RADIOISOTOPE METHODOLOGY COURSE. RADIOPROTECTION ASPECTS.

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INTRODUCTION

The advancement of knowledge in molecular and cell biology, biochemistry, medicine and pharmacology, which has taken place during the last 50 years, after World War II finalization, is really outstanding. It can be safely said that this fact is principally due to the application of radioisotope techniques. The research on metabolisms, biodistribution of pharmaceuticals, pharmacodynamics, etc., is mostly carried out by means of techniques employing radioactive materials. Radioisotopes and radiation are frequently used in medicine both as diagnostic and therapeutic tools. The radioimmunoanalysis is today a routine method in endocrinology and in general clinical medicine. The receptor determination and characterisation is a steadily growing methodology used in clinical biochemistry, pharmacology and medicine. The use of radiopharmaceuticals and radiation of different origins, for therapeutic purposes, should not be overlooked.

For these reasons, the importance to teach radioisotope methodology is steadily growing. This is principally the case for specialisation at the post-graduate level but at the pre graduate curriculum it is worthwhile to give some elementary theoretical and practical notions on this subject. These observations are justified by a more than 30 years teaching experience at both levels at the School of Pharmacy and Biochemistry of the University of Buenos Aires, Argentina. In 1960 we began to teach Physics III, an obligatory pre graduate course for biochemistry students, in which some elementary notions of radioactivity and measurement techniques were given. Successive modifications of the biochemistry pre graduate curriculum incorporated Radiochemistry as an elective subject and since 1978, Radioisotope Methodology, as obligatory subject for biochemistry students. This subject is given at the Radioisotope Laboratory during the first semester of each year and its objective is to provide theoretical and practical knowledge to the biochemistry students, even though this knowledge does not imply any possibility to obtain a license to work with radioactive material. Pharmacy students receive since 1975 some very elementary notions of radioactivity in the Physics courses in the same Department and some notions of Radiopharmacy are given in Pharmaceutical Technology.

Since 1962 we are giving every year during a complete semester in the second half of the year, at the same Radioisotope Laboratory of the School of Pharmacy and Biochemistry, the Radioisotope Methodology Course for professionals mostly engaged in the health area. Its objective is to provide a throughout theoretical and practical knowledge for the utilisation of radioactive materials in different disciplines, particularly those related to health. The experience obtained in this course is sufficient to obtain a license from the National Regulatory Authority to manipulate radioactive material "*in vitro*".

COURSE ORGANISATION

The teaching experience acquired during successive courses given since 1962, allowed us to define a well settled complete theoretical and practical program embodying 222 training hours, 122 being theoretical and the remaining 100 are personal and intensive experimental work. It should be added that each graduate has to study for each practical activity and make a report of the obtained results; this activity is not taken into account in the foregoing chronogram. In order to estimate the degree of knowledge, the practical activities are evaluated; we take two partial examinations and a final, written and oral examination. Radioprotection aspects have a relative weighting in the evaluations of approximately 50 per cent.The program includes a first part of basic and general concepts. In the second part all the specific applications of radioisotopes to the biomedical area are included and as new methodologies appear they are incorporated. The titles of each chapter of the program are:

Nuclear stability. Binding Energy. Nuclear models. Radioactive decay mechanisms and kinetic equations. Particles and radiation interaction mechanisms. Instrumentation: ionisation chamber, proportional counters, Geiger-Müller tubes, mono and bidimensional radiochromatogram analysers, solid and liquid scintillation spectrometry, solid state detectors, radioautography (whole sample, histology, cellular), absolute activity determination. Detection efficiency. Statistics in the radioactivity measurements. Production of radioisotopes and radiopharmaceuticals. Purity control and criteria. Activation analysis. Biochemical

applications of radioisotopes: radioimmunoanalysis, receptors, radioautography, precursors and others. Medical applications: image diagnosis and radiopharmaceuticals. Radiotherapy: internal and external. Notions.

Since the objective of this paper is radioprotection, we shall analyse these points of the program with more detail. Radioprotection is one of the most important chapters of the course, since it is our experience that professionals having passed the final examination frequently will be responsible for the radioprotection aspects in his/hers work place. We emphasise from the very beginning that a throughout knowledge of radioprotection is essential for a good professional practice. The theoretical subjects are approximately a 30 per cent of the classes and include:

Definitions, magnitudes and units of: dose, dose equivalent, collective dose equivalent, committed dose equivalent, exposure and their respective rates. Internal and external sources. Shielding. General aspects of radioprotection: justification, optimisation and dose limitation. Biological effects of ionising radiation. Radiobiology. Classification of working areas. Occupational radiological protection. Internal and external contamination. Monitoring. Instruments for radioprotection. Regulation for the transportation of radioactive materials. Regulations for the utilisation of radioactive material in Argentina.

Even though the specific practical activity related to this chapter is only a 10 per cent of the total practical training, in all these activities radioprotection regulations are taken into account and discussed permanently with the graduate students. Specifically in the first practical work the rules to work safely with radioisotopes are given and discussed with the trainees and afterwards problems and shielding calculations are carried out. At the end of the course a substantial part of the final examination is the planning of an experiment with radioisotopes, taking into account radioprotection regulations as well as all the other knowledge throughout the course. The main idea of stressing the importance of radioprotection considerations is to take for granted that, at least in principle, any professional having passed the final examination and consequently licensed by the Regulatory Authority, should be capable to act as security officer.

The objective of the training in radioprotection consists in the acquisition of criteria for the adequate application of the radioprotection *philosophy*, independently on the previous university training of the graduate students participating in the course. The global synthesis include:

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 and *calculation* of the doses absorbed by the personnel during the practices. At the same time we emphasise those aspects related to the specific future activities of the graduates assisting to the course, principally ^{125}I for biochemists mainly interested in radioimmunoanalysis. In the case of physicians interested in future radioisotope applications to their profession, ^{99m}Tc is the mostly used radionuclide in Argentina. Even as its Γ value is 0.08 Rm^2/hCi, quite similar to that of ^{125}I, in the ^{99m}Tc case activities of 0.5 to 1 Ci are used, which obviously increase the dose due to irradiation.

RESULTS

Since the beginning of the course until 1995, a total of 1106 professionals have passed their examinations. It should be mentioned that the graduates are chosen not only taking into account their academic profiles but also considering the necessity of their respective working places to have well trained personnel in radioisotope techniques. We receive mainly biochemists, physicians, chemists, biologists, engineers, pharmacists and others. In the Figure 1 we show the proportion of the main professions in periods of five years as a function of time. The preponderance of biochemists and physicians is evident. Another interesting point to be noted is the increasing tendency of the number of professionals as a function of time. In the last years the number of physicians is growing steadily. This is due to the increasing expansion of medical diagnosis with radioisotopes, principally in cardiology.

The participating professionals live principally (88 per cent) in Buenos Aires and its surroundings. In the last few years the proportion of graduates from the provinces is increasing. This fact should be due to a growing interest in smaller cities to have, at least, certain minimal radioisotope using health care practices, both in medicine and biochemistry. During these years 10 professionals from different Latin-American countries (Peru, Venezuela, Colombia, Brazil and Uruguay) have passed their examinations.

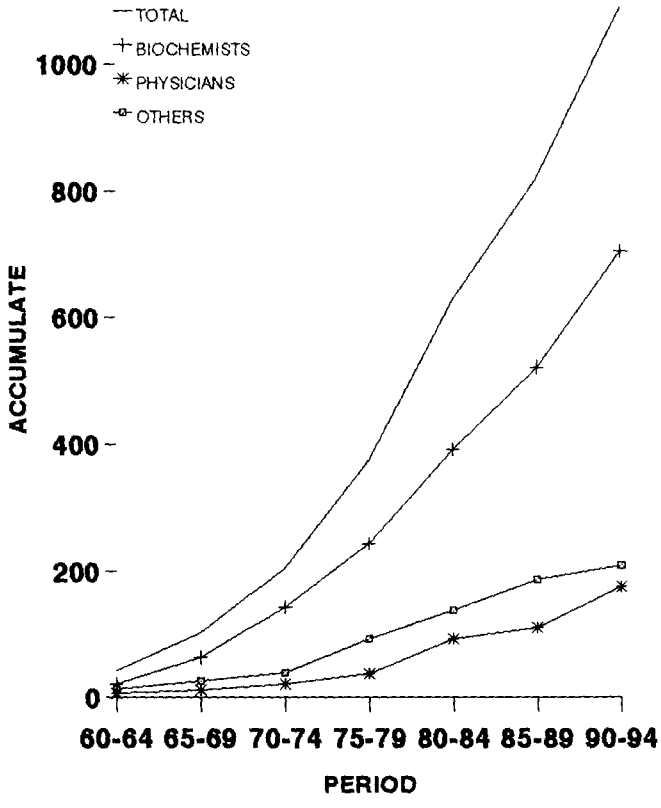

Fig. 1.- Number of professionals trained from 1960 to 1994.

CONCLUSIONS.

The application of radioisotopes and radiation to different professional activities is already a common practice in modern science and technology. However, these activities are only possible in a framework of radiological safety, if adequately trained personnel is employed. The course we describe in the present paper is organised and conceived with this purpose in mind, with a background of more than 30 years of permanent and actualised teaching activity.