Universitat Autònoma de Barcelona

2019/2020

Advanced Structural Analysis

Code: 100907
ECTS Credits: 6

Degree	Type	Year	Semester
2500252 Biochemistry	OT	4	0

Contact

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Use of Languages

Principal working language: catalan (cat)
Some groups entirely in English: No
Some groups entirely in Catalan: Yes
Some groups entirely in Spanish: No

Teachers

Joan-Ramon Daban
Alex Peralvarez Marin
Marc Torrent Burgas

External teachers

Fernando Gil

Prerequisites

The student must have passed the courses: Basic instrumental techniques, Advanced instrumental techniques and Chemistry and protein engineering.

Objectives and Contextualisation

The overall objective of the course is to learn the knowledge and skills that allow the structural analysis of biological macromolecules. The course will allow you to master the main techniques for the determination of the three-dimensional structure and visualization of biological samples by electron microscopy.

The aim is to give the maximum emphasis on the practical application of the knowledge imparted, so that students can use themselves the techniques described.

Specific objectives of the course:

1) To learn the theoretical bases of the main techniques for the analysis of the structure of macromolecules:

- Electron microscopy
- Nuclear magnetic resonance
- Crystallography and X-ray diffraction
- Applications of the synchrotron light
- Bioinformatic tools

(2) To apply the theoretical knowledge on the structural and functional analysis of macromolecules.

Competences

- Apply the principal techniques used in biological systems: methods of separation and characterisation of biomolecules, cell cultures, DNA and recombinant protein techniques, immunological techniques, microscopy techniques, etc.
- Clearly perceive current advances and possible future developments by reviewing scientific and technical literature in the area of biochemistry and molecular biology.
- Collaborate with other work colleagues.
- Define the structure and function of proteins and describe the biochemical and molecular bases of their folding, intracellular traffic, post-translational modification and replacement.
- Design experiments and understand the limitations of experimental approaches.
- Identify molecular structure and explain the reactivity of the different biomolecules: carbohydrates, lipids, proteins and nucleic acids.
- Integrate scientific and technological knowledge.
- Interpret experimental results and identify consistent and inconsistent elements.
- Read specialised texts both in English and ones own language.
- Stay abreast of new knowledge of the structure, organisation, expression, regulation and evolution of genes in living beings.
- Think in an integrated manner and approach problems from different perspectives.
- Understand the language and proposals of other specialists.
- Use the basics of mathematics, physics and chemistry that are required to understand, develop and evaluate the chemical procedures of living matter.

Learning Outcomes

1. Collaborate with other work colleagues.
2. Describe in detail the biophysical methods used to reveal the dynamic structure and properties of DNA and chromatin.
3. Describe the scientific and technical principles underpinning knowledge of the structure and chemical properties of biomolecules.
4. Design experiments and understand the limitations of experimental approaches.
5. Explain in detail the biophysical methods used to reveal the dynamic structure and properties of proteins.
6. Explain the basic physical principles, and applications to biochemistry and molecular biology, of advanced techniques in electron and atomic force microscopy and in the study of individual biomolecules.
7. Identify fundamental issues in present-day biophysics.
8. Identify scientific and technical advances in biophysics.
9. Identify the applications of emerging technologies (especially those linked to Synchrotron radiation and nanotechnology) to biochemistry and molecular biology.
10. Interpret experimental results and identify consistent and inconsistent elements.
11. Read specialised texts both in English and ones own language.
12. Think in an integrated manner and approach problems from different perspectives.
13. Understand the language and proposals of other specialists.

Content

THEORY PROGRAM

Unit 1. Advanced microscopy techniques.

Transmission electron microscopy: physical foundations; electron microscopes; preparation of samples; cryotechniques; electron tomography; single particle structure determination; elemental analysis; applications in Biochemistry and Molecular Biology. Scanning electron microscopy. Ion microscopy. Tunneling and atomic

force microscopy: physical foundations; microscopes and imaging methods; preparation of samples; force spectroscopy; nanotribology; applications in Biochemistry and Molecular Biology.

Unit 2. Applications of synchrotron radiation

Introduction: what is a synchrotron? Basis and Applications in biomedicine: reflection , scattering, absorption and fluorescence of X-ray , microscopy, of X-Ray and IR

Unit 3. Crystallography and X-ray diffraction.

Theoretical foundations of the determination of the three-dimensional structure of macromolecules using X-ray diffraction and crystallography; history of crystallography; methods of crystallization; properties of crystals; obtaining and processing of diffraction data; methods for obtaining the phases; Electron density maps; reconstruction and optimization of the model; parameters for the evaluation of the model quality.

Unit 4. Nuclear magnetic resonance (NMR).

Theoretical foundations of the magnetic resonance (NMR) applied to the structural study of macromolecules. Functional studies by monodimensional NMR. Bi and multi-dimensional spectroscopy, structural analysis of proteins, protein-ligand complexes, nucleic acids, and biological membranes.

Unit 5.Bioinformatics Tools applied to the structural analysis of macromolecules.

Introduction to the Unix operating system. Databases. Structures comparison methods. Calculation of structural and biophysical parameters. Study of structural complexes. Identification of functional domains. Graphical applications for analysis and visualization of macromolecules. Modeling of macromolecules and applications for drug design.

Problems

The resolution of practical cases that will facilitate the consolidation of the theoretical concepts will be performed. Most of the problems' teaching will be held in the computer room.

Tutorials

Several tutoring sessions can be performed during the semester. These sessions aim to answer questions and review concepts.

LABORATORY PRACTICES

Three practical sessions will be held:

1st session:Practices of microscopy at the UAB microscopy service.

2nd session: Practice in the classroom's computer SID.

3rd session: Guided tour of the ALBA Synchrotron Light laboratory. Seminar by Dr. Fernando Gil and explanation of the operation stations of X-ray microscopy, BL-09; non-crystalline diffraction, BL-11, and Macromolecule crystallography, BL-13.

Methodology

Theoretical master classes

The teacher will explain the contents of the program with the support of audiovisual material that will be available for students at the Moodle/Virtual Campus section. This support material will be written in English, Catalan or Spanish.

Optionally, seminars by specialists in the field will be held.

Problem cases

Throughout the course you will attend 8 hours of problems' teaching. Classes will include sessions at the computer room.

Practices

There will be guided tours to large installations with specialized equipment. The Protocol of practices will be available at the Virtual Campus before the practice session. Practices will also include sessions at the computer room.

Students must attend the practice session with the Protocol (available at the Virtual Campus) printed and read beforehand and bring a notebook to write down observations and data.

Practices, as well as its evaluation, will be carried out individually or in groups of two people. Attendance at practical sessions is mandatory, except in cases where there is a justified reason to prove the student absence.

Tutorials

Several tutorial sessions can be held during the semester. The aim of these sessions is to answer questions and review concepts with a high level of difficulty.

Activities

Title	Hours	ECTS	Learning Outcomes
Type: Directed			
Theoretical lectures	30	1.2	2, 3, 5, 6, 8, 7
Type: Supervised			
Practicum	9	0.36	1, 3, 4, 5, 10, 12
Problems	10	0.4	1, 2, 3, 4, 5, 6, 7, 10, 12
Type: Autonomous			
Autonomous work	52.5	2.1	1, 4, 13, 5, 6, 8, 7, 10, 11, 12
solving of practical cases	41	1.64	1, 4, 13, 5, 6, 8, 9, 10, 11, 12

Assessment

Description

The qualification will be based on the following elements:

1 - Final test of theoretical content (1st parcial + 2on parcial): a maximum of 7 points

2 - Problems' reports: maximum 1.5 points

3 - Participation in practices: maximum 1.5 points

The content of the course will be evaluated in two partial exams.

The proportional weight in the final mark for each of the issues will be proportional to the number of hours taught by each teacher.

The course will be overcome when the final mark is equal to or greater than 50 for a maximum of 100.

Other considerations

Students who cannot attend an individual evaluation test due to a justified cause must provide an official documentation to the Coordinator of the course and shall be entitled to perform the corresponding test in a different date.

To be eligible for the retake process, the student should have been previously evaluated in a set of activities equaling at least two thirds of the final score of the course or module. Thus, the student will be graded as "No Avaluable" if the weighthin of all conducted evaluation activities is less than 67% of the final score

Rules for improving your mark:

It is possible to improve the note of the midterms exam on the occasion of the Recovery Examination. The second note obtained will be considered asfinal ifthis one is higher than the one obtained in the first test.

When the obtained note at the second chance is less than 1 point or more than the first note obtained, the final note considered will be the average of the two notes.

The student will have 10 minutes at the start of the test to decide whether or not to perform the test.

For the maximum awardof honours qualification priority will be given to qualifications obtained in midterms' exam.

Calculation of the final mark:

Final mark = 0.70 * Theory + 0.15 * Problems + 0.15 * Practices

To pass the course the final mark must be$\geq$ 5

Assessment Activities

Title	Weighting	Hours	ECTS	Learning Outcomes
Evaluation 1st+ 2nd part Theory Exam	70%	5.25	0.21	1, 2, 3, 4, 13, 5, 6, 8, 9, 7, 10, 11, 12
Practicum evaluation	15%	1	0.04	1, 4, 8, 9, 10, 12
Problems Evaluation	15%	1.25	0.05	1, 4, 6, 9, 10, 12

Bibliography

Molecular Biology of Assemblies and Machines.A. C. Steven et al. (2016) Garland Science.

Biophysical Chemistry D. Klostermeier & MG Rudolph (2017) CRC Press

Proteins. Structures and Molecular Properties. T.E. Creighton, (1993) 2ed Freeman W.H.and co

Introduction to Biophysical Methods for Protein and Nucleic Acid ResearchGläsel and Deutscher (1995) Academic Press

Crystal Structure Analysis for Chemists and Biologists.J.P. Glusker, M. Lewis and M. Rossi (1994) VCH Publishers, Inc.

NMR of Proteins and Nucleic AcidsK. Wüthrich (1986) Wiley

NMR in Medicine and Biology. K.H. Hausser and HR Kalbitzer (1989) Springer-Verlag.

Web links

- Protein Crystallography course. Structural Medicine. MRC-LMB Cambridge University:

http://www-structmed.cimr.cam.ac.uk/course.html

- University of Cambridge. Crystallography. Teaching and Learning packages.

http://www.doitpoms.ac.uk/tlplib/crystallography3/index.php

- Department of structural biology. CSIC, Madrid

http://www.xtal.iqfr.csic.es/Cristalografia/index-en.html