Training on Radioisotopes Techniques and Radioprotection Aspects at The School of Pharmacy and Biochemistry of the Buenos Aires University (Argentina).

R. M. Bergoc [(1)], E.S. Rivera [(1)], A. M. Bomben [(2)].

[(1)] Radioisotopes Laboratory, School of Pharmacy and Biochemistry, Buenos Aires University, 956 Junín St., 1113-Buenos Aires, ARGENTINA. [(2)] Nuclear Regulatory Authority, 8250 Libertador Ave., 1429-Buenos Aires, ARGENTINA. rmbergoc@ffyb.uba.ar / abomben@sede.arn.gov.ar

Abstract. The use of ionizing radiation sources and radioisotopes in Argentina takes place at more than 1700 facilities, which operate in Nuclear Medicine, in telecobaltherapy, in Industry, in Biochemistry, and in research. All of these centers have one or more professional trained in the specific field of radioprotection and they have been authorized by the Nuclear Regulatory Authority. At the School of Pharmacy and Biochemistry of the Buenos Aires University, Argentina, we consider of great interest to teach radioisotopes methodology at different levels, to harmonize the use of these methodologies with environmental preservation and to provide education and training on radioprotection. Currently, the school offers five different courses in all of which the radioprotection is one of the most important subjects: 1) Course on Methodology of Radioisotopes for students at the undergraduate level, in the Biochemistry Career (140 hrs). Since 1960, more than 6000 students have passed their examinations. 2) Course on Methodology of Radioisotopes for post-Graduates in Biochemistry, Biology, Chemists or other related disciplines. 3) Course for Graduates in Medicine. Since 1962, the School delivers every year these two courses. Their syllabus (212 hrs) dedicates a 50% of the time schedule to subjects related to radioprotection aspects. More than 1800 professional have passed their examinations, many of them from different Latin American countries. 4) Up-date on Methodology of Radioisotopes (100 hrs) a course delivered since 1992 for professionals wishing to up-date their knowledge. 5) Course for Technicians in Nuclear Medicine (more than 200 hrs). At present, this course is the basic level of the Technicians in Nuclear Medicine Career. At the present paper it will be presented statistics regarding the different courses and the experience that has been gathered for the last 40 years organizing courses and carrying out research activity on radiobiology, radioimmunoanalysis, radioreceptors and radiopharmacy.

1. Introduction. The application of the techniques employing radioisotopes to cellular and molecular biology, biochemistry and pharmacology for the last 50 years is one of the reasons that explains the notorious advance in these sciences. These techniques have found a field of study particularly promising in the metabolism and biodistribution of pharmaceutical drugs, pharmacodynamy, etc. Besides, radioisotopes and radiation are frequently employed in medicine for diagnosis as well as for therapy of malignant and non-malignant diseases. Radiopharmaceutical and radiations of different types are extensively used for therapeutic protocols. Moreover, radiometric techniques are a methodology routinely employed in human endocrinology and general clinic and, also, in veterinary and agriculture; receptor characterization by radiometric techniques is very important in basic and clinical investigations and their quantification has clinical use in pharmacology and in medicine. Therefore, the importance of the training in different methodologies for the use of radioisotopes has also been growing noticeably.

Early in the 1960s the School of Pharmacy and Biochemistry of the University of Buenos Aires introduced as an optional course the subject Physic III, which provided students with the basis of radioactivity. This Course was given at the Radioisotopes Laboratory and, very soon, it became apparent both for teachers and students that, owing to the growing use of this methodology, this subject should be compulsory for all the biochemistry students. Hence it was added to the syllabus of the Biochemistry Career.

As a result of the researches performed in our Laboratory employing radioisotope techniques and their use in many fields, it has been evident that it is essential for biomedicine graduates to be able to manage radioactive materials prudently and safely.

Thus, the School currently offers five different Courses on Radioisotopes Methodology in which Radiological Protection is focused from different points of view according to the students background, but always as a fundamental subject; the courses are: 1) Course on Methodology of Radioisotopes for undergraduate Biochemistry students; 2) Course on Methodology of Radioisotopes for Biochemistry,

Biology, Chemists (and other related disciplines) post-Graduates; 3) Course for Medicine post-Graduates; 4) Up-date on Methodology of Radioisotopes; 5) Course for Nuclear Medicine Technicians.

The objective of the present paper is to provide a description of the scope and structure of these courses as well as the goals achieved.

2. Organization of the Courses and Results.

2.1. Undergraduate Course.

This Course started in 1960 as a part of the general subject Physic. It provided students with the basic knowledge on radioactivity and measurement techniques and, owing to changes in the Biochemistry Career syllabus, it became first an optional subject called Radiochemistry and, later, a compulsory one called Radioisotopes Methodology.

The Course is given at the Radioisotope Laboratory of the School of Pharmacy and Biochemistry, University of Buenos Aires, and the students attend to a 140 hour (84 hours of theory and 56 hours of practical work). The theoretical syllabus of the course includes a first part of basic and general concepts and a second part with all the specific applications of radioisotopes to biochemistry. The practical syllabus is focused on the basic and general aspects of radioisotopes but emphasizing those that are of specific significance to biochemistry, both in hospitals and in research, as this will be the students' future working field.

Besides, the objective of the training in radioprotection at undergraduate level in Biochemistry is to give guidelines for the adequate application of radioactive materials and the radioprotection philosophy, with special emphasis on biochemical-clinical practices and on radioisotope techniques utilized in different research areas. Students tend either to neglect or to enhance radiological risks associated with the work with radioisotopes due to lack of knowledge. In this sense, students are led to acquire adequate criteria by the analysis of different practical situations.

One of the most common practices with radioisotopes in Argentina at biochemical level for the diagnosis of different diseases is the labeling of molecules with ^{125}I and their utilization on different radiometric assays. Then, we analyze the decay scheme of ^{125}I and give the calculus of estimate dosimetry for workers in different operational situations as radiolabeled of proteins and radiometric assays.

Up to the present, more than 6200 students have been trained in our classrooms (Figure 1).

2.2. Course on Methodology of Radioisotopes for post-Graduates in Biomedicine.

The Course on Methodology of Radioisotopes for Biomedicine post-Graduates began in 1962.

The basic syllabus includes: Nuclear stability. Binding Energy. Nuclear models. Radioactive decay mechanisms and kinetic equations. Particles and radiation interaction mechanisms. Instrumentation: ionization chamber, proportional counters, Geiger-Müller tubes, mono and bidimensional radiochromatograph analyzers, solid and liquid scintillation spectrometry, solid state detectors, radioautography, activity determination. Detection efficiency. Statistics of radioactivity measurements. The specific syllabus includes: Production of radioisotopes and radiopharmaceutical materials. Purity control criteria. Activation analysis. Biochemical applications of radioisotopes. Radiometry: radioimmunoassay and radioreceptor characterization and determination.

The training in Radiological Protection is theoretical and practical. It encompasses the study of the general principles of radioprotection, quantities, dosimetric units, internal and external dosimetry of nuclides for diagnosis and therapy, with the needed amplitude according to each specialty, barriers to

avoid contamination, shielding, management of radioactive wastes, national and international legislations.

This Course has been designed to enable graduates in biomedicine to:
- Acquire criteria for the adequate application of the radioprotection philosophy, independently of the previous university training the graduates attending the course have, emphasizing the importance of this practice as well as the potential environmental impact that it may have,
- Planning professional practices with an adequate training of the personnel involved in order to keep the doses as low as it is reasonably possible (ALARA principle),
- Adequate the procedures taking into account the elements to be utilized.

Graduates attend 122 hours of theory and 100 hours of practice. They have to pass two partial examinations and a final one, this allows them to apply to the Argentine Nuclear Regulatory Authority for permission to use radioactive materials.

2.3. Course on Methodology of Radioisotopes for post-Graduates in Medicine.

This Course began simultaneously to the Course for post-Graduates in Biomedicine, in 1962. It shares many characteristics with the latter regarding its organization and contents. Graduates have 122 hours of theory and 100 hours of practice (divided in 20 classes of 5 h. each), and take two partial examinations and a final one.

The basic syllabus includes similar subjects than course 2). The specific syllabus includes: Production of radioisotopes and radiopharmaceutical materials. Purity control criteria. Notions of biochemical applications of radioisotopes as radioimmunoassay and radioreceptor determination. Medical applications of radioisotopes and radiations: radioisotopes and images. Radiopharmaceuticals for diagnosis. Radiopharmaceuticals for treatment. National and international regulations. Radiopharmaceuticals for endocrinology, cardiology, lungs, G.I, kidney and urinary system, hematology, lymphatic system, C.N.S. Radiopharmaceutical employed in Pediatric. Radioisotopes for oncological studies. Radiopharmaceutical for metabolic therapy: basics, different radioisotopes. Therapeutic procedures. Radioisotopes by accelerator. Instrumentation in Nuclear Medicine. Scintillography. Gamma chamber. SPECT. PET. Collimators. Sensitivity and Resolution. Computation in Nuclear Medicine. Image Interpretation. Phantoms. Quality control.

The training in Radiological Protection comprises: Dose; Effective Dose; Equivalent Dose; Collective Equivalent Dose; Compromised Equivalent Dose; Environmental and Directional Equivalent Dose; Kerma; Dose Rate, in all the cases with their correspondent magnitude and unities. Internal and External sources. Shielding. General aspects of Radioprotection: dose justification, optimization and limitation. Biological effects of ionizing radiations. Radiobiology. Working areas classification. Occupational radiological protection. Internal and external contamination. Monitoring. Instrumentation in radioprotection. Management of wastes produced by the practices with radioactive material, with special emphasis in those produced by the medical and biomedical practices. Norms, recommendations and national and international regulations. Transportation regulations for radioactive materials. International and Argentine regulations for the use of radioactive materials. The safety culture.

The practical training makes special emphasis in the:
- Acquisition of criteria for the adequate application of the radioprotection philosophy,
- Planning of professional practices with an adequate training of the personnel involved in order to keep the doses as low as it is reasonably possible (ALARA principle),
- Adequation of the procedures taking into account: elements to be utilized, techniques, time required for the practice, radiological risks for patients and other workers.
- Internal dosimetric calculus, including MIRD methodology.
- External dosimetry.

As Radiological Protection is a key aspect of the Courses 2 and 3), 30% of the theoretical classes and 40% of the practices are devoted to its teaching. The first practice is totally dedicated to the basic principles of radiological protection: justification, optimization of practices and dose limitation. It is explained and analyzed how to work minimizing risks, and concepts that will be developed in each subsequent practice, when the graduates work with radioisotopes of frequent use. Each practice is specifically designed for a particular theme and provides graduates attending the Courses with the tools and skills necessary to successfully manage similar situations in their professional lives. For example, to perform and/or control procedure for decontamination, simple internal and external dosimetry and shielding calculus, etc.

At the end of the Course, to pass the final examination -open-book type- it is essential to plan and carry out an experiment employing radioisotopes, taking into account, very particularly, the radioprotection organization. The basic idea of this approach is to consider that any one who has done this Course and is consequently authorized by the Argentine Nuclear Regulatory Authority must be able to resolve the Radiological Protection matters arising in their respective laboratories, being it for medical applications (Nuclear Medicine) or biomedical (Radiopharmacy, Protein labeling, Radioreceptor determination, Radioinmunoanalysis, Radiopharmacodinamy, others.)

In total, more than 1900 graduates have attended Courses 2) and 3) from all over Argentina and from different Latin American countries as Uruguay, Chile, Peru, Bolivia, Venezuela, Mexico, and have passed their examinations.

The fluctuation in the proportion of graduates from different careers attending Courses is a sensible mirror of the labor demand in Argentina. In the 1970s, the introduction of radioimmunoassay in the biochemist diagnose made a great number of biochemists train in that technology. Early in the 1980s an important surge in the medical application of radioisotopes made the proportion of physicians attending the Courses rise. In the same way the need of biologists able to set-up molecular biology in diagnostic laboratories increased their attendance to the Courses. An important trend for the application of radiopharmaceutical in equines, which practically is a non-exploited field till present in Argentine, is arising, as well as a greater application in the agronomic area as consequence of the current economic situation (Figure 2).

2.4. Up-date on Methodology of Radioisotopes.

This Course has been given since 1992 and provides graduates the opportunity to up-date not only the general and specific knowledge on methodology techniques with radioisotopes but also this concerning their professional activities. The Course is divided in modules. The Radioprotection module is mandatory and encompasses around 50% of the total time-load.

Up to now many graduates from different biomedical areas have taken this Course at our Laboratory.

2.5. Technicians in Nuclear Medicine.

For thirty-five years technicians attended the Course simultaneously with the Graduates, although some specific items were covered separately.
In 1997 an special Course for technicians was started. It is given at the Radioisotopes Laboratory of the School of Pharmacy and Biochemistry, and is applied at Nuclear Medicine centers.

This Course was the basis for the Technicians in Nuclear Medicine Career and, from 2003, it is called the Superior Technologist in Nuclear Medicine Career. The basic knowledge of this new career is given at our Laboratory and its application is impaired at approved Nuclear Medicine Centers of Buenos Aires; in total, students must attend 2000 hours of theoretical and practice sessions. The objective is to provide knowledge with the focus on specific practices they will fulfill once graduated in this career.

Our experience is that it is extremely important the acquisition of the knowledge on radiological protection needed by this population occupationally exposed by their tasks in radiopharmaceutical, fractioning of radioactive materials, etc., and that they must be adequately trained for it.

However, the need of professional technical assistance in Nuclear Medicine Services has led to the setting of an Interdisciplinary Commission at Ministerial level with the objective to create the Superior Technologist in Nuclear Medicine Career. Our Laboratory has actively participated in the creation of this career, whose incumbencies, minimal contents, time-load, jurisdiction areas, matriculation, etc., have been extensively analyzed by the Interdisciplinary Commission. The Commission is formed by members of the Argentine National Regulatory Authority, Argentine Association of Technicians in Nuclear Medicine and Argentine Association of Biology and Nuclear Medicine. As of this year our Laboratory offers students the possibility of following this Career at our premises

3. Conclusions.

The use of radioisotopes and radiations in different professional activities is currently a common practice in research and applications, in special in the biomedical field. However, these activities are acceptable only in a context of radiological safety, with personal appropriately trained and with full awareness of the need of harmonizing these tasks with the environmental preservation. The Courses described in this paper have been conceived and organized with these purposes in mind, and a background of more than 40 years of constant teaching and up-dating in the thematic area. The students must show to have the conceptual clarity and theoretical/practical fitness needed for the safe and efficient manipulation of radioactive tools in their respective field to pass the final exams. The results are amply satisfactory: more than 95% of the applicants have succeeded in their exams at their respective levels.

We think that the experience in our Laboratory, the only one of its kind in the University of Buenos Aires with more than 40 years of experiences in research and teaching this topic, a teaching staff of more than 20 professors, most of them with the maximum academic degree given by the University of Buenos Aires (Ph.D.), and the participation of specialists from the National Nuclear Regulatory Authority, the Nuclear Medicine, and others, allow us to offer a level of excellence to those who take some of our courses. Since 1975 Pharmacy students have also been taught some elemental notions of radioactivity in the Physics syllabus at our Department. Our present goal is the preparation of the syllabus of a new subject that we considered indispensable, Radiopharmacy, to be offered in the Pharmacy cycle.

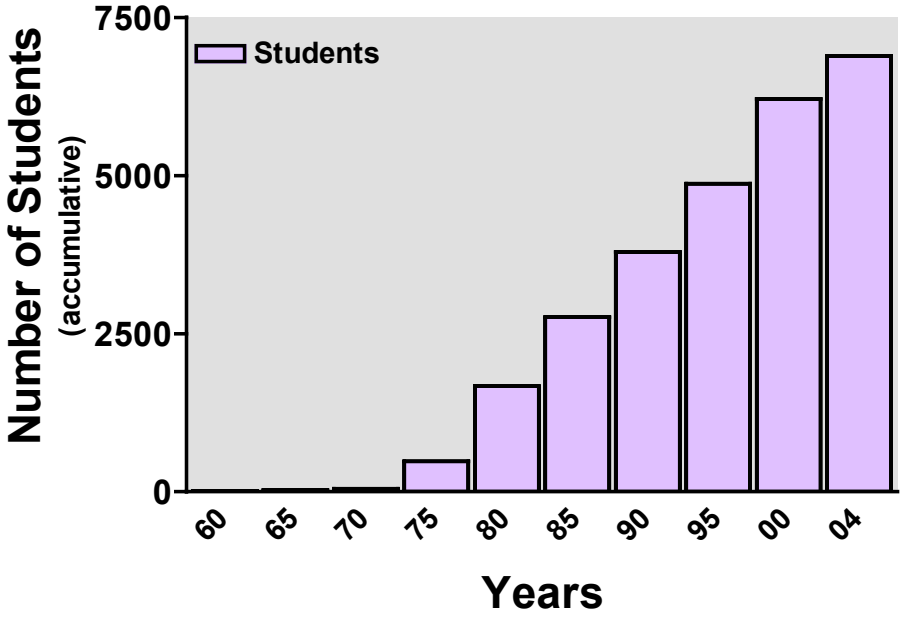

FIG 1. Undergraduate Course. Number of students per quinquennium (accumulated).

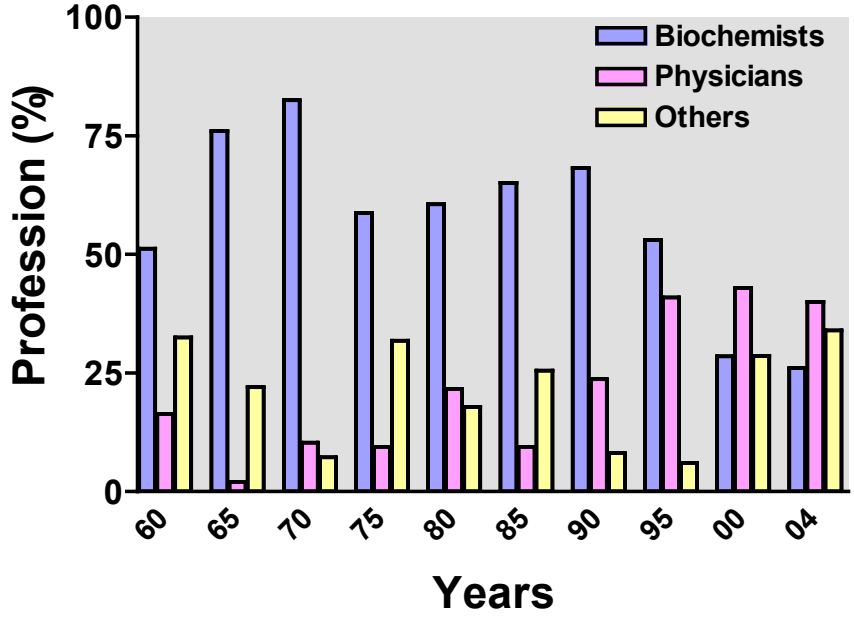

FIG 2. Post-graduate Courses. Percentage of professionals per quinquennium.

References

1. Dutreix, J., Desgrez, A., Bok, B., Chevalier, C. *Física y Biofísica: radiaciones*. Edited by AC, Madrid, (1980).
2. Sprawls, P., Jr. *Physical Principles of Medical Imaging*. P. Aspen Publishers Inc., Maryland, USA, (1987).
3. Tubiana, M., Dutrieux, J., Wambersie A. *Introduction to Radiobiology*. Edited by Taylor & Francis, London, New York, Philadelphia, (1990).
4. Annals of the ICRP. Published on behalf of the International Commission of Radiological Protection, (1989-1993)
5. Statkiewicz-Sherer, M. A., Visconti, P. J., Ritenour, E. R. *Radiation Protection in Medical Radiography*. Mosby Inc. St. Louis, Missouri, (1998).
6. ElBaradei, M., IAEA. Edited by Micharl F. L´Annunziata, (1998).
7. Saha, G. *Fundamentals of Nuclear Pharmacy*, Pringer-Verlag, New York, (1998).

Corresponding author: Prof. R.M. Bergoc, Radioisotopes Laboratory, Faculty of Pharmacy and Biochemistry, Junin 956 St.-1113 Buenos Aires, ARGENTINA.
Fax: +54 (11) 4 964 8204; Tel: +54 (11) 4 964 8277
E-mail: rmbergoc@ffyb.uba rmbergoc@arnet.com.ar

Keywords: capacitation, radiological protection, post-grade, technicians, biomedicine, nuclear medicine.

*Radioisotopes Laboratory, School of Pharmacy and Biochemistry, University of Buenos Aires, Buenos Aires (Argentina). * *Argentine NationalNuclear Regulatory Authority, Buenos Aires (Argentina). (Received October 4,1995).Â The training in radioprotection throughout the whole program is oriented to consolidate the general knowledge on the subject, independently from the previous universilary formation. We stress also the importance and differentiate the applications to biochemistry, principally those concerning the use of 125-1, as well as to nuclear medicine fundamentally through the utilisation of 99m-Tc generators.
@inproceedings{Bergoc2004TrainingOR, title={Training on Radioisotopes Techniques and Radioprotection Aspects at the School of Pharmacy and Biochemistry of the Buenos Aires University (Argentina)}, author={Rosa M. Bergoc and Ernesto S. Rivera}, year={2004} }. Rosa M. Bergoc, Ernesto S. Rivera. Published 2004. Medicine. The use of ionizing radiation sources and radioisotopes in Argentina takes place at more than 1700 facilities, which operate in Nuclear Medicine, in telecobaltherapy, in Industry, in Biochemistry, and in research. All of these centers have one or more professional trained in the Research activities are focussed on a greater understanding of the molecular interactions and development of unique genetic therapies that can be applied for the detection and treatment of highly aggressive metastatic disease. Nano-delivery of macromolecules. Professor Helen McCarthy. Dr Jonathan Coulter. Dr Wafa Al-Jamal. Research activities are focussed on the design and synthesis of nanotechnologies as local and systemic delivery systems for DNA, RNAi, miRNA, and Au nanoparticle therapies. Proteases in Disease. Professor Lorraine Martin.