Year 1

Fundaments of Chemistry with exercises (9 ECTS)

The Matter. International System of Units (Système international d'unités). Physical and chemical properties. Intensive and extensive properties. Mass, volume and density. Chemical substances and mixtures. Phases, homogeneous and heterogeneous systems. Chemica elements and compounds. Atom and subatomic particles. Isotopes, atomic masses. Atomic mass unit, mole. Mass fraction, elemental analysis. Empirical and molecular formulas.

Atomic electron structure and periodic table. Bohr's atomic model. Wave-particle dualism. Uncertainty principle. Hydrogen atomic orbitals. Quantic numbers.

Multi-electronic atoms. Electronic configurations. Aufbau principle. Pauli exclusion principle. Hund's rule of maximum multiplicity.

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

Chemical bond and molecular structure. Bond energy. Ionic bond. Covalent bond. Lewis structures for bi-atomic and multi-atomic molecules. Resonance and contributing structures. Covalent bond parameters: enthalpy, bond length. Bond order. Polarity of covalent bonds. Molecular and ionic geometry, VSEPR model. Molecular dipole moment. Valence bond theory. Orbital hybridization. σ and π bonds.

Main inorganic compounds. Oxidation number and status. Periodic system. Accessible valence status as function of electronic configuration. Systematic naming. Hydrogen and oxygen binary compounds. Hydroxides and oxyacids. Salts.

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.

Solutions and their properties. Liquids in liquid. Solids in liquid. Gases in liquid. Henry's law. Pressure and temperature effect on gas solubility.

Raoult's law. Colligative properties for electrolytes and non-electrolytes: relative lowering of vapor pressure, elevation of boiling point, depression of freezing point, osmotic pressure.

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.

Aqueous equilibria: acid-base equilibria. Acid and base definitions according to Arrhenius, Brønsted and Lowry, Lewis. Brønsted equilibria. Water protonation and pH scale. Acid and base strength. Polyprotic acids and bases. Acids, bases and salts in aqueous solution.

Buffer solutions. Henderson-Hasselbalch equation. Hydrolysis. Acid-base titrations. pH indicators.

Aqueous equilibria: solubility equilibria. Low solubility salts. Solubility and solubility product constant. Precipitation and dissolution. Common ion effect. pH effect. Complex ions.

Electrochemistry: Galvanic cells and electrolysis. Daniell cell. Cell potential. Nernst equation and electromotive force of a battery. Electrochemical electrodes classification. Standard hydrogen electrode. Standard electrode potentials. Glass electrode and pH-meter. Concentration cell.

Electrolysis: Faraday's laws of electrolysis. Water electrolysis. Sodium chloride electrolysis as fuse and as solute.

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. Powers and logarithms. Logarithmic, exponential inequalities and inequalities with absolute value. Rudiments of trigonometry.
Set theory: Meaning of set. Subsets. Set of parts. Transactions between sets. Relationships between sets. Order relation. Functions. Numeric sets. Limited and unlimited sets. Intervals. Neighbourhood of a point. Accumulation point of a set of real numbers. Sequences. Limitis of Uniqueness Theorem. Comparison Theorem. Sign permanence of Theorem. Monotone sequences. Limited sequences. Euler 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.
Continuous functions: Definition of a continuous function at one point. Points of discontinuity. Properties of continuous functions on an interval: Weierstrass's theorem, Cauchy – Bolzano's theorem, Darboux's theorem.
Derivative of functions of a real variable: Definition of derivative. Continuity of differentiable functions. Geometric meaning of derivative. Derivative of elementary functions. Rules for finding derivative. Derivative of composite and inverse functions. Rolle's theorem. Lagrange's theorem. Corollaries of Lagrange's theorem. Maximums and minimums for a differentiable function. Increasing, decreasing, concavity, convexity and inflection point of a function. Asymptotes. Study of the graph of a function. Differential of a function.
Integral: Indefinite Integral, common integrals. Methods of integration. Definite integral its geometrical meaning. Integral function. Mean theorem. Fundamental theorem of integral calculus. Computation of areas. Improper integral and numerical series. Methods of characters of series.
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.
Histology: Epithelial, connective, muscle and nervous tissues. Cartilage and bone. Blood and lymphopoietic organs.
Histological techniques and observation of blood smears and tissue sections.

General and Systematic Botany with practice (12 ECTS)

Part I. General Botany

Cytology - Structure of plant cell. Plant model-systems. Prokaryotic and eukaryotic photoautrophs. Structural levels and nutritional patterns. Elements of plant biochemistry.

Cellular organization: cellular types. Plastids (classification, structure and function). Vacuoles (tonoplast, structure and function). Water balance. Stored reserves. Secondary metabolites. Cell wall (structure, function, metabolism). Cell wall modifications. Protoplasts.

Cytosoms (structure and function). Growth and mechanism of cell division. Cell - environment relationships.

Determination. Differentiation and function of tissues and organs. Dedifferentiations and ridifferentiations. Cell totipotency. Levels of morphological organization.

Meristematic tissues. Unlimited growth and meristems. Permanent embryogenesis. Adult or definitive tissues. Histological responses to abiotic and biotic stress. Cell compartmentation. Organization of a typical plant body.

Developmental biology and comparative anatomy. Initial cells activity. Shoot and root apex. Root organization. Root modifications and adaptations to the environment.

Shoot organization. Primary and secondary plant body. Structure of woody plants. Shoot modifications and adaptations to the environment..

Leaf morphology and anatomy. Leaf modifications and adaptations to the environment.

Reproductive structures. Relationship between structure and functions.

Practicals

Methods to study plant cells. Microscopic and cytochemical techniques. Preparation and staining of plant structures. Interpretation of microscopic images and anatomical patterns. Observation and interpretation of cyto-histo-anatomical characters related to taxonomy and adaptations to the environment.

Part II. Systematic Botany

Course items. Systematics and Phylogenetics. Main classification systems. Artificial and natural systems. Taxonomic categories and botanical nomenclature. Methodological approaches in taxonomic studies. Living and preserved collections. Botanical Gardens and Museums (Herbaria).

Concept of Species and Speciation. Survey of vegetative reproduction, sporogony and sexual reproduction. Apomixis. Life cycle patterns: ontogenetic and metagenetic cycles (aplonts, diplonts, aplodiplonts). Sexuality in plants: hermaphroditism, monoecious and dioecious plants.

Prokaryotic photoautrophs: main features, reproductive biology and ecological role of Cyanobacteria (blue-green algae).

Eukaryotic algae: general features, body organization, reproduction, ecological role and distribution. Major features, systematics, life cycle patterns and ecological role of main algal groups: Rhodophyta (red algae), Bacillariophyta (diatoms), Ochrophyta (brown algae), Chlorophyta (green algae).

Plant colonization of land: challenges, ancestors and theories, plant terrestrial adaptations. The early land plants.

Bryophytes: Vegetative and reproductive features. Life cycle pattern. Taxonomy of main groups (Bryophyta, Hepatophyta, Anthocerotophyta) and ecological role.

Pteridophytes: Vegetative and reproductive features. Life cycle pattern. Isosporous and heterosporous. Major characteristics and systematics of main taxonomic groups (Lycophyta, Psilotophyta, Sphenophyta, Pterophyta).

Spermatophyta: General features of seed plants. Pollen, ovule and seed. Systematics.

Gymnosperms: Vegetative and reproductive systems. Life cycle pattern. Major characteristics and systematics of extant groups (Cycadophyta, Ginkgophyta, Coniferophyta, Gnetophyta).

Angiosperms: Vegetative features of flowering plants. Flowers, pollination and fertilization. Life cycle pattern. Fruits. Seed dispersal. Main characteristics of Monocots, Magnolids and Eudicots.

Fungi: Body organization. Reproductive structures. Life cycle patterns, ecological role. Nutrition modes in fungi. Systematics. Oomycota, Zygomycota, Ascomycota, Basidiomycota: Main features, reproduction and life cycle patterns, ecological role and economic use.
Flora and vegetation concept. Plant diversity. Indigenous and alloctonous flora. Relevant species of the Mediterranean flora.
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 cinematic
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, imidazolo, 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.
Reproduction and reproductive strategies. Comparative study of the development and morphogenesis of the phyla of reference in the context of the development of training plans.
Recognition systems (protozoa, colonial organisms) and internal defense in the evolution of biodiversity.
Profile protozoa, sponges and cnidarians in the evolution of complexity
Bilaterian Metazoans ACELOMATA: Platyhelminthes
Metazoans PSEUDOCELOMATA: Rotifers, Gastrotricha, Nematodes
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.
Functional classification of amino acids. Protein and non-protein amino acids,
essential and non-essential amino acids. Chemical classification of amino acids.
Structural levels of proteins, and their relationship to function. Structural motifs and protein domains. Protein folding. Examples of families of proteins.
Enzymes. structure / function relationship. Enzymatic catalysis. The enzyme kinetics. Menten kinetic and kinetic parameters (Vmax and Km). Enzyme inhibition. Pharmacological inhibitors. Allosteric enzymes. Kinetics cooperative and cooperative models. Mechanisms of regulation of enzyme activity
The hemoglobin as an example of cooperative protein and as a model of adjustment functional.
Main pathways of signal transduction. Characters of the markers. Classification of receptors.
The cellular metabolism. Role of transporters of energy metabolism. Mechanisms of production of ATP: oxidative phosphorylation and substrate-level phosphorylation
Carbohydrate metabolism. The language of sugars. Glycogen: structure, metabolism and regulation. Glycemic control. Glycolysis and gluconeogenesis. Pentose phosphate pathway. The citric acid cycle. Hormonal and metabolic regulation.
Lipid metabolism. lipid transport and storage. Synthesis and degradation of fatty acids and triglycerides. Ketogenesis. Notes on the synthesis of cholesterol. Hormonal and metabolic regulation

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.

Genetics with practice (9 ECTS)
Mendelian genetics.
Chromosomal theory of eredity.
Genetic analysis of bacteria and bacteriophages.
Refined gene analysis.
Mutations.
Meiosis and alterations.
Gene function.
Regulation of gene expression.

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.
Water relations. Water potential and its components. Water flow between a cell and its environment.
Transport. Transport pathways in the plant. Water in the soil. Water transport in the xylem. Resistance and hydraulic conductance to water flow. Cavitation. Transpiration.
Transport of sugars in the phloem. Source and sink organs. Phloem loading and unloading.
Mineral nutrition. Essential elements and nutrient stress. Nutrient assimilation. The contribution of symbioses to plant mineral nutrition.
Main experiments in the history of the discovery of photosynthesis. Photosynthetic pigments. The light reactions; synthesis of ATP and NADPH. Carbon organication: the Calvin-Benson cycle. Photorespiration. Mechanisms for the concentration of CO2: C4 and CAM plants. Synthesis of sucrose and starch. The ecophysiology of photosynthesis.
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.
Stress physiology: plant resistance and adaptation. Drought stress. Salt stress. Heat stress. Oxidative stress.
Lab practicals:
Methods to measure water potential.
Assaying photosynthetic pigments.
In vitro plant culture.

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 idratation bonds)
DNA bending (intrinsec 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 signifiance)

The bacterial genome is a single replicon,wereas 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 semidiscontinous 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 ; phosphorilation 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, wereas 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 enzimes. Plasmid vectors, ligation and transformation. Selection of recombinats clones. Plasmidic DNA extraction. Electrophoretic analysis of plasmidic DNA

Microbiology with practice (9 ECTS)
History of microbiology and its techniques. Microorganisms prokaryotes and eukaryotes. Phylogeny of prokaryotic organisms: Archaea and Bacteria. Culture media, selective media, isolation in pure culture. The methods of microbiology: sterile conditions, methods of sterilization. Staining techniques. Gram staining.
Morphology, structure and ultrastructure of prokaryotic cell. Bacterial cell wall. Flagella. Pili. Fimbriae. Formation and structure of bacterial spores. Endospore and esospore.
Growth of microorganisms. Microbial nutrition: nutritional requirements for growth. Growth curves. Diauxic curves. Environmental factors that affect growth. Metabolism: energy production and carbon sources, general principles of metabolism. Fermentation. Respiration. Anaerobic respiration. Glycolysis and alternative routes
Differentiation. Bacterial "quorum sensing". Biofilms. Life Cycle of Streptomyces, Caulobacter, Bacillus subtilis, Pseudomonas aeruginosa. Antibiotics: mechanism of action and resistance mediated by plasmids and bacterial transposons.
Eukaryotic microorganisms: yeasts, molds and protozoa
Animal, plant and bacterial viruses. Replication and virus titration. Prions and viroids.
Medical microbiology: diagnostic methods. Endo-and exo-toxins. Transcriptomic and genomic analysis of bacterial microbiota and pathogenic bacteria (Vibrio cholerae, Yersinia). Microorganisms for the production of molecules with therapeutic activity.
Microbial Ecology and Environmental microbiology. Rhizobia and symbiotic associations. Agrobacterium and transformation of plant cells. Analysis of non-culturable bacteria. Metagenomics.
Tutorials:
Gram staining, microscopic observation. Total and vital counts. Preparation of a pure culture, Bioassay and analysis results; miniaturized biochemical tests. Molecular diagnostic methods.

Comparative Anatomy (6 ECTS)
Educational objectives: The module of Comparative Anatomy aims to present the main lines of the evolution of vertebrates.
Detailed program:
Overview of evolution: the key points of the evolution of Vertebrates. Bauplan and evolutionary radiation of the Cambrian: extinct and present phyla. Phylogeny and classification. Homology and analogy. The phylum Hemichordata. The Tunicata. Chordate characters and their evolution. The Cephalochordata, the Vertebrata. The diversity of Vertebrate. Class Agnata. Ostracoderms. Class Chondrichthyes. Class Osteichthyes. Class Amphibia. Class Reptilia. Class Aves. Class Mammalia.
Development and comparative evolutionary embryology. Development of the Gametes. Characteristics and membranes of eggs. Fertilization. Cleavage. Gastrulation. Mesoderm formation and early Neurulation. Neural crest. Mesoderm differentiation and the derivates of germ layers. The extra embryonic membranes.
Characteristics of Tissues: Connective, Cartilage, Bone.
The Integument. General structure and development of the skin. The skin of Fishes, Amphibians, Reptiles, Birds, Mammals. The epidermis and derivatives. Dermis and subcutaneous tissue.

Evolution and function of Skeleton. Division of the skeleton. Composition of the head skeleton: the chondrocranium, the visceral skeleton, the dermatocranium. Evolution of the postcranial skeleton. The structure and development of vertebrae. The evolution of the trunk skeleton. The chest and pelvic girdles. The evolution of appendicular skeleton.
Functional anatomy of support and locomotion. Swimming; terrestrial locomotion: walking, jumping and running; flight.
The Respiratory system. The structure and development of internal gills. Gills of Agnathans, Elasmobranches, Bony Fishes. Accessory respiratory organs. Respiration in Amphibia, Reptilia, Aves, Mammalia class.
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.
The Nervous system. Component of the Nervous system: neurons and synapses, Schwann cells, neuroglia. Organization of the Nervous system. The spinal cord and spinal nerves. Cranial nerves. The Autonomic Nervous system. The development of the Brain. The Meninges.
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.
The Excretory system and Osmoregulation. Renal Tubule structure and function. Kidney development and evolution. Excretion and Osmoregulation.

Year 3

Developmental Biology (6 ECTS)
Lesson planning and Textbooks. Introducing Developmental Biology. Select embryonic developmental models and their history. Weissman model. Some classic experiments of Roux, Driesh, Spemann and Mangold. Cell commitment, specification and determination. Autonomous specification with mosaic embryos. Conditional specification. Syncytial specification.
Fertilization: Sperm and egg structure. Fertilization in sea urchin (external) Actraction, acrosome reaction, fusion, fast and slow block to polyspermy. Calcium function and pathway activation. Fertilization in mouse (internal). Translocation in oviduct and capacitation, recognition, binding, traversing and fusion, block to polyspermy. Sea urchin embryos development. Cleavage, blastula, fate map and determination of cells, specification of vegetal cells: micromeres, gene regulatory networks, signals and pathway, ingression of mesenchyme cells, gastrulation. Experiments of regulative capacity and induction. Drosophila embryo development. Cell germ determination and oocyte formation. Body plan genes: A/P polarity in the oocyte and D/V patterning. Protein gradients in early embryo, bicoid, nanos and hunchback gradient and terminal gene group acron and telson. Segmentation genes: gap, pair-rule and segment polarity. Effect of the Dorsal protein gradient. The Cartesian coordinate model. Homeotic selector genes. Amphibian embryo development. Fertilization and cortical rotation. Clevage and blastula. Induction of mesoderm. Gastrulation and involution of blastopore lip and expression of protocadherin. Progressive determination of amphibian axes and molecular mechanisms. Signals and pathways. Dorsal signal from Dsh to beta-catenin; vegetal signal as TGF beta like. Nieuwkoop center. Spemann experiments: inductive interaction in regulative development. Function of the Spemann organizer and induction of neural ectoderm and epiderm. epidermal inducers: the BMPs role, Wnt signals. Tunicate embryo development. Embryo model of autonomous specification but also conditional specification. Fertilization and bilateral holoblastic cleavage. The fate map. Autonomous specification and the

transcription factor Macho 1 for the muscle development. Nuclear beta-catenin for autonomous specification of endoderm. Conditional specification of mesenchyme and notochord by endoderm. Specification of embryonic axes. Nematode C. elegans embryo development.. Embryo model of autonomous specification but also conditional specification. PAR protein distribution at fertilization. Formation of the dorsal-ventral and right-left axes. SKN-1, PAL-1 and PIE-1 transcription factor in autonomous specification. Conditional specification and integration of autonomous and conditional specification. Vulval induction and cell patterning. Stem cells. Stem cell concept. Terminology. Adult stem cells and their niches. Embryonic stem cells. Mesenchymal stem cells. The cancer stem cell hypothesis (as disease of stem cell regulation, as migration reactivated). Stem cells and tissue regeneration. Induced pluripotent stem cells.

General Physiology (9 ECTS)
Homeostasis. Feed-back-control system. Fluid compartments in the body. Equilibrium distribution of ions.
Membranes, channels and transport. Passive transmembrane movements and active transport. Electrochemical potentials. The resting potential.
The neural and hormonal regulation. The physical basis of neuronal function. action potential. Propagation of action potentials.
The transmission of the information: the synapses. Presynaptic release of neurotransmitters. The chemical nature of neurotransmitters. Direct and indirect neurotransmission. Integration at synapses. The neuromuscular junction. General properties of sensory reception. Transduction and encoding. Typical neuronal circuits. The reflexes.
Hormones. Regulation and action.
Muscle and movements. Structural basis of muscle contraction. The sliding filament theory. Cross-bridge and force production. Mechanics of muscle contraction. Excitation-Contraction coupling. Cardiac muscle and Smooth muscle.
Circulation. Function of the heart. Electrical activity of heart. Properties of myocardium. Regulation of cardiac activity. Functions of the vascular system. Hemodynamic. Relationship between pressure and flow. Arterial system. Venous system. Capillaries and microcirculation. Functions of the blood.
The respiratory function. Ventilation. Exchange of gases. Blood gas transport.
The physiology of salt and water. Control of the ionic concentration, osmotic and hydrogen ions. Osmoregulation in aquatic environment and air.
Renal physiology. The glomerular filtration process. Tubular transport processes. The concentrating of urine.
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 enviroment: The principle of Liebig– The principle of Shelford
Population ecology: Population structure, distribution and density – Population dynamic and growth – R and K strategies
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.