The continuing widespread adoption of radiation and nuclear techniques for non-energy applications is a major driver of the IAEA’s continued involvement in strengthening nuclear science capabilities in Member States. The adoption and use of credible atomic and nuclear data is crucial, as such data provide accurate descriptions of the underlying processes that are harnessed in both energy and non-energy studies, including nuclear fusion, medicine and environmental monitoring. To encourage the use of peaceful nuclear techniques, the IAEA serves as the central agency for the collection and dissemination of data worldwide.

Working as a Part of the Global Community

Contributing to the Millennium Development Goals, the IAEA’s role is to accelerate and enlarge the contribution of nuclear science and technology to global peace, health and prosperity. This requires the sustainable cooperation of Member States, intergovernmental and non-profit organizations, educational and research institutes and laboratories in a variety of fields.

The IAEA works alongside a long list of IAEA collaborating centres, which contribute their own research, training and facilities, and has developed coordinated research activities with experts around the world across various fields related to nuclear science and technology. The training offered by the IAEA sets a high standard for procedures and practices, improves the use of technologies and ensures the reliability of data generated by national and regional laboratories.

The establishment and maintenance of a sound infrastructure in nuclear science is essential to capacity building in a wide range of applications, from health care and agriculture to industry and the environment. By offering training and promoting the transfer of technology, techniques, knowledge, data and expertise in nuclear sciences, the IAEA through its technical cooperation programme offers developing Member States a means of achieving sustainable development objectives.

The technical expertise and multilateral mandate of the IAEA allows its many collaborating centres and laboratories around the world to deliver the benefits of nuclear technologies and maximize their sustainability. Given the growing emphasis on utilizing existing capabilities and expanding the use of networks for programme delivery, the collaboration across fields and between the many Member States is likely to grow in the years to come.

Nuclear Sciences and Applications

Applying 21st Century Nuclear Science to 21st Century Problems

Integrating Nuclear Techniques for Development

By enhancing the integration across various thematic areas, the IAEA plays a role in helping to address today’s emerging challenges. In radiation medicine, for example, nuclear technology is used for the diagnosis and treatment of major non-communicable diseases such as cancer and cardiovascular disorders. The Human Health Campus at http://humanhealth.iaea.org provides on-line resources and learning for health professionals working in radiation medicine. Responding to the world cancer crisis, the IAEA developed a unique initiative, the Programme of Action for Cancer Therapy which works closely with the World Health Organizational (WHO) through the WHO-IAEA Joint Programme on Cancer Control. The programme aims at providing assistance to Member States to adopt comprehensive national cancer control programmes that encompass early detection, cancer treatment, and palliative care.

In a joint division with the Food and Agriculture Organization of the United Nations, the IAEA assists Member States in applying nuclear techniques to alleviate challenges in food safety, food security and sustainable agricultural development. The IAEA has made significant contributions to helping developing countries adopt sterile insect techniques to suppress and eradicate pest insects that pose a threat to human and animal health.

Using scientific methods based on the tracing of isotopes, the IAEA is improving the management of the world’s freshwater resources, a key aspect of sustainable development in the face of climate change. The IAEA also helps Member States monitor known sites of radioactive contamination, as manifested by their ongoing efforts in Japan after the incident at Fukushima.

Radioisotope products and radiation technology are essential components for applications across all fields, be it medicine, industry, or agriculture. The demand for the most used radioisotopes has been steadily increasing, such as, for example, the fission produced 99Mo and 99mTc, used for more than 30 million medical procedures worldwide per year. As a result, many countries seek support from the IAEA in integrating these technologies into their development plans, which include strengthening quality assurance practices and regulatory compliances as well as facilitating human resources development.

Fostering global socioeconomic development while promoting and maintaining a clean, sustainable environment is essential in order for modern civilizations to prosper. To help achieve this, the Department of Nuclear Sciences and Applications, in cooperation with the Department of Technical Cooperation and the rest of the IAEA, help Member States use nuclear and isotopic techniques to attain sustainable development objectives in food and agriculture, human health, water resource management, marine and terrestrial environments, and industrial applications.
Cancer is an enormous — and growing — global public health problem. In 2010, cancer killed nearly eight million people worldwide, while over 13 million new patients were diagnosed with the disease. Formerly considered more pervasive in affluent countries, cancer now places its heaviest burden on poor and disadvantaged populations. According to the World Health Organization (WHO), more than two thirds of new cases and cancer deaths occur in lower and middle income countries, where such numbers are increasing at alarming rates. In some low income countries, fewer than 15% of breast and cervical cancer patients survive longer than five years following diagnosis, both of which are highly curable diseases elsewhere in the world.

Radiation Medicine in Brief
Radiation medicine includes radiotherapy, diagnostic radiology, nuclear medicine and medical physics. Radiotherapy or radiation oncology involves treating cancer by radiation through external beam or brachytherapy (in-tumor radiation where the radioactive source is placed directly into the tumor or close to it). Nuclear medicine uses techniques that employ unsealed radioactive material in the diagnosis or treatment of cancer. Medical physics ensures the safe and effective diagnosis and treatment through comprehensive quality assurance.
Ensuring water now and for the future

The objective of the IAEA in the area of radiation oncology is to enhance Member States’ capabilities to establish sound policies for radiotherapy and cancer treatment, and to ensure the effective, efficient and safe utilization of current and future advances in radiotherapy. Member States receive assistance in modernizing and establishing new radiotherapy facilities, brachytherapy services, new technologies and education programmes.

ENSURING HIGH QUALITY DOSIMETRY AND MEDICAL RADIATION PHYSICS

Medical procedures utilizing radiation play a central role in modern health care. To ensure maximum benefits and minimal risks, it is essential that these techniques rely on adequate dosimetry (i.e. dose measurement) and medical physics procedures.

In therapeutic procedures, accurate dose measurement and delivery are critical for effectively treating patients. In diagnostic imaging, quality assurance processes enable accurate image generation with minimal radiation dose to patients and medical personnel. The IAEA contributes to ensuring the safe and effective use of radiation in medicine through its activities in dosimetry and medical radiation physics. Through the WHO-IAEA network of secondary standards dosimetry laboratories, independent dosimetry audits and comprehensive clinical audits are offered to radiation medicine facilities around the world, where traceable dosimetry calibrations services are also provided.

One ongoing project aims at developing, in collaboration with professional societies, guidelines on the dosimetry of small and composite fields used in novel radiotherapy techniques. These guidelines are needed to ensure standardization and harmonization of dosimetry practices and will contribute to the safe and effective implementation of new radiotherapy treatment modalities worldwide.

FIGHTING MALNUTRITION WITH NUCLEAR TECHNIQUES

One out of every ten children born in developing countries will die before their fifth birthday as the result of malnutrition. In total, about ten million children die each year. This extremely high death toll demonstrates the vulnerability of infants and young children to poor nutrition and health. Fighting malnutrition is a key part of the IAEA’s agenda, in its efforts to contribute to Millennium Development Goal #4, to reduce the mortality rate among children under five years of age by two thirds.

The IAEA assists Member States in their efforts to develop effective, evidence based interventions to combat malnutrition using stable (non-radioactive) isotope techniques. For example, as recommended by the WHO and UNICEF, exclusive breastfeeding during the first six months of life is vitally important for a child to begin a healthy life.
Ensuring water now and for the future
and how to obtain and track their order. In addition, proficiency tests allow Member States to
available on-line via a webshop, allowing customers to know, in real-time, what is in stock
interlaboratory comparison exercises and analytical quality control. Reference materials are
remediation measures when needed.

The laboratories study the fate and impact of contamination on a variety of ecosystems in
accumulation in sediments. Radioisotopes are also used to study bioaccumulation in organ-
isms and the food chain, as well as to track signals of climate change throughout history.

Natural and manmade radionuclides are used to track ocean currents in key regions. They
about the age, origin and renewal rate of groundwater, its dynamics, as well as vulner-
he goal of the IAEA is to aid Member States in assessing and managing all aspects of
water resources assessment and hydrology tools in the context of

The IAEA activities take place around the world and address terrestrial, atmospheric, freshwater
and marine environments in a variety of ecosystems.

The environment laboratories assist in developing tools and in finding solutions for all types of
environmental issue by providing reliable, comparable and ‘fit for purpose’ environmental
assessments. In the case of global assessment, where decisions are made based on the in-
formation produced by different laboratories, these requirements are even more pronounced. The
laboratories also help build capabilities at a regional level to reduce the anthropogenic and
natural degradation of coastal ecosystems.

With an ongoing, three decade long relationship with the Mediterranean Long-Term Pollu-
tion Monitoring and Research Programme (MED-POL), the IAEA has a long record of close
collaboration with numerous United Nations and regional organizations. In this particular
project, the IAEA has been assisting national and regional laboratories to improve their analy-
sis of trace metals and organic compounds in marine samples.

In one instance, the laboratories successfully developed a new analytical method to detect
the presence of radionuclides in environmental samples, such as those that may occur dur-
ing a nuclear accident. The method included a rapid and accurate determination of radioac-
tive strontium in milk, one of the key pathways for human contamination. The test will be
especially helpful in avoiding health risks to infants during cases of emergency.

A current project in the Arctic aims to assess the effect of climate change by conducting field observations that monitor the complex and rapidly changing Arctic environment and by providing data for modellers. Since 2009, the IAEA environment laborator-
ies have been collaborating with Nor-
way to conduct annual studies of the transportation of radionuclides into the
Arctic sea. Over the last three years, the laboratories have also assisted in establishing a nuclear analytical labo-
atory in Doha for the Qatar Ministry of Environment, where they installed the
necessary equipment and trained the laboratory technicians. Further-
more, the IAEA assists Member States
around the world in protecting the
quality of their seafood from increas-
ting toxic algal blooms in coastal areas (southeast Asia, Latin America and southern Africa). In Argentina, for ex-
ample, the laboratories were involved in an independent assessment of pos-
sible uranium contamination of soil, surface water and groundwater.

IAEA reference product services are provided by the environment laboratories to support
Member States’ own laboratories in conducting quality of environmental sample analyses, interlaboratory comparison exercises and analytical quality control. Reference materials are available on-line via a webshop, allowing customers to know, in real-time, what is in stock and how to obtain and track their order. In addition, proficiency tests allow Member States to receive performance assessments for their laboratories.

Since 1995, the IAEA environment laboratories have coordinated the international network of
Analytical Laboratories for the Measurement of Environmental Radioactivity (ALMERA), pro-
viding accurate analysis in the event of an accident or an intentional release of radioactive.
Specifically, MDG 7 seeks to halve the proportion of the population without sustainable access to safe drinking water. Investigation and assessment of water sources is necessary to provide a comprehensive water resources assessment, thus leading to a sustainable system. The IAEA has projects focusing specifically on this issue, including the IAEA Water Availability Enhancement Project, which is currently developing templates and methodologies for national scale assessments of water resources.

International Cooperation Key To Success

The IAEA supports technology transfer through the implementation of hydrology projects, training and technical analytical support, as well as by assisting in the procurement of equipment and expert services. The programme works to manage and enhance regional projects, including promotion of exchanges between neighbours. The IAEA supports the development of a community of experts who can oversee local projects. The IAEA grants research contracts to universities, research centres and other Member State institutions to support innovative research in the field of isotope hydrology. The programme works in cooperation with other United Nations (UNDP, UNICEF, UNESCO), national (USGS, GTZ, etc.) and international (WB, GEF, OAS) bodies. The Isotope Hydrology Laboratory plays an important role in providing access to laboratory services for analysis, quality assurance and in support of global databases.

Who We Are

Isotope hydrology is a relatively young science, dating back to the 1950s. Extensive nuclear research, leading to the discovery of isotopes in natural systems and measurements of atmospheric radioactivity, following nuclear bomb tests, then led to the discovery the stable isotopes of hydrogen, oxygen and carbon as well as the radioisotopes of carbon (radiocarbon, 14C) and hydrogen (tritium, 3H). The use of stable and radioactive isotopes has ever since provided unmatched insights into both atmospheric and terrestrial elements of the water cycle. The IAEA has played a key role in the development and promotion of isotope hydrology tools in the context of water resource assessment and management.

5 Water

Securing A Better Future For All

Nuclear Techniques for Global Development and Environmental Protection

Water Resource Programme

Isotope Hydrology: Ensuring Water Now and For the Future

Water Is Essential for Development

The goal of the IAEA is to aid Member States in assessing and managing all aspects of their water resources and to ensure their secure and equitable use into the future. Isotopes provide unique information about water characteristics in a cost efficient, accurate and easy-to-use way. Isotopes are water’s ‘fingerprints’ and are used to gain information about the age, origin and renewal rate of groundwater, its dynamics, as well as its vulnerability to sources of pollution, salt water intrusion and climate change. During evaporation and condensation of water within the water cycle, the concentrations of oxygen and hydrogen isotopes – naturally occurring atoms of different mass – change, allowing distinct identification of water in differing environments. There are other isotopes in rainwater, such as tritium and 14C, the concentrations of which decrease with time.

Global monitoring isotope programmes are an important feature of the IAEA. These provide Member States with global isotope data for water resource investigations and climate modeling. The Global Network of Isotopes in Precipitation (GNIP), undertaken in collaboration with the World Meteorological Organization, has been in existence since 1961. GNIP data have become increasingly important, allowing unique insights into hydrological and climatic processes at the local, regional and global scales. The IAEA GNIP database now includes over 120 000 monthly data records, and can be downloaded from the IAEA website (www.iaea.org/water). Two other programmes are still in their infancy: the Global Network of Isotopes in Rivers and the Moisture Isotopes in the Biosphere and Atmosphere.

Supporting Member States

The IAEA works together on technical cooperation projects to address priority water issues in Member States. Training, meetings, technical expertise and infrastructure support aid in capacity building so that Member States can address their practical problems. Currently, nearly 70 water resource projects exist in Africa, Asia, Europe and Latin America, which address a variety of groundwater and surface water resource issues. These include characterizing and monitoring transboundary aquifers, such as the Nubian Sandstone Aquifer System and the Guarani Aquifer System, as well as river basins, such as the Nile basin. Coordinated research projects support international research efforts to develop new scientific approaches to relevant themes.

Meeting Millennium Development Goals

Access to safe water is a basic precondition of all the Millennium Development Goals (MDGs).
Ensuring water now and for the future examined as a practical solution to at least partly alleviate shortages in countries that have

Application of radiation and isotopes in industrial process management.

- Treatment, sterilization of medical products, disinfestation of food grains, and synthesis and beam and X ray technology for varied applications, including tackling pollutants, wastewater eases, especially cancer;
- Development, production and quality assurance of reactor and accelerator based advice, assistance and capacity building support for:
  - human resources development. The multi-pronged need based approach includes providing States to achieve self-sufficiency in the production of radioisotopes and radiopharmaceuticals and radiation technology to developing countries. In particular, the IAEA helps Member States to take full advantage of the benefits offered by this technology, it is essential to provide the most importantly in medicine, industry, agriculture and the environment. However, in order to take full advantage of the benefits offered by this technology, it is essential to provide the necessary infrastructure as well as qualified personnel. The IAEA strives to promote worldwide availability of products and facilities in order to offer the benefits of radioisotope products and radiation technology to developing countries. In particular, the IAEA helps Member States to achieve self-sufficiency in the production of radioisotopes and radiopharmaceuticals, strengthen quality assurance practices and regulatory compliance as well as facilitate human resources development. The multi-pronged need based approach includes providing advice, assistance and capacity building support for:
  - Development, production and quality assurance of reactor and accelerator based medical isolopes and radiopharmaceuticals for both the diagnosis and treatment of diseases, especially cancer;
  - Establishment of irradiation facilities and utilization of gamma radiation, electron beam and X ray technology for varied applications, including tackling pollutants, wastewater treatment, sterilization of medical products, disinfection of food grains, and synthesis and characterization of advanced materials;
  - Application of radiation and isotopes in industrial process management.

Facilitating the supply of molybdenum-99 and technetium-99m

The 2007-2010 shortages in the supply of fission produced molybdenum-99 (99Mo) — and in turn of technetium-99m (99mTc) — involved annually worldwide using 99mTc. In this context, the IAEA has been working towards ensuring the sustained supply of 99Mo to all Member States. While on the one hand, coordination efforts with the OECD Nuclear Energy Agency to address the production and supply of 99Mo from the large scale are expected to have a desirable outcome, the IAEA is also exploring alternative technologies for 99Mo production. One promising example is the cyclotron based direct production of 99mTc proposed by Canadian researchers, which is being examined as a practical solution to at least partly alleviate shortages in countries that have cyclotrons available for use.

Enabling wastewater reuse through radiation processing technology

Quick Facts

- Diagnostic radiopharmaceuticals used in conjunction with modern medical imaging devices such as gamma camera and PET CT scanners are used to diagnose specific pathological conditions such as cancer, cardiac disorders and neurological conditions much earlier than was previously possible.
- Therapeutic radiopharmaceuticals, most often used in the treatment of cancers, are designed as ‘smart’ molecules to target cancerous cells and subject them to a payload of lethal dose radioactivity. On successful targeting, radiation damages the structure of the cancerous cells, thus creating a therapeutic effect, and ultimately leading to complete destruction of the cancerous tissue.
- Radiation processing technology, in which materials are exposed to ionizing radiation, is an additive-free treatment process that can improve the physical, chemical and biological properties of a material without generating radioactivity. The use of radiation in developing and studying polymer composites and nanostructured materials is an emerging and innovative area which has attracted the interest of many countries.
- Ionizing radiation can be a powerful tool for the deactivation of microbes, either to address threats to public health and safety that might be posed by deliberate or inadvertent

Chronic shortages of water in arid and semi-arid regions of the world and environmental policy regulations have stimulated the use of appropriate technologies in treating wastewater for reuse in urban irrigation, gardens and parks, industry, cleaning purposes, etc. Standard biological processes commonly used for wastewater treatment are not capable of neutralizing many of the complex organic chemicals found in varying quantities in wastewaters.

Electron beam or gamma irradiation can treat such pollutants, transforming them into less harmful substances or reducing them to levels below permissible concentrations. On the industrial scale, the combined biological and electron beam treatment of wastewater from textile dying is in operation in the Republic of Korea, where more than 10,000 m3 of wastewater is successfully treated per day. Based on this successful example of radiation treatment for water remediation, the IAEA has launched a programme to assist Member States in developing strategies to address the issue of wastewater treatment in their countries using EB or gamma radiation.

Optimizing industrial processes

The oil and gas industry is vital in many Member States, and inspection of oil and gas pipelines to assess corrosion is necessary to ensure safety. Computed tomography (CT) using gamma rays is a rapid, sensitive and effective imaging technique increasingly used by industry to uncover corrosion and defects in the metal structure of pipelines. The IAEA has supported the development of simple transportable gamma CT systems in several Member States, such as Vietnam, primarily for oil and gas pipeline scanning.

Preserving and protecting our past

For the past 40 years, radiation treatment has been successfully used in the preservation of a large variety of cultural heritage artifacts, such as furniture, statues, archaeological objects, ethnographic collections, mummies, books, leather, porous stones, tiles, mosaics, frescos and textiles. The IAEA assists Member States in developing and establishing radiation processing technology for preservation of their cultural heritage artifacts by setting up facilities as well as training personnel. Several Member States worldwide are using this technology in cooperation with conservators, curators and restorers to preserve the world’s cultural heritage.

Radioisotopes and Radiation Technology

For Better Healthcare and a Cleaner Environment

Radioisotope and radiation technology finds numerous applications in a wide variety of fields, most importantly in medicine, industry, agriculture and the environment. However, in order to take full advantage of the benefits offered by this technology, it is essential to provide the necessary infrastructure as well as qualified personnel. The IAEA strives to promote worldwide availability of products and facilities in order to offer the benefits of radioisotope products and radiation technology to developing countries. In particular, the IAEA helps Member States to achieve self-sufficiency in the production of radioisotopes and radiopharmaceuticals, strengthen quality assurance practices and regulatory compliance as well as facilitate human resources development. The multi-pronged need based approach includes providing advice, assistance and capacity building support for:

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ensuring water now and for the future

Meeting the Growing Demand for Nuclear Techniques

Supporting Member States

The Future of Applied Nuclear Sciences

The IAEA supports Member States’ needs based development efforts through technical cooperation programmes, coordinated research activities, advisory missions, laboratory training and analytical services, publication of state of the art reports on specific topics and issues, and preparation and provision of materials for human resources development. Such activities address the requirements of both nuclear energy systems and non-power nuclear applications.

In light of the current growing interests and commitment towards opting for nuclear power, qualified human resources are vital. In the future, human resources will be needed to not only ascertain the safe and continuing operation of exiting nuclear programmes, but also develop and implement new and expanding ones. The IAEA nuclear science programme supports Member States in maintaining and developing innovative nuclear education, training in nuclear sciences and the use of sustainable technologies.

A major emphasis of the IAEA’s fusion programme is on increasing international cooperation and support for the development of fusion power plant science and technology. This approach includes the use of smaller facilities in about 40 Member States for proof-of-principle experiments and basic research and training for scientists. Additional attention will be given to encourage talented female and male scientists to pursue higher education and research in nuclear fusion.

Providing the Tools for Global Development

By facilitating the peaceful use of nuclear techniques around the world, the IAEA has contributed to many developments in nuclear applications across a variety of fields. The laboratory-based services offered by the Nuclear Spectrometry and Applications laboratory, located in Seibersdorf, contribute to activities in the field of instrumentation maintenance, servicing and repair, with a particular emphasis on assisting developing countries. A major research activity is the X-ray fluorescence spectrometry, used worldwide for the analysis of geological materials, the monitoring of environmental pollution, and the study of cultural heritage objects.
Nuclear and Atomic Data

Values for Science

“Nuclear data are fundamental to all nuclear research and innovation”, Daud Mohamad, Dep-uty Director General, Department of Nuclear Sciences and Applications

The IAEA supports nuclear research activities in Member States by providing essential nuclear-clear data and serving as the central agency for the collection and dissemination of data from laboratories worldwide. The EXFOR database contains a compilation of experimental reaction data from all around the world, and this effort — led by the IAEA — has been very well received, as it provides invaluable data for nuclear calculations and evaluations to researchers in Member States. ENSDF is a collection of evaluated data on the structure and decay properties of radioactive nuclides collected worldwide through a network coordinated by the IAEA.

The IAEA has also developed tools to allow users to visualize data, since visual presentation of data in the form of a plot makes them easier to understand and appreciate. Two important applications are available from the Nuclear Data Services website (http://www-nds.iaea.org/). LiveChart interactively presents nuclide properties, and ZView plots reaction cross-sections, both from evaluated files and from EXFOR, as 2d or 3d plots.

Concerted efforts by the IAEA include coordination of activities in Member States, such as EXFOR and ENSDF. Coordinated Research Project (CRP) implementation, and also staff efforts, which have resulted in data libraries of immense value. IBANDL and RIPL-3 are examples of two databases resulting from CRPs. IBANDL is a database of experimental nuclear cross-sections relevant to ion beam analysis. RIPL-3 is a library of reference input parameter values which are essential ingredients of theoretical modelling codes. By providing a complete set of verified parameters, we ensure that evaluations carried out around the world are compatible, and can be produced easily and efficiently.

All matter is made of atoms, meaning “indivisible” in Greek and Latin. However, discoveries in physics have shown that each atom consists of a tiny but massive nucleus surrounded by electrons. While chemistry and atomic physics deal with electrons and changes in their states, nuclear physics deals with changes to the nucleus. The nucleus contains neutrons and protons existing together in a dynamic equilibrium, and by impacting the nucleus with a particle such as a neutron, many types of reaction can be induced, leading to the formation of new nuclei and the fission or the emission of other particles. Often, the resulting nuclei are radioactive; such nuclear reactions are the basis for production of the artificial radionuclides which are used in nuclear applications.

Accurate nuclear data are essential for many technologies and applications, the most important being the production of nuclear energy; both nuclear fission, which is well established, as well as nuclear fusion, which is still in the research and development stage.

Neutron induced fission reaction.

Atomic data: Supporting fusion technology

Fusion programmes all over the world rely heavily on atomic and molecular data, and although at present these data support research, with the construction of ITER the focus will switch towards use of this technology for energy production. The same approach is followed for these data as for nuclear data, namely the development of high quality data through CRPs and dissemination through web pages. ALADDIN is the main database for numerical data covering collisions of electrons and heavy particles with atoms, ions and molecules as well as for particle-surface interactions. Bibliographic information for atomic processes can be found in the AMBDAS database. The scope of atomic and molecular data is so large that an exciting new way of describing it has been implemented through the Knowledge Base for Atomic, Molecular and Plasma Material Interaction Data for Fusion, which is a “wiki” based page that users can directly add to.

• The Medical Portal (http://www-rds.iaea.org/medportal/) provides a unified view of medical applications, including databases, documents, libraries and on-going projects. Links to diagnostic and therapeutic radioisotope production, heavy charged particle interactions and phase-space databases are only a mouse click away.

• Nuclear Data for Safeguards provides a handbook of relevant data, both as a downloadable report and in the form of individual data tables. In addition, a specially customized LiveChart application provides safeguards data interactively.

• Evaluated nuclear data libraries in ENDF format have been produced by many data centres throughout the world. Twenty-six of these libraries can be interrogated and cross-section data plotted. Experimental data from EXFOR can then be added to provide evaluation validation.

• Covariance data enable uncertainties in quantities to be calculated. When a physical quantity depends on several variables, then correlations between these variables are needed to provide an accurate estimate of uncertainty. The figure below shows a typical 3d plot.

• The EXFOR database covers about 19 000 experiments and contains about 11 500 000 data points. Data have been compiled since 1935 and cover reactions induced by neutrons, charged particles and photons.

The interactive LiveChart application enables users to find the properties of nuclides, both stable and radioactive, with just the click of a mouse.

Database glossary:

ALADDIN — Database of numerical atomic and molecular data
AMBDAS — Database of bibliographic references to atomic and molecular papers
ENDF — Format of evaluated nuclear data libraries, also the name of a set of evaluated data files
ENSDF — Database of nuclear structure and decay properties
EXFOR — Database of measured nuclear reaction data
IBANDL — Database of ion beam reaction data
RIPL — Database of parameters used in theoretical calculations

A 3-D plot illustrating the correlations that exist between the various quantities involved in the description of a nuclear reaction. Such data are needed to provide uncertainly estimates in derived quantities.

Nuclear data: Fundamental for applications

Nuclear and atomic data are essential for many applications such as:

• Nuclear power (fission)
• Research reactors
• Nuclear fusion
• Medicine
• Non-destructive testing
• Environmental monitoring

International cooperation key to success

Strengthening the IAEA's role in sustainable development

IAEA Water Availability Enhancement Project (IWAPE), which is currently developing tem-

plates.

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variables are needed to provide an accurate estimate of uncertainty. The figure
below shows a typical 3d plot.

The EXFOR database covers about 19 000 experiments and contains about 11 500
000 data points. Data have been compiled since 1935 and cover reactions induced by

neutrons, charged particles and photons.

The interactive LiveChart application enables users to find the properties of
nuclides, both stable and radioactive, with just the click of a mouse.

Database glossary:

ALADDIN — Database of numerical atomic and molecular data
AMBDAS — Database of bibliographic references to atomic and molecular papers
ENDF — Format of evaluated nuclear data libraries, also the name of a set of
evaluated data files
ENSDF — Database of nuclear structure and decay properties
EXFOR — Database of measured nuclear reaction data
IBANDL — Database of ion beam reaction data
RIPL — Database of parameters used in theoretical calculations

A 3-D plot illustrating the correlations that exist between the various quantities
involved in the description of a nuclear reaction. Such data are needed to provide
uncertainly estimates in derived quantities.

Nuclear data: Fundamental for applications

Nuclear and atomic data are essential for many applications such as:

• Nuclear power (fission)
• Research reactors
• Nuclear fusion
• Medicine
• Non-destructive testing
• Environmental monitoring

International cooperation key to success

Strengthening the IAEA's role in sustainable development

IAEA Water Availability Enhancement Project (IWAPE), which is currently developing tem-

plates.

The IAEA supports technology transfer through the implementation of hydrology proj-

ects, including promotion of exchanges between neighbours. The IAEA supports the

programmes all over the world rely heavily on atomic and molecular data, and

Although at present these data support research, with the construction of ITER the focus

switch towards use of this technology for energy production. The same approach is fol-

lowed for these data as for nuclear data, namely the development of high quality data

through CRPs and dissemination through web pages. ALADDIN is the main database for

numerical data covering collisions of electrons and heavy particles with atoms, ions

and molecules as well as for particle-surface interactions. Bibliographic information

for atomic processes can be found in the AMBDAS database. The scope of atomic and

molecular data is so large that an exciting new way of describing it has been

implemented through the Knowledge Base for Atomic, Molecular and Plasma Material

Interaction Data for Fusion, which is a “wiki” based page that users can directly add to.

The Medical Portal (http://www-rds.iaea.org/medportal/) provides a unified view of medical

applications, including databases, documents, libraries and on-going projects. Links to
diagnostic and therapeutic radioisotope production, heavy charged particle interactions

and phase-space databases are only a mouse click away.

Nuclear Data for Safeguards provides a handbook of relevant data, both as a
downloadable report and in the form of individual data tables. In addition, a specially

controlled LiveChart application provides safeguards data interactively.

Evaluated nuclear data libraries in ENDF format have been produced by many
data centres throughout the world. Twenty-six of these libraries can be interrogated

and cross-section data plotted. Experimental data from EXFOR can then be added to

provide evaluation validation.

Covariance data enable uncertainties in quantities to be calculated. When a
physical quantity depends on several variables, then correlations between these
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A 3-D plot illustrating the correlations that exist between the various quantities
involved in the description of a nuclear reaction. Such data are needed to provide
uncertainly estimates in derived quantities.
improve productivity and reproductive efficiency while immunoassay methods help diagnose disease and to environmental stresses such as drought and salinity. So that not only improve farmers’ livelihoods, they mean better quality and safer food for consumers. The methods used vary: isotope measurements identify and trace the efficiency of crop inputs such as water and fertilizer and of animal feed; gamma rays control insect pests that threaten crop production or jeopardize human health by sterilizing males so that native females will not produce offspring; irradiation stops the growth of pests and expands the shelf life of grains, spices and processed foods; radiation induced mutation speeds up natural genetic changes in crops to support plant breeders; and genetic markers expedite the identification of animal diseases so treatment begins more effectively. All of these methods, plus a host of others that come under the heading of nuclear technology, are invaluable tools for agriculture and food production.

For almost five decades, the IAEA has guided development of new nuclear based methodologies, requested by its Member States and facilitated their adaptation, adoption and application. A harbinger of the United Nation’s Delivering as One, the Joint FAO/IAEA Division stands as the United Nations’ system’s only joint venture; it also operates its own agriculture and biotechnology laboratories in Siebersdorf where technical services, R&D and laboratory training activities are conducted in support of the development and transfer of new technologies and their adaptation to local needs and environments. The IAEA works on developing and applying nuclear technologies in five areas:

1. **Soil and Water Management and Crop Nutrition**: Isotopic and radiation methods measure genetic changes in crops to support plant breeders; and genetic markers expedite the identification of animal diseases so treatment begins more effectively. All of these methods, plus a host of others that come under the heading of nuclear technology, are invaluable tools for agriculture and food production.

2. **Plant Breeding and Genetics**: Radiation creates variability in desired traits of food and industrial crops and accelerates the breeding of varieties with higher yields and improved resistance to disease and to environmental stress such as drought and salinity.

3. **Animal Production and Health**: Isotopes are used to develop diets and feeding strategies that improve productivity and reproductive efficiency while immunoassay methods help diagnose diseases and monitor effectiveness of disease control and eradication programmes.

4. **Food Safety and Control**: Radiation provides a safe and environmentally friendly way of controlling food-borne diseases and stored product insect pests; other nuclear technologies are used to trace and authenticate food products and to detect, monitor and track the fate of contaminants in foods and the environment.

Quick Facts:

- **Successful application of nuclear technologies contributes to food security by**:
  - ensuring judicious use of water and other threatened resources through tracing and quantifying methodologies
  - controlling pests that affect yields and lead to export restrictions which negatively affect developing countries
  - offering proof of provenance, authenticity and safety of food
  - accelerating the natural mutation process needed for breeding crops and livestock better adapted to withstand future climate changes
  - reducing risk of animal disease with tools for rapid diagnosis
  - contributing to climate change combating efforts through applications that help define and design efficient, integrated agricultural systems.

Through the peaceful application of nuclear science and technology, the IAEA contributes to the UN Millennium Goals to address critical needs in developing countries by:

- progressively ensuring a world in which all people at all times have sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life
- increasing food production, enhancing rural development and sustainable livelihoods to help eliminate poverty and drive forward economic and social progress for all
- aiding the sustainable management and utilization of natural resources, including land, water, air, climate and genetic resources, for the benefit of present and future generations.

Developed through the use of nuclear techniques, Qatar is currently planning to use 60 million m³ of treated sewage water to irrigate 83 300 hectares of highly saline coastal and inland Sabkha lands to produce livestock fodder, thereby increasing the country’s total arable land from 8000 to 91 000 ha.

Mutation breeding has provided Vietnamese farmers from the Mekong delta and the highlands with higher yields and better market prices due to the high quality of mutant rice varieties. In highland areas, farmers are halting deforestation as they can now produce sufficient crops in lowland areas.
Securing A Better Future For All

Nuclear Techniques for Global Development and Environmental Protection

Collaborating Centres

Establishing a Culture of Cooperation

Recognizing the need to preserve and transfer nuclear knowledge, the IAEA collaborating centres (IAEA-CC) are dedicated to furthering the research, development and training in peaceful applications of nuclear science and technology. The approach draws upon the experience of the World Health Organization, which has established a global network of collaborating centres. In this regard, by facilitating the cooperation of various nuclear related institutions from around the world, the IAEA contributes to reaching important targets laid out by the United Nations Millennium Development Goals.

The main purpose of the IAEA-CC is to utilize Member States’ institutions to further the contribution of nuclear science and technology for development. By creating an international network of distinguished institutions, Member States can assist the IAEA with their own original research, development and training in nuclear technologies. As a cooperative mechanism, the IAEA-CC is also cost effective, as it encourages centres to share resources, knowledge and expertise.

Officially designated collaborating centres, such as a laboratory research institute, will receive public recognition for their collaboration with the IAEA in a particular field of work, for example food safety, environmental protection, water resources, or human health. The goal of the IAEA-CC is to help Member States by expanding their capabilities in these areas and thus improve the quality of life of their citizens. So far, the IAEA-CC has led to socioeconomic benefits in many parts of the world, from Asia to Latin America.

[Recent Projects]

Fostering Human Nutrition in India and Worldwide

The IAEA formalized its relationship with the St. John’s Research Institute (SJRI) in Bangalore, India, by designating it an IAEA-CC in May 2010. The SJRI had been working with the IAEA’s Nutrition and Health Related Environmental Studies Section since 1988, and is well networked both in India and internationally. The SJRI was the first collaborating centre designated by IAEA in the field of human nutrition. Its research also focuses on cancer, infectious diseases and lifestyle related diseases.

The longstanding relationship between the IAEA and SJRI has allowed them to collaborate on a variety of levels. For example, the SJRI analyses samples for Asian and African Member States, provides lecturers for the IAEA’s courses on stable isotope techniques and trains research fellows from Member States worldwide.

Quick Facts

— There are more than 20 IAEA-CCs worldwide.
— In addition to a single institution, a department or laboratory within an institution may also be designated as a collaborating centre.
— Official selection of an IAEA-CC depends on a variety of criteria, including their adherence to nuclear safety and security guidelines, and a proven record of collaboration with the IAEA and other institutions at the bilateral, regional and international levels.
— The IAEA works alongside collaborating centres in accordance with a time limited work plan, which can be up to a maximum of four years. The work must have clearly defined targets and expected results while also meeting the objectives of the IAEA’s ongoing projects.
— Collaborating centres carry out the work at no cost to the IAEA. Nevertheless, in selected cases, the IAEA may agree to provide limited funding for supplies, materials, or necessary services for work plan implementation.
— Designation may be renewed by mutual agreement and requires a new or extended work plan.

Sharing Accelerator based Analytics with the Global Community

In 2010, the IAEA added El Centro Nacional de Aceleradores in Seville, Spain to its list of collaborating centres for its outstanding research activities in accelerator based analytical techniques. During the four year work plan, the two organizations will work on a common project studying long lived radionuclides in marine samples in order to provide Member States with state of the art accelerator based science.

Eradicating Fruit Flies to Facilitate Trade

The IAEA-CC for the Development and Application of the Sterile Insect Technique for Fruit Fly Area wide Integrated Pest Management in Southern Mexico and Guatemala is a recent addition to the IAEA-CC scheme. The initial goal of the project is to reduce both horticultural losses and insecticide use while also facilitating more international trade in fruits and vegetables. The programme provides training for entomologists and plant protection officials from the entire region. It also develops and validates new methodologies that complement the research done by the IAEA. Thanks to this method, both the Mediterranean and Mexican fruit flies have been almost completely eradicated in Mexico.
Coordinated Research Activities

Uniting the World Through Research

The IAEA's programme of coordinated research activities has been designed to stimulate and coordinate the undertaking of research in selected nuclear fields by scientists in the IAEA Member States. The programme brings together scientists in research institutes in both developing and developed IAEA and FAO Member States to collaborate on research topics of common interest. Research, technical and doctoral contracts and cost free research agreements are awarded to Member State institutes for completion of designated research work. For each contract or agreement, one institute staff member is designated as the Chief Scientific Investigator, responsible for the progress of the research work. Preference is given to younger and to female researchers.

Through contracts and agreements with institutes in Member States, the Coordinated Research Projects (CRPs) are implemented. Each CRP is a network of 10 to 15 institutes that work in coordination towards achieving the research objectives set by the design of the CRP. The research is conducted at the participating institutes identified in the research contracts and agreements of the CRP. The IAEA acts as the sponsoring and coordinating body whereby an IAEA staff member—or project officer—is assigned to lead each CRP which normally lasts between 3 and 5 years. A few years ago, a new type of CRP, called a 'doctoral CRP,' was introduced whereby PhD students in developing countries are paired with professors in developed country research institutions.

The research encourages the acquisition and dissemination of new knowledge and technology generated through the use of nuclear technologies and isotopic techniques in the various fields of work covered by the IAEA's mandate. The majority of CRP topics are concentrated in the areas of nuclear sciences and applications in agriculture, human health, industry, hydrology and terrestrial and marine environments. However, CRPs related to nuclear energy and economic studies, waste technology, radiation and radioactive waste safety and nuclear security are also covered by the programme.

The results of the CRPs are made available free of cost to Member States and the international scientific community via the IAEA's scientific and technical publications, as well as through other relevant national and international journals.

Quick Facts

In 2010:

- 106 Member States participated in the programme of coordinated research activities
- More than 1500 contracts and agreements under 125 active CRPs
- 6000 was the average IAEA contribution per contract per year
- 80 research coordination meetings held
Ensuring water now and for the future

The Dosimetry Laboratory, based in Seibersdorf, is part of the IAEA's human health programme and is responsible for the quality assurance aspects of the use of radiation in medicine to ensure safety and effectiveness, and deals with the science and technology involved in this area.

From its facility in Seibersdorf, the Nuclear Spectrometry and Applications Laboratory, as part of the IAEA's nuclear science programme, works with laboratories in Member States to enhance their use of nuclear instrumentation and nuclear spectrometry based analytical techniques in environmental pollution monitoring and other applications, including nuclear energy systems related needs.

The Terrestrial Environment Laboratory facility in Seibersdorf is part of the IAEA's environment laboratories. Its role is to foster the capabilities of Member States in understanding and protecting the terrestrial environment. To achieve this, the laboratory develops suitable radiological assessment strategies and ensures the quality of measurement results by recommending methods, providing reference materials and organizing proficiency tests.

There are three marine environment laboratories located in Monaco, also part of the IAEA's environmental laboratories, dedicated to the preservation of a healthy marine environment and the sustainable development of environmental resources.

- Radiometrics Laboratory is an internationally recognized centre for the study of the oceans by use of radionuclides and isotopes as environmental tracers, in collaboration with leading research centres around the world. It develops analytical methods and supports Member States in their quality assurance activities by enabling interlaboratory intercomparisons and production of reference materials of marine origin.
- Radioecology Laboratory focuses on the study of nuclear and non-nuclear contaminants in seafood and foodwebs using radiotracer techniques, on the impact of ocean acidification on the development and biology of marine organisms of commercial interest, and on the tracking of carbon export from the upper ocean using natural radiotracers.
- Marine Environmental Studies Laboratory covers isotopic and elemental analysis of trace elements, organic contaminants and lipid biomarkers. It supports capacity building in Member States to enhance the quality of analytical measurement and capabilities for marine environmental surveys.

In Vienna, the Isotope Hydrology Laboratory, as part of the IAEA's water resources programme, plays a substantial role in the dissemination of knowledge about state of the art analytical techniques in isotope hydrology.

The IAEA supports technology transfer through the implementation of hydrology projects, including promotion of exchanges between neighbours. The IAEA supports the donor agencies — to help mitigate the effects of acidification on the development and biology of marine organisms of commercial interest, and on the tracking of carbon export from the upper ocean using natural radiotracers.

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Applied research and development is related to coordinated research activities and technical cooperation projects. The IAEA laboratories provide support for development of new technology and/or its adaptation to local needs and environments. In this area, scientists and laboratory technicians have the opportunity to put theories into practice by developing or fine tuning methodologies tailored to the needs of developing countries. Laboratory results can be tested and then disseminated through field projects.

Training and capacity building is an essential part of technology transfer and is frequently provided at the IAEA laboratories or in regional laboratories. Dozens of training courses, workshops and seminars are held annually at the Nuclear Applications Laboratories, involving hundreds of trainees, with the overall goal of building the capacity of Member States. IAEA fellowships usually extend no more than six months, and while importance is given to training in technology, every effort is made to ensure that equal emphasis is given to the wider aspects of the problem to be studied or solved.

For example, in the courses, trainees learn nuclear techniques but also conventional techniques so they recognize the links. They receive intensive hands-on experience in laboratory analysis and also undertake field work. Most training also includes ‘training of trainer’ elements, so the training will have a multiplier effect. Regional and interregional training courses are held periodically to train young scientists from developing countries in the technologies associated with the application.

Another important function of the IAEA laboratories is the technical and analytical support provided to Member States through evaluation, standardization and selection of appropriate equipment for each specific project or need. Equipment supplied is most effectively used when it is simple, robust and easily repaired and fits well within the local infrastructure and conditions. This is why technical staff, scientists and fellows who are responsible for implementing the projects aim to acquire experience in the routine operation, maintenance and even repair of commonly used equipment. Supplies of frequently required spare parts also can be purchased in bulk and held for quick dispatch to field projects when required.
Ensuring water now and for the future

The IAEA has a long history of cooperation with other international organizations, regional agencies, non-governmental organizations (NGOs), local and national governments, research and academic institutions. These cooperative efforts make it possible for the IAEA to implement many of its projects undertaken in the area of nuclear applications for peaceful purposes.

Another example of a successful joint programme is the Global Environment Facility/World Bank/IAEA partnership on the Nubian sandstone aquifer system. An essential first step in developing management strategies for the system has been to understand both the transboundary and local effects of recovering water from the aquifer now and in the future. This has been achieved through the creation of an IAEA model, which relied extensively on collaborative efforts between organizations and the countries themselves.

For nearly 50 years, the ICTP has been ensuring that scientists from the developing world have access to the same resources and opportunities enjoyed by their wealthier counterparts. The ICTP is now a focal point of cooperation between north and south, aiming to help scientists from developing countries overcome their isolation and contribute to state of the art research in physics and mathematics. The ICTP has been a major force in countering the scientific brain drain from the developing world.

Managing Water Resources

The IAEA currently works with UNESCO on the Joint International Isotopes in Hydrology Programme, launched to foster cooperation between hydrologists and isotope professionals at the national level. It also cooperates with other United Nations, international and national organizations to facilitate programmes and technology transfer, and is an active member of the United Nations interagency group UN Water.

The Global Network of Isotopes in Precipitation, undertaken in collaboration with the World Meteorological Organization, has been in existence since 1961. The IAEAs Isotope Hydrology Laboratory works together with partner laboratories to provide access to laboratory services for analysis, for quality assurance and in support of global isotope databases.

Building Better Agriculture

The link between atomic energy and agriculture has proven to be extremely valuable and unique in agricultural research and development. In 1964, the FAOs atomic energy branch and the IAEAs agriculture unit came together to become the joint IAEA/FAO Division of Nuclear Techniques in Food and Agriculture. Since then, the Joint Division has made critical contributions to global efforts to combat hunger and attain food security.

It operates with a staff of 100 scientists, technical experts and support personnel divided between offices and laboratories. It oversees an annual budget of approximately US $17.5 million plus an additional US $10–14 million in technical cooperation projects, all geared to helping Member States solve practical agricultural problems with nuclear technology. Its research and development activities are broken into five separate but interrelated work areas: soil and water management and crop nutrition, plant breeding and genetics, animal production and health, insect pest control, and food and environmental protection.

The Joint Division fosters extensive cooperation and networking with national and international institutions and organizations. Its potential to secure extra budgetary contributions is exemplified by current research and development projects funded by external partners, including the EU, UNIFRT, UNITIS, USAID, USDA and the Wellcome Foundation.

Promoting Science in the Developing World

The Abdus Salam International Centre for Theoretical Physics (ICTP) in Trieste, Italy, was founded in 1964 under the patronage of the IAEA. Today, it operates under a tripartite agreement between the IAEA, the Italian Government and UNESCO.

The IAEA and ICTP cooperate on many levels and through a large variety of projects. Topics range from material science and nuclear energy management to computer simulations and plasma physics. The IAEA-ICTP Sandwich Training Educational Programme offers PhD fellowships to candidates from IAEA Member States supported by the IAEA Technical Cooperation Fund. The programme allows students to receive part of their training at the ICTP, other institutes in the Trieste area, or at the IAEA laboratories in Seibersdorf and Monaco, while remaining enrolled in their home institutes.