IAEA BULLETIN

INTERNATIONAL ATOMIC ENERGY AGENCY

55-2-June 2014 • www.iaea.org/bulletin

Bringing the IAEA Nuclear Sciences and Applications Laboratories in Seibersdorf to Meet 21st Century Challenges

IAEA BULLETIN
is produced by the
Office of Public Information and Communication
International Atomic Energy Agency
PO Box 100, 1400 Vienna, Austria
Phone: (43-1) 2600-21270
Fax: (43-1) 2600-29610
iaeabulletin@iaea.org

Editor: Aabha Dixit
Design & Production: Ritu Kenn

IAEA BULLETIN is available
- online at **www.iaea.org/bulletin**
- as an App at **www.iaea.org/bulletinapp**

Cover Photos:
IAEA

Read this edition on the iPad

CONTENTS

IAEA Bulletin 55-2-June 2014

What the IAEA Laboratories Bring to the World 2
by Yukiya Amano

IAEA Laboratories in Seibersdorf: Then and Now 4
IAEA Department of Nuclear Sciences and Applications

ReNuAL: Renovation of the Nuclear Applications Laboratories 6
by Ruzanna Harman

Contributing to Food Security in the Context of Climate Change 7
IAEA Department of Nuclear Sciences and Applications

50 years of Successful Partnership: The Joint FAO/IAEA Division 9
by Aabha Dixit

Fighting the Global Cancer Epidemic Through Precise Measurements 10
IAEA Department of Nuclear Sciences and Applications

Building and Benefiting from Member State Laboratory Capacities 12
IAEA Department of Nuclear Sciences and Applications

How the Nuclear Applications Laboratories Help in Strengthening Emergency Response 14
IAEA Department of Nuclear Sciences and Applications

Accelerator Applications Support Nuclear Science and Technology 15
by Ralf Bernd Kaiser

The Development of Eldo Ngano I: The World's first Ug99 Resistant Mutant Wheat Variety 18
by Brian P. Forster

The Seibersdorf Labs through the Eyes of Visiting Scientists 20
by Norbertin M. Ralambomanana, Motlatsi James Ntho, Tahani Bashir Abd Elkareim and Fatimata Ndiaye

Tsetse Fly Genome Breakthrough: the FAO and IAEA Crack the Code 23
by Aabha Dixit

WHAT THE IAEA LABORATORIES BRING TO THE WORLD

I attach great importance to the IAEA's work in making nuclear technology available to developing countries for peaceful purposes. Through our technical cooperation programme, we help countries to improve the health, well-being and prosperity of their people and to respond to developments such as climate change, which affect us all.

The IAEA is unique in the UN family in having dedicated specialist laboratories that support its activities in the peaceful uses of nuclear technology.

The IAEA is unique in the UN family in having dedicated specialist laboratories that support its activities in the peaceful uses of nuclear technology. These laboratories, managed by the Department of Safeguards and the Department of Nuclear Sciences and Applications, develop innovative technologies and provide training to scientists from its 162 Member States.

The safeguards laboratories are critical to the IAEA's work to help prevent the spread of nuclear weapons. The nuclear applications laboratories, located in Vienna, Seibersdorf, near Vienna, and Monaco, help Member States tackle fundamental development issues such as food security, water resource management, human health, and the monitoring and management of environmental radioactivity and pollution.

Five of the eight nuclear applications laboratories in Seibersdorf are dedicated to agriculture and biotechnology and are jointly operated with the Food and Agriculture Organization of the United Nations (FAO). These laboratories specialize in insect pest control, soil and water management and crop nutrition, animal health and production, plant breeding and genetics, as well as food safety. This unique collaboration assists Member States in using nuclear technologies to enhance food production and food security as well as boost farmers' incomes. Our partnership with the FAO, now in its 50th year, is a model of best practice and of the 'One UN' approach.

In addition, the Dosimetry Laboratory works closely with the World Health Organization to help Member States use radiation safely and effectively in medicine, while the Nuclear Science and Instrumentation Laboratory helps countries to develop and use highly specialized instruments and diagnostic tools in various applications of nuclear science and technology.

Finally, the Terrestrial Environment Laboratory helps countries to monitor radiation in the environment, develop emergency response measures and improve the analytical and measurement capabilities of scientists in national laboratories.

I have seen for myself, when visiting dozens of IAEA Member States, the real difference which the work of our laboratories has made to the lives of countless people all over the world. For example, the environmentally friendly sterile insect technique was introduced in Africa with support from the IAEA and the FAO to control the tsetse fly, which transmits a parasitic disease that kills livestock and spreads sleeping sickness among humans. Tsetse flies have been successfully eradicated from the island of Zanzibar using the sterile insect technique and are presently being suppressed in parts of southern Ethiopia. Recently, our scientists have participated in deciphering the genetic code of the tsetse fly, an encouraging breakthrough which will assist future efforts to control one of the most dreadful livestock diseases in sub-Saharan Africa.

IAEA Director General, Yukiya Amano, with a group of Fellows receiving training at IAEA Laboratories in Seibersdorf.
(Photo: Kirstie Hansen, IAEA)

The nuclear applications laboratories in Seibersdorf are a significant asset to the IAEA and its Member States.
(Photo: Dean Calma, IAEA)

IAEA plant breeding and genetics experts have used radiation-induced mutation techniques to develop new varieties of crops that can thrive in unfavourable conditions such as drought and high altitudes. New varieties of wheat resistant to a disease known as wheat stem rust have been distributed to farmers in Kenya.

When the Seibersdorf nuclear applications laboratories celebrated their 50th anniversary in 2012, I decided that it was high time to modernize and upgrade them. In the same year, the IAEA General Conference gave its support and we launched a project known as ReNuAL (Renovation of the Nuclear Applications Laboratories), which aims to establish fit-for-purpose facilities and equipment at Seibersdorf. Good progress is being made and I hope to invite Member States to a ground-breaking ceremony at Seibersdorf before the end of 2014.

The nuclear applications laboratories at Seibersdorf are a significant asset to the IAEA and to our Member States. This edition of the IAEA Bulletin provides an overview of the work of the laboratories in finding scientific and technological solutions that benefit humanity. We hope it will give readers a wider understanding of the broad range of activities undertaken by these important laboratories.

Yukiya Amano, IAEA Director General

IAEA LABORATORIES IN SEI

1 On 28 September 1959, the first IAEA Director General, William Sterling Cole, inaugurated the construction project on the first IAEA laboratory in Seibersdorf by pouring the initial load of concrete into the laboratory's foundations. The laboratory officially came into operation in January 1962.

2 In 2012, the IAEA commemorated 50 years of dedicated support provided to Member States through the laboratories of the Department of Nuclear Sciences and Applications (NA laboratories) in Seibersdorf. The IAEA's Director General, Yukiya Amano, opened the celebration with a ribbon cutting ceremony for a laboratory exhibit on display for the occasion.

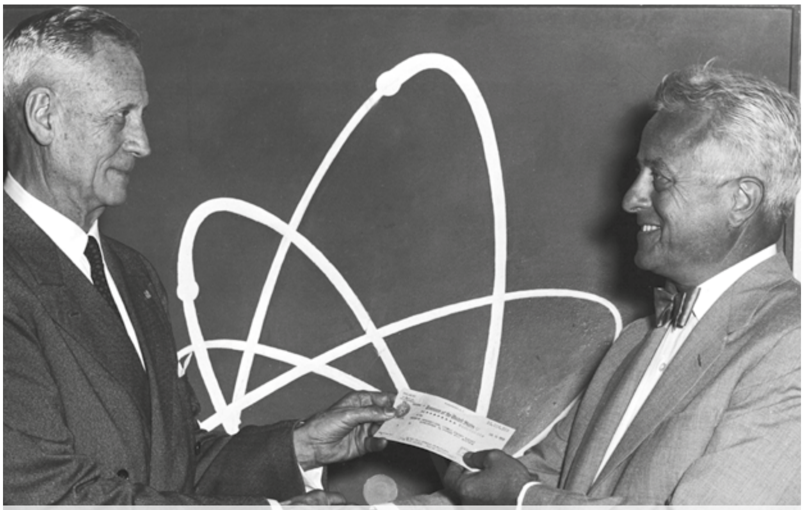
3 When the IAEA laboratory in Seibersdorf first opened in 1962, it had fewer than 40 staff members. A year later, in November 1963, ten international participants were welcomed to its first training course that focused on the bioassay of radionuclides.

4 Today, the NA laboratories host nearly 100 scientists, technicians, fellows, scientific visitors, interns and students from around the world. Additionally, training courses in all areas of the laboratories' work are held in Seibersdorf each year, with 440 trainees participating in 2013.

BERSDORF: THEN AND NOW

5 In the first phase of construction, the total space of the IAEA laboratory building in Seibersdorf was only 1736 m^2. The original space only contained one laboratory, which distributed information on radioactive isotope reference sources to IAEA Member State laboratories and their medical facilities. This information was used to calibrate radiation measuring instruments using radioisotopes in the peaceful application of nuclear science and technology.

6 The IAEA laboratories in Seibersdorf have since expanded to around 21 000 m^2 and now house the Safeguards Analytical Laboratories and eight NA laboratories. The NA laboratories respond to Member States' needs in areas such as food and agriculture, human health, environmental monitoring and the use of nuclear analytical instruments.



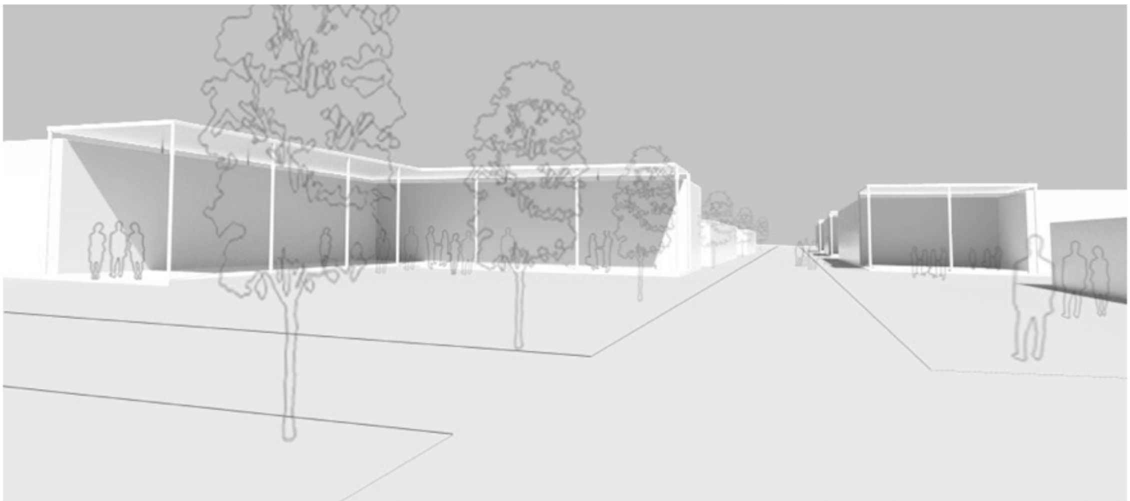
Former IAEA Director General Sterling Cole (right) and Paul F. Foster, former Resident Representative of the United States of America to the IAEA (left) handing over the donation check for the IAEA laboratories.

7 Support from IAEA Member States has been a critical factor in the success of the laboratories in Seibersdorf. The laboratories were built on land provided by the Austrian Atomic Energy Research Company, the forerunner of today's Austrian Institute of Technology, while construction was made possible through a donation of US $600 000 by the United States.

8 In 2013, the IAEA's Director General, Yukiya Amano, once again called upon Member States to provide their support to the NA Laboratories and assist in the modernization of the laboratories to be carried out under the ReNuAL project that was approved by the IAEA General Conference in September 2012.

Text: IAEA Department of Nuclear Sciences and Applications; Photos: IAEA

ReNuAL: RENOVATION OF THE NUCLEAR APPLICATIONS LABORATORIES



View from entrance to north-west. Initial image of projected new space for the NA laboratories.
(Image: URS Corporation/IAEA-ReNuAL Project)

The IAEA Department of Nuclear Sciences and Applications (NA) operates eight laboratories in Seibersdorf, near Vienna. Each of these laboratories performs unique functions that include supporting research and training for improving animal production and health, ensuring the effective and safe use of radiotherapy equipment, reinforcing food safety and developing hardier and higher-yielding food crops. They also contribute to protecting the global environment, enhancing countries' capabilities in using nuclear instrumentation and analytical techniques, eliminating insect pests and managing soil and water sustainably. These are essential contributions to the IAEA's mission of supporting the peaceful use of nuclear technologies to help meet global development challenges.

While the importance of their work has grown over the years, the structure and facilities of the NA laboratories have not kept up with this growth. No comprehensive renovation or significant upgrading of equipment has taken place at the laboratories since their establishment in 1962. As a result, the laboratory buildings are generally in average to below average condition; space is critically limited and much of the equipment needs replacing or modernizing. The laboratories are no longer fully fit-for-purpose and are struggling to respond to Member States' requests.

With this in mind, the IAEA Director General, Yukiya Amano, in his speech to the IAEA General Conference in September 2013, announced the official launch of a project for the renovation of the NA laboratories, known as ReNuAL. The vision for the project is to achieve fit-for-purpose laboratories that will be well equipped to share the benefits of nuclear sciences and applications with Member States in response to key socio-economic challenges contributing to a peaceful, healthy and prosperous world.

The ReNuAL project formally commenced on 1 January 2014, with a target budget of €31 million, financed by the IAEA Regular Budget and by extrabudgetary funding from Member States. A comprehensive needs assessment process was undertaken to determine the laboratories' most pressing building and space requirements as well as the urgently needed upgrade of the NA laboratories. The project plan includes new building construction, the refurbishment of existing buildings, the acquisition of new equipment to replace ageing or obsolete hardware and infrastructure upgrades. These improvements to the effectiveness as well as the efficiency of laboratory services and operations will enable the laboratories to address emerging issues and/or changes in technology.

The ReNuAL project completion date is set for December 2017.

Ruzanna Harman, IAEA Department of Nuclear Sciences and Applications

CONTRIBUTING TO FOOD SECURITY IN THE CONTEXT OF CLIMATE CHANGE

Since the laboratories of the IAEA Department of Nuclear Sciences and Applications were established in Seibersdorf in 1962, the world's population has grown from 3.14 billion to 7.15 billion, which, combined with continuously increasing industrialization and economic development, has led to greater global food demand. This has placed substantial stress on natural resources as well as the agricultural production chain. The challenges to food safety and security have also been amplified by the impacts of climate change, which have global ramifications, as noted in the March 2014 report of the UN Intergovernmental Panel on Climate Change.

Climate change impacts include higher temperatures, drought, more frequent extreme weather events and increased soil salinity which can have severe effects on agricultural production. Helping Member States adapt to and mitigate these impacts is a main focus of the five laboratories of the Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture in Seibersdorf. These laboratories are dedicated to increasing food security and safety using nuclear science and technology.

Agriculture accounts for roughly 70% of global water consumption. As climate change can result in drought or variations in water quality due to extreme weather events, it is critical to use this resource efficiently. The Soil and Water Management and Crop Nutrition Laboratory (SWMCNL) assists Member States in using nuclear techniques to optimize on-farm water conservation and to improve irrigation methods to produce more crops and increase water use efficiency. In addition, the SWMCNL builds Member States' capacities to monitor and assess the repercussions of climate change and variations on soil erosion, land degradation, salinization and nutrient depletion. This includes developing climate-smart practices that enhance soil resilience against climate impacts, while also increasing soil productivity, promoting soil carbon storage and reducing greenhouse gas (GHG) emissions from farmlands.

This work is complemented by the activities of the Plant Breeding and Genetics Laboratory (PBGL), which uses nuclear technologies to induce and detect useful mutations in crop plants. These mutations can be developed into new plant varieties that are able to grow under harsher conditions such as drought, higher temperatures and high soil salinity. Such adverse conditions are increasingly prevalent as a result of climate change. In a number of Member States, new plant varieties are helping farmers to increase crop production. This, in turn, contributes to higher income and greater food security in spite of the growing difficulties presented by climate change.

Approximately 22% of all GHG emissions are the result of agricultural production, and nearly 80% of these emissions are caused by animal production. With the constant rise in demand for animal products, livestock can serve as instruments for poverty alleviation and food security as they provide a livelihood for around a billion people. Without mitigating steps, however, increased animal production will lead to increased GHG emissions. The Animal Production and Health Laboratory (APHL) conducts research and development involving nuclear and nuclear-related techniques to improve the genetic potential of local breeds in order to maximize animal productivity and health. These techniques can also be implemented to breed livestock that produce fewer GHGs and are more tolerant to the higher temperatures and drought conditions that may result from climate change.

Higher temperatures also increase the occurrence and geographical distribution of transboundary animal diseases that can affect livestock and humans. Through its work in developing rapid-response diagnostic tools and animal vaccines to combat disease outbreaks, the APHL is increasing Member States' capacities to respond to new disease threats that may emerge as a result of climate change. Just as higher temperatures increase the geographical distribution of animal diseases, they are also increasing the survival of many insect pests in previously inhospitable climates. These pests can destroy crops and carry illnesses that endanger livestock and people.

To help control these insects, the Insect Pest Control Laboratory (IPCL) assists Member States in developing and transferring the sterile insect technique (SIT). This technique involves mass-rearing and sterilizing male insects that

Training Member State Scientists in the Food and Environmental Protection laboratory on the use of radiotracer techniques to manage the risks associated with residues of pesticides in foods.
(Photo: Dean Calma, IAEA)

IAEA Fellows receive field training given by an IAEA soil scientist at the Seibersdorf Soil and Water Management and Crop Nutrition (SWMCN) Laboratory.
(Photo: Dean Calma, IAEA)

are then released in large numbers into wild populations to mate with wild females without producing offspring. This results in a reduction in the overall population of the targeted insect pest. The SIT can be highly effective when combined with other pest control measures, such as biological control, insecticide spraying and other suppression methods. The SIT is becoming increasingly important for the control of mosquito populations. Many mosquito-disease affected zones are in populated urban areas and mosquitoes are reaching and surviving in new areas. Responding to this particular challenge with the SIT is one of the IPCL's current priorities.

Climate change and variability also affect how food security, as well as food safety and quality, are managed. With the expanding geographical distribution of insect pests and animal diseases, more pesticides are used to control insect populations, and livestock are being kept healthy through antimicrobials and related pharmacological substances. Shifts in temperature and humidity also result in the more widespread growth of toxin-producing fungi, which can lead to a greater presence of toxins in food. Without appropriate monitoring and measuring techniques, residues of all of these potentially harmful substances can enter the food chain and endanger human health. The Food and Environmental Protection Laboratory (FEPL) assists Member States in using nuclear and isotopic techniques to monitor and measure the presence of any potential contaminants, and to trace their origins. This protects consumers and also helps producers increase their exports by ensuring compliance with the food safety regulations of importing countries.

Each of the laboratories is successfully responding to Member State needs for increased food security and safety by formulating effective responses to the wide-scale impacts and challenges of climate change. In doing so, the laboratories are continually demonstrating the potential and capacity that nuclear science and technology offer for enhancing the socio-economic development of Member States.

IAEA Department of Nuclear Sciences and Applications

50 YEARS OF SUCCESSFUL PARTNERSHIP: THE JOINT FAO/IAEA DIVISION

October 2014 will mark the long lasting 50 years of partnership between the Food and Agriculture Organization of the United Nations (FAO) and its partner in the UN system, the IAEA. Established in 1964, the objective of the Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture was to use the talents and resources of both organizations to broaden cooperation between their member countries in applying nuclear technology and related biotechnologies to develop improved strategies for sustainable agricultural development and food security.

From research laboratories to global agrarian systems, nuclear techniques play a vital and distinct role in agricultural research and advancement. They are used in a wide range of applications, from food preservation to crop production and from soil management to animal disease control.

The collaborative work of the Joint Division has over the years helped countries solve practical, as well as costly, problems in a variety of areas. The work addresses the application of isotopes and radiation technology in areas such as soil fertility, irrigation, and crop production; plant breeding and genetics; animal production and health; insect pest control; the control of food contaminants and other food safety issues; and food preservation. These activities are executed only once they have been reviewed and endorsed by the IAEA's and FAO's governing bodies.

From the beginning, the FAO/IAEA Agriculture and Biotechnology Laboratories, situated in Seibersdorf near Vienna, have been central to the Joint Division's work and impact. Some of its most successful activities have relied on the innovative and distinctive work done in these laboratories. Their role has been to support research, develop, test and transfer techniques and applications to Member States; pursue new lines of methodology; provide support to capacity building for Member States; offer analytical services; and perform essential backup for coordinated research activities and other field programmes. They specialize in research, development and the transfer of nuclear and related methods in soil science, plant breeding, animal production and health, insect pest control and food safety.

Among their broad range of work, the laboratories also provide training for scientists through individual fellowships and interregional and group training courses in various disciplines. The scientists receive training and engage in applied research and development to develop, adapt and transfer technologies for local needs and specific environments. The laboratories also provide sample analysis services for Member States that lack the capabilities to conduct such analyses on their own, and typically analyse hundreds of samples annually.

Various mechanisms such as coordinated research projects (CRPs) further facilitate the Joint Division's work to support developing countries in solving practical problems of economic significance by providing technical and advisory services as well as equipment, expert advice and training. CRPs are an important delivery mechanism for enabling national agricultural research institutions to achieve specific research objectives consistent with the FAO's and IAEA's programme of work.

The joint partnership has witnessed numerous successes in various problem areas, which if not addressed would have had disastrous worldwide implications. These successes include:

- Global freedom from rinderpest
- The use of mutation induction to develop crop varieties with resistance to the wheat rust disease Ug99
- The eradication of the tsetse fly in Zanzibar Island, Tanzania
- The establishment of the regional analytical laboratory network for food safety
- Water-saving agriculture in seven African countries

For almost five decades, the activities supported by the Joint FAO/IAEA Division worldwide have contributed prominently to Member States by helping them to sustainably increase agricultural production, food security and food safety. This model of cooperation within the UN system will undoubtedly continue to produce successes in the years to come.

Aabha Dixit, IAEA Office of Public Information and Communication

IAEA Director General Yukiya Amano and FAO Director-General José Graziano da Silva sign the Revised Arrangements regarding the work of the Joint FAO/IAEA Division during the FAO Conference's 38th Session at the FAO's headquarters in Rome, Italy on 19 June 2013.
(Photo: Conleth Brady, IAEA)

FIGHTING THE GLOBAL CANCER EPIDEMIC THROUGH PRECISE MEASUREMENTS

Setting up equipment for dosimetry calibration at the IAEA Dosimetry Laboratory
(Photo: Rodolfo Quevenco, IAEA)

Cancer has passed heart disease to become the single leading cause of death worldwide. In 2000, there were 10.1 million new cases of cancer and 6.2 million deaths caused by cancer. By 2012, these numbers had risen respectively to 14.1 million and 8.2 million. As the global cancer epidemic continues to spread, the need for effective diagnosis and treatment is growing. Nuclear and other related technologies, such as diagnostic imaging techniques and radiotherapy, are fundamental to diagnosing and treating cancer. Both diagnostic imaging and radiotherapy involve radiation exposure, which can be highly effective for treating patients, but also dangerous to medical staff and patients if not used accurately and safely. Techniques such as medical dosimetry help to ensure the safe use of radiation.

Medical dosimetry is a cornerstone of safe and effective cancer diagnosis and treatment. It deals with the measurement of absorbed doses and the optimization of dose delivery in radiation medicine. This includes activities such as audits and the calibration of equipment, the development and dissemination of dosimetry techniques, and the implementation of quality assurance programmes.

The IAEA's Dosimetry Laboratory (DOL) helps Member States around the world to improve the safety and quality of radiation medicine. This in turn helps to maximize the effectiveness of diagnosis and treatment to improve a patient's health. For example, the DOL conducts audits in response to Member States' requests. It provides dose audits to over 2000 radiation therapy centres in countries that have no other means of verifying the quality of their clinical dosimetry. An integral part of the auditing process is resolving discrepancies that are discovered.

Many Member States have no means of verifying the quality of their calibration and measurement capabilities other than through the IAEA. Thus the DOL also serves as the coordinating laboratory of the IAEA/WHO Network of Secondary Standards Dosimetry Laboratories (SSDL Network). The global SSDL Network comprises 86 laboratories in 67 Member States that provide quality assurance services, and develop and disseminate

dosimetry methods. The DOL has been coordinating SSDL activities in close partnership with the World Health Organization (WHO) since 1976. SSDL services and activities help to ensure quality and safe practices, which ultimately benefit patients who are undergoing diagnostic tests or radiotherapy as well as medical staff who operate radiation equipment.

To maintain the DOL calibration and auditing services at the appropriate level and to enable dosimetry standards to be disseminated properly by the SSDL Network, the DOL carries out research and development on radiation dosimetry techniques and collaborates with international organizations focused on dosimetry and medical physics. The DOL contributes to the organizations' work and benefits from early access to projects. The SSDLs, as well as the radiotherapy centres and the communities that they serve, benefit from this collaboration and the research and development.

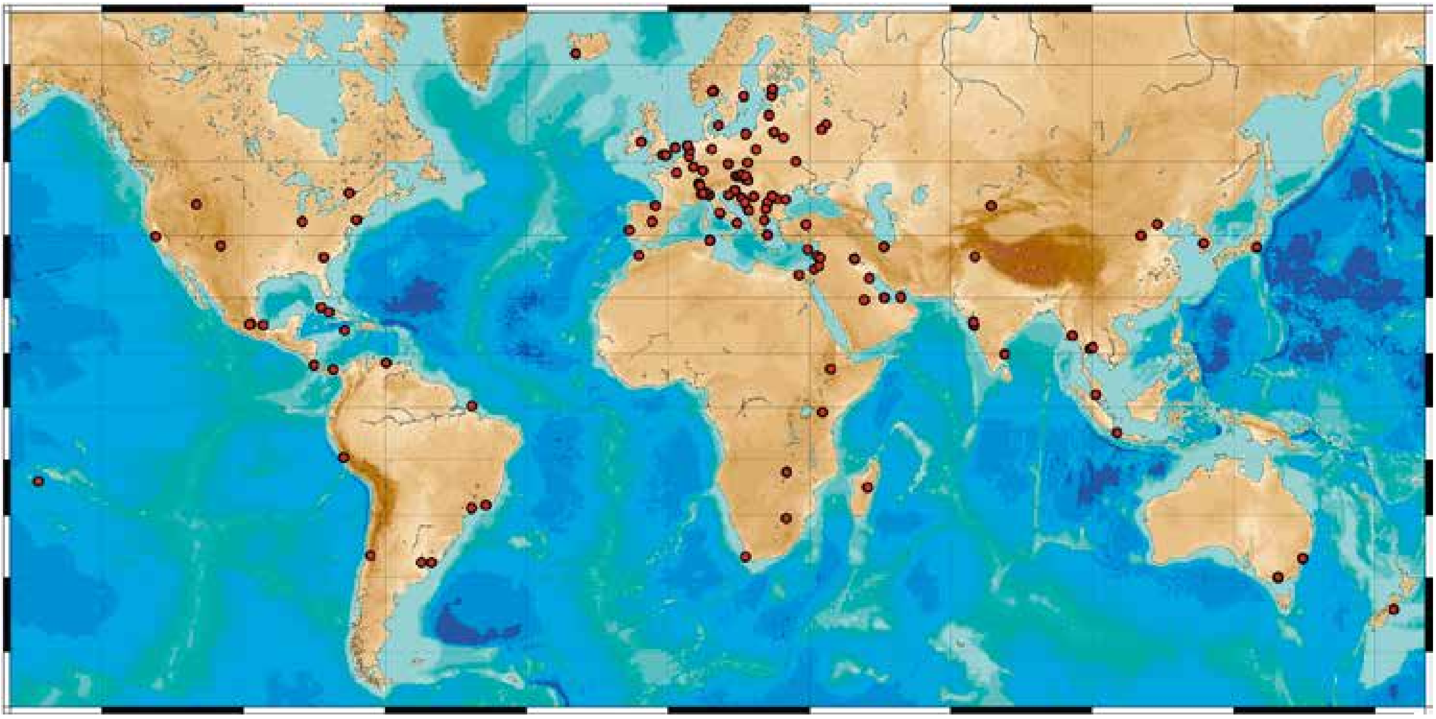
It is also imperative that the DOL remain cognizant of changes in medical technology that can lead to changing needs in dosimetry. For example, radiotherapy for many years depended on the use of cobalt-60 or caesium-137 as sources of radiation. But as nuclear security concerns have increased, it has become increasingly difficult to procure these sources. Consequently, many countries are shifting towards linear accelerators that can generate radiation without a radioactive source. This in turn requires the DOL to develop and disseminate methods and techniques and provide quality assurance support to ensure that Member States can adapt to this important technological trend.

The many activities and services of the DOL are valuable contributions to the worldwide fight against cancer and help cancer patients around the globe live longer, healthier lives.

IAEA Department of Nuclear Sciences and Applications

The dosimetry auditing activities of the IAEA Dosimetry Laboratory help to ensure that cancer patients receive safe and effective treatments with radiation beams generated by radiotherapy machines such as this one.
(Photo: Nancy Falcon Castro, IAEA)

BUILDING AND BENEFITING FROM MEMBER STATE LABORATORY CAPACITIES



The global presence of the ALMERA network's 140 laboratories

(Image: Staff of the IAEA Terrestrial Environment Laboratory)

The Department of Nuclear Sciences and Applications implements a number of activities that are designed to enhance and capitalize upon the capacities of Member States' laboratories worldwide. The Nuclear Sciences and Applications (NA) laboratories strengthen Member States' analytical capacities through activities such as proficiency tests and inter-laboratory comparisons, and share the capacities of Member States' laboratories with other Member States through the coordination of relevant networks and participation in the IAEA Collaborating Centre scheme.

An example of these activities is the collaborative work carried out by the Terrestrial Environment Laboratory (TEL). The TEL cooperates with the IAEA Environment Laboratories in Monaco to distribute 92 types of reference materials for characterizing radionuclides, stable isotopes, trace elements or organic contaminants. These materials serve as international standards for establishing and evaluating the reliability and accuracy of analytical measurements.

The TEL also produces and characterizes several test materials annually that are sent out to around 400 Member States' laboratories for proficiency and intercomparison exercises. The Member States' laboratories use these materials to carry out their own analytical measurements and then report on their results to the TEL. If they achieve the appropriate results, the reliability and accuracy of their analytical capabilities is confirmed. If they do not, then the TEL staff will review the results to identify potential sources of analytical error and will recommend corrective measures.

Similarly, the Soil and Water Management and Crop Nutrition Laboratory, in cooperation with Wageningen Evaluating Programmes for Analytical Laboratories (WEPAL), which is part of Wageningen University in the Netherlands, conducts test exercises with other laboratories in the use of stable isotope and radiation methods to measure and monitor the nutrients in plant, water and soil samples.

In addition, the NA laboratories coordinate and engage with global laboratory networks that pool resources and expertise for mutual benefit. The IAEA's Dosimetry Laboratory, together with the World Health Organization (WHO), coordinates the IAEA/WHO Network of Secondary Standards Dosimetry Laboratories (SSDL Network) to improve the safety and quality of radiation medicine. One of the principal goals of the SSDL Network is to guarantee that the dose delivered to patients undergoing radiotherapy treatment in Member States is in accordance with internationally

The Nuclear Sciences and Applications (NA) laboratories strengthen Member States' analytical capacities through activities such as proficiency tests and inter-laboratory comparisons, and share the capacities of Member States' laboratories with other Member States through the coordination of relevant networks and participation in the IAEA Collaborating Centre scheme.
(Photos: IAEA)

accepted standards to maximize the effectiveness and safety of treatment.

The Analytical Laboratories for the Measurement of Environmental Radioactivity (ALMERA) network is a global network established by the IAEA and coordinated by the TEL as a worldwide system for monitoring and measuring radioactivity in the terrestrial environment. ALMERA currently includes 140 laboratories in 81 Member States. Its main objective is to improve the reliability and timeliness of its members' analytical results for environmental radioactivity monitoring in routine and emergency situations.

The NA laboratories also work with IAEA Collaborating Centres to help Member States benefit from one another's capabilities. The Collaborating Centres are Member State laboratories and research institutions that operate as formal partners to assist the Agency in implementing selected programmatic activities. These Centres often work with NA laboratories in organizing and hosting training courses on NA's behalf, contribute to the NA laboratories' efforts to develop new or improved nuclear techniques, and provide or support the provision of analytical services, such as the collection and preparation of candidate reference materials. Through this mechanism all Member States can potentially benefit from the advanced capabilities of each other's laboratories.

This collaborative work between NA laboratories, Member States and laboratories around the globe contribute to the IAEA's mandate of fostering scientific and technical exchanges for the peaceful use of nuclear science and technology throughout the world.

IAEA Department of Nuclear Sciences and Applications

HOW THE NUCLEAR APPLICATIONS LABORATORIES HELP IN STRENGTHENING EMERGENCY RESPONSE

Unmanned aerial vehicle designed by NSIL for remote environmental radiation monitoring.
(Photo: Steve Thachet, IAEA)

Safety is one of the most important considerations when engaging in highly advanced scientific and technological activities. In this respect, utilizing the potential of nuclear technology for peaceful purposes also involves risks, and nuclear techniques themselves can be useful in strengthening emergency response measures related to the use of nuclear technology.

In the case of a nuclear incident, the rapid measurement and subsequent monitoring of radiation levels are top priorities as they help to determine the degree of risk faced by emergency responders and the general public. Instruments for the remote measurement of radioactivity are particularly important when there are potential health risks associated with entering areas with elevated radiation levels.

The Nuclear Science and Instrumentation Laboratory (NSIL) — one of the eight laboratories of the Department of Nuclear Sciences and Applications (NA) in Seibersdorf, Austria — focuses on developing a variety of specialized analytical and diagnostic instruments and methods, and transferring knowledge to IAEA Member States. These include instruments capable of carrying out remote measurements.

One such instrument developed by NSIL is an unmanned aerial vehicle (or drone) that can be rapidly deployed to areas potentially affected by elevated radiation levels. This drone carries out remote measurements of radioactivity and provides visual images of radioactive distribution. It can quickly provide accurate and vital data on radiation levels while limiting human exposure to potentially harmful radioactivity.

Member States also need laboratories capable of using nuclear analytical techniques for monitoring and measuring radioactivity in the environment and in potentially affected organic and inorganic materials that can affect human health. Another NA laboratory, the Terrestrial Environment Laboratory (TEL), provides Member States with high precision measurements as well as reference materials, proficiency tests, and regular workshops and training events for staff in their laboratories. This helps to ensure that Member States have the necessary analytical capabilities to accurately and reliably assess environmental radioactivity in emergency situations.

One of the most significant impacts of unintended radiation exposure can be the contamination of local food supplies. In the case of a nuclear incident, nuclear techniques are necessary to analyse food samples in order to ensure their safety for consumers and to reassure consumers of the safety of uncontaminated supplies. The TEL, the Food and Environmental Protection Laboratory and the Soil and Water Management and Crop Nutrition Laboratory combine their expertise to develop and transfer nuclear techniques and protocols to Member States that are designed to assess the impact of unintended radiation exposure on food sources.

This emergency response work carried out by the NA laboratories supports health and safety in Member States and supports the IAEA's mandate to promote the safe and peaceful use of nuclear energy.

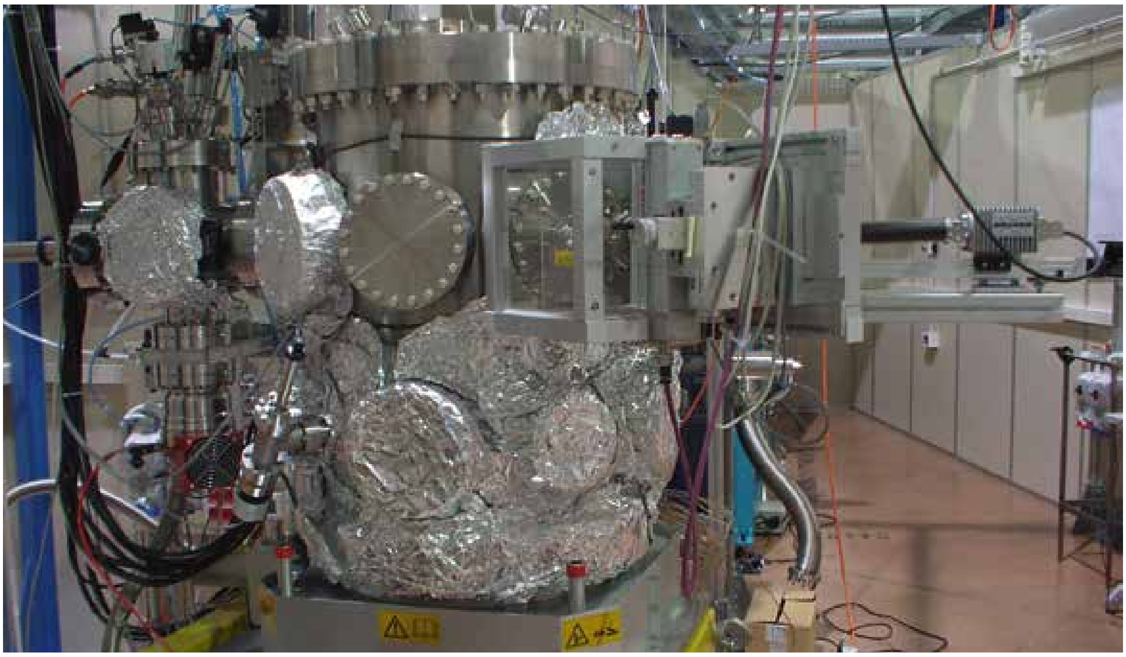
IAEA Department of Nuclear Sciences and Applications

ACCELERATOR APPLICATIONS SUPPORT NUCLEAR SCIENCE AND TECHNOLOGY

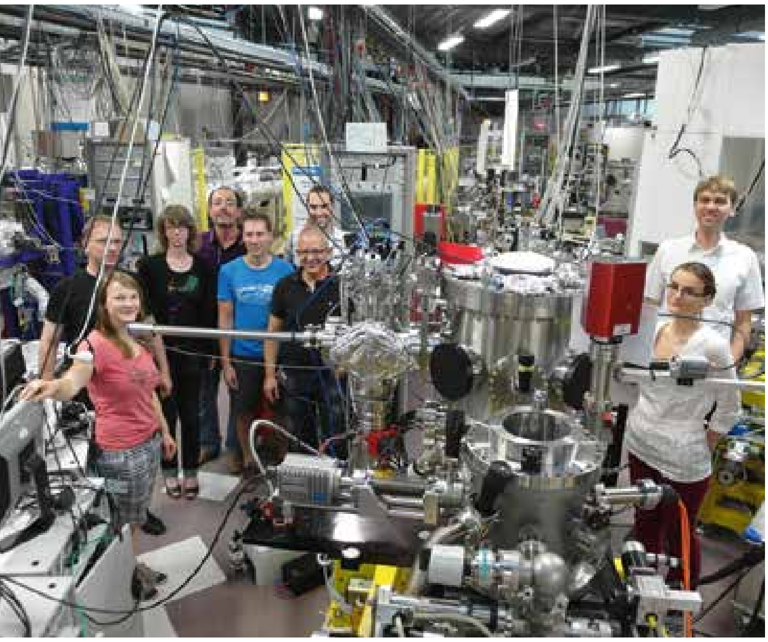
Accelerators are machines that use high voltages to produce artificial radiation in the form of beams of energetic particles. They are more versatile and safer than radioactive sources because the energy can be varied, and when the accelerator is turned off, so is the radiation. Accelerators are used for diverse applications such as to treat cancer, analyse artwork and old artefacts, clean up waste effluent gases, produce computer chips and map the structure of proteins. Accelerator technology makes a valuable contribution to the technological progress of a country, which in turn can also contribute to a country's economic development.

Accelerators have been around for more than 80 years. In 1929, Dr Robert Jemison Van de Graaff, an American physicist, successfully demonstrated how a high voltage machine could accelerate particles. There are currently about 30 000 accelerators operating globally. About 99% of them are used for industrial and medical applications and only about 1% are used for basic research in science and technology. The production of industrial accelerators is a worldwide business with an annual revenue of over US $2 billion and the products processed by them have annual sales valued at about US $500 billion.

As part of the IAEA Division of Physical and Chemical Sciences, the Nuclear Science and Instrumentation Laboratory (NSIL) supports Member States in the development of a broad range of nuclear applications and in the effective use of related instrumentation. The IAEA Physics Section and the NSIL currently support 17 national and regional technical cooperation (TC) projects in 56 Member States in accelerator applications, as well as coordinate seven coordinated research projects with institutes from 40 Member States. To support these programmes, the IAEA Physics Section cooperates with external institutions through mutual agreements. Elettra in Trieste, Italy and the Ruđer Bošković Institute in Zagreb, Croatia are two such partners.

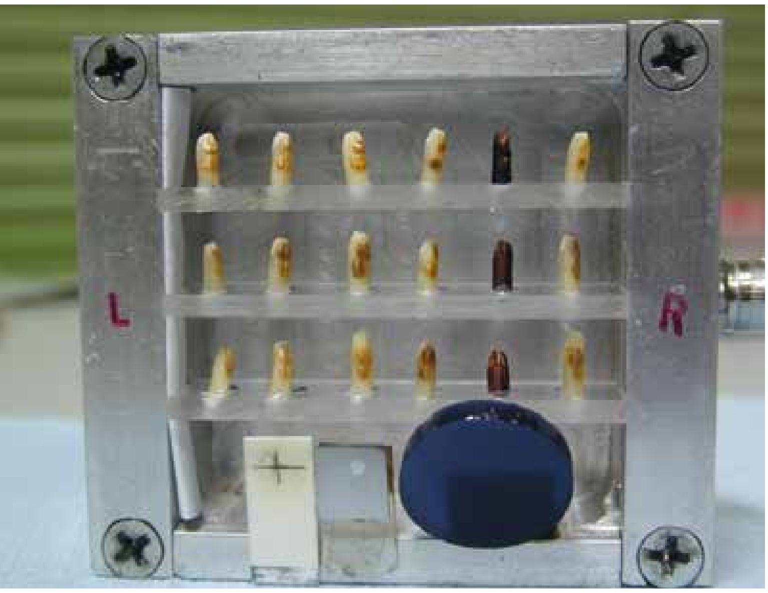


1 The ultra-high vacuum chamber (UHVC) end station at the new IAEA beam line at the Elettra synchrotron in Trieste, Italy. This state-of-the-art X-ray fluorescence beam line can be used to analyse which chemical elements are found in a material. One of the results of this advanced technology is its ability to produce 2D and 3D maps of the chemical analysis of the material being tested. The machine was shipped from Berlin to Trieste and is in the process of being commissioned for Member States' use by July 2014. (Photo: IAEA)

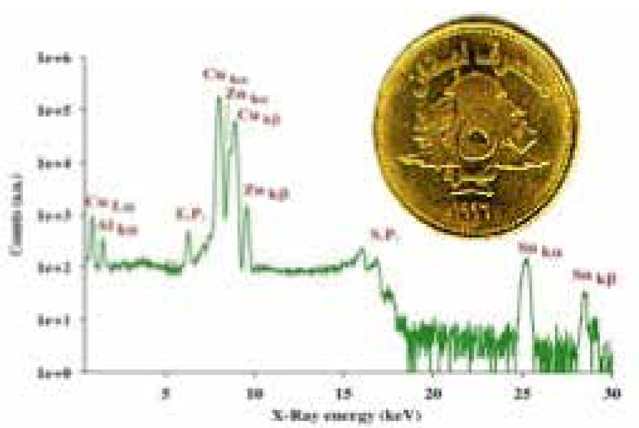


2 Staff from the IAEA NSIL, the German Institute for Standardization in Berlin, as well as Elettra in Trieste came together in August 2013 for the joint beam test of the UHVC at the BESSY II synchrotron radiation source in Berlin. The test of the X-ray fluorescence beam line was successful in analysing which chemical elements are found in a material and confirmed that the chamber performed the technical task as intended. The test was conducted prior to shipping the accelerator to Trieste, Italy. (Photo: IAEA)

3 Installation of an ion beam accelerator that was donated by the Netherlands to the new accelerator centre in Accra, Ghana. The accelerator will offer training opportunities for students in nuclear research and applications in material sciences, environmental topics and cultural heritage analysis, such as determining age and authenticity of artwork and artefacts. This is the subject of a TC project for Ghana supported by the IAEA Physics Section. (Photo: IAEA)



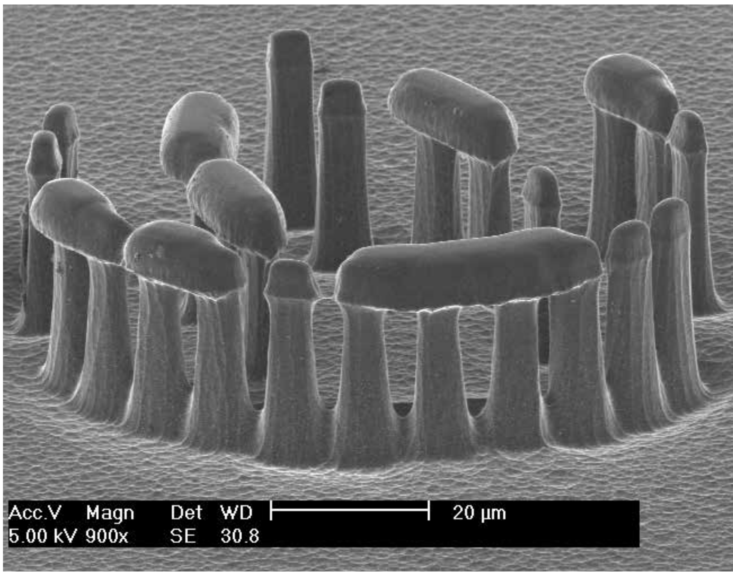
4 Ion beam irradiation can be used to initiate mutations which can lead to plant varieties with better properties. This is an example of rice that has received ion beam irradiation at Chiang Mai University, Thailand. This type of work is carried out as part of TC projects supported by the IAEA Physics Section. (Photo: Chiang Mai University, Thailand)



5 A graph of an ion beam analysis of a 250 Lebanese Lira coin to determine its layer composition and thickness. This kind of analysis through nuclear technology can be used to assess and authenticate coins or other ancient artefacts. This analysis was part of a TC project in Lebanon supported by the IAEA Physics Section. (Photo: Lebanese Atomic Energy Commission)

6 A panoramic view of the IAEA beam line at the Elettra Synchroton Chamber in Trieste, Italy. The synchrotron radiation beam line enters from the right side of the chamber and finally reaches the UHVC, which is the end station seen just left of centre. Synchrotron beam light facilities produce X-rays that are millions of times brighter than medical X-rays. Scientists use these highly focused, intense beams of X-rays to reveal the identity and arrangement of atoms in a wide range of materials, including metals, semiconductors, ceramics, polymers, catalysts, plastics and biological molecules. The IAEA beam line has been working since April 2014. This beam line is especially suited to material science applications. (Photo: IAEA)

7 Ion beam accelerator at the Ruđer Bošković Institute (RBI) in Zagreb, Croatia. The IAEA NSIL has been operating a beam line at this accelerator since 1996. The accelerator uses a voltage of six million volts to accelerate protons that are used for a wide variety of applications, such as material analysis. (Photo: RBI, Zagreb)



8 A 3D nanostructure 'Silicon Henge' produced by focused proton beam irradiation of silicon at the Centre for Ion Beam Applications (CIBA), Department of Physics, National University of Singapore. This illustrates how ion beams can be used to produce complicated nanostructures, a key requirement for nanotechnology.
(Photo: Professor Martin Breese, CIBA)

Text: Ralf Bernd Kaiser, Head of the Physics Section, IAEA Division of Physical and Chemical Sciences

THE DEVELOPMENT OF "ELDO NGANO 1": THE WORLD

1 The wheat black stem rust disease is a virulent race of fungus, Puccinia graminis, which affects wheat plants and is caused by a strain of fungus known as Ug99.

Named for its place and year of origin, Ug99 was first discovered on wheat in Uganda in 1999. The spores of this plant disease are airborne and can be easily spread by wind. If not prevented, the disease can destroy 70 to 100 per cent of the yield of wheat crops. Annually on average 8.3 million tonnes of wheat grain is lost to this disease, costing US $1.23 billion per year. Ethiopia, Kenya and Uganda are hot spots for this disease. (Photo: Miriam Kinyua, School of Agriculture and Biotechnology, University of Eldoret, Kenya)

2 In 2009, growing international concern regarding the horrific impact of Ug99 on wheat led to the establishment of IAEA project INT/5/150, Responding to the Transboundary Threat of Wheat Black Stem Rust (Ug99).

This project has involved over 18 countries and 5 national and international institutions, and examined possible mutation induction treatments to deal with the challenges posed by Ug99. Meetings and workshops to facilitate the project efforts have been held in Kenya and Turkey. (Photo: IAEA)

3 Mutation induction treatments were carried out in 2009 at the IAEA Plant Breeding and Genetics Laboratory (PBGL) in Seibersdorf. This involved irradiating seeds of selected wheat varieties from participating countries using gamma rays. Radiosensitivity testing of seedlings was carried out to determine the optimum dose of irradiation.

The seeds were transferred between the PBGL and Member States using the IAEA Standard Material Transfer Agreement which guarantees access and benefit sharing among Member States. (Photo: IAEA)

4 Irradiated seeds were sent to Eldoret, Kenya in 2009 where the disease is prevalent. IAEA support to Kenya also included the establishment of irrigation systems which allowed for two generations of wheat to be grown and tested each year from 2009 onwards.

Thirteen resistant mutant lines were selected in wheat varieties from 6 countries: Algeria, Iraq, Kenya, Syrian Arab Republic, Uganda and Yemen. (Photo: IAEA)

D’S FIRST UG99 RESISTANT MUTANT WHEAT VARIETY

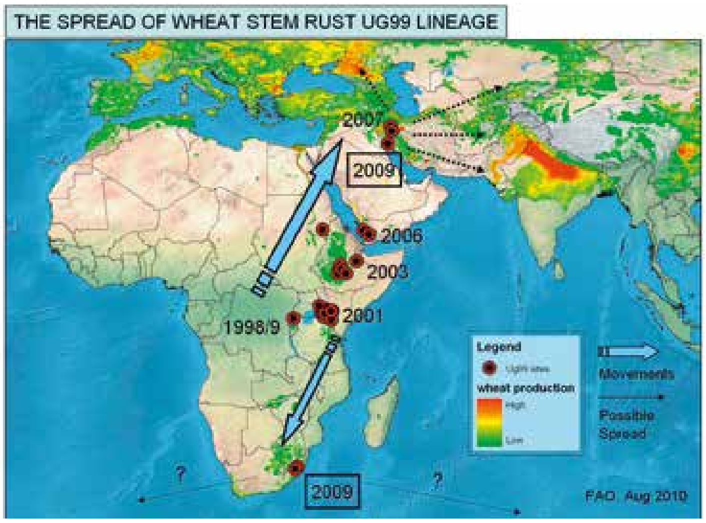
5 In 2012, in parallel with the field testing for Ug99 resistance in Kenya, a fellowship training programme was established at the PBGL for Mr Amos Ego from Kenya to learn skills in mutation induction, mutation detection, advancement of mutant lines and their validation using DNA analyses. (Photo: IAEA)

Certificate of “Eldo Ngano 1” Published by Authority of the Republic of Kenya

6 The first successful mutant variety of wheat resistant to Ug99 was released in February 2014 and named “Eldo Ngano 1”. Six tonnes of seeds were produced for distribution to farmers in Kenya and a “Farmers’ Day” was organized to demonstrate the disease resistant mutants and to explain the project.

Recently, a second advanced mutant line was tested for varietal status. In addition, a promising advanced mutant line in Uganda is being prepared for official testing and release in 2015.

7 Extrabudgetary funding was used to support a special training workshop in December 2013 at the IAEA in Vienna and the laboratories in Seibersdorf to discuss the next steps and challenges. This included exchanging seeds of resistant mutant lines for breeding, biotechnologies to speed up the introgression of the mutant resistant genes into elite lines from other Member States, and DNA methods to screen for disease resistance. (Photo: IAEA)



8 Ug99 continues to spread globally and has now reached the Islamic Republic of Iran. There are also reports of suspected disease occurrences in Europe.

It is essential that work continues on developing mutant lines for further crop protection that can be utilized worldwide to safeguard the wheat crop from this devastating disease.

(Photo: Food and Agriculture Organization of the United Nations, Ug99 Lineage Overview — April 2011)

Text: Brian P. Forster, Head, IAEA Plant Breeding and Genetics Laboratory

THE SEIBERSDORF LABS THROUGH THE EYES OF VISITING SCIENTISTS

(Photo: Mohammad Hasanuzzaman, IAEA)

LESOTHO

***Motlatsi James Ntho**, Laboratory Technician–Research Officer, Department of Agriculture Research, Ministry of Agriculture and Food Security, Maseru, Lesotho*

"In Lesotho, we are being affected by climate change, meaning we have more and longer droughts, and the rains farmers need for their crops to grow and flourish are often late. We are also seeing more agricultural crops blighted by disease. Therefore I am working to improve sweet potatoes and wheat because of wheat's importance in the daily diet, and because sweet potatoes could become an equally important staple in the next 10 years if we make a greater effort to promote its consumption.

In Lesotho's Department of Agriculture Research, we are focusing on these two staple foods initially because we want to improve the country's food security — growing more and better crops to adequately feed the population.

Once I return home at the end of my two-month fellowship at Seibersdorf, I will be using nuclear and other techniques to improve the drought tolerance, yield, nutritional value and disease resistance of both sweet potato and wheat.

The Department of Agriculture Research is hoping to establish a tissue culture lab where we can conduct this kind of plant breeding and the IAEA is helping us with equipment as well as with training. I was sent to the Seibersdorf labs in Austria because there are no institutions in southern Africa where these skills (induced mutation through irradiation) are taught.

When I've completed my training I have no doubt that I will be a competitive candidate to undertake tissue culture research in my country's new laboratories. And this fellowship will help me participate fully in the development of these skills in Lesotho.

Bonus

Apart from learning the specific techniques I'll need to conduct my own research, I have gained even more than I had hoped to receive when I first came to Seibersdorf.

I've learned how to work with other plants like chillies and tomatoes, and I've been inspired by the other fellows from across Africa and by the IAEA staff in the Plant Breeding and Genetics Laboratory. I think these relationships, which will make professional collaboration easier when we return home, are one of the greatest additional benefits I have received."

(Photo: Pichler Rudi, IAEA)

MADAGASCAR

***Norbertin M. Ralambomanana**, Engineer of Agronomy, responsible for the Genetic and Reproduction Laboratory, Department of Zootechnic and Veterinary Research, National*

Centre for Applied Research in Rural Development (FOFIFA), Ministry of Agriculture of Madagascar

"The island of Madagascar has a population of more than 23 million. Over half of its rural dwellers are agricultural workers, particularly in cattle farming. But the country still has to import milk as it is depleting its stock of indigenous Malagasy Zebu cattle in order to keep up with beef exports to neighbouring islands.

Therefore, the Madagascar Government is partnering with the IAEA to improve milk and beef production from the indigenous Zebu, Renitelo and Manjani Boina cattle breeds, through selective breeding based on the intimate knowledge of their DNA.

We in the Ministry of Agriculture doubt that our efforts will completely eliminate milk imports, but our aim is to significantly reduce the quantities the country needs to buy elsewhere. And we are aiming to significantly increase the number of cattle produced in our country.

One key element of the project is the training scientists from Madagascar receive at the Animal Production and Health Laboratory at Seibersdorf in Austria. I am currently participating in a three month fellowship in Seibersdorf where we are using the 172 DNA samples from three cattle breeds indigenous to the island to compare relationships between genotypes and phenotypes and to compare cattle breeds in our country with those in other countries in order to improve the quality of our home-grown animals.

Tools of the Trade

Madagascar doesn't have the right equipment to conduct the necessary DNA analysis. So the IAEA trains scientists like me in using its equipment at the Seibersdorf laboratories, while helping our government procure and purchase equipment of its own.

When I return home, my colleagues at the Ministry of Agriculture and I will use the information I've gathered here to figure out the best way to improve our indigenous cattle breeds. It won't be easy, however. We face a number of significant challenges.

First, the animals are scattered in rural settlements where it's not easy to get blood samples. And second, local breeders have their own ideas about the best way to do things. It will be very difficult to change these perceptions and convince breeders that the more scientific approach will produce better results than what they have been doing all along.

Fellowships like the one from which I am benefitting are very important for developing Member States because by training our scientists, the IAEA is giving us the tools we need to meet our own needs now and in the future."


(Photo: Klaus Gaggl, IAEA)

SENEGAL

***Fatimata Ndiaye**, Researcher and Consultant, Laboratory of Fungal Biotechnology, Faculty of Science and Technology, Cheikh Anta Diop University, Dakar*

"In Senegal, we are struggling to adequately feed our population as persistent drought and poor soil quality combine to cause crop failure year after year. My area of focus is the improvement of soil fertility and quality. That is, increasing soil nutrient content by introducing more carbon into poor soil and ensuring that soil retains this carbon. The techniques I need to conduct such experiments and get the right results are what I'm learning at the IAEA's nuclear applications laboratories in Seibersdorf during this four-month fellowship.

My colleagues in Senegal and I will use this data to create an agro-technology package that will adequately address Senegal's agricultural problems (at least as far as they relate to soil). Our recommendations to the government and farmers will deal with better soil management and more effective and efficient ways to increase organic matter (carbon) in soil.

These types of fellowships are good opportunities for young scientists like me to improve our expertise, further our careers, and have access to the technical tools which are available at Seibersdorf. Such opportunities are necessary and help us obtain positive results in our agriculture industries."

(Photo: Klaus Gaggl, IAEA)

SUDAN

***Tahani Bashir Abd Elkareim**, Researcher, Tropical Medicine Research Institute, Sudan*

"Malaria is a treatable but deadly disease transmitted by the bite of female Anopheles mosquitoes. According to the US Centers for Disease Control and Prevention, malaria is a major international public health problem causing an estimated 215 million infections and 655 000 deaths worldwide each year.

Sudan is one of the countries where malaria is endemic, and we are engaged in a number of efforts to limit transmission and get rid of the Anopheles mosquito. One of these efforts involves using the sterile insect technique (SIT) where male mosquito larvae are irradiated, making them unable to produce offspring when, as adults, they are released into the wild to mate with females.

If successful, the SIT will help to gradually reduce the mosquito population available to infect humans. At the IAEA's Seibersdorf labs I've been learning how to raise large quantities of sterilized mosquitoes. This includes understanding the feeding, caging, equipment and cleaning requirements of mosquitoes from larvae to adulthood.

I'm here to see how the IAEA's system for mass rearing compares to our own, what more we need in terms of equipment and expertise, and to see the methods used to make the SIT process more efficient and effective.

I think that these fellowships for scientists from developing Member States are golden gifts that give young professionals training opportunities they wouldn't normally have had. Also, the hands-on experience and interaction with the IAEA's patient and knowledgeable staff is invaluable."

TSETSE FLY GENOME BREAKTHROUGH: THE FAO AND IAEA CRACK THE CODE

A pregnant female of the tsetse species Glossina morsitans.

(Photo: Geoffrey M. Attardo, Research Scientist, Yale School of Public Health, Yale University, USA)

With the breakthrough in sequencing the genome of the tsetse fly species Glossina morsitans in April 2014, another milestone has been achieved in helping to solve a problem that has had horrendous ramifications for Africa.

Tsetse flies, large biting flies, which populate most of mid-continental Africa between the Sahara and the Kalahari deserts, are vectors for single-cell parasites known as trypanosomes. This specific parasite causes trypanosomiasis, or sleeping sickness, in humans. Konstantinos Bourtzis, a Molecular Biologist with the Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture, explained the potential gravity of the tsetse bite for human health, for which a vaccine is not available and for which costs of medical treatment are very high. He mentioned that, currently, approximately 70 million people face the risk of sleeping sickness while over 50 000 people are estimated to be infected. Sleeping sickness attacks the central nervous system, changes the biological 'time clock', and causes changes in personality including confusion, slurred speech, seizures and difficulty in walking and talking.

Livestock on the other hand can be hit by nagana, a wasting disease that is transmitted when the tsetse flies bite animals to feed on their blood. Nagana is the root cause of a debilitating chronic condition that reduces fertility, weight gain, meat and milk production, and makes livestock too weak to be used for ploughing or transport, which in turn affects crop production. It results in the yearly death of around 3 million animals, with over 50 million animals facing the risk of infection. For African farmers, the tsetse flies are a nightmare; they also impact food security and socio-economic progress in sub-Saharan Africa.

Finding a solution to the havoc created by tsetse flies to livestock has been a major challenge for the combined scientific efforts of the IAEA and the Food and Agriculture Organization of the United Nations (FAO), as well as for the World Health Organization (WHO), which has focused on combating human sleeping sickness.

Joint research over the past decades to block the spread of severe infection from tsetse flies resulted in the introduction by the FAO and IAEA of the environmentally friendly sterile insect technique (SIT), a biologically-based method for the management of key insect pests of agricultural, medical and veterinary importance. A form of insect birth control, the SIT involves releasing mass-bred male flies that have been sterilized by low doses of radiation into infested areas, where they mate with wild females. These do not produce offspring and, as a result, the technique can suppress and, if applied systematically on an area-wide basis, eventually eradicate populations of wild flies.

The newly acquired knowledge of the tsetse fly genome provides a wealth of information for the improvement of the entire SIT package and can help unravel interactions between tsetse flies, symbionts and trypanosomes. The decoding of the genome was detailed in a press release issued by the IAEA on 24 April 2014 entitled *Tsetse Fly Genome Breakthrough Brings Hope for African Farmers*.

The successful unravelling of the tsetse fly genetic code has been part of an international collaboration that involved the FAO/IAEA Insect Pest Control Laboratory and the support of over 140 scientists worldwide. This scientific breakthrough will enable a better understanding of the biological and genetic potential of the tsetse flies including their nutrition, reproduction, immunity and vectorial capacity, explained Bourtzis.

Bourtzis further elucidated that this discovery will enable scientists to enhance the SIT by integrating it with new and complementary methods in an area-wide approach to control the devastating impact from tsetse flies on animals and humans, and that the purpose of developing solutions is not to eliminate a tsetse species but to eradicate local populations of tsetse flies.

Tsetse flies were successfully eradicated in 1997 from the Tanzanian island of Zanzibar using the SIT. Ethiopia and Senegal are making significant progress in infested areas with the same method. The FAO and IAEA are helping 14 countries control tsetse populations through applying area-wide integrated pest management approaches.

Aabha Dixit, IAEA Office of Public Information and Communication

FACT BOX — TSETSE FLIES

Tsetse flies are known to have established sophisticated symbiotic associations with three different symbiotic bacteria. All tsetse fly species examined to date harbour an obligate symbiont of the genus *Wigglesworthia*, which has a long-lasting symbiotic association with tsetse flies providing them important nutrients, such as vitamins, which are not available in human and animal blood.

Tsetse flies have also established a symbiotic association with another bacterium, namely *Sodalis*. Recent experimental work suggests that both tsetse fly midgut-associated symbionts (*Sodalis* and *Wigglesworthia*) can affect trypanosome development and thus can be exploited in order to prevent the establishment and transmission of these parasites.

Tsetse's third symbiont is the alphaproteobacterium, *Wolbachia*. This bacterium is the most successful symbiont on Earth since it infects more than 40% of all insect species. *Wolbachia* is known to manipulate the reproductive properties of its hosts, most commonly causing cytoplasmic incompatibility, a kind of male sterility. Recently in mosquitoes, it has been shown that this symbiont prevents the establishment and transmission of major human pathogens that cause such diseases as dengue, chikungunya and malaria.

Whether *Wolbachia* can also prevent the establishment and transmission of African trypanosomes in tsetse flies, thus blocking the spread of sleeping sickness and nagana, is currently under investigation. Interestingly, the deciphering of the genome of *Glossina morsitans* also unraveled the presence of hundreds of *Wolbachia* genes in the tsetse fly genome. The potential function of these genes, if any, is as yet unknown.

CONTRIBUTORS

Yukiya Amano

Konstantinos Bourtzis

Andrew Cannavan

Gerd Dercon

Adama Diallo

Yacouba Diawara

Aabha Dixit

Tahani Bashir Abd Elkareim

Brian P. Forster

Andy Garner

Brandon Thomas Gebka

Ruzanna Harman

Sasha Henriques

Joanna Izewska

Nicole Jawerth

Ralf Bernd Kaiser

Pierre Jean Laurent Lagoda

Qu Liang

Katherine Long

Julian Gregory Ludmer

Fatimata Ndiaye

Motlatsi James Ntho

David Osborn

Norbertin M. Ralambomanana

Meera Venkatesh

Marc Vreysen

Rodolfo Quevenco

ISSN 0020-6067

The IAEA is unique in the UN family in having dedicated specialist laboratories that support its activities in the peaceful uses of nuclear technology. These laboratories develop innovative technologies and provide training to scientists from its 162 Member States.

Follow us on:
www.iaea.org
www.facebook.com/iaeaorg
www.twitter.com/iaeaorg