en enfermedades infecciosas y parasitarias.

Conocer los organismos patógenos de humanos, las patologías que provocan y conocer los fundamentos de las principales estrategias terapéuticas.

Conocer los principales métodos y técnicas experimentales aplicadas al estudio de la salud y enfermedad humanas, su etiología y la efectividad de los tratamientos.

Conocimiento de las enfermedades y disfunciones más frecuentes.

Know how to apply the knowledge gained in the diagnosis, prevention and treatment of human diseases.

DESCRIPTION OF CONTENTS

Theoretical contents

Topic 1. General concepts in microbial pathogenesis. Pathogen and infectious disease. Classification of pathogens according to their relationship with the host and the immune status of the host. Primary, secondary, opportunistic, accidental and obligate pathogens. Stages of infection: colonization, invasion, multiplication, tissue damage and transmission. Virulence, virulence factors, infectious dose and lethal dose. Reservoirs, sources of infection, zoonoses and host jumps. Genome, accessory genome, pangenome, mobile genetic elements and horizontal gene transfer in pathogen evolution.

Topic 2. Vaccines, immunization and control of infectious diseases. Concept of vaccine and protective immunity. Types of vaccines: live, inactivated, toxoids, subunit, conjugate, recombinant, vectored and new-generation vaccines. Rational vaccine design according to the colonization niche, mechanism of pathogenesis, virulence factors and type of protective immune response. Adjuvants and immunostimulants. Passive immunization. Successes, limitations and current challenges of bacterial vaccines.

Topic 3. Host colonization, adhesion and biofilms. Colonization of mucosal surfaces and host barriers. Mucus, local antimicrobial defences, mucosal immunity and microbiota. Fimbrial and afimbrial adhesins. Adhesion to biotic and abiotic surfaces. Invasion and intracellular survival. Formation of microcolonies and biofilms. Role of biofilms in persistence, chronicity, resistance to the immune system and tolerance to antimicrobials.

Topic 4. Bacterial aggressins, toxins and secretion systems. Concept of aggressin. Modulins, LPS and immunopathological damage. Extracellular and intracellular toxins. Superantigens, cytolysins, A+B toxins, injectable toxins and bacterial effectors. Bacterial secretion systems and delivery of virulence factors. Role of toxins in cellular damage, inflammation, immune evasion and manipulation of the host.

Topic 5. Regulation of virulence genes. Virulence as a dynamic gene-expression programme. Operons, regulons, modulons and regulatory networks. Directional regulation in response to host and environmental signals. Two-component systems, global regulators, sigma factors, H-NS proteins, regulatory RNAs, quorum sensing and second messengers. Random regulation, phase variation, duplications and gene rearrangements. Regulation of virulence as a therapeutic target.

Topic 6. Model of host-pathogen interaction: *Vibrio cholerae*. General characteristics, environmental ecology, aquatic reservoirs and transmission cycle. Cholera, pandemics and molecular epidemiology. Intestinal colonization, TCP, cholera toxin, CTXφ phage, pathogenicity islands and other virulence factors. Coordinated regulation of virulence through ToxR/TcpP/ToxT. Diagnosis, treatment, rehydration, prevention and cholera vaccines.

Topic 7. Model of evolution and virulence: *Yersinia*. Pathogenic *Yersinia* species and associated diseases. *Yersinia enterocolitica*, *Yersinia pseudotuberculosis* and *Yersinia pestis*. Bubonic, septicaemic and pneumonic plague. Evolution of *Y. pestis* from an enteropathogen to a vector-borne pathogen. Adaptation to flea-borne transmission. Virulence factors, tropism for lymphoid tissue, evasion of phagocytosis, type III secretion system and injectable toxins. Diagnosis, treatment, prevention and vaccination.

Seminars and critical analysis activities

The seminars will address current problems in microbial pathogenesis from a mechanistic, evolutionary, biomedical and One Health perspective. Students will work in groups on selected topics, prepare an oral presentation, solve scientific questions requiring in-depth reasoning, critically use artificial intelligence tools as support for analysis, and produce a science communication summary aimed at a non-specialist audience.

Seminar topics may include, among others:

1. Pathogenesis as a collateral effect in accidental pathogens: bacterial toxins as anti-predator weapons.
2. Adhesion and biofilm as determinants of chronic infection and strategies for their control.
3. Dysbiosis, opportunistic pathogens and disease.
4. Obligate intracellular pathogens: extreme adaptation, persistence and virulence.
5. Climate change and emerging infectious diseases.
6. Immune storms and immunopathology in bacterial infections.
7. Regulation of virulence as a therapeutic target in antivirulence strategies.
8. Bacterial vaccines: successes, failures and current challenges.

These activities aim to integrate theoretical knowledge, analysis of scientific literature, mechanistic reasoning, critical discussion, oral communication and science communication.

Laboratory practicals and applied activities

The practical component will focus on the experimental and bioinformatic study of microbial pathogenesis using *Vibrio vulnificus* as the main model, a zoonotic pathogen associated with aquatic environments and influenced by environmental factors such as temperature and iron availability.

Practical 1. Introduction to *Vibrio vulnificus* and vibriosis. Ecological, clinical and epidemiological characteristics of the pathogen. Risk factors, life cycle, environmental reservoirs, transmission, virulence factors, climate change and relevance to human and animal health.

Practical 2. Isolation of *Vibrio vulnificus* from environmental and food samples. Selective enrichment, plating on selective and differential media, isolation of suspected colonies, purification of cultures and preparation of bacterial DNA.

Practical 3. Molecular identification by multiplex PCR. Species identification and discrimination of potentially dangerous strains for public and animal health through DNA extraction, PCR amplification, electrophoresis and interpretation of results.

Practical 4. Toxins and exoenzymes. Production and functional assessment of bacterial toxins and exoenzymes. Analysis of haemolytic and proteolytic activities and other phenotypes related to tissue damage and virulence.

Practical 5. Resistance to the innate immune system. Evaluation of bacterial resistance to serum and other components of innate immunity. Role of the capsule, iron and other virulence factors in survival during septicaemia.

Practical 6. Antibiogram and antimicrobial susceptibility. Determination of bacterial susceptibility to antibiotics using phenotypic tests. Interpretation of results and discussion of treatment, antimicrobial resistance and infection control.

Practical 7. Prophages and mobile genetic elements. Induction, detection and analysis of prophages in pathogenic bacteria. Relevance of phages and other mobile genetic elements in evolution, virulence and potential therapeutic applications.

Practical 8. Triparental conjugation. Transfer of plasmids by triparental conjugation. Introduction of marker genes and discussion of their usefulness in bacterial genetics, mutagenesis and functional study of virulence factors.

Practical 9. Bioinformatics applied to bacterial genomics using Galaxy. Introduction to genomic data analysis. Obtaining sequencing reads, quality control, filtering, de novo assembly, comparison and polishing of assemblies, calculation of average nucleotide identity, genome annotation and identification of genes of interest, including virulence genes.

Methodological and science communication activity. Cooperative work on methodologies used in biomedical and microbiological research, such as digital PCR, next-generation sequencing, phylogenomics, RNA-seq, dual RNA-seq, RT-qPCR, immunoblot, histology, mutagenesis, mass spectrometry or statistical analysis. Students will apply the selected methodologies to an experimental or clinical situation and prepare a science communication product accessible to a non-specialist audience.

WORKLOAD

PRESENCIAL ACTIVITIES

Activity	Hours
Tutorials	3,00
Theory	37,00
Laboratory	20,00
Total hours	**60,00**

NON PRESENCIAL ACTIVITIES

Activity	Hours
Attendance at other activities	0,00
Individual or group project	30,00
Independent study and work	45,00
Preparation of lessons	10,00
Preparation for assessment activities	5,00
Resolution of case studies	0,00
Total hours	**90,00**

TEACHING METHODOLOGY

The course will combine different teaching methodologies aimed at the progressive acquisition of knowledge, the development of scientific reasoning and the application of theoretical contents to real problems in microbial pathogenesis.

Lectures. Lectures will be based on the presentation and discussion of the fundamental contents of the course. Presentations, conceptual diagrams, examples of bacterial pathogens and case studies will be used to explain the mechanisms of microorganism-host interaction, regulation of virulence, pathogen evolution, immune response, tissue damage and strategies for the prevention and control of infectious diseases. Student participation will be encouraged through reasoning questions, discussion of examples and resolution of mechanistic questions related to each topic.

Active learning and critical use of artificial intelligence. Throughout the course, classroom activities will be carried out to apply theoretical concepts to specific situations. These activities may include hypothesis analysis, interpretation of virulence mechanisms, comparison of pathogenic strategies, discussion of experimental results and resolution of biomedical problems. Students may use artificial intelligence tools as support to explore ideas, formulate hypotheses, detect conceptual errors, compare explanations and improve scientific communication. Their use must be critical, supervised and aimed at strengthening students' own reasoning, not replacing it.

Seminars and critical analysis of scientific literature. Students will work in groups on current problems in microbial pathogenesis. Each group will prepare an oral presentation, solve scientific questions requiring in-depth mechanistic reasoning, analyse current scientific literature and produce a science communication summary aimed at a non-specialist audience. The seminars will be aimed at integrating theoretical knowledge, critical interpretation of evidence, scientific argumentation, oral discussion and rigorous communication of science.

Laboratory practicals. Laboratory practicals will allow students to become familiar with methodologies used in the experimental study of pathogenic bacteria, using Vibrio vulnificus as the main model. Techniques will include bacterial isolation and identification, selective enrichment, culture on differential media, DNA extraction, multiplex PCR, electrophoresis, assessment of toxins and exoenzymes, study of resistance to the innate immune system, antibiogram, prophage analysis and triparental conjugation. These activities will be aimed at understanding how virulence factors, transmission, antimicrobial resistance and control of infectious diseases are experimentally studied.

Bioinformatics practicals and genomic analysis. The course will include bioinformatics activities applied to bacterial genome analysis using accessible environments such as Galaxy. Students will work with sequencing reads, quality control, filtering, de novo assembly, comparison and polishing of assemblies, calculation of average nucleotide identity, genome annotation and identification of genes of interest, including virulence genes. These activities will allow students to connect bacterial genomics with the identification, epidemiology, evolution and pathogenic potential of microorganisms.

Case solving and scientific escape room. Integrative activities based on the resolution of microbiological, clinical or experimental cases may be carried out. These include a scientific escape room, in which students will work cooperatively to interpret data, solve methodological problems, identify pathogens, relate experimental results to virulence mechanisms and reach a reasoned conclusion. This methodology aims to reinforce active learning, teamwork, decision-making and knowledge integration.

Methodological work and science communication. Students will prepare activities or assignments related to methodologies used in biomedical and microbiological research, such as digital PCR, next-generation sequencing, phylogenomics, RNA-seq, dual RNA-seq, RT-qPCR, immunoblot, histology, mutagenesis, mass spectrometry or statistical analysis. These assignments will be presented in a science communication format, with the aim of developing the ability to explain complex methodologies in a rigorous, clear, accessible and inclusive way.

Tutorials and follow-up. Individual or group tutorials will be used to guide autonomous work, resolve doubts, support the preparation of seminars and practical activities, supervise the critical use of bibliographic sources and digital tools, and facilitate the integration of theoretical, practical and applied contents of the course.

EVALUATION

Assessment will be carried out using the assessment systems established in the degree verification report and will aim to evaluate the acquisition of the knowledge, competences and learning outcomes defined in the course guide.

The final mark will be obtained from the following components:

1. **Objective tests on the course contents: 55%.** This component will include the assessment of the theoretical contents of the course and of the contents related to seminars and critical analysis activities. The tests may be written or oral and may include multiple-choice questions, short-answer questions, reasoning questions, interpretation of results, problem solving or analysis of cases related to microbial pathogenesis.

2. **Individual follow-up of practical and applied activities: 15%.** This component will assess the work carried out in laboratory practicals and associated applied activities. It may include daily tasks, resolution of practical problems, interpretation of experimental results, methodological/science communication work and other activities related to the methodologies used in the experimental study of microbial pathogenesis.

3. **Assessment of written reports and oral presentations: 25%.** This component will include the preparation and oral presentation of seminars, the preparation of written reports or science communication summaries, the resolution of mechanistic questions, the critical analysis of scientific literature and participation in cooperative or case-solving activities. Artificial intelligence tools may be used as support for analysis, provided that their use is critical, supervised and aimed at strengthening students' own reasoning.

4. **Objective tests on the use of computer tools: 5%.** This component will assess the acquisition of competences related to the use of computer and bioinformatic tools applied to the study of microbial pathogenesis, including genomic data analysis, quality control of sequencing reads, assembly, annotation, calculation of average nucleotide identity and identification of genes of interest, including virulence genes.

To pass the course, students must obtain at least 50% of the final mark.

Attendance at laboratory practicals is compulsory. In order for practical activities to be assessed, students must attend at least 80% of the practical sessions, except in duly justified cases supported by documentation. Attendance at lectures or theoretical-practical classes will not, in itself, constitute a minimum requirement to pass the course.

In the second examination period, students' right to pass the course will be guaranteed through tests or recovery activities that allow the assessment of the acquisition of the learning outcomes. The component corresponding to objective tests on the course contents will be recoverable through a new written or oral test. Objective tests on the use of computer tools will be recoverable through an equivalent test or activity. Practical and applied activities will be recoverable when it is possible to design an equivalent test or task assessing the same learning outcomes. Activities corresponding to written reports, oral presentations, seminars, discussions, cooperative work and activities carried out during the course will be non-recoverable when, due to their face-to-face, progressive or cooperative nature, they cannot be reproduced in the second examination period under equivalent conditions.

Any conduct contrary to academic integrity in tests, assignments, seminars or assessable activities will be governed by the current regulations of the Universitat de València. When there are reasoned doubts regarding authorship, originality or the individual acquisition of learning outcomes, the teaching staff may establish complementary verification mechanisms, including an academic interview or an individual oral test on the assessed contents.

REFERENCES

Basic bibliography

• Wilson, B. A., Salyers, A. A., Whitt, D. D. & Winkler, M. E. *Bacterial Pathogenesis: A Molecular Approach*. 4th edition. ASM Press, Washington, D.C., 2019.

• Current scientific reviews and research articles selected by the teaching staff for each topic, available through the Virtual Classroom. These materials will be used for the preparation of seminars, critical analysis activities, resolution of mechanistic questions, case discussion and content updating.

Complementary bibliography by topic

Topic 1. General concepts of microbial pathogenesis, virulence, evolution and horizontal gene transfer

• Casadevall, A. & Pirofski, L. A. Host-pathogen interactions: redefining the basic concepts of virulence and pathogenicity. *Infection and Immunity* 67:3703–3713, 1999.

• Gal-Mor, O. & Finlay, B. B. Pathogenicity islands: a molecular toolbox for bacterial virulence. *Cellular Microbiology* 8:1707–1719, 2006.

• Schmidt, H. & Hensel, M. Pathogenicity islands in bacterial pathogenesis. *Clinical Microbiology Reviews* 17:14–56, 2004.

Topic 2. Vaccines, immunization and control of infectious diseases

• Chen, H. et al. Next-generation vaccines against bacterial pathogens. *npj Vaccines*, 2025.

• Garling, A. et al. Outer membrane vesicles as a versatile platform for vaccine development. *Journal of Extracellular Vesicles*, 2025.

• Zhang, Z. et al. Mucosal immunity and vaccination strategies: current insights and future perspectives. *Frontiers in Immunology*, 2025.

• Zumárraga, J. Is the reverse vaccinology idea becoming exhausted? *Frontiers in Immunology*, 2026.

Topic 3. Host colonization, adhesion and biofilms

• Berne, C., Ducret, A., Hardy, G. G. & Brun, Y. V. Adhesins involved in attachment to abiotic surfaces by Gram-negative bacteria. *Microbiology Spectrum* 3, 2015.

• Sahoo, K. et al. Biofilm formation in chronic infections: a comprehensive review of pathogenesis, clinical implications and novel therapeutic approaches. *Microorganisms*, 2024.

• Sharma, S. et al. Microbial biofilm: a review on formation, infection, antibiotic resistance, control measures and innovative treatment. *Microorganisms* 11:1614, 2023.

Topic 4. Bacterial aggressins, toxins and secretion systems

• Green, E. R. & Mecsas, J. Bacterial secretion systems: an overview. *Microbiology Spectrum* 4, 2016.

• Jamali, H. et al. Bacterial protein secretion systems: mechanisms, functions and roles in virulence. *Microbiological Research*, 2025.

• Los, F. C. O., Randis, T. M., Aroian, R. V. & Ratner, A. J. Role of pore-forming toxins in bacterial infectious diseases. *Microbiology and Molecular Biology Reviews* 77:173–207, 2013.

• Popoff, M. R. Multifaceted interactions of bacterial toxins with the gastrointestinal mucosa. *Future Microbiology* 6:763–797, 2011.

Topic 5. Regulation of virulence genes

• Childers, B. M. & Klose, K. E. Regulation of virulence in *Vibrio cholerae*: the ToxR regulon. *Future Microbiology* 2:335–344, 2007.

• Chu, X. et al. Regulatory mechanisms and physiological impacts of quorum sensing in Gram-negative bacteria. *Microorganisms*, 2024.

• Rutherford, S. T. & Bassler, B. L. Bacterial quorum sensing: its role in virulence and possibilities for its control. *Cold Spring Harbor Perspectives in Medicine* 2:a012427, 2012.

• Vakulskas, C. A., Potts, A. H., Babitzke, P., Ahmer, B. M. M. & Romeo, T. Regulation of bacterial virulence by Csr/Rsm systems. *Microbiology and Molecular Biology Reviews* 79:193–224, 2015.

Topic 6. Model of host-pathogen interaction: *Vibrio cholerae*

• Deen, J., Mengel, M. A. & Clemens, J. D. Epidemiology of cholera. *Vaccine* 38:A31–A40, 2020.

• Faruque, S. M. & Mekalanos, J. J. Phage-bacterial interactions in the evolution of toxigenic *Vibrio cholerae*. *Virulence* 3:556–565, 2012.

• Montero, D. A. et al. *Vibrio cholerae*: classification, pathogenesis, immune response and trends in vaccine development. *Frontiers in Medicine* 10, 2023.

• Waldor, M. K. & Mekalanos, J. J. Lysogenic conversion by a filamentous phage encoding cholera toxin. *Science* 272:1910–1914, 1996.

Topic 7. Model of evolution and virulence: *Yersinia*

• Atkinson, S. & Williams, P. *Yersinia* virulence factors: a sophisticated arsenal for combating host defences. *F1000Research* 5:1370, 2016.

• Chen, S., Thompson, K. M. & Francis, M. S. Environmental regulation of *Yersinia* pathophysiology. *Frontiers in Cellular and Infection Microbiology* 6:25, 2016.

• Demeure, C. E., Dussurget, O., Mas Fiol, G., Le Guern, A. S., Savin, C. & Pizarro-Cerdá, J. *Yersinia pestis* and plague: an updated view on evolution, virulence determinants, immune subversion, vaccination and diagnostics. *Genes and Immunity* 20:357–370, 2019.

• Sun, Y. C., Jarrett, C. O., Bosio, C. F. & Hinnebusch, B. J. Retracing the evolutionary path that led to flea-borne transmission of *Yersinia pestis*. *Cell Host & Microbe* 15:578–586, 2014.