MEDTEC SHOOL

Course: CELL PHYSIOLOGY AND BIOCHEMISTRY-1 (CPB-1)

Year: 1st

Period: 2nd semester

Credits: 7

Objectives

Knowledge. The integrated CPB-1 course will provide ground for understanding the biochemical mechanisms and processes that sustain life, and how these translate into human physiology, with major regard to energy balance, homeostasis, regulation, and adaptation. Major themes and aspects of the course are outlined as follows:

- the course will commence with a journey from small organic compounds to macro-biomolecules as a way to illustrate how natural polymers fold into hierarchically defined structures endowed with biological functions, and build a bridge with Chemistry and Organic Chemistry (from the first semester);
- the journey will continue with a presentation of the major structure/function relationships of macro-biomolecules, and a discussion of how biological functions are conveyed in time and space by their dynamic and regulated assembly into high-order structures. This will pave the way to the general aspects of enzymology and gas transport by haemoglobin;
- we will focus on the thermodynamics of life with an emphasis on how cells and organisms gather energy from the environment and employ it to establish an “internal milieu”, respond to stimuli, and adapt to changes;
- in the light of bioenergetics, we will illustrate and review pathways and mechanisms of the metabolisms of carbohydrates, lipids, proteins, amino acids, nucleotides, and their regulation. Cellular respiration, oxidation of energetic substrates, and their control will be discussed. Major emphasis will be on the regulatory mechanisms that allow energy to be harvested from food, converted into suitable “currency” for utilization in the human body, and smartly released to fuel biochemical reactions in the cell;
- fundamental cellular and molecular processes will be presented and critically discussed in the light of their roles in the human body, with major regard to the way cells and tissues organize and control metabolic inter-organ pathways. This is a pre-requisite to a comprehensive understanding of the body’s adaptation to starvation and response to stress and disease;
- the students will be introduced to the physiological perspective on the cell, looked at as a complex system in which numerous processes and programs take place in a coordinated and finely controlled way. This is made possible by the regulation of exchanges, biochemical and bioelectrical functions and gene expression, under control by internal programs as well as in response to external signals, through the activation of receptors and their signal transduction pathways;

- this physiological perspective will be extended to present and discuss initiation and propagation of the inter-cellular communications, with a focus on the electrical and molecular mechanisms that take part in these processes;
- the specific properties of excitable cells and the cellular physiology of neurons will be explored to understand how they can code and elaborate, interpret and communicate information;
- an "experimental" teaching approach will be exploited throughout the course. In this regard, emphasis will be placed on "how" scientific knowledge is generated as a way to build method-driven and critical thinking;
- in order to stimulate the students to begin the integration of Biochemistry and Cell Physiology with Human Pathology, examples will be provided that illustrate the biochemical and physiological bases of major diseases (clinical drops);
- key interdisciplinary and transdisciplinary aspects will be addressed through seminars, collaborative work and flipped classrooms to train students to re-elaborate knowledge in a broader perspective;
- in an effort to transcend the specific borders of individual sciences, and integrate their distinctive approaches and methodologies into a unified vision of Science, transdisciplinary workshops will be offered that cover concepts and topics of General Chemistry/Organic Chemistry/Biochemistry and Physics/Cell Physiology identified as major transversal themes in the building of students' CV.

Competences and skills. At completion of the course, the students are expected to:
- discuss why and how the structural complexity of macro-biomolecules (as compared to small organic compounds) is necessary to provide and support biological functions;
- illustrate and critically review the structure/function relationships underlying both activity and regulation of enzymes and haemoglobin;
- describe and explain the major bioenergetic aspects of life, in particular how cells and organisms harvest energy from the environment and use it to establish, maintain, adapt and restore homeostasis;
- understand and discuss the major catabolic and anabolic routes of cell metabolism, and their regulation;
- illustrate how cells and tissues organize the metabolic inter-organ pathways, and their roles in the human body;
- present and explain the major mechanisms of control of the cellular functions, by integrating pathways and processes of cellular biochemistry and physiology;
- understand and argue how excitable cells function, with regard to how they can code, interpret and communicate information;
- develop a critical thinking and analytical reasoning attitude that integrates and complements cell biochemistry and physiology, via attendance to joint seminars, collaborative work and flipped classrooms;
- improve communication and presentation skills, through active participation in oral and written assignments, and flipped classrooms;
- appreciate the value of collaboration and peer discussion;
- develop a transdisciplinary mindset with an "out-of-the-box" thinking attitude.

Prerequisites

The students must possess the bases of Chemistry and Organic Chemistry that are needed to grasp the conceptual aspects of execution and regulation of molecular and cellular processes, with particular regard to the gas theory, acid-base equilibria, electrochemistry, high-energy compounds, and physical/chemical properties of common organic functional groups: these are the topics faced in the Chemistry and Organic Chemistry course that must have been proficiently attended (exam passed).

Contents

The CPB-I course comprises two modules: *Biochemistry* (5 formative credits) and *Cell Physiology* (2 formative credits). Contents and specific learning objectives of each module are detailed below.

BIOCHEMISTRY

Structure/function of biomolecules *(Chemistry/Organic Chemistry/Biochemistry transdiscliplinary workshop – 1)*

Topics:

- from amino acids to proteins;
- protein folding;
- chemical *vs* enzymatic catalysis.

Specific Learning Objectives:

- the students will be able to understand basic structure/function relationships of complex biological macromolecules, such as enzymes and proteins, through the fundamental knowledge acquired from the Chemistry and Organic Chemistry course (in the first semester).

How chemical reactions take place in the cell *(lectures 1-4)*

Title of lectures:

- *Mechanisms of enzymatic catalysis (1)*
- *Enzyme kinetics and inhibition (2)*
- *Hemoglobin (3)*
- *Bioenergetics (4)*

Topics:

- principles of the metabolic control;
- metabolic functions as complex systems;
- enzymes and cofactors;
- mechanisms and control of the enzymes' activity;
- oxygen transport;

- thermodynamics of metabolisms.

Specific Learning Objectives:

- define, classify, and describe the general properties of enzymes;
- explain the role of the cofactors in enzyme catalysis;
- illustrate mechanisms and regulation of the enzyme-mediated catalysis;
- describe the principles of enzyme kinetics (Michaelis-Menten's theory) and the major mechanisms of enzyme inhibition;
- a non-enzymatic protein to understand enzymes: use hemoglobin as a model of allosterism;
- understand how energy flows through and across metabolic pathways ("high-energy" and "electron carrier" compounds as energetic "currencies" of the cell).

Clinical drops*:*

- enzymes as diagnostic markers and therapeutic agents;
- sickle-cell anemia.

Catabolic and anabolic pathways of carbohydrate metabolism *(lectures 5-9)*

Title of lectures:

- *Glycolysis (5)*
- *Metabolism of other hexoses and fermentation (6)*
- *The pentose phosphate pathway (7)*
- *Glycogen breakdown (8)*
- *Glycogen synthesis and gluconeogenesis (9)*

Topics:

- carbohydrate digestion;
- glycolysis;
- catabolism of fructose, galactose and mannose;
- homolactic fermentation;
- the pentose phosphate pathway;
- glycogen phosphorylase;
- properties and functions of glycogen synthase;
- gluconeogenesis.

Specific Learning Objectives:

- understand how polysaccharides and disaccharides are digested and adsorbed in the intestine;
- describe reactions and regulation of glycolysis;
- explain how other hexoses than glucose enter glycolysis;
- illustrate the anaerobic fate of pyruvate (homolactic fermentation);
- describe reactions and roles of the pentose phosphate pathway;
- explain how glucose is mobilized from glycogen (glycogen phosphorylase);
- describe the chemical reactions of glycogen synthesis (from glucose to glucose-1-phosphate, to UDP–glucose, and finally to glycogen);
- illustrate how the opposing processes of glycogen breakdown and synthesis are reciprocally regulated by allosteric interactions, and the covalent modification (phosphorylation/dephosphorylation) of key enzymes in both pathways (hormonal control of glycogen metabolism: insulin, glucagon, and epinephrine);

- define the non-carbohydrate precursors of glucose in gluconeogenesis (Cori and alanine cycles);
- describe the reactions of gluconeogenesis (role of biotin in the reaction catalyzed by pyruvate carboxylase);
- explain the reciprocal control of glycolysis and gluconeogenesis by allosteric effectors and phosphorylation/dephosphorylation (fructose-2,6-bisphosphate as a glycolytic/gluconeogenic "switch").

***Clinical drops**:*

- the metabolic Warburg's effect in cancer biology;
- deficiencies of glucose-6-phosphate dehydrogenase;
- glycogen storage diseases.

Mitochondrial ATP synthesis *(lectures 10-13)*

Title of lectures:

- *Synthesis of acetyl-CoA (10)*
- *The citric acid cycle (11)*
- *Electron transport (12)*
- *Oxidative phosphorylation (13)*

Topics:

- acetyl-CoA as a metabolic "hub" at the crossroad of anabolic and catabolic pathways;
- acetyl-CoA fuels the citric acid cycle;
- reactions and regulation of the citric acid cycle;
- oxidation-reduction reactions in the mitochondrial redox centers;
- proton gradient across the inner mitochondrial membrane and ATP synthesis (oxidative phosphorylation).

Specific Learning Objectives:

- illustrate the central role of acetyl CoA in metabolism;
- discuss structure, catalytic mechanism and regulation of pyruvate dehydrogenase;
- illustrate the shuttle systems that allow transferring electrons across the inner mitochondrial membrane (glycerophosphate and malate-aspartate shuttles);
- describe reactions and control of the citric acid cycle;
- explain how the citric acid cycle cross-talks to other metabolic pathways: cataplerotic and anaplerotic reactions;
- describe the ultrastructure of the mitochondrion (matrix, inner and outer membranes, transport systems for electrons, ADP, and P_i);
- discuss organization and function of the electron transport chain components (electron flow, reduction potential, and proton pumping in complexes I-IV);
- illustrate how the proton gradient across the inner mitochondrial membrane links electron transport to ATP synthesis (chemiosmotic theory);
- explain structure/function of ATP synthase;
- describe how electron transport and ATP are uncoupled in brown adipose tissue to generate heat (non-shivering thermogenesis);
- discuss the links between the mitochondrial metabolism and oxidative damage, and the major anti-oxidant mechanisms of the cell.

***Clinical drop**:*

- mutations of enzymes of the citric acid cycle and cancer.

Lipid metabolism *(lectures 14-17)*

Title of lectures:

- *Absorption and transport of lipids (14)*
- *Oxidation of fatty acids (15)*
- *Biosynthesis of fatty acids and membrane phospholipids (16)*
- *Cholesterol and bile acids metabolism (17)*

Topics:

- lipoproteins as "shuttle" systems for lipids transport;
- metabolism of fatty acids and eicosanoids;
- biosynthesis of triacyglycerols and membrane phospholipids;
- synthesis and metabolic fates of cholesterol.

Specific Learning Objectives:

- understand how lipids are digested, absorbed, and transported (lipoproteins and their dynamics);
- describe reactions and energy yield of fatty acid β-oxidation;
- discuss how the cell catabolizes unsaturated and odd-chain fatty acids (isomerases, reductase, and the coenzyme B_{12}-dependent methylmalonyl-CoA mutase);
- describe the synthesis of ketone bodies and their metabolism in peripheral tissues;
- illustrate how the tricarboxylate transport system transfers acetyl-CoA into the cytosol for fatty acid synthesis;
- describe the reactions of fatty acid biosynthesis (comparison with β-oxidation);
- explain the reciprocal control of fatty acid breakdown and biosynthesis (allosteric and hormonal control of acetyl-CoA carboxylase, malonyl-CoA as an inhibitor of carnitine palmitoyl transferase I);
- describe the mechanisms of fatty acid chain elongation and desaturation;
- illustrate the chemical reactions in the biosynthesis of triacylglycerols and major membrane phospholipids (phosphatidylcholine, phosphatidylethanolamine, phosphatidylserine);
- explain how lipids affect dynamics and plasticity of the biological membranes;
- discuss reactions and regulation of cholesterol synthesis;
- describe cholesterol as a precursor of steroid hormones and bile acids (cholesterol catabolism and the enterohepatic circle).

Clinical drops*:*

- aspirin and eicosanoids;
- treatment of hypercholesterolemia.

Synthesis and degradation of amino acids *(lectures 18,19)*

Title of lectures:

- *Protein degradation and the urea cycle (18)*
- *Breakdown and biosynthesis of amino acids (19)*

Topics:

- nitrogen homeostasis;
- digestion and absorption of proteins;

- urea cycle;
- biosynthesis and breakdown of amino acids.

Specific Learning Objectives:

- understand nitrogen balance (glucose-alanine cycle, glutamine as a "carrier" of nitrogen);
- describe the major mechanisms of intracellular protein degradation (lysosome and ubiquitin/proteasome);
- illustrate amino acid transamination and oxidative deamination of glutamate;
- describe the reactions of urea cycle and its connection with the citric acid cycle;
- discuss the catabolic fates of the carbon skeleton of amino acids (glucogenic and ketogenic amino acids, role of tetrahydrofolate);
- illustrate the major reactions involved in the synthesis of nonessential amino acids.

Clinical drops*:*

- genetic disorders of amino acid catabolism (nonketotic hyperglycinemia, hyperhomocysteinemia, maple syrup urine disease, hyperlysinemia, phenylketonuria, alcaptonuria).

Metabolism of neurotransmitters *(lecture 20)*

Title of lectures:

- *Metabolism of neurotransmitters (20)*

Topics:

- classification of neurotransmitters (classical, peptide and lipidic transmitters);
- paths and control of neurotransmitter biosynthesis and metabolism.

Specific Learning Objectives:

- describe the biosynthetic pathways of small nitrogen-containing neurotransmitters (glutamate, GABA, glycine, acetylcholine, dopamine, norepinephrine, epinephrine, serotonin, and histamine) from common amino acid (glutamate, tyrosine, tryptophan, histidine) and membrane lipid (phosphatidylcholine) precursors;
- discuss the mechanisms that control synthesis and availability of neurotransmitters, with major regard to catecholamines, serotonin, histamine, glutamate, GABA, and acetylcholine;
- illustrate the proteolytical processing of model pro-neuropeptides (proopiomelanocortin) to active peptides.

Clinical drop*:*

- excitotoxicity injury in brain infarction.

Heme metabolism *(lectures 21,22)*

Title of lectures:

- *Heme synthesis (21)*
- *Heme degradation and iron metabolism (22)*

Topics:

- synthesis of δ-aminolevulinic acid and porphobilinogen;
- uroporphyrinogen III synthase;
- bilirubin and its conjugation with glucuronic acid;
- ferrochelatase;
- iron absorption and transport.

Specific Learning Objectives:

- describe reactions and control of heme synthesis;
- illustrate the general features of heme degradation;
- explain how iron is adsorbed, transported and stored in the body (transporter systems, ferritin, ferroportin, transferrin, hepcidin).

***Clinical drops**:*

- porphyrias;
- jaundice;
- hemochromatosis.

Nucleotide synthesis and degradation *(lectures 23,24)*

Title of lectures:

- *Synthesis of purine and pyrimidine ribonucleotides (23)*
- *Formation of deoxyribonucleotides and nucleotide degradation (24)*

Topics:

- *de novo* and salvage pathways of nucleotides biosynthesis;
- ribonucleotide reductase;
- synthesis of dTTP;
- nucleotides catabolism.

Specific Learning Objectives:

- illustrate the general scheme of the *de novo* and salvage pathways of purine and pyrimidine biosynthesis;
- discuss the coordinated regulation of purine and pyrimidine synthesis;
- describe the reaction mechanisms and the control of ribonucleotide reductase;
- illustrate the strategy to convert dUMP to dTMP (thymidylate synthase and dihydrofolate reductase);
- describe the catabolic reactions of nucleotides (formation of uric acid, ribose-1-phosphate, and malonyl-CoA).

Clinical drops:

- dTTP synthesis as a target of chemotherapy;
- adenosine deaminase and severe combined immunodeficiency disease (SCID);
- gout.

An integrated view of fuel metabolism *(lectures 25,26)*

Title of lectures:

- *Organ specialization and hormonal control of metabolism (25)*
- *Metabolic homeostasis and its dysregulation (26)*

Topics:

- organ specialization;
- insulin, glucagon and catecholamines;
- regulation of energy metabolism, appetite and body weight;
- alterations of the metabolic homeostasis.

Specific Learning Objectives:

- discuss the metabolic requirements of major organs (brain, muscle, liver, kidney, adipose tissue);
- describe the counteracting effects of insulin and glucagon/catecholamines on organ

metabolisms;
- illustrate the effects of AMP-dependent protein kinase on organ metabolisms;
- understand regulation of fuel usage and appetite by hormones produced in adipose tissue, hypothalamus, stomach, and intestine (adiponectin, leptin, ghrelin, PYY3-36, neuropeptide Y);
- discuss metabolic adaptations during starvation.

***Clinical drop**:*
- diabetes as a paradigm of metabolic diseases.

Reactive oxygen species (ROS) *(Chemistry/Organic Chemistry/Biochemistry transdiscliplinary workshop – 2)*

Topics:
- oxygen chemistry and generation of ROS in living systems;
- radical reactions and reactivity of ROS *in vivo*;
- physiological and pathological roles of ROS.

Specific Learning Objectives:
- the students will be able to understand the chemical bases of ROS reactivity, the modifications they cause in major classes of biomolecules, and how these processes contribute to pathology (e.g., neurodegeneration). New vistas on emerging roles of ROS in physiology will be introduced to stimulate "out-of-box" thinking.

Special issues *(seminars 1,2)*

Title of seminars:
- *Monoclonal antibodies (seminar 1)*
- *Metabolomics (seminar 2)*

Topics:
- monoclonal antibodies and their applications;
- metabolomics as a branch of systems biology.

Specific Learning Objectives:
- describe the general characteristics of the human immunoglobulin classes;
- discuss the key structure/function relationships of IgGs;
- explain how monoclonal antibodies are made (a Nobel prize story);
- illustrate the major analytical, preparative and diagnostic applications of monoclonal antibodies (western blotting, flow cytometry, ELISA, immunoaffinity chromatography, immunohistochemistry, positive electron tomography);
- understand the prominent *in vivo* activities of monoclonal antibodies and their applications in cancer therapy;
- describe the major types of metabolomic analyses (from targeted analyses to holistic approaches);
- illustrate the key properties of common preparative and analytical tools of metabolomics (chromatography, capillary electrophoresis, nuclear magnetic resonance, mass spectrometry);
- discuss applications of metabolomics in the discovery of cancer biomarkers (sarcosine and prostate cancer, diacetylspermine and colon cancer) and unexpected metabolic links (trimethylamine N-oxide and atherosclerosis, amino acids and diabetes).

CELL PHYSIOLOGY

Physical modelling of electrical signals in the axon *(Physics/Cell Physiology transdiscliplinary workshop)*

Topics:

- Physics *vs* Cell Physiology: mapping links;
- the coaxial cable analogy.

Specific Learning Objectives:

- students will able to map connections between topics faced in the Fundamentals of Experimental Physics course (from the first semester) and others "to be faced" in the Cell Physiology module of CPB-I;
- using the coaxial cable as a physical and theoretical model, students will be able to anticipate how electrical signals passively propagate in an axon, a process that will be presented in the second semester.

Physiology and neurophysiology: what they study and how *(lectures 1,2)*

Title of lectures:

- *Introduction to Physiology and cell membrane (1)*
- *Cell transport (2)*

Topics:

- the scientific method: learning physiology by studying the experiments;
- the internal milieu and homeostasis: membrane transport, membrane properties.

Specific Learning Objectives:

- define the field of study of physiology and neurophysiology;
- describe the scientific method and its role in building new knowledge;
- identify the essential features, requirements and tasks of a living system;
- explain the concept of internal milieu and homeostasis control;
- illustrate the main properties of cell membranes;
- describe the membrane transport mechanisms;
- active and passive transport (diffusion, facilitated and regulated transport, pumps and secondary active carriers);
- describe the axonal transport.

Clinical drop*:*

- axonal transport and neurological diseases.

Bioelectricity *(lectures 3-6)*

Title of lectures:

- *Membrane potential (3)*
- *Passive electrical communication (4)*
- *Ion channels (5)*
- *Action potential (6)*

Topics:

- history of bioelectricity;
- resting membrane potential;
- ion channels;

- recording and stimulation techniques;
- electrical signal conduction;
- passive and active electrical proprieties.

Specific Learning Objectives:

- illustrate the main historical moments of the discovery of bioelectricity;
- describe the main rules underlying the maintenance of the equilibrium potential (the Nernst equation);
- compute the resting membrane potential (the Goldman's equation);
- explain the contribution of the different ion species in setting the resting membrane potential;
- explain the passive responses of the plasma membrane (the RC circuit analogy);
- illustrate the current/voltage relation of cell membrane;
- define the role and the principal features of the ion channels;
- illustrate the control mechanisms of the ion channels;
- describe the electrophysiological proprieties of the ion channels;
- describe the different techniques for recording cellular electrical activity;
- reproduce the circuit diagram of the voltage patch clamp;
- describe the features of the passive electrical propagation;
- illustrate the characteristics of an action potential;
- describe different recording and stimulating techniques of a nerve fiber;
- illustrate the proprieties of different nerve fibers.

Clinical drops*:*

- "channelopathies";
- toxins acting on the ion channels;
- demyelination;

Synapses *(lectures 7-9)*

Title of lectures:

- *Synaptic communication (7)*
- *Modulation of the synaptic transmission (8)*
- *Synaptic development (9)*

Topics:

- electrical and chemical synapsis;
- the neuromuscular junction;
- modulation of synaptic transmission;
- neurotransmitters;
- intracellular communication;
- synaptic plasticity;
- formation and elimination of axons and synapses.

Specific Learning Objectives:

- describe the electric synapse (gap junctions, signaling proprieties);
- describe the general proprieties of the chemical synapse (EPSP, IPSP, signal amplification);
- illustrate the example of the synaptic communication in the neuromuscular junction (an example of directly gated transmission, end plate potential, acetylcholine receptor);
- explain the different synaptic signaling and transduction modality (direct and indirect

communication, intracellular communication, second messengers);
- illustrate the general proprieties of the neurotransmitter release and of the synaptic vesicle turnover;
- illustrate the functioning mechanisms of the main neurotransmitter receptors (GABA, glutamate, AMPA, NMDA);
- explain the concepts of spatial and temporal summation;
- explain the concepts of long-term potentiation and depression;
- explain the main mechanisms underlying neurogenesis (strategy of cell division, radial cells and ventricular zone, delta-notch signaling, phenotype maturation, neuronal polarization);
- describe the growth cone;
- describe the mechanism of the neuron "movement".

***Clinical drops**:*
- myasthenia gravis;
- peripheral neuropathies;
- cancer cells and their ability to "hijack" the brain's communication;
- neurotransmitters: drugs and mood alteration.

Meeting the "WISE" experience *(seminar 1)*

Two representatives of the "Wise" Company will present and discuss their experience. Emphasis will be placed on the importance of transferring knowledge from technological discovery to medical application.

Technical details of the company's main products will be presented, and their links with relevant topics of the Cell Physiology module will be highlighted and discussed.

Teaching Methods

The course will be implemented based on a teaching schedule that combines and integrates:
- lectures and seminars;
- indications of reading;
- individual and group assignments (quizzes, research assignments, open questions, self-evaluations);
- interactive and multidisciplinary re-elaborations;
- flipped classrooms;
- formative revision tests and question time.

The course is organized on three distinct levels:
1. *knowledge transfer* – Lectures and seminars (face-to-face but also available in streaming or recorded) will remain accessible to students online; students will also be addressed to textbook chapters, scientific articles and other studying material: through all this the students are expected to acquire the knowledge required to master the topics at hand. Lectures and seminars will be held on Campus, and programmed in the daily schedule;
2. *active knowledge mastering* – self-assessment tests, small-group (either physical or digital) assignments and suggested readings will help the students process and master the acquired

knowledge. These activities will be carried out by the students off Campus either individually or in small groups;

3. *knowledge activation* – interactive and multi-disciplinary re-elaborations, joint interdisciplinary seminars, transdisciplinary workshops, question and answer sessions, discussions of group assignments and flipped classrooms will help the student to fully understand, assimilate and frame the acquired knowledge in an organized general perspective, and to clearly and linearly explain the complex issues of the functioning of living systems. Knowledge activation sessions will be held on Campus and, if necessary, made available for online synchronous attendance.

Verification of learning

The students' learning achievements will be evaluated via formative and summative assessments.

Formative assessments will be carried out on-the-way (during the course) in the form of active knowledge mastering sessions (*self-assessment tests*, including multiple choice questions, matching, ordering and other similar items) and knowledge activation sessions (*"tricky" journal clubs* and *"Acting in Science" sets*). Both are designed to promote active participation, foster scientific thinking, and provide the students with real-time feedbacks on their learning performances.

All students will have to take a final exam (summative assessment) at completion of the course, which comprises two steps, i.e. a written and an oral evaluation. The written evaluation (first step) is a questionnaire (including multiple choice questions, matching, ordering and other similar items) with 30 questions (20 for Biochemistry, 10 for Physiology) and 60 min duration; in order to be allowed to the interview (second step) a minimum score of 60% in each module (12/20 for biochemistry, and 6/10 for Physiology) is required. Students who have passed the written evaluation in the first session of a term (i.e., either Summer, Fall, or Winter) can opt to be interviewed in the second session of the same term without further written testing.

Grading scheme

Formative assessments			**Summative assessments**			**Final grade**
	Marks			**Marks**		
Self-assessment tests	**a**¶	0.5/30	*Written test*	**d**	(18-30)/30	**(d+e)/2 + (a+b+c)**‡
"Tricky" journal clubs	**b***	0.5/30	*Oral exam*	**e**	(18-30)/30	
"Acting in Science" sets	**c***	0.5/30				

¶The self-assessment tests are meant to evaluate the learning performance of individual students. To receive a 0.5/30 mark, two criteria must be met: *i)* participation in at least three-fourth (75%) of the offered tests, and *ii)* a minimum score of 60% in the participated tests. If either one of the two criteria is not met, a "0" mark is assigned.

*The "tricky" journal clubs and "Acting in Science" sets are carried out by groups of students, and intended to promote collective learning and original thinking. Instructions and information on the assigned assessments are provided in due time during the course. The "0.5/30" mark is received based on the following evaluation criteria: *i)* understanding, *ii)* critical thinking, *iii)* creativity/originality, and *iv)* communication/presentation skills. A "0" mark is assigned to groups (thereof, to the corresponding students) whose performance is judged of poor/insufficient quality.

‡To be eligible for extra marks from formative assessments (i.e., a+b+c), a minimum mark of 18/30 is required at the summative assessments (i.e., (d+e)/2 ≥ 18/30).

Registration to the final examination on the LMS of the University is mandatory. During the registration, students are warmly recommended to fill the Teaching Evaluation Form, as a way for the course's instructors to receive and elaborate feedbacks from the class.

Texts

Required

- Principles of Biochemistry. International student version - Voet, Voet and Pratt - Publisher: Wiley (4th edition)
  or
  Voet's Principles of Biochemistry. Global Edition - Voet, Voet and Pratt - Publisher: Wiley (5th edition)
- E.R. Kandel, J.H. Schwartz et al. - Principles of neural science - McGraw Hill

Additional readings

- Lehninger Principles of Biochemistry - Albert Lehninger, David L Nelson and Michael M Cox - Publisher: W. H. Freeman (6th or 7th edition)
- Biochemistry - Berg JM, Tymoczko JL and Stryer L - Publisher: Palgrave MacMillan (7th edition)
- Biochemistry - Garrett and Grisham - Publisher: Thomson Brooks/Cole (5th edition)
- Purves, D., Augustine, G. J., et al. - Neuroscience - Sinauer Associates
- Articles provided by the course's instructors