



International Organization for Chemical Sciences in Development

*Promoting the chemical sciences
for sustainable
human development and
economic growth*

Achievements and Strategic Priorities

An overview of the contributions made by IOCD's Working Groups and Projects and IOCD's progress on its current strategic priorities:

*Chemistry for better health
Chemistry for a better environment
Capacity building in chemistry education*

2014

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The chemical sciences:

A key resource for sustainable development and economic growth

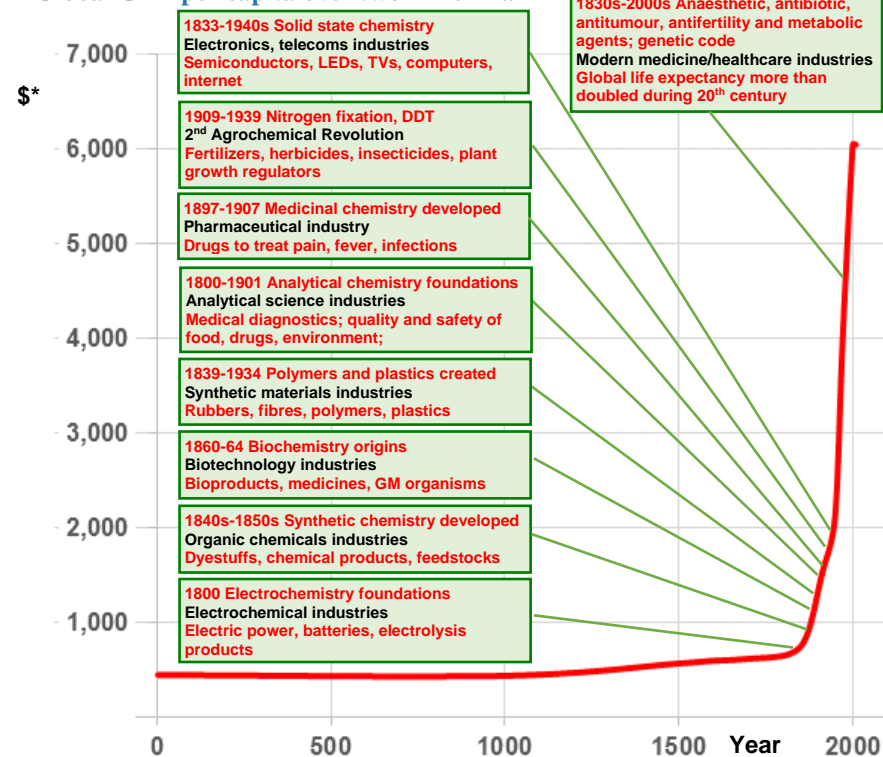
Chemistry is an enabling science, contributing to fundamental aspects of a range of physical and life sciences, underpinning dramatic advances seen in recent decades in e.g. biotechnology, energy, environment, genetics, materials and medicine. The chemical sciences provide us with understanding of the properties of atoms and molecules and practical methods for creating useful new materials.

The chemical sciences have played fundamental roles in global development,¹

contributing greatly to the massive growth in global prosperity and health that took place during the last two centuries (**Box 1**).

Since its foundation in 1981, IOCD has worked to encourage the participation of chemists everywhere, including in low- and middle-income countries (LMICs), in activities promoting sustainable national and global development. It has supported research programmes, training, networking and capacity building, especially in LMICs.

Box 1 Global GDP per capita over two millennia



* 1990 international Geary-Khamis dollars

IOCD's Strategy 2011-2020

The world faces many challenges, including increasing demands for energy, advanced materials and health products from an expanding, aging and urbanizing global population; and concerns about environmental pollution, the impact of climate change and depletion biotic and mineral resources. *The chemical sciences can and must make a major contribution to tackling these global challenges.*

After 30 years of successful service in promoting the chemical sciences for development, in 2011 IOCD refreshed its strategy and decided to focus on *three strategic priorities* for the current decade:

1. **Chemistry for better health**
2. **Chemistry for a better environment**
3. **Capacity building in chemistry education**

IOCD works to support ownership, partnership and capacity building for the use of the chemical sciences globally, but especially in and for the benefit of LMICs. It fosters science applied to equitable global

development; and seeks to serve as an umbrella, facilitator and promoter for programmes and funding for research, education and capacity building in the chemical sciences.

Working Groups and Projects

IOCD operates through Working Groups and Projects. Each Working Group evolves a sustained, multi-year programme focusing on a key area of the chemical sciences with an international team of scientists, including many from LMICs. In addition, more specific and restricted or time-bound activities are undertaken as Projects.

Working Group and Project activities map onto IOCD's strategic priorities shown in **Box 2**. The following sections describe these activities and the progress being achieved in the priority areas.

Box 2 IOCD Working Groups and Projects and Strategic Priorities

Working Groups and Projects	Strategic Priority Programmes	Strategic Priority 1	Strategic Priority 2	Strategic Priority 3
		Chemistry for better health	Chemistry for a better environment	Capacity building in chemistry education
Plant Chemistry		++	+++	+
Biotic Exploration		+	+++	+
Analytical services			+++	+
Medicinal Chemistry		+++		+++
Analytical chemistry		+++	+++	+
Books for International Development				+++
On-line chemistry tutorials				+++
Microscale Science Project				+++
Chemistry Education				+++

Strategic priority 1

Chemistry for Better Health

The nature of health challenges faced in every part of the world is changing, as a result of shifting patterns of disease, the globalization of health threats, changes in the environment and in human behaviour.

IOCD's strategy is to support:

- capacity building for medicinal chemistry, including drug analysis, discovery and development, in and for the health needs of LMICs.
- isolation, structure elucidation and bioassay of natural products. More than half of all currently used medicines are derived from compounds first extracted from natural sources such as plants, bacteria and fungi.² IOCD has long supported regular symposia on plant chemistry; and the Biotic Exploration Working Group has helped countries in Africa, Asia and Latin America to develop policies for ethical, sustainable bioprospecting, helping establish the foundations for new products and processes that will contribute to better health and economic development.

Medicinal Chemistry Background

Medicinal chemistry has helped transform human health, providing drugs for prevention and treatment of many life-threatening infections, metabolic disorders and diseases of lifestyle and ageing and helping alleviate pain and suffering and improve the quality of life.

New drugs are constantly needed to provide better treatment of known illnesses, combat the constantly evolving resistance mechanisms of pathogenic organisms and provide an armoury of defences against newly emerging infections. The creation of affordable drugs for diseases mainly affecting poor populations (e.g. many tropical infections) remains a global challenge.

IOCD Activities

IOCD forms Working Groups to promote attention to neglected areas of medicinal chemistry of particular relevance to LMICs; to strengthen participation of chemists from LMICs in programmes of national and global relevance; and to build LMIC capacities for medicinal chemistry.

- The **Working Group on Male Fertility Regulation**, one of IOCD's first, operated in the 1980s-90s. Chemists in a dozen LMICs conducted research, synthesising hundreds of compounds which were submitted to bioassays as antifertility agents (collaboration with the US National Institutes of Health) and also to screening against HIV (collaboration with the USAID CONRAD Program). Before being wound up in the mid-1990s, the Working Group contributed significantly to research, training, capacity building and awareness raising in this neglected field and collaborated closely with the World Health Organization Special Programme in Human Reproduction.
- The **Tropical Diseases Working Group** conducted synthesis and bioassay work in the 1980s-90s, with compounds being synthesised by chemists (many being located in LMICs) and tested against a range of tropical parasitic infections including malaria, leishmaniasis and trypanosomiasis (cooperation with the US Walter Reed Institute). Later, it was associated with the European Cooperation in Science and Technology programme on Drug Discovery and Development for Parasitic Diseases (COST B32) and IOCD provided travel grants for LMIC scientists to participate in COST meetings. After COST B22 closed, IOCD ended the Tropical Diseases Working Group as a separate activity in 2010, subsuming it within the **Medicinal Chemistry Working Group**.

- IOCD's **Medicinal Chemistry Working Group** has organized international symposia and workshops on medicinal chemistry to facilitate professional updating, training and networking.

The current focus of the Medicinal Chemistry Working Group is now on capacity building and its principal strategy involves organizing a Distance Learning Course on Medicinal Chemistry, developed at the College of Pharmacy, University of Kansas, USA to help scientists in LMICs gain knowledge about the latest methods to advance their research.

This course, running free online for over 5 years, illustrates fundamental concepts and their application to designing potential therapeutic agents and solving problems that arise in their progression to clinically useful materials. Annually updated, the course includes segments covering an introduction, pharmacodynamics, pharmacokinetics and operational stratagems.

Plant Chemistry Background

Plants provide a wide array of materials for nutrition, health, clothing, structural uses, energy and much else. A key element of the economy for many LMICs, the value of plants can be further enhanced by the identification and commercial development of specific compounds they contain.

IOCD Activities

Since 1988, the **Plant Chemistry Working Group** (superseding IOCD's earlier **Agrochemistry Programme**) has provided opportunities for LMIC natural products chemists to network, update their knowledge about isolation and structure elucidation and learn techniques for preliminary biological screening. It has organized international symposia on the chemical, biological and pharmacological properties of medicinal plants and workshops for training in chemical screening and bioactivity-guided fractionation, the most recent being in China in 2012 (**Box 3**). Previous ones have been held in Africa, Asia and Latin America (**Box 4**). Some IOCD funds are provided to assist with travel grants for younger scientists from LMICs to attend.

Box 3 2012 IOCD International Conference on Functional Molecules in Nature



Her Royal Highness Princess Chulabhorn of Thailand presenting the opening lecture of the *IOCD International Conference on Functional Molecules in Nature*, held in Nanjing, China on 22-24 September 2012, attended by 115 participants from 11 countries.

The next IOCD Plant Chemistry symposium will be held in Rabat, Morocco on 7-10 April 2015.

In 2013 IOCD initiated collaboration with a group at France's National Natural History Museum, working on identification of natural products of potential benefit to animal and human health through studies of self-medication by the great apes in Africa. The IOCD Project "Medicinal Compounds from Plants" will highlight zoopharmacognosy as an important approach both to health and conservation work.

IOCD's **Biotic Exploration Working Group** has helped countries in Africa, Asia and Latin America to develop policies for ethical, sustainable bioprospecting, to establish the foundations for new products and processes that will contribute to economic development, better health and a sustainable environment. Its work is discussed in more detail below, under **Chemistry for a Better Environment**.

Box 4 IOCD International Symposia and Workshops on Plant Chemistry

- 2012 **Functional Molecules in Nature**, Nanjing, China on 22-24 September 2012. Symposium co-sponsored by the China Pharmaceutical University, Nanjing.
- 2011 **African Plants as sources of drugs, agrochemicals, cosmetics and food supplements**. University of the Western Cape, South Africa, 12-15 January 2011.
- 2009 **Biology, Chemistry, Pharmacology and Industrial Applications of Plants of the Americas**. Viña del Mar, Chile, November 8-11, 2009.
- 2008 **Natural Products: Unlimited Resources for the Development of Drugs, Cosmetics and Food**. Kasane, Botswana, 24 - 29 February 2008. A joint symposium of IOCD and the International Society for the Development of Natural Products (ISDNP)
- 2007 **Biology, Chemistry, Pharmacology and Clinical Studies of Asian Plants**. Surabaya, Indonesia, 9-11 April 2007.
- 2004 **Chemistry, Biological and Pharmacological Properties of Medicinal Plants in the Americas**. Pedro, Brazil. Co-sponsored by IOCD and the Programa Iberoamericano para la Ciencia y Tecnología para el Desarrollo (CYTED).
- 2002 **Chemistry and Pharmacology of Plants Used in African Traditional Medicine**. Bamako, Mali, 2002.
- 2000 **Chemistry and Pharmacology of Asian Plants and Validation of Phytopharmaceuticals**. Bangkok, Thailand, 2000.
- 1999 **Chemistry, Biological and Pharmacological Properties of African Medicinal Plants**. Addis Ababa, Ethiopia, 1999.
- 1997 **Chemistry, Biological and Pharmacological Properties of Medicinal Plants from the Americas**. Panama, 1997. Co-sponsored by IOCD and CYTED.
- 1996 **Chemistry, Biological, and Pharmacological Properties African Medicinal Plants**. Victoria Falls. Zimbabwe. February 1996.

Strategic priority 2

Chemistry for a better environment

With global concern over contamination of air, land and water, countries are learning to develop sustainably and avoid historic pathways that led to pollution, exhaustion of resources and loss of biodiversity.

IOCD's strategy is to:

- enhance capacities for **chemical analysis** applied to the environment;
- support capacity building for the **exploration and sustainable, ethical exploitation of natural resources** in and for the benefit of LMICs.
- promote development of **new materials at the forefront of renewable energy technologies**, including in LMICs.

Analytical Chemistry

For many years, IOCD's **Working Group on Environmental Chemical Analysis**, formed in partnership with the International Union of Pure and Applied Chemistry (IUPAC), supported building national capacities for high-quality analytical chemistry (**Box 5**), for example through workshops and training in laboratory management and in practical analytical techniques, including for the analysis of pesticide residues and water quality. The Working Group assisted analytical laboratories in LMICs to build their capacities to produce test results that are accurate, reliable, and acceptable internationally, that are required in

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Box 5 IOCD team visits Uganda National Bureau of Standards



Team members (*rear, from left*) Walter Benson, Albert Pohland and Geoffrey Kamau, with (*front left*) Anthonia Nakamya (head of the National Drug Authority Quality Control Laboratory in the Uganda National Drug Authority) and Hope Kamusiime (head of the Chemistry Section at UNBS).

monitoring a country's environment or ensuring the quality and purity of agricultural or manufactured products intended for export. The Working Group organized workshops to provide training in analytical methods, metrology, and good laboratory practice; and worked directly with selected laboratories in LMICs to identify and help to overcome barriers to obtaining test results of sufficient accuracy and reliability when testing commodities for export.. Working Group activities were undertaken in Africa, Latin America and Central and Eastern Europe. Examples of the Working Group's contributions include:

- In collaboration with the African Regional Chemical Society in Burkina Faso, IOCD co-organized a high-level International Conference on Pesticide Pollution, with speakers from all neighbouring countries and about 100 participants. Delegates from Cameroon, Kenya, Nigeria, Tanzania and Zimbabwe agreed to form a network with leadership from academic, industry and government organizations.
- **Uganda:** In agreement with the Ugandan government, IOCD partnered with the Uganda National Bureau of Standards (UNBS) to strengthen its capacity to test export commodities to international standards. IOCD provided technical consulting to seven Ugandan Commodity Testing Laboratories engaged in testing commodities for export, with continuing follow-up (**Box 6**). UNBS has continued to enhance its capabilities for internationally acceptable analytical methodology – e.g. in 2011 receiving certification from the South African National Accreditation System as an accredited calibration laboratory.
- Networks: the Working Group supported the work of a number of networks in Africa devoted to strengthening capacities for chemical analysis, including E-SALAMA³ and SEANAC.⁴

Box 6 Working with Uganda



IOCD scientists Al Pohland, Walter Benson and Patrick Wilson consult with Ugandan economist Nicodemus Rudaheranwa

- **IAEA-IOCD-TEAC Joint Workshop on Air Particulate Matter:** With increasing urbanization and greater industrialization, urban air quality in many countries is worsening. Many African countries have begun to adopt air quality management legislation, regulations, or policies. In collaboration with the International Atomic Energy Agency (IAEA) and the Tanzania Atomic Energy Commission (TAEC), IOCD's Environmental Analytical Chemistry Working Group organized a workshop in Arusha, which focused on the analysis of air particulate matter.

In 2013, IOCD decided to reformulate and widen the scope of its work, standing down the Environmental Chemical Analysis Working Group and beginning the process of developing a new Working Group in Analytical Chemistry, with a remit to strengthen capacities and encourage application of analytical chemistry techniques to solving a range of environmental and other challenges.

Analytical Services

To provide support and capacity building for scientists working in settings with limited resources, IOCD began a programme in the 1980s to provide analytical services for chemists in LMICs. This was initially a North-South network, with chemists in the Mexico, the UK and USA receiving samples from chemists in a range of countries in Africa, Asia and Latin America and providing, free of charge, infrared, ultraviolet, NMR and mass spectra and, on request, giving assistance with interpretation of spectra and elucidation of structures of synthetic and natural products.

Changing strategy, in 1992 IOCD supported the launch of a new activity, the Network for Analytical and Bioassay Services in Africa (NABSA), (Box 7) based

at the University of Botswana. NABSA promotes the development of scientific activities in Africa by offering analytical, bioassay and literature support services to chemists; cooperates with active scientists in a joint short-term intensive-research undertaking by inviting them to the reasonably well equipped laboratory in Botswana; and promotes the professional development of young scientists by arranging sub-regional symposia. From 2005, NABSA's focus shifted into research cooperation with research groups in selected countries and institutions, particularly in Cameroon, Ethiopia, Nigeria, South Africa, Tanzania and Zimbabwe, in order to help build and strengthen capacities and increase the overall impact of the collaboration.

Box 7 Network for Analytical and Bioassay Services in Africa (NABSA) A case study of successful development of an indigenous, regional network for capacity building and technical support in the chemical sciences^{5,6}

With encouragement and support from IOCD, NABSA was founded in 1992 as a network of laboratories in the Chemistry Departments of Addis Ababa University in Ethiopia, University of Nairobi in Kenya and University of Botswana in Gaborone. NABSA's aim was to assist scientists in Africa working on the isolation and structure elucidation of natural products, who were often constrained by of inadequate facilities for spectroscopic analysis. The International Foundation for Science (IFS) has worked with NABSA over many years to support its activities and to provide proper maintenance and functioning of the analytical equipment, including HPLC, NMR and mass spectrometry.



300 MHz NMR facility and technician in the University of Botswana
(Photo courtesy of Berhanu Abegaz, former Director of NABSA and IOCD Senior Advisor)

Biotic Exploration Background

Economic developmental through increasing production and processing to add value to minerals and primary agriculture products must be balanced with concern for the environment, conservation of natural resources and sustainable development. Key chemistry contributions include the discovery and sustainable exploitation of new nutrients, pest-resistant crops and medicines from biological resources.

IOCD Activities

IOCD encourages and facilitates the sustainable and equitable exploitation of natural resources for local benefit in LMICs and for global benefit.

Collaborating with Thomas Eisner ("father of chemical ecology."), in 1995 IOCD established the **Biotic Exploration Fund Working Group** (BEF). This has assisted African, Asian and Latin American

countries to develop policies for ethical, sustainable bioprospecting that will contribute to better health and economic development. This has often involved sustained engagement over several years to support national initiatives. Examples of ongoing work include:

Kenya: IOCD's BEF has assisted Kenya since 1998, when it cooperated with Nairobi's International Centre of Insect Physiology and Ecology (ICIPE) to establish a bioprospecting programme. Follow-up with the Government of Kenya continued over a number of years. IOCD participated in a national Biodiversity Roundtable Meeting⁷ held in Mombasa in 2009; and later facilitated a study tour by a group of Kenya's senior government officials to Costa Rica's National Biodiversity Institute (INBIOS) and to the USA's Yellowstone National Park to gain insights into other countries' successes in bioprospecting.

Box 8 Launch of Kenya's new Bioprospecting Strategy



Safari Park Hotel, Nairobi, 3 November 2011

Left to right: Mr. M.A. Wa Mwachai, Permanent Secretary, Ministry of Forestry and Wildlife; Hon. Mutula Kilonzo, Minister for Justice, National Cohesion and Constitutional Affairs; Dr. John Kilama, IOCD; Mr. Julius Kipng'etich, Director, Kenya Wildlife Service

In 2011 Kenya established a national bioprospecting strategy (**Box 8**) – among the first countries in the world to have a bioprospecting roadmap after agreement of the Nagoya Protocol⁸ (**Box 9**) on access and benefit sharing of genetic resources. Bioprospecting now forms part of Kenya's national plan for sustainable development.⁹

The BEF has continued supporting efforts to put bioprospecting-suitable legislation in place in Kenya and to facilitate the establishment of a new public-private partnership in Kenya to conduct bioprospecting. IOCD is also assisting in developing the training of Kenya scientists and officials in the management of intellectual property, to ensure the protection of Kenya's resources.

Uganda: At the request of a group of scientists in Uganda in 1998, IOCD began a long-term programme to assist the country

in establishing bioprospecting. In 2005, IOCD and the Uganda National Council for Science and Technology convened the National Conference on "Bioprospecting for Economic Development", which called for establishment of the Uganda National Centre for Bioprospecting.

To facilitate passage of essential legislation on biodiversity by the Uganda Parliament, at the request of the Uganda Minister of Planning in 2007 IOCD convened a consultative briefing with members of Parliament, university vice chancellors, entrepreneurs and representatives of indigenous peoples.

IOCD has continued to assist Ugandan policy makers to develop draft legislation on bioprospecting for parliamentary approval. Contacts with Ugandan authorities are continuing in 2014 to support further progress.

Box 9 Nagoya Protocol on access and benefit sharing⁸

The *Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilization to the Convention on Biological Diversity* is an international agreement which aims at *sharing the benefits arising from the utilization of genetic resources in a fair and equitable way*, including by appropriate access to genetic resources and by appropriate transfer of relevant technologies, taking into account all rights over those resources and to technologies, and by appropriate funding, thereby contributing to the *conservation of biological diversity* and the *sustainable use of its components*. It was adopted by the Conference of the Parties to the Convention on Biological Diversity at its tenth meeting on 29 October 2010 in Nagoya, Japan.

Article 17 of the Protocol call on each Party to take appropriate measures to monitor and to enhance transparency about the utilization of genetic resources; while **Article 21** requires each Party to take measures to raise awareness of the importance of genetic resources and traditional knowledge associated with genetic resources.

Ethical bioprospecting, as encouraged and facilitated by IOCD, helps countries to meet these requirements by ensuring that genetic resources such as the indigenous plants, fungi and bacterial are explored, catalogued and preserved during the search for products of potential value.

Materials for Energy Conversion, Saving and Storage (MATECSS) Background

With finite stocks of carbon-based fuels, growing demands for energy from emerging economies and an increasingly serious impact of the emission of greenhouse gases like carbon dioxide on the planet's climate, the world faces a growing energy crisis. Power generation is responsible for more than 75% of the 35 billion tonnes of CO₂ emitted into the atmosphere each year.

The UN has declared 2014-2024 the Decade of Sustainable Energy for All, calling on Member States to galvanize efforts to make universal access to sustainable modern energy services a priority, noting that 1.3 billion people are without electricity and 2.6 billion people in LMICs rely on traditional biomass for cooking and heating. It expressed concern that millions of poor people are unable to pay for energy services.¹⁰

IOCD has responded to this challenge by initiating a new Working Group focusing on the contributions that the chemical sciences can make to sustainable energy production.

IOCD Activities

Formed in 2013, the goal of IOCD's **MATECSS Working Group (Box 10)** is to enable local-scale energy conversion, storage and savings in targeted regions in LMICs through new materials at the forefront of renewable energy technologies. Cooperating with LMIC researchers, MATECSS works towards identifying specific energy needs and developing solutions, using inexpensive adaptive technologies that do not require significant investments in capital equipment and infrastructure and that can make use of local/regional resources. It will also emphasize capacity building through training of young scientists and engineers.

To initiate its activities, MATECSS conducted a survey of freely-available materials describing sustainable energy technologies. This provided an overview of documents, academic papers and online courses, available via the internet (mostly open access), that offer introductory-level instruction in sustainable energy technologies.

Box 10 Materials for Energy Conversion, Saving and Storage (MATECSS)



Federico Rosei (left) and Mohamed Chaker, professors at the Centre Énergie Matériaux Télécommunications at the Institut national de la recherche scientifique of the Université du Québec, Canada: co-chairs of IOCD's MATECSS Working Group

The network of partners that comprise MATECSS currently spans Algeria, China, Costa Rica, India, Mexico, Morocco, Nigeria, South Africa and Vietnam.

With IOCD support, in 2014 MATECSS is developing a short course providing an introduction to materials for sustainable energy technologies, to be offered in an online version as a webinar and as lectures in traditional format.

In the initial phase, the course will be offered at least twice in both its webinar/online version and in person, with feedback solicited from the attendees on how to improve it. In-person lectures will be delivered in partner institutions in Mexico and Costa Rica. After course refinement, the online materials will be launched and there will be delivery of the course by webinar.

- The work of MATECSS has recently been boosted by the award of a UNESCO Chair in MATECSS to the Co-Director, Federico Rosei.
- His outstanding work in the field of education has also been honoured with the the 2014 José Vasconcelos Award by the World Cultural Council. The prize is awarded for his impressive career both within the Chemical Sciences and as an advocate of a global approach to societal development through scientific knowledge and innovation, inspiring and educating people.

Strategic priority 3 Capacity building in chemistry education

Countries need a broad array of capacities and enabling factors so that they can use the chemical sciences in responding to changing conditions and new challenges over time and to be self-reliant in their abilities to determine their own futures.

Education at all levels is one of the critical determinants – not only to provide a well-trained body of chemical scientists who can work in industry, public sector laboratories, teaching institutions and research facilities; but also to help create a level of chemical literacy in the general public, policy makers and the media to ensure a broad understanding of the role of chemistry and enable evidence-informed debate on a host of contemporary issues where the chemical sciences play a role.

IOCD's strategy is to help enhance capacities for chemistry education, including through web-based resources, library provisions and microscale science:

Web-Based Resources

- **Distance Education:** Open and distance learning (ODL) in chemistry provides a very flexible, cost-effective approach to delivering technical training, continuing education and high quality source materials that can be quickly, efficiently and cheaply up-dated to keep pace with advances in fast-developing field.
- **Medicinal Chemistry:** Responding to the increasing demand for trained medicinal chemists in LMICs in the last few years, a medicinal chemistry distance training programme, available on-line and as a CD, has been developed, piloted and delivered by IOCD's Medicinal Chemistry Working Group based at the University of Kansas.

Organic chemistry tutorials – Spanish:

An IOCD group in the Faculty of Chemistry, Universidad Nacional Autónoma de México (UNAM) has established a series of web-based organic chemistry tutorials online in Spanish, including modules on structure, synthesis, stereochemistry and nomenclature. This is one of the most visited websites in the world in Spanish related to chemistry, registering well over 2 million visits/year.

- **Chemistry knowledge resources on the internet:** IOCD has embarked on the development of a suite of free on-line resources, **ChemKnowCore**, for teaching and learning in chemistry.

- The suite will include a chemical dictionary, accounts of chemistry research, chemistry experiments and games and, most important of all, **ChemKnowBase**, a new chemistry knowledge repository.
- **ChemKnowBase** will cover the entire field of chemistry and include a comprehensive, searchable contents/index that will enable the user to quickly find subjects, topics and data. It will be

curriculum, examination and pedagogy independent, providing a unified global standard of verified chemistry knowledge, while supporting context-dependent knowledge delivery by teachers and learning by their students.

During 2014, a pilot ChemknowBase project is under development, in which the structure and architecture of the website will be developed and some selected areas of organic, organometallic and theoretical chemistry will be used to model the table of contents, content structures and cross-linkages required.

Books for International Development

Access to good quality, contemporary textbooks is critical for education and professional development in all areas, including the chemical sciences, but university libraries in LMICs often lack a stock of suitable materials due to the high costs of purchasing and shipping. Aided by student volunteers, (Box 11) IOCD established a programme at Millersville

Box 11 Books for International Development



Volunteers working with project head Dr James Cosentino (*centre*) at the University of Millersville, USA to package container loads of books for shipment to libraries in low- and middle-income countries

University, USA to collect good quality textbooks (across all disciplines) donated by libraries and private sector companies. The project has received support from UNESCO and the State of Pennsylvania, with cooperation and donations in kind from the World Bank, the American Association for the Advancement of Science and Millersville University.

Since 2003, more than 20 shipments of about 7,000 kg each have been sorted, packaged, shipped and delivered to libraries in LMICs, including over a dozen countries in Africa and Asia (Angola, Bangladesh, Benin, Comoros, Democratic Republic of the Congo, Eritrea, Ethiopia, Guinea-Bissau, Liberia, Mauritius, Morocco, Pakistan, Swaziland and Vietnam).

The Millersville group has also successfully arranged deliveries of functioning, used computers (24 per shipment) to 13 LMICs and of essential medical supplies to Haiti following the 2009 earthquake.

During 2012 BID collaborated with the African Academy of Sciences (AAS) in Nairobi, Kenya to help supply the Academy with computers and conference/classroom furnishings, enabling the Academy to conduct conferences, classes, seminars etc. to benefit the scientific community throughout Africa.

The BID continues to collect donations of books, journals and equipment and to arrange the packaging and shipment of container-loads of these to institutions in LMICs. Further consignments are planned for 2014-15.

Microscale Science

Practical laboratory work is often extremely limited in LMIC science courses due to the poor availability of equipment, chemicals and lab facilities. To overcome these difficulties, chemistry professor John Bradley (University of Witwatersrand, S Africa), developed portable micro-scale kits involving miniature pieces of apparatus that teachers could use in the classroom enabling with very small quantities of chemicals, enabling chemical reactions to be conducted and experiments observed at first hand even in very poorly resourced schools. The RADMASTE Centre at the University of Witwatersrand continues to promote micro-scale science and hosts one of a global network of UNESCO-Associated Centres for Microscience Experiments that form the **Global Microscience Project**, involving partnerships with IOCD, UNESCO, IUPAC and the International Foundation for Science Education (IFSE). The kits and materials are designed to be easily adaptable to different national curricula, including in chemistry, physics and biology teaching and are supported in multiple languages. Under the auspices of UNESCO, IUPAC, IFSE and IOCD, more than 80 countries have benefited from introductory microchemistry workshops and training courses, all of which have had positive review by local experts and teachers alike.

As part of its work to promote the development and use of microscience chemistry kits IOCD has engaged in discussions with partners in Africa to explore the potential for a programme to integrate microscale science kits into school chemistry curricula.

Promoting the chemical sciences

IOCD was established in 1981 under the auspices of UNESCO, *as the first international NGO devoted to enhancing the role of the chemical sciences in development work and involving chemists in LMICs* – enabling them to contribute to key areas of science and technology for development. Today, IOCD remains the only international NGO with this focus.

IOCD promotes recognition of the importance of the chemical sciences for development, through its website, publications by members, presentations at symposia, organization of meetings on scientific advances and engagement with policy-makers to promote understanding of the potential for the chemical sciences to contribute to economic advancement and enhanced human health and wellbeing.

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