

# **MASTER IN BIOCHEMISTRY FOR HEALTH**



**CURRICULAR GUIDE 2014-2015**

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# CURRICULAR STRUCTURE

## SEMESTER 1

- **Bioanalytical Procedures** (6 ECTS)
- **Integrated Laboratory Practicals I** (6 ECTS)
- **Methods for Characterization of Biomolecules** (6 ECTS)
- **Option 1:** \*
  - Active Ingredients (3 ECTS)
  - Bioenergetics (3 ECTS)
  - Biopharmaceuticals (3 ECTS)
  - Drug Discovery, Design and Development (3 ECTS)
  - Functional Organization of the Cell (3 ECTS)
  - Molecular Immunology (3 ECTS)

## SEMESTER 2

- **Advanced Topics in Bioinformatics** (6 ECTS)
- **Integrated Laboratory Practicals II** (6 ECTS) \*\*
- **Molecular Bases of Disease** (6 ECTS)
- **Option 2:** \*
  - Basics of Toxicology (3 ECTS)
  - Bioethics (3 ECTS)
  - Biological Effects of Radiation (3 ECTS)
  - Bionanotechnology (6 ECTS)
  - Nutritional Biochemistry (3 ECTS)
  - Structural Biochemistry A (6 ECTS)
  - Synthetic and Systems Biology A (3 ECTS)

## SEMESTERS 3 AND 4

- **Dissertation** (60 ECTS)

\* Students choose up to four curricular units corresponding to a total of 12 ECTS

\*\* Classes take place between the 1<sup>st</sup> and 2<sup>nd</sup> semesters

## **DESCRIPTION OF CURRICULAR UNITS**

### **Mandatory Curricular Units**

## **ADVANCED TOPICS IN BIOINFORMATICS**

### **PROFESSORS**

João Aires de Sousa (FCT-UNL)

Cláudio Soares (ITQB-UNL)

António Baptista (ITQB-UNL)

José Pereira Leal (IGC)

Jorge Carneiro (IGC)

### **LEARNING OUTCOMES OF THE CURRICULAR UNIT**

This curricular unit aims at giving a general overview of the major areas of Bioinformatics and Chemoinformatics, providing the students with knowledge on the fundamentals as well as on practical applications in biosciences. The knowledge and skills acquired in this curricular unit will allow the students to have a general understanding of the scientific literature in the area, to be able to (individually) deepen their knowledge in selected areas in bioinformatics, and to use some computational tools to study real-life problems in biosciences.

### **SYLLABUS**

The topics in this curricular unit are very varied, reflecting the large number of areas and methodologies present in the field. The topics below aim at covering this vast field. The depth of coverage will vary depending on the topic.

- 1) Computational genomics and evolution.
- 2) Computational systems biology.
- 3) An experimentalist survival guide in computational biology methods – Practical sessions, in a problem solving context.
- 4) Representation and visualisation of molecular structures.
- 5) Introduction to molecular mechanics/dynamics.
- 6) Molecular docking.
- 7) Protein structure prediction
- 8) Quantitative Structure-Activity Relationships (QSAR).
- 9) The role of Chemoinformatics in drug discovery and development.

### **TEACHING METHODOLOGIES AND EVALUATION**

Classes will be Lectures/problem-solving with computers.

Some modules will adopt the Team-Based Learning (<http://www.teambasedlearning.org>, TBL) method. TBL is centered on permanent teams of 5-7 members, individual accountability for pre-class preparation, application activities and peer evaluation. The first phase of each

module assures the acquisition of the essential concepts – it includes an individual test, repetition of the test in teams and mini-lecture. In the second phase, teams perform application activities.

Evaluation consists of class evaluation (50%) and final exam (50%). In the TBL modules, class evaluation will be based on the TBL intrinsic deliveries (individual and team tests, application activities and peer evaluation). In other modules, class evaluation may be based on a computational work.

## MAIN BIBLIOGRAPHY

1. Leach, A. R., *Molecular Modelling: Principles and Applications*, 2nd ed., Prentice Hall, 2001
2. *Bioinformatics and Molecular Evolution* by Paul G. Higgs and Teresa K. Attwood. Wiley-Blackwell (ISBN-13: 978-1405106832)
3. *An introduction to systems biology. Design Principles of Biological Circuits.* U. Alon. Chapman & Hall/CRC Mathematical & Computational Biology; 2006.
4. *Chemoinformatics - a Textbook*, Gasteiger, J. Engel, T., Eds.; Wiley-VCH: Weinheim, 2003.
5. Leach, A. R.; Gillet, V. J. *An Introduction to Chemoinformatics*, 2<sup>a</sup> ed.; Springer: Dordrecht, 2007.
6. *Handbook of Chemoinformatics: from Data to Knowledge*, Gasteiger, J., Engel, T., Eds.; Wiley-VCH: Weinheim, 2003.
7. Selected papers from specialized international journals.

## BIOANALYTICAL PROCEDURES

### PROFESSORS

Ana Maria de Jesus Bispo Varela Coelho (ITQB-UNL)

Maria Cristina de Oliveira da Costa (FCT-UNL)

### LEARNING OUTCOMES OF THE CURRICULAR UNIT

- To acquire knowledge and skills in Analytical Biochemistry and related procedures
- To know the bioanalytical methods (spectrophotometry, mass spectrometry, chromatography, electrophoresis, enzymatic and immunologic methods) used to quantify and/or characterize drugs and compounds in biological matrices.
- To be able to implement and develop bioanalytical methods.
- To know the validation parameters, perform validation plans and conclude on the validity of bioanalytical methods.
- To be familiar with the basic aspects of regulation, quality control and quality systems.
- To be able to search and critically interpret the literature in this field.

### SYLLABUS

1. Introduction to Analytical Biochemistry.
2. Bioanalytical methods relevant for the quantification and/or characterization of drugs, metabolites and other compounds in biological matrices.

3. Strategies for the development and implementation of bioanalytical methods.
4. Validation of bioanalytical methods.
5. Introduction to regulation, quality control and quality systems in the Clinical Biochemistry Laboratory

#### **TEACHING METHODOLOGIES (INCLUDING EVALUATION)**

This curricular unit includes lectures, tutorials and practical laboratory classes. The lectures classes will be given using “data show”, together with complementary bibliography made available at the *Web* page of the curricular unit.

Tutorial classes: resolution of problems, literature search, study and discussion of clinical case studies.

Laboratory practical classes: experimental work following provided protocols and integrated in the curriculum of Integrated Laboratories I.

Attendance of the curricular unit: mandatory for 2/3 of the total tutorial and lab classes.

Evaluation: Continuous evaluation in the tutorial classes (40 %) and lab classes (30%).

Preparation of the validation plan for a bioanalytical method (30 %).

#### **MAIN BIBLIOGRAPHY**

- Thomas Devlin. Textbook of Biochemistry with Clinical Correlations. 6<sup>th</sup> Edition, Wiley-Liss, 2006.
- Allan Gaw, Michael J. Murphy, Robert A. Cowan, Denis St. J. O'Reilly, Michael J. Stewart, James Shepherd. Clinical Biochemistry: An Illustrated Colour Text. 4<sup>th</sup> Edition, Churchill Livingstone Elsevier, 2008.
- David Sheehan. Physical Biochemistry: Principles and Applications, 2nd Edition, Wiley, 2009
- Garofolo, F. (2004) Bioanalytical Method Validation, in Analytical Method Validation and Instrument Performance Verification (eds C. C. Chan, H. Lam, Y. C. Lee and X.-M. Zhang), John Wiley & Sons, Inc., Hoboken, NJ, USA

## **DISSERTATION**

#### **PROFESSORS**

Maria Teresa Catarino (FCT-UNL)

All the members of the teaching staff of the Master in Biochemistry for Health

#### **LEARNING OUTCOMES OF THE CURRICULAR UNIT**

The main aim of this unit is the development of a research project in biochemistry. Students will learn how to conduct a research project and how to interpret and present their results.

#### **SYLLABUS**

The curricular unit is fully dedicated to carrying out laboratory work and writing of the dissertation which will focus on topics addressed in previous semesters, or topics suggested by professors and discussed with students.

### **TEACHING METHODOLOGIES AND EVALUATION**

The unit includes research and development work with individual tutorial support from an advisor chosen by the student. The evaluation will be performed by public discussion of the Master's thesis with a jury.

### **MAIN BIBLIOGRAPHY**

Specific scientific papers and other literature search to be carried out by the student.

## **INTEGRATED LABORATORY PRACTICALS I**

### **PROFESSORS**

Maria Teresa Catarino (FCT-UNL)

Margarida Frazão (ITQB-UNL)

Ana Coelho (ITQB-UNL)

Cristina Costa (FCT-UNL)

Ana Luísa Simplício (ITQB-UNL)

### **LEARNING OUTCOMES OF THE CURRICULAR UNIT**

This course has the objective of endowing students with an extensive knowledge of the experimental techniques used in different areas of Biochemistry. The students will be exposed to a broad range of techniques available at the Department of Chemistry of FCT and at ITQB.

It is intended that students improve their knowledge of the selected experimental techniques, and develop a critical approach to the analysis and interpretation of experimental data.

### **SYLLABUS**

The students will have the opportunity to perform experimental work in different areas of Biochemistry, from molecular biology to biophysics. They will apply techniques used in the isolation and purification of biomolecules and their characterization at the biochemical and biophysical, kinetics, spectroscopic and structural levels. The experimental work will be integrated with the syllabus of other curricular units in the 1st semester of this Master's program.

### **TEACHING METHODOLOGIES AND EVALUATION**

The students will be organized in groups with a maximum of 3 elements. The assessment will be continuous and will take into account the student's laboratory work and his/her critical analysis of the data. The final grade will be given by a three-member panel including at least one examiner external to the teaching staff of this curricular unit, and will also be based on the presentation by the students of the scientific reports of their experimental work, followed by a discussion.

## **MAIN BIBLIOGRAPHY**

Biochemistry textbooks of general interest:

LEHNINGER PRINCIPLES OF BIOCHEMISTRY

Nelson, D.L., & Cox, M.M.

W.H. Freeman and Company, San Francisco, 5th ed. 2008

PRINCIPLES OF BIOCHEMISTRY

Voet, D., Voet, J.G. & Pratt, C.W.

John Wiley & Sons, Inc., New York, 3rd ed. 2008

BIOCHEMISTRY

Lubert Stryer

W. H. Freeman and Company, San Francisco. 6th Ed. 2007

BIOANALYTICAL CHEMISTRY

Andrea Manz, Nicole Pamme and Dimitri Iossifidis

Imperial College Press, 2004

More specialized books, reviews and/or original papers will depend on the selected experimental techniques.

## **INTEGRATED LABORATORY PRACTICALS II**

### **PROFESSORS**

Lígia Martins (ITQB-UNL)

Cristina Costa (FCT-UNL)

All the other members of the Teaching Staff of the Master Programme in Biochemistry for Health.

### **LEARNING OUTCOMES OF THE CURRICULAR UNIT**

This course follows up on Integrated Laboratory Practice I, where the students have acquired a knowledge of the multiple techniques used in biochemistry.

In this course, students will choose short research projects from a list presented by the instructor. Throughout the semester, students will have to plan and carry out experimental work in order to achieve the objectives of the project. The work will be undertaken in research laboratories at FCT or ITQB and each student will participate in up to 3 such projects during the semester. Each project will be a team work of up to 3 members in each team.

It is intended that students acquire an integrated view and practice of several methodologies used in biomolecular laboratorial research.



## **SYLLABUS**

The students will plan and undertake experimental work to achieve the goals of the chosen research projects, making use of the different experimental techniques and methods available at FCT and ITQB.

## **TEACHING METHODOLOGIES AND EVALUATION**

At the beginning of the semester, specific projects will be distributed to the student groups, chosen from a list prepared by the instructor, with the collaboration of the other instructors of this Masters program.

The students must begin by preparing a feasible work plan. Upon approval of this plan, the students will execute the experimental work, in a research laboratory environment, using the several experimental techniques available at FCT and ITQB.

The execution of the project will be monitored by tutorials.

There will be a continuous evaluation system and at the end of the semester the students will write a short report and make an oral presentation with the results.

## **MAIN BIBLIOGRAPHY**

The students will research specific literature for each assigned project.

# **METHODS FOR CHARACTERIZATION OF BIOMOLECULES**

## **PROFESSORS**

Manuela Alexandra de Abreu Serra Marques Pereira (ITQB-UNL)

Maria João Lobo Reis Madeira Crispim Romão (FCT-UNL)

## **LEARNING OUTCOMES OF THE CURRICULAR UNIT**

This course aims at introducing the basic concepts and the potential of multiple methodologies for functional and structural characterization of biomolecules, in an integrated and complementary perspective.

## **SYLLABUS**

Brief overview of basic concepts related to the different biomolecules, followed by a deeper introduction to the multiple methodologies for their functional and structural characterization, referring to the respective complementarities.

### I-Biomolecules

Proteins; Lipids and Membranes; Nucleic Acids; Molecular Complexes and interaction of biomolecules.

### II- Methodologies

#### 1.Spectroscopic Techniques

- a) UV-Visible spectroscopy;
- b) Fluorescence spectroscopy;

- c) Spectroscopies with polarized light: Circular Dichroism (CD) and Magnetic Circular Dichroism (MCD). Surface Plasmon Resonance;
  - d) Vibrational spectroscopies: Infra-red and FTIR. Raman and Resonance Raman;
  - e) NMR spectroscopy;
  - f) EPR spectroscopy.
2. Mass spectrometry
  3. Determination of 3D structures of biologic macromolecules by:
    - a) NMR spectroscopy;
    - b) X-ray Crystallography (Crystallization; X-ray diffraction; calculation of electron density maps). Structural information by SAXS.
    - c) Electron Microscopy (EM).

### TEACHING METHODOLOGIES AND EVALUATION

This curricular unit includes lectures, tutorials and practical laboratory classes. The lectures classes will be given using “data show”, together with complementary bibliography made available at the *Web* page of the curricular unit.

Tutorial classes: resolution of problems, literature search, study and discussion of clinical case studies.

Laboratory practical classes: experimental work following provided protocols and integrated in the curriculum of Integrated Laboratories I.

Attendance of the curricular unit: mandatory for 2/3 of the total tutorial and lab classes.

Evaluation: Continuous evaluation in the tutorial classes (40 %) and lab classes (30%).

Preparation of the validation plan for a bioanalytical method (30 %).

### MAIN BIBLIOGRAPHY

*Proteins: From Analytics to Structural Genomics* (Hardcover) by Robert A. Meyers (Editor) , Vols. I and II, Wiley-VCH Verlag (2007)

*Biophysical Chemistry: Part I, II e III* (Paperback) by Charles R. Cantor (Author), Paul R. Schimmel (Author) W. H. Freeman; 1st edition (1980)

## MOLECULAR BASES OF DISEASE

### PROFESSORS

Lígia Saraiva (ITQB-UNL)

Paula Videira (FCM-UNL)

### LEARNING OUTCOMES OF THE CURRICULAR UNIT

- To acquire knowledge and skills about the biochemical mechanisms underlying human disease.
- To be able to relate biochemical mechanisms with associated pathologies
- To acquire knowledge and skills on a seminar context and to be able to develop critical analysis, using the scientific literature.

## **SYLLABUS**

- Molecular aspects underlying neurological and immune disorders, cardiovascular diseases, infectious diseases, rare diseases, cancer and aging.
- Current molecular methodologies in the context of understanding human pathologies.

## **TEACHING METHODOLOGIES AND EVALUATION**

The course includes theoretical, practical classes and seminars. The lectures will be taught using the "data show", accompanied by complementary bibliography previously available on the website of discipline.

The practical classes and seminars will focus on discussion of more specialized subjects. The seminars consist of lectures by invited speakers followed by discussions with active student participation.

Evaluation:

- Final examination on the subjects of theoretical classes: 60%
- Reports on practical classes: 40%
- Compulsory attendance of 70%

## **MAIN BIBLIOGRAPHY**

Essential Concepts in Molecular Pathology. (2010) William B. Coleman and Gregory J. Tsongalis (Eds), Academic Press.

Molecular Basis of Health and Disease (2011) Undurti N. Das, Springer.

## Optional Curricular Units

### ACTIVE INGREDIENTS

#### PROFESSORS

Paula Cristina de Sérgio Branco (FCT-UNL)

Luísa Pinto Ferreira (FCT-UNL)

Maria Manuela Araújo Pereira (FCT-UNL)

#### LEARNING OUTCOMES OF THE CURRICULAR UNIT

It is intended that students understand the development process, the design strategy and the organic transformations used in the preparation of drugs.

#### SYLLABUS

- Drug Synthesis. Prime considerations in designing a synthesis. The retro-synthetic approach. New trends in synthetic medicinal chemistry.
- The chiral center. The methods for the preparation of enantiomerically pure drugs.
- Classical and bio-assisted organic synthesis
- Biocatalyzed reactions
- Peptides and peptidomimetic compounds
- Drugs based on a substituted benzene ring
- Opioid analgesics
- Five-membered heterocyclic based-drugs
- Rings that contain three or more heteroatoms

#### TEACHING METHODOLOGIES AND EVALUATION

Students have to attend lectures, where the theoretical concepts will be presented. There will be also a tutorial component in which the students analyze a theme in the form of a monograph which will be presented orally and discussed.

The evaluation consists of a written test on the lecture contents (60%) and an oral presentation and discussion of a written monograph (40%).

#### MAIN BIBLIOGRAPHY

*New Trends in Synthetic Medicinal Chemistry*, F. Gualtieri, Wiley 2000.

*Advanced Practical Medicinal chemistry*, Ashutosh Kar, New Age International Publishers, New Delhi (2004)

# **BASICS OF TOXICOLOGY**

## **PROFESSORS**

António Sebastião Rodrigues (FCM-UNL)

Ana Luisa Simplício (ITQB-UNL)

José Rueff (FCM-UNL)

Michel Kranendonk (FCM-UNL)

Marta Gromicho (FCM-UNL)

## **LEARNING OUTCOMES OF THE CURRICULAR UNIT**

- basic knowledge on pharmacokinetics, pharmacodynamics, metabolism and toxicology as well as the biological and chemical mechanisms of these phenomena.
- understanding the toxic biological effects due to exposure to environmental xenobiotics, food xenobiotics or pharmacological agents.
- understanding the toxicological consequences associated with inter-individual variations in biotransformation enzymes and membrane transporters, genetic polymorphisms and genetic variation in metabolism and drug transport.
- knowledge of practical examples of the application of these concepts in the clinics, research and industry
- skills concerning analytical methodologies applied in pharmacology and toxicology studies
- knowledge on the national, European and worldwide regulations, their differences, similarities and implications.

## **SYLLABUS**

1. Principles of pharmaco/toxicodynamics and pharmaco/toxicokinetics.
2. Principles of toxicology.
3. Drug Metabolism.
4. Strategies for the improvement of the absorption and distribution of drugs: Prodrugs and drug delivery systems.
5. Membrane transporters and response to xenobiotics. Efflux and drug resistance.
6. Environmental Toxicology. Mechanisms of action of environmental toxic agents; Drugs in the environment and toxic effects; Endocrine disruptors; Metals; Organic industrial pollutants.
7. Pharmacogenomics and pharmacogenetics. Personalized medicine.
8. Methods in pharmacology and toxicology
9. Genetic Toxicology and cancer.
10. Risk evaluation
11. Regulation

## **TEACHING METHODOLOGIES AND EVALUATION**

24 hours of lectures and 4 hours of problem-solving classes.

Evaluation will include a written examination and a group seminar (3 students) with equal weight.

## **MAIN BIBLIOGRAPHY**

*Goodman & Gilman's The Pharmacological Basis of Therapeutics*, 12<sup>th</sup> Edition, Laurence L. Brunton, ED

*Pharmacology for chemists*, ACS, Oxford University press, 1999, Joseph Cannon

*Casarett & Doull's Toxicology: The Basic Science of Poisons*, 6th Edition, Curtis D. Klaasen, Ed.

The bibliography will also consist of recent original scientific articles in specialized journals and review articles (e.g., Annual Review of Pharmacology and Toxicology).

## **BIOENERGETICS**

### **PROFESSORS**

Maria Teresa Catarino (FCT-UNL)

Ricardo Louro (ITQB-UNL)

### **LEARNING OUTCOMES OF THE CURRICULAR UNIT**

The course on Bioenergetics will focus on the various aspects of energy transduction performed by living organisms. By the end of the course the student should understand the thermodynamic and kinetic principles involved in energy transduction and be able to solve numerical application problems. He should know the components and organization of the respiratory chains and photosystems and understand the mechanisms of electron/proton coupling. He should be aware of the diversity of bacterial respiration and photosynthesis. It is also expected that the student develops skills in searching, understanding, and discussing the scientific literature in this field.

### **SYLLABUS**

1. Introduction to Bioenergetics: Life, energy and metabolism.
2. Quantitative Bioenergetics: the measurement of driving forces. Gibbs free energy. Oxidation-reduction potential. Electrochemical potential.
3. Chemiosmotic energy transduction. Electron transfer and electron/proton coupling. Proton motive force generation.
4. Mitochondrial respiratory chain.
5. ATPsynthase: structure, mechanism and regulation.
6. Light reactions of photosynthesis: organisation of the photosystems and proton motive force generation.
7. Bacteriorhodopsin and halorhodopsin: generation of ion gradients.
8. Diversity of bacterial respiration and its environmental relevance.
9. Oxidative stress and health. Mitochondria in the cell and its involvement in genetic and neurodegenerative diseases.

### **TEACHING METHODOLOGIES AND EVALUATION**

The course is organized in lectures, workshops, journal club sessions and seminars. In the workshops the students will solve numerical and computational problems of Bioenergetics. For the journal club sessions the students have to read, present and discuss scientific articles

in the Bioenergetics field. For the seminars the students have to prepare an oral presentation of a particular subject related to Bioenergetics. The presentation is followed by discussion.

The final evaluation mark is the average of two theoretical examination papers (70%) plus the journal club discussions and seminar presentation (30%).

### **MAIN BIBLIOGRAPHY**

1. "Bioenergetics 3", David G. Nicholls and Stuart J. Ferguson (2002) Academic Press.
2. "Energy and Life", John M. Wrigglesworth (1997) Taylor and Francis.
3. "Bioenergetics at a Glance", David A. Harris (1995) Blackwell Science.

## **BIOETHICS**

### **PROFESSOR**

Isabel Maria da Silva Pereira Amaral (FCT-UNL)

### **LEARNING OUTCOMES OF THE CURRICULAR UNIT**

- To contextualize the ethical dimension of the life sciences and their applications;
- To promote an informed debate on the increasing importance of the life sciences and biotechnology in society;
- To develop the ability of students to debate scientific and ethical problems;
- To reflect about the neutrality of science and the social responsibility of scientists and engineers.

### **SYLLABUS**

1. The Social responsibility of scientists and engineers in society.
2. The creation of Bioethics as a discipline - history and principles
3. Bioethics and Technology - Landmarks in the history of Biotechnology
  - a. Access to genetic information;
  - b. Cloning and stem cells;
  - c. Gene therapy;
  - d. Genetically Modified Organisms and biotechnological agriculture
4. Bioethics and medicine
  - a. Genetics and prenatal diagnosis
  - b. Sexuality and humane procreation
  - c. Experimentation in animals and humans
5. The bioethics committees - codes of conduct and scientific research at national and international level

### **TEACHING METHODOLOGIES AND EVALUATION**

The classes involve a combination of theory and practice. The lecturer will provide introductions to the main themes of the course and questions for debate as well as case studies for discussion by the students. All the materials (articles, books, PowerPoint slides) will be available online to the students in the course page in Moodle.

Evaluation includes:

- Participation in classes (15%);
- Group presentation of an article (4 members) concerning a specific subject of the course (30%);
- An individual essay on a course topic (45%).

### **MAIN BIBLIOGRAPHY**

- Cristina Beckert (2012), *Ética*. Lisboa: CFUL.
- Fukuyama, Francis,(2002), *Our Posthuman Future: Consequences of the Biotechnology Revolution*, Profile Books.
- Elio Screccia (1999), *Manual de Bioética – fundamentos e ética biomédica*, Edições Loyola, S. Paulo, Brasil.
- Gehring, Verna V. (ed. 2003), *Genetic Prospects: Essays on Biotechnology, Ethics, and Public Policy*, Rowman & Littlefield Publishers.
- Singer, P. (2000), *Ética Prática*. Gradiva.
- Guy Durand, (2<sup>a</sup> ed. 2007), *Introdução Geral à Bioética*, Edições Loyola, S. Paulo, Brasil.
- Walter, L. (1999), *Contemporary Issues in Bioethics*, Wadsworth Publishing.
- Warren, T. R. (ed.) (1995), *Encyclopedia of Bioethics*, 5 vols., Macmillan Library.

## **BIOLOGICAL EFFECTS OF RADIATION**

### **PROFESSORS**

Pedro António de Brito Tavares (FCT-UNL)

Maria Alice Santos Pereira (FCT-UNL)

### **LEARNING OUTCOMES OF THE CURRICULAR UNIT**

This curricular unit aims to provide a basic understanding of the effects of ionizing radiation in biological systems. Mainly, it seeks to provide understanding of the interaction of ionizing radiation with matter on the molecular level and how molecular-level effects lead to damage at the cell and tissue levels. At the end of this curricular unit, students should be able to:

1. Understand the effect of radiation on atoms and molecules;
2. Distinguish between different mechanisms of damage at the molecular level;
3. Understand the biological mechanisms of defense and repair against radiation damage;
4. Critically review the pertinent scientific literature in this field.

### **SYLLABUS**

1. Introduction and Historical Perspective
2. Sources and types of Ionizing Radiation
  - a. Particulate vs. Electromagnetic
  - b. Atomic structure, origin and nature of ionizing radiation
  - c. Radiation dose and units



- d. Principles of radiation dosimetry
- e. Interaction of radiation with matter
- 3. Introduction to Radiation Chemistry
  - a. Water radiolysis
  - b. Free radical formation
  - c. Direct vs. indirect effects
- 4. Radiation-induced cell death
  - a. Survival curves *in vivo* and *in vitro*
  - b. Damage repair at the cellular level
  - c. Dose rate effects
- 5. Radiation effects on cell cycle
- 6. Antioxidants
- 7. Radiation Effects on DNA
  - a. Types of damage caused by ionizing radiation
  - b. DNA repair mechanisms
- 8. Genetic Effects of Radiation
  - a. Chromosome and chromatid aberrations
  - b. Radiation-induced mutations
- 9. Radiation effects on proteins and lipids

#### **TEACHING METHODOLOGIES AND EVALUATION**

The contents of the curricular unit will be presented in two types of class: i) lectures, illustrated whenever possible with practical cases; and ii) seminar classes, that will include presentation and group discussion of articles published in international journals. The students will also be asked to prepare an individual essay in specific chosen themes. Evaluation will take into account the presentation (40%) and the essay (60%).

#### **MAIN BIBLIOGRAPHY**

“Radiation Biology: A Handbook for Teachers and Students”, training course series no. 42, International Atomic Energy Agency, Vienna, 2010.

“Essentials of Radiation, Biology and Protection”, Steve Forshire, Delmar Cengage Learning; 2 edition, 2008.

Selected papers from international scientific journals.

## **BIONANOTECHNOLOGY**

#### **PROFESSORS**

José Ricardo Ramos Franco Tavares (FCT-UNL)

Pedro Miguel Ribeiro Viana Baptista (FCT-UNL)

#### **LEARNING OUTCOMES OF THE CURRICULAR UNIT**

The main objective of this course is to raise awareness towards the increasing relevance of nanosciences and nanotechnology, with particular emphasis on nanotechnology for

biomedical applications.

Specific objectives are:

- To stimulate the students' understanding of concepts and underlying mechanisms of nanotechnology applications in biodiagnostics and construction of biosensors, within a broader field of developments in clinical diagnostics and biomedicine research.
- To develop basic laboratory skills in synthesis and characterization of nanostructures;
- Knowledge transfer from theory into practical application of nanoscale properties of materials in a biodiagnostics context;
- Critical evaluation and discussion of scientific work.

## **SYLLABUS**

1. Historic perspective on the origin of Nanotechnology
2. Scale effect and properties of nanomaterials.
3. Nanofabrication: bottom-up vs. top-down approach
4. Microscopy for nanomaterials characterisation (TEM, SEM, SPR)
5. Bionanotechnology and Bionanomachines
6. Nanoparticles for clinical applications
7. Nanotechnology and Green Chemistry
8. Nanotoxicology
9. Construction of nanostructures
  - 9.1. Surface functionalisation
    - 9.1.1. Self-assembling
    - 9.1.2. Bio-polymerisation
    - 9.1.3. Cross-linking
  - 9.2. DNA based nanostructures
    - 9.2.1. Electronics
    - 9.2.2. Bio-mimetizing
  - 9.3. Protein based nanostructures
10. Bionanodetection applications
  - 10.1. DNA & RNA (cross-linking vs. non-cross-linking)
11. Nanoparticles for drug delivery and nanovectors for gene therapy.

## **TEACHING METHODOLOGIES AND EVALUATION**

Lectures will have a duration of 2 h, and will include problem solving. Practical classes with 3 h duration will take place in a laboratory, and will consist of a prior protocol preparation, its implementation and a written report by the students.

Evaluation: Reports and discussion of the practical sessions (25% of the final grade); Presentation and discussion of papers (10% of the final grade); Monograph on a selected theme (45% of the final grade) and its oral presentation (20% of the final grade).

## **MAIN BIBLIOGRAPHY**

"Nanobiotechnology: Concepts, Applications and Perspectives" C.M. Niemeyer, C.A. Mirkin (Eds.), 2004, Wiley-VCH, Weinheim, Germany.

"Materials Chemistry" B.D. Fahlman, 2007, Springer, Dordrecht, the Netherlands.

"Bionanotechnology", D.S. Goodsell, 2004, Wiley-Liss, Hoboken, NJ, USA.

# BIOPHARMACEUTICALS

## PROFESSORS

Paula Marques Alves (ITQB-UNL)

Catarina Brito (ITQB-UNL)

Margarida Serra (ITQB-UNL)

Ana Sofia Coroadinha (ITQB-UNL)

## LEARNING OUTCOMES OF THE CURRICULAR UNIT

- Establishment of Animal Cell Technology as a key area in the discovery and development of complex biopharmaceuticals, including recombinant proteins (*e.g.*, monoclonal antibodies), vaccines and viral vectors for gene therapy.
- Relevance of stem cells as products of high therapeutic potential.
- Development of skills in cell culture technologies as *in vitro* models for basic research and preclinical trials (*e.g.*, primary cultures of brain cells and hepatocytes for toxicology testing).
- Case studies and examples of biotechnological applications of Animal Cell Technology.
- Impact of Animal Cell Technology in Pharma and Small Biotech companies.
- Commercial exploitation of the areas of animal technology and its contextualization in the biotechnology market.

## SYLLABUS

- Basic principles of animal cell culture techniques, cellular immortalization and development of production cell lines.
- Culture of animal cells in bioreactors, upstream, downstream and product characterization.
- Production of biopharmaceuticals, vaccines, VLP's (Virus-Like Particles) and gene therapy vectors.
- Introduction to GMP (Good Manufacturing Practices).
- Animal cells as models in preclinical research.
- Aspects of stem cell bioengineering and applications in cell therapy and as tools for biopharmaceuticals screening.

## TEACHING METHODOLOGIES AND EVALUATION

- This course includes lectures, theoretical/practical and laboratory classes. In the lectures, subjects are presented and in the tutorial sessions case studies are presented (analysis of scientific papers). These will allow the consolidation of knowledge that will later be put into practice in the laboratory sessions.
- The evaluation has two components that contribute equally to the final grade: a written examination on the themes explored in lectures (60 %), on the student presentations and discussions during the tutorial sessions and workshops on issues

previously suggested by the lecturers (20 %) and on the reports from the laboratory practical work (20%).

### **MAIN BIBLIOGRAPHY**

- "Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications", R. Ian Freshney, Wiley-Blackwell, 6th edition, 2010.
- "Animal Cell Technology: From Biopharmaceuticals to Gene Therapy", Castilho, Morais, Augusto e Butler (Ed), Taylor and Francis Group (Pub).
- "Tecnologia do Cultivo de Células Animais de Biofármacos e Terapia Gênica", Morais AM, Castilho L, Augustos EP (Eds), Editora Roca (Pub).
- Scientific articles published in specialized international journals with high impact factor, such as Nature Biotechnology, Trends in Biotechnology, Biotechnology and Bioengineering, Tissue Engineering, Journal of Biotechnology, Gene Therapy.

## **DRUG DISCOVERY, DESIGN AND DEVELOPMENT**

### **PROFESSORS**

Carlos José Rodrigues Crispim Romão (ITQB-UNL)

Rita Ventura (ITQB-UNL)

### **LEARNING OUTCOMES OF THE CURRICULAR UNIT**

The objective of this curricular unit (CU) is to contribute to the formation of future researchers or pharmaceutical industry professionals, equipped to understand and act upon the several stages of the creation of an active principle, its transformation into a drug and its introduction to the market as an efficient and safe medicine.

At the end of this CU the student must grasp and be able to articulate the following topics:

1. Processes of identification and discovery of new active principles;
2. Methodologies for the design and optimization of the active principles relative to their therapeutic target;
3. Methods to optimize administration, distribution and delivery of the active principle *in vivo*;
4. Stages and requirements of the process of bringing a drug to the market.

### **SYLLABUS**

Drugs and drug targets: Introduction

Drug targets

Proteins as drug targets

Enzymes as drug targets

Receptors as drug targets

Nucleic Acids as drug targets

Other molecular drug targets: lipids, carbohydrates, etc...

Drug discovery, Design and Development

Finding a lead compound

Develop a bioassay

## Design of the Lead compound

optimize interactions with the Target: (SAR; pharmacophore)

optimizing the drug

optimizing access to the target

drug targeting

prodrugs

## Problems of Formulation and Drug Delivery

methods to prepare water soluble compounds

solubilizing drugs in organic solvents, micelles or colloidal dispersions

solubilization with cyclodextrins

## Bringing Drugs to the Market

Selected Topics (e.g. antibacterials, anti-cancer drugs) and Case Studies.

## TEACHING METHODOLOGIES AND EVALUATION

Presentational teaching will be made through regular lectures and tutorials as well as through seminars on selected topics or relevant Case Studies. The final evaluation will comprise two written tests to be done during the semester, and a final seminar (with public discussion) on a theme to be selected from a previously announced set. Each type of evaluation (written and oral) will contribute 50% to the final grade.

## MAIN BIBLIOGRAPHY

- Graham L. Patrick, An Introduction to Medicinal Chemistry
- Gareth Thomas, Fundamentals of Medicinal Chemistry
- The Practice of Medicinal Chemistry
- Camille G. Wermuth, (Ed) The Practice of Medicinal Chemistry
- B. Silverman, The Organic Chemistry of Drug Design and Drug Action
- Drug Discovery Today, Elsevier periodical with extensive discussions, updates and case studies in Drug Discovery and Development.

## FUNCTIONAL ORGANIZATION OF THE CELL

### PROFESSOR

Júlia Carvalho Costa (ITQB-UNL)

### LEARNING OUTCOMES OF THE CURRICULAR UNIT

1. To acquire knowledge about the organization and functional dynamics of proteins, membranes and organelles in the eukaryotic cell, more specifically, in sorting and processing of proteins, vesicular transport, cytoskeleton organization and dynamics, cell cycle, interactions between cells and their environment.
2. To be able to characterize specific types of cells, for example, cancer cells and neural cells.
3. To acquire knowledge about deregulated molecular and cellular mechanisms associated with disease, for example, cancer and neurodegenerative diseases.

4. To perform bibliographic search and to develop critical reading of scientific literature to acquire knowledge about a specific theme for the elaboration of a monograph.

## **SYLLABUS**

1. Protein sorting and processing in the eukaryotic cell: mechanisms of vesicular transport; secretory pathways; protein folding and glycosylation; endocytic pathways; deregulation in human diseases.
2. Organization and dynamics of the cytoskeleton: intermediate filaments; microtubules; actin filaments.
3. The cell cycle: overview of the cell cycle; mechanisms of control of the cell cycle; S phase; M phase; mitosis.
4. Interactions between cells and with their environment: cell junctions; cell adhesion; extracellular matrix.
5. Cancer: characteristics of cancer cells.
6. Nervous system: cellular components of the nervous system and their characteristics; neuroregeneration.
7. Deregulated mechanisms in neurodegenerative diseases: protein misfolding; protein degradation; axonal transport; mitochondrial dysfunction; apoptosis; excitotoxicity.

## **TEACHING METHODOLOGIES AND EVALUATION**

The curricular unit is constituted by lectures and tutorials.

The lectures will address the theoretical aspects of the syllabus.

The tutorial component consists of a monograph written by the students about a specific theme which is presented orally and discussed with the lecturer and the colleagues. The theme is selected from a set of themes supplied by the lecturer.

The evaluation consists of a final exam about the theoretical component (60%) and the written monograph with oral presentation and discussion (40%).

## **MAIN BIBLIOGRAPHY**

- Alberts, B., Bray, D., Hopkin, K., Johnson, A., Lewis, J., Raff, M., Roberts, K., Walter, P. (2010) *Essential Cell Biology*. 3<sup>rd</sup> Edition. Garland Science, Taylor & Francis Group, New York, USA. ISBN 978-0-8153-4129-1.
- Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K., Walter, P. (2008) *Molecular Biology of the Cell*. 5th Edition. Ed. Garland Science, Taylor & Francis Group, New York, USA. ISBN 978-0-8153-4106-2.
- Lodish, H., Berk, A., Kaiser, C.A., Krieger, M., Scott, M.P., Bretscher, A., Ploegh, H., Matsudaira, P. (2007) *Molecular Cell Biology*. 6th ed., W. H. Freeman. ISBN-10: 0716776014.
- Siegel, G.J., Agranoff, B.W., Albers, R.W., Fisher, S.K., Uhler, M.D. (1999) *Basic Neurochemistry. Molecular, cellular and medical aspects*. 6th Ed. Lippincott Williams & Wilkins. ISBN 0-397-51820
- Papers published in international journals with high impact factor.

# MOLECULAR IMMUNOLOGY

## PROFESSOR

Paula Videira (FCM-UNL)

## LEARNING OUTCOMES OF THE CURRICULAR UNIT

- Acquisition of knowledge about the constitution and function of the Immune System.
- Acquisition of basic knowledge about the mechanisms of immune response, in the different steps of the immune response.
- Learning the molecular basis and mechanisms of antigen recognition and leukocyte activation
- Introduction of knowledge on the role of immune dysfunction in autoimmune diseases and immunodeficiencies.
- Development of skills on the applicability of methodologies / technologies used in the study of Immunology in different areas, such as, basic research, diagnosis and new therapies.
- Understanding the dynamics of knowledge contained in a rapidly developing science that integrates in all other biomedical sciences.

## SYLLABUS

- The human immune response in action: general concepts
- Elements and mechanisms of innate response
- Adaptive response and T and B cell cooperation
- Bases of the diversity of antigen recognition (antibodies and T cell receptors)
- Th1/Th2 balance
- Immunologic memory
- Adhesion molecules and leukocyte migration
- Cytokines
- Immune signalling pathways
- MHC and antigen presentation
- HLA immunogenetics and its relevance in the context of clinical histocompatibility.
- Immunotherapy
- Elementary techniques and animal models in Immunology
- Diagnostic techniques in Immunology
- Hypersensitivity and autoimmunity
- Immunodeficiencies
- Immunity in health and disease

## EVALUATION

The student will be evaluated according to the weighted average of: 1) a written examination (50% weighting) which will include the themes explored in all classes, themes from the student's presentations and the discussions on research seminars; 2) presentation and discussion of high impact papers which will be supplied by responsible of the course (40% weighting); and 3) participation and attitude in all course (weighting 10%).

## MAIN BIBLIOGRAPHY

- Cellular and Molecular Immunology, Saunders/Elsevier, 2011 by Abbas, Lichtman, and Pillai
- Janeway's Immunobiology; Garland Science, 7<sup>th</sup> edition, by Murphy, Travers, Walport
- Kuby Immunology; Kindt, Goldsby, Osborne
- Fundamentos de Imunologia, Lidel 2007, Fernando A. Arosa, Elsa M. Cardoso, Francisco C. Pacheco
- Scientific papers published in specialized international journals with high impact factor, such as
- Nature Immunology, Nature Reviews Immunology, Journal of Immunology, Molecular Immunology, European Journal of Immunology.

## NUTRITIONAL BIOCHEMISTRY

### PROFESSOR

Isabel Borges Coutinho de Medeiros e Dias (FCT-UNL)

### LEARNING OUTCOMES OF THE CURRICULAR UNIT

To acquire knowledge on the composition, ingestion, digestion and metabolism of food materials and on food-related diseases. To know topics on food-linked sensorial experiences. To know the main standards, regulations and legislation concerning food quality. To be qualified to present, analyze and discuss topics on human and animal nutrition and on food science and technology.

### SYLLABUS

- 1. Introduction** - Nutrition, nutrients and foodstuffs. Evolution of the human diet and its consequences. The natural human and animal food chains. Composition of food materials: water, macronutrients and micronutrients. Distribution of nutrients in foodstuffs.
- 2. Ingestion, digestion and metabolism of foods** - Biochemical basis of digestion and absorption of macronutrients. Hunger. Protein, mineral and vitamin deficits. Metabolic and diet-related diseases.
- 3. Food quality and safety** - Authenticity of foodstuffs. Additives. Undesirable components in human and animal foods. Endogenous toxins. Toxic residues. Toxic contaminants.
- 4. Food-linked sensorial experiences** - The fundamental tastes. Sugar substitutes. Natural and synthetic sweeteners. Bitter and umami compounds. The sense of smell. Aromatizers. Chemical irritants (chemestetics) and associated sensations. Non-chemical senses. Natural and synthetic food dyes.



## **TEACHING METHODOLOGIES AND EVALUATION**

Lectures and tutorials will be presented using Datashow, and their contents will be made available in the web page of the curricular unit. The evaluation during the semester includes two written tests which will contribute 70% to the final grade and the presentation of a seminar, which will cover the remaining 30%.

## **MAIN BIBLIOGRAPHY**

H. K. Biesalski, P. Grimm "Pocket Atlas of Nutrition", Georg Thieme Verlag (2005)  
Tom Brody, "Nutritional Biochemistry", Academic Press, 1<sup>a</sup> Ed., 1999

## **STRUCTURAL BIOCHEMISTRY A**

### **PROFESSORS**

Maria João Romão (FCT-UNL)  
Maria dos Anjos Macedo (FCT-UNL)  
Pedro Manuel Matias (ITQB-UNL)  
Pedro Miguel Lamosa (ITQB-UNL)

### **LEARNING OUTCOMES OF THE CURRICULAR UNIT**

This curricular unit will provide the students with theoretical and practical skills to: plan, execute and analyze protein crystallization assays;

- carry out a crystallographic characterization of the crystals obtained;
- collect and process diffraction data from a protein crystal;
- plan and execute the 3D structure determination of a protein;
- build, refine and critically analyze the 3D structural model of a protein;
- perform the structural analysis of the model obtained, compare it with models obtained by other methods and find similar structures in databases;
- carry out a basic interpretation of 1D and 2D NMR spectra of proteins;
- collect and process 1D and 2D NMR spectra of proteins;
- determine by NMR the structure of a protein with MW < 15 kDa.

### **SYLLABUS**

- Crystal symmetry; crystallization methods; characterization of crystals;
- sources of X-rays, diffraction by single crystals, instruments and methods for diffraction data collection;
- The structure factor, electron density maps, the "phase problem" and methods for its solution;
- Methods for building and refining a crystallographic structural model; convergence criteria;
- Electron Crystallography and Electron Microscopy for 3D structure analysis;
- Validation methods for crystallographic protein 3D structures; structural comparison; crystallographic databases. Comparison with other methods of 3D structural analysis. *On-line* computational tools;

- Basic theory of 1D and 2D NMR. Structural information: angles, distances, chemical environment.
- Pulse sequences for data acquisition and spectral assignment. 2D and 3D methods.
- Protein structure determination methods by NMR: Proteins with MW <15kDa vs. proteins with MW >15kDa.

### **TEACHING METHODOLOGIES AND EVALUATION**

- Theoretical classes - direct contact with the teaching staff in a classroom for presentation and discussion of the theoretical and theoretical-practical concepts included in the syllabus.
- Practical classes - direct contact with the teaching staff in classroom or laboratory for application of the concepts presented in the theoretical classes. The students will be divided into groups and each group will choose a project dealing with the structural characterization of a protein by X-ray crystallography and/or NMR. The work progress will follow as closely as possible the contents of the theoretical classes so as to allow the students a better assimilation of the concepts presented.
- Independent study - time used by the students to prepare project reports and study for the final examination.
- Evaluation - will consist of a written examination (45% of the final grade) and an oral presentation and discussion of the project(s) executed by the student (55% of the final grade).

### **MAIN BIBLIOGRAPHY**

“Crystallography made Crystal Clear - A Guide for users of Macromolecular Models” G. Rhodes, 2<sup>nd</sup> Ed., Academic Press: San Diego, London (2000)

“Introduction to Protein Structure” Branden, C.-I. & Tooze, J. Garland Pub. (1999)

“Structural Biology; Practical NMR applications” Q. Teng, Springer Science +Business Media, Inc, NY (2005)

Wlodawer, A., Minor, W., Dauter, Z., and Jaskolski, M. (2008) "Protein crystallography for non-crystallographers, or how to get the best (but not more) from published macromolecular structures", *FEBS J* 275, 1-21. doi:10.1111/j.1742-4658.2007.06178.x

## **SYNTHETIC AND SYSTEMS BIOLOGY A**

### **PROFESSOR**

Ana Margarida Palma Teixeira (ITQB-UNL)

### **LEARNING OUTCOMES OF THE CURRICULAR UNIT**

- To acquire a solid background in fundamental concepts of this new interdisciplinary field;
- To learn the state-of-the-art experimental techniques to measure omic data;
- To understand how Systems Biology advances our understanding of fundamental cellular processes, and its importance for biomedicine;

- iv) To learn introductory concepts of Synthetic Biology, including the basic circuitry in transcription regulation and signal transduction;
- v) To understand how synthetic networks can be built and tested in cells;
- vi) To learn cutting-edge biomedical applications of Synthetic Biology.

### **SYLLABUS**

- 1) Basic concepts in Systems Biology;
- 2) Omics high-throughput techniques and data analysis;
- 3) Metabolic, transcriptional regulatory and signaling networks;
- 4) Molecular networks in stem cell pluripotency and differentiation;
- 5) Molecular networks in cancer biology;
- 6) Basic concepts in Synthetic Biology;
- 7) Experimental approaches in Synthetic Biology;
- 8) Basic network motifs, including switches and oscillators;
- 9) Synthetic metabolic networks;

### **TEACHING METHODOLOGIES AND EVALUATION**

This course includes lectures and theoretical/practical classes. It will focus on papers that made significant conceptual contributions to Systems and Synthetic Biology. Research papers will be discussed during classroom sessions, and topics will include experimental methodology, principles of experimental design, data analysis and interpretation. Grades will be based on student participation in classroom discussions (15%), and completion of assignments (25%), presentations and a written final examination (40%).

### **MAIN BIBLIOGRAPHY**

No textbooks are required for this course. The course material is composed of recent research and review papers selected by the teacher. The review papers are intended to provide an overview about each topic and will be incorporated into the lectures by the teacher. The research papers will be used to facilitate in-depth discussions about cutting-edge methods and approaches.