Universitat Autònoma de Barcelona

2020/2021

Analytical Nanobiosystems

Code: 103274
ECTS Credits: 6

Degree	Type	Year	Semester
2501922 Nanoscience and Nanotechnology	OT	4	0

The proposed teaching and assessment methodology that appear in the guide may be subject to changes as a result of the restrictions to face-to-face class attendance imposed by the health authorities.

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

Prerequisites

To enroll in any fourth year subject, you must have a minimum of 120 ECTS approved and all the first course passed (Academic Affairs Committee of the Faculty of Sciences of February 27th 2007).
It is convenient to have passed the subjects of Analytical Chemistry and Supramolecular Chemistry / Molecular Recognition

Objectives and Contextualisation

To apply the concepts, principles, theories and fundamental facts related to nanoscience and nanotechnology in the systems for chemical analysis and diagnosis. Familiarize yourself with the new bio-inspired analytical systems. To illustrate this application of the convergence of technologies that combines nanomaterials and biotechnology.

Competences

- Adapt to new situations.
- Apply the concepts, principles, theories and fundamental facts of nanoscience and nanotechnology to solve problems of a quantitative or qualitative nature in the field of nanoscience and nanotechnology.
- Apply the general standards for safety and operations in a laboratory and the specific regulations for the use of chemical and biological instruments, products and materials in consideration of their properties and the risks.
- Be ethically committed.
- Communicate clearly in English.
- Communicate orally and in writing in ones own language.
- Demonstrate knowledge of the concepts, principles, theories and fundamental facts related with nanoscience and nanotechnology.
- Interpret the data obtained by means of experimental measures, including the use of computer tools, identify and understand their meanings in relation to appropriate chemical, physical or biological theories.
- Learn autonomously.
- Manage the organisation and planning of tasks.

- Obtain, manage, analyse, synthesise and present information, including the use of digital and computerised media.
- Operate with a certain degree of autonomy.
- Perform correct evaluations of the environmental and socioeconomic impact of chemicals and nanomaterials.
- Propose creative ideas and solutions.
- Reason in a critical manner
- Recognise and analyse physical, chemical and biological problems in the field of nanoscience and nanotechnology and propose answers or suitable studies for their resolution, including when necessary the use of bibliographic sources.
- Recognise the terms used in the fields of physics, chemistry, biology, nanoscience and nanotechnology in the English language and use English effectively in writing and orally in all areas of work.
- Resolve problems and make decisions.
- Show motivation for quality.
- Show sensitivity for environmental issues.
- Work correctly with the formulas, chemical equations and magnitudes used in chemistry.
- Work on the synthesis, characterisation and study of the properties of materials on a nanoscale from previously established procedures.

Learning Outcomes

1. "Identify in the bibliography scientific studies of interest on analytical nanobiomaterials and nanobiosystems; correctly interpret the physical, chemical and biological bases of these works."
2. Adapt to new situations.
3. Be ethically committed.
4. Communicate clearly in English.
5. Communicate orally and in writing in ones own language.
6. Correctly use the necessary computer tools to interpret and expose the results obtained.
7. Evaluate the danger and risks of the use of samples and reagents, and apply suitable safety precautions for each case.
8. Evaluate the environmental impact of the nanomaterials and processes used in bionanotechnology.
9. Identify integrated analysis systems and analytical methodologies based on nanomaterials.
10. Interpret analytical results and their quality.
11. Learn autonomously.
12. Manage the organisation and planning of tasks.
13. Obtain, manage, analyse, synthesise and present information, including the use of digital and computerised media.
14. Operate with a certain degree of autonomy.
15. Perform experiments with analytical nanobiosystems.
16. Present brief reports on biology and bionanotechnology in English.
17. Propose creative ideas and solutions.
18. Reason in a critical manner
19. Recognise the English terms employed in biochemistry, molecular biology, microbiology, immunology and in subjects related with nanoscience and nanotechnology.
20. Recognise the application of analytical nanobiosystems to large scale analysis.
21. Resolve problems and make decisions.
22. Safely handle the nanoparticles and nanomaterials used in biological systems.
23. Show motivation for quality.
24. Show sensitivity for environmental issues.
25. Understand texts and bibliographies in English on biochemistry, molecular biology, microbiology, immunology and in subjects related with nanoscience and nanotechnology.
26. Understand the design and operation of specific analytical nanobiosystems, and resolve quantitative problems related with these technologies.
27. Work correctly with the formulas, chemical equations and magnitudes used in chemistry.

Content

The syllabus of the subject is subdivided into the following lessons:

1. Integration in analytical chemistry. Integration of the analytical process. Immobilization. Automation. Miniaturization. Multiplexed (bio)sensors and micro / nanosystems.
2. The biological element: use of cells, enzymes - detection of substrates or inhibitors, antibodies and other proteins for recognition, oligonucleotides and aptamers, molecularly imprinted polymers.
3. Nanomaterials and nanofabrication: nanoparticles, quantum dots, magnetic particles, fullerenes, nanotubes, nanoespheres, graphene, nanowires, dendrimers, nanoarrays, nanopores.
4. Surface phenomena in systems for analysis. Self-assembled monolayers. Langmuir-Blodgett films. Functionalization. Printing and lithography at the nanometric scale.
5. Immobilization of biomolecules. General principles of immobilization. Non-covalent immobilization. Sol-gel matrices. Co-valent immobilization via hydroxyl, amino or thiol groups. Affinity: avidin-biotin interaction, hexahistidine group and Ni (II). Strategies for oriented immobilization.
6. Analytical methodologies using nanomaterials. Labeling. Competitive, capture or signaling strategies. Amplification of signals. Reduction of non-specific interaction. Blocking. Stabilization. Systems for sample treatment - magnetic particles and MIPs.
7. Systems with electrochemical transduction. Potentiometry: Selective electrodes and FETs. Voltammetry. Systems with enrichment. Electrochemical impedances spectroscopy.
8. Systems with optical transduction. Principles of optical measurement with the use of nanocomponents. Continuous methods and with resolution of time. Evanescent wave SPR and SERS. Fluorescence Methods: FRET. Detection of "single molecules", "up-converting" fluorophores.
9. Other principles of transduction. Systems with mass transduction. Quartz microbalance and surface acoustic wave sensors. Systems with magnetic transduction. Bioinspired Systems: Electronic noses and electronic tongues.
10. Biosensors based on Nanoporus. Nanometric porosity arrays. Intercalation of Ion channel proteins. Stochastic biosensors. Applications in sequencing.
11. Systems with micro and nanofluidics. Lateral flow devices. Lab on a chip. Capillary electrophoresis. Chips in genomics and proteomics. Field-flow fractionation. Nanorobots.
12. Nanobiosensors for clinical diagnosis. Teranostics. Glucose and metabolites, protein markers, cancer markers, DNA, viruses, bacteria, isolation and CTC detection. Application of analytical nanobiosystems for large-scale analysis.

Methodology

Students will have to develop various types of activities throughout this course:

a) Guided activities: Classes will be held on the contents of the subject with audiovisual support (materials deposited on the virtual campus) and classes of problems.
Numerical exercises will be used in the classes of problems about the contents of the course, and in addition the students will present presentations of scientific articles related to the subject.
For each lesson 7 to 12 (included), the teacher will prepare a list of scientific articles. Each student will choose one of the articles, and they will expose and analyze these works in an individual oral presentation of 10 min, with a question session, so that each student will carry out various presentations throughout the course.
On the other hand, the students will also carry out practices in the chemistry laboratory related to analytical nanobiosystems. The materials needed for these activities will be found in the space of the course on the Virtual Campus.

b) Supervised activities: Tutorials will be carried out in order to monitor the preparation of oral presentations.

c) Autonomous activities: Students will have to study the contents of the course, solve problems, prepare laboratory practices and prepare various presentations on scientific articles related to the subject.

Activities

Title	Hours	ECTS	Learning Outcomes
Type: Directed			

i. Theoretical lectures	32	1.28	1, 2, 11, 8, 26, 25, 4, 5, 23, 12, 9, 3, 24, 13, 14, 17, 18, 19, 20, 21, 27
ii. Problem classes	12	0.48	1, 2, 11, 8, 26, 25, 4, 5, 23, 16, 12, 10, 3, 24, 13, 14, 17, 18, 19, 21, 27, 6
iii. Laboratory	12	0.48	2, 11, 8, 25, 4, 5, 23, 15, 12, 10, 22, 3, 24, 13, 14, 17, 18, 19, 20, 21, 27, 6, 7
Type: Supervised			
i. Search of information for oral presentations	12	0.48	1, 11, 26, 25, 12, 9, 13, 14, 18, 19, 20
Type: Autonomous			
i. Personal study	40	1.6	2, 11, 26, 25, 23, 12, 9, 3, 13, 14, 17, 18, 19, 20, 21, 27
ii. Troubleshooting	20	0.8	1, 2, 11, 26, 25, 4, 5, 23, 16, 12, 10, 3, 24, 13, 14, 17, 18, 19, 21, 27, 6
iii. Preparation of oral presentations	12	0.48	1, 2, 11, 26, 25, 5, 16, 9, 10, 3, 13, 14, 17, 18, 19, 20, 27, 6
iv. Reading of laboratory scripts	1	0.04	2, 11, 8, 5, 23, 15, 12, 10, 22, 3, 24, 14, 17, 18, 19, 20, 27, 6, 7

Assessment

The assessment of the students will consist of several written and oral components:

- Written exams: There will be two partial exams throughout the course, one in half and the other at the end of the semester (33% each). The test will consist of a test part and a writing part. You must obtain a minimum score of 4 to be promoted by the final grade.

- Oral presentations, each student will do several during the course, lasting 10 min, summarizing scientific articles that are representative of the syllabus. The articles, corresponding to lessons 7,8,9,10, 11 and 12, will be chosen by the students from a list proposed by the teacher (34%).

- Students who need to improve the written part, may present themselves to a final exam at the end of the semester, which will replace 66% of the corresponding grade, and that will include the whole course. In order to be able to attend this final exam, it must have been evaluated before a minimum of 2/3 of the continuous assessment activities.

Assessment Activities

Title	Weighting	Hours	ECTS	Learning Outcomes
First partial exam	33%	4	0.16	2, 11, 8, 26, 25, 23, 12, 9, 10, 3, 24, 13, 14, 17, 18, 19, 20, 21, 6
Laboratory	coeficient multiplicatiu (entre 0.90-1.10)	0	0	2, 11, 8, 26, 4, 23, 15, 12, 9, 10, 22, 3, 24, 13, 14, 17, 18, 20, 21, 27, 6, 7
Oral presentations	34%	1	0.04	1, 2, 11, 8, 25, 4, 5, 23, 16, 12, 9, 10, 3, 24, 13, 14, 17, 18, 19, 20, 27, 6
Second partial	33%	4	0.16	2, 11, 8, 26, 25, 23, 12, 9, 10, 3, 24, 13, 14, 17, 18,

exam	19, 20, 21, 6

Bibliography

Nanobiosensing. Principles, development and application
H. Ju, X. Zhang, J. Wang
Springer, Heidelberg, 2011
ISBN 978-1-4419-9621-3

Nanomaterials for biosensors
C. Kumar
VCH Verlag, Weinheim, 2007
ISBN 978-3-527-31388-4

Chemical Sensors
P. Gründler
Springer, Heidelberg, 2007
ISBN 978-3-540-45742-8

Chemical Sensors and Biosensors: Fundamentals and Applications
F.G. Bănică
Wiley, Chichester, 2012
ISBN 978-0-470-71067-8