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The International Atomic Energy Agency's

L A B O R A T O R I E S

at Seibersdorf and in Vienna

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FOREWORD

The Role of the IAEA's Laboratories

The activities of the IAEA's Laboratories in the fields of agriculture, physics, chemistry and the life sciences are geared mainly towards the transfer of techniques and technologies to Developing Countries. Exceptions are the activities of the Safeguards Analytical Laboratory which are fully in support of the Safeguards programme.

Work at the Laboratories concentrates on nuclear techniques, that is on those techniques which can be regarded as spin-offs from nuclear science or industry and which make use mainly of radioisotopes or radiation procedures developed in response to the technological challenges imposed by the nuclear age. Their range of application is extremely broad and includes matters affecting our everyday lives. Radioisotopes and controlled radiation can be used to preserve food, determine groundwater resources, sterilize medical supplies, diagnose and treat diseases, analyse hormones, check pipelines, or study environmental pollution. Among other things the IAEA's Laboratories help to establish measurement standards for radiation therapy, to induce plant mutations with the objective of obtaining better crops and to analyse samples of nuclear materials submitted to them by the Agency's Safeguards inspectorate. The Laboratories have achieved a unique position in the UN family, performing, within one organization, functions of technology transfer, education and regulation.

The Laboratories contribute to the transfer of selected techniques and technologies to national laboratories and research centres in Developing Countries using essentially three tools: (i) training; (ii) technical support to Co-ordinated Research Programmes and Technical Co-operation Projects; and (iii) scientific services.

These tools are parts of an integrated mechanism in which the Laboratories play the role of a 'transfer catalyst', providing assistance to national laboratories and centres in selected programme areas in a more efficient, rapid and economical way than would be possible through the alternative mechanism of 'direct', unmediated assistance. Knowhow of nuclear applications, to which they have facilitated access because of the international character of the IAEA, is channelled through the Laboratories to Developing Countries after performing the necessary adaptations required to match local conditions. The final objective is to develop independent national capabilities. The Laboratories, through their activities and their hands-on expertise, contribute to making this process technically sound, respondent to the diversified regional and national needs, rapid and as inexpensive as possible.

Scientific services are rendered by the Laboratories in direct response to the needs of and requests from Developing Countries. They are usually provided within the framework of Technical Co-operation projects and Co-ordinated Research Programmes, and frequently through a network of decentralized laboratories as for example in the case of Dosimetry. This network mechanism is implemented whenever it represents an improvement in programme delivery.

This catalytic role of the Laboratories is easily visualized by considering that:

(a) the approach to training is mostly through 'training the trainers', i.e. its objective is to create independent national capabilities in training;

(b) the Laboratories participate in Co-ordinated Research Programmes as one link of a chain (or network) of laboratories in Developing and Developed Countries working on a common theme, usually related to a problem pertinent to Developing Countries. The Laboratories, with their limited but direct involvement in experimental activities (support role in selected topics), guarantee the most efficient, rapid and economical transfer of technologies from Developed to Developing Countries. Their activities neither duplicate national efforts nor are they performed 'instead of' activities in Developing Countries. On the contrary, the Laboratories assist to speed up and rationalize the build-up of national capabilities by complementing the work of national institutions and fulfilling the role of a reference laboratory, whenever this is necessary;

(c) a remarkable fraction of the Laboratories' resources (manpower and equipment) are devoted to supporting Technical Co-operation projects, by providing direct and qualified assistance to national centres and laboratories. It goes without saying that the quality and extent of this assistance, as well as of the training provided, is directly correlated to the extent and quality level of the corresponding experimental activities performed at the Laboratories.

Pier Roberto Danesi
Director of IAEA's Laboratories
Seibersdorf, October 1988

Origin and Development of the IAEA's Laboratories

The International Atomic Energy Agency (IAEA) was set up in the mid-fifties for the purpose of accelerating and enlarging the contributions of atomic energy to peace, health and prosperity throughout the world.

Assistance in the establishment of a modern and safe technological base in developing countries in its area of competence is one of its main objectives. Another primary concern of the IAEA is to make sure that any assistance provided by it or under its auspices should not be used in such a way as to further any military purpose.

To accomplish these tasks and many subsidiary ones, the need for which has arisen over the years of its existence, the IAEA requires laboratory support which is provided mainly by its laboratories at Seibersdorf and in Vienna (In the text below, these will be referred to simply as "the Laboratories"). In addition the Agency is served by its Laboratory of Marine Radioactivity at Monaco, by the International Centre for Theoretical Physics at Miramare - Trieste, run jointly with UNESCO, and by many national laboratories under research contracts or other agreements.

The nucleus of the Laboratories was formed in 1959 when a handful of scientists set up a physics laboratory, a chemistry laboratory and an electronics workshop in the basement of the Grand Hotel in Vienna, which at that time was housing the IAEA's Headquarters.

Early work at these laboratories centred on absolute radionuclide calibrations, environmental radionuclides determinations and radiation dosimetry.

Soon afterwards, a gift of US$ 600000 from the Government of the United States and the donation of valuable equipment by several Member States enabled the Agency to build a new laboratory to which most activities were transferred in 1961. This new laboratory was built near Seibersdorf, a little village about 35 km away from Vienna, on the premises of the Austrian Nuclear Centre, on a piece of ground given to the IAEA for a nominal rent of one Austrian Schilling per year. Additional buildings were subsequently added as new requirements arose for laboratory support in additional fields such as agricultural and medical applications of isotopes and safeguards.

From the very beginning, training of scientists from Member States represented an important part of the work of the Laboratories. This initially consisted of:

- in-service training of fellows for periods varying between a few weeks up to one or two years, continued with
- formal training courses, each course lasting for approximately one month and involving lectures as well as practical work,

  and was finally extended to include
- group training in specific practical topics for three to six months through a combined approach of technical tutoring, hands-on experience, periodical lecturing and direct experimental supervision.

In addition to their immediate usefulness to participants and their home institutions, the Laboratories' training activities also helped to form links between the participants and the Agency's scientists, links which became more important when many of the former participants moved up in their careers in the course of time and became responsible for programmes in their home countries' establishments.

Another early mission assigned to the Laboratories, in addition to the experimental support to the Agency's own programmes, was to provide directly to Member States a diversity of technical services, ranging from the assessment of radioactive contamination, or the assistance in mineral surveillance by nuclear techniques, to having its staff lecturing at seminars, evaluating nuclear related projects, and consulting on nuclear related problems.

At the present time (1989), the Laboratories are organized in three branches:

- the Agriculture Laboratory
- the Physics, Chemistry and Instrumentation Laboratory (PCI)
- the Safeguards Analytical Laboratory (SAL)

Together, these laboratories occupy a floor space of more than 7000 m^2 and have a total staff of 180.

In addition to regular budgetary resources, the Laboratories have also access to additional funds for specific projects (promotional or regulatory), the scientific responsibility for which lies with the Laboratories' staff or is shared by it.

The number of fellows from Developing Countries receiving in-service training is now about 60 per year, and a similar number receives instruction during the three to four training courses organized yearly.

ORGANIZATION AND FUNDING

The Laboratories are part of the IAEA's Department of Research and Isotopes to which they report directly. They back up the programmes of that Department in

- Food and Agriculture
- Physical and Chemical Sciences
- Life Sciences

At the same time, they also support other Departments, i.e. the Department of Technical Co-operation by providing

- in-service training of fellows
- three to four interregional training courses per year
- the services of technical officers for Technical Co-operation projects,

the Department of Nuclear Energy and Safety by performing analytical and advisory services in support of projects related to

- uranium prospection
- the assessment of environmental radioactivity,

and the Department of Safeguards by operating a facility for

- uranium and plutonium analysis in safeguards samples and by co-ordinating the activities of the Network of Analytical Laboratories (NWAL) performing safeguards analyses.

These activities are carried out by a staff of about 180, consisting of scientists, technicians and supporting personnel drawn from about 40 different nations.

With one exception, the Isotope Hydrology Unit located at Vienna International Centre, all individual laboratories are located within the perimeter of the Austrian Research Centre Seibersdorf, named after a nearby

village in the countryside, 35 kilometers southeast of Vienna.

Most of the budget is provided out of the Agency's regular funds, with sizeable contributions from the FAO (United Nations Food and Agriculture Organization), and from individual governments.

The activities at the Laboratories are organized in the following three sectors:

1. The Agriculture Laboratory which works on programmes originating in the Joint FAO/IAEA Division of Nuclear Applications in Food and Agriculture (called Joint FAO/IAEA Division for short), and consists of five Units dealing with
   - Soil Science
   - Plant Breeding
   - Agrochemicals
   - Entomology
   - Animal Production
2. The Physics Chemistry and Instrumentation Laboratory (PCI) which consists of four Units dealing with
   - Chemistry
   - Dosimetry
   - Instrumentation and Physics
   - Isotope Hydrology
3. The Safeguards Analytical Laboratory (SAL) which is split into two Units dealing with
   - Isotopic Analysis
   - Chemical Analysis

The work of these laboratories and individual Units is described in the following pages.

AGRICULTURE

The consequences of shortfalls in the supply and quality of food are severe. According to recent estimates, at least 450 million people around the world suffer from hunger, undernourishment, malnutrition or food-borne diseases, and, as a result, 20 million die each year. In addition, there are serious implications for global trade in food and, hence, the financing of national development.

A number of factors contribute to this situation:

- Adverse soil conditions may limit the productive capacity of field crops and orchards. Structural fragility of soils, erosion, salinity, moisture, and lack or imbalance of nutrients are among the factors which are critical in many areas of the world.
- Crop production may also be limited by the currently grown cultivars. They may not respond with higher yields to inputs like fertilizers, may be affected by environmental stress, may be susceptible to pests and diseases or may not fit into intensive cropping systems.
- High temperature and/or humidity, scarce and/or poor fodder, feed and grazing, pests and diseases of a parasitic or infectious nature all affect animal productivity. The resulting insufficiencies in meat and milk production reduce the quality of human diets, while shortages of valuable livestock products, such as wool and hide, have economic implications.
- The ineffective use of fertilizers and pesticides may lead to less than optimal yields and increased production costs. In addition, the unwise and indiscriminate utilization of these agrochemicals may have an adverse impact on human health and the environment, interfere with food trade and aggravate plant pest and disease related problems.

- Before harvest or slaughter, between 10% and 20% of the overall global production of crops and livestock is damaged by such insects as numerous species of fruit flies, tsetse flies and Lepidoptera (e.g. moths). These pests cause direct losses through animal death and outright crop destruction, and indirect losses through the transmission of diseases which reduce productivity and yield.
- After harvest or slaughter, one quarter to one third of the total food supply is lost during storage and distribution. The main reasons are destruction by insects, rodents and other pests, contamination by microorganisms which lead to spoilage and, in the case of fresh fruit and vegetables, premature ripening or sprouting.

These problems are most pronounced in Developing Countries, where food shortages resulting from inadequate production and infrastructure mean greater imports or decreased exports of agricultural products - factors which strain national financial resources and contribute to poverty and hunger. Food-borne diseases, moreover, are now considered to be one of the most widespread health problems in Developing and Industrialized Countries alike, as well as an important cause of reduced economic productivity. Through information exchange, research and field applications, the Joint FAO/IAEA Division and the Agriculture Laboratory focus on the use of nuclear techniques and related biotechnologies to help increasing and stabilizing agricultural output, reducing production costs, improving food quality, preventing spoilage and losses, and minimizing the pollution of food and the agricultural environment.

The Agriculture Laboratory is designed to support the Joint FAO/IAEA Division's programmes. Through Units which function as counterparts to five of the six Sections of that Division, this laboratory specializes in research, development and technology transfer in the fields of soil fertility, irrigation and crop production, plant breeding and genetics, animal production and health, insect and pest control, and agrochemicals and residues. The remaining Section, responsible for food preservation, is supported by the International Facility for Food Irradiation at Wageningen in the Netherlands.

The Laboratory provides a broad range of specialized services and research to the several co-ordinated research programmes of the Joint FAO/IAEA Division. These services encompass chemical and isotopic analyses, radiation treatments, microbiological studies, plant tissue culture techniques, radioanalytical method development, supplementary model experiments and expert advice. A major activity is training of scientists from developing countries either by training courses or guidance to fellowship holders. Other services include the supply of radiation sterilized insects, mutagen treated seeds, hormone and disease diagnostic kits, radiolabelled compounds and assistance in the procurement of supplies and equipment. Similar support is provided to technical co-operation projects and to training courses held at other institutions around the world.

SOIL SCIENCE

In modern agriculture, use of fertilizers and irrigation are essential to maximize yield on most soils. However, fertilizers are expensive and have to be used carefully while water is a scarce commodity particularly in the arid climates which characterize many developing countries. Radioactive and stable isotopes are utilized to quantitatively measure fertilizer supplied nutrients in soils and plants and to study the natural process of nitrogen fixation. Nuclear based methods are used to measure the soil water content and bulk

density. By research and development, by the provision of analytical services and by training the Soil Science Unit supports activities aimed at

- optimizing the effective use of soil resources through the development of better fertilizer and water management practices,
- maximizing the use of alternative (natural) nutrient sources, such as biological nitrogen fixation, rock phosphates and organic materials.

Individual studies have included research aimed at identifying the best fertilizer practices for the main food crops such as maize, rice and wheat. Similarly, nuclear techniques (neutron moisture meters and gamma density probes) have been applied to develop improved water management practices in arid and semi-arid environments. The ^{15}N methodology of quantifying the amount of biologically fixed nitrogen in field grown legumes was largely developed at the laboratory.

A number of the Co-ordinated Research Programmes supported by the Soil Science Unit involve the improvement of yields by increasing nitrogen fixation in the agricultural system. At present, there are six programmes in the soil area with the following individual objectives:

- to increase the yield and nutritive value of pastures by incorporating high nitrogen fixing legumes species;
- to assess nitrogen fixation and nitrogen cycling in the Azolla/Anabaena system and the usefulness of the waterfern Azolla as a biofertilizer to paddy rice;
- to ameliorate the properties of salt affected soils and their effects on plant growth;

- to examine genetic variation in symbiotic nitrogen fixation by the common bean with the aim of improving nitrogen fixation in order to save fertilizer and increase food production (in Latin America);
- to improve yield and nitrogen fixation in several grain legumes (in tropics and subtropics of Asia);
- to evaluate and calibrate nuclear techniques compared to traditional methods in soil water studies.

Two additional programmes to be initiated in the near future are related to

- the management of trees as regards to soil fertility for sustainable agriculture, soil conservation and provision of fuel wood, and
- root biology and the efficient use of soil resources for increased productivity, including the identification of genotypes highly effective in water and phosphate use.

Additionally, technical assistance projects backed by the laboratory cover a wide range of topics such as

- water management and irrigation
- fertilizer use efficiency
- biological nitrogen fixation
- amelioration of saline soils
- foliar fertilization
- physiology of pastures and tree crops
- basic studies in plant physiology and soil microbiology.

For the last mentioned basic studies, and for soil physics, special facilities have been set up.

Services

The unit performs ^{15}N determinations on plant samples and other analytical services for research contractors and some Technical Co-operation projects. ^{15}N labelled fertilizer is distributed to participants in these programmes. Agronomic evaluation of natural rock phosphates, for which ^{32}P isotope techniques are routinely used, is performed for various Developing Countries in support of the FAO Fertilizer Programme.

Training

A general training course on "Isotope and Radiation Techniques in Soil-Plant Relationship Studies" is held at the laboratory every second year. The laboratory staff also supports the organization and conduct of regional and national training courses. In the alternate years an advanced course on special topics is offered. Each course is open to approximately 20 scientists from Developing Countries. Additionally, individual fellowship training, for periods from two to four months, to learn a specific technique (e.g. ^{15}N assay by emission spectroscopy) and research fellowships, for six to twelve months, are available. On the average, ten fellowships are offered every year.

PLANT BREEDING

Genetic variation is the basis of all plant breeding and is used to develop cultivars of improved yield and quality, stress tolerance or resistance to diseases. If desired variants are not available, mutagens like radiation and certain chemicals can be applied to induce genetic mutations from which the desired mutants may be selected. Recently in vitro culture

techniques in combination with mutagen treatments have been applied to increase the probability of selecting mutants and promote the breeding of better crop cultivars, especially in vegetatively propagated crops.

Work at the laboratory has focused on the development of methods which assure the highest possible reproducibility in mutagenic treatments. The laboratory has actively contributed to standardizing neutron irradiation of seeds in reactors by developing a special facility for this purpose and to the establishment of accurate treatments with chemical mutagens. The latter aspect is studied with the aid of isotope labelled compounds.

As each crop species varies in reproductive capacity (number of progenies per plant) and reproductive system (self- or cross-pollinated sexual reproduction or asexual propagation) a universal breeding approach cannot be taken and species-specific procedures have to be applied. Several important crop species are difficult to improve genetically by conventional breeding methods because of sterility (no seed setting) or because of the lack of desirable characters in the available germ plasm (e.g. resistance to diseases and pests). Such species include bananas and plantains which are currently under study at the laboratory.

Activities that fall within the laboratory's terms of reference are supported by research and development, training, and the provision of a mutagen treatment service to plant breeding institutes in Member States.

The following research is actively pursued:

- comparison of genetic variation arising in tissue culture (somaclonal variation) with that induced either by irradiation or by chemical agents using maize as the model species,
- improvement of disease resistance in banana and plantain by mutation breeding using in vitro techniques,

- improvement of environmental stress tolerance in Azolla by mutation induction to create mutants tolerant to high salinity, toxic aluminium levels and to certain herbicides,
- investigation of methods of mutation breeding of cassava and yam which are the most important staple food crops of the tropics, but so far have received very little systematic attention by plant breeders.

Contributions are also made to

- increasing the efficiency of mutation breeding of cocoa by using in vitro techniques,
- investigating the effectiveness of laser radiation to induce mutations,
- inducing mutations in tissue cultures of citrus and date palm,
- regenerating in vitro and inducing mutations in garlic,

The laboratory of the plant breeding Unit has greenhouses and experimental fields as well as facilities for aseptic in vitro manipulation of plant cells and tissue cultures. A plant cytology laboratory and a specialized laboratory for chemical mutagen application with a bio-hazard cabinet are available, as well as a ^{60}Co gamma cell for in vivo and in vitro irradiation of plant material, and facilities for radioisotope work. Four walk-in growth chambers with controlled temperature, humidity and artificial illumination are used for the culturing of plant material. The swimming pool type ASTRA reactor of the Austrian Research Centre, Seibersdorf, is used for fast neutron irradiation.

Supporting services

A mutagen treatment service is provided free of charge to plant breeding institutes in FAO and IAEA Member States. In vivo and in vitro material can be exposed to gamma rays from ^{60}Co or to fast neutrons using the facilities described. The doses are carefully calibrated to assure reproducible effects (service treatments with chemical mutagens are not provided).

Training

An interregional training course on "Induction and use of mutations in plant breeding" is held every year for twenty participants. In addition, about eight individual fellowships per year are awarded to young scientists from Developing Countries for specialized training in different aspects of mutation breeding.

ANIMAL PRODUCTION

Animals play an important role in meeting man's need for food, clothing and energy. Ruminant animals (cattle, sheep, goats, buffaloes and camelids) form the largest proportion of domestic livestock in developing countries. The dependence of man on such animals is increasing, particularly in developing countries, because ruminants can convert materials of little or no value to products which are of considerable economic and nutritional value, such as meat, milk, butter, cheese, wool, leather or to draught power. Animal production in developing regions is often limited by poor reproductive performance, inefficient utilization of potentially available feedstuffs, poor adaptation to the environment and infectious and parasitic diseases. The Animal Production Unit supports activities aimed at improving the productivity and health of livestock in tropical and sub-tropical countries by way of research and development, the provision of quality control services, standardized diagnostic kits, training and other ancillary services.

The three major disciplines are:

- nutrition
- reproduction
- disease diagnosis

Nutrition

The laboratory uses the rumen simulation technique (RUSITEC), in which rumen microorganisms are maintained in vitro in an artificial rumen under normal physiological conditions, to evaluate with the help of isotopic tracers the fermentative digestion of crop residues and agro-industrial by-products. If the RUSITEC results indicate satisfactory fermentation with regard to digestibility, production of end products of fermentation such as volatile fatty acids and ammonia and the synthesis of microbial protein, then the feedstuff can be of potential value for ruminants and will be tested further by animal nutritionists in Member States. In addition, isotopes are used with the RUSITEC in formulating and testing of new diets based on fibrous residues. Investigations of mineral nutrient requirements of ruminant lifestock, aimed at improving reproductive performance, are planned in the future.

Reproduction

One of the major causes of the poor productivity of livestock in Developing Countries is a low reproduction efficiency. This, in turn, is due to a number of factors i.e. livestock mismanagement, poor nutrition, climatic stresses and disease constraints. The influence of these factors on reproduction can be monitored by measuring the levels of reproductive hormones such as progesterone in biological material, e.g. blood or milk. A simple and cost effective method for the quantitative determination of these hormones is the immunoassay technique which employs either radioisotopes (radioimmunoassay, RIA) or enzymes (enzyme immunoassay, EIA). The laboratory has developed RIA and EIA kits for progesterone determination in biological fluids of various livestock species. In 1988 approximately 400000 assay

units were distributed to participants in FAO/IAEA Co-ordinated Research Programmes and to Technical Co-operation project counterparts in Developing Countries. These kits will allow researchers to monitor the reproductive status of animals and subsequently introduce improvements in livestock management to improve reproductive efficiency.

Disease diagnosis

The activities of the laboratory are focused on the use of enzyme linked immunosorbent assay (ELISA) in the diagnosis of animal diseases. The ELISA kits developed by the laboratory for the diagnosis of diseases such as rinderpest, brucellosis, babesiosis, infectious bovine rhinotracheitis (IBR) and trypanosomiasis are designed for use under conditions found in laboratories in Developing Countries. Each kit contains a detailed protocol and information on kit contents and assay trouble shooting and has sufficient reagents to carry out 40000 assays. Development work is underway on the use of radioactively labelled DNA probes for detecting disease agents and the production of monoclonal antibodies for use in disease diagnostic kits.

Supporting services

The nutrition laboratory produces analytical standards for the *in vitro* digestibility technique, volatile fatty acid determination by gas-liquid chromatography, and fibre fractionation by the van Soest method. The RIA laboratory tests and provides suitable radiometric detection systems, simple and multiple micropipette systems and contamination meters, in addition to the advisory backup services already available with the kits. An external quality control service for the progesterone kits has been established.

Training

A training course on "Isotope-aided techniques in ruminant nutrition" is held every two years for 15 to 20 young scientists from Developing Countries. In addition, fellows and cost-free interns receive in-depth training in nuclear and related techniques in the areas of nutrition, reproduction and disease diagnosis through active participation in on-going research and development work.

E MOLOGY

Vast amounts of food are destroyed every year by crop insect pests, particularly in Developing Countries. Other insect pests are vectors of animal diseases and may also be dangerous to man. Prevention of damage by modification of agricultural or animal holding practices, and by extensive use of insecticides has obvious limitations. A biological method of eradicating or controlling insect pests, the sterile insect technique (SIT), consists of the repeated release of large numbers of laboratory reared and radiation sterilized insects in the infected area to suppress the indigenous insect population. As matings between the sterile and the wild insects produce no viable offspring, continuing releases of sterile insects over successive generations leads to a gradual decrease and finally to the eradication of the pest.

The SIT has been used successfully since 1954 against many species of harmful insects in different parts of the world. The laboratory has participated in programmes against

- the codling moth and olive fly in Europe
- the Mediterranean fruit fly in the Mediterranean area and in Central and South America
- the tsetse fly in Africa.

Work at the laboratory consists of

- entomological research
- development of methods for all phases of SIT projects
- training
- servicing of SIT projects.

The following two major pests have received most substantial attention at Seibersdorf:

The Mediterranean fruit fly (*medfly*)

This widespread insect attacks more than 200 varieties of fruits and vegetables. At Seibersdorf a 500 m^2 pilot rearing facility is used to develop mass rearing techniques for medflies to be used in SIT projects.

A SIT programme based on Seibersdorf developmental work has been successfully implemented in Mexico where eradication of the medfly is estimated to produce annual savings of approximately US$ 500 million. Continued research aims at further development and improvements in mass rearing, among others by using local diet ingredients for feeding.

The tsetse fly (Glossina spp.)

This exclusively bloodsucking insect is a vector of trypanosomes that cause sleeping sickness in human beings and fatal infections in cattle. The presence of tsetse flies represents, therefore, one of the main obstacles to

rural development in many African countries. While the natural low reproductive rate of the fly resulting in low density field populations makes the tsetse a good target for SIT control, it is also a major obstacle to laboratory mass rearing. In recent years advances in rearing techniques have been made at Seibersdorf by replacing living hosts as food sources with an artificial system using blood obtained from a slaughter house. The diet, when freeze-dried, can be stored for many months and easily shipped to any place in the world. Artificial diets to replace blood by commercially available ingredients are now being developed. A successful SIT project, for which a backup colony was kept at the laboratory, has been completed in Nigeria. Present work involves continuing efforts to improve feeding and rearing procedures of several other Glossina species.

General research and development work in support of sterile insect technologies is being undertaken in the following areas:

Mass rearing

The ability to rear large numbers of insects is a major requirement for a successful SIT project. In some cases the numbers required may reach hundreds of millions of insects each week. The quality and vitality of the insects must be adequate for the sterile ones to compete in mating ability with the native population. Furthermore, since the rearing of insects for release may comprise up to 70% of the costs of an SIT project, constant effort is required to find more effective and efficient rearing procedures. Locally available supplies and feed are investigated for use in the mass rearing system in areas where a project will be implemented. The objective is to support local economies and lessen the dependence of SIT projects in Developing Countries on

imported goods. Additional species and strains of insects are colonized at Seibersdorf to provide material for the biological studies needed to plan an expanded application of SIT into new areas.

Sexual sterilization

Means are needed to sexually sterilize the males produced for an SIT project without altering their behaviour after release in the field. Gamma radiation is commonly used to induce dominant lethal mutations in the sperm of treated insects to render them sterile. Experiments on irradiation are performed to determine the optimal doses and application time during the insect's development, so that somatic damage to the insect is negligible.

Prerelease and release handling

Sterile, laboratory reared insects must be delivered to the field and released with little loss in viability. Suitable packaging and release techniques are developed at the laboratory.

Insect biology

Conduct of a successful SIT project requires extensive knowledge of all aspects of the target insect's biology, in particular its reproductive physiology. The necessary studies on the insect species of interest are carried out at the laboratory.

Genetic sexing

Since sexually sterile males are the active components in an SIT project, females, which are produced along with the males, make no positive contribution while they do add to the costs of the project. Unfortunately,

for most insects a separation of the sexes in large numbers is not conveniently possible. One project attempts to use genetic manipulation to eliminate medfly females at an early stage in the rearing process. When successful, males will carry genetic traits which make them exclusively resistant to some lethal factor which can then be applied to eliminate females.

Microbial control

The SIT is most effectively applied when the number of native insects is low. The sterile male can then seek out the remaining fertile females and render them non-productive. Where natural factors that reduce populations are lacking, artificial means are required. Research is done at the laboratory to find and develop strains of the bacterium Bacillus thuringiensis, for use in bait sprays for suppressing wild populations of the medfly. This bacterium is safe for beneficial insects and higher forms of animals and is more environmentally acceptable than chemical insecticides.

Supporting services

Services are provided in support of Co-ordinated Research Programmes and Technical Co-operation projects on medflies and tsetse flies. Large quantities of freeze dried blood are produced at Seibersdorf and supplied to laboratories maintaining tsetse flies. Back-up colonies of tsetse flies are maintained for SIT field projects as well as stocks of mutant strains of medflies for other laboratories doing genetic research. Entomological equipment is designed, tested and procured for other laboratories.

Training

Approximately six fellows at a time are trained for periods from a few months up to a maximum of two years under fellowship arrangements. An average of 12 fellowship holders are accepted each year.

AGROCHEMICALS

Agrochemicals in the form of fertilizers and of pesticides are universally used to increase crop yields and reduce damage to plants, crops or animals. Their indiscriminate application may pose hazards to human health and the environment. Radiotracer aided studies are conducted on the dissipation and fate of these chemicals and their residues in order to develop more effective methods of application and to ensure safety to the comsumer and protection of the agricultural environment.

Three fields of studies are supported by laboratory work at Seibersdorf:

- investigation into the fate of trypanocidal drugs in animals,
- development and preparation of several controlled-release formulations of pesticides,
- bioconversion of agricultural waste to animal feeds and industrial chemicals.

Trypanocidal drugs

The fate of the trypanocide drugs Berenil, Homidium and Samorin and their residue levels in animals were studied. Analytical methods were developed for the determination of these residues in animal tissues, blood and milk. With the setting up of a laboratory at the Kenya Trypanosomiasis Research Institute in 1987 and the completion of the training at Seibersdorf of two fellows for that laboratory the project was then terminated. The methodology developed at Seibersdorf can be now utilized by Member States.

Controlled release formulations of pesticides

Pesticides are often applied in excessive amounts to compensate for their environmental dissipation and degradation and to make sure that the expected effects are obtained. In a controlled-release formulation the active ingredient is slowly released at predetermined rates. This method of application decreases environmental hazards and also saves cost. Laboratory and greenhouse experiments on controlled release of pesticides are performed at Seibersdorf. The results are field tested by Technical Co-operation counterparts and Co-ordinated Research projects contractors. Present studies include:

- Formulation of insecticides used in the control of the tsetse fly. Cotton fabrics impregnated with controlled release formulations of insecticides are used as targets. The formulations include inert carrier chemicals which reduce the degradation of the pesticides by sunlight and leaching by rain. The ultimate objective of these experiments, in which ^{14}C labelled insecticides are used, is the development of a target screen for trapping which will remain effective against tsetse flies for several months.
- Formulation of herbicides and insecticides for the control of weeds and insect pests affecting rice. Natural polymers such as alginates or rubber and synthetic polymers such as polyethylene vinylacetate are studied as protectors of carbofuran in one project. In another biodegradable polymers are used to protect herbicides employed in the control of weeds in rice/fish agro-ecosystems. The herbicide in this type of formulation is incorporated into a biodegradable matrix which is then crosslinked-polymerized, trapping the herbicide and allowing its release, at a controlled rate, to reduce its toxicity to rice plants and to fish.

- Formulation of pesticides for other agro-ecosystems.

  Controlled-release formulations of aquatic herbicides have been developed and tested against weeds such as water hyacinth and hydrilla. Similarly, formulations of carbofuran, originally tested against insect pests of cotton in Pakistan, as well as other insecticides, will be tested against insect pests of vegetables and of banana plants.

Bioconversion of agricultural waste

This project involves screening of microbial strains for their ability to degrade ligninocellulose, in an attempt to develop cultures capable of bioconverting agricultural wastes to animal feeds and industrial chemicals. In this project, the laboratory is supporting a Co-ordinated Research Programme.

Services

Co-ordinated Research Programmes and Technical Co-operation projects are supported by laboratory services including:

- procurement, purification, quality control and supply of radioactively labelled pesticides
- preparation, supply and analysis of pesticide formulations
- analysis of samples for pesticide residues
- expert services

Training

Training to scientists from institutes participating in Co-ordinated Research Programmes is provided and involves participation in on-going

research and development work of the Unit. The training includes the use of radioisotopes and radioanalytical techniques, as well as that of analytical techniques in organic chemistry such as gas chromatography, gas-liquid chromatography, high pressure liquid chromatography and mass spectrometry.

PHYSICS, CHEMISTRY AND INSTRUMENTATION

The earliest tasks of the Agency's Laboratories were within the scope of physics and chemistry. Metrology of radionuclides, radiation dosimetry and radioanalytical chemistry were the main disciplines, soon to be followed by tracer work in support of hydrology. Sophisticated instrumentation had to be acquired, developed and maintained, and this required the services of an electronics group which, once established, soon began to render services also beyond the Laboratories' own requirements. When the main task of the physics group, the preparation and distribution of absolutely calibrated radioisotope solutions, was terminated because adequate services had become available at national standardization laboratories in the Member States, the staff of that group and that of the electronics group were joined into an Instrumentation and Physics Unit. Since 1985, this newly formed Unit joined three other Units dealing with activities supporting the IAEA's programmes in physical, chemical and life sciences, i.e. the Chemistry, Dosimetry and Isotope Hydrology Units, in the Physics, Chemistry and Instrumentation Laboratory (PCI).

The PCI Laboratory provides support to Agency programmes in the physical, chemical and life sciences by conducting and co-ordinating research and development work, by providing calibrations and analytical and measurement services, and by advising on and assisting in Co-ordinated Research Programmes

and Technical Co-operation projects. Training is also performed in all the various activities of this laboratory.

INSTRUMENTATION AND PHYSICS

Electronic instruments of various degrees of sophistication, computers and accessory devices are used in practically all laboratories throughout the world, particularly in those using nuclear and isotope techniques. In many Agency projects in Developing Countries, serious problems are caused by a lack of staff adequately trained to work with, maintain and repair complex electronic equipment.

The Instrumentation and Physics Unit provides supporting services to Agency programmes involving instrumentation, by carrying out development work and by the training of scientists and technicians to use, repair, maintain and modify electronic instrumentation.

Separate laboratory rooms have been set up and equipped for the following purposes:

- Analog electronics
- Microprocessor development
- Microcomputer applications
- Neutron moisture gauging
- Electronics training

The following projects are handled:

Neutron moisture gauges

The water content of soil is an important parameter in water management and irrigation practices. With neutron moisture gauges this content can be measured simpler and faster than by traditional methods. Up to now, more than a hundred neutron moisture gauges have been provided to projects in developing

Member States. Guide lines are being prepared for the users, covering proper operation and calibration procedures for various soil conditions. Training is provided involving field measurements and class room exercises to estimate water requirements of crop.

IAEA UNO-LAB Kits

In an effort to assist and to standardize electronics training in Developing Countries, simple laboratory kits are provided for local assembly. IAEA UNO-LAB kits consist of the components of a single channel radiation analyser and a radiation monitor together with instructions for assembly, testing and use. So far, about 300 such kits have been distributed to 50 countries.

Development of electronic instruments

Research programmes and Technical Co-operation projects sometimes require special instruments which are not commercially available. Instruments built by the Unit have, among others, included:

- a ^{15}N emission spectrometer
- a radioimunoassay analyser
- a urine analyser
- a gamma-ray density scanner

Evaluation and maintenance of instruments

The Instrumentation and Physics Unit collects information from commercial manufacturers of instruments to be used in Technical Co-operation projects concerning specification and availability of products offered, spare parts and service facilities, delivery time and other details and stores this

information for use by Technical Co-operation technical officers. The Unit also assists in the evaluation of instruments, sometimes also checking their performance in its electronics workshop.

Each year the Unit sends three to four staff members to Developing Countries as experts, to instruct local technicians in development and repair work. If necessary, a limited amount of repair work on electronic instruments to be utilized in IAEA's projects is also undertaken at Seibersdorf. A Nuclear Instrumentation Network (NIN) aimed at a better co-ordination of all the efforts concerned, having as ultimate objective the reduction of defective equipment provided to Member States within the frame of Technical Co-operation projects from the present estimated value of 25% to less than 10% within three years, is planned to become operative in the near future.

Training

Fellowship training to three fellows per year is provided in the operation, calibration and application in the field, of neutron moisture gauges. Four to five fellows are accepted for training in the design, construction and repair of nuclear instrumentation such as detectors, preamplifiers, filters, and microprocessor techniques. Training on personal computers in computer aided design, database, data organization and data processing in nuclear measurement systems is emphasized.

Some of this training is offered in the form of group training, for a period of six months, to a maximum of eight trainees at a time.

CHEMISTRY

The activities of the Chemistry Unit support the Agency's programmes through the provision of several analytical chemistry services and training programmes intended to increase the technical ability of specialists from Developing Countries in analytical chemistry. Training, which covers different aspects of modern nuclear and other micro-analytical techniques, involves determination of trace elements in various inorganic materials, in biological substances and foodstuffs, in soils, rocks and minerals, in rain and other natural waters, as well as the determination of radioactive contaminants in food products and environmental compartments.

Nuclear methods, such as neutron activation analysis, are competing in this field with other modern single or multi-element determination techniques such as

- atomic absorption spectrometry
- inductively coupled plasma atomic emission spectrometry
- UV spectrophotometry
- conventional and laser based fluorimetry

The Chemistry Unit is equipped for the use of all these and several other techniques and uses them in a number of projects performing approximately 10000 determinations per year.

A more traditional role of the Unit, which has recently received renewed emphasis, is its participation in environmental radionuclide determinations. Available techniques for this purpose are:

- gamma spectrometry, using sodium iodide and germanium detectors
- alpha spectrometry, using silicon detectors
- beta emission measurements, using anti-coincidence equipment
- liquid scintillation counting

- chemical separation techniques for different radionuclides.

Also traditional is the analytical support given to Agency projects in uranium prospecting and preparation, including the determination of uranium in biological materials.

The Chemistry Unit also contributes to Agency programmes by advising on the installation of laboratories and equipment, by providing reference materials and intercalibration services and by the training of fellows individually or through the conduct of training courses.

Analytical Quality Control Services (AQCS)

This programme started in 1961 and was devised to assist laboratories which are engaged in the analysis of nuclear, environmental, biological or marine materials for major, minor or trace elements, as well as of radionuclides or some stable isotopes, to verify the accuracy of their results through the use of reference materials and by participation in intercomparison runs. Almost 60 different reference materials are presently available and several new intercomparisons are started each year. The Chemistry Unit selects, homogenizes, tests and packages candidate materials and distributes samples to participating laboratories in Member States. All the necessary calculations on results reported by these laboratories are performed at the laboratory. Successful intercomparisons, which yield sufficiently consistent data, are used as a basis for the certification of new reference materials.

Trace elements as air pollutants

The Unit gives support to the Background Air Pollution Monitoring Network (BAPMON) of WMO (World Meteorological Organization), by analysing for it samples of precipitation and dust particles collected by stations of the

Network distributed all over the world. The samples are analysed for ten constituents including lead, zinc, cadmium, and various anionic pollutants such as sulfate and nitrate.

Trace elements in human diet

Trace elements have received considerable attention by the public as well as by scientists during the last three decades. Increasing awareness of the role played by minute concentrations of chemical elements and certain molecules in human, animal and plant metabolism and of their toxicity, has been paralleled by the development of increasingly sensitive methods for their determination.

The Unit contributes to a Co-ordinated Research Programme on daily dietary intakes of nutritionally important trace elements. The purpose of this CRP is to obtain comparative data on the average daily intake of 25 nutritionally important minor and trace elements through diets consumed in different countries.

Fallout radioactivity monitoring

A new programme dealing with "Fallout Radioactivity Monitoring in Environment and Food" (MEF) was initiated by the Agency in 1986 in response to the Chernobyl accident. The main objectives of the programme are:

- to provide a set of recommended reference methods for the determination of key radioactive contaminants in basic environmental compartments (air, water, soil, grass) and food;
- to provide additional reference materials and intercomparison services;

- to assist developing Member States in establishing analytical facilities;
- to organize training courses.

In this frame the laboratory has published a guidebook on fallout radioactivity measurements. Selected methods and radiochemical procedures for strontium-90 and actinide analyses are evaluated and tested in the laboratory. Services are provided in support of a Co-ordinated Research Programme on "Rapid instrumental and separation methods for the determination of radionuclides in food and environmental samples". A number of intercomparisons are being carried out to produce natural matrix reference materials with known (relatively high and actual) concentrations of radionuclides.

Supporting services

Several Co-ordinated Research Programmes and Technical Co-operation projects as well as national laboratories are assisted with technical advice through expert missions or by intercalibration and analytical services. The Unit also provides assistance to Members States in radioactivity monitoring. The demand in this field has greatly increased after the Chernobyl accident.

Training

Individual fellowship training for periods ranging from one month up to one year is offered in each of the analytical and radiochemical techniques available at the laboratory as well as in analytical quality control work, including the relevant statistics.

DOSIMETRY

The accurate adjustment of a prescribed dose delivered in radiation therapy is of utmost importance since insufficient dose will not achieve the desired effect (e.g. destruction of malignant growth) while too high a dose will unnecessarily increase the damage to normal tissue.

The IAEA and the WHO (World Health Organization) have together set up a network of Secondary Standard Dosimetry Laboratories (SSDLs) in which the laboratory of the Dosimetry Unit at Seibersdorf serves as the central laboratory. SSDLs are laboratories at the national or regional level that have been authorized by a government to perform calibration measurements at the secondary standard level. At present, the IAEA/WHO Network of SSDLs consists of about 50 laboratories, 40 of which are located in Developing Countries. It is supported by twelve national primary standardizing laboratories holding affiliated membership and five collaborating international organizations.

The main objectives of the network are

- to improve the accuracy and reliability in applied radiation dosimetry by providing the appropriate knowledge to centres and laboratories dealing with radiation therapy and radiation protection,
- to promote the compatibility of methods applied for calibration and performance of dosimetry in order to achieve uniformity of measurements throughout the world,
- to facilitate links between the member laboratories and the international system of radiation measurements through primary standard dosimetry laboratories and establish measurement traceability to BIPM (Bureau International de Poids et Mesures).

The major tasks of the Dosimetry Unit are

- to organize dose intercomparisons among member laboratories of the SSDL network;
- to provide similar services to hundreds of radiation therapy centres each year;
- to accept SSDL staff for training;
- to undertake technical co-operation missions to SSDL's;
- to design and develop special dosimetry devices for use by the SSDLs.

For use in these tasks the Unit has two irradiation rooms housed in an irradiation bunker, a ^{60}Co teletherapy unit and two X-ray machines with a total of three X-ray tubes. In addition, low level irradiators for calibration in gamma as well as neutron radiation fields are available.

In detail the following work is performed:

Postal dose intercomparison of ^{60}Co dosimetry

About 50 sets of thermoluminescent dosimeters (TLDs) are sent out every second year to member laboratories of the SSDL network for irradiation to a certain absorbed dose. The doses actually received are read and evaluated at the IAEA laboratory. Very good agreement, within the 2% limit of TLD reproducibility, has recently been achieved by all but a few laboratories. In future, intercomparisons will be performed by ionometric methods which have considerably higher reproducibility and permit the detection of smaller calibration errors. A redundant transfer instrument, consisting of a system of two ionization chamber/electrometer dosimeters, will be used in a new programme, called CARE (coherent and accurate reference instrumentation). The purpose of this programme is to improve the accuracy of calibrations at the SDDLs, link them into the world calibration network and give them confidence in the supervision of radiation dosimetry at local hospitals.

Postal dose calibration service

A postal dose calibration service for radiation therapy has been provided by IAEA and WHO since 1970. Sets of TLDs are prepared and calibrated by the Dosimetry Unit and mailed through WHO and its regional offices to participating hospitals in Developing Countries. There they are exposed under defined conditions to what the hospital laboratory believes is a specified dose. After their return to the Agency's Laboratories, the TLDs are read, the readings evaluated and compared with the quoted dose and the results reported back to the participant. Possible causes for the difference are discussed and appropriate action is suggested. At present more than 300 sets of TLDs are processed per year. The need for this service may be illustrated by the fact that, in recent measurements, about 70% of the hospitals served still showed deviations of more than 5% from the correct value and the number of participating hospitals increased by more than 100% over the recent years.

Support to SSDLs

Support to SSDLs through technical co-operation missions and through development of special equipment for laboratory use is another task of the Dosimetry Unit. The laboratory, in its role as central laboratory of the network, developed a whole safety package as a guidance for the establishment of SSDLs. In addition, a number of devices were designed including a precision calibration stand, a standard water tank made of perspex for in-phantom measurements, fast shutters for X-ray machines and an automatic remote-controlled filter wheel for determination of X-ray radiation qualities. Furthermore, the staff of the Dosimetry Unit developed basic concepts of neutron and gamma calibration irradiators. All these devices have been constructed by the mechanical workshop of the IAEA Laboratories in

Seibersdorf or by local firms under IAEA supervision and have been made available to Developing Member States through the Technical Co-operation Programme of the Agency.

Training

Senior scientific staff from calibration laboratories frequently pays scientific visits, normally lasting two or three days, to discuss techniques and instrumentation. Group training is provided twice yearly, for periods of about two months, to four junior scientists of Network laboratories. Additionally, one or two trainees per year can be accepted for individual fellowship training lasting up to one year.

Follow-up training is also available at regional calibration workshops organized by the staff of the Dosimetry Unit together with the Agency's Dosimetry Section in one of the Network's SSDLs. A three years'cycle of such workshops is maintained, covering the regions Asia/Pacific, Latin America and Europe/Middle East/Africa.

ISOTOPE HYDROLOGY

Water is one of the most essential natural resources available to man. In addition to its use as drinking water, large quantities of it are required for household, industrial and agricultural uses. Hydrological data are needed for a proper management of this resource and in their collection radioactive or stable isotope tracers of the natural constituents of water, hydrogen and oxygen, are very useful tools. Isotope techniques have distinct advantages over conventional techniques, such as the use of dyes to trace water courses, which suffers from possible losses by adsorption or chemical reaction with dissolved constituents.

The Isotope Hydrology Unit, which is the only Unit of the Laboratories situated in Vienna and not at Seibersdorf, supports the Agency's programme in hydrology by the servicing of research contracts and Technical Co-operation projects, and by monitoring isotopes in precipitation for a worldwide network of stations. The services include

- analysis of water samples
- distribution of reference materials
- assistance in the installation of isotope hydrology laboratories in Member States
- development of standard measurement procedures
- organization of analytical intercomparisons
- training of fellows

Analytical facilities are available for

- electrolytic enrichment followed by liquid scintillation or proportional gas counting of tritium in water;
- proportional gas counting of ^{14}C in water;
- mass spectrometry for stable isotope ratio determination of deuterium and ^{18}O in water and ^{13}C in carbon dioxide;
- chemical analysis for major and trace ions in water, conductivity and pH measurements.

In detail, the following work is performed:

Analysis of water

The analysis of natural water samples is performed for Technical Co-operation projects, research contracts and the worldwide precipitation network. For Technical Co-operation projects, approximately 850 samples are analysed each year for their deuterium/hydrogen and $^{18}O/^{16}O$ ratio, 60 samples for their $^{13}C/^{12}C$ ratio and ^{14}C content of dissolved carbonates,

600 samples for tritium and 200 samples to determine the different anions and cations, as well as pH and conductivity. For research contracts, in addition, 300 water samples per year are analysed for deuterium and ^{18}O, 100 for tritium and 30 for ^{14}C. For the precipitation network, 500 water samples per year are analysed for deuterium, ^{18}O and tritium.

The methods used are:

- ^{18}O is determined by equilibrating the water samples with carbon dioxide which is then used for the measurement using an isotope ratio mass spectrometer;
- deuterium is determined by mass spectrometry on hydrogen gas evolved from water by reduction with zinc;
- $^{13}C/^{12}C$ ratios, ^{14}C and tritium in natural water samples are determined, after appropriate pretreatment, by highly sensitive measuring instruments (mass spectrometers, gas proportional counters or liquid scintillation counters, respectively) with detection limits meeting the low concentrations of these nuclides in the various samples.

Reference materials

Several reference materials such as

- water
- carbonates
- sulfates
- sulfides
- nitrogen
- natural gas

covering a range of isotope compositions in natural substances, are kept on stock. Samples are shipped to laboratories in Member States upon request.

Intercomparisons

At regular intervals intercomparisons are organized to assist laboratories in different countries to check their analytical performance in the determination of stable isotope ratios and of tritium.

Installation of isotope hydrology laboratories

Within the framework of Technical Co-operation projects, technical assistance is supplied to isotope hydrology laboratories in Member States. This assistance varies from the construction of equipment to advice on the purchase of equipment and development of measurement procedures.

Training

Individual fellowship training in hydrological techniques and isotope analysis is provided to between three and seven fellows per year for periods ranging from two weeks to six months.

SAFEGUARDS RELATED ANALYSIS

The Agency is required under its Statute to make sure that any assistance provided by it to a Member State should not promote any military purpose. In this context the establishment and administration of safeguards is foreseen and the Agency is specifically empowered to "acquire or establish any facilities, plant and equipment useful in carrying out its authorized functions". Since these words were written in 1955, the Agency has been given additional safeguards duties under the Non-Proliferation Treaty (signed in 1968).

A basic element of the Safeguards system is the verification of safeguarded material, to which Agency safeguards are applied, by physical inspection, sampling and measurement. The concept of the IAEA's Safeguards Analytical Services was laid down in the early 1970s. It foresaw that the Agency would establish and operate a fully equipped Safeguards Analytical Laboratory (SAL). The analytical capability of SAL was to be such that samples taken from any key measurement point of the fuel cycle could be analysed and that the results of these analyses would meet the requirements of safeguards accounting verification. However, the capacity of SAL was never intended to be sufficient for analysing all the 5000 or more inspection samples which, at that time, were annually anticipated. To accommodate such a number of samples, SAL was to become part of a Network of Analytical Laboratories (NWAL), along with existing laboratories nominated by Member States for this purpose at the request of the IAEA. This approach was selected for reasons of economy and flexibility of services, but also because it provided the possibility of controlling the accuracy of the analyses of actual inspection samples by the intercomparison of results obtained by different verification laboratories. Such an intercomparison was to become an important feature of the Quality Control Programme that the IAEA would maintain to ensure the quality of measurements made by the network.

In 1972-1973, the IAEA carried out an experiment to investigate the operational aspects of the intended system and the performance to be expected in the analysis of typical plutonium products which were supplied by the spent fuel reprocessing plant of WAK (Leopoldshafen) and the fuel fabrication plant ALKEM (Hanau) in the Federal Republic of Germany. This experiment, called PAFEX-1, was performed by SAL and eight other laboratories of NWAL. After the successful completion of this first test twelve laboratories, including SAL,

took part in a similar exercise (PAFEX-2) in 1974-75. In this case, the input solutions from the spent fuel reprocessing plant of EUROCHEMIC (OECD) in Mol, Belgium, were analysed.

NWAL became operational in 1975. That year about 350 samples, mostly uranium products but also a few of plutonium dioxide, were analysed at the IAEA's laboratories, while seven other network laboratories had been asked to analyse a total of about 130 uranium samples.

The early analyses at SAL were carried out in a small facility at the Laboratories' main building. In 1975, SAL moved into a new building where uranium and spent fuel analysis was started in 1976, followed by plutonium analysis in 1979. To the original 750 m^2 of working space available there, a further 250 m^2 were added in 1983. Since then SAL has worked at full capacity and has analysed about 1100 samples annually, including uranium, plutonium and spent fuel samples. Safeguard's related analytical services are now continuously provided in a joint effort of the Technical Services Section of the Department of Safeguards and the Safeguards Analytical Laboratory at Seibersdorf, in collaboration with the Network of Analytical Laboratories and the Data Evaluation Section of the Department of Safeguards.

SAL has developed a training programme for Safeguards inspectors to demonstrate the requirements for sample acquisition and handling. Currently, training programmes for inspectors to allow them to make on-site destructive analyses are being developed.

The work of SAL is split between two Units, the Chemical Analysis Unit and the Isotopic Analysis Unit. Administration and supporting services are shared by both.

CHEMICAL ANALYSIS

The Chemical Analysis Unit of SAL

- controls the flow of samples in NWAL and SAL
- operates the Laboratory Information System
- checks the results according to the Laboratory Quality Control System
- prepares the report on analyses

It also performs

- the chemical assay of uranium
- the preparation of uranium samples for isotopic analysis
- the chemical assay of plutonium
- the chemical purification of plutonium samples for isotopic or isotope dilution analysis
- the chemical treatment of spent-fuel samples
- the preparation of tracer solutions

Methods of wet-chemical analysis

The main methods used are:

- automatic potentiometric titration for U and Pu
- ignition gravimetry for U, Th and Pu
- emission spectrography for impurities

Chemical separation treatment is also performed before isotopic analysis of Pu and spent-fuel samples to ensure accurate spectrometric results. A new generation of automatic equipment using programmable robot arms will soon come into operation.

ISOTOPIC ANALYSIS

The Isotopic Analysis Unit of SAL provides

- alpha spectrometry
- gamma spectrometry
- mass spectrometry
- electronic and mechanical workshop services

Mass spectrometry

Three fully automatic thermal ionization mass spectrometers are used for the complete isotopic analysis of all samples and for the elemental assay of fresh fuel and plutonium samples by isotope dilution.

- ^{242}Pu tracer is used in the isotope dilution technique for the measurement of elemental content in fresh fuels.
- ^{239}Pu tracer is used to determine the concentration of plutonium in industrial plutonium material originating from highly spent fuels; the technique allows a precision of 0.1% to 0.2% and a similar accuracy to be achieved.
- ^{239}Pu is also applied in the metal spike technique under test, at present, for safeguarding spent fuel reprocessing solutions with the goal of achieving precisions and accuracies of 0.1 to 0.2%
- Another technique, based on the simultaneous use of four isotope tracers, ^{233}U, ^{236}U, ^{242}Pu and ^{244}Pu, leads to even higher precision, using a calculation procedure known as internal calibration.
- Other sample loading techniques (such as resin beads) and data taking formats (such as total evaporation) are being investigated. If proven successful, they will allow the use of very small (a few nanograms) of material from a representative sample. In the proper

form, these quantities are small enough to allow even air mailing of the samples.

Radiometry

- Gamma spectrometry with sodium iodide scintillation detectors was the only acceptable method available to SAL in 1971 for the measurement of ^{235}U isotopic abundance in fresh uranium samples. The method is still in routine operation as a backup technique.
- High resolution semiconductors are now also available and used for a variety of analyses, including ^{235}U isotopic assay, ^{241}Am determination in plutonium products and fission product analysis in spent fuel.
- Alpha spectrometry is utilized in parallel with mass spectrometry to determine ^{238}Pu isotopic abundance in all plutonium bearing samples.
- High resolution gamma spectrometry (HRGS) is a new field for SAL which has already provided encouraging results in the isotopic analysis of plutonium and neptunium.
- X-ray techniques, developed for field work, will also be installed in the future to provide technical support and training facilities for the verification activities on plant sites.

Electronic and Mechanical Workshop (SAL)

An electronic and mechanical workshop located within SAL provides maintenance and repair for all instrumentation plus development of specialized components as required in the laboratory.

SUPPORTING SERVICES

Work at the Laboratories is supported by a number of services. These services are provided by the following three Units:

- Health Physics
- Mechanical Workshop
- Maintenance

Although the services of these Units are mostly for internal needs, occasionally they are also utilized for Agency's projects not directly related to the activities of the Laboratories.

A Library complements the technical/scientific activities performed at the Laboratories.

HEALTH PHYSICS

The Health Physics Unit provides advice on radiation protection and monitors all operations in which radioisotopes are handled, including also decontamination and waste management. It is supervised by the Head of the Radiation Protection Services Section (NENS) and is administratively independent of the Laboratories.

Analytical work carried out by the Unit includes the monitoring by whole body counting (700 measurements per year) and urine analysis (400 samples per year for gamma emitters and 400 for plutonium by alpha counting or alpha spectrometry), for possible incorporation of radionuclides. The staff of the Unit also provides expert advice on many aspects of personnel monitoring and environmental surveys for several Technical Co-operation projects.

Training

The Unit is responsible for the training of the Laboratories' staff in radiation protection. In addition fellows from Member States receive training during the "Introductory course on radiation protection services", organized by the Agency each year.

MECHANICAL WORKSHOP

The Mechanical Workshop provides assistance to all laboratory Units in the design, construction and testing of equipment, as well as in its maintenance and repair. It also provides similar services to other Agency Divisions and manufactures instruments for use in Technical Co-operation projects. Examples of manufactured items are radioactivity counters of unconventional design, seals for safeguards inspectors, and sample changers.

MAINTENANCE

The Maintenance Unit is responsible for keeping up all laboratory installations such as heating, cooling, water, electricity, compressed air and telephone equipment and for the cleaning and landscaping around the Laboratories. A separate maintenance building holds workshops for various trades including

- carpentry
- mechanical engineering
- electrical engineering
- painting

- plumbing
- gardening
- masonry

Occasionally, craftsmen from the Laboratories have been called upon also to render assistance to Agency projects abroad.

LIBRARY

The Laboratories' Library at Seibersdorf holds a stock of about 5000 books and periodicals. In addition, it can order material from the Main Library at the Vienna International Centre and from other libraries in Vienna and elsewhere. The library is utilized by the Laboratories' own staff, by trainees working at Seibersdorf under fellowship programmes and by participants in training courses.

ORGANIZATIONAL STRUCTURE OF THE IAEA'S LABORATORIES

IAEA'S Laboratories	Director
Agriculture Laboratory	Head
Soil Science Unit	Head
Plant Breeding Unit	Head
Animal Production Unit	Head
Entomology Unit	Head
Agrochemicals Unit	Head
Physics, Chemistry and Instrumentation Laboratory	Head
Instrumentation and Physics Unit	Head
Chemistry Unit	Head
Dosimetry Unit	Head
Isotope Hydrology Unit	Head
Safeguards Analytical Laboratory	Head
Chemical Analysis Unit	Head
Isotopic Analysis Unit	Head
Supporting Services	
Personnel Administration and Finance	Admin. Assistant
Library	Librarian
Health Physics Unit	Head
Mechanical Workshop	Head
Maintenance Unit	Head

APPENDIX

Description of some forms of assistance to which the Laboratories may contribute

Co-ordinated Research Programmes

Research contracts and agreements are awarded by the Agency to research centres, laboratories, universities and other institutions in Member States, for the conduct of projects of both applied and fundamental nature. Contractors are generally awarded about US$ 5000 per year and can spend the money on equipment and supplies or for hiring staff. While research contracts are usually awarded to institutes in Developing Countries, reseach agreements, carrying no funding, are awarded to institutes in Industrialized Countries. Research contracts and agreements form the basis of the IAEA's Co-ordinated Research Programmes. Participants from ten to fifteen institutes, from both Developing and Industrialized Countries, are co-ordinated by the IAEA to perform research work on a common theme, usually related to a problem in Developing Countries. Research contracts or research agreements are awarded on the basis of project proposals submitted by these institutes. The basic role of the IAEA in a Co-ordinated Research Programme is to define the programme of work, secure its financial backing, and ensure that the various efforts forming that programme are properly combined. To this end, Research Co-ordination Meetings are usually held at intervals of fifteen to eighteen months. One representative from each institute with a research contract or agreement in the programme is invited to the meeting at the IAEA's expense. Research contracts and agreements are awarded to research institutes for a period of one year and can be renewed up to a total project period of three years or, in some cases, five years.

When a Co-ordinated Research Programme is initiated, a letter of invitation is normally sent to all institutes known by the IAEA's project officer to be potentially interested. Formal applications to join the programme should be submitted on the relevant proposal form. For a research contract proposal Form N-17 and for a research agreement proposal Form N-20 must be used. Both forms can be obtained either from the IAEA in Vienna or from the appropriate government authority (e.g. Ministry, Atomic Energy Commission) dealing with nuclear matters. In most countries, the proposals require only the signature of the Principal Investigator and of the Head of the institute before submission to the IAEA.

Technical Co-operation projects

Technical Co-operation projects, many of which are supported by the Laboratories and referred to in this brochure, are initiated at the request of Developing Member States in order to transfer skills, knowledge and equipment. Within the frame of these projects, expert services are provided and training of scientists and scientific visits can be arranged.

Technical Co-operation projects differ from research contracts in a number of important respects:

- Technical Co-operation projects provide expertise through scientists who are already well versed in particular techniques (experts) and who visit the recipient institutions in order to train, advise, or otherwise assist local scientists.

- Technical Co-operation projects can support the transfer of technology through the training abroad in specific techniques of scientists from Developing Countries (see below for IAEA-Training Fellowships).

- Provision can be made through technical co-operation projects to supply larger items of equipment (e.g. a gamma-ray spectrometry system) than through a research contract.

Technical Co-operation projects aim at building up research capability of institutions in Developing Countries to the point where scientists are able to conduct such work independently and without further substantial outside funding when the project terminates. The inputs and time required to achieve these ends vary from institute to institute as well as with the nature of the problem(s). It is therefore impossible to give hard and fast guidelines as to the funds which are provided in each case. The IAEA does, however, encourage requests for assistance for technically sound projects which involve a multi-disciplinary approach. Projects may extend over more than one calendar year. The projects are financed by voluntary and extrabudgetary contributions from Member States, by funds from the United Nations Development Programme (UNDP), by gifts in kind, such as equipment, grants, cost-free fellowships and cost-free expert services, and from funds in trust.

All requests for IAEA Technical Co-operation Projects must be made on Form TA-1E, which can be obtained either from the IAEA in Vienna or from the government authority (e.g. Ministry, Atomic Energy Commission) dealing with nuclear matters. The completed form must then be submitted to the IAEA through the appropriate official government channels. Implementation of the Technical Co-operation project can begin not earlier than nine months after submission of the request. Therefore, any proposal to be considered for IAEA Technical Co-operation funding should be submitted to the IAEA by the end of March of the year preceding the year when funding is needed.

Training

Fellowship training

The IAEA offers fellowships to personnel from Developing Member States for training in the application of nuclear techniques. As a general rule, the applicant must have a suitable academic background and be currently working in the area in which further training is requested. Applicants should have a basic degree in science and be involved in a research programme. In addition, fellowships are sometimes offered to technicians for basic technical training, particularly relating to the operation and maintenance of nuclear instruments. The length of award of an IAEA fellowship is normally between three and twelve months. In exceptional cases, fellowships of longer duration may be awarded. It is not the objective of the IAEA's fellowship programme to support training which leads directly to a higher degree, although degrees are sometimes earned while completing fellowship training. The following limitations apply to fellowship awards by IAEA:

- Applicants must be from a Member State of the IAEA
- Applications must be endorsed by the government agency responsible for nuclear matters. Without this endorsement the fellowship application cannot be considered.
- Applicants must be employed by a Government, Ministry, Research Institute, University or similar body, and there must be ensurance of continued employment upon completion of the fellowship.
- In general, awards for training are not made if suitable facilities for the requested training are already available in the applicant's own country.

- The submission of an endorsed application does not constitute a guarantee that an award will be made. All applicants are evaluated by the IAEA and the selection is made on merit and according to the availability of funds and of a suitable host institution (which includes the IAEA Laboratories).

A fellowship may also be awarded for a scientific visit. This is usually intended for a senior scientist to enable him or her to visit one or more institutes in a particular geographic region over a period of two to four weeks. In exceptional cases, attendance at a scientific conference can also be included.

Applications for IAEA fellowships should be submitted on an Application for Fellowship and Scientific Visit Form No. TA-2ES (English-Spanish) or TA-2EF (English-French) obtainable from the Fellowship and Training Section of the IAEA or through the applicant's National Atomic Energy Commission or the Ministry responsible for nuclear matters.

Training Courses and Study Tours

A further feature of the IAEA's training programme is the organization of regional and interregional training courses. These are usually of short duration (four to six weeks) and can be attended by participants from Developing Countries. In Study Tours arranged by the IAEA the participants visit institutes in one or a number of host countries. Information about courses and study tours is distributed to appropriate organizations in Member States. The qualifications required and the application procedures are the same as those for training fellowships, except that Form TA-3E, Nomination for Training Course/Study Tour, should be completed and sent to the IAEA in Vienna through the appropriate official channels.

Sabbatical or Study Leave

It is possible to spend a period of sabbatical or study leave at the IAEA, including its Laboratories. Travel support plus a supplementary financial grant to partly cover cost of living are provided by the IAEA. An applicant must receive a base salary from her or his home institute in order to qualify for a sabbatical or study leave post.