Universitat Autònoma de Barcelona

Nanotechnology for Therapy and Remediation

2016/2017

Code: 43434
ECTS Credits: 6

Degree	Type	Year	Semester
4314939 Advanced Nanoscience and Nanotechnology	OT	0	A

Contact

Name: Imma Ratera Bastardas

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Use of languages

Principal working language: english (eng)

Teachers

Fernando Novio Vazquez

Leonor Ventosa Rull

Ana Maria López Periago

Víctor Franco Puntes

Martí Gich García

Anna Laromaine Sague

External teachers

Nora Ventosa

Prerequisites

The same admission requirements as the ones to be admited to the Master's Degree:

A degree certificate in **Nanoscience** and **Nanotechnology**, Physics, Chemistry, Geology, Biochemistry, Biotechnology, Telecommunication Electronic Engineering, Materials Engineering, or another degree whose contents fit the profile of this **master's degree**. You may also be admitted to the **master's degree** if you hold an official university degree issued in Spain (in compliance with the legal ordinance prior to the Royal Decree 1393/2007) or in another country, as long as its contents are closely related to the subjects offered in the **master's degree**.

- Good level of English, equivalent to Level B2 of the Common European Framework of Reference for Languages.

Objectives and Contextualisation

The objective of this course is to give a broad overview of how nanotechnology is impacting medicine, biomaterials and enviroment remediation. Brief basic concepts in nanomedicine and biomaterials will be detailed at the beginning of the course. Following the introduction, the course is divided in five main sections: Nanotoxicology, Drug delivery, Thermal Therapies, Tissue Engineering, and environment remediation.

Skills

- Analyse research results to obtain new products or processes, assessing their industrial and commercial viability with a view to transferring them to society
- Analyse the benefits of nanotechnology products, within one's specialisation, and understand their origins at a basic level
- Communicate and justify conclusions clearly and unambiguously to both specialised and non-specialised audiences.
- Continue the learning process, to a large extent autonomously
- Designing and applying nanomaterials and nanoparticles in diagnosis and therapy in biological systems. (specialty nanobiotechnology)
- Identify and distinguish the synthesis/manufacture techniques for nanomaterials and nanodevices typically adopted in one's specialisation.
- Integrate knowledge and use it to make judgements in complex situations, with incomplete information, while keeping in mind social and ethical responsibilities.
- Seek out information in the scientific literature using appropriate channels, and use this information to formulate and contextualise a research topic.
- Show expertise in using scientific terminology and explaining research results in the context of scientific production, in order to understand and interact effectively with other professionals.
- Solve problems in new or little-known situations within broader (or multidisciplinary) contexts related to the field of study.
- Use acquired knowledge as a basis for originality in the application of ideas, often in a research context.

Learning outcomes

1. Analyse research results to obtain new products or processes, assessing their industrial and commercial viability with a view to transferring them to society.
2. Analyse the basic principles of cancer therapies.
3. Analyse the differences between different drug liberation systems.
4. Communicate and justify conclusions clearly and unambiguously to both specialised and non-specialised audiences.
5. Continue the learning process, to a large extent autonomously
6. Define the concepts of biocompatibility and toxicity in nanomaterials.
7. Define the properties needed for nanomaterials that are efficient in water remediation.
8. Describe the concept of biomineralisation and the role of the different components involved.
9. Describe the drug encapsulation methods.
10. Describe the most important characteristics for designing materials for tissue regeneration.
11. Describe the principles of tissue engineering.
12. Integrate knowledge and use it to make judgements in complex situations, with incomplete information, while keeping in mind social and ethical responsibilities.
13. Recognise the role of particle size in bioavailability.
14. Seek out information in the scientific literature using appropriate channels, and use this information to formulate and contextualise a research topic.
15. Show expertise in using scientific terminology and explaining research results in the context of scientific production, in order to understand and interact effectively with other professionals.
16. Solve problems in new or little-known situations within broader (or multidisciplinary) contexts related to the field of study.
17. Use acquired knowledge as a basis for originality in the application of ideas, often in a research context.

Content

Module in which the interrelations of nanomaterials in biological systems, and its impact on toxicity, tissue engineering, drug delivery, thermal therapies and water remediation will be exposed.

Content:

Biocompatibility: Interactions of nanomaterials with biological matter. Toxicity of nanomaterials.

Tissue engineering: molecular and polymeric gels. Biomineralization. Scaffoldings and cell growth. Importance of 3D validation of materials for medicine. Material applications in tissue regeneration.

Principles of drug delivery: Bioavailability. Concepts on encapsulation, distribution and targeting of drugs. Materials for the delivery: micelles, liposomes, nanoencapsulated compounds, porous organic and inorganic materials as drug carriers. Release of proteins and genes. Practical cases.

Principles of thermal therapies: hyperthermia, photothermal, magneto, termoradio therapy to target and destroy cancer cells. Analysis of appropriate nanomaterials. Current methods and future prospects.

Description of the necessary properties of **nanomaterials for water remediation**. Techniques based on photocatalysis, adsorption etc.

Methodology

Lectures

Seminars

Practical cases

Oral presentation of works

Preparation of papers

Personal study

Reading articles / reports of interest

Activities

Title	Hours	ECTS	Learning outcomes
Type: Directed			
Lectures	36	1.44	2, 3, 6, 7, 8, 9, 10, 11, 13
Oral presentations of works	7	0.28	4, 5, 12, 17
Personal study	30	1.2	2, 3, 6, 7, 8, 9, 10, 11, 13
Practical cases	4	0.16	17
Preparation and presentations of scientific papers	10	0.4	1, 14, 15
Reading articles and reports	20	0.8	1, 14, 15
Seminars	2	0.08	3

Evaluation

20% Assistance and class participation

40% Short oral presentations (10 min) of research papers related to the topics and questions of the evaluation panel

40% Multiple choice exam

Evaluation activities

Title	Weighting	Hours	ECTS	Learning outcomes
Assitance and calss participation	20%	38	1.52	4, 5, 12, 16, 17
Multiple choice exam	40%	1	0.04	2, 3, 6, 7, 8, 9, 10, 11, 13
Short oral presentations	40%	2	0.08	1, 4, 14, 15, 17

Bibliography

1. **Biocompatibility. Interaction of nanomaterials with biological matter. Toxicity of nanomaterials.**

1.1 A. Nel et al. Understanding biophysicochemical interactions at the nano-bio interface. Nature Materials 8, 543 (2009).

1.2. EU Commission recommendation on the definition of nanomaterial, http://bit.ly/gxqKMb

1.3. OECD document "Current developments/activities on the safety of manufactured nanomaterials": http://bit.ly/katdxW

1.4. Chapter R11 - PBT Assessment p. 13, ECHA Guidance.

1.5. GoodNanoGuide shares best practices, how to handle nanomaterials safely, http://www.nanowiki.info/#[[GoodNanoGuide%20shares%20best%20practices%3A%20how%20to%20handle%20nanomaterials%20safely]]

1.6. The appropriateness of existing methodologies to assess the potential risks associated with engineered and adventitious products of nanotechnologies (SCENIHR document), http://ec.europa.eu/health/archive/ph_risk/committees/04_scenihr/docs/scenihr_o_003b.pdf

1.7. G.J. Oostingh et al. Problems and challenges in the development and validation of human cell-based assays to determine nanoparticle-induced immunomodulatory effects. Particle and Fibre Toxicology 8, 8 (2011).

1.8. Monopoli et al. Nanobiotechnology: Nanoparticle coronas take shape. Nat. Nanotechnol. 6, 11 (2011)

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http://www.cdc.gov/niosh/blog/nsb082409_nano.html.

1.10. Lison et al. In vitro studies: ups and downs of cellular uptake. Nat. Nanotechnol. 6, 332 (2011)

2. Tissue engineering. Molecular and polymeric gels. Biomineralization. Scaffolds and cell growth. Importance of the 3D validation in materials for medicine. Application of materials in tissue regeneration.

2.1. "Introduction to biomaterials". Editor: Donglu Shi. Tsinghua University Press. World Scientific 2005

2.2 "Principles of Tissue Engineering". Edited by: Robert Lanza, Robert Langer and Joseph Vacanti. 2007 Elsevier Inc

2.3. "Biomaterials & scaffolds for tissue engineering" Fergal J. O'Brien Materials Today , Volume 14, Issue 3, March 2011, Pages 88-95 DOI: 10.1016/S1369-7021(11)70058-X

2.4. " Nanotechnological strategies for engineering complex tissues" Tal Dvir Brian, P. Timko Daniel, S. Kohane and Robert Langer, Nature Nanotec Doi: 10.1038/nnano.2010.246

2.5. "Nanotechnology for tissue engineering: Need, techniques and applications" Journal of pharmacy research 7 (2013) 200-204.

2.6. Influence of a three-dimensional, microarray environment on human cell culture in drug screening systems , L. Meli, E.T. Jordan, D.S Clark, R. J. Linhardt, J. S. Dordick, Biomaterials 2012, 33 (35), 90

2.7. From 3D cell culture to organs-on-chips, Dongeun Huh1, Geraldine A. Hamilton1 and Donald E. Ingber, Trends in Cell Biology December 2011, Vol. 21, No. 12

2.8. Bhatia, Sangeeta - Ingber, Donald - Microfluidic organs-on-chips - Nat Biotech32, 760-772 (2014) doi:10.1038/nbt.2989 - - http://dx.doi.org/10.1038/nbt.2989L3

2.9. 3D cell culture: a review of current approaches and techniques.MethodsMol Biol. 2011;695:1-15. doi: 10.1007/978-1-60761-984-0_1.

2.10. Scaffolds for tissue engineering and 3D cell culture. MethodsMol Biol. 2011;695:17-39. doi: 10.1007/978-1-60761-984-0_2.

3. Principles of drug delivery: Bioavailability. Concepts of encapsulation, drug delivery and targeting. Materials for the delivery: micelles, liposomes, nano-encapsulated organic and inorganic porous materials as drug carriers. Release of proteins and genes. Practical cases.

3.1. Patrick Couvreur1 and Christine Vauthier, Nanotechnology: Intelligent Design to Treat Complex Disease, Pharmaceutical Research, 2006, 23, 1417-1448

3.2. Rupa R. Sawant and Vladimir P. Torchilin, Liposomes as 'smart' pharmaceutical nanocarriers, Soft Matter, 2010, 6, 4026-4044

3.3. Duncan, R.; Nanoparticle therapeutics: an emerging treatment modality for cancer, Nature Rev. Drug. Discov. 2003, 2, 347

3.4. Frank Alexis, Eric M. Pridgen, Robert Langer, and Omid C. Farokhzad; Nanoparticle Technologies for Cancer Therapy; Drug Delivery, M. Schäfer-Korting (ed.); Handbook of Experimental Pharmacology 197, Springer-Verlag Berlin Heidelberg, 2010

3.5. Owen R. Davies, Andrew L. Lewis, Martin J. Whitaker, Hongyun Tai, Kevin M. Shakesheff b, Steven M. Howdle, Applications of supercritical CO2 in the fabrication of polymer systems for drug delivery and tissue engineering, Advanced Drug Delivery Reviews 2008 ,60, 373-387

Gene therapy:

3.6. Mastrobattista E, van der Aa MA, Hennink WE, Crommelin DJ. Artificial viruses: a nanotechnological approach to gene delivery. Nat Rev Drug Discov. 2006 Feb;5(2):115-21.

3.7. Medina-Kauwe LK, Xie J, Hamm-Alvarez S. Intracellular trafficking of nonviral vectors. Gene Ther.2 005 Dec;12(24):1734-51.

3.8. Riehemann K, Schneider SW, Luger TA, Godin B, Ferrari M, Fuchs H. Nanomedicine--challenge and perspectives. Angew Chem Int Ed Engl. 2009 48(5):872-897.

4. Principles of thermal therapies:

A-Fundamentals of hyperthermia (without nanomaterials) [4.1 - 4.12]

B- Magnetic hyperthermia & Photothermal therapy [4.13 - 4.14]

C- Examples of appropriate nanomaterials [4.15 - 4.19]

4.1. A. Jordan, in Hyperthermia in Cancer Treatment: A Primer, Springer US, 2006, p 60-63; DOI: 10.1007/978-0-387-33441-7.

4.2. J.Van der Zee et al. Int. J. Hypertherm.24 (2008) 111

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4.4. F. W. Hetzel and J.Mattiello "Interactions of hyperthermia with other modalities". In: Paliwal BR, Hetzel FW, and Dewhirst MW, eds. Medical Physics Monograph no. 16. Biological, Physical and clinical aspects of hyperthermia. Am Inst Phys, 1987: 30-56.

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4.6. P. Gabriele et al. "Hyperthermia alone in the treatment of recurrences of malignant tumors" Cancer 66 (1990) 2191-2195.

4.7. J. van der Zee et al. "Comparison of radiotherapy alone with radiotherapy plus hyperthermia in locally advanced pelvic tumours: a prospective, randomised, multicentre trial". The Lancet 355 (2000) 1119-25.

4.8. R. D. Issels et al. "Neo-adjuvant chemotherapy alone or with regional hyperthermia for localised high-risk soft-tissue sarcoma: a randomised phase 3 multicentre study" . The Lancet Oncology 11(2010) 561-70.

4.9. R. S. Benjamin. "Regional hyperthermia: new standard for soft-tissue sarcomas?" The Lancet Oncology 11(2010) 505.

4.10. S. A. Sapareto et al., "Effects of Hyperthermia on Survival and Progression of Chinese Ovary Cells" Cancer Res 38(1978) 393.

4.11. R. D. Issels, "Hyperthermia adds to chemotherapy" Eur. J. Cancer 44 (2008) 2546.

4.12. A. Bettaieb et al. , Hyperthermia: Cancer Treatment and Beyond in "Cancer Treatment - Conventional and Innovative Approaches", 2013.
http://www.intechopen.com/books/cancer-treatment-conventional-and-innovative-approaches/hyperthermia-canc

4.13. M. Colombo et al. "Biological applications of magnetic nanoparticles". Chemical Society Reviews 41 (2012) 4306.

4.14. I. K. Puri and R. Ganguly "Particle Transport in Therapèutic Magnetic Fields" Annu. Rev. Fluid Mech. 46 (2014) 407.

4.15. S. Link , M. A. El-Sayed J Phys Chem B 109 (2005) 10531; X. Huang et al. J Am Chem Soc 128 (2006) 2115.

4.16. K. Maier-Hauff et al. "Efficacy and safety of intratumoral thermotherapy using magnetic iron-oxide nanoparticles combined with external beam radiotherapy on patients with recurrent glioblastoma multiforme" Journal of Neuro-Oncology 103 (2011) 317.

4.17. L. Alexander et al. , "Ultra-Low Doses of Chirality Sorted (6,5) Carbon Nanotubes for Simultaneous Tumor Imaging and Photothermal Therapy" ACS Nano 7 (2013), 3644-3652.

4.18. J. Kolosnjaj-Tabi et al. "Heat-Generating Iron Oxide Nanocubes: Subtle "Destructurators" of the Tumoral Microenvironment"ACS Nano 8 (2014) 4268-4283.

4.19. M. Hembury et al. , "Gold-silica quantum rattles for multimodal imaging and therapy" PNAS 112 (2015) 1959.

5. Description of the necessary properties of nanomaterials for environmental remediation. Techniques based on photocatalysis, adsorption etc.

General:

5.1. Tania Dey,Nanotechnology for Water Purification. Brown Walker Press. 2012

5.2. T. E. Cloete, M. de Kwaadsteniet, M. Botes, J. M. López-Romero, Nanotechnology in Water Treatment Applications, Caister Academic Press, 2010, ISBN: 978-1-904455-66-0.

5.3. S. Bhattacharya, I. Saha, A. Mukhopadhyay, D. Chattopadhyay, U. Chand Ghosh and D.Chatterjee, Role of nanotechnology in water treatment and purification: Potential applications and implications, International Journal of Chemical Science and Technology 2013; 3(3): 59-64

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5.5. B. Karn, T. Kuiken, M. Otto, Nanotechnology and in Situ Remediation: A Review of the Benefits and Potential Risks, Environmental Health Perspectives 2009, 117(12), 1823-1831.

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Specific:

5.8. Manoj A. Lazar , Shaji Varghese, Santhosh S. Nair, Photocatalytic Water Treatment by Titanium Dioxide: Recent Updates, Catalysts 2012, 2, 572-601; doi:10.3390/catal2040572.

5.9. Xitong Liu, Mengshu Wang, Shujuan Zhang, Bingcai Pan, Application potential of carbon nanotubes in water treatment: A review, Journal of Environmental Sciences 2013, 25(7) 1263-1280

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