Degree Course in Dentistry and Dental Prosthetics

Course: MEDICAL CHEMISTRY AND PHYSICS

CFU Number: 17

Coordinator of the integrated course: Prof. Giacomo Lazzarino mail: giacomo.lazzarino@unicamillus.org,

Module: Biochemistry

SSD Course: BIO/10

CFU Number: 10

Professor names: Prof. Almerinda Di Venere, Prof. Giacomo Lazzarino, Prof. Eleonora Nicolai

Professor email: almerinda.divenere@unicamillus.org, giacomo.lazzarino@unicamillus.org, eleonora.nicolai@unicamillus.org

Module: Physics

SSD Course: FIS/07

CFU Number: 7

Professor names: Prof. Alessandra Filabozzi e Prof. Antonio Napolitano

Professor email: alessandra.filabozzi@unicamillus.org, antonio.napolitano@unicamillus.org

OBJECTIVES:

The aim of the Biochemistry module (General and Inorganic Chemistry, Introductory Biochemistry and Biochemistry), as a part of the Integrated Course of MEDICAL CHEMISTRY AND PHYSICS, is to provide students with the fundamental knowledge relating to the structure of atoms and chemical elements and of the macromolecules necessary for the functioning and regulation of living organisms and their transformation processes. Put the student in a position to understand the basics of chemistry and cellular metabolism. The teaching also intends to provide the student with the fundamental knowledge relating to the basic concepts of chemistry, the structure of macromolecules underlying the metabolic processes necessary for the functioning and regulation of living organisms: carbohydrates, lipids, nucleic acids. To enable the student to understand the basics of cellular metabolism. The course aims to provide the student with some essential methods used in chemistry and biochemical practice and the theoretical principles on which these methodologies and their field of application are based.

The aim of the Physics module (Applied Physics, Medical Statistics and Informatics), as a part of the Integrated Course of MEDICAL CHEMISTRY AND PHYSICS, is to provide students with knowledge on the fundamentals of applied physics, Statistics and Informatics necessary for their future activity. In particular, the comprehension of physical principles at the base of medical physics and of functioning of medical instrumentation will be addressed. At the end of the course, the students will know the fundamental concepts of application of the Scientific Method to the study of biomedical phenomena (choice and measure of parameters, evaluation of

errors), they will be able to describe physical phenomena of complex systems using suitable mathematical tools, they will know the scientific basis of medical procedures and principles of functioning of the equipment commonly used for diagnostics and therapeutics. The student should be able to understand the tools and computer concepts that will be useful for their future profession in the medical field and understand the importance of medical statistics in the research methodology in the medical field; - read a basic biomedical scientific article, understanding its structure and critically evaluating methods and results; handle a simple database, with particular reference to clinical medicine; make a descriptive and inferential analysis.

COURSE SILLABUS

Biochemistry module:

General and inorganic chemistry (3 CFU):

Introductory notes - Periodic table of the elements and its meaning: Inorganic nomenclature: acids, bases, salts. Balance of a chemical reaction. Concept of mole, Avogadro number.

Constitution of the atom - Elementary particles: proton, neutron, electron. Isotopes. Electrons and electronic configuration of atoms. Quantum numbers and orbitals. Auf-bau. The chemical bond: covalent, ionic, dative. Hybridization. Weak bonds: ion-dipole, Van der Waals, hydrogen bond. Electronegativity.

States of matter - Gas: equation of state of ideal gases. Absolute temperature and relationship with the average molecular speed. Gaseous mixtures; Dalton's law. Liquids: vapor pressure of a liquid. Solids: structural characteristics of covalent, ionic, molecular solids. Metallic solids (outline).

Chemical thermodynamics - Concept of state function. Internal energy of a system. Enthalpy, Hess's law. Entropy. Free energy.

Solutions - Concentration of solutions: % by weight, mole fraction, molarity, molality, normality. Dilutions and mixing of solutions. Vapor pressure of a liquid-liquid solution (Raoult's law). Ideal solutions. Colligative properties: variation of vapor pressure, of melting and boiling temperatures; osmosis and osmotic pressure. Solubility of gases in liquids: Henry's law.

Chemical equilibrium - Equilibrium in the gas phase. Expression of the equilibrium constant. Relationship between Kc and Kp. Factors that influence the balance. Homogeneous and heterogeneous equilibria.

Electrolyte Solutions - Strong and Weak Electrolytes; degree of dissociation. Colligative properties of electrolyte solutions; combination of Van't Hoff. Acids and bases according to Arrenius, Bronsted and Lowry, Lewis. Strong and weak acids and bases. Ionic dissociation of water. Kw. Equilibrium constant of an acid and a base. Relationship between the equilibrium constant and the degree of dissociation of a weak electrolyte: Oswald's law of dilution. The pH; calculation of pH in solutions of strong and weak acids (and bases). Saline hydrolysis. Buffer solutions. Dissociation of polyprotic acids (outline). Acid-base titrations.

Chemical Kinetics - Introduction to Kinetics; activated complex theory; activation energy. Kinetic equations

Redox reactions and electrochemical potentials - Oxidation number. Redox reactions and their balance. Standard reduction potentials.

UNICAMILLUS

Introductory biochemistry (2 CFU):

Hybridization of the carbon atom - sp^3, sp^2, sp hybridizations and their geometry.

Hydrocarbons - Saturated hydrocarbons: alkanes and cycloalkanes. Nomenclature. Unsaturated hydrocarbons: alkenes and alkynes. Nomenclature. Conformational isomerism and geometric isomerism (cis-trans).

Aromatic compounds - Structure of benzene: the resonance model. Nomenclature of aromatic compounds. Polycyclic aromatic hydrocarbons (outline).

Alcohols, phenols, thiols - Nomenclature. Acidity and basicity of alcohols and phenols. Thiols, analogues of alcohols and phenols.

Aldehydes and ketones - Nomenclature. Preparations of aldehydes and ketones. The carbonyl group. The nucleophilic addition to the carbonyl groups; formation of semiacetals and acetals. The aldol condensation (outline).

Carboxylic acids and their derivatives - Nomenclature of acids. Derivatives of carboxylic acids: esters, amides. Mechanism of esterification; triesters of glycerol.

Amines and other nitrogen compounds - Classification of amines and nomenclature.

Stereoisomery - Chirality. Enantiomers. Polarized light; the polarimeter (outline). Diastereomers.

Carbohydrates - Definitions and classification. The monosaccharides. Chirality in monosaccharides; Fischer's projections. Cyclic structures of monosaccharides. Anomers. Phenomenon of mutarotation. Pyranosic and furanotic structures.

Lipids - Structure, nomenclature, properties.

Nitrogen bases and nucleotides -Structure, nomenclature.

Biochemistry (5 CFU):

Proteins - Amino acids and their properties.-Peptide bond. Primary structure. Non-protein amino acids. Secondary structure: alpha helix, beta sheet, loops and beta turn. Tertiary and quaternary structure: hydrogen bonds and hydrophobic effect. Misfolding and related pathologies. Generic structure of fibrous and globular proteins. Techniques for the analysis and purification of proteins

Enzymatic kinetics - steady state. The Michaelis-Menten equation. Meaning of Km. Catalytic efficiency: meaning of kcat / Km. Reciprocal Doubles Graph. Classification of enzymes-Inhibitors: competitive and incompetitive inhibition. Mechanisms and graphs of reciprocal doubles. The inhibitors: a-competitive (pure non-competitive) and mixed (non-competitive) inhibition. Irreversible inhibitors and suicide inhibitors. - The transport and storage of oxygen.

Myoglobin - structure and function.

Hemoglobin - structure and function. The Bohr effect; the effect of 2,3 BPG; the transport of CO_2 and NO. Introduction to the theory of protein-ligand interaction: case of only 1 site. Case of *n* fully cooperative sites. General case. Concerted and sequential model. Effects of point mutations.

Carbohydrates - the different types of classification (structural and functional). Stereoisomerism. Reducing sugars. Main monosaccharides and disaccharides. Sugar derivatives.

Membrane lipids. Cholesterol. Lipids-signal and cofactors: eicosanoids, steroid hormones, fat-soluble vitamins. -Architecture of biological membranes: composition of membranes, common properties of membranes, the bilayer sheet, types of proteins in biological membranes. Dynamics of biological membranes. Transport across biological membranes: simple diffusion and passive transport, glucose transporter, chloride-bicarbonate exchanger, active transport, sodium-glucose symports, aquaporins.

Vitamins - historical introduction. Fat-soluble vitamins structure, function, avitaminosis, hypervitaminosis. Water-soluble vitamins structure, function avitaminosis.

Bioenergetics - free energy in biochemical reactions. Standard free energy and Keq free energy. Examples.

Glycolysis. Pathway of pentose phosphate. Coordinated control of glucose metabolism. Lactic fermentation and alcoholic fermentation. Anaerobic metabolism and caries. The Krebs cycle. Glycogen metabolism and its regulation. Glycogen storage diseases.

Physiological digestion of fats. Lipoproteins - structure and function of chylomicrons, VLDL, LDL and HDL. Glucagon-induced fat mobilization: roles of triacylglycerol lipase and perilipin. Activation of fatty acids and transport across the mitochondrial membrane. Carnitine. Beta-oxidation of saturated fatty acids, even. Examples. Ketogenesis. Beta-oxidation of unsaturated and odd fatty acids.

Protein digestion - role of pH and digestive enzymes. alanine-glucose cycle. Transamination, oxidative demination, non-oxidative demination. glutammine-synthetase: role and its regulation.

Urea cycle.

Notes on the catabolism of the academic year branched and "maple syrup" urine disease. Catabolism of glycine and serine.

Notes on the catabolism of nitrogenous bases - excess uric acid and gout.

The metabolism of heme - introduction to biosynthesis (the glycine pathway, the synthesis of δ-aminolevulinate and the formation of porphobilinogen). The porphyrias. Notes on the catabolism of EME and its degradation to biliverdin and bilirubin.

Chemosmotic coupling - general principles; the change in free energy associated with the flow of electrons and protons; ATP synthase as an energy transducer. Electron transporters (nicotinamide and flavin nucleotides; ubiquinone; cytochromes; iron-sulfur proteins; complexes I, II, III, IV; Q cycle; respirasome. ATP synthase (structure and catalysis; ATP synthase as molecular motor). Inhibitors and uncouplers of respiratory chain.

COURSE SYLLABUS

Physics module

Program 4 CFU

Mechanics

Chapter 1: Introduction, Measurement, Estimating

1.4: Measurement and Uncertainty; Significant Figures

1.5: Units, Standards, and SI Units

1.6: Converting Units

1.8: Dimensions and Dimensional Analysis

Chapter 2: Describing Motion: Kinematics in One Dimension

2.1: References Frames and Displacement

2.2: Average Velocity

2.3: Instantaneous Velocity

2.4: Acceleration

2.5: Motion at Constant Acceleration

Chapter 3: Kinematics in Two Dimensions; Vectors

3.1: Vectors and Scalars

3.2: Addition of Vectors-Graphical Methods

3.3: Subtraction of Vectors and Multiplication of a Vector By a Scalar

3.4: Adding Vectors by Components

Chapter 4: Dynamics: Newton's Laws of Motion

4.1: Force

4.2: Newton's First Law of Motion

4.3: Mass

4.4: Newton's Second Law of Motion

4.5: Newton's Third Law of Motion

4.6: Weight-The Force of Gravity; and the Normal Force

4.7: Solving Problems with Newton's Laws: Free-Body Diagrams

4.8: Problems Involving Friction, Inclines

4.9: Problem Solving-A General Approach

Chapter 5: Circular Motion; Gravitation

5.1: Kinematics of Uniform Circular Motion

5.2: Dynamics of Uniform Circular Motion

5.6: Newton's Law of Universal Gravitation

Chapter 6: Work and Energy

6.1: Work Done by a Constant Force

6.3: Kinetic Energy and the Work-Energy Principle

6.4: Potential Energy

6.5: Conservative and Nonconservative Forces

6.6: Mechanical Energy and its Conservation

6.7: Problem Solving Using Conservation of Mechanical Energy

6.8: Other Forms of Energy: Energy Transformations and the Law of Conservation of Energy

6.10: Power

Chapter 7: Linear Momentum

7.1: Momentum and Its Relation to Force

7.2: Conservation of Momentum

7.8: Center of Mass (CM)

7.10: Center of Mass and Translational Motion

Chapter 8: Rotational Motion

8.1: Angular Quantities

8.2: Constant Angular Acceleration

8.4: Torque

8.5: Rotational Dynamics; Torque and Rotational Inertia

8.6: Solving Problems in Rotational Dynamics

8.7: Rotational Kinetic Energy

Chapter 9: Static Equilibrium; Elasticity and Fracture

9.1: The Conditions for Equilibrium

9.2: Solving Statics Problems

9.3: Applications to Muscles and Joints

9.4: Stability and Balance

9.5: Elasticity; Stress and Strain

9.6: Fracture

Fluids

Chapter 10: Fluids

10.1: Phases of Matter

10.2: Density and Specific Gravity

10.3: Pressure in Fluids

10.4: Atmospheric Pressure Gauge Pressure

10.5: Pascal's Principle

10.6: Measurement of Pressure; Gauges and the Barometer

10.7: Buoyancy and Archimedes' Principle

10.8: Fluids in Motion; Flow Rate and the Equation of Continuity

10.9: Bernoulli's Principle

10.10: Applications of Bernoulli's Principle: from Torricelli to Airplanes, Baseballs, and TIA

10.11: Viscosity

10.12: Flow in Tubes: Poiseuille's Equation, Blood Flow

Electricity and Magnetism

Chapter 16: Electric Charge and Electric Field

16.1: Static Electricity; Electric Charge and its Conservation

16.2: Electric Charge in the Atom

16.3: Insulators and Conductors

16.4: Induced Charge; the Electroscope

16.5: Coulomb's Law

16.6: Solving Problems Involving Coulomb's Law and Vectors

16.7: The Electric Field

16.8: Field Lines

16.9: Electric Fields and Conductors

Chapter 17: Electric Potential

17.1: Electric Potential Energy and Potential Differences

17.2: Relation Between Electric Potential and Electric Field

17.3: Equipotential Lines

17.4: The Electron Volt, a Unit of Energy

17.5: Electric Potential Due to Point Charges

17.7: Capacitance

17.8: Dielectrics

17.9: Storage of Electric Energy

Chapter 18: Electric Currents

18.1: The Electric Battery

18.2: The Electric Current

18.3: Ohm's Law: Resistance and Resistors

18.4: Resistivity

18.5: Electric Power

18.8: Microscopic View of Electric Current

Chapter 19: DC Circuits

19.1: EMF and Terminal Voltage

19.2: Resistors in Series and in Parallel

19.3: Kirchhoff's Rules

19.4: EMFs in Series and in Parallel; Charging a Battery

19.5: Circuits Containing Capacitors in Series and in Parallel

19.6: RC Circuits-Resistor and Capacitor in Series

Chapter 20: Magnetism

20.1: Magnets and Magnetic Fields

20.2: Electric Current Produce Magnetic Fields

20.3: Force on an Electric Current in a Magnetic Field: Definition of B

20.4: Force on an Electric Charge Moving in a Magnetic Field

20.5: Magnetic Field Due to a Long Straight Wire

20.8: Ampere's Law

Chapter 21: Electromagnetic Induction and Faraday's Law

21.1: Induced EMF

21.2: Faraday's Law of Induction; Lenz's Law

21.3: EMF Induced in a Moving Conductor

21.4: Changing Magnetic Flux Produces an Electric Field

PROGRAM 3 CFU:

Vibrations and Waves

Chapter 11: Vibrations and Waves

11.7: Wave Motion

11.8: Types of Waves: Transverse and Longitudinal

11.9: Energy Transported by Waves

11.10: Intensity Related to Amplitude and Frequency

11.11: Reflection and Transmission of Waves

11.12: Interference; Principle of Superposition

11.13: Standing Waves; Resonance

Chapter 12: Sound

12-1 Characteristics of Sound

12-2 Intensity of Sound: Decibels

12-4 Sources of Sound: Vibrating Strings and

Air Columns

12-6 Interference of Sound Waves; Beats

12-7 Doppler Effect

Chapter 22: Electromagnetic Waves

22.1: Changing Electric Fields Produce Magnetic Fields; *Maxwell's Equations*

22.2: Production of Electromagnetic Waves

22.3: Light as an Electromagnetic Wave and the Electromagnetic Spectrum

22.5: Energy in EM Waves

Chapter 24: The Wave Nature of Light

24.4: The Visible Spectrum and Dispersion

Chapter 25: Optical Instruments

25-11: X-Rays and X-Ray Diffraction

25-12: X-Ray Imaging and Computed Tomography (CT Scan)

Nuclear Physics and Radioactivity

Chapter 27: Early Quantum Theory and Models of the Atom

27.10: Early Models of the Atom

27.12: The Bohr Model

Chapter 30: Nuclear Physics and Radioactivity

30.1: Structure and Properties of the Nucleus

30.2: Binding Energy and Nuclear Forces

30.3: Radioactivity

30.4: Alpha Decay

30.5: Beta Decay

30.6: Gamma Decay

30.7: Conservation of Nucleon Number and Other Conservation Laws

30.8: Half-Life and Rate of Decay

30.9: Calculations Involving Decay Rates and Half-life

Chapter 31: Nuclear Energy; Effects and Uses of Radiation

31.1: Nuclear Reaction and the Transmutation of Elements

31.5: Measurement of Radiation-Dosimetry

31.9: Nuclear Magnetic Resonance (NMR) and Magnetic Resonance Imaging (MRI)

Thermodynamics

Chapter 13: Temperature and Kinetic Theory

13.1: Atomic Theory of Matter

13.2: Temperature and Thermometers

13.3: Thermal Equilibrium and the Zeroth Law of Thermodynamics

13.4: Thermal Expansion

13.6: The Gas Laws and Absolute Temperature

13.7: The Ideal Gas Law

13.8: Problem Solving with the Ideal Gas Law

13.9: Ideal Gas Law in Terms of Molecules: Avogadro's Number

13.10: Kinetic Theory and the Molecular Interpretation of Temperature

Chapter 14: Heat

14.1 Heat as Energy Transfer

14.2 Internal Energy

14.3: Specific Heat

14.4: Calorimetry

14.5: Latent Heat

14.6: Heat Transfer: Conduction

14.7: Heat Transfer: Convection

14.8: Heat Transfer: Radiation

Chapter 15: The Laws of Thermodynamics

15.1: The First Law of Thermodynamics

15.2: Thermodynamic Processes and the First Law

15.4: Second Law of Thermodynamics-Introduction

COURSE STRUCTURE

The course is structured in 170 hours of frontal teaching broadcast simultaneously in streaming. Divided into 2 or 4-hour lessons basing on the academic calendar, including theoretical parts and exercises. Attendance is mandatory for at least 75% of the hours, summed over all the teachings of the integrated course.

COURSE GRADE DETERMINATION

Biochemistry module:

To verify students' preparation will be performed a written exam, followed by an oral exam.

The written test will consists of a test with open-ended and multiple-choice questions. The score is awarded out of thirty. The questions may have a different weight based on the complexity of the question and on the particular knowledge that is verified. Wrong or not given answers correspond to zero points. To pass the written test and be admitted to the oral test, it is necessary to achieve a score equal to or greater than 18.

The oral test will focus on some questions relative to the entire program. The score of the oral test will be mediated with that of the written test to obtain the final score.

During the oral proof, the examiner will test the student’s skills in applying the knowledge obtained and in solving chemistry and biochemistry issues. Further skills which will be evaluated, that encompass making judgments, communication skills and learning skills according with Dublin Descriptors.

Physics module:

The Physics test consists of a mandatory written test and an optional oral exam. The written test is aimed at evaluating both the theoretical knowledge and the student's ability to solve problems; the oral exam is aimed at improving the evaluation obtained with the written test. The written test consists of a series of multiple

choice questions. The maximum score, equal to 30 cum laude, is foreseen for those who answer all the questions correctly; the minimum score, equal to 18 out of 30, is foreseen for those who correctly answer 18/30 of the questions, taking into account the different weight attributed to them. The questions may have a different weight based on the complexity of the question and on the particular knowledge that is verified. There is no penalty for wrong answers. Only students wishing to improve the assessment obtained with the written test are admitted to the oral exam.

Final score of the Integrated Course:

The final score of the Integrated Course of CHEMISTRY AND MEDICAL PHYSICS will be assigned by making the weighted average between the scores obtained in the two modules of the Integrated Course (Biochemistry and Physics).

READING MATERIALS/BOOK LIST:

- *Chemistry 10th edition*, Kenneth W. Whitten/Raymond E. Davis/Larry Peck/George G. Stanley.
- *Foundations of College Chemistry, 14 Edition*, Hein M, Arena S. John Wiley and Sons Inc.
- *Lehninger Principles of Biochemistry*, Nelson D. Cox Michael M.
- *"PHYSICS: Principles with Applications"* Seventh edition or subsequent, Douglas C. Giancoli, Pearson Education. Inc