YEAR: II
SEM: 1st-2nd semester
A.Y.: 2025-2026

Scientific Field	**BIOCHEMISTRY AND MOLECULAR BIOLOGY**	TUTOR	CFU
BIO/10	BIOCHEMISTRY I	**Massimo Bottini**	5
BIO/11	MOLECULAR BIOLOGY	**Massimiliano Agostini**	3
BIO/10	BIOCHEMISTRY II	**M. Valeria Catani**	5
BIO/10	BIOCHEMISTRY II	**Massimiliano Agostini**	1
		TOT	14

COORDINATOR:
Maria Valeria Catani

PROGRAM

MOLECULAR BIOLOGY

INTRODUCTION-HISTORY, DNA AND RNA STRUCTURE: The structure of DNA, mitochondrial DNA. The structure of RNA, RNA editing and human diseases.

GENE, GENOME, CHROMOSOME, CHROMATIN: Genome structure, transposons, genome sequences and gene number, chromosome territories. Chromatin and the nucleosome.

EPIGENETICS: DNA methylation, histone modifications, nucleosome positioning, epigenetic modifications and human diseases.

DNA REPLICATION: The Replication of DNA, replication fork, DNA replication fidelity, regulation of DNA replication, DNA synthesis as a therapeutic target.

TELOMERE: Structure and function. Telomere disfunction and human diseases, cellular senescence: from physiology to pathology.

DNA REPAIR/HOMOLOGOUS RECOMBINATION: Mutations, type of DNA damage, mismatch repair, nucleotide excision repair, base excision repair, homologous recombination, non-homologous end joining, BRCA1 and BRCA2 mutation in cancer, microbial pathogens and DNA integrity.

	TRANSCRIPTION: Mechanisms of transcription, mediator, epitrascriptomic. REGULATION OF TRANSCRIPTION: Transcription factors, mechanisms of regulation, deregulation of transcription in human diseases. microRNA, lncRNA and circRNA: miRNA and human disease, lncRNA and human disease, circRNA biogenesis, clinical utility of circulating non-coding RNAs. RNA SPLICING: The spliceosome machinery, mechanism of splicing, therapeutic targeting of splicing in human disease. TRANSLATION AND GENETIC CODE: Translation, the genetic code, ribosome and human pathologies. p53 FAMILY: p53 p63 and p73 structure and function. When mutants gain new powers: news from the mutant p53 field. METHODS IN MOLECULAR BIOLOGY: Cloning, DNA sequencing, PCR and real-time PCR, blotting methods, mouse models, genome editing.
PROGRAM **BIOCHEMISTRY**	PROTEINS: Amino acids: structure and classification. Stereoisomerism. Acid-base properties. Peptide bond. Peptides of biological importance. Primary, secondary, tertiary, quaternary structure of proteins and bonds stabilizing structures. BLOOD PROTEINS AND ENZYMES: structure, function, diagnostic significance. Albumin. Fibrinogen and mechanisms of blood coagulation. Globulins. High- and low-density lipoproteins. Heme proteins. Transport and use of oxygen: hemoglobin and myoglobin; structure to function relationship, properties, and allosteric cooperativity. STRUCTURAL PROTEINS: collagen. ENZYMES. Concept of catalysis. Properties of enzymes as catalysts. Classification. Kinetics of reactions enzyme. Michaelis-Menten constant. Factors that affect enzyme activity. Enzyme inhibition. Active sites and allosteric sites. Mechanism of action of enzymes: effects of proximity and orientation, acid-base catalysis, covalent catalysis. Concept of isoenzyme. Enzyme cofactors. CARBOHYDRATES. Mono and disaccharides of biological importance. Reserve and structural polysaccharides: starch, glycogen, cellulose; pectin; mucopolysaccharides; dextran. Polysaccharides such as components of bacterial cell walls. Polysaccharides of fundamental substances of animal tissues. Protein N- glycosylated and O- glycosylated. Carbohydrates such as carriers of information. LIPIDS. Classification and structure. Properties of fatty acids. Essential fatty acids. Prostaglandins, thromboxanes and leukotrienes. Neutral fats. Phospholipids. Glycolipids. Steroids. Lipids as structural components of the membranes. Lipids deposit as intracellular metabolic fuel. WATER-SOLUBLE AND FAT-SOLUBLE VITAMINS. Structures and biochemical functions.

	BIOENERGETICS. General principles of chemical thermodynamics. Oxidation-reduction potential. ATP; its role in energy use. Phosphorylation at the substrate level. Mitochondrion. Respiratory chain and its components. Oxidative phosphorylation. Coupling of oxidative phosphorylation to electron transport. Chemiosmotic mechanism. Energy balance. Uncoupling agents and inhibitors of oxidative phosphorylation. SOME METHODS OF BIOCHEMISTRY INVESTIGATION AND RELATED APPLICATIONS. Centrifugation. Spectroscopic techniques. Electrophoresis techniques. DIGESTION AND ABSORPTION of carbohydrates, lipids, and proteins. Cycles, main metabolic pathways, and their interconnection. Glycolysis. Krebs cycle. Via pentose–phosphate. Glycogen synthesis and glycogenolysis. Gluconeogenesis. β-oxidation of fatty acids. Other routes of fatty acid oxidation. Ketogenesis. Biosynthesis of fatty acids. Biosynthesis of triglycerides. Biosynthesis and catabolism of cholesterol and of its derivatives. Catabolism of proteins. General metabolism of amino acids: transamination, deamination, decarboxylation. Urea cycle. Biosynthesis of amino acids. Biosynthesis and catabolism of heme. Biosynthesis and catabolism of purine and pyrimidine. METABOLISM OF OLIGOELEMENTS. OVERALL REGULATION OF METABOLISM.

TEXTBOOKS
Nelson, Cox, Lehninger Principles of Biochemistry 5th Ed Christopher K.
Mathews, Kensal E. van Holde, Dean R. Appling and Spencer Anthony-Cahill, Biochemistry, 4th Ed
The Molecular Biology of the Gene Edition 7 (JD Watson; COLD SPRING HARBOR LABORATORY PRESS)
Lewin's Gene XI (JE Krebs, ES Goldstein; Jones & Barlett Learning)
Reviews

TEACHING METHODS
The course includes lectures and support from the teacher, in the classroom and through e-mail.

ASSESSMENT METHODS AND LEARNING VERIFICATION CRITERIA
The exam consists of an oral test.
The final evaluation is expressed by a mark out of thirty, according to the following criteria:
Unsuitable: major deficiencies in subject knowledge and understanding; limited judgment and critical skills, inappropriate language.
18-20: just enough knowledge and understanding of the topics; sufficient ability to analyze synthesis and independent judgement, inappropriate/technical language.
21-23: knowledge and understanding of routine topics; correct analysis and synthesis skills with appropriate/technical language.
24-26: good knowledge and understanding of the topics; good analysis and synthesis skills, but with a language that is not always appropriate/technical.
27-29: knowledge and understanding of the complete topics; remarkable skills of analysis and synthesis. Good autonomy of judgment. Topics presented perfectly and with appropriate/technical language.

30-30L: excellent level of knowledge and in-depth understanding of the topics. Excellent skills of analysis, synthesis, and independent judgement. Arguments expressed in an original way and with appropriate technical language.

EXAM COMMISSION	The exam Commission of the Integrated Course is composed by the Coordinator, full Professors of the disciplines, Professors of similar disciplines, Specialists of the subject.

President **M. Valeria Catani**
Component **Massimiliano Agostini**
Component **Massimo Bottini**

CONTACTS

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EDUCATIONAL OBJECTIVES AND EXPECTED LEARNING OUTCOMES: Aim of the integrated course of Biochemistry is the knowledge, with particular reference to the human being of: 1) the structure of biological molecules and their transformations in dynamic cells; 2) the mechanisms that regulate the transmission of information at the molecular level; 3) the homeostatic mechanisms that regulate the functioning of the cell and the integration of organs and tissues; 4) the methods of investigation at the molecular level, to understand the significant biological phenomena in medicine.

PREREQUISITES: Previous knowledge and competence in the following subjects: Chemistry and Introductory Biochemistry, Physics and Statistics, Biology and Genetics.

Dublin Descriptors

The specific learning outcomes of the program are coherent with the general provisions of the Bologna Process and the specific provisions of EC Directive 2005/36/EC. They lie within the European Qualifications Framework (**Dublin Descriptors**) as follows:

1. **Knowledge and Understanding**

- To demonstrate a comprehensive theoretical knowledge of the main molecular genetic principles and biochemical processes.
- To identify the structural components of the cell and define the main processes of cell survival and regulation, with a particular focus on DNA structure and protein synthesis.
- To understand the importance of these processes and recognize their impact for maintenance of cell homeostasis.
- To learn the major components of the human metabolism, such as proteins, carbohydrates, lipids, vitamins, and analyze their role in the metabolic processes of the human body. Integrate each process in a more systematic view.
- To understand the mechanisms of action of the new molecular biology investigation techniques and their critical utility in the clinical setting.

2. **Applying Knowledge and Understanding**
   - To determine the core consequences of metabolic abnormalities.
   - To apply the theoretical knowledge to the clinical setting, being able to recognize the general diagnostic aspects of metabolic abnormalities and therapeutic utilities.
   - To identify and recognize the proper molecular diagnostic techniques to utilize for any topic of examination, giving a comprehensive description of all the available possibilities.
   - To learn the practical aspects of investigative tests and their execution.
   - To assess the major metabolic values and cut-offs utilized in the clinical scenario.

3. **Making Judgements**
   - To recognize the most relevant outcomes of metabolic processes and emphasize the role of regulation.
   - To compare the human metabolic activities to those of lower developed species and appreciate the intrinsic perfection of the human body.
   - To define the most relevant factors for the evaluation of metabolic activities

4. **Communication Skills**
   - To present the topics orally in an organized and consistent manner.
   - Use of proper scientific language coherent with the topic of discussion.

5. **Learning Skills**
   - To identify the possible use of the acknowledged skills in the future career.
   - To assess the importance of the acquired knowledge in the overall medical education process.