Nuclear applications for health: Keeping pace with progress

A look at the evolution of the IAEA's programmes and the range of health-related nuclear applications benefitting people today

by Alfredo Cuarón

Just before the turn of the 20th century, the discoveries of X-rays, in 1895, and of radioactivity, in 1896, opened up whole new worlds of science. For the medical community, the world has been changing ever since, in some countries far more rapidly than in others.

Over the past 100 years, the X-ray has become as familiar to most people as the dentist's chair. As we move into the next century, greater attention is being placed upon less known but more far-reaching radiation technologies and nuclear applications that today's physicians are able to use for earlier diagnosis and treatment of serious illness. Many of these tools stand at the core of the IAEA's own programmes in the field of human health. These programmes — which aim to encourage and support the transfer of health-related nuclear applications — are being increasingly tailored to the changing and challenging conditions affecting health care and treatment, especially in the developing world.

This article, in question-and-answer format, explains the differences between the various types of nuclear applications for human health, and looks at the evolution of, and strategies for, the IAEA's related activities.

Nuclear applications: What they are

What are nuclear applications for human health? Fundamentally, they are applications that either take advantage of nuclear radiation's ionizing power or of the specific properties of a particular radionuclide. The first type of applications is used to destroy diseased tissues, as in radiation therapy of cancer. The second type generally is used to gain information useful in medical diagnosis, as in nuclear medicine studies. Some of these applications represent the oldest and most humane applications of nuclear energy. They are also the most widely used nuclear techniques throughout the world.

What is radiation therapy? Radiation therapy uses highly intense ionizing radiation centred on tumours for purposes of destroying all traces of malignant tissues. At present, it is estimated that 10 million new cancer cases occur every year, most of them in developing countries. More than 60% of all cancer patients require some kind of radiation therapy as part of their treatment. Although a high percentage of cancer patients are treated with surgery alone, the use of radiation therapy and chemotherapy in combined treatment approaches is becoming frequent for curative purposes.

The patient for whom cure is possible (30% to 40% of cancer patients) would have a much better chance of being successfully treated if all the facilities for a correct diagnosis and optimum treatment were used for his or her benefit. However, this is not always possible, necessitating choices. As the World Health Organization (WHO) has put it: "Good surgery is preferable to bad radiotherapy but, equally, good radiotherapy is preferable to bad surgery". Radiation therapy also has an important role in palliation. This means that it will eventually play a role in most cases where the disease has entered advanced stages.

Is radiation therapy a new medical application? Not at all. It started nearly a century ago — in 1896 — by using X-rays and it was known as *roentgentherapy*, in recognition of German physicist W. C. Roentgen, who discovered X-rays in 1895. Beginning in 1903, it was gradually replaced by *curietherapy*, in honour of French scientist Marie Curie. Technically speaking, this was the first practical application of *nuclear* energy. It used radium sources in close contact with the tumours. Its use lasted for nearly half a century, until artificial radionuclides with supe-

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rior nuclear and radiobiological characteristics were produced in cyclotrons and nuclear reactors.

Today's radiation oncologists have a choice of different approaches depending on the clinical needs of particular patients:

Brachytherapy, which can be used by applying beta particle sources in close contact with the tumour, as in the case of cancer of the uterine cervix and other cavities or surfaces, and

Teletherapy, where a gamma radiation source is positioned at a certain distance from the tumour, as in the case of deep-seated cancers.

In most industrialized countries and in quite a few developing ones, electron accelerators, instead of radiation sources, are also used, often with better results. In addition, new techniques are emerging which are increasingly complex and expensive, but safer and more accurate. These techniques rely upon the use of proton accelerators, neutron irradiators, boron-neutron capture, and heavy-ion accelerators.

Tracer techniques and nuclear medicine

What is meant by "tracer methodology"? Thousands of years ago, the Chinese used pieces of coloured cork to trace the water currents in the Yang-Tse river. A few millenia later, the Egyptians improved the method by using massive amounts of water-soluble dyes to trace the currents in the Nile river. At present, a few molecules of radioactive water are needed to follow radioactivity and trace either the water currents in a river, a lake or a sea — or to trace water metabolism in a living organism.

The best example of the exquisite sensitivity of the radiotracer methodology was provided just a few months after Becquerel discovered radioactivity in 1896. Marie Curie found that radioactivity in pitchblend was four times higher than expected from its content of the two radioactive elements known at that time: uranium and thorium. She concluded that pitchblend had to contain another still unknown radioactive element. She decided to trace its radioactivity through different solvents and chemical reactions to learn its chemical properties. She was finally able to isolate 100 mg of radium contained in eight tons of pitchblend: a weight-by-weight ratio of one part of radium against 80 million parts of other elements!

When did tracer methodology become applicable to biomedical sciences? In 1932, Blumgart used a natural radioisotope of bismuth as a tracer of blood flow. By detecting its radioactivity in different regions of the body, he was able to measure with great accuracy the corresponding blood circulation times from the site of its intravenous injection. It was the first experiment on human physiology ever performed by using the radiotracer principle.

A few years later, some chemists started using other radionuclides to trace the continuous buildup and breakdown of specific organic molecules, giving birth to modern biochemistry. Knowledge of the different metabolic cycles occurring in a living organism could not be possible without the isotopic tracer principle. Only stable and radioactive isotopes can label the atoms to follow the pathways of a given atom from one molecule to others in the intricate biochemical crossroads.

How does nuclear medicine take advantage of the radiotracer principle? Nuclear medicine is based on the use of minute amounts of radioactive molecules of known biological behaviour to trace specific functions and biochemical processes. These tracers or "radiopharmaceuticals" can be thought of as guided molecular probes. If they are administered to the patient (*in-vivo*) or added to a tissue sample in a test tube (*in-vitro*), the hundred million molecular probes search through the body or the sample. They do so until they encounter recognition sites in the targeted cells where their solubility, charge, and shape lead them to be selectively bound to a cell component, to be concentrated by a specific tissue, or to be excreted by a given organ.

How can this information be of diagnostic value? These molecular probes can be tracked by external detectors and measured by their emitted radiation as they move in blood and concentrate in specific sites, providing functional and biochemical quantitative data. This information is usually given by a gamma camera in the form of planar or bidimensional images. These images show the spatial distribution of the radiotracer in the body, reflecting the quality and the regional distribution of a given biochemical or functional process. A method known as single-photon emission tomography (SPET) shows the same distribution but in bidimensional images of slices of the body. The most advanced system is called positron emission tomography (PET). It provides images obtained through the use of molecular probes labelled with positron emitters produced in a cyclotron. Its use allows the analysis of the most delicate biochemical processes of life, including the interactions between radioactive neurotransmitters and neuroreceptors within the brain. It thus provides unique images of the biochemical foundation of diseases previously believed to be of "mental" origin (dementia, schizophrenia, depression, paranoia) or just "degenerative" (Parkinson's disease).

In any case, a unique feature of nuclear medicine imaging is that it is able to resolve the diverse functions in a given organ by using different radiotracers. In the case of the heart, for instance, it is possible to investigate fourteen of its functions, including biochemical and metabolic processes in its different structures.

Is nuclear medicine just a sophisticated variation of clinical radiology? Not at all. Although both are based on the use of ionizing radiation, they are directed at two different medical specialties:

Clinical radiology started in November 1895, shortly after the discovery of X-rays by Roentgen. For the first time, physicians were able to explore the structure of the internal organs of their patients without surgery, but rather through the shadows they produced on a photographic plate. The intensity of these shadows are dependent on the density of the tissues. The result is an image with very neat information about the size, shape, position and density of the different organs. In other words, they are anatomical images. In the process, however, a wide area of the patient's body is exposed for a very short time to a very intense ionizing radiation, which is not nuclear in origin. Although certainly important, anatomy is limited to the study of structures, which are only altered in the very late stages of disease. A radiograph does provide any clue regarding biochemistry and and function. In fact, a radiologist can obtain magnificent radiographs from a dead body.

Nuclear medicine, on the other hand, started nearly half a century after radiology when artificial radionuclides became available through the use of cyclotrons and nuclear reactors. It evolved naturally from the principle of the tracer methodology to explore living molecular behaviour. Nuclear medicine goes far beyond anatomy into the realms of physiology, biochemistry, and molecular biology — it needs the gentle breeze of life and cannot provide an image from a corpse.

Do these differences between radiology and nuclear medicine have any implication in medical diagnosis? Each provides different medical indications. Radiology is used to detect the structural effects of disease while nuclear medicine is used for studying its biochemical and functional consequences. Radiology is vital for the successful treatment of a bone fracture whereas nuclear medicine would play a minor role, if any. Their relative values need to be seen in the context of the natural history of disease, which usually begins with a biochemical disturbance at the molecular level in a region of a given organ or system. With time, the regional or global function of the organ is affected, but the first structural alterations are only evident in very late stages. For instance, nuclear medicine is able to detect the first biochemical signs produced by bone metastases from breast and prostatic cancers six to twelve months before the structural changes are evident in a radiographic image of the skeleton. In this particular case, nuclear imaging is vital for the patient.

The major advantage of nuclear medicine is that it is not organ-oriented, as radiology, but problem-oriented. Nuclear medicine does not just provide new tests for old diseases. It defines clinical problems in terms of regional biochemistry and physiology and uses these measurements to help solve the problems. Biochemical and functional characterization of disease provide a strong basis not only for diagnosis but also for prognosis and treatment, whether it be drug therapy, surgery, radiation therapy, or some combination of them.

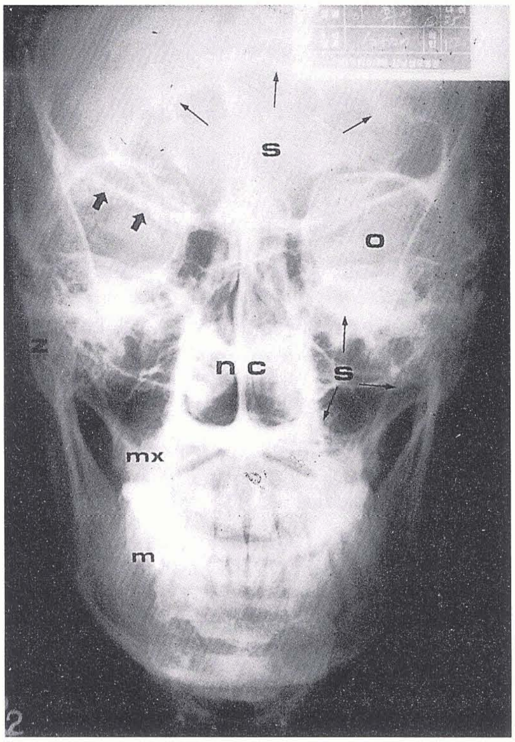
An example can be found in breast cancer. It may be well diagnosed by radiological mammography which may indicate a serious prognosis and the need for surgery and radiation therapy. But if a nuclear image shows the ability of the tumour to concentrate radioactive estrogens, it is a demonstration that the tumour has estrogen receptors, and this can be successfully treated with drugs. The finding changes not only the prognosis but avoids traumatic treatment. This does not mean that nuclear medicine excludes radiology. Both have complementary roles. In this case, mammography is diagnostic but nuclear medicine defines the best treatment.

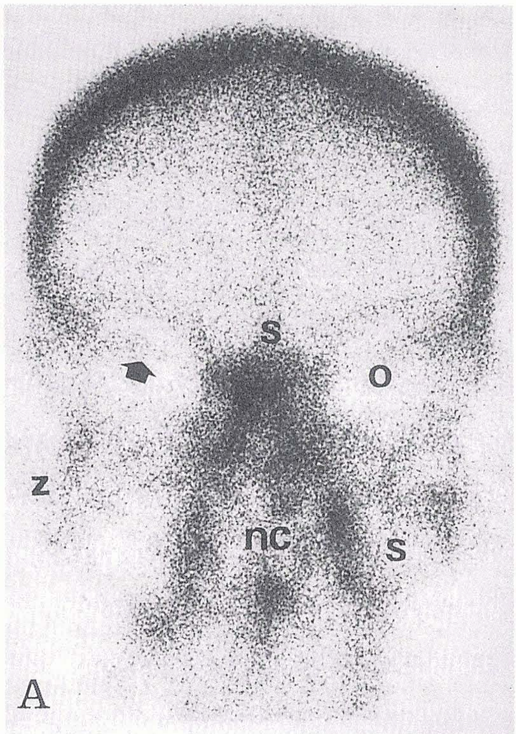
Safety and sensitivity

Is the internal administration of radionuclides safe for patients? In nuclear medicine, radionuclides are especially selected and have short half-lives. The radioactivity in the dose is just enough to be detected by the sensitive instruments of nuclear medicine. Although the radionuclide remains in the body for a relatively long period when compared with the extremely short exposure time during an X-ray study, nuclear medicine exposes patients to lower radiation doses than clinical radiology where radiation intensity is fundamentally high.

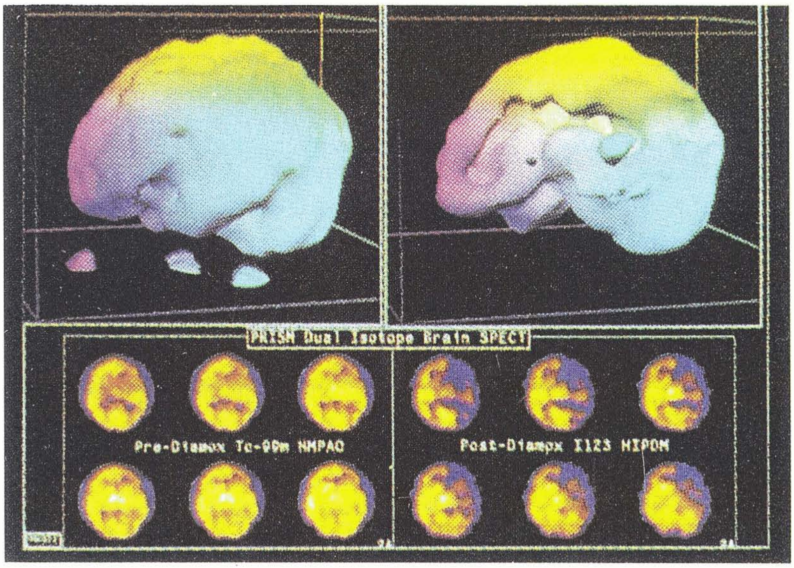
On the other hand, the chemical amounts of radiotracers are so small that they cannot induce pharmacological effects or alter physiological parameters. Neither are they able to produce toxic effects. These special features allow nuclear medicine procedures to be performed in pregnant women and in newborn babies as well as to be periodically repeated either to monitor the evolution of disease or the effects of treatment.

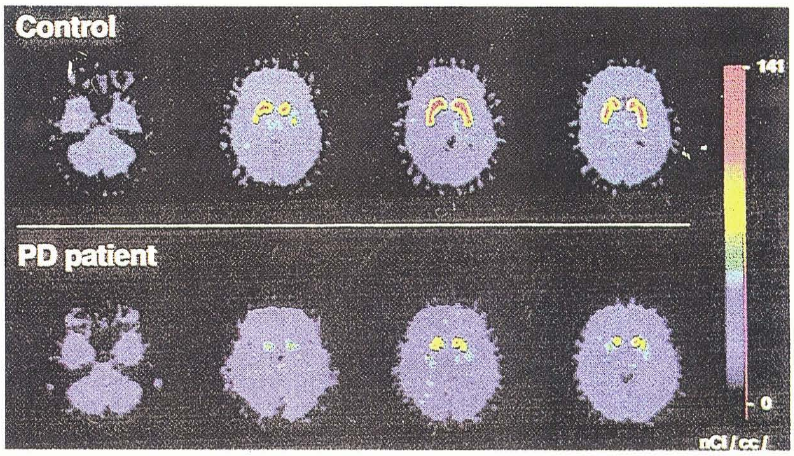
What is in-vitro testing in nuclear medicine? These tests are the simplest and





(Clockwise from top left) **VIEWS OF THE HUMAN SKULL: An anterior X-ray view of a normal individual showing in great detail the anatomy of bone structures in the skull. Shown next is the planar, anterior view of the same subject obtained from nuclear medical imaging. It shows physicians that the normal magnitude of phosphonate metabolism is different in each region of the skull, being more active in cranial and facial bones. VIEWS OF THE HUMAN BRAIN: A single photon emission tomography [SPET] of the brain obtained using technetium-99m-HMPAO. The magnitude of concentration of the radiotracer in brain tissue is proportional to regional blood flow. The 12 tomographic slices (lower half) show a severe decrease of blood flow in the left brain regions. In the upper half of the photo, the reconstruction of three-dimensional images from the series of tomographic slices clearly defines the infarcted region. The bottom photo is the result of positron emission tomography [PET] of the brain. The photo's upper half shows images obtained in a normal subject. The lower half shows images of decreased functional neuro-receptors in the basal ganglia in a patient with Parkinson's disease.**





cheapest in nuclear medicine. They are performed in a laboratory with very simple instrumentation, where hundreds of samples can be simultaneously processed in just a few hours. As in other clinical laboratory tests, they are performed in test tubes on biological samples (blood or other tissues) so they do not expose the patient to ionizing radiation. The most common are radioimmunoassays (RIA) and immunoradiometric assays (IRMA), which combine the unique specificity of immunological processes with the unique sensitivity of tests based on radioactivity.

These procedures have increased the sensitivity of biochemical measurements by a factor of one million, from micrograms (0.001 mg) to picograms (0.000,000,001 mg), allowing the discovery of unsuspected hormonal production. They are practically used to detect and measure the minute amounts of any immunogenic substance of medical interest. Among these are hormones, enzymes, proteins, medical and hard drugs, as well as substances specifically produced and secreted by certain tumours, the so-called tumour markers.

In-vitro testing also includes the use of radioactive DNA probes or genetic markers. They are used to identify specific bits of DNA present in the genetic material of the cells. These bits can be further amplified or copied by the polymerase chain reaction method so that there is enough material to test even the sample containing the tiny amount of DNA of a single cell. Genetic fingerprinting, as it is popularly known, is of special value in the detection of communicable diseases such as malaria, lepra, leishmaniasis, and schistosomiasis, as well as inherited diseases such as cystic fibrosis, haemophilia, and thallazaemia. It is also of value in parental identification, in forensic medicine, and in criminalistics, anthropology, and paleontology.

Are the therapeutic applications of nuclear medicine different from those of radiotherapy? Radiation therapy uses radiation beams from external sources to destroy malignant tissues. Therapeutic nuclear medicine seeks the specific, physiological concentration of orally or intravenously administered beta emitting radionuclides with enough radioactivity to specifically destroy targeted tissue. In this case, the molecular probes are transformed into molecular "guided missiles" of great accuracy. If the binding site of the radioactive molecular missile is a cancerous tumour, the aim is the specific and total destruction of malignant tissues with a highly radioactive dose, with nearly no effects on surrounding normal cells. Lower therapeutic doses of radioactivity are used when the aim is to partially ablate over-active non-malignant tissues to restore normal chemistry and function in specific organs. Such is the case in the administration of iodine-131 to destroy hyperactive thyroid tissue in the treatment of hyperthyroidism, as well as of phosphorus-32 to destroy hyperactive bone marrow overproducing red blood cells. Doses of iodine-131 ten times higher are needed to destroy the metastases of a thyroid cancer.

In a similar way, bone-seeking radionuclides are used to palliate pain in patients with bone metastases from breast or prostatic cancers. A new chapter under investigation is radioimmunotherapy. This is based on the use of specific radioactive monoclonal antibodies as "magic" guided missiles to destroy specific types of cancer and their metastases — such as melanoma, lymphoma, and cancers of the colon, ovary, and liver — without undue irradiation to normal surrounding tissues.

Are the costs of nuclear medicine competitive with those of radiology and other clinical imaging modalities? Nuclear medicine is not inexpensive, but the overall costs are competitive. Some types of medical imaging procedures are more expensive than others. For example, PET is nearly a matter of "science fiction" — science in industrial countries and fiction in developing countries — because a cyclotron is needed on site.

Generally speaking, the cost of equipment for nuclear medicine is on par with those of radiology and below those of advanced imaging systems, such as magnetic resonance imaging. Operating costs of nuclear medicine, however, are higher than those in radiology. This stems from the need to have a constant supply of radionuclides and radiopharmaceuticals which, used or not, decay with time. In terms of human resources, a radiological department needs a core staff of radiologists, technologists, and an expert in medical physics. The requirements for nuclear medicine are broader and multidisciplinary in character, encompassing nuclear physicians, technologists, radiopharmacists, biomedical engineers, and experts in medical physics and informatics.

Nuclear medicine may seem expensive, but when well applied it can actually reduce costs of health care. Decision-making under conditions of uncertainty is what makes health care expensive. Increased certainty at the earliest stages of disease results in better patient care and lower costs. Precisely this is the highest value of nuclear medicine: an early diagnosis leads to opportune prescription of the optimal treatment, and eliminates the danger of complications. It further reduces the costs for drugs, for more complex, expensive, and traumatic diagnostic modalities, and for hospital beds. It can also shorten the period of recovery for patients, and their time away from work.

Other radiation applications for health

Are there other health-related applications of irradiation? Irradiation is an efficient method of bacteriological sterilization. Many medical products, such as surgical dressings, sutures, catheters, and syringes, cannot be subjected to sterilization by steam or dry heat because they incorporate heat-sensitive materials such as plastic bases. Sterilization by ethylene oxide gas or other chemicals may introduce undesirable residues which are hazardous to health. For such products, sterilization by gamma rays from cobalt-60 has proven to be highly effective and low in cost. Tissues for graft implants in humans, such as bone, nerve, fascia, dura, heart valves, and chorion dressings for burns, also have been successfully sterilized by gamma radiation. They thus have found more use in clinical practice in many developing countries.

Other health-related applications of irradiation have been successfully promoted by the Joint Division of Nuclear Techniques in Food and Agriculture of the IAEA and Food and Agriculture Organization (FAO). Food irradiation, for example, can kill viable organisms and specific, non-spore forming, pathogenic micro-organisms such as salmonella, thus eliminating many health risks in food. Another important application is in sexual sterilization of insects in eradication campaigns of pests threatening human health, such as the New World Screw-worm and the tsetse fly.

What about nutrition and health-related environmental problems? The tracer principle has been fundamental in the study of all processes involved in human nutrition. The use of stable isotopes of hydrogen, carbon, nitrogen, and oxygen is completely safe to the person being studied because they are non-radioactive. Nuclear analytical techniques also have been used to provide information on the bio-availability and dietary intakes of different elements through the normal human diet in various countries of the world, providing important new data useful for setting dietary guidelines. *(See the article beginning on page 18.)*

Nuclear techniques and the tracer principle are fundamental as well in the study of environmental pollution, which affects the health and well-being of millions of people. The fact that radioactive and non-radioactive isotopes can be detected in very small amounts and that their path can be traced, make them ideal tools for tracing pollutants, be it in air, water, or soil. Non-radioactive isotopes can be measured accurately by nuclear methods, such as activation analysis or X-ray fluorescence. Other nuclear methods such as electron beam radiation also can be employed successfully to remove gaseous pollutants, including obnoxious gases such as sulphur dioxide or nitrogen oxide emitted from coal-fired power stations.

What is the role of radiation dosimetry in human health? Accurate doses are of utmost importance for all radiation applications. For therapeutic applications, it can be a matter of life and death. A dosage lower than intended may be insufficient for treatment and may increase radioresistence in the malignant tissues; if higher, it may produce severe complications.

In modern radiation oncology, it has been stressed that accuracy, or at least repeatability, in the delivery of the dose should be within 5%. For this purpose, 70 Secondary Standard Dosimetry Laboratories (SSDLs) have been established by the IAEA and WHO in developing countries. As accurate dosimetry is a prerequisite in radiotherapy, the dosimeters of the radiotherapy centres must be calibrated regularly by the SSDLs. They are checked yearly by intercomparisons organized by the IAEA Dosimetry Laboratory. In addition, the IAEA in co-operation with WHO provides a worldwide dosimetry service for radiotherapy centres. Results of more than 700 radiotherapy centres show that more than 10% of cancer patients receive doses that differ from the prescribed dose by more than 20% through lack of proper equipment, personnel, or training. For 70% of all hospitals participating in a recent assessment, the mean deviations of their radiation dosage measurements were reduced from 20% to 5%. Other centres now are improving their measurements. *(See the article beginning on page 33.)*

Much higher doses of radiation are used for some industrial applications, such as sterilization of medical products and food irradiation. Newly developed techniques are being used through the SSDLs for the assurance of the prescribed dose. Additionally, both of these services have a broad programme which include the calibration of all instruments for radiation protection and high-dose measurements.

Technology transfer: Supporting applications in developing countries

Are developing countries ready for nuclear applications for human health? It all depends on their particular level of historical development. One should not forget the significant role played by some developing countries in the progress of nuclear medicine, which is the most complex of the medical applications of nuclear energy. The first National Institute of Nuclear Medicine was founded in 1948 by the University of Sao Paulo, Brazil; complete validation of the radiotracer principle as a practical tool for medical research was made during the 1950s in the Andean countries (Argentina, Bolivia, Chile, Ecuador, Peru) and in Mexico through pioneering studies on endemic goitre; the first national societies of nuclear medicine to be founded after the one in the United States were in Latin American countries in the early 1960s; the first regional federation of societies of the specialty was in Latin America, founded in 1965 and was catalytic to the foundation of the World Federation, in Mexico City, in 1970. Many of the procedures in use in nuclear medicine were originally developed in these countries during the 1960s and early 1970s.

But this optimistic start was broken by the coincidental appearance of the international financial crisis in the late 1970s and the unprecedented technological advances achieved in industrial countries during the 1980s. These developments closed all doors for the progress of nuclear medicine in developing countries. These countries now urgently need to catch up with progress and to narrow the technological gap. But commercial firms only produce state-of-the-art equipment — very expensive and sophisticated but unsuitable for the conditions in many developing countries. These countries need to be very careful in *adapting* new technologies to their own needs and conditions instead of *adopting* expensive, unsuitable technologies.

Nuclear techniques for human health do not depend upon sophisticated nuclear infrastructure within the country. What is fundamental is a reasonable *medical* infrastructure. Nuclear medicine is relevant but only as a support to other basic diagnostic modalities such as a clinical laboratory, routine radiology, and ultrasound. Similarly, radiotherapy could not be effective in curing cancer if it is not supported by a system for the early diagnosis of cancer or if there are no oncologists and chemotherapists available. In these cases, it could be used mostly to relieve pain and some symptoms, but the patient will eventually die of cancer.

Health professionals in Peru are among those receiving IAEA-supported assistance in applying nuclear medical applications.

Evolving to meet the challenges

Over the past decade, the IAEA's programmes in support of nuclear applications for human health have evolved to address new realities. The move is reflected in the organization structure, as well as in more sharply focused projects. In August 1993, the Division of Life Sciences disappeared from the organizational chart of the IAEA. In its place emerged a new name, the Division of Human Health, whose staff are grouped into four sections — nuclear medicine; applied radiation biology and radiotherapy; dosimetry; and nutritional and health-related environmental studies.

Why the change of title? The old title became inappropriate and misleading because its sub-programmes no longer related to animal and vegetal biology, areas covered under the former Division of Life Sciences. These sub-programmes have fallen fully within the scope of the Joint IAEA/FAO Division. Furthermore, the new title would have the added advantage of helping potential counterparts — mostly from medical institutes — to identify the Division's objectives with their own. This evolutionary change better enables the IAEA to keep pace with progress and to mold the IAEA's medium-term strategies concerning nuclear applications for human health. These strategies include mechanisms for reaching most users of nuclear medical instruments in developing countries.

Will the Division be in competition with WHO? Certainly not. WHO's priorities are in sanitation and prevention of disease. This means that the IAEA is the only international agency with the direct mandate to promote the applications of nuclear energy to human health which are primarily focused on diagnosis and treatment of disease. The IAEA has long enjoyed excellent relations with WHO and usually seeks its advice and frequently co-ordinates its projects with those of WHO, its regional offices such as PAHO, and other international agencies dealing with human health or the environment.

New strategies at the IAEA

Medical applications of nuclear techniques are of value only when they are available when they are needed for patient care, and when they render reliable results to the clinicians. Consequently, the IAEA is placing greater emphasis on creating mechanisms to reach most users of these applications, aiming to promote *clinical quality assurance* and to increase the *availability* of nuclear applications in developing countries.

Availability can only be increased by cost reduction. Technical co-operation and co-ordinated research programmes are especially designed for building up indigenous capabilities in the production of reagents for radioimmunoassay, technetium-99m generators, and radiopharmaceuticals. Support is also given to nuclear centres for producing radionuclides of medical value to make them available at low cost within each region.

A hardware interface to link any gamma-camera to a personal computer as well as processing software for nuclear medicine imaging has been developed through technical contracts. This low-cost system is presently being evaluated in Vienna and will be used to upgrade approximately 1000 old analogue gamma-cameras in developing countries to bring them into the digital era. A worldwide survey on gamma cameras was started and regional programmes have been developed to certify that preventive maintenance and fault repairs are integrated with the quality control checks. This policy will decrease the downtime of the instruments and increase their productive life. Successful efforts have been made to induce manufacturers to produce simple, low-cost instruments for nuclear medicine and radiation therapy with updated technology.

But the projects expected to have the greater impact in developing countries are those which have been planned to reach all users of nuclear techniques for human health in developing countries. These projects are implemented through symbiotic associations of the IAEA with the WHO/PAHO and national medical authorities, as well as with national and regional medical societies and commercial firms. The purpose is to establish co-ordinated networks to improve the clinical effectivenes of nuclear techniques for human health preservation and improvement on a national, regional, and global basis.

The first attempt at this was crowned with the successful establishment of the Ibero-American Board of Nuclear Physicians founded under the IAEA's auspices in Bogotá, Colombia, 15 October 1993. It was integrated with six past presidents of the Latin American Association of Societies of Nuclear Medicine and Biology, a Committee of Examiners with 10 internationally recognized experts in different aspects of nuclear medicine, and national Governors representing the Board in each country. This network will act as an external quality-control scheme to elevate the standards of graduate education in nuclear medicine in Latin America, Spain, and Portugal. It will conduct examinations to test the knowledge of voluntary candidates and will issue certificates to those found qualified for the clinical practice of nuclear medicine. These certificates will be revalidated every 5 years through individual curricular evaluations to assure that the holder is keeping pace with progress in the specialty. The certificate will be a source of confidence to patients and institutions, as well as of prestige for the certified physician. Its periodical revalidation will promote a wider and more active participation of nuclear physicians in scientific and academic activities, which are the best expedients for the progress of a specialty in any country.

Two other similar associations are to be initiated with the Asia and Oceania Federation of Nuclear Medicine. One network will be used for interactive, long-distance approaches for the training and certification of technologists in nuclear medicine. The other network is a Gamma-Camera Users Association to monitor the maintenance and repair services for nuclear medicine instruments rendered by commercial firms in the region.

These new strategies, complementing the traditional approaches used by the IAEA for decades, demonstrate valuable characteristics of a flexible and dynamic organization. By being able to respond to changing conditions, the IAEA has reinforced its efforts to improve both the efficiency and quality of medical applications of nuclear techniques in developing countries. ❐