

**RADIOPHARMACY**

Updated in the last meeting of Department 24/06/2016



MODULE	SUBJECT	COURSE	SEMESTER	CREDITS	TYPE
Chemistry	Radiopharmacy	From 2nd	First	6	Optional
<b>PROFESSOR</b>			<b>FULL CONTACT ADDRESS FOR TUTORING</b>		
<ul style="list-style-type: none"> <li>Antonio Matilla Hernández</li> </ul>			Department of Inorganic Chemistry, 3rd floor, Faculty of Pharmacy. Email: amatilla@ugr.es, Tel: 958243854, Room: 288		
			<b>TUTORING HOURS</b>		
			TBD (See Department website).		
<b>DGREEE IN WHICH IS OFFERED</b>			<b>OTHER DEGREES IN WHICH THE SUBJECT COULD BE TAUGHT</b>		
Degree in Pharmacy			Nursing, Medicine, but these students would need to study an introductory unit on Coordination Chemistry, which can selectively provide the end of the first block of the course.		
<b>Prerequisites and / or recommendations (if applicable)</b>					
<ul style="list-style-type: none"> <li>Have adequate knowledge about: <ul style="list-style-type: none"> <li>Coordination Chemistry</li> <li>Spreadsheets and graphics software.</li> </ul> </li> </ul>					
<b>BRIEF DESCRIPTION OF CONTENTS (AS GRADE VERIFICATION REPORT)</b>					
<ul style="list-style-type: none"> <li>Section 1. - Radioactivity Basics. Calculations and equations. Radioprotection</li> <li>Section 2. - Radiopharmaceuticals in the EU. Properties. Chemical labeling reactions. Clinical indications. Preparation and control.</li> <li>Section 3. - Radioactive methods used in clinical analysis, RIA, IRMA and biomedical research.</li> </ul>					



## General and specific abilities

### General skills

- Identify, design, synthesize, analyze, control and produce drugs and medicines, and other products and raw materials of health interest of human or veterinary use.
- Learn to apply the scientific method and acquire skills in handling legislation, sources of information, literature, development of protocols and other aspects that are considered necessary for the design and critical assessment of preclinical and clinical trials.
- Design, prepare, deliver and dispense medications and other health products of interest.
- Design, implement and evaluate reagents, clinical analytical methods and techniques, knowing the basics of medical tests and the nature and content of the reports of laboratory diagnosis.
- Develop communication and information skills, both oral and written, to deal with patients and users of the center where play their work. Promote job capabilities and collaboration in multidisciplinary teams and other related healthcare professionals.
- Recognize your limitations and the need to maintain and update professional skills, with particular emphasis on self-learning of new knowledge based on scientific evidence.

### Specific skills

- Identify, design, synthesize, analyze and produce active ingredients, drugs and other products and materials of sanitary interest
- Select appropriate techniques and procedures in the design, implementation and evaluation of reagents, methods and analytical techniques.
- Perform standard laboratory procedures including the use of scientific equipment for synthesis and analysis, including appropriate instrumentation.
- Estimating the risks associated with the use of chemical and laboratory processes.

## OBJECTIVES (EXPRESSED AS EXPECTED RESULTS OF EDUCATION)

- Acquire basic knowledge about radioactivity and radiation protection calculations to allow safe use of radioactive preparation methods, quality control of radiopharmaceuticals, clinical analysis and biomedical research.
- Understand the concept of radiopharmaceutical. Know the radiopharmaceuticals in the EU. Knowing the chemical processes that occur during preparation (labeling). Knowing their clinical indications and the general protocols for preparation and quality control.
- Understand the principles of radioimmunoassay and its use in clinical analysis.
- Know the radioactive methods commonly used in biomedical research.

## DETAILED SYLLABUS



## THEORETICAL SYLLABUS:

### SECTION 1. Basic principles of radioactivity. Calculations and equations. Radioprotection

#### UNIT 1: Constitution of matter and radioactive emissions.

Elemental particles: leptons, quarks and carriers force. Transformations responsible for radioactive emissions. Electronic shield and radioactive emissions. Nuclear stability: neutron / proton ratio. Unstable nuclei: stabilization.

#### UNIT 2: Properties of radioactive emissions.

Features of radioactive decay: Characteristics of  $\alpha$ -decay, characteristics of  $\beta$ -decay (+/-), characteristics of  $\gamma$ -decay. Quantities and units used in radioactivity. Law of radioactive decay: decay constant, half-life, mean lifetime. Combined decays: decay of mixtures of radionuclides. Calculations and problems.

#### UNIT 3: Interaction of radiation with matter.

General aspects of the interaction of charged particles with matter. Interaction of  $\alpha$ -particles, mechanisms, penetration, self-absorption.  $\beta$ -particles interaction: mechanisms, penetration, braking radiation (Bremsstrahlung). Interaction of  $\gamma$ -radiation with matter: mechanisms penetration. Interaction of radiation with biological systems: chemical consequences of interaction, biological effects. Calculations and problems of penetration and shielding for different types of radiation.

#### UNIT 4: Detection and quantification of radiation.

Classification of detection systems. Gas ionization detectors: basis and types. Scintillation detectors. Solid scintillation: fundamentals, calibration. Liquid Scintillation: extinction, luminescence calibration. Semiconductor detectors: functioning and types. Thermoluminescence detectors. Photographic film detectors. Spectrometry.

#### UNIT 5: Introduction to radiation protection in radiopharmacy and health sciences.

Radioprotection: Definition. Irradiation and contamination. General safety rules for working with radioactive material. Radiation dosimetry, dose rates: absorbed dose, equivalent dose, dose rate and cumulative dose. Dose limits. Classification of working areas. Supervised area, signal label Controlled Area, signal label Limited permanence zone, signal label, Regulated permanence area, signal label. Prohibited access zone, i signal label. Commonly used equipment in radiation dosimetry. Updated review of the Spanish legislation on the protection of occupationally exposed to ionizing radiation workers.

### SECTION 2. Radiopharmaceuticals authorized in Spain. Properties. Clinical indications. Preparation and control.

#### UNIT 6: Radiopharmaceuticals.

Definition of radiopharmaceutical: Medicines Act. Characteristics of radiopharmaceutical. Tracers used in relation to their application. Applications of radiopharmaceuticals in Nuclear Medicine. Diagnostic imaging: SPECT scanning techniques, PET, PET-CT. In vivo diagnosis. In vitro diagnostic. Therapy. Radiopharmaceuticals authorized in Spain. Availability of radionuclides used in the preparation of radiopharmaceuticals.

#### UNIT 7: Availability of radionuclides for clinical use using generators

Principles of operation of the generator systems. Activities calculation. Separation procedures. Classification of chromatographic column generators. Advantages and disadvantages of each type. Major generating systems. Problems that generating system may present.

#### UNIT 8: $^{99}\text{Mo}$ / $^{99\text{m}}\text{Tc}$ Generator.

Principle of operation and construction.  $^{99}\text{Mo}$  extraction methods. Elution and performance. Eluted quality control: pH, absence of  $^{99}\text{Mo}$ . Absence of other radionuclides, absence of Al(III), Radiochemical purity. Calculations and problems on performance, availability of  $^{99\text{m}}\text{Tc}$  along the generator life, successive elutions, etc.



### UNIT 9: Technetium Radiopharmaceuticals

Tc Chemical Characteristics: chemical properties, oxidation states and stereochemistry. Coordination compounds. Tc radiopharmaceutical preparations: TcO<sub>4</sub><sup>-</sup> reduction. "Cold Kits": definition and composition. Tc radiopharmaceuticals authorized in Spain and diagnostic indications: Tc-albumin radiopharmaceuticals, radiopharmaceuticals for kidney scans, radiopharmaceuticals for brain scans, radiopharmaceuticals for bone scans, radiopharmaceuticals for heart scans, radiopharmaceuticals for cell markings. Other Tc Radiopharmaceuticals.

### UNIT 10: Radiopharmaceuticals of other radionuclides.

Iodine <sup>123</sup>I and <sup>131</sup>I radiopharmaceuticals, chemical properties of I, radiopharmaceuticals. Transition elements radiopharmaceuticals: <sup>51</sup>Cr radiopharmaceuticals, <sup>57</sup>Co radiopharmaceuticals, <sup>90</sup>Y radiopharmaceuticals. Post-Transition elements radiopharmaceuticals: <sup>67</sup>Ga radiopharmaceuticals, <sup>111</sup>In and <sup>201</sup>Tl. D-block elements radiopharmaceuticals: <sup>75</sup>Se radiopharmaceuticals, <sup>18</sup>F radiopharmaceuticals. Noble Gases radiopharmaceuticals: <sup>81m</sup>Kr and <sup>133</sup>Xe radiopharmaceuticals. Radiopharmaceuticals used in radiotherapy.

### UNIT 11: Radiopharmaceuticals prepared by cell labelling.

Leukocyte labeling Technetium (<sup>99m</sup>Tc-HMPAO exametazine), process and quality control. Platelet labeling with <sup>111</sup>In-oxine, process and quality control. In vitro labeling of red blood cells with <sup>51</sup>Cr, process and quality control. In vitro labeling of red blood cells with <sup>99m</sup>Tc, process and quality control.

### UNIT 12: Quality control of radiopharmaceuticals.

Quality control of labeled compounds: radionuclide purity control, chemical purity control, radiochemical purity control, efficiency labeling control. Quality control of radiopharmaceuticals, legal framework. Minimum frequency controls: radiopharmaceuticals ready for use, radiopharmaceuticals obtained from generators and radiopharmaceuticals reagents or equipment obtained from autologous samples, self-manufacturing, etc. Quality programs in Radiopharmacy Units.

## SECTION 3. Radioactive methods used in clinical analysis: RIA and IRMA. Techniques used in biomedical research.

### UNIT 13: Use of radioactive isotopes in medical biology and biomedical research.

Features to consider depending on their use: availability, half-life, type of radiation, radiation energy. Choosing the right radioisotope.

### UNIT 14: Use of radioactive isotopes in Clinical Analysis.

Radioimmunoassay RIA and IRMA. Principles, characteristics of the technique and sensitivity. General process sequence. Changes to the radioimmunoassay technique. Data processing and selection of the most appropriate calculation method, graphical representations. Reporting and validation of results. Other laboratory tests not based on immune reactions: Shilling test, <sup>14</sup>C-Urea test, etc.

### UNIT 15: Using radioactive research methods.

Frequent procedures. Considerations to select the appropriate technique. Choosing the right radioisotope for research. Methods for labeling molecules. Security measures and working with animals.

## PRACTICAL SYLLABUS:

### Seminars / Workshops

- Problems Seminars Lessons 1, 2 and 3: Notations, Activity calculations, Shielding calculations.
- Problems Seminar: <sup>99</sup>Mo/<sup>99m</sup>Tc generator. Calculation of yields and elution.

### Laboratory practices

- Working standards in radioisotope laboratory: Regulations of installation, signage, precautions and conduct rules. Management of dosimetry and radiation-protection equipment.
- GM camera response curve, calculating the optimal potential and efficiency of the system.
- Management account: counting statistics.
- Dosimetry, dose calculation and isodose charts.
- Generator <sup>99</sup>Mo/<sup>99m</sup>Tc. Management and controls elution.
- Quality control of radiopharmaceuticals (determination of radiochemical purity)



## BIBLIOGRAPHY

### FUNDAMENTAL BIBLIOGRAPHY:

#### RADIOACTIVITY

- J. Ortega and J. Aramburu Jorba Bisbal. (Eds), Las radiaciones ionizantes: su utilizacion y riesgos. Ediciones de la Universidad Politecnica de Cataluña (UPC). Volumen 1 (1994), Volumen 2 (1996).

#### MOLECULAR BIOLOGY radioisotopes and radioimmunoassay

- - A. J. Moss, G. V. Dalrymple, C. M. Boyd; Practical Radioimmunoassay; The C.V. Mosby Company, 1997, 158p., ISBN: 0-8016-3561-6
- - RF Boyer Modern experimental biochemistry, Addison-Wesley Publishing Co, Reading (Mass., USA), p.185-6, 1996.

#### RADIOPHARMACY

- Gopal B. Saha, Springer-Verlag, Fundamentals of Nuclear Pharmacy, 6th ed., 2010, ISBN: 978-1-4419-5860-0, DOI:10.1007/978-1-4419-5860-0
- C. A. Sampson (Ed.), Textbook of Radiopharmacy, Theory and Practice, Gordon and Breach Science Publishers, 1999.
- R.J. Kowalsky, S.V. Falen, American Pharmacists Association, Radiopharmaceuticals in Nuclear Pharmacy and Nuclear Medicine, 3th Ed., 2011, ISBN: 978-7-758212-118-5, [www.pharmacylibrary.com](http://www.pharmacylibrary.com)
- B.T. Smith, Pharmaceutical Press, Nuclear Pharmacy , 1 th. Ed., 2010, ISBN: 978-0-85369-866-1

### COMPLEMENTARY BIBLIOGRAPHY

- Guides radiopharmaceutical procedures of the Spanish Agency of Medicines, AEMPS (9 guides):  
<http://www.aemps.es/proffHumana/farmacopea/rfe/quias/home.htm>
- CIMA: Online information center AEMPS.
- [Manual for Nuclear Medicine examinations in nursing.](#)
- Spanish Pharmacopoeia 3th edition.
- 8<sup>th</sup>. Edition of European Pharmacopoeia.

### RECOMMENDED LINKS

- The Particle Adventure: <http://particleadventure.org/index.html>
- Spanish Drug Agency: <http://www.aemps.es>
- Positron Emission Tomography (PET): <http://estaticos.elmundo.es/elmundosalud/documentos/2008/05/pet/pet.swf>
- Radiopharmaceuticals authorized by the Spanish Agency of Medicinal and Sanitary Products, AEMPS (CIMA data base, ATC code Search: V09):  
<http://www.aemps.gob.es/cima/fichasTecnicas.do?metodo=detalleForm>

### TEACHING METHODOLOGY

- The student will have available a tutorial with all the information concerning the development of the subject, objectives, content and skills to develop. This information will be available through SWAD and identified through access on the website of the subject.
- Expositive classes where the teacher will promote the active participation of students with questions, comments, etc.
- Seminars on issues where practical questions will be solved.
- Promote attitudes for work group collaboration
- Practical classes in which will introduce students to the handling and use of radioactive material and preparation of radiopharmaceuticals.
- S.W.A.D. (Sistema Web de Apoyo a la Docencia: Web System Teaching Support).



## ACTIVITY PROGRAMME

First semester	Units	Presental activities					Not Presental activities		
		Classroom activities (hours)	Practical sessions (hours)	Problems seminars (hours)	Exams (hours)	Academic tutorials (hours)	Individual study and student work (hours)	Group work (hours)	Preparation Study and Practice.
Week 1	1	2	*	1			4		**
Week 2	2	2	*	1			4		**
Week 3	3	2	*	1			4		**
Week 4	4	2	*			1	4		**
Week 5	5	2	*	1	1.5		4		**
Week 6	6-7	2	*			1	4	5	**
Week 7	8-9	2	*	1			4		**
Week 8	9	2	*	1			4		**
Week 9	10	2	*	1			4		**
Week 10	11	2	*	1			4		**
Week 11	12	1	*	1			4		**
Week 12	13	1	*	1	1.5		4		**
Week 13	14	1	*			1	4	5	**
Week 14	14	1	*	1			4		**
Week 15	15	1	*			1	4	5	**
Week 16									
Week 17					2				
Week 18									
Total hours		25	15	11	5	4	60***	15	15

\* The practical sessions will be held for 5 consecutive days of 3 hours. The number of hours per semester has distributed 18 weeks, 15 plus 3 teaching exam, as indicated in Real Decreto 1125/2003, de 5 September, by which the European credit system and the system is set qualifications in the university degrees of official and valid throughout the national territory (BOE 224, of 18-09-2003)

\*\* 15 hours of study and preparation practices that will coincide with the completion of these are recorded.



\*\*\* The estimation and distribution of hours of study by the student's guidance, given the different preparation and capacity that can be individually.

#### SYSTEM FOR ASSESSING THE ACQUISITION OF THE COMPETENCES AND KNOWLEDGE

The evaluation will be based on the presentations and / or exhibitions of the work of theory and problems and examinations in which students must demonstrate the skills acquired.

Overcoming any of the tests will not be achieved without a uniform and balanced understanding of all matter.

SKILLS (Competences)	EVALUATION SYSTEM	% OF FINAL SCORE
CG3 CG13.	SE.1, SE.2 o SE.3	60%
CEM1.2 CEM1.3 CEM1.4	SE.10	20%
CG.3 CG.13	SE.15 SE.11 SE.12	20%

#### ADDITIONAL INFORMATION

##### INORGANIC CHEMISTRY DEPARTMENT: EXPERIENCE IN THIS FIELD OF SCIENCE.

Inorganic Chemistry Department has extensive experience in educational, research and practice in the field of radioactivity, has the installations and the right equipment for the use of radioactive isotopes in Radiochemistry, Environmental Sciences, Biomedical Research and Radiopharmacy. Since 1992 it is member of the Network of Spanish Environmental Monitoring (REVIRA Sampling Network Stations) and his staff performs sampling and analysis for Eastern Andalusia. Also since 2000 collaborates in the Radiological Independent Monitoring Plan of Cabril. Its radioactive laboratory was the first of our university authorized by the Nuclear Safety Council (CSN) in 1969. Currently its laboratories are legally integrated in Radioactive Units of the Sciences and Pharmacy Faculties, approved and supervised by the CSN, as required by law relating to the use of radioactive materials.

At its Unit in the Pharmacy Faculty, has a laboratory enabled the use of sealed radioactive sources authorized by CSN. Also, this lab has the adequate infrastructure for practices. (practice kits, shields, dosimeters, etc.). [Radiopharmacy Unit](#)

In relation to teaching, Inorganic Chemistry Department has adequately prepared teachers with the title of Radioactive Laboratories Supervisors approved by CSN, and teacher with a long history in the field of radioactivity degrees in Chemical, Environmental Sciences and Pharmacy. Specifically teaching Radionuclide the subject and its applications and Radiopharmacy in the Bachelor of Pharmacy since 1995. <http://www.ugr.es/~qinorgf/rn.html>

Professor of the Department, Dr. Antonio Matilla, launched Radiopharmacy Unit, Faculty of Pharmacy (<http://farmacia.ugr.es/cont.php?sec=8&paq=1> and <http://www.ugr.es/~radiofar/>) participated in its design and in the committees of the Ministry of Education for the purchase of scientific equipment. Is its director since its formal establishment in 1997. Since then the Unit collaborates in working with radioactive isotopes with different University departments, not only with radioactive measurements but also collaborating in the experiments planning. (Ecology Department, Animal Biology Department, Biochemistry Department, etc.). Prof. Matilla was director of Radiopharmaceutical Sciences Master's degree taught at our University (1996-1997), director of the Training Course for Supervisors Radioactive Facilities approved by the CSN and integrated into this Master. He is also Professor of Clinical Analysis School of the University (<http://www.ugr.es/~faclinil/main.html>) and teaches the Radioimmunoassay module within the Masters in Biological Analysis and Laboratory Diagnostics, and has taught the subject of Radionuclides And Their Applications from the academic course 2003-04. Currently also, he teaches Radiopharmacy in the Degree of Pharmacy.

