
# COMMON EUROPEAN CURRICULUM FOR DEGREES IN HEALTH SCIENCES

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# COMMON CURRICULUM ON MICROBIOLOGY FOR HEALTH SCIENCES

## AIM

To provide microbiology teachers of health sciences degrees, with a guide to design their subject-specific teaching programs.
Defining basic ideas about the knowledge to be acquired, and the methods for training professionals who must be capable to deliver microbiology knowledge and practice in the health context.

## INTRODUCTION: THE HEALTH CONTEXT

Definition: areas of medical science in which microorganisms matter.
Physiological aspects: the human and animal microbiome.
Microorganisms in health and disease: role of specific microorganisms and microbiomes in health and diseases of human and/or animals. Reservoirs and transmissions pathways.
Diagnostic and disease monitoring strategies: detection and identification of the etiologic agent(s) of infection, evaluation of the microbiome; diagnosis based on the reaction to pathogens (immune response to microorganisms or disease-specific metabolites).
Therapy: knowledge of available strategies to fight infections and minimize the development of antimicrobial resistance (AMR).
Hygiene and Prevention: vaccines and other strategies for the prevention of infectious diseases.
Biotechnology: industrial use of microbes and their products for medical purposes.

## OBJECTIVES AND COMPETENCIES

- Objectives:
  Students will be able to:
  - Identify the basic concepts that explain microbial life, the diversity of microorganisms and their evolution.
  - Identify the benefits of the microorganisms-human/animal relationships: understand the role of the microbiota and their genes, the microbiome, in the maintenance of the homeostasis of the human/animal body.
  - Understand the main virulence factors as the microbial strategies involved in the infectious process and derived pathologies.
  - Distinguish basic aspects of the morphology, physiology and genetics of the diverse microbial groups.
  - Distinguish the specific physiological targets in the microbial cell used in the development of antimicrobial drugs and understand the mechanisms of resistance to these drugs.
  - Infer the measures for the control of infections based on the knowledge of pathways and mechanisms for the acquisition and spread of pathogenic agents.

- Understand the fundaments of vaccines composition, effectiveness and limitations.
- Apply experimental methods for the detection and identification of pathogenic agents.

- Competencies (what we want that the students will be able to do, based on the understandingof contents and after the acquisition of practical skills)
  - Handle basic laboratory material and techniques, especially those used in culture and identification of microorganisms.
  - Recognize the main infectious agents and their virulence mechanisms.
  - Perform and interpret antimicrobial susceptibility tests.
  - Correctly assess the main microbiological diagnostic techniques
  - Correctly interpret the results of basic microbiological diagnostic tests.
  - Be able to obtain and process a biological sample for its study by means of the different diagnostic procedures.
  - Manage antimicrobial products and processes with respect to the basic ideas of the One Health concept.
  - Update the knowledge and skills by constant reading and sharing information and experiences (read scientific literature, consult with colleagues, attend scientific meetings, be able to present papers)

**CURRICULUM CONTENT**

**For every section, it would be important to classify the content as follows:**

- **Essential content:** what we consider MUST be in every health sciences microbiology program.
- **Desirable content:** important but not essential in all programs. Perhaps essential in some degrees but not in all (although convenient in most).
- **Dismissible:** additional content of interest. Suggestions for advanced students or as extra content.

**Main Sections**

- **Introduction and history of microbiology**: the approach to the invisible life. History of microbiology. The discovery of microorganisms by Antonie van Leeuwenhoek. The role of Louis Pasteur and Robert Koch in the formation of microbiology as a science. The value of work of Martinus W. Beijerinck, Sergei N. Winogradsky, Alexander Fleming and others. Carl Woese and the impact of the taxonomy based on phylogenetic relationship. The main directions in development of modern microbiology: impact of Molecular Biology and "Omics" in current trends.
- **Concepts in general microbiology** (see the FEMS curriculum on general microbiology). Diversity of the microbial world. Cellular and acellular micro-organisms. Prokaryotic and eukaryotic organisms. Introduction to microbial taxonomy. Structure of prokaryotic cell. Cell morphology and sizes of prokaryotes. The bacterial cell wall. Peptidoglycan. Gram-positive and Gram-

negative bacteria, acid-fast bacteria. Bacteria with defective or absent cell wall. Organelles of the cytoplasm and their functions. Bacterial cell nucleoid: chemical and structural organization, functions. DNA replication in bacteria. Mechanisms of genome recombination in bacteria. Plasmids Replicon concept. Regulation of cell division. Organelles of the movement of bacteria. Pili. Bacterial endospores and their importance. Eukaryotic microbial cells. Major eukaryotic cell structures: the nucleus, mitochondria, chloroplasts, peroxisomes and others. Acellular microorganisms: viruses (including bacteriophages), prions, viroids. Microscopy principles and types. Biochemistry and genetics of microorganisms. Growth and physiology of microorganisms. Systematics, biodiversity and ecology of microorganisms.

- **Microorganisms in the healthy individuals**: concepts in microbiota and microbiome, and its role in the physiology of humans and animals. Transient microorganisms. Resident microbiota. Factors influencing the microbiota (diet, hygiene, and others). Concepts that characterize the microbiota: richness, abundance, alpha and beta diversity. Resilience. Culture-dependent and independent methods for the study of the microbiome: High Throughput Sequence Methods. Distribution of the microbiome in the human and animal organism. Concept of dysbiosis.
- **Pathogenesis of infectious diseases**: reservoirs and transmission mechanisms. Environmental and animal reservoirs. Emerging infections. Microbial virulence strategies: mechanisms for microbial adhesion. Strategies for penetrating tissues and cells. Dissemination of microbes through tissues, blood, and lymphatic system. Role of microbial toxins and enzymes. Adaptation of the pathogen to the host: mechanisms of evasion or survival of phagocytosis. Evasion of the immune response. Importance of the state of the host's defenses. Opportunistic infections (ageing population and immunocompromised patients). Nosocomial infections
- **Most important groups of microbial pathogens**: bacteria, eukarya (fungi and protozoa), viruses and other transmissible elements. For each group: most important biological and behavioral characteristics (morphology, size, physiology). Study of the main families, genera and species of human and animal pathogens and their geographical distribution, route of acquisition, strategies to generate disease, pathology caused, methods of diagnosis, treatment and prevention. Priority pathogens: multidrug-resistant and emerging pathogens.
- **Detection and identification of microorganisms**: clinical microbiology. Diagnostic methods of infectious diseases. Selection and collection of biological samples. Optical microscopy: direct examination and main staining procedures (i.e. Gram, Ziehl-Neelsen). Culture-based methods: isolation of viable pathogens. General, selective and differential culture media. Identification tests. Immunological methods. Serology: detection of microbial antigens and specific antibodies. Detection of cellular response. Molecular methods: nucleic acid extraction. Amplification methods: Polymerase Chain Reaction based techniques. Hybridization methods. Detection of microbial proteins: Matrix-Assisted Laser Desorption/ionization Time-of-Flight mass spectrometry (MALDI-.TOF) and

Western blot techniques. Antimicrobial sensitivity tests. Laboratory safety: levels of biological hazard.

- **Control of microorganisms**: definition of sterilization, disinfection, and antisepsis. Procedures and agents. Classification of disinfectants by mode of action and microbicidal activity. Factors that determine the effectiveness of a disinfection or sterilization method. Classical antimicrobial drugs: microbial targets in microorganisms. Development of antimicrobial resistant (AMR) emerging pathogens. New approaches in antimicrobial therapy: phage therapy, probiotics, microbiota transplant and other points of view. Ecological approaches as alternatives to disinfectants.
- **Biotechnology in health sciences**: use of microorganisms, including recombinant ones, in production of medicines (microbial production of antibiotics, other antimicrobials, alkaloids, hormones, monoclonal antibodies, vaccines, vitamins and coenzymes, probiotics, enzymes, analytical devices including biosensors etc.), in food industry and for environmental control. Recombinant DNA technology for construction of the efficient producers of medicines and diagnostics. Phage display and CRISPR/Cas technologies. Market for antimicrobials and other health-important products obtained by microorganisms.
- **Environmental microbiology and health**: the *OneHealth* concept. Influence of the environmental conditions on microbial life. Understanding the world-wide impact of antimicrobial resistance. Monitoring and control of potentially dangerous microorganisms in nature and among habitants. Control of biosafety especially of food and water supply. Climate change and its impact on biodiversity and human and animal health. Emergence of new pandemics and their spread.

**METHODS**

Suggestions about the best methods for the **acquisition of the defined competencies**

Student centered Methods: The teacher as a guide through the sources of knowledge and acquisition of technical skills.
Avoid intense memorizing in favor of understanding.
Inverse teaching (≠ passive attendance). Give the students the chance to discuss the content after they have worked on it. Minimize lectures.
Use of diverse sources of knowledge
Engagement of students through various activities (lectures, laboratory sessions, self-learning activities, problem based-learning or case-based learning…)

**ASSESSMENT**

Suggestions about the best methods **to assess the acquisition of the competencies**

**Plural** (diversity of tests). Assess all the competencies defined as goals (practical skills acquired; ability to understand concepts; to search updated information; to share

information with others; to choose the main ideas in a context; to solve practical situations…). Employ practical assessment, multiple choice and short answer test; long dissertation; presentations in public; analysis of scientific papers, etc.

**Continuous assessment.** Grade **every activity** that the students are performing during their training. Give appropriate weight to each of them.