Study Tour in the USSR

From August 23 to September 13 a study tour was held in the USSR on the subject of Radiation Dosimetry in Medicine and Biology, at the invitation of the State Committee on the Utilization of Atomic Energy of the Soviet Union. Twenty-eight scientists from 28 developing countries – medical doctors, physicists and biologists – participated in the tour. The group visited 12 institutes in 5 towns, namely Moscow, Pushino, Leningrad, Tashkent and Kiev. The study tour was organized by the IAEA Division of Technical Assistance and the Dosimetry Section of the Division of Life Sciences.

The group was received everywhere with warm hospitality, and their extensive tour programme was highlighted by well organized lectures and lively discussions.

MOSCOW

The Tour started at the Medical Radiology Chair of the Central Institute of Advanced Training of Physicians in Moscow where the participants were welcomed by Mr. Afonin, Head of the State Committee for the Utilization of Atomic Energy, and by Prof. Kasatkin,

The use of ionizing radiation in the fields of medical diagnosis and radiotherapy has developed to a most powerful tool in practical medicine. Many thousands of cancer patients are treated every day in the numerous radiation therapy departments all over the world, and they trust that the methods applied are the best available. The high level of radiotherapy reflected in the remarkably increased rate of cures is to a large extent based on recent achievements in radiobiological research and in dosimetry. This research is necessary for an understanding of the mechanisms of the radiation effect. Detailed knowledge of the mechanisms involved in the chain of events starting with the physical absorption process in an atom or molecule of a cell and ending at a particular radiation effect enables the radiotherapist to determine not only the appropriate total dose, but also a proper timing (fractionation) schedule. Dosimetry, in this context, means the accurate pre-determination of the dose delivered and the often very complex pattern of the dose distribution within the patient's body. Modern optimization methods in treatment planning help the hospital physicist to ensure that the tumour volume be irradiated under optimum conditions, i.e. in such a way that the radiation exposure of the surrounding, healthy tissue be kept to a minimum. The use of computers considerably facilitates the design of complex treatment plans.

Chief of the Medical Radiology Chair. Professor Kasatkin in his opening lecture gave an excellent survey on the organization of the Institute and its main lines of activity, which covers the whole field of nuclear medicine (training, research and clinical applications, *in-vitro* and *in-vivo* studies), treatment of malignant tumours and the radiation safety of patients, personnel and the population. The importance of early diagnosis and the good results of combined therapy (external radiation combined with

chemotherapy and surgery) were emphasized. The Institute, with 80 chairs and 75 laboratories, is very well staffed and equipped. Advanced equipment has been developed at the Institute itself, e.g. the AGAT-B, a suitable instrument for the remote-control gynaecological after-loading therapy, using a pneumatic device.

At the Oncology Research Institute the participants of the Study Tour were mainly attracted by the Institute's activities in the field of proton therapy. In his lecture Prof. Goldin (ITEP) pointed out that the utilization of proton beams in the USSR for medical and biological purposes takes place in two institutes, the Laboratory of Nuclear Problems (JINR), Dubna, and the Institute for Theoretical and Experimental Physics of the State Committee on the Utilization of Atomic Energy (ITEP), Moscow. The accelerator at JINR provides protons with energies of between 90 and 200 MeV (initial energy 680 MeV). The beam consists of pulses, 160 μs long and separated by 8 ms intervals. The beam intensity is $9 \cdot 10^8$ protons per second, the dose rate in the Bragg-peak is 200 rads/min. The ITEP clinical proton beam with energy of up to 200 MeV is extracted from the 7.2 GeV ITEP strong-focusing proton synchroton which has been previously used for physical experiments only. Its external beam intensity reaches 10^{11} protons per pulse with 4 μs intervals between pulses. The dose rate is several thousand rads/min. Proton beam intensity during irradiation is measured by a current monitor. Dose field distributions were studied by TLD and by photographic methods. More than 200 patients with cancer of the lung, esophagus, tongue, cervix and uterus were treated with protons. It is, however, too early yet for a comparative assessment of the cure rate achieved with protons as against conventional radiation types.

PUSHINO

A visit was paid to the Biophysics Research Institute of the USSR Academy of Sciences in Pushino. Its activity covers a wide range of research at the forefront of science: studies in biophysics (molecular structures, micromolecular biology, structure of nuclear acid proteins, polyencymatic systems, membrane potentials, etc.); radiation biology (principles of radiation damage and repair, RBE studies); biological processes (principles of control, photosynthesis, cytogenetics, enzyme activity, and metabolic processes); agricultural studies, and soil chemistry; automation of biological research (introduction of computer systems, design of equipment, and mathematical modelling of certain theories and concepts); physical, chemical and biological characteristics of memory. The participants saw the computer centre and various laboratories. In the computer centre spectroscopic data obtained from ESR and paramagnetic resonance studies of different molecules of biological interest are being processed. A special system of karyotyping of human chromosomes has been developed and demonstrated. By this new method the contour of each individual chromosome can be displayed on an oscillograph and printed out. Another programme is concerned with mathematical models for muscle fibrilations.

One laboratory deals with experimental studies on the biological action of high energy particles. The results are used essentially for space flights. It was reported that certain radiation effects observed during space flight do not repeat in simulating conditions on earth. The doses required in space to produce certain genetic effects are many orders of magnitude less than under simulating laboratory conditions using 70 GeV protons. It is believed that the secondary particles produced by the high energy space protons lead to the extremely high RBE observed. In this context it is interesting to note that all

Soviet radiobiologists with whom the group talked believed in a linear dose-effect relationship in the low dose range (i.e. no dose threshold).

MOSCOW

At the Research Institute of X-rays and Radiology in Moscow, Prof. Krongaus introduced the group to the Dosimetry Department. In this department they have a first category dosimetry laboratory in which the dosimeters of the existing 10 dosimetry laboratories in the USSR of the second category are calibrated and controlled. The standards equipment consists of a normal free air ionizing chamber for X-ray exposure measurements in the range from 50 to 200 keV with an accuracy within ± 2%. The laboratory also maintains standard ionization chambers for soft X-rays (5 to 25 KeV, accuracy within ± 3%) and for Co-60 gamma radiation. Intercomparison with the IAEA Dosimetry Laboratory in the frame of the Agency's Co-60 postal dose inter-comparison showed agreement within 1%.

In the radiotherapy department a very powerful treatment planning system has been developed. It is done by feeding the input data into a computer by putting differently coloured pins into a rectangular matrix, thereby delineating the contour of the tumour and other relevant data on the matrix. The radiotherapist can easily manipulate some parameters until he gets a suitable dose distribution which is seen on an oscilloscope. Finally, the dose distribution is printed out by a typewriter. The whole calculation takes about 20 minutes per patient.

LENINGRAD

In Leningrad the group visisted the Radiation Hygiene Research Institute. This Institute was established in 1956 to deal with problems resulting from the use of ionizing radiation and nuclear energy in various branches of science and economy. Its main activities are carried out in three directions: dosimetry, radiobiology and radiation protection. In one of the excellent lectures given it was pointed out that the number of radiobiological examinations carried out in the USSR has reached such a level that their contribution to radiation exposure to the population is comparable to that of natural background radiation. As there is evidence that even very low doses cause biological effects it must be concluded that, as far as possible, radiological examinations should be reduced.

Of the various uses of ionizing radiation in medicine, that of radionuclides is increasing at the fastest rate, and it is therefore anticipated that in the near future they will become the most common radiation source for man. For this reason, the international organizations are concerned about regulating radioisotopic investigation in order to protect the patients.

In the USSR such a regulation has been prepared by staff of this Institute. It is applied in the whole country and has the force of law. It is based on striking a balance between the need to carry out examinations and the effort to apply the lowest possible radiation dose. The document is based on the recommendations contained in ICRP publications 9 and 10, and takes into consideration the following factors: Risk of the direct effect of radiation; risk of the late effect of radiation; risk of the teratogenic effect on pregnancy; risk of the genetic effect.

The standards are divided into three categories in accordance with the patients' condition: Patients suffering from or suspected to be suffering from an oncological disease; patients for whom there is a clinical need for an examination but who are not suffering or suspected to be suffering from an oncological disease; patients subjected to prophylactic examinations or examinations for scientific purposes.

In the Biophysics Laboratory of the Central Research Institute of X-ray Radiation and Radiology, Professor Alexandrov delivered a lecture on his investigations of the pathogenesis of the late effects of radiation, in particular the shortening of life span, after whole-body irradiation. The studies are carried out by measuring the fluorescence of the amino acids of human cells after irradiation. This effect is independent of dose-rate and can be followed up without an observable decay over a period of many years. It is believed that investigation of this physical effect will throw some light on the mechanism of the genetic effects in somatic cells.

In the Pharmacology Laboratory Professor Rusanov reported on research on Proxiphein and Etaden, chemical derivates of caffeine, which are used against injuries of radiation in the experimental radiation treatment of cancer in animals.

TASHKENT

After a long flight over more than 5000 km, the Study Tour was continued at the Oncology Institute of the Uzbek Union Republic in Tashkent. This modern institute founded in 1958 now consists of 500 scientific workers, 4 of them professors at the local university. Its main activity is the epidemology of malignant diseases and the development of optimum treatment methods. In this area of the USSR malignant diseases of the esophagus are most prevalent and it was stated that natives suffer most from this disease. There seems to be evidence that certain spicy dishes preferred by the native population cause the disease. Good treatment results have been reported by the combined use of radiation and certain chemical drugs, stimulating blood formation. The participants of the Tour were very impressed by the modern equipment used in this institute.

KIEV

The group's last visit was to the Oncology Institute in Kiev. A small institute before 1971, it has been considerably enlarged since then and is now the largest institute of the Ukrainian Republic (1200 staff of whom 100 are scientists). Besides a big Co-60 source, a home-made linear accelerator of 5 MeV electron energy, and a 25 MeV betatron are used for treatment. The Linac can be rotated over 120 degrees on both sides and it produces an exposure rate of about 150 R/min at an SSD = 117 cm with an effective energy of 1.5 MeV. For treatment planning computers are not used in daily routine work. Instead, a simple but ingenious hand calculation method, developed by the physicist of the institute, is used for the construction of depth dose charts. Whereas application of conventional methods of hand calculation requires one to two working days, with the new method a depth dose chart may be obtained within one to two hours an example that scientific progress can also be achieved without very sophisticated technical equipment.