Year 1

*Fundamentals of Chemistry with exercises (9 ECTS)*


Periodic trends: atomic and ionic radii, first ionization energy, Electron affinity, electronegativity.


**Chemical reactions and their balancing.** Combustions. Aqueous chemical reactions. Redox reactions. Quantitative relations in chemical reactions.

**Liquids.** Liquid properties. Evaporation and equilibrium vapor pressure. Boiling and melting points.


**Chemical equilibrium.** Law of mass action. Homogeneous and heterogeneous equilibria. \( K_p \) and \( K_c \). Reaction quotient and equilibrium constant. Le Chatelier’s principle: equilibrium shifting.


**Numerical Applications**
The mole. Chemical reactions and their balancing Quantitative aspects of chemical reactions Solutions and their concentrations Colligative properties for electrolyte and non-electrolyte solutions Homogeneous and heterogeneous chemical equilibrium Aqueous chemical equilibrium. Acid, base and salt solutions. Amphoteric species Buffer solutions. Hydrolysis Acid-base titrations
Solubility equilibrium. Solubility and solubility product constant. Precipitation and dissolution.
Common ion effect
Electrochemistry

Mathematics with exercises (6 ECTS)
Some notions on: Equations and inequalities. Absolute value of a real number.
Analytic geometry: Coordinates on a straight line oriented. Cartesian coordinates
on the plane. Distance of two points. Midpoint of a segment. Equation of a straight line. Slope of a straight line and its geometrical meaning.
Perpendicularity and parallelism condition for two lines. Distance from a point to a line. Equation of circle, parabola, hyperbola and ellipse.
Real functions of real variable: Domain and range of a function. Symmetric, periodic, invertible, and composed functions.
Limits of functions: Definition of limit of a function at a point. Left and right
limits. Infinite limit of a function at a point. Limit of a function at infinity.
Uniqueness Theorem of limit. The sign permanence of Theorem. Working with limits.
Notable special limits.
Notes on: Linear differential equations of first order, of second order and with separable variables. Complex numbers. Operations with complex number.
Trigonometric form and esponential form.

Cytology and Histology with practice (9 ECTS)
Cytology: Introduction to the study of the cytology, molecular structure of cells and tissues, plasma membrane, cellular organelles, the inner compartments, the cytoskeleton and cellular motility, the nucleus, cell-cell and cell-matrix adhesion.
Methods in cytology: microscopy and staining techniques.
Histological techniques and observation of blood smears and tissue sections.
General and Systematic Botany with practice (12 ECTS)

Part I. General Botany

Part II. Systematic Botany

Practicals
Techniques of herbaria preparation. Identification of main taxonomic groups based on morphological characters.

Physics and Physical Chemistry (9 ECTS)

Mechanics:
- Motion in one dimension
- Motion in two and three dimensions
- Newton's laws of motion
- Application of Newton's laws
- Work and energy
- Linear momentum
- Rotational cinematics
- Statics of the rigid bodies
- Statics and dynamics of ideal and viscous fluids
- Centrifugation and surface phenomena

Thermodynamics:
- Temperature and kinetic theory of ideal gases
- First principle and second principles of the thermodynamics
- Heat engines and their thermal efficiency
- Electromagnetism:
  - Electrostatics
  - Electric current and DC circuits
  - Magnetostatics
  - Magnetic induction
- Introduction to electromagnetic waves and their interaction with biological matter
- Geometric optics

Organic Chemistry with exercises (9 ECTS)
- Alkanes, alkenes, alkynes, cycloalkanes, cycloalkenes, stereochemistry.
- Nucleophilic substitution reactions (SN2, SN1), elimination reactions (E2, E1).
- Alcohols. Diols.
- Aromatic compounds and reactivity. Phenols.
- Heterocyclic compounds (pyrrole, imidazole, pyridine, pyrimidine).
- Carbonyl compounds: aldehydes, ketones: reactivity.
- Carbanions, aldol reaction, Claisen reaction.
- Carboxylic acids, acyl chlorides, anhydrides, esters, amides, phosphoric esters.
- Lipids.
- Carbohydrates.
- Aminoacids.
- Proteins.
- Nucleic acids.
Year 2

*General and Systematic Zoology with practice (12 ECTS)*

Biodiversity. Animal classification, theoretical assumptions and methods. Theories and the scientific basis of evolution. Microevolution. The concept of population and animal species, the genetic basis and environmental effects.

Methodological skills. The taxonomic and phylogenetic analysis methods. Cladistics and cladograms. Using fonts body and / or molecular.

Evolutionary pressures, changes, environmental stress and natural selection. The responses of organisms and populations

Levels of hierarchical organization of complex animal, and systematic. The training plans of the major phyla and their evolution.


Recognition systems (protozoa, colonial organisms) and internal defense in the evolution of biodiversity.

Profile protozoa, sponges and cnidarians in the evolution of complexity

Bilaterian Metazoa: ACELOMATA: Platyhelminthes

Molluscs (Monoplacofora, Poliplacofora, Scaphopods, Gastropods, Bivalves, Cephalopods)

Annelids (Polychetes, Oligochetes, Hirudinea)

Arthropods (Chelicerata, Shellfish)

Arthropods (Myriapods, Hexapods)

Minor Protostome Phyla

Echinoderms, Hemichordata

Chordates (Urochordata, Cephalochordata)

Chordates (Vertebrates aquatic and terrestrial)

Practice: Observations protozoa, sponges, cnidarians, ctenophores and elements of phylogeny.

Observation and identification of animal organisms

*Biochemistry with practice (9 ECTS)*

Presentation of the statement of purpose and discipline. The proteins in the biological world. The versatility of the structural and functional proteins.


Structural levels of proteins, and their relationship to function. Structural motifs and protein domains. Protein folding. Examples of families of proteins.


The hemoglobin as an example of cooperative protein and as a model of adjustment functional.


The cellular metabolism. Role of transporters of energy metabolism. Mechanisms of production of ATP: oxidative phosphorylation and substrate-level phosphorylation


Metabolism of amino acids. Transamination reactions. Metabolism and transport of ammonium ion.

**TUTORIALS**

Cell cultures as an experimental model. Methods for evaluating cell viability. Protein electrophoresis and western blotting analysis.

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**Genetics with practice (9 ECTS)**

Mendelian genetics.
Chromosomal theory of heredity.
Genetic analysis of bacteria and bacteriophages.
Refined gene analysis.
Mutations.
Meiosis and alterations.
Gene function.
Regulation of gene expression.

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**Plant Physiology with practice (6 ECTS)**

Introduction to the course. Definition and common features of plant organisms.
Main functions of the plant cell and its organelles.
Transport of sugars in the phloem. Source and sink organs. Phloem loading and unloading.
Plant respiration.
Light as an environmental signal. Phytochromes and their ecophysiological role. Blue light responses.
Plant hormones: discovery, structure, metabolism and the main physiological effects of auxin, gibberellins, cytokinins, ethylene and abscissic acid.
Oxidative stress.
Lab practicals:
Methods to measure water potential.
Assaying photosynthetic pigments.
In vitro plant culture.

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**Molecular Biology with practice (9 ECTS)**

DNA components; DNA structure (A,B,Z); ribose puckering; beta glycosidic bond; DNA double helix and its stabilization (stacking and hydration bonds)
DNA bending (intrinsic and induced); DNA axial and torsional flexibility; Linking Number and DNA topology; The Topoisomerases; Supercoiling influences the structure of the double elix
Genome size and genetic content; The eukaryotic gene: conserved exons and unique introns. Gene numbers: repetition and redundancy
Chromatin structure and nucleosome; 10-30- 300- 700 A° chromatin organization
DNA replication; the replicon is the replication unit (replication origin structure and its functional significance)
The bacterial genome is a single replicon, whereas each eukaryotic chromosome contains many replicons.

Replication forks: mono or bidirectional movement?

DNA polymerase: the enzymes that make DNA (its structure and specialization)

DNA synthesis is semidiscontinuous and primed by RNA

Primosome initiates synthesis of Okazaki fragments

Common events in priming replication at the origin

Coordinating synthesis of lagging and leading strands

D loops and mitochondrial replication

Rolling circle replication (single genome or concatameres?)

The problem of linear replicon

Connecting bacterial and eukaryotic replication to cell cycle (methylation of origin sequences; phosphorylation by CDK complexes)

Prokaryotic gene expression:

Transcription is catalyzed by RNA polymerase

Bacterial RNA polymerase consist of core enzyme and sigma factor

Sigma factor control binding to DNA

Promoter recognition depends on consensus sequences

Substitution of sigma factor may control initiation

Sporulation utilizes a cascade of many sigma factors

The operon: a structural gene clusters that are co-ordinately controlled (both negatively and positively)

Repression can occur at multiple loci

The activity of repressor is controlled by small inducer molecule

Catabolite repression involves positive regulation at the promoter

Termination of transcription: intrinsic termination and Rho dependent termination

The attenuation of transcription: alternative structures can control termination or attenuation

The lambda lytic cascade relies on antitermination, whereas lysogeny is maintained by autogenous circuit: the alternative function of two repressor (Cro and CI) and antitermination

Eukaryotic transcription:

Promoters, factors and RNA polymerase (structure and function)

Features of transcription factor (DNA binding domain and transactivation/repression domains; dimerization domains)

The transcription complex of class I, II and III genes

The apparatus for nuclear splicing

Are transcribed genes arranged in nucleosomes?

Are nucleosomes arranged in phase?

Chromatin domains and its regulation

Chromatin dynamic: remodelling and histone modifications.

Translation the mechanism for express genes as proteins

Transfer is the adaptor

Messenger RNA is translated by ribosomes

The meaning of genetic code

The ribosomal sites of action

Initiation in bacteria needs 30S subunits and accessory factors

A special iniziator tRNA starts the polipeptide chain

Eukaryotic initiation factor involves many factors

exercise

Restriction enzymes. Plasmid vectors, ligation and transformation. Selection of recombinats clones.

Plasmidic DNA extraction. Electrophoretic analysis of plasmidic DNA
Microbiology with practice (9 ECTS)

Comparative Anatomy (6 ECTS)
Educational objectives: The module of Comparative Anatomy aims to present the main lines of the evolution of vertebrates.
Detailed program:

Functional anatomy of support and locomotion. Swimming; terrestrial locomotion: walking, jumping and running; flight.


The Circulatory system. Components of the circulatory system. Embryonic development of the blood vessels and heart. Evolution of heart, arteries and venous system in Fishes, Amphibians, Reptiles, Birds, adult Mammals.

The Sense Organs. Chemoreceptors, Olfactory receptors, Gustatory receptors, Thermoreceptors, Mechanoreceptors of the skin, Proprioceptors, Lateral Line receptors. The Ear system. Photoreceptors. The origin, development and adaptation of the eye.


Major Sensory and Motor Pathways in the mammalian brain. Ascending sensory pathways. The optic system, the auditory system, the olfactory and limbic systems. Cerebellum. Cortical integration.


Year 3

Developmental Biology (6 ECTS)


General Physiology (9 ECTS)
Homeostasis. Feed-back-control system. Fluid compartments in the body. Equilibrium distribution of ions.
The neural and hormonal regulation. The physical basis of neuronal function. action potential. Propagation of action potentials.
Typical neuronal circuits. The reflexes.
Hormones. Regulation and action.
Hemodynamic. Relationship between pressure and flow. Arterial system.
Venous system. Capillaries and microcirculation. Functions of the blood.
The physiology of salt and water. Control of the ionic concentration, osmotic and hydrogen ions. Osmoregulation in aquatic environment and air.
The nutrition. Digestion and absorption. The gastrointestinal secretions.

General and Applied Ecology with practice (12 ECTS)
Ecology: The historical development of ecology - Basic ecological terms and concepts - Relationship to other sciences – Hierarchical levels of organization – Ecological systems - Ecological models –
The abiotic environment: Climate and global climate change – Climatic factors – Climate generators - The abiotic environment: light, temperature, pH, nutrients – Limiting factors –
Organisms and the abiotic environment: The principle of Liebig– The principle of Shelford
Ecosystem and energy flow: Ecosystem structure – Ecosystem proprieties - Background of energy flow - Primary production and its limiting factors- Secondary production - Food chains – Food
webs – Ecological pyramids – Energetic efficiency – Bioaccumulation

**Biogeochemical cycles:** Hydrologic cycle – Carbon Cycle – Nitrogen Cycle – Phosphorous Cycle – Sulphur Cycle – Decomposition

**Community ecology:** Community structure – Interactions between species – Biodiversity – Ecological succession

**The biosphere:** Definitions - The Gaia hypothesis – Examples of the Gaia hypothesis

Basic Ecology with special referring to the main processes and biogeochemical cycles in aquatic ecosystems. Introduction to some basic aspects of marine biology and oceanography. The seagrasses of the world. Posidonia oceanica meadows in the Mediterranean Sea: habitat features, ecological functions and services, trends and threats, biological indicators, conservation management. Seagrass monitoring and recovery initiatives. The eutrophication problem: causes, effects, management, restoration techniques. Biological indicators. according to European directive (WFD 2000/60/UE) and Italian laws (D.Lgs. 152/1999 and 152/2006). Monitoring and management of marine and freshwater ecosystems.