Degree Course in Biomedical Laboratory Techniques

INTEGRATED COURSE: BIOCHEMISTRY, PHYSIOLOGY AND MICROBIOLOGY; SSD: BIOS-06/A, BIOS-07/A, BIOS-09/A, MEDS-03/A, MEDS-26/D

CFU: 10

COORDINATOR:: Ilaria Vicenti e-mail: ilaria.vicenti@unicamillus.org

MODULE: Biochemistry

SSD: BIOS-07/A

Teacher: Maria Gabriella De Martino

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Number of CFU: 4

MODULE: Applied Biochemistry

SSD: BIOS-09/A

Teacher: Verena Damiani

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Number of CFU: 1

MODULE: Physiology

SSD: BIOS-06/A

Teacher: Sabina Ficili

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Number of CFU 2

MODULE: Microbiology

SSD: MEDS-03/A

Techer: Ilaria Vicenti

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Number of CFU: 2

MODULE: **Technical sciences of laboratory medicine**

SSD: MEDS-26/D

Teacher: Paolo Casalino

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Number of CFU: 1

PREREQUISITES

Although there is no prerequisite, basic concepts of the exact sciences (physics, chemistry and mathematics) and a knowledge of the basics of cell and molecular biology are necessary.

LEARNING OBJECTIVES

The integrated teaching of Biochemistry, Physiology, Microbiology, and Technical Sciences of Laboratory Medicine aims to provide students with fundamental knowledge of the structure of macromolecules, essential for the functioning and regulation of living organisms and their transformation processes. The course is designed to enable students to understand the foundations

of cellular metabolism and the changes induced by physical exercise.

The Biochemistry module further aims to provide students with essential knowledge of the basic concepts of chemistry and of the structure of macromolecules underlying metabolic processes (carbohydrates, lipids, proteins, and nucleic acids). By the end of the course, students should have acquired some essential methods used in biochemical practice, as well as the theoretical principles on which these methodologies are based and their fields of application.

Cellular mechanisms and the integrated functions of the main organs and systems will therefore be analyzed, with a focus on maintaining body homeostasis, including in the context of environmental changes. Finally, fundamental objectives include understanding the structure of different microorganisms, the mechanisms of microbial pathogenicity, the interactions between microorganisms and the host, and the processes leading to the onset of major microbial diseases.

LEARNING OUTCOMES

The expected learning outcomes are consistent with the general provisions of the Bologna Process and the specific provisions of Directive 2005/36 / EC. They are found within the European Qualifications Framework (Dublin descriptors) as follows:

Knowledge and understanding

At the end of the course, the student will be able to:

- Describe the structure and function of the main biological macromolecules and explain their role in cellular metabolic processes.
- Use appropriate biochemical terminology.
- Identify the main metabolic pathways and explain their integration.
- Describe the general features of the immune system.
- Explain the principles of immunochemical assays.
- Apply knowledge of centrifugation, electrophoretic, and immunochemical techniques, and discuss the role of genetic mutations and DNA sequencing methods.
- Describe the anatomical and functional organization of human organs and systems.
- Interpret anatomical and physiological mechanisms and phenomena.
- Apply bacterial and viral classification criteria.
- Explain the basic mechanisms of bacterial and viral genetics, including transformation, transduction, bacterial conjugation, and viral genetic variability.
- Describe the pathogenic action of bacteria and viruses, including transmission routes and steps of the infectious process.
- Identify fungi responsible for human diseases and apply diagnostic methods for fungal infections.
- Describe the characteristics of vaccines.
- Apply general principles for the diagnosis of diseases caused by pathogenic microorganisms.
- Explain the organization of a clinical biochemistry laboratory.
- Operate and describe the main instruments used in clinical biochemistry investigations (complete blood count, coagulation, clinical chemistry).
- Explain and critically evaluate the analytical processes of a laboratory (pre-analytical, analytical, and post-analytical phases).

Applying knowledge and understanding
At the end of the course, the student will be able to:

- Apply the acquired knowledge to independently explore and study aspects of the specific field relevant to their future professional activity.
- Use the tools, methodologies, terminology, and conventions of biochemistry and physiology, applying the acquired knowledge also in applied biochemistry, to test and communicate ideas and explanations.
- Use the tools, methodologies, terminology, and conventions of microbiology to test and communicate ideas and explanations.
- Apply the technologies learned during the course to real-world applications.

Communication skills
At the end of the course, the student must know:

- Use specific scientific terminology appropriately
- Use of adequate scientific language that is in keeping with the topic of the discussion

Making judgements
At the end of the course, the student must:

- carry out general evaluations relating to the topics covered
- develop the ability to interpret biological complexity through these methodologies
- carry out general evaluations relating to the topics covered in clinical biochemistry

Learning skills
At the end of the course, the student will have acquired the learning skills and methods necessary to further develop, expand, and strengthen their knowledge and competences in human physiology, biochemistry (including applied biochemistry), microbiology, and basic sciences. The student will also be able to do so independently, through the consultation of textbooks and scientific publications.

COURSE SYLLABUS
BIOCHEMISTRY
Elements of chemistry: Atoms and molecules, Chemical reactions, Ionic balance in solution, Water. Elements of organic chemistry: Carbohydrates, Lipids, Nucleic acids, proteins, Food digestion. Amino acids: general structure and classification. Proteins: structure and function. Structural levels. Protein folding. Fibrous proteins: structure of alpha-keratin, collagen and silk fibroin. Globular pro- teins: structure and function of myoglobin and hemoglobin; the heme group; saturation curve; regu- lation of the affinity of hemoglobin for oxygen. Enzymes: general characteristics; activation energy and reaction rate; general concepts on enzymatic kinetics. Regulatory mechanisms: competitive and non-competitive inhibitors; allosteric enzymes and enzymes regulated by covalent modifications. Catalytic strategies. Catalysis of serine-proteases. The blood coagulation cascade as an example to clarify determinants of specificity, the role of cofactors and the formation of macromolecular com- plexes.

INTRODUCTION TO METABOLISM: general organization. Catabolism and anabolism. Bioener- getics. Energetically relevant molecules. Use of energy within the cell. Examples of regulation of metabolic processes. Glucose as a fuel for energy production. Hormonal control of glucose metabolism.

Glycolysis - phases and regulation. The pentose phosphate pathway and its biochemical importance. Degrada- tion of glycogen - glycogen phosphorylase and its hormonal control. Gluconeogenesis and other biosynthetic pathways of carbohydrates.

Lactic fermentation and alcoholic fermentation. Anaerobic metabolism. Pyruvate oxidation mechanism - the pyruvate dehydrogenase complex. The citric acid cycle - Functions, energy balance and cycle regulation. Oxidative Phosphorylation - The mitochondrion as the cell's powerhouse. The machinery for transporting electrons: structure and function of complexes I, II, III and IV. The electrochemical potential in the transport of elec- trons. Use of oxygen. ATP synthase: structure and mechanism of action. Stoichiometry of electron transport, proton transport, oxygen consumption and ATP production. The catabolism of lipids - β-oxidation. Ketogenesis. Synthesis of fatty acids - Regulation of the metabolism of fatty acids.

APPLIED BIOCHEMISTRY

- Preparation of solutions and methods to indicate solution concentration.
- Centrifugation techniques and associated instrumentation.
- Electrophoresis techniques: general principles, instrumentation, and applications.
- Immunochemical techniques: general principles, instrumentation, and applications.
- Molecular investigation techniques, genetic mutations, and their relevance in clinical practice. PCR, Sanger sequencing, and NGS sequencing.

PHYSIOLOGY

INTRODUCTION TO PHYSIOLOGY AND HOMEOSTASIS: Description of physiological mechanism. Structure-Function relationships of the body. Levels of organization in the body. Concept of Homeostasis. Homeostatic Control Systems.

CELL PHYSIOLOGY AND PLASMA MEMBRANE: Membrane transport of ions and molecules. Membrane potential and action potentials. Synapses and neuronal integration. Intercellular communication and signal transduction. Neurotransmitters.

MUSCLE PHYSIOLOGY: Motor unit, neuromuscular junctions. Excitation and contraction of skeletal muscle tissue. Skeletal muscle contraction and mechanics. Physiology of skeletal, smooth and cardiac muscle.

PHYSIOLOGY OF THE NERVOUS SYSTEM: Functional organization of central nervous system and peripheral nervous system. The peripheral nervous system: afferent and efferent divisions. Role of glia cells. Autonomic nervous system. Integrative functions of nervous system.

CARDIAC PHYSIOLOGY: Anatomy and electrical activity of the heart. Mechanical events of the cardiac cycle. Cardiac output and its control. General principles of hemodynamics. Blood vessels and blood pressure. Blood and hemostasis.

PHYSIOLOGY OF ENDOCRINE SYSTEM AND REPRODUCTIVE SYSTEM: General principles of endocrinology. Principles of general functioning of hormones. Central and peripheral endocrine glands and their hormones. Hypothalamic-Pituitary Axis. Control of calcium and phosphate metabolism. Physiology of male and female reproductive system.

PHYSIOLOGY OF RESPIRATORY SYSTEM: Respiratory anatomy and mechanic. Gas exchange and transport of oxygen and carbon dioxide. Control of respiration.

PHYSIOLOGY OF URINARY SYSTEM: Elements of renal function: kidney and nephron. Glomerular filtration. Tubular reabsorption and tubular secretion. Urinary tract. Ureter, bladder and urethra. Urine excretion and plasma clearance.

PHYSIOLOGY OF DIGESTIVE SYSTEM: Digestive tract and accessory digestive organs. General aspects of digestion. Secretory function of digestive system. Motility of digestive tract. Nutrient digestion and absorption.

MICROBIOLOGY

- Basic principles of microbiology
- Morphology and structure of the bacterial cell; structure of bacterial spores and the process of sporulation
- Gram staining: differences between Gram-positive and Gram-negative bacteria
- Bacterial metabolism, growth, and replication
- Sterilization, disinfection, and asepsis
- Structure, replication, and pathogenic mechanisms of fungi
- Morphology of viral particles, classification of viruses, cell tropism, host range, and phases of viral replication
- Basic concepts of the immune response; natural and acquired immune mechanisms against infections; mechanisms of action of interferons
- Vaccination
- Mechanisms of bacterial and viral pathogenesis; bacterial virulence factors
- Demonstration of the causal relationship between pathogen and disease: Koch's postulates
- Normal microbial flora of the human body
- Modes of transmission of infections and stages of the infectious process
- Persistence and latency of viral infections; viral oncogenesis
- Effects of viral infections in cellular systems

LABORATORY MEDICINE

Organization of a laboratory Knowledge of the main laboratory instruments Types of test tubes (with and without anticoagulant) used in analytical investigations CBC and basic concepts of blood tests The various stages of an analytical process.

TEACHING METHODS

Biochemistry: the module is structured in 40 hours of frontal teaching, organized in sessions of 2 or 3 hours according to the academic calendar. Teaching includes theoretical lectures and integrative seminars on the topics covered.

Applied Biochemistry: the module is structured in 10 hours of frontal teaching, divided into 2- or 3-hour lessons according to the academic calendar.

Physiology: the module is structured in 20 hours of frontal teaching, organized in sessions of 2, 3, or 4 hours depending on the academic calendar. Teaching includes theoretical lectures and integrative seminars on the topics covered. In addition, group work is planned, in which students will be engaged in the critical reading, comprehension, and discussion of a scientific article related to the topics addressed in the teaching module.

Microbiology: the module is structured in 20 hours of frontal teaching, organized in sessions of 2 or 3 hours according to the academic calendar.
Laboratory Medicine: the module is structured in 10 hours of frontal teaching, organized in sessions of 2 or 3 hours according to the academic calendar. Teaching includes theoretical lectures and, where appropriate, the projection of videos related to the topics covered.

COURSE GRADE DETERMINATION

The examination of the integrated course consists of a written test with multiple-choice questions. The examination board will assess the student's ability to apply the acquired knowledge and will verify that the competences are adequate to address problems within the specific disciplinary field, in line with the learning objectives of the course. The written test will cover the scheduled topics of all modules of the integrated course. It will be structured as a multiple-choice quiz, with a minimum passing grade of 18/30.
The assessment methodology will be communicated at the beginning of the course, together with the bibliography and/or the teaching materials required for the preparation of the final evaluation.
Grading scale:

- **Fail (Not suitable):** Poor or insufficient knowledge and understanding of the topics.
- **18–20:** Barely sufficient knowledge and understanding of the topics, with evident shortcomings.
- **21–23:** Sufficient knowledge and understanding of the topics.
- **24–26:** Fair knowledge and understanding of the topics.
- **27–29:** Good knowledge and understanding of the required contents.
- **30–30L (cum laude):** Excellent level of knowledge and understanding of the required contents.

ADDITIONAL LEARING ACTIVITIES

- **Biochemistry:** In addition to lectures, faculty members will be available to students for further insights or clarifications on topics of particular interest.
- **Physiology:** In addition to lectures, students may have the opportunity to participate in seminars and monographic courses. These activities are part of the course program and are subject to assessment. Attendance is mandatory (100%) in order to acquire the corresponding credits, and a pass/fail evaluation is required.
- **Laboratory Medicine:** In addition to lectures, students may be given the opportunity to participate in continuing medical education (CME) courses related to the topics covered. These activities are not subject to examination. Attendance is mandatory (100%) in order to acquire the corresponding credits, and a pass/fail evaluation is required.

RECCOMENDED TEXTS AND BIBLIOGRAPHY

BIOCHEMISTRY: "Chimica e Biochimica". Massimo Stefani, Niccolò Taddei; Zanichelli editore

APPLIED BIOCHEMISTRY: *Biochemical and Biomolecular Methodologies: Tools and Techniques for the Laboratory of the New Millennium*, M. Maccarrone. Zanichelli

PHISIOLOGY: "Fondamenti di Fisiologia Umana". Sherwood. Editore: Piccin. "Berne & Levy Fisiologia". Koeppen and Stanton. Editore: Casa Editrice Ambrosiana. "Fisiologia Medica". Guyton and Hall. Editore: Edra.

MICROBIOLOGY: “Prescott. Microbiologia Generale”, Willey et al., Ottava edizione, Mc Graw Hill
LABORATORY MEDICINE: The teacher will provide teaching materials, such as handouts and presentations