United Nations
Educational, Scientific and
Cultural Organization

Chemistry and Life

THE UNESCO
Courier
January-March 2011

ISSN 2220-2285

OUR AUTHORS

International Year of
CHEMISTRY
2011

IYC 2011

The International Year of Chemistry 2011 (IYC 2011) was proclaimed by the United Nations General Assembly following a proposal by Ethiopia. It aims to celebrate the contributions made by chemistry to the wellbeing of mankind. Under the banner of "Chemistry: our life, our future", the Year will highlight the role that science is expected to play in such varied fields as health, food, the environment, energy and transport. The Year is especially addressed at youth and non-specialists, inviting them to join in a whole range of interactive, entertaining and educational events across the world (www.chemistry2011.org/).

The year 2011 also marks the centenary of the award of the Nobel Prize for chemistry to Marie Sklodowska-Curie and of the establishment, in Paris, of the International Association of Chemistry Societies, which changed its name in 1919 to the International Union for Pure and Applied Chemistry (IUPAC).

With its headquarters in Zurich (Switzerland), IUPAC was founded by chemists from both universities and industry, with the aim of encouraging international cooperation in chemistry and as a means to bridge the divide between scientific research, industrial applications and the public sector. It is because of IUPAC that chemists all over the world share a common 'language', in terms of nomenclature, symbols, terminology, standard atomic weights, etc. Fifty-four National Adhering Organizations and Associate National Adhering Organizations are members.

UNESCO and IUPAC are jointly organizing IYC 2011, along with industrial partners. The International Year of Chemistry 2011 will be launched on 27 January 2011 at UNESCO headquarters in Paris, with the participation of several leading scientists and researchers.

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The UNESCO Courier is published by the United Nations Organization for Education, Science and Culture.
7, place de Fontenoy
75352 Paris 07 SP, France
www.unesco.org/courier

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Design and layout: Baseline Arts Ltd, Oxford
Printing: UNESCO – CLD
Information and reproduction rights:
+ 33 (0)1 45 68 15 64 · k.markelova@unesco.org
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With thanks to: Danica Bijeljac, Fabienne Dumur, Cathy Nolan, Michel Ravassard, Marie Renault, Susan Schneegans and Fan Xiao

Barium single-crystal fibres. Barium is mainly used in the petroleum industry, as well as medecine (x-rays of the digestive tract) and construction industry (anti-radiation heavy concrete).
© SPL



Historical vacuum line, formerly used for gas phase synthesis / From the collections at the University of Copenhagen

In this issue

In 1932, the German physician, Gerhard Domagk, confirmed the anti-bacterial action of a new dye developed by the company, IG Farben. Seven years later, *Prontosil* earned him the Nobel Prize, but, because of the Nazi regime, he was unable to accept it. Today, a South African, Tebello Nyokong, is developing new treatments for cancer using substances usually used for dying denim jeans. These discoveries are not mere anecdotes; they mark a new phase in a highly colourful science – chemistry. The articles in this latest issue of the *UNESCO Courier* will enable everyone to form a more complete picture of progress in this science.

Chemistry is so all pervading in our lives, that it often passes unnoticed, says Jean-Marie Lehn, French Nobel Prize laureate in chemistry in 1987. "A world without chemistry," he says, in our Introduction, "would be a world without synthetic materials, and that means no telephones, no computers and no cinema […] without aspirin or soap, shampoo or toothpaste, without cosmetics, contraceptive pills, or paper – and so no newspapers or books, glues, or paints" (p.8).

After tracing the early history of chemistry, which "began the moment our ancestors became human," (pp. 11-16), we take a look at its applications, particularly in medicine. This is an opportunity to inquire about the interactions between nature, research and industry, from South Africa to Australia, Brazil, China, Ethiopia and India (pp. 17-28).

Chemistry, though, is Janus-faced: one face embodies the prodigious benefits to humanity; the other the harm caused by pollution. The disaster that struck Hungary last October sounded the alarm once again (p. 35). All the more reason to focus on the solutions chemistry can offer to the pollution it has caused. Once again, we can travel from China, and Europe, to the USA and New Zealand, to discover, in the company of Philip W. Boyd and Klaus Lackner, some attempts to tackle climate change (pp. 32-33).

An encouraging sign is that industry is "acting much more responsibly" (p. 31), according to Ole John Nielsen (Denmark), a member of the Intergovernmental Panel on Climate Change (IPCC). Chemistry is becoming this new science that Akira Suzuki (Japan), Nobel laureate in Chemistry in 2010, is dreaming of (pp. 39-41). New generations of young chemists will undoubtedly steer it on the right course (pp. 42-43).

As a supplement to these special features, the *Courier* also gives a glimpse of the UNESCO World Science Report 2010, commemorates the anniversary of the creation of CERN and looks at culture, as the International Year for the Rapprochement of Cultures (2010) draws to a close.

– **Jasmina Šopova**

Editorial

Irina Bokova

Chemistry, and our ability to master its secrets, is fundamental to our understanding of the material world. The chemical elements are at the core of all known matter. They are involved in all living processes. We owe most of the 20th century's advances in medicines, the food industry and technology to modern chemistry. This science has revolutionized the manufacture of drugs, clothing and cosmetics, as well as the distribution of energy and the manufacture of technological equipment. Chemistry is everywhere in our daily lives – and if we are to make the best use of it, we have to understand it better.

At the initiative of Ethiopia, the United Nations declared 2011 International Year of Chemistry (IYC 2011) and entrusted its organization to UNESCO. It provides a special opportunity to improve our knowledge of this science and the contribution it has made to our ability to understand, control and transform matter. It is also an opportunity for UNESCO to further its efforts in its areas of competence, namely, development and diplomacy through science, strengthening the research capability of Member States and quality science education for all – where chemistry is an essential component.

IYC 2011 also celebrates the centenary of the award of the Nobel Prize in chemistry to Marie Curie, providing us with the perfect framework for paying homage to and promoting the contribution of women to science. And this homage starts the same day the International Year is launched, with a visit to UNESCO headquarters by Hélène Langevin-Joliot, scientist and grand-daughter of Marie Curie and daughter of Irène Joliot-Curie, to speak at a conference on the role of women in chemistry.

The latest World Science Report, published by UNESCO in November 2010, demonstrated the importance of science and science diplomacy for peace and development. Basic research on the building blocks of matter requires colossal resources and the participation of a great many researchers, from all over the world. This calls, in particular, for a strengthening of international cooperation and a more even global distribution of research resources. Through initiatives such as the SESAME research centre in the Middle East, where chemistry is a major component, UNESCO is endeavouring to help meet this need.

The future science of chemistry must, above all, be responsible. It will undoubtedly be playing a major role in the development of alternative

It provides a special opportunity to improve our knowledge of this science and the contribution it has made to our ability to understand, control and transform matter.

Irina Bokova, Director General of UNESCO with the Canadian astrophysicist Hubert Reeves, at a conference on the loss of biodiversity, at the Organization's headquarters on 3 November 2009.
© UNESCO/M. Ravassard

The quasi-absence of a "general culture of chemistry", compared to the culture of astronomy or mathematics, prevents the general public from having access to aspects of the world that affect our daily lives and hampers our collective ability to have a say in this.

energy sources and in feeding an ever-growing global population. Discoveries made in chemistry can help to meet the challenges raised by global climate change – without chemistry there would be no solar panels, no biofuels… These discoveries can also help provide access to non-polluted water supplies. The International Year of Chemistry follows on from the International Year of Biodiversity (2010) and takes on its full meaning within the context of the United Nations Decade of Education for Sustainable Development (2005-2014).

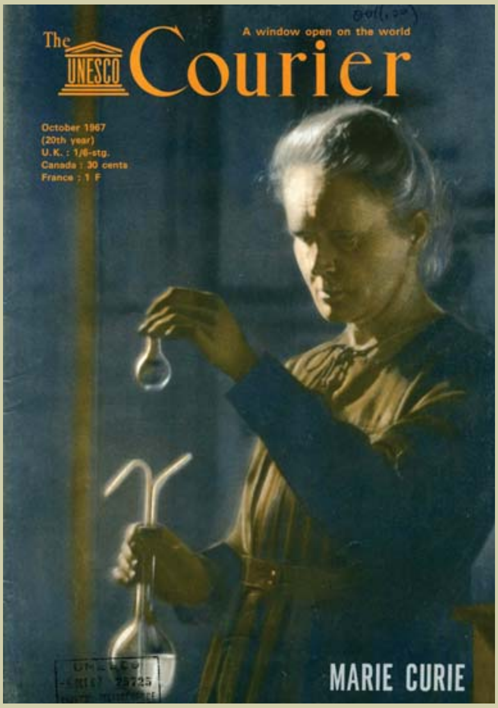
The chemistry of the future must also be a science that is more evenly shared. The quasi-absence of a "general culture of chemistry", compared to the culture of astronomy or mathematics, prevents the general public from having access to aspects of the world that affect our daily lives and hampers our collective ability to have a say in this. This lack of understanding also fuels the public's stereotyped view of chemistry as diabolical, toxic and dirty. We need to improve and to accelerate the teaching of chemistry, training the chemists of tomorrow and giving everyone, everywhere, the possibility of understanding chemical processes and measuring their impact. Interest in this fascinating science is a resource for development. It is up to us to make good use of it.

In order to attract young people to take an interest in chemistry, UNESCO and the International Union of Pure and Applied Chemistry – its main partner in organising the IYC, celebrating its centenary this year – are launching a global experiment, the first of its kind, to help schoolchildren gain a better understanding of our most precious resource – water. All across the world, schools will be testing water for its quality and purity and will then be able to share their results.

It is a priority for the years to come that we all improve our understanding of science in general and of chemistry in particular. As the United Nations agency specializing in education, science and culture, UNESCO will do its utmost to see that this is achieved. It is our collective duty to make decisions that are fully informed if we are to act responsibly on the world around us. ■

A POOR SHOWING FOR WOMEN NOBEL LAUREATES

The first woman to receive a Nobel Prize in chemistry was Marie Curie. That was a century ago. Since then, the list of women laureates in chemistry has not grown much longer. Just three names have been added: Irène Joliot-Curie, Dorothy Mary Crowfoot Hodgkin and Ada Yonath.



In 1967, the UNESCO Courier *devoted an entire issue to Marie Curie.*

Since it was created in 1901, the Nobel Prize has been awarded to 40 women, across all disciplines, Marie Curie having been honoured twice. Born in Warsaw (Poland) in 1867, Maria Skodowska (married name Curie) received the Nobel prize in Physics in 1903, with her husband, Pierre Curie and Henri Becquerelle, before being rewarded herself, in 1911, "in recognition of her services to the advancement of chemistry by the discovery of the elements radium and polonium."

In 1935, it was to be the turn of her daughter, Irène, to share this prestigious award with her husband, Frédéric Joliot-Curie, "in recognition of their synthesis of new radioactive elements."

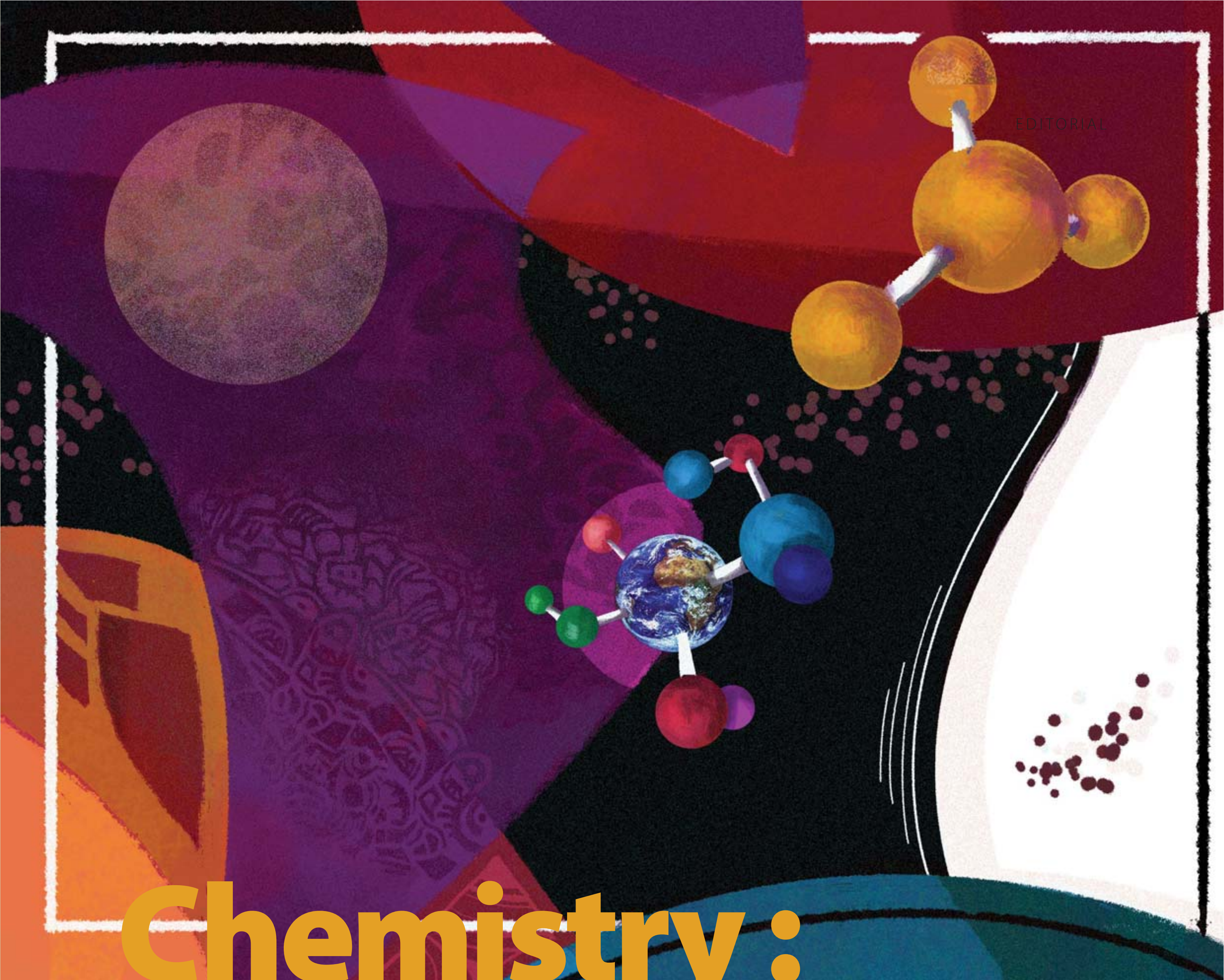
It was nearly a further three decades before another woman was to attract the attention of the Swedish Royal Academy of Sciences, when Dorothy Mary Crowfoot Hodgkin (United Kingdom), was honoured in 1964, "for her determination by X-ray techniques, of the structures of important biochemical substances."

Finally, 45 years later, Ada Yonath (Israel) shared the Nobel Prize in Chemistry with Venkaterman Ramakrishnan (India) and Thomas Steitz (USA), "for studies of the structure and function of the ribosome." The year before, Ada Yonath had received the L'Oréal-UNESCO Award for Women in Science (2008).

Since it was launched in 1998 by L'Oréal and UNESCO, the Women in Science Programme has been supporting women who are carrying out scientific research, designating one laureate for each continent, every year. Also, 15 international fellowships have been awarded each year since 2000, to young researchers, whose projects have been accepted by renowned research laboratories outside of their country of origin.

J.Š.

1. *Chemistry, 4; Physics, 2; Medicine, 10; Literature, 12; Peace, 12.*



Chemistry : the science and art of matter

Chemistry is intrinsic to life. Original drawing by Sejung Kim (Republic of Korea).

Jean-Marie Lehn

The science of chemistry is not just about discovery. It is also, and especially, about creation. It is an art of the complexification of matter. To understand the logic of the latest discoveries in nanochemistry, we have to take a 4-billion year leap back in time.

Chemistry has a pivotal role to play, as much because of its place within the natural sciences and knowledge as a whole, as through its economic importance and its omnipresence in our daily life. But, because it is everywhere, we often forget about it, and could even not mention it at all. Chemistry doesn't flaunt itself, but without it, some truly spectacular achievements would never have been made, such as breakthroughs in the treatment of illness, space exploration, and marvels of technology. It makes an essential contribution to humanity in food and medicines, clothes and housing, energy and raw materials, transport and communications. It supplies materials for physics and industry, models and substrates to biology and pharmacology, and properties and procedures to the sciences and technology.

"May your search be guided by the highest dreams"
– Roland Barthes

A world without chemistry would be a world without synthetic materials, and that means no telephones, no computers and no cinema. It would also be a world without aspirin or soap, shampoo or toothpaste, without cosmetics, contraceptive pills, or paper – and so no newspapers or books, glues, or paints.

And we must be careful to remember that chemistry helps art historians delve into the secrets behind paintings and sculptures in museums, and helps forensic scientists to analyse samples taken from a crime scene and quickly track down the perpetrators, as well as revealing the molecular basis of dishes that delight our taste buds.

While physics decodes the laws of the universe and biology deciphers those of the living world, chemistry is the science of matter and its transformations. Life is its highest form of expression. Chemistry plays a primordial role in our understanding of material phenomena, in our ability to act upon them, to change them and control them.

For almost two centuries now, molecular chemistry has put together a vast array of increasingly sophisticated molecules and materials. This discipline has not ceased to assert its power over structure and the transformation of material, from the synthesis of urea in 1828 – which started a veritable revolution, by providing the proof that it was possible to obtain an 'organic' molecule from a mineral component – to the synthesis of vitamin B12 in 2006 after a quest that had started in 1948.

The molecule as Troy horse

Above and beyond molecular chemistry there is the vast area of what is called supramolecular chemistry, which is not so much interested in what happens *within* molecules, as what happens *between* them. Its objective is to understand and control the manner in which molecules interact with one another, transform themselves, bind to one another, while ignoring other partners. Emil Fischer (the German Nobel laureate for chemistry in 1902) used the image of the lock and key. Today we refer to "molecular recognition".

It is in the field of biology that the role of these molecular interactions is most striking: protein units group together to form haemoglobin; white blood cells recognize and destroy foreign bodies; the AIDS virus finds its target and takes it over; the genetic code is transmitted by reading and writing the alphabet of protein bases. In the vivid example of the 'self organisation' of the tobacco mosaic virus: no fewer than 2130 simple proteins join together to form a helical tower.

A chemist finds the efficacy and elegance of these natural phenomena so fascinating that he is tempted to reproduce or invent novel processes to create new molecular architectures, with a panoply of applications. Why not imagine molecules that can transport a fragment of DNA to the very centre of a target in gene therapy, for example? These molecules would be "Troy horses" which would, in turn, cross supposedly insurmountable barriers, like cell membranes.

A great many researchers around the globe are patiently creating 'designer' supramolecular structures. They observe how molecules that are jumbled with no apparent order can find and recognize one another and then gradually assemble themselves spontaneously, but in a perfectly controlled manner, to reach the final supramolecular edifice.

So, inspired by phenomena that nature has presented to us, the idea was born of eliciting and guiding the appearance of supramolecular assemblages – in other words, "molecular programming". The chemist conceives the basic building blocks (molecules with certain structural and interactional properties), then applies the "cement" (assembly code) to link them together.

"Where Nature ceases to produce its own species, Mankind begins, using natural things, and with the aid of this very Nature, creates an infinity of species…" – Leonardo da Vinci

This yields a superstructure via self organization. The synthesis of molecular blocks capable of self organization is much more simple than synthesizing the final edifice. This line of research opens vast horizons, notably in the field of nanotechnology – instead of fabricating nanostructures, we let the nanostructures fabricate themselves by self organization, thus moving from fabrication to self-fabrication.

Even more recently 'adaptive' chemistry has emerged, where the system, in order to construct itself, makes its own selection among the available building blocks, and becomes able to adapt its objects to the demands of the environment. This form of chemistry, which I call "dynamic constitutional chemistry", has something of a Darwinian flavour to it!

From matter to life

In the beginning there was the original explosion, the Big Bang, and physics reigned. Then came chemistry, with more clement temperatures. Particles formed atoms, which

united to form increasingly complex molecules, which, in turn, grouped together in aggregates and membranes, giving rise to the first cells, as life emerged on our planet, 3.8 billion years ago.

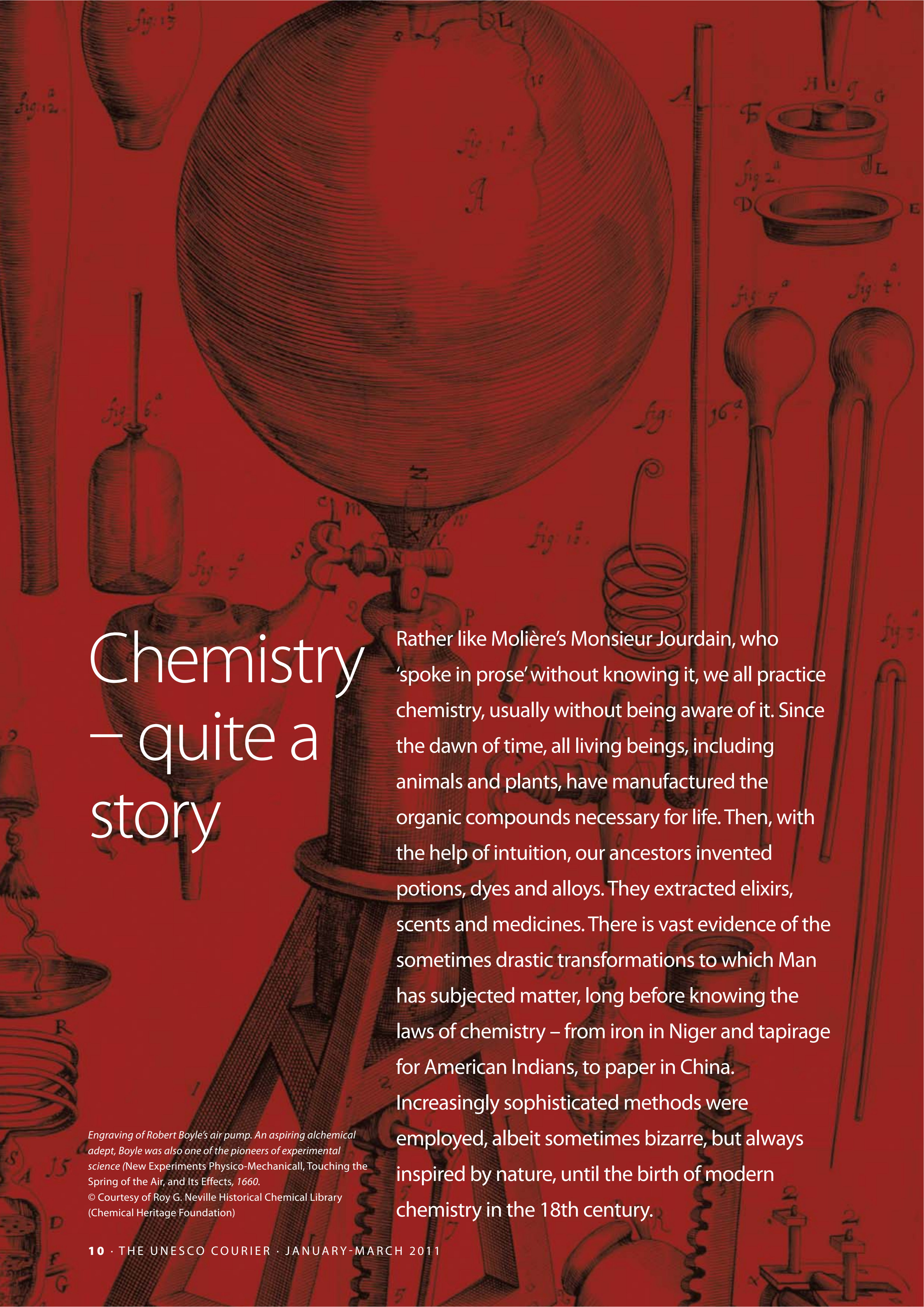
From divided matter to condensed matter, then organized, living and thinking matter, the unfurling Universe is nudging the evolution of matter towards increasing complexity through self organization, under the pressure of information. The task of chemistry is to reveal the pathways of self organization and to trace the paths leading from inert matter, via a purely chemical, prebiotic evolution, to the creation of life, and beyond, to living and then thinking matter. In this way, it offers the means to interrogate the past, to explore the present and to build bridges towards the future.

Through its subject matter (the molecule and material), chemistry expresses its creative force, its power to produce new molecules and materials, that never existed before they were created by the rearrangements of atoms into original and infinitely varied combinations and structures. Chemistry is, in some ways, analogous to art, through the plasticity of the chemical object's forms and functions. As artist, the chemist imprints matter with the products of his imagination. Just as stone, sounds and words do not contain the work that the sculptor, composer or author shapes with them, so the chemist creates original molecules, new materials and unknown properties from the elements that make up matter.

The particularity of chemistry is not only to discover, but to invent and, above all, to create. The Book of Chemistry is not only to be read, but to be written. The score of Chemistry is not only to be played, but to be composed. ■

Jean-Marie Lehn, is a chemist specializing in supramolecular chemistry, Emeritus professor at the University of Strasbourg (France), Nobel laureate in 1987 with Donald Cram and Charles Pedersen. Honorary professor at the Collège de France and member of the French Academy of Sciences, Jean-Marie Lehn founded the Institut de Science et d'Ingénierie Supramoléculaires (ISIS) in Strasbourg. http://www-isis.u-strasbg.fr/

Witherite in crystal form. The crystal makes it possible to shed light on the relationships between the properties, chemical composition and arrangement of atoms in materials. Chemists "cultivate" crystals in order to study and visualize them and to imagine new ones. This allows them to discover new materials, with a wide range of applications. © SPL



Chemistry – quite a story

Rather like Molière's Monsieur Jourdain, who 'spoke in prose' without knowing it, we all practice chemistry, usually without being aware of it. Since the dawn of time, all living beings, including animals and plants, have manufactured the organic compounds necessary for life. Then, with the help of intuition, our ancestors invented potions, dyes and alloys. They extracted elixirs, scents and medicines. There is vast evidence of the sometimes drastic transformations to which Man has subjected matter, long before knowing the laws of chemistry – from iron in Niger and tapirage for American Indians, to paper in China. Increasingly sophisticated methods were employed, albeit sometimes bizarre, but always inspired by nature, until the birth of modern chemistry in the 18th century.

*Engraving of Robert Boyle's air pump. An aspiring alchemical adept, Boyle was also one of the pioneers of experimental science (*New Experiments Physico-Mechanicall, Touching the Spring of the Air, and Its Effects, *1660.*
© Courtesy of Roy G. Neville Historical Chemical Library (Chemical Heritage Foundation)

Chemistry: how it all started

Chemistry began the moment our ancestors became human.

Michal Meyer

In the very early 1700s the Elector of Saxony and King of Poland, August the Strong, locked an alchemist in his laboratory and told him to make gold. The young alchemist, Johann Friedrich Böttger, failed in his royally-appointed task. Instead he helped create a substance far more beautiful and useful than gold – porcelain. And in a happy fairy-tale ending, the king was pleased. For this was no longer a feudal world, but a growing commodity-driven society, and until that time porcelain had to be imported at great expense from a technologically more advanced China to feed a growing European appetite for beauty and luxury. Wealth flowed to the king, for the new Meissen porcelain soon proved popular and a grateful king made Böttger, originally a pharmacist's apprentice, a baron.

One more story, this one beginning in the gutter: Around 1669 Hamburg resident Hennig Brandt believed he might have discovered the fabled Philosopher's Stone, which could turn lead into gold and open up the secrets of the cosmos. An ex-soldier with experience in making glass, Brandt began with old urine and boiled it up and heated the residue until glowing vapours – white phosphorous reacting with oxygen – filled his glassware. Within a few years, Brandt sold his secret and soon phosphorous was well enough known that the secretive alchemist Isaac Newton could begin a recipe for it with the instructions, "Take of urine one barrel." (Though I do wonder where one could easily procure a barrel of urine). From urine to art – another transformation –the moment of discovery was

James Gillray's satirical etching shows a public lecture at London's Royal Institution in the early 19th century.

immortalized in the eighteenth century in a painting by Joseph Wright of Derby, and recorded again as a mezzotint by William Pether in 1775 as "The Discovery of Phosphorous." In this work, the alchemist kneels in awe before the glowing wonder in his alchemical laboratory. Many years later, in 1943, in another transformation, Brandt's city burned when thousands of pounds of phosphorous fell in the form of bombs.

Homo chemicus

We turn clay into porcelain, urine into phosphorous, phosphorous into bombs, flour into bread, grapes into wine, minerals into pigments. There is almost no limit to the ways in which we transmute matter. Biological anthropologist, Richard Wrangham (United Kingdom), believes that it is cooking that made us human -- by making more energy available to feed our growing brains. If that is so, chemistry

An alchemist presents liquid gold to amazed courtiers. The alchemist's dream of turning lead into gold remained alive until the 18th century.

THE TOAD AND THE PARROT

The Achagua tribe living in the upper reaches of the Meta River (Colombia) know how to make their parrots grow feathers of different colours, thus increasing their value when used in ceremonies, or their price when sold. They obtain this result in the following manner: "they first catch a live toad and prick it several times with a thorn until it bleeds. They then put the animal into a pot and cover its wounds with pepper and ground pigment. Enraged by this cruel treatment, the toad distils the most active ingredients in its humours, which get mixed with the poison and blood. They add to this a certain red powder, which they call *chica* and, by mixing these extraordinary ingredients together, obtain a varnish. They then pluck out the parrot's feathers and anoint it with the varnish, introducing it into the holes left by the feather, with the aid of a pointed stick. The parrot does not seem happy with this treatment, acting for days like a sick chicken, all ruffled and sad. After a while, its feathers grow back. But this time they have become so splendid that their beauty and elegance is the object of great admiration. A variety of feathers with red spots on a yellow background stand out most admirably against the background of green feathers."

We owe this picturesque description of tapirage carried out by an indigenous tribe from Colombia to the Spanish Jesuit, Juan Rivero (*Historia de las misiones de los llanos de Casanare y los Rios Orinoco y Meta,* written in 1728 and published in 1883). It was cited by Alfred Métraux, an American anthropologist of Swiss origin and former staff member at UNESCO, in his article (in French) entitled "A biological discovery by South American Indians: artificial discoloration of feathers on living birds." (*Journal de la Société des Américanistes*. Volume 20, 1928. pp. 181-192.)

"By plucking the feathers they need from living [birds] kept in captivity, the Indians spare themselves the trouble of hunting and the risk of damaging the feathers by killing the birds with a number of arrow wounds," explains the anthropologist, who attributes the spread of tapirage in Amazonia to the Arawak peoples, who began migrating some three thousand years ago.

– **J.Š.**

began the moment our ancestors became human. *Homo chemicus* – to be human is to transform matter. And the material transformations we – being human – make will reflect the best and the worst of us.

We cannot go back to that first chemical moment when raw food turned into cooked food, but we can go back to prehistoric humans and their desire for beauty. Philippe Walter, of the *Centre de Recherche et de Restauration des Musées de France*, studies chemical processes and substances in the ancient and prehistoric world. While he says these prehistoric peoples did not have an understanding of how or why processes worked, they still produced practical chemists who could mix natural ingredients to produce pigments – whether to adorn themselves or the walls of caves. Four thousand years ago the ancient Egyptians, says Walter, synthesized new chemicals to treat eye diseases. Their lead-based cosmetics – think Cleopatra and her kohl eyeliner [see box] – stimulated the wearer's immune system in an early health and beauty regimen.

Al-kimia

In Hellenistic Egypt, the refining of metals was known as *chemia*. With the rise of early Islamic civilization, Muslim scholars translated many Greek texts, including ones on *chemia*, which they called *al-kimia*. How matter changed, how to purify substances, how to colour metals, all came under *al-kimia*. A side benefit of this new fascination was the refinement in practical knowledge such as distillation and

The misfortunes of an over-materialistic alchemist

Tayra M.C. Lanuza-Navarro

In 1603, Giraldo Paris had already been living in Madrid for 33 years, as advisor to Philippe II on Flemish affairs. He had grown up in Anvers and made his fortune in the spice trade. He entertained all the Flemings at the Spanish court, surrounding himself with ambassadors and dignitaries, as well as pharmacists, doctors and scholars. Having retired from commerce with an immense fortune, Paris maintained a passion for alchemy. He was interested in the skills and knowledge of diamond cutters, apothecaries, distillers and herbalists.

That year, some known enemies of Paris denounced him to the Inquisition, accusing him of heresy. During the ensuing trial, it was claimed that the Fleming "extracted quintessences, flowers of metal and herbal salts." It was also claimed that he was a great natural philosopher, being interested in the "secret art of chemistry". Paris was condemned to one year of seclusion in a monastery and made to pay a heavy fine.

Told in this way, his story sounds like one of a man pursued by the Spanish Inquisition because of his activities as an alchemist. But the reality is more complex. The distillations, the experiments with metals and the herbal extracts were not what his Inquisitors were really concerned about. The reason for the sentence lay in the alchemist's explanations for certain religious questions. Giraldo Paris, for example, explained the Virgin Birth by comparing it to an alchemical procedure where a pure substance is mixed with another, finding, at the end of the operation, that the former had remained intact "without having lost any of its virtue […] immaculate as it was in the beginning."

So the Inquisition took issue with Giraldo Paris not for his occult activities but for his "mistaken theses". At the time, Madrid had many alchemists who were not persecuted for their practices, but nonetheless, many of their works turned up on the *Index Librorum Prohibitorum* (list of banned books). Also on the list was the *Theatrum Chemicum*, the most complete compendium of alchemical knowledge in 17th century Europe. The work was so important that the Inquisition had to lift its ban, but did not omit to censor it.

So, unless proven otherwise, it seems the Inquisition did not persecute alchemists for their acts, but for their convictions on material affairs, which were contrary to the dogma.

Tayra M.C. Lanuza-Navarro is a Spanish historian of science. She is currently working on a project on books on alchemy at the beginning of the modern era.

"La Pharmacie Rustique", 1775. The famous Swiss medical practitioner Michel Schuppach examines a patient's urine in his pharmacy.
© Courtesy of the Chemical Heritage Foundation Collections
Photograph by Gregory Tobias

The hanging alligator shown in this scene was commonly found in alchemical laboratories.
© Courtesy of the Chemical Heritage Foundation Collections

crystallization, still important skills in twenty-first century labs. On a more theoretical level, Muslim scholars built on earlier Greek understandings of matter – the four elements of air, earth, fire, and water – and its behaviour, including the transmutation of one metal into another. *Al-kimia* arrived in Europe in the twelfth century, along with some knowledge of *al-iksir* (elixir, which became known as the Philosopher's Stone).

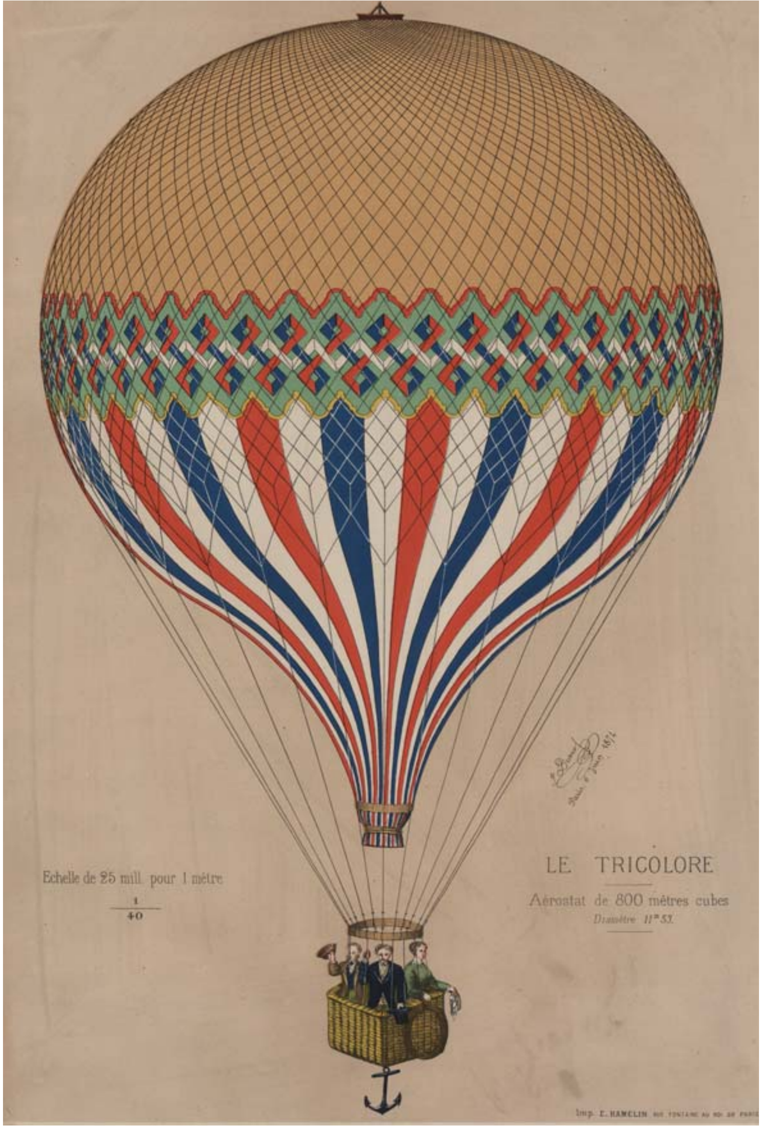
Unsurprisingly, alchemy ran into the same kinds of problems that still occasionally plague medicine – hucksters hawking miracle cures and charlatans, etc. Even less surprising, this caught the attention of both rulers and the legal profession, if for different reasons. Later, in England, it became illegal to *succeed* in turning lead into gold, for this was considered as debasing the currency.

Some claimed that, since human manipulation of matter was essentially inferior to what nature does, naturally (an early version of the still running natural versus artificial debate – check back next century for an update) human attempts at transmuting metals were doomed. Despite such criticisms, there were those who believed that human art was powerful enough to transform the world. But these were discussions for the elites at

Every time you boil an egg you change the very nature of matter, in this case the shape of the egg proteins.

"An Alchemist at Work", Mattheus van Helmont, Flemish, 17th century. Seated in a disorderly workshop, the alchemist appears as a figure of folly.
© Courtesy of the Chemical Heritage Foundation Collections
Photograph by Will Brown

Robert Boyle, by Johann Kerseboom, 1689 (United Kingdom).
© Courtesy of the Chemical Heritage Foundation Collections
Photograph by Will Brown



The French hot-air balloon, Le Tricolore, *taking off, on 6 June 1874, in Paris.*
© Library of Congress (Tissandier collection)

universities. And matter in all its manifestations was on the move through all social strata. We don't know who first created kohl or a clay pot, who first tanned leather or brewed beer, and we don't know the names of the medieval artisans who mixed sand, wood ash, and metal salts to create the great stained-glass windows of medieval cathedrals. But these people all transformed matter and our lives.

By the early modern period, the status of painters, goldsmiths and artisans with an intimate association with matter, was on the rise. Science, long associated with understanding rather than doing, and with elites rather than common folk, was now turning to the practical makers of things for knowledge and power. Such an approach, where matter was central, found its expression in Sir Francis Bacon's 1620 manifesto *Novum Organum*, and the origins of modern science. Doing – poking, prodding, changing the material world – would now be allied with understanding, and our world of art, science, and the everyday, would never be the same. Robert Boyle (Ireland), of Boyle's Law fame – which connects the pressure, volume and temperature of a gas – epitomized this new experimental approach. An inheritor of the alchemical tradition, (almost by definition, alchemists were experimentalists and careful measurers) and an aspiring alchemist, Boyle is considered a founding figure of modern chemistry, in the 17th century

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A colourful science

Many chemists believe chemistry became a proper science in the eighteenth century. The investigation of air by Antoine Lavoisier (France), the discovery of oxygen by Joseph Priestly (England), and the new scientific language of chemistry, all played a part. But chemistry, or at least its results, could not be confined to the world of scientific research. The craze for hot-air and hydrogen ballooning in the late eighteenth century and the ballooning-related fashions in clothes, playing cards, and ceramics were only part of the story. Priestley's invention of carbonated water, as the poor man's alternative to the sickly rich drinking the waters at expensive spas, continued chemistry's association with health that had begun with alchemy. On the other hand, the Victorian craze for green-coloured (courtesy of arsenic) wallpaper helped create what might be the worlds' first recognized (and reported as such) environmental hazard.

In 1856, an eighteen-year old Englishman, William Henry Perkin, tried to turn coal tar into the malaria-preventative quinine (a material transformation worthy of an alchemist). Like Böttger, he failed, and in his failure he launched a colour revolution and inadvertently helped found the German dye and pharmaceutical industry. Perkin had created mauve, the first of the synthetic aniline dyes that brightened the world from the 1860s. Queen Victoria, before her black phase, wore the new chemistry and started a fashion for that shade of purple. A rapidly industrializing Germany adopted the colourful anilines and made them its own, incidentally creating the first strong link between chemistry as a modern science and industry. A German physician, Gerhard Domagk, working for I.G. Farben, found, in 1932, that a modified red dye

DARK-EYED CLEOPATRA

Everyone knows about Cleopatra's famous eyeliner and her green eyelashes. But what we didn't know is that she used her makeup for medicinal reasons, a detail left out of the history books.

A recent study published in the science journal *Analytical Chemistry* (15 January, 2010) shows that the ancient Egyptians' makeup contained lead salts, which produce nitric oxide. This dilates the blood vessels and opens the way for macrophages – immune cells that devour foreign particles.

The French research team analysed residues found in "makeup bags" in the Egyptian collection at the Louvre. With the help of nanochemistry, they found that when lachrymal fluid is in contact with the very low doses of lead found in ancient cosmetics, it creates a milieu that is toxic for microorganisms. – **J.Š.**

killed bacteria and so the first true antibiotics, the sulfa drugs, came into use. The link between fashion and medicine remained, for the skin of patients sometimes turned red, an indication that the drug was working.

The very roots of the German chemical industry lie in fashion, but the same industry that began with the world's brightest colours went on to produce Zyklon B – the poison gas of choice in the Nazis' extermination plans. World War II is known as the physicists' war for the development of the atomic bomb, but every war has been a chemist's war from the time humans learned to smelt metal. Just before World War II, Lise Meitner (an Austrian-born, later Swedish physicist) showed that the alchemists were right -- we can transmute one metal into another, in this case via nuclear reaction, and, by the end of the war, uranium 238 was transmuted into plutonium.

The hallmarks of the old alchemists, the grandiose goals and sometimes secrecy, continue today in our chemical quests – the creation of synthetic life, a cure for aging. At the same time, every time you boil an egg you change the very nature of matter, in this case the shape of the proteins in the egg.

The rise of modern science and its growing prestige, especially the professionalization of science in the nineteenth century, pushed out the non experts. We've lost that sense of chemistry as the art and science of the everyday, and of ordinary people. But we can get it back. Recently, as part of the Chemical Heritage Foundation's museum programme, I asked a glass artist to give a talk and presentation of her work. She was a little nervous at first, saying she had never studied chemistry and didn't know anything about it. But after speaking about what she did -- her tools, the furnace, how she pulled molten glass about, the metals she added, what happened to the glass at different temperatures – she turned to me in surprise and said, "I am a practical chemist."

Near the beginning of this essay I wrote: "To be human is to transform matter." I'd like to end it with a variation. *To transform matter is to be*

Mendeleev's periodic table

"The Man Who Brought Law and Order to Chemistry." This is the title of an article in the June 1971 issue of the UNESCO Courier devoted to Dmitri Mendeleev, the man who enabled "the passing of the study of chemistry from almost medieval trial-and-error methods to a modern science."

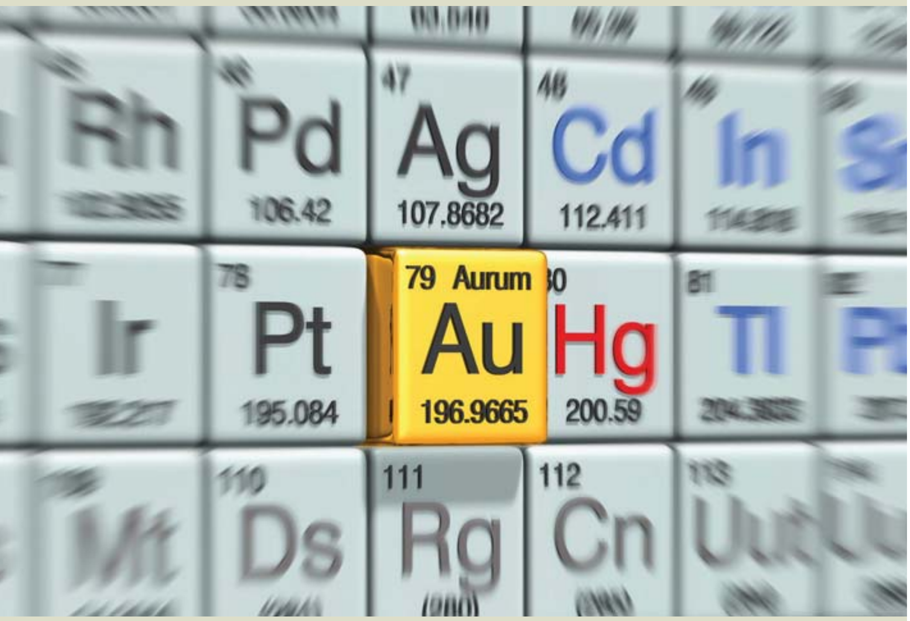
What, then, was Mendeleev's theory all about? "Briefly," the article goes on, "he proposed arranging the elements in lines and columns (also called 'periods' and 'groups') inside a rectangle, with their atomic weights rising in number from left to right along the same line, one line following the other down the page. The columns were determined by elements possessing analogous properties, the same kind of combining oxide, for example."

So what was so revolutionary about this table? The theory of the periodic classification of the elements according to their atomic weights, that the 35 year-old Siberian presented to the Russian Chemical Society, in March1869, was in fact the discovery of a natural law. The method he used not only made it possible to correct a large number of calculation errors, but also to predict the existence of hitherto unknown elements, such as gallium, scandium and germanium (which were given these names later, in honour of the countries in which they were discovered).

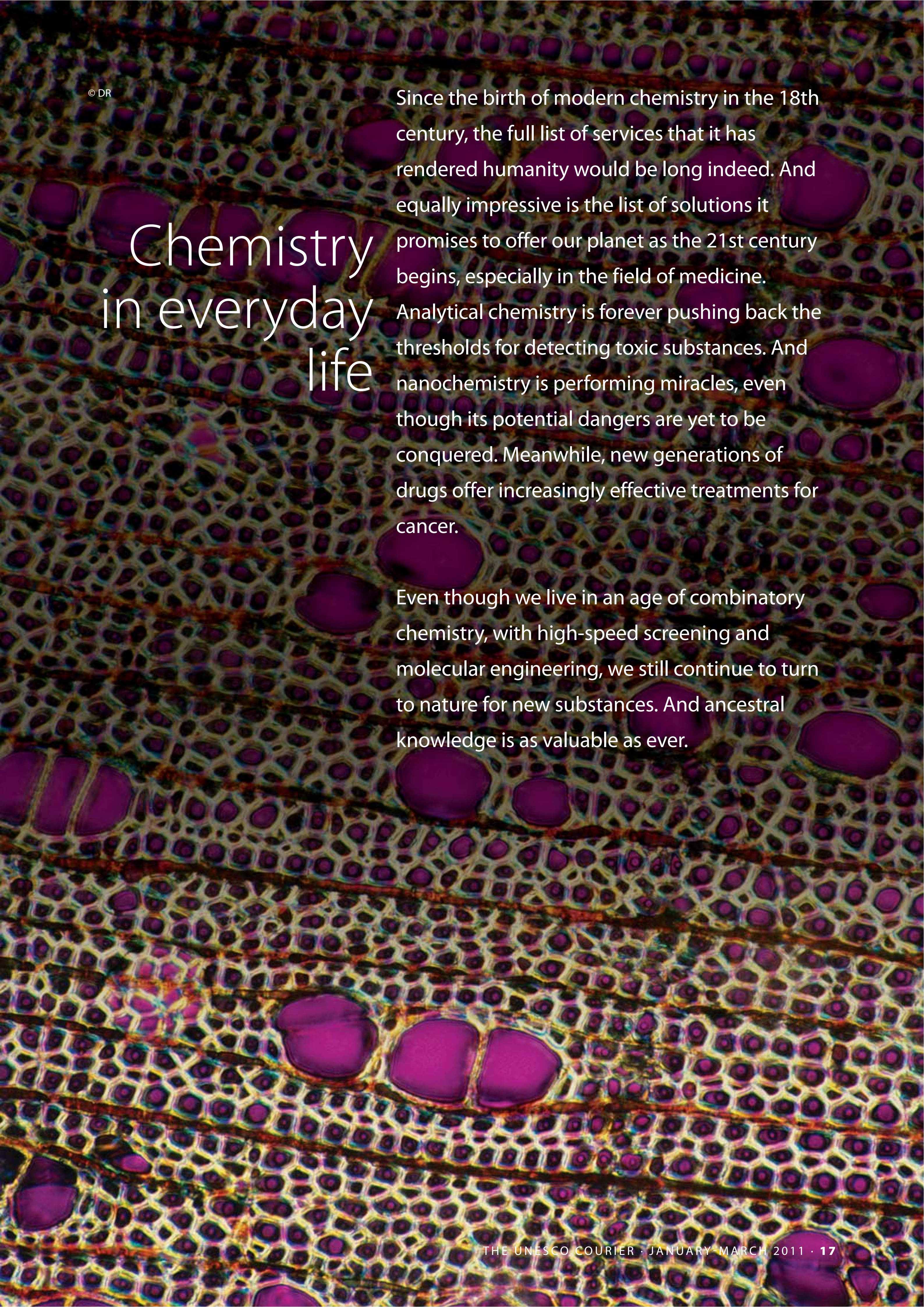
The great discoverers and inventors stir people's imagination. There is the apocryphal story of Newton discovering the law of gravitation when an apple fell on his head, or that a boiling pot inspired James Watt to come up with the idea for the steam engine. Similarly, some say that Mendeleev saw the periodic table in a dream!

"Man tends to overlook that while scientific truth may suddenly strike one man's mind as a flash of lightning," the article goes on, "that same scientist may have spent years of arduous research on his subject. Indeed, it was Pasteur who later commented that 'chance favours only the prepared mind.' If we take a look at Mendeleev's activities before 1869, it becomes fairly clear that the emergence of the periodic table was no mere accident."

Apart from the periodic table, one of Mendeleev's statements about petroleum will remain forever graven in the memory of humanity: "This substance is too precious to be burned; when we burn it, we burn money; it should be used as a raw material for chemical synthesis." – **K.M.**



Michal Meyer was born in Israel. She has worked as a meteorologist in New Zealand and Fiji and as a journalist in Israel. She has a Ph.D. in the history of science and has worked for the Chemical Heritage Foundation since September 2009. She is the editor in chief of *Chemical Heritage magazine* (http://www.chemheritage.org/discover/magazine/index.aspx)*index.aspx*



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Chemistry in everyday life

Since the birth of modern chemistry in the 18th century, the full list of services that it has rendered humanity would be long indeed. And equally impressive is the list of solutions it promises to offer our planet as the 21st century begins, especially in the field of medicine. Analytical chemistry is forever pushing back the thresholds for detecting toxic substances. And nanochemistry is performing miracles, even though its potential dangers are yet to be conquered. Meanwhile, new generations of drugs offer increasingly effective treatments for cancer.

Even though we live in an age of combinatory chemistry, with high-speed screening and molecular engineering, we still continue to turn to nature for new substances. And ancestral knowledge is as valuable as ever.

I love laser – it's my guiding light

What is the common thread that could possibly link denim jeans, cancer and pesticides? None is evident. Yet when South African chemist Tebello Nyokong describes her fascinating research, the link that emerges is light. Nyokong, a specialist in nanochemistry, loves laser, and is using it in ways that could have a revolutionary impact on medicine and the environment.

PROFESSOR NYOKONG answers questions put by Cathy Nolan, UNESCO

Professor Nyokong, you are currently involved in research on a new cancer diagnosis and treatment methodology, intended as an alternative to chemotherapy. Can you give us a simple explanation of your work?

As chemists, we are designers. My research deals with the development of drugs from compounds called phtalocyanines. We call them dyes because their molecules are similar to those of dyes you use in colouring blue jeans. They are used in a treatment of cancer called photodynamic therapy, or PDT. It's a multidisciplinary approach – chemists, biologists, biotechnologists are working together. As a chemist I am in the centre of it because I make the molecules. I have a big team, about 30 people. And then I have other people all over the world who are doing the preclinical testing.

Molecules that dye blue jeans can also treat cancer?

Look at a plant - leaves are green because of chlorophyll. Blood is red because of haemoglobin. Those molecules are actually almost the same, except the one in leaves has magnesium in the centre, the one in blood has iron in the centre. A small change like that can make the difference between non-medicine and medicine. The molecule in the jeans is the same as mine, with a slight change, a different metal, to make it do what you want it to do.

PDT is a new treatment?

No, what is new is the drugs we are making. PDT is already available for some cancers, in America, Europe and Russia. It works with light. The drug is introduced into the body and activated with light. The problem is that right now the side effects are very strong. The drug must be introduced into the body and it must go to the cancer tissue. If it goes to healthy tissue, which is the case with the drugs now available, the patient has to stay indoors out of the sun or the healthy tissue also begins to get killed, like chemotherapy.

Your molecules are safer?

This is the whole aim. We are making molecules that are cancer specific – targeted to cancer. Also, with my own drugs, you need very little in order to absorb light. And I have gone much further because I am now combining my drugs with drug delivery, which has never been done before. This is the nanotechnology aspect. The molecules have nanomaterials called quantum dots attached to them that can penetrate very easily any part of the body. They are good at drug delivery and secondly they also give off light, so we can see more easily where the cancer is. So it is just beautiful what we do.

Can this treatment be used for all kinds of cancer?

This treatment cannot replace surgery. The light (to activate the drug) is transported with tubes – we are using laser and fibre optics. If the cancer is spread throughout the body, this cannot work. It's localized treatment. You have to direct the laser exactly where the cancer is.

How did you come to choose this domain for your research?

It was accidental – that's the beauty of chemistry. Once you have the interest, you are always thinking: 'what more can I do with molecules?' The bottom line for me is that I started working with laser, because I just really love light. I love laser. It's bright, direct and it has different colours. I started finding different applications for it. That was wonderful for me. My interest was laser, not cancer.

Is nanochemistry dangerous?

I am afraid it is. Because something that can penetrate and enter any part of the body is dangerous. Secondly, the molecules that we have made so far, the nanoparticles, in the centre of them there are heavy metals. If they leak out, they can attach themselves to your haemoglobin, to other parts of the body and can be dangerous to you. With the help of biologists, we are testing to see how toxic they are and trying to develop those that are least toxic. We do research both on applications and their toxicity.

How long do you think it will take before your drugs are in general use?

There are many variables when it comes to using these drugs on people. One thing which is problematic for oncologists is that lasers are expensive and difficult to maintain. I can do nothing on my own. I am a chemist - we can develop things – but collaboration is what's important to see if they work. The Centre for Scientific and Industrial Research is doing pre-clinical testing for me in South Africa. Beyond that, a group in Switzerland has developed a very interesting way to test – using egg embryos. You inject the dye into the veins around the embryo and test its activity.

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I can do nothing on my own. I am a chemist - we can develop things – but collaboration is what's important to see if they work.

Your research also has environmental applications.

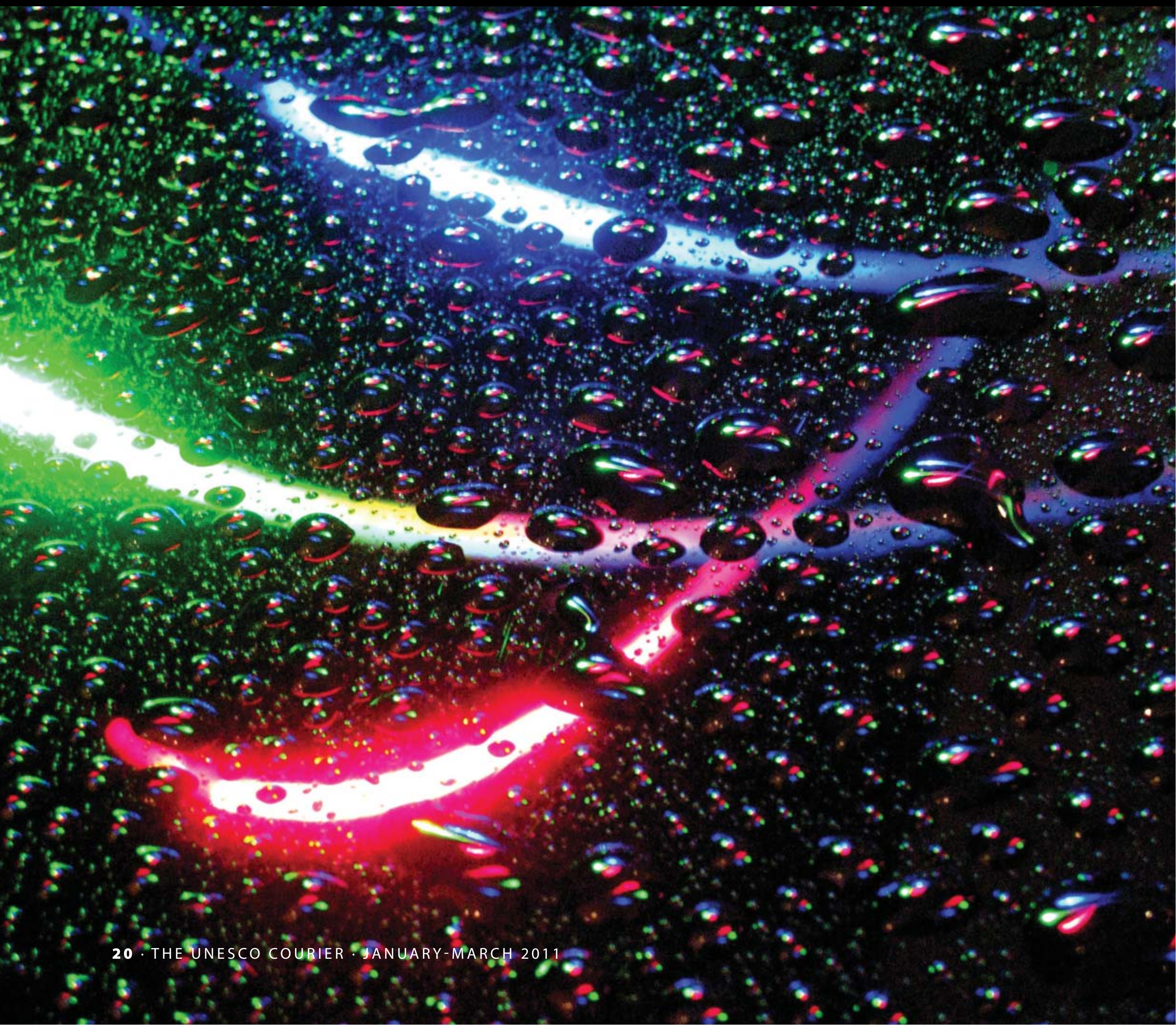
These molecules are really magic. They can do so many different things. The process can be used to purify water that has been polluted, particularly by pesticides. In our countries, people still have to have water from open sources – run-off from the fields ends up in household water, and we have to deal with that. Throughout time, light has been used to purify water. You expect bacteria and so on to be killed by light. But if you put these molecules in the water, that process is made faster. And also the products that are formed are less toxic. If you do it just biologically – just the sun - they can form molecules that are more harmful to the body. We have managed, by using this drug and light, to make molecules that are no longer toxic at all to human beings. This is much closer to success – we have just patented how to do it.

Your goal is to develop a product?

That is my mission. It will come more quickly from the pollution side. Dealing with people has so many rules, it will take much longer. But I would like to do it so that young people can see that, in South Africa, they can take science and develop a product. They cannot imagine this, they believe things come from somewhere else.

Did you imagine when you were younger that chemistry would be your life's work?

Not in a million years, no. We had no role models. But I was always ambitious – I always thought I could be a doctor or a dentist. And teachers are very important. I met a lecturer when I was in my first year at the University (of Lesotho) He was in the Peace Corps from America. He just made chemistry so much fun. He made me feel that chemistry is the place to be, and then I was



hooked. I also had opportunities. The university – I originally come from Lesotho – gave me the opportunity to be trained as an academic. I won a scholarship to train in Canada. I took that opportunity and managed to complete my masters and doctorate. And I am doing the same for others now. I have lecturers from all over Africa – from all over the world, in fact - training with me for their universities.

As the first woman in your department at Rhodes University, you have said you get challenged by doing the "impossible".

This is the reality – it was very difficult for me to progress with very little support. Many women give up because of this. You've got to be a little mad to do what I have done. But what I vowed is that I will help other women as much as I can. Their confidence levels are not as high. I don't know why, but men are confident even when what they are saying does not make much sense!

As a trailblazer, would you say this is a good time to be a woman scientist in South Africa?

Yes, it's a good time. I have a lot of girl students. I attract them like bees, even though I'm a little bit tough!

To be honest, I think people don't take the opportunities that are provided for us. We are in a very lucky country. South Africa is both a first and a third world country. There are very poor people, eating from bins out there, and very rich. The infrastructure is there and the government has made a conscious decision that they are not just going to combat poverty, they will also develop science and technology. People must really take advantage of this and work hard…but apparently hard work is not very popular. Funding is available for us to get equipment, to get more students – I'm applying, I'm grabbing. ■

Tebello Nyokong, 59, is a Professor of Medicinal Chemistry and Nanotechnology at Rhodes University (South Africa) and Director of the Nanotechnology Innovation Centre for Sensors (Mintek). She was one of the five Laureates of the 2009 L'Oréal-UNESCO Awards for Women in Science.

Lasers have a host of scientific applications. Shown here is "Reflections and drops of water", an illustration of the "Giant Laser Fountain" experiment at the Laser Physics Laboratory (CNRS/Paris 13). It reveals the functioning of optical fibres while demonstrating the fundamental principles of optics. See www.fontainelaser.fr
© K. Penalba/INP-CNRS

Monitoring the country's health

Chemistry can provide information about the thorny question of heavy metal contamination, playing an important part in decision-making in Ethiopia, where the idea of making 2011 International Year of Chemistry first arose.

Bhagwan Singh Chandravanshi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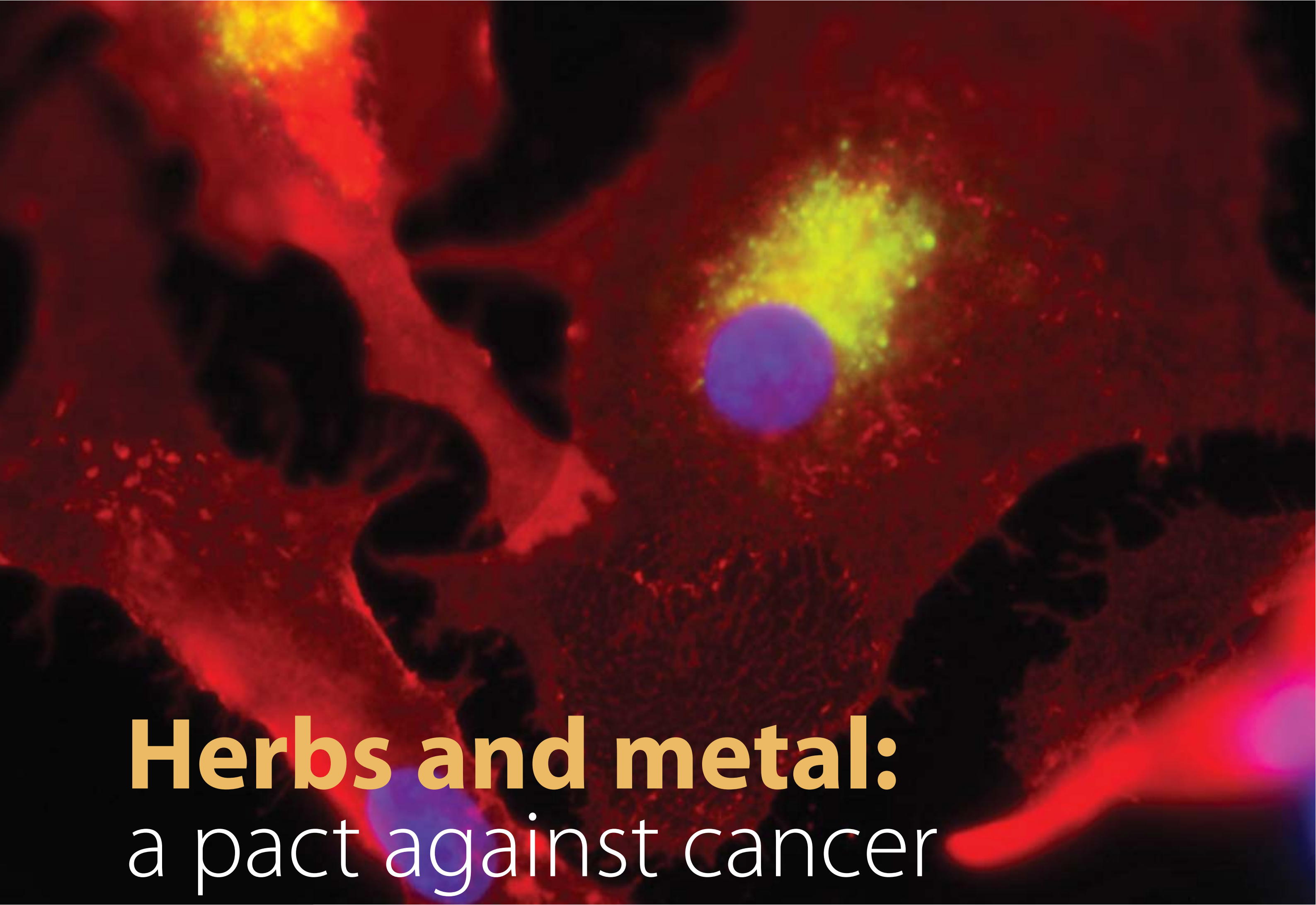
Heavy metal contamination of the food chain is becoming a serious issue, globally. Cadmium, lead, mercury and arsenic are polluting the air, water and soil and turning up in foods. Meanwhile, rapid industrial growth, the widespread use of chemicals in agriculture, and increasing urbanization are all contributing factors.

Heavy metals are present in nature in trace quantities, even infinitesimally small amounts. In order to detect them, a range of sophisticated analytical methods is needed, with three broad steps: sampling, pre-treatment of the sample and analysis. The choice of method depends on several factors, including cost, sensitivity (limits of detection), speed and availability of equipment. The samples for analysis can come from water, soil, fish, plants (especially khat, tea and coffee), vegetables and fruit.

While heavy metals occur naturally in small quantities in agricultural soils, their capacity to accumulate makes them toxic. By detecting them, we can identify their harmful effects, not just on the development of crops, but also on human health.

The research we are carrying out in Ethiopia provides baseline data on the concentrations of heavy metals, enabling us to keep government and the public informed of any potential risks. According to our analyses, the concentration of heavy metals is still relatively low in Ethiopia, but, because of human activity, may rise above natural levels from time to time. Chemistry, then, is helping us to monitor the health of our country. ■

Bhagwan Singh Chandravanshi is professor in the Department of Chemistry, Faculty of Science, Addis Ababa University, Ethiopia..



Herbs and metal: a pact against cancer

Anlong Xu

New chemotherapy cancer treatments aim to target the affected cells without harming healthy tissues. Easier said than done, though. Researchers are following a number of promising paths, including age-old herbal remedies. One herb that has been used in traditional Chinese medicine to treat digestive tract tumours is opening new horizons for modern medicine.

Although significant advances have been made in cancer prevention, diagnosis and treatment, cancer remains one of the leading causes of death in all societies. Until the 1960s, cancer was treated by surgery and radiation therapy. But, in the last fifty years or so, as people gain further understanding of the molecular basis of the disease, and with the rapid development of new chemical agents in the treatment of cancer, chemotherapy has become one of the most powerful weapons against the illness.

The first modern antitumor drug, nitrogen mustard, was discovered by chance during World War II. Researchers accidentally noticed that mustard gas – which got its name from its yellow colour and was used as a chemical weapon in the First World War – can reduce white blood cell counts. In 1942 a team of Yale pharmacologists, including Louis Goodman and Alfred Gilman, used it to treat advanced lymphomas and found that it could induce tumour regression if administered systemically. In 1949 the U.S. Food and Drug Administration (FDA) authorized nitrogen mustard to be put on the market. This gave a boost to the development of a number of other chemotherapeutic drugs for the treatment of various types of cancer.

But, as we know, these chemotherapy drugs can cause serious side effects. We had to wait until the beginning of the third millennium for the dawn of a new era of molecular targeted cancer therapy. This consists of a new generation of drugs that are not dispersed throughout the body (damaging healthy tissue as they go) but target precisely tissues where the cancer cells are to be found.

Avoiding collateral damage

Most of the drugs applied in clinic for the treatment of cancer are organic compounds, but there are also drugs based on inorganic compounds, particularly metals. The use of metals to treat human disease can be traced back to Antiquity. For example, 2,500 years ago,

Fragments of cancerous cells.
© INSERM/J. Valladeau

the Chinese discovered that gold could be used as a medicine. More recently, platinum, another precious metal, has become the basis for one of the most frequently used anticancer treatments in the world, cisplatin, shown in 1965 by an American chemist, Barnett Rosenberg and his colleagues, to block the spread of cancer cells.

Once again, though, the side effects were toxic, which encouraged researchers to develop drugs based on other metals, such as ruthenium. Thanks to the pioneering work of chemists like Michael J. Clarke (USA), Bernhard K. Keppler (Austria), Peter J. Sadler (UK) and their colleagues, ruthenium seems to be a particularly attractive alternative to platinum. Like iron, it is able to bind to transferrin, the blood serum protein that transports iron to the organs. But, instead of spreading throughout the body, it accumulates in tumours, attracted by cancer cells, which have approximately 5–15 times more transferrin receptors than normal cells. In this way ruthenium directly targets the cancer cell and destroys it. Apart from their great precision, compared with their platinum counterparts, certain ruthenium complexes have the capacity to inhibit tumour metastasis – in other words to prevent the spread of cancer to other parts of the body.

A novel strategy

Broadening its field of research to ruthenium complexes, our research group has recently reported that the combination of ruthenium and the active ingredients of a Harmel *(Peganum harmala)* may provide a novel strategy for developing anticancer drugs. The powdered seeds of this plant have long been used in herbal formulas of traditional Chinese medicine to cure tumours of the digestive tract. Today, some of the chemical complexes formed by the alliance of metals and herbs are able to halt the spread of cancer cells much more effectively than cisplatin. What is more, we have noticed that these complexes can simultaneously induce apoptosis and cytoprotective autophagy in human cancer cells (see below). To our knowledge, this is the first time this dual action has been demonstrated.

Apoptosis, sometimes known as "programmed cell death" is a normal process that results in the death of certain 'damaged' cells, at a given moment. But with cancer cells, apoptosis is switched off or deregulated, which may explain their continuous proliferation. So, some of the latest research in oncology is focusing on molecules that can induce the suicide of cancer cells.

Autophagy, on the other hand, which literally means "eating oneself," is a mechanism that enables a cell partially to digest its own contents, in order to survive. But it is a double-edged sword, as, although it can mean the survival of healthy cells to the detriment of ailing cells, the inverse can also be true. The molecules we are working on aim to activate autophagy as a way to destroy cancer cells that are resistant to apoptosis. This is a new approach in the treatment of cancer, which should help combat the disease.

According to statistics provided by the U.S. National Cancer Institute (NCI), the survival rates of some types of cancer have been greatly improved in the last few decades. Even so, cure rates for certain types of cancer remain very low. For example, the overall 5-year survival rate for liver cancer is less than 10%. The United Nations International Agency for Research on Cancer (IARC) estimates that approximately 760 million people died of cancer in 2008, and the number could reach 1320 million in 2030. The war is not over yet. ■

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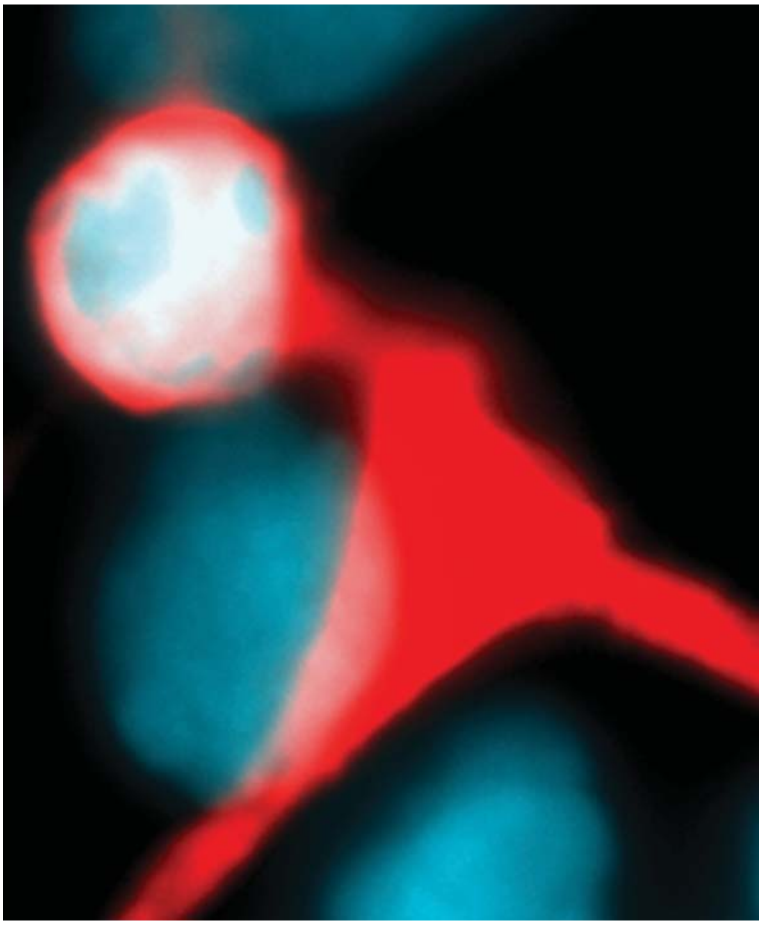

Cell culture: apoptosis in a dopaminergic neuron.

Anlong Xu is Vice-president for Research and Development, and Professor of Molecular Immunology and Biology at Sun Yat-sen (Zhongshan) University, Guangzhou, China. He is the Director of State Key Laboratory of Biocontrol, and serves on the expert committee on new drugs at the State Food and Drug Administration of China (SFDA). He is also a member of the *Pharmacopoeia Commission of China.*

The primacy of nature

Vanderlan da Silva Bolzani

Nature has provided over half of the chemical substances that have been approved by regulatory bodies across the world over the past 40 years.

The Kallawaya are an itinerant community of healers and herbalists living in the Bolvian Andes. The Andean Cosmovision of the Kallawaya was inscribed in 2008 on the Representative List of the Intangible Cultural Heritage of Humanity.

Since the Earth Summit (Rio de Janeiro, Brazil, 1992), the exploitation of natural resources and the socio-economic benefits of bioprospecting have become increasingly poignant issues. One of the principal goals of the Convention on biological diversity, which was adopted at the Summit, is "the conservation of biological diversity, the sustainable use of its components, and the fair and equitable sharing of the benefits arising from the utilization of genetic resources." But bioprospecting, which consists of making an inventory of the components of biodiversity with a view to ensuring their conservation and sustainable use, has, on the contrary, not ceased to be misused to further the interests of industry, which often patents the substances as they are found.

The tenth Conference of Parties to the Convention, held in Nagoya (Japan) in October this year, will change the picture, though, as it reached a legally binding agreement on the fair and equitable use of genetic resources. As from 2012, this Protocol will regulate commercial and scientific relations between countries which possess not only most of the organic substances, but also the knowledge – often non-scientific – surrounding these resources, and those countries wishing to use them for industrial purposes. A new page has turned in the history of the exploitation of the extraordinary chemodiversity of so-called 'megadiverse' countries.

Chemodiversity is one component of biodiversity. Secondary metabolites – alkaloids, lignans, terpenes, phenylpropanoids, tanins, latex, resins and the thousands of other substances identified so far – which have a whole host of functions in the life of plants, are also playing a crucial role in the development of new drugs.

And, although we are living in the era of combinatory chemistry, with high-speed screening and molecular engineering, we still continue to turn to nature for the raw materials behind many medically and economically successful new treatments. Nature has provided over half of the chemical substances that have been approved by regulatory bodies across the world over the past 40 years.

Vanderlan da Silva Bolzani is Professor of Chemistry at the Institute of Chemistry-UNESP, (Araraquara, Sao Paulo, Brazil) and Past President of the Brazilian Chemical Society (2008 - 2010)

India's pharmaceutical boom

Interview with SUNIL MANI, by Shiraz Sidhva, correspondent for the *UNESCO Courier*

In three decades, India's pharmaceutical industry has become the third most important in the world. Almost self-sufficient in medicines, it holds first place for the number of factories approved by the US Food and Drug Administration (FDA). Specializing in the manufacture of generics at unbeatable prices, its industry boasts some 5000 factories, employing 340,000 workers. What is the key to this incredible success? And what is the downside?

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What explains the phenomenal growth of India's pharmaceutical industry, which has become synonymous with the production of high-quality, low-cost generic drugs in the last few decades?

One of India's foremost science-based industries, India's pharmaceutical industry has wide-ranging capabilities in the complex fields of drug manufacturing and technology. Industrial turnover has grown from a modest US$ 300 million in 1980 to about US$ 19 billion in 2008. India now ranks third worldwide after the USA and Japan in terms of the volume of production, with a 10% share of the world market. In terms of the value of production, it ranks 14^{th} for a 1.5% global share.

Several factors have contributed to the industry's dynamic growth. In 1970, the government introduced the Indian Patents Act to reduce the hold of foreign multinationals (which had dominated the Indian market since the country's Independence in 1947). Favourable to intellectual property rights, this policy allowed Indian pharmaceutical companies to come up with cost-effective processes for imitating known products, by not recognizing international product patents for pharmaceutical products.

Sunil Mani is Planning Commission Chair in Development Economics at the Centre for Development Studies in Trivandrum (India). He is a contributing author to the UNESCO Science Report 2010.
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A long learning period for the nation's industry has allowed Indian drug producers to become experts in 'reverse engineering.'

This afforded the industry a long learning period, which allowed Indian drug producers to become experts in 'reverse engineering' (or the copying of patented foreign pharmaceuticals drugs), or developing technologies locally and in an extremely cost-effective manner.

Another factor that has fuelled the industry's growth is the copious supply of science graduates. India's higher education system is biased in favour of natural sciences compared to engineering and technology. During the 1970s and 1980s, and even up to the 90s, the ratio of science graduates to engineers was about 8:1 (eight science graduates for every engineer produced). This gave India a comparative advantage in science-based industries like the pharmaceuticals industry.

The Indian state also gave research grants and tax incentives for setting up R&D facilities.

How has the industry changed after 2005, when India ended its protectionist policy and amended its patent laws to comply with its World Trade Organization (WTO) Trade Related Intellectual Property Agreement (TRIPS) obligations? Does the emphasis remain on exports, even though the Indian domestic market has doubled in the last decade?

Much of industrial growth is fuelled by exports, with exports growing by an average rate of 22% between 2003 and 2008. India currently exports drug intermediates, bulk drugs, APIs [Active Pharmaceutical Ingredients], finished dosage formulations, biopharmaceuticals and clinical services. The top five destinations in 2008 were, in descending order, the USA, Germany, Russia, the United Kingdom and China.

The industry is made up of about 5,000 licensed Indian and foreign manufacturers, which directly employ about 340,000 individuals. It is dominated by pharmaceutical formulations – the process of combining different chemical substances to manufacture a drug – and over 400 active pharmaceutical ingredients (APIs) for use in drug manufacture.
India is self-sufficient in most drugs, as witnessed by a growing positive trade balance. The pharmaceuticals industry is one of India's most innovative, in terms of R&D and the number of patents granted, both in India and abroad. It is very active in the global market for generics, supplying even developed countries.
India accounted for one out of every four abbreviated new drug applications (generic product approvals) from the US government's Food and Drug Administration (USFDA) in 2007 and 2008. The Indian pharmaceutical industry

Manufacturing drugs wearing protective clothing in India, one of the world leaders in the pharmaceutical industry.
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also accounts for approximately 25% of drug master files with USFDA and has the highest number of plants approved by that agency, of any foreign country.

Some Indian manufacturers who were at the forefront of producing generic drugs are now keen to formulate new drugs instead of copies. Is India poised to launch its first domestically developed drug?

To bring a new drug to the market is an extremely costly affair, sometimes involving billions of dollars. India also has regulations, which may not be as stringent as those of the USFDA, but they are not easy, because, ultimately, the drugs are being used on people. Clinical trials are extremely costly, and the failure rates are extremely high. And the period involved in these processes could easily take nine to ten years. Drug discovery on a small scale is already going on, but if it wants to become an originator of the global drug manufacturing industry, it will take quite a bit of time. It is unlikely this will happen on a very large scale. It calls for massive amounts of investment in R&D, which most Indian companies are not in a position to do.

Could you elaborate on the recent emergence of India as a hub for pharmaceutical research and development, and a favoured destination for foreign pharmaceutical companies to hold clinical trials?

One spin-off of India's innovative capability in pharmaceuticals is that it has become a popular destination for clinical trials, contract manufacturing and R&D outsourcing. These capabilities hold great promise for the Indian pharmaceutical industry, as an estimated US$ 103 billion of patented US drugs are at risk of losing patents by 2012. Furthermore, the global market for contract manufacturing of prescription drugs is expected to grow from US$ 26 billion to US$ 44 billion by 2015 or so.

The costs of conducting clinical trials in India are much lower compared to Western countries. Another important factor is that there is a large supply of treatment-naïve patients, who have never used drugs before – the study of the drug being tested is much more effective on these first-time drug users. The third factor is that there are highly-skilled English-speaking doctors available to conduct these trials (most higher education is conducted in English in India). Also, the time taken to conduct clinical trials in India is much shorter, because it is easier to get patients to agree to these trials.

India continues to be a leading supplier of less expensive antibiotics, cancer therapy, and AIDS drugs to the developing world. What has been the impact of generic drugs produced by Indian companies on health care in India? And for the rest of the world?

This is difficult to measure because the Indian pharmaceutical industry has been more interested in exporting to other developing countries and also to the West. Indian pharmaceutical companies have been instrumental in dramatically lowering the prices of anti-retroviral drugs, and this has made AIDS treatments much more affordable. This is one of the most important recent contributions of India's pharmaceutical industry to India and the rest of the world.

Unfortunately, however, the emphasis on exports by Indian companies has prevented them from manufacturing drugs for the so-called neglected diseases, like malaria and tuberculosis, which Western companies are simply not interested in, because the markets are very small, and patients suffering from these diseases are usually poor and cannot afford to pay anything. There isn't much money in these drugs. Indian companies also share the same ideology, so none of them have any credible R&D projects to manufacture drugs to combat these diseases. ■

The costs of conducting clinical trials in India are much lower compared to Western countries. Another important factor is that there is a large supply of treatment-naïve patients, who have never used drugs before – the study of the drug being tested is much more effective on these first-time drug users.

Seaweed for health

Vicki Gardiner

Soon after the archaeological site at Monte Verde (Chile) was discovered in 1977, samples of nine different seaweeds were found in a healer's hut, dating back over 14,000 years. And, 17,000 kilometres away, in the Okinawa archipelago (Japan) the health benefits of a brown seaweed have long been known. It turns out to contain fucoidan, which is rich in sulphated polysaccharides (natural sugars).

Over the past 30 years, some 800 scientific papers on fucoidan and other marine polysaccharides have confirmed what the Japanese have known for centuries – it is a powerful anti-inflammatory and anticoagulant, which blocks certain viruses and boosts the immune system. And very recent research shows that fucoidan-based products can also reduce the symptoms of osteoarthritis of the knee.

Nowadays, a number of drugs and nutritional supplements contain algae or their extracts. Whole dried, milled kelp is used for its iodine content, while agars and alginates have gelling properties. Agars, which are extracts from red seaweeds, are also commonly used as microbiological culture mediums for identifying infectious agents, and in proprietary laxatives. Alginate salts form gels, a property that makes them useful in patches, where drugs can be encapsulated and released slowly. Similarly, alginates are used in dressings, to absorb wound fluids.

Very recent research shows that fucoidan-based products can reduce the symptoms of osteoarthritis of the knee.

Marine algal extracts, such as fucoidan, have great potential for further development as products in the nutraceutical (from "nutrition" and "pharmaceutical") and pharmaceutical markets. However, one of the greatest challenges ahead for the use of these types of ingredient, is sourcing high quality seaweed. With decreasing water quality through heavy industrialization, it is becoming increasingly difficult to find seaweed that has low levels of toxins, such as heavy metals. The other great challenge is to use this resource in an environmentally sustainable way, so that the biodiversity of the marine ecosystem is maintained.

Vicki Gardiner is a member of the Australian Academy of Science and is Honorary General Secretary of the Royal Australian Chemical Institute (RACI). She is Manager of Innovation and Product Development at Marinova Pty Ltd and is the RACI Convenor for the 2011 International Year of Chemistry.

Wakame, or sea fern, is an edible seaweed very popular in Japan.
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The new face of chemistry

Chemistry is behind most of the innovations that have improved our lives, but, for much of the general public, it is still the devil in disguise, conjuring images of black smoke from factory chimneys. And it is easy to see why – an accumulation of drug scandals, toxic pesticides and industrial disasters have tarnished its image to such an extent that we often no longer see the good it does.

But there are chemical solutions to chemical pollution. Over the past two decades, university researchers and industrial chemists have been competing to find ingenious responses to climate change and environmental degradation. "Green chemistry" has the wind in its sails, in developed, emerging and developing countries alike. This is born out by the enthusiasm of the students who wrote to us. And they are just a tiny fragment of the world's young people who, having abandoned chemistry, are now returning, reinventing it at the same time.

New diet for the ozone eaters

Jes Andersen
Danish journalist and documentary filmmaker, meets
Ole John Nielsen

After the chemical gas industry ran into problems with both the hole in the ozone layer and then global warming, research has been carried out to find less dangerous alternatives. Over the past few years, the potential global warming effect of gases used in aerosol cans, refrigerators and air-conditioning units has been reduced by a factor of 350.

It was not until the 1970s that scientists discovered the harmful effects of Freon gas, used in aerosols.
© iStockphoto.com/Franck Boston

Anyone using a pressurized spray-can in 1973 was effectively helping to kill the planet. But no one knew. A year later, the chemists Mario Molina and F. Sherwood Roland (1995 Nobel laureates in chemistry) had found the answer, discovering that the Freon gas powering aerosol sprays was destroying the ozone layer.

After that, a young graduate student, Ole John Nielsen, developed a passion for predicting the fate of chemicals in the atmosphere. He was to go on to become a professor at the University of Copenhagen, a member of the Intergovernmental Panel on Climate Change (IPCC) and 'chemical fortune teller'.

According to Nielsen, "They were saying that these chlorofluorocarbons (CFCs) were going to eat away the ozone layer protecting the planet from ultraviolet radiation. The increase in radiation would cause cancers… They were practically announcing the end of the world. And, being a young and naïve student of chemistry, I naturally felt I had to study these compounds, and how they affected the atmosphere."

The idea that human activity could harm the Earth's atmosphere may have been novel in 1974. But by the mid-eighties it was confirmed.

The idea that human activity could harm the Earth's atmosphere may have been novel in 1974. But by the mid-eighties it was confirmed – CFCs were creating a hole in the ozone layer above Antarctica.

With CFCs also being used in air-conditioners and refrigerators, millions of tons were being released into the atmosphere. "Back then, you just didn't think about what might happen with these compounds, or what their effect might be", remembers Ole John Nielsen.

Having said this, the United Nations Environment Programme (UNEP) was becoming concerned and was preparing to plug every suspect aerosol nozzle. As a result, the Montreal Protocol on Substances That Deplete the Ozone Layer was opened for signature on 16 September, 1987. Today it has been ratified by 196 states. In essence, this international treaty declared all compounds threatening the ozone layer illegal. The death knell had been sounded for CFCs.

Meanwhile Nielsen had built a reputation within atmospheric chemistry. He was getting ready to tackle the "ozone-eaters". In one year he and his group had published no fewer than 25 articles on the subject. So, when chemical manufacturers approached him to test a new compound that might replace CFCs, he wasn't surprised. "We were the right people at the right time, with the right competencies," says Nielsen.

The new compound was a hydro-fluorocarbon, known as HFC 134a. And it really was less dangerous for the ozone layer, even not dangerous at all. So, as from 1994, HFC 134a replaced CFCs in most applications. And for a while Professor Nielsen thought that he'd better find himself a new scientific field.

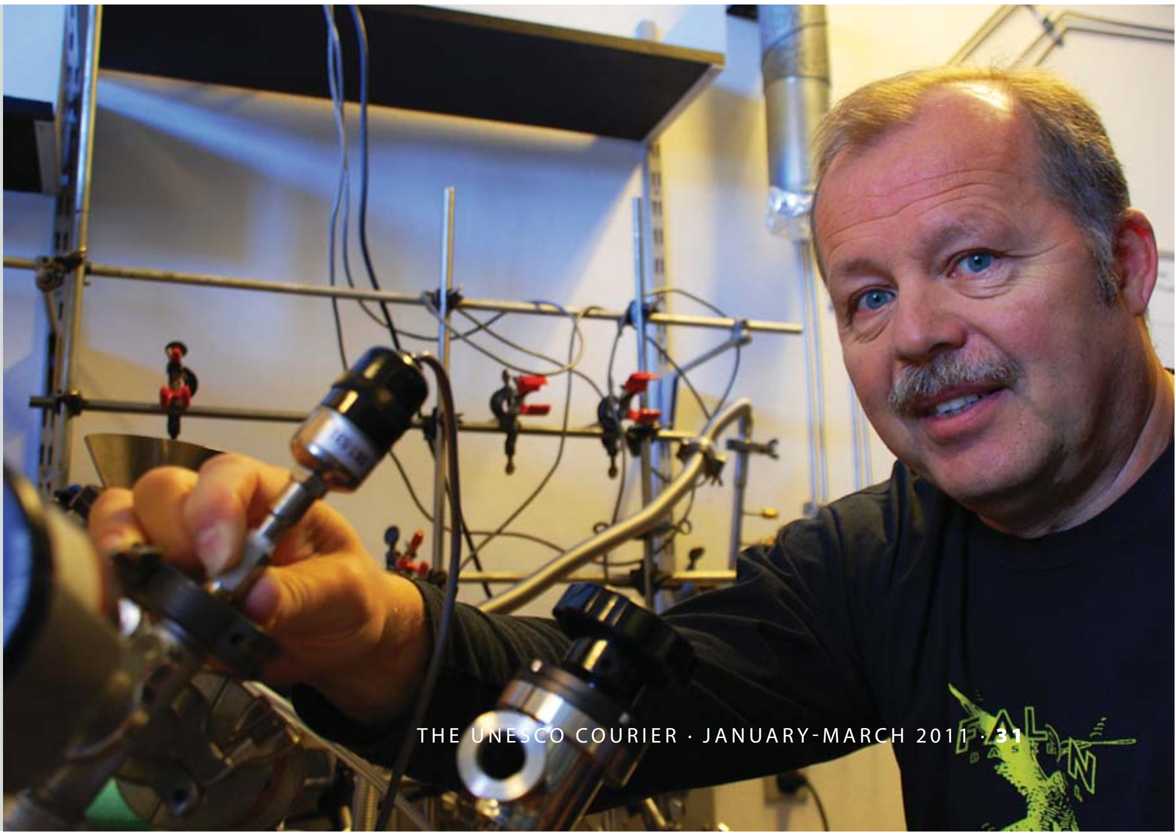
But the Danish scientist didn't have to hang up his atmospheric gloves. The product that he had pronounced safe for ozone threatened Earth in a different way.

It turned out that HFC 134a prevents infrared radiation from escaping from the planet, producing a greenhouse effect. The ozone-friendly compound turned out to have a global warming potential (GWP) some 1400 times greater than CO_2.

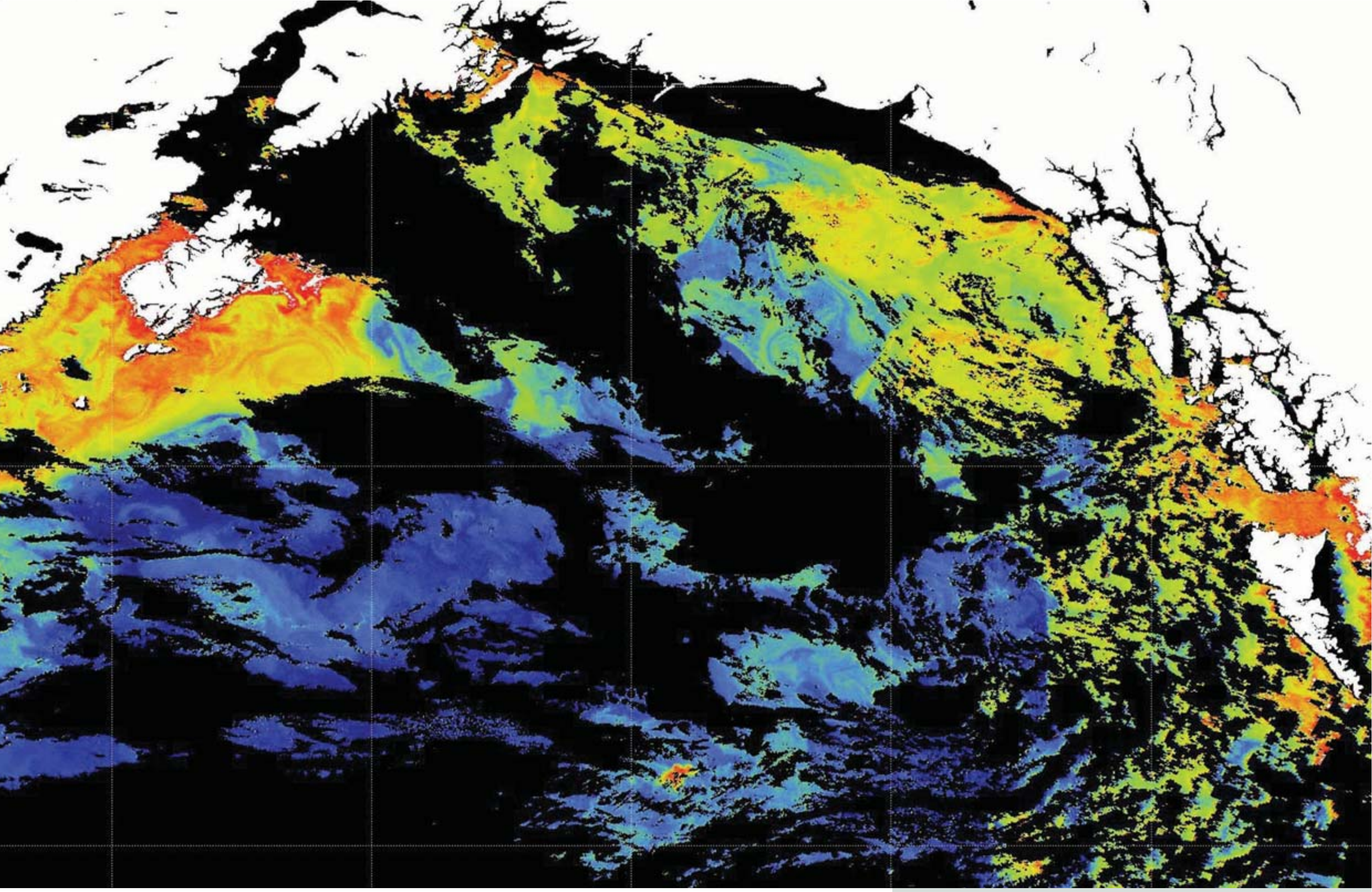
As it happened, the industry seemed open to the idea of testing and adopting a better refrigerant . "I have seen a gigantic shift in attitude in my time," says Nielsen. "Nowadays, if someone wants to produce a compound in large quantities, they will ask a specialist what will happen if it is released. That wasn't always the case. Of course we also see legislation to protect the environment, but it is clear that industries, especially big corporations, are acting much more responsibly today".

From 2011, European automobile air-conditioning systems in Europe will have to use a refrigerant with a GWP below 150. HFC 134a had a GWP of 1400. Nielsen and his team, have tested a new compound, HFO-1234yf, which has a GWP of just 4. This should help car manufacturers meet European regulations.

Next in line, says Nielsen, are bio-fuels. It may turn out that ethanol and butanol have no effect on global warming but, in the atmosphere they might generate products that are harmful to man. "If bio fuels are to replace diesel and gasoline, we'd better be sure of what they do to the atmosphere before we use them. And that holds for any compound released into nature", he says. ■



Ole John Nielsen, is a professor at the University of Copenhagen and a member of the Intergovernmental Panel on Climate Change (IPCC), which was awarded the Nobel Peace Prize in 2007. He is a specialist in atmospheric chemistry.



Global warming: Plan B

Geo-engineering is a hot topic within the scientific community. Trying to limit global warming by manipulating the environment is an idea with a whole raft of ramifications currently being looked at by a growing number of chemists and physicists, including Klaus Lackner (USA), Ian Jones (Australia), James Lovelock (UK), and Paul Crutzen (Netherlands), to mention just those quoted here.

They naturally hope that their research will bring us new sources of energy to help slow down climate warming. But, in the meantime, they are working on what they call "Plan B". There are two preferred alternatives for saving the planet from global warming – one consists of capturing CO_2 in order to reduce the concentration of greenhouse gases (e.g. doping trees with nitrogen, synthetic trees, seeding the oceans or covering the seabed with calcium); the other involves deviating some solar radiation with giant parasols made up of billions of minute glass discs, or a protective layer of salt or sulphate particles .

While there are fewer risks with the former approach, scientists feel it is too slow compared to the second option, which is considered too risky. In both cases, the costs are very high and the efficacy of the solutions remains limited.

Iron tonic for the ocean's anaemia?

Philip W. Boyd

Iron is one of the main elements taken up by phytoplankton – the microscopic organisms living on the surface of the oceans. The iron encourages these micro-algae to proliferate, assimilating dissolved carbon dioxide (CO_2) through photosynthesis as they grow. When they die, a small, but significant portion of the carbon remains trapped in the ocean, sinking to the bottom, where it is effectively taken out of circulation. This natural process is called a "biological pump" for carbon.

One idea for limiting global warming is to use these pumps to trap part of the CO_2 released into the atmosphere by man since the Industrial Revolution, by 'seeding' the ocean with massive quantities of iron in the form of micro-particles.

Why? Because phytoplankton are anaemic. Although iron is the fourth most abundant element in the Earth's crust, it is very scarce in much of the remote ocean, too far from the

Evidence of purposeful iron supply driving a phytoplankton bloom in offshore waters in summer 2002. The 'Ocean Color' *satellite image provides a map of the stocks of phytoplankton in the ocean, with blue denoting low stocks and progressively warmer colours – from green to red – indicating higher stocks.*
© Courtesy of Jim Gower (IOS, Canada)/NASA/Orbimage

coast to be supplied with iron from rivers. In about a third of these remote waters, the phytoplankton are anaemic, and just like humans, they do not function well when they are run down. Although small, these cells are found over vast swathes of ocean, so their collective anaemia has a global influence, particularly on the climate. Indeed, healthy phytoplankton produce more oxygen than all the planet's forests put together.

This gave rise to the idea of artificially 'fertilizing' parts of the ocean with iron particles in order to stimulate the growth of algae. But, between cup and lip…

Today, a growing number of scientific experts are sceptical of the wisdom of adding iron to the world's oceans in order to mop up CO_2 emissions, and warn of the possibility of creating unwanted side effects, far from simply imitating what Nature does. This 'seeding' with iron could lead to vast underwater areas starved of oxygen (because the algae take up oxygen that is then not available for other marine species) and thus more acidic, while possibly encouraging the spread of toxic algae.

Artificially fertilizing the oceans in the hope of solving rising levels of atmospheric CO_2 is, then, a high-risk venture that appears to be as expensive as many other geo-engineering schemes with much lower risk for marine resources. These include 'artificial trees' consisting of a column and the equivalent of branches, designed to capture CO_2.

Philip W. Boyd is a professor in ocean biogeochemistry at the joint National Institute of Water and Atmosphere/ University of Otago Centre for Chemical and Physical Oceanography based in Dunedin (New Zealand).

Synthetic trees

A meeting with Klaus Lackner

Katerina Markelova

Topping the list of solutions to capture CO_2 and reduce the concentration of greenhouse gases are synthetic trees, invented by geophysicist, Klaus Lackner, of Columbia University (USA). Although still at the testing stage, this 'CO_2 scrubber' should filter air rather like a natural tree does, but with a much higher capacity. "A CO_2 scrubber of the same size as a windmill can remove far more CO_2 than the windmill can avoid," explains Lackner.

He got the idea in 1998, "having realised how much CO_2 is in the air. My daughter, Clare, did a science project and demonstrated that she can take CO_2 out of the air." In one night, he says, she was able to capture half of the CO_2 in the air.

Extending this experiment, Klaus Lackner built a "vacuum cleaner" which, when placed in a windy area, absorbs air carrying CO_2 and filters it, before releasing the purified air again. Caustic soda is the key to the method's success. When it is in contact with carbon dioxide it makes a sodium bicarbonate solution. This liquid is then compressed until it forms a highly concentrated gas that can be stored in porous rocks on the sea floor. Because it is denser than seawater, it cannot escape and can be sequestered for millions of years.

For Professor Lackner, "the first step is to remove some CO_2 from the air. If it proves cost-effective, it could balance out emissions from cars and aeroplanes. If air capture, together with other CO_2 reduction technologies, manages to stop the rise in CO_2 in the atmosphere, we could then start to use additional air capture."

Synthetic trees provide another piece of the jigsaw for international negotiations on carbon dioxide emissions, because the technology makes it possible to collect CO_2 on behalf of another country. "Air capture can separate the [CO_2] sources from the sinks" says Klaus Lackner. "This makes it possible to import and export carbon reductions. It also makes it possible to strive for a world in which all CO_2 emissions can be addressed. Automobiles and airplanes need not be off-limits in this discussion."

At present, this process is still expensive, "just like a hand-made car", says Lackner, who is nevertheless optimistic that costs will come down. But artificial trees are not a miracle cure. As he explains, "the major energy cost is in the compression, which, if it uses electricity, would result in the release of an equivalent of some 20% of the captured CO_2 at the site of a distant power plant."

It is, though, a long and involved process. "It needs time and commitment," says Lackner, anticipating the increased use of renewable energy. "We may be able to reduce the CO_2 in the atmosphere, but this does not give us an excuse to continue to emit."

The capacity of plants to capture CO_2 served as a model for Kalus Lackner's synthetic trees.
© UNESCO/Linda Shen

Venus to the rescue

Jasmina Šopova

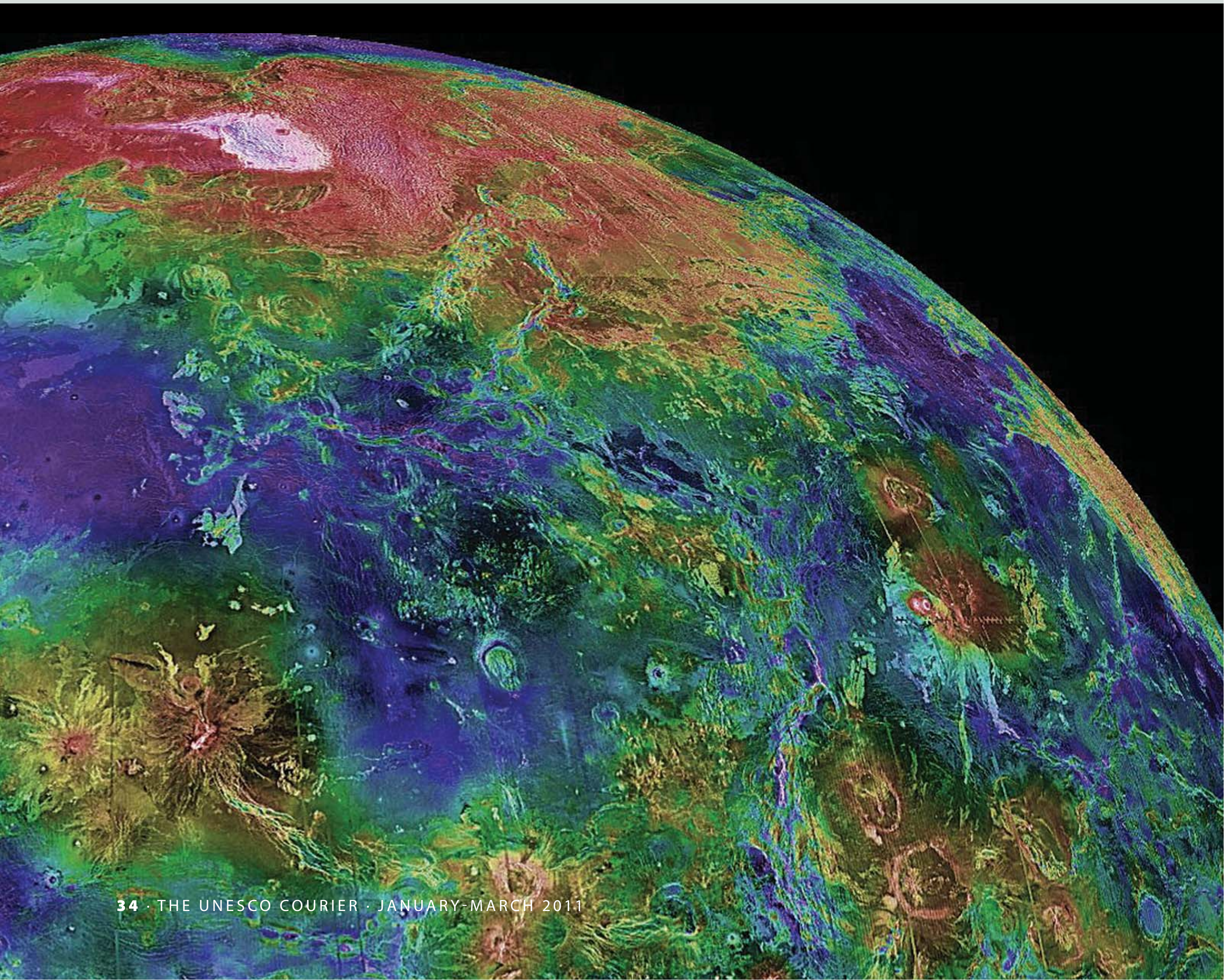
Does Venus hold the key to our deliverance from global warming? In a press release dated 5 November 2010, the French National Scientific Research Centre (CNRS) announced that an international team of scientists had just located a layer of sulphur dioxide (SO_2) in the upper atmosphere of Venus. "SO_2 is of particular interest [to them] since this gas could be used to cool down the Earth via a geo-engineering process put forward by Chemistry Nobel Laureate Paul Crutzen [1995]", explains the CNRS communiqué.

Five years ago, the celebrated Dutch chemist and meteorologist imagined an emergency solution to accelerated warming, which consisted of releasing a million tons of sulphur into the stratosphere. Via a natural chemical reaction, this would turn into sulphur dioxide, then into particles of sulphate. By reflecting the sun's rays, these particles would reduce the average temperature of Earth. This idea was inspired by research in the 1970s by the Russian climatologist, Mikhail Budyko, as well as by the eruption of the Pinatubo volcano (Philippines), which threw 10 million tonnes of sulphur into the air in 1991, leading to a drop in the Earth's mean temperature of half a degree the following year.

Xi Zhang, who carried out the computer simulations that confirmed the presence of SO_2 in the upper atmosphere of Venus, says that the applications of this discovery to the manipulation of climate are outside his field of competence. Even so, the article that this researcher and his team at the Californian Institute of Technology [Cal Tech] published in *Nature Geoscience*, (31 October 2010), does not exclude this possibility. He concludes that, "as there is a high degree of similarity between the upper haze layer on Venus and the terrestrial stratospheric sulphate layer (Junge layer), which is an important regulator of the Earth's climate and the abundance of ozone, these experimental and modelling results may be relevant to stratospheric aerosol chemistry and the applications of this chemistry for geoengineering of the Earth's climate."

We are still at the stage of hypotheses. SO_2 is a gas that, at high concentrations, can provoke lung and cardio-vascular diseases, while rendering the oceans more acidic and corroding metals, etc. Researchers are agreed that there is still a long way to go before even thinking of applying this kind of "sun screen" on Earth. ■

View of one face of Venus taken by the Magellan probe.. © NASA/ Courtesy nasaimages.org



From dark to green ages

The chemical industry is one of the most important in the world, worth a staggering US$3.6 trillion a year. For decades it was not interested in sustainability or protecting the environment. But after major disasters such as Bhopal and Seveso, attitudes have begun to change. Instead of dirty chemistry, green chemistry is now all the rage all over the world.

Jens Lubbadeh
German correspondent for The UNESCO Courier and journalist for *Greenpeace Magazine*

On 4 October 2010, disaster struck in Hungary. In the aluminium plant operated by the company MAL near the town of Kolontár, 160 kilometres from Budapest, the walls of a reservoir gave way. A two metre-high torrent of red toxic sludge poured out, burying people and houses in its wake. Nine people died, 150 were injured. Several hundred thousand tonnes of toxic sludge contaminated 40 square kilometres of land. The sludge was a waste product of the aluminium production process and hazardous because it contained highly caustic sodium hydroxide as well as toxic heavy metals such as mercury, arsenic and chromium.

In recent decades, chemical accidents have repeatedly been the cause of worldwide horror and dismay – and the apocalyptic images of them have had a lasting negative effect on the chemical industry. In 1976, dioxin gas was released from a plant operated by Icmesa, a subsidiary of Roche, in Seveso, a Northern Italian town near Milan. The gas cloud, thousands of times more toxic than potassium cyanide, left a trail of death and destruction – plants shrivelled,

The main principles of Green Chemistry, which emerged at the end of the 1980s, are to avoid producing waste, to lower energy consumption, improve production efficiency and explore renewable resources.
©123rf.com/Michal Rozewski

trees were defoliated, thousands of animals perished. Pictures of children's disfigured faces and workers wearing gas masks and white protective clothing went round the world. Eight years later, there was an even more horrific accident in India. Forty tonnes of highly toxic Methyl isocyanate gas escaped from a factory belonging to the US chemical giant Union Carbide (now a subsidiary of Dow Chemical) in the Central Indian town of Bhopal. Several thousand people died and up to half a million are still suffering from the after-effects of the disaster today. Bhopal is considered to be the most serious chemical accident to date. Two years later, Europe became a victim again, when a warehouse near Basel belonging to the chemical giant Sandoz (now Novartis) went up in flames. Toxic pesticides poured into the Rhine, turning the water red for hundreds of kilometres; tonnes of dead fish drifted down the river.

In the 1950s, nylon, plastic and Persil washing powder stood for progress. By the 1970s and 80s the image of the chemical industry was as dirty as its origins.

In March 2010, a hundred tonnes of dead fish filled the Rodrigo de Freitas lagoon, in Rio de Janeiro (Brazil). There were several possible causes, including discharge of sewage carrying toxic industrial and domestic waste. The proliferation of algae is due to an excess of nitrates and phosphates, which could have suffocated the fish.
© M.Flores – UNEP/Specialist Stock

Nº1 polluter

Kolontár, Bhopal, Seveso, Sandoz. The reasons for these disasters are almost always the same – negligence, sloppiness and human error. And almost always the companies try to cover up and play down the causes and the consequences of the accidents. The results are similar too – devastated countryside, vegetation destroyed, dead animals and, in amongst them, workers in their protective gear, looking like aliens. The general public is increasingly worried about these invisible deadly dangers, now not just radiation but chemicals, too. This lay behind the establishment of the environmental movement in the 1970s and 80s. More and more often, the practices of the chemical companies are now exposed – simply pouring their toxic waste into the environment or dispatching it to poor countries. In the eyes of an increasingly ecologically aware public, the chemical industry has become number one polluter. The word "chemical" has become synonymous with "toxic". Today, products use the "chemical-free" tag to boost sales. Within just a few decades, a dramatic change in image has taken place. In the 1950's, nylon, plastic and Persil washing powder stood for progress. By the 1970s and 80s the image of the chemical industry was as dirty as its origins.

The Ancient Egyptian word *kemi* originally referred to the black soil of Egypt, but also to black eyeliner (kohl) [see p. 15]. In Arabic, *kemi* became *al-kimia*, or alchemy [see p.13]. This occult pastime had turned into a proper science by the 18th century and, from the 19th century, one of the most important industries in the

An ecological disaster in Hungary in October 2010 killed nine people. The toxic red sludge is a waste product from the production of aluminium.
© Waltraud Holzfeind/ Greenpeace

world. This is when today's global players were founded: BASF, Bayer, DuPont and Roche. The chemical industry manufactures over 70,000 different products, from plastics and fertilizers, to detergents and drugs. Its total global annual production is worth a breath-taking US$ 3.6 trillion, according to the American Chemistry Council (ACC). It has dramatically changed and improved our lives. It is impossible to think of modern-day civilisation without it.

But after a century-long success story, the chemical industry, inflated by mechanised mass production, has become the cause of a growing number of ecological problems. It is enormously resource- and energy-hungry; many solvents and catalysts are toxic, disposal of its waste is complicated and expensive, while toxic and carcinogenic substances are released into the air and water. According to the United Nations Environment Programme (UNEP), Western Europe produced a total of 42 million tonnes of toxic waste in the year 2000, five million of which were exported in 2001.

Green chemistry

The careless disposal of toxic waste was for a long time tolerated or concealed by politicians – the chemical industry was too important for the economy. But after Bhopal and Seveso, they had to respond – in the 1980s and 90s chemical companies had to meet increasingly stringent environmental requirements. In 1990 the United States Environmental Protection Agency (EPA) passed the Pollution Prevention Act, marking a change of direction in policy. Manufacturing processes and products had to be made sustainable, pollution was to be avoided – dirty chemistry gradually started to turn green. "After defining the term 'green chemistry' in 1991 it became clear that a design framework would be desirable for those wishing to put the theory of green chemistry into practice", says Paul Anastas, who is regarded as the "Father of Green Chemistry". He is the director of the Center for Green Chemistry at Yale University and also works for the EPA. In 1998 he published the "Twelve Principles of Green Chemistry" along with his colleague, Jack Warner. The first of these principles dictates that "it is better to prevent waste than to treat or clean up waste after it has been created." Also, harmless alternatives are to be found to toxic chemicals and solvents. The latest milestone on the path towards green chemistry was the European Union's 2007 REACH Directive (Registration, Evaluation, Authorisation and Restriction of Chemicals). Now it is no longer up to the authorities to demonstrate to manufacturers that the substances they use are potentially harmful; the shoe is on the other foot. Thanks to REACH, some 40,000 chemicals now have to be tested.

Other goals of green chemistry are to lower energy consumption, to improve the efficiency of the production process and to switch to renewable resources. After all, the chemical industry also depends on petroleum, consuming 10% of global oil production to make 80% to 90% of its products. And the chemical industry is energy-hungry: in 2008, for example, the German chemical industry consumed some 12.5% of the entire national demand for energy. Since the 1990s the industry has increasingly been pursuing the goal of sustainability – while improving its image at the same time. BASF, the world's largest chemical corporation with annual sales of 50 billion euros and more than 100,000 employees around the world, like other giants, DuPont, Dow Chemicals and Bayer all want to become greener. "At BASF we are running all our activities according to the principles of sustainable development," says BASF CEO, Jürgen Hambrecht. And, he adds, "we are developing products that help our customers to save energy and resources, while improving quality of life." These are primarily insulating materials that enable home-owners to lower their heating costs and reduce carbon emissions.

Since the 1990s the industry has converted to sustainability – improving its image at the same time.

BASF publishes its carbon emissions, not only for its own production facilities but for the entire life cycle of its products – from the extraction of the raw materials through to final disposal. The company's website reveals that the production of BASF products led to the overall release of some 90 million tonnes of CO_2 into the atmosphere in 2010 – corresponding to 10% of Germany's total CO_2 emissions. By the year 2020, BASF wants to lower its production-related greenhouse gas emissions by 25 % (compared with 2002). But since the production process only accounts for part of the total, this reduction target only represents 7.5 % of BASF's total emissions.

Even so, Hambrecht emphasises that BASF products themselves also reduce carbon emissions – a total of 287 million tonnes of CO_2 per year, or three times as much as is released during their manufacture, as the company website proudly announces. Also, BASF promises to implement the REACH directive by 2015, and to reduce the amount of organic compounds, nitrogen compounds and heavy metals released into air and water by some 70% by 2020. On its website, BASF claims to have already done so. And the company is on the lookout for renewable resources, such as using natural castor oil in the manufacture of mattresses, and the biodegradable plastic Ecovio, which is largely made from polylactic acid, derived from maize.

Green chemistry is not only booming in the West. "Recently, there has been growing support for and interest in green chemistry in developing countries", says Paul Anastas, who recently addressed the Pan African Chemistry Network (PACN), which he helped to establish, at the first Green Chemistry conference. In emerging nations, like India and China, he adds, "green chemistry has been implemented in academia, research institutions, and industry at a much faster rate than anywhere else in the world." It seems that these countries do not intend to make the same mistakes as the West. ■

CHEMISTRY:
a common denominator in Africa

The first African conference on green chemistry was held in the capital of Ethiopia, Addis Ababa, from 15 to 17 November, 2010. It was one of a long series of continent-wide seminars, conferences and workshops, that bring together African and international experts around themes as wide-ranging as biodiversity, sustainable development, education or water, with one common denominator – chemistry.

The conference was organized by the Pan-Africa Chemistry Network (PACN), launched in November 2007 on the initiative of the *Royal Society of Chemistry* (RSC) and *Syngeta*, a Swiss company specializing in chemistry and the food industry. A year earlier, the RSC had launched the *Archive for Africa* initiative, which provides free access to specialized chemistry journals for a large number of African universities.

PACN's remit is to facilitate communication between African chemists and thereby encourage innovation and scientific development across the continent. It operates in partnership with the Federation of African Societies of Chemistry (FASC), founded in 2006 with UNESCO support. To date there are three centres in the network – in Kenya, Ethiopia and South Africa. Other centres are expected to be set up in Nigeria and Egypt.

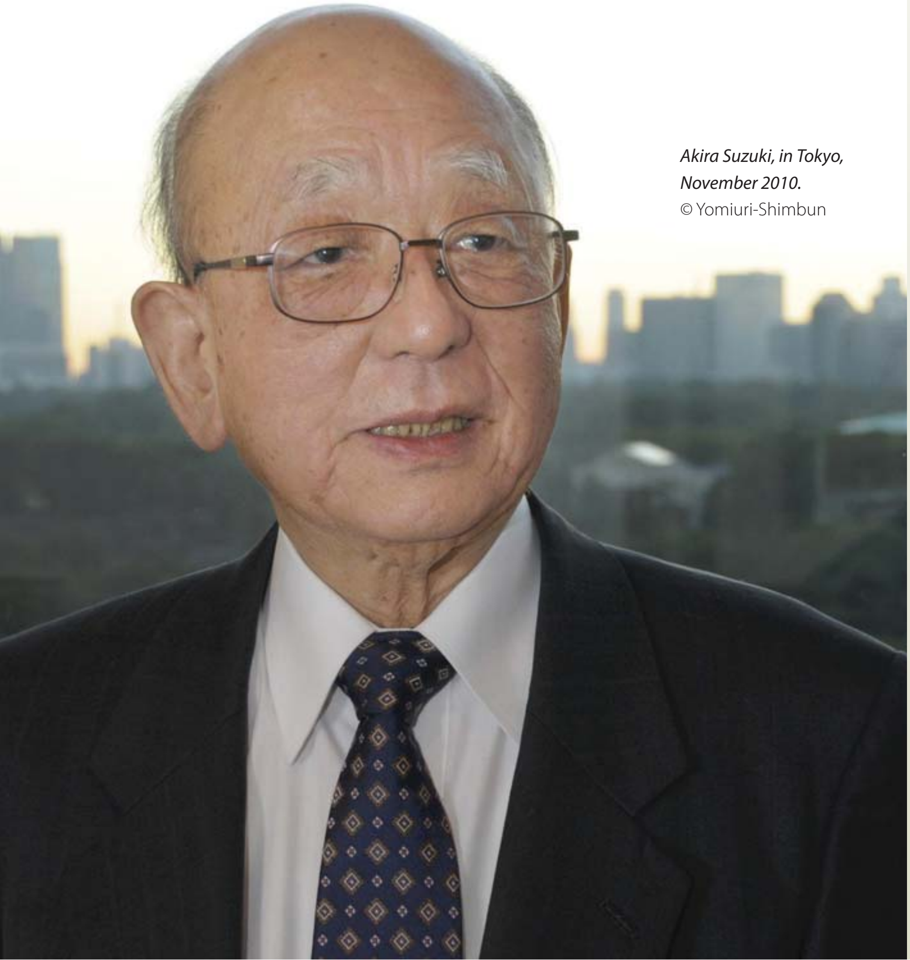
By awarding bursaries or contributing to travel costs, the network facilitates the mobility of African chemists, enabling them to further their research abroad or to participate in international conferences. Its specialist fields are: food security, biodiversity and disease prevention. – **J. Š.**

www.rsc.org/Membership/Networking/InternationalActivities/PanAfrica/

Letter to a young chemist

AKIRA SUZUKI answers questions put by Noriyuki Yoshida, journalist for *Yomiuri Shimbun*, Tokyo

The 2010 Nobel prize in chemistry was awarded to the American scientist, Richard Heck and to Ei-ichi Negishi and Akira Suzuki from Japan, for their work on organic synthesis, which paved the way for the invention of one of the most sophisticated tools in chemistry – cross coupling. One of the cornerstones of this immense scientific endeavour is "Suzuki coupling", after the laureate we interviewed. In this interview, Akira Suzuki talks about his research, aiming above all at young people today, who are deserting the sciences. He is encouraging them to turn towards chemistry, with the idea of making it into a new science.



Akira Suzuki, in Tokyo, November 2010.
© Yomiuri-Shimbun

What is cross coupling used for?

If I give you an example, you will understand right away. After the Nobel I had so many requests for interviews that my blood pressure went right up! My doctor prescribed a drug to bring down the pressure and the pharmacist explained to me that it had been made by "Suzuki coupling." The procedure has also been used to make certain antibiotics, as well as drugs to treat cancer and AIDS.

The process has also been used in the IT and communications worlds to make liquid crystals for television and computer screens, and for organic electroluminescent displays, which are widely used for small devices like mobile telephones and so on.

How long did it take you to perfect this method?

The discovery of the coupling reaction only took two or three years, at the end of the 1970s. But I had worked on the chemistry of boron, a metalloid close to carbon, since 1965, when I returned from the USA, after finishing my studies at Purdue University. That means it is the result of over ten years of research.

What did other people think when you started work in this field?

On the whole, they thought the chances of success were zero. That is also why there were so few researchers in this field, anywhere in the world. But I am optimistic by nature and I thought these disadvantages could become advantages. I told myself that by overcoming the difficulties, it would be possible to come up with a stable synthesis procedure that would be easy to use.

Some say that there is fair amount of luck in research. What do you think?

At the outset, in research, one cannot rely on chance. Research has, above all, to be rational.

It is important to analyse the successes and failures of experiments and to apply them in the next phase. That is when chance can intervene. Anyone can be lucky. But to attract luck, one has to be attentive, to make an effort and remain humble, above anything else.

Were you interested in science as a child?

I was born in a small town called Mukawa, south of Sapporo (in Hokkaido). Nowadays, the town is called Shishamo. In primary school, I was just a child, like all the others – I liked going fishing with my friends and playing baseball. At that time, the *juku* [private schools offering evening classes] did not exist and I think that the children were free and full of spirit. I was not especially interested in science, but in junior high school, I did like mathematics. Looking back, I think I did like things that were clear.

Why did you choose to study chemistry at university?

I entered Hokkaido University to study mathematics. But during a chemistry class, I stumbled on a manual, which had a great effect on me. The author was a professor of organic chemistry at Harvard. I had a dreadful time trying to understand the English, but I found it very interesting. And I ended up forgetting about mathematics.

During my chemistry studies, I was very influenced by Professor Harusada Sugino, who taught me why chemistry was important and what use it was. And Professor Sugino was not just interested in chemistry. He was rector at Hokkaido University, but was also president of the Japanese national commission for UNESCO!

Akira Suzuki's discoveries have made it possible to optimize the blue light in the organic electroluminescent diodes present in flat screens. Shown here is a flat screen made by Sharp.
© Yomiuri Shimbun

"As I have already said, just the wish that you may find in yourself enough patience to endure and enough simplicity to have faith"

– Rainer Maria Rilke, *Letters to a Young Poet*

From 1963 to 1965, you studied in the USA. At Purdue University, you also followed courses by Herbert Charles Brown, 1979 Nobel laureate in chemistry, who also had Ei-ichi Negishi as a student.

When I was about thirty, I was assistant professor at Hokkaido University, and I had to find a research field. I went into a bookshop in Sapporo and looked at books on chemistry. My gaze fell on a book with a black and red cover – it looked more like a novel – and I picked it up. It was by Professor Brown. It was so interesting that I stayed up whole nights reading it. I wrote a letter to the professor, telling him that I wanted to study with him, and that is how I left for the USA.

In the USA, I was a post-doc, but my salary was four times higher than that of an assistant professor in Japan. And meat and petrol were cheap, too... I really noticed the difference between the two countries. There were several other foreign researchers and I was able to make many friends. The discussions I had with them opened up new worlds for me. When Japanese people are together, they can understand each other without saying anything, but I learned that when one is immersed in another culture, one has to say a lot to be understood. I also learned English. I recommend young people to go abroad, without hesitating. One learns a great deal – and not just on a professional level or in one's specialized area.

What did you learn from Professor Brown outside of your research?

Professor Brown often said: "Do something that would be worth doing a class on". That meant do something new, which could be published in a lecture. And which could also be useful. That is not easy. But I also ended up by telling my students not to *clean your lunch box with toothpicks*, as we say in Japan, meaning avoid getting bogged down in details. I tell them, on the contrary, to fill the lunchbox with their own products.

Is there a method of working that guarantees success?

Even if it did exist, one couldn't expect someone else to adopt it. Everyone has their qualities and what they can do is to make use of them. In my case I think it was optimism. When experiments were not working out well, I went for a drink to relax with the students and, the next day, I could resume my experiments with a new frame of mind.

What do you think needs to be done to attract new generations to chemistry?

Young people are moving away from science and it is a very serious problem. This phenomenon is particularly apparent in Japan. The only thing to do in a country with no natural resources, like Japan, is to use ingenuity to create something new.

It is up to young people and them alone to find their hopes and ideals in science. But I would like to lend my support as an "elder". Thanks to the Nobel prize, the term "cross coupling" is beginning to be known, even by children. The dissemination and popularization of science are, for me, a great source of motivation.

What links do you think we will have with chemistry in the future?

Chemistry is not very fashionable at the moment. It is associated with bad smells, dirtiness, and can provoke aversion. It was already like that when we were young, but at the time, the petrochemical industry was booming and several students chose to study chemistry.

Today, some people see chemistry just as a polluting industry, but that is a mistake. Without it, productivity would drop and we could not enjoy the life we know today. If there is pollution, it is because we are releasing harmful substances. Obviously, we have to adapt treatment and management regimes and work to develop chemical substances and manufacturing processes that respect the environment.

Chemistry is indispensible for the development of Japan, and for the world. I hope that young people will study chemistry, with the idea of creating a new science. There have been many discoveries and developments so far, and an incalculable number of substances have been manufactured. Chemistry will always remain important in the years to come.

Which are the areas of organic chemistry where you think developments will be needed in the future?

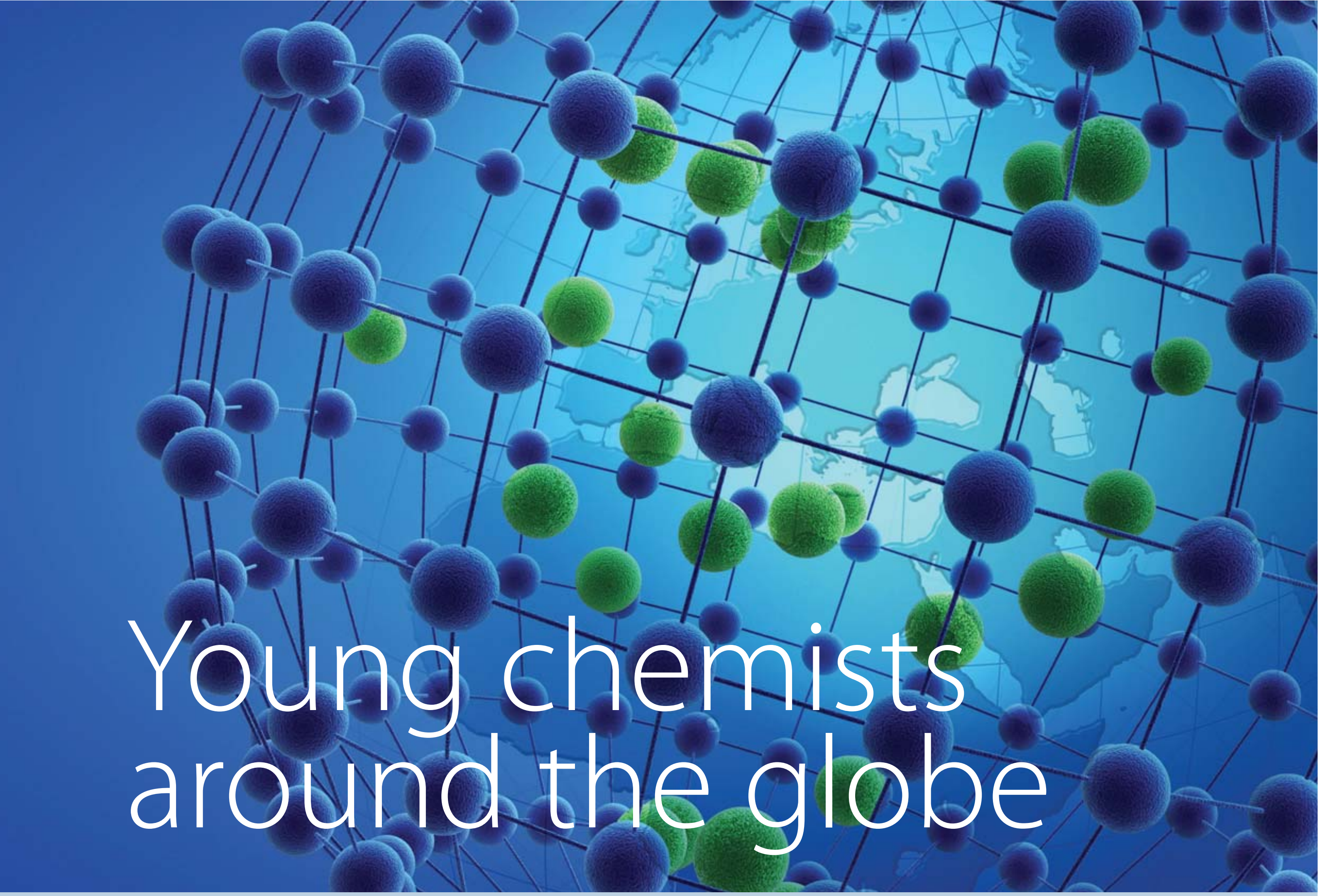
As Professor Negishi said, I think that we have to turn towards the industrialization of photochemistry, based on carbon dioxide, as for example in plant photosynthesis. The energy produced in this sector is still very low. Nature produces complex organic compounds from carbon dioxide, using sunlight as the energy source. And these reactions take place in the temperature ranges in which we live, in an environment where water exists. I hope we will be able to shed light on the mechanisms and apply them.

I recommend young people to go abroad, without hesitating. One learns a great deal and not just on a professional level or in one's specialized area.

The Organic Light Emitting Display (OLED) is one of the many applications of "Suzuki coupling".
© Yomiuri Shimbun

2011 has been proclaimed International Year of Chemistry. Do you have any particular message for readers of the* UNESCO Courier*, who live in the four corners of the world?

Chemistry plays a very important role in our lives. Most specialisms and technologies in chemistry are aimed at the manufacture of products to improve the well being of humanity. There are a considerable number of substances manufactured in the world and no-one knows exactly how many, but almost all are organic compounds. This is why organic chemistry is one of the most important branches of this science, and deserves more people to be interested in it and to contribute to its development. ■



Young chemists around the globe

For the International Year of Chemistry (IYC 2011), the *UNESCO Courier* was interested in young people who decided to take up chemistry at University. We carried out a survey of students who had joined the IYC 2010 network. For most of them, chemistry is more than just a career. It is a passion.

Long live recycling!

© Ana Alejandra Apaseo Alaniz

My name is Ana Alejandra Apaseo Alaniz. I am 19 years old and am studying at the University of Guanajuato in Mexico. I wanted to do a degree in chemistry to help understand the world around me. What I like about chemistry is that it can be applied to anything. When I was little I used to love boiling up plants to see what they tasted like. I made myself sick more than once, I can tell you! But that's what I liked doing – research.

I am specially interested in organic chemistry and its applications. Something I'd really like to do in the International Year of Chemistry is to develop a procedure for recycling products that are made with polystyrene.

And when I get a job, I want to start a project on the creation of organic components used in laboratories and the chemical industry, using recycled materials.

Ana Alejandra Apaseo Alaniz (Mexico)

I chose chemistry without hesitating

© Sougata Maity

My name is Somnath Das. I am 21 years old and am a second year M.Sc student at the Indian Institute of Technology, in Kanpur, Uttar Pradesh.

When starting college, we had to choose either physics, chemistry, or mathematics as the major (honours). Without hesitation, I chose chemistry. I was curious to learn how to control the behaviour of molecules that we can't even see with the naked eye. I wanted to know about their behaviour, their reactions. So I took chemistry, to know more about the molecular world.

I love everything about chemistry, except when there is no theoretical explanation for a reaction. For example, in most reactions using chiral environments, one of the two enatiomers is always dominant. As a rule we can't explain this selectivity, except in the few cases where a model is available. Of the three major fields, I prefer organic chemistry and want to do research in this field.

Somnath Das (India)

© DR

"Anyone can be lucky. But to attract luck, one has to be attentive, to make an effort and remain humble, above anything else...

It is up to young people and them alone to find their hopes and ideals in science."

– Akira Suzuki,

The wisdom of careful attention

© Fatemeh Farjadian

I was born in 1981 in Shiraz, the cultural capital of Iran. I grew up in an adorable and loving family. I was already a curious student at elementary school, so I chose experimental science in high school, where my talent in chemistry blossomed. I was very upset to learn that there is no real cure for cancer, or treatment for those affected by chemical weapons or certain diseases. That's what made me want to study chemistry at university. I wanted to synthesize new molecules. In 1999 I was accepted as a degree student in pure chemistry at Yasuj university. It was there that I realised that chemistry is all around us. In 2006 I started on a Ph.D in polymer chemistry at Shiraz University.

Chemistry has taught me the wisdom of careful attention, which affects all aspects of my life. Now what I find most disturbing is the neglect of governments and people in general concerning the side effects of the use of chemicals in industry, such as pollution, global warming, illnesses, etc. All of these things should be carefully studied by scientists.

In 2011 I will be on sabbatical leave in Germany, at Duisburg University, working on membrane synthesis, which is widely employed in the selective removal of impurities from different media. After I finish my Ph.D I would like to work on pollution control.

Fatemeh Farjadian (Iran)

Chemistry is the 'mother of sciences'

© Courtesy of Research Link Nigeria

My name is Kufre Ite, I am 28 years old. At the end of this year I hope to finish my Master's degree at the University of Uyo. During my junior high school days, an introductory technology course kindled my interest in science. I later opted for chemistry because the principles of this science underpin all the natural and applied sciences. It is the "mother of sciences". Chemistry reflects Nature and also recreates it. I was very inspired by a motto of the Chemical Society of Nigeria (CSN) that asks "Is there anything around us that is not chemistry?" Everyone benefits from the practical applications of chemistry every day, from the soap we wash with to the clothes we wear. I also appreciate the meticulousness and precision of chemists.

For the IYC 2011 I have chosen to focus on "chemists in modern society". I would like to help raise awareness of local and medium-sized manufacturers on safety in the work place, and the safe handling, storage and transportation of chemicals and reagents. This should increase public appreciation and understanding of chemistry and its role in the public and private sectors of our economy.

Kufre Ite (Nigeria)

Don't forget the test-tubes

© Morten Aalbaek Christensen

I'm 21 years old and am a student of applied chemical engineering at the Faculty of Chemical Engineering and Technology, University of Zagreb, Croatia. For me the study of chemistry is an obvious continuation of my love affair with nature, which has continued since I was a child. I appreciate the multidisciplinary character of my studies, but also dislike the heavy reliance on computers, as it distances us from the traditional, experimental approach. However, I'm aware that it also has many advantages. After I graduate I would like to study for a PhD in Croatia or abroad and learn more about polymers. I would like to celebrate the IYC popularising chemistry through interesting yet simple experiments that explain phenomena occurring around us.

Marko Viskic (Croatia)

Studying chemistry in Ethiopia

Shimalis Admassie

Since 1950 the Ethiopian university system has been trying to fill the country's need for high-level chemists. In just 17 years, a simple unit of the University College of Addis-Ababa has become a full-fledged department of the Haile Selassie I University, offering a Bachelor of science (BSc) degree in chemistry. In 1978 the department launched a Master of science (MSc) programme in chemistry with four specialization options: analytical, inorganic, organic and physical. A PhD programme was launched in 1985.

Currently there are 27 full-time academic staff and eight technicians in the chemistry department. In the present academic year (2010-2011), there are 1121 undergraduates studying chemistry, 81 postgraduates registered for an MSc and 45 PhD candidates. Department staff are engaged in research areas such as the analysis of trace and heavy metals (see page 21), biosensors, the chemistry of natural products, green chemistry, electrochemistry, computational chemistry and several other fields of this complex science.

The department buildings cover an area of some 2800 m^2, with 25 laboratories and 13 associated areas. Chemical and hardware stores occupy a further 700 m^2. High-grade instruments for research and teaching include a 400 MHz NMR spectrometer, a high performance liquid phase chromatograph, a Fourier Transform Infrared spectrometer, an ultraviolet/ visible light spectrophotometer and Gas chromatography-mass spectrometry (GC-MS) facilities.

While the overall image of our department is positive, there are still a number of constraints affecting the teaching and research activities, including inadequate safety provisions, too many students, inadequate laboratories for undergraduate instruction, poor administrative support for research, the prohibitively high cost of chemicals and scientific equipment. Most research is carried out with the very limited funds the department receives from the university. Some research projects do receive funding from foreign organizations, such as the Swedish International Development Cooperation Agency (SIDA/SAREC), International Programme in the Chemical Sciences (IPICS), the British Council Development Partnerships in Higher Education (DelPHE) programme and the International Foundation for Science (IFS).

Another constraint is the lack of a data analysis centre. We are very often obliged to send samples abroad for analysis, with obvious delays for students, whose research has to be completed in a limited time frame.

Shimalis Admassie is Head of the Department of Chemistry at the University of Addis-Ababa, Ethiopia.

Postscript

Science without borders

The UNESCO Science Report 2010, published by UNESCO last November, takes a look at the latest trends in scientific research and cooperation across the world. In particular it highlights an increasing number of partnerships, forging alliances in science, but also in terms of international diplomacy. – *p. 46*

UNESCO and CERN: like hooked atoms

The idea of creating a European Council for Nuclear Research (CERN) first arose at the fifth session of the UNESCO General Conference, in 1950. For 60 years, these two organizations have striven to facilitate access to scientific knowledge and to promote scientific cooperation. We meet Rolf-Dieter Heuer, Director General of CERN. – *p. 48*

Arts as a bridge between cultures

Cultures have always mixed and interacted, creating new hybrid cultures. Yet they also have a tendency to reject neighbouring cultures. Looking at the examples of North American and Arab/Muslim cultures, Stephen Humphreys highlights the role of literature and the arts as special means for rapprochement. – *p. 51*

Touki Bouki's new life

Promoting African cinema, supporting its directors, safeguarding the film heritage of his continent – these are the goals of the Malian director, Souleymane Cissé, a fierce defender of African national languages. In 1997 he founded the West African Union of Film-makers and Producers (UCECAO). – *p. 53*

The Symbolic Globe by Erik Reitzel (Denmark), outside UNESCO headquarters, Paris.

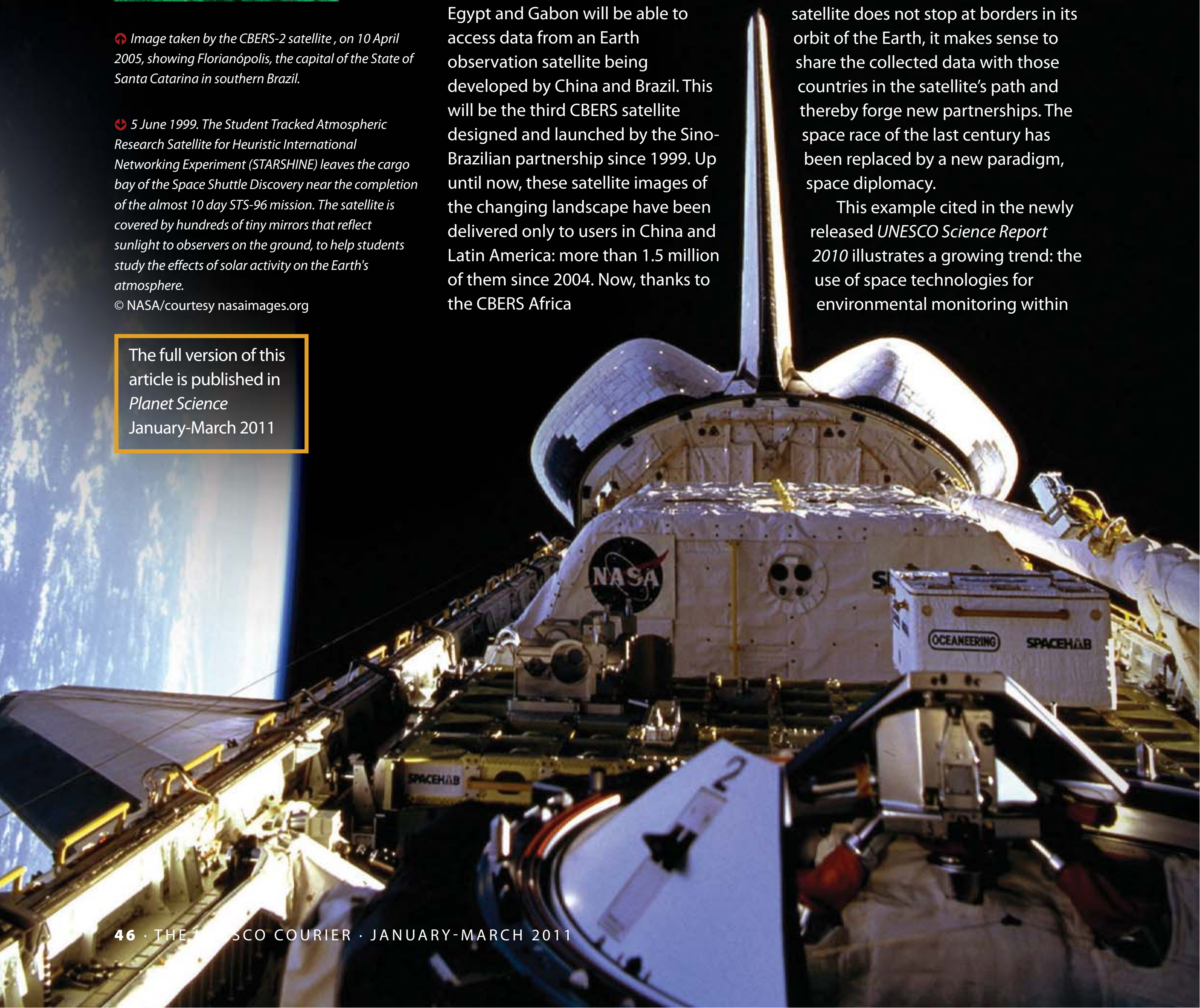
"Increasingly, international diplomacy will take the form of science diplomacy in the years to come."
Irina Bokova

Science without borders

If there is one field where globalization seems to be doing good, it is research. Everywhere, partnerships are being developed, forging scientific, and even diplomatic alliances between countries that may sometimes be poles apart geographically or in terms of resources. By working together, partners can capitalize on one another's strengths and save time and money. Here are a few examples from the UNESCO Science Report 2010.

Susan Schneegans, Editor, *UNESCO Science Report 2010*

Image taken by the CBERS-2 satellite , on 10 April 2005, showing Florianópolis, the capital of the State of Santa Catarina in southern Brazil.



5 June 1999. The Student Tracked Atmospheric Research Satellite for Heuristic International Networking Experiment (STARSHINE) leaves the cargo bay of the Space Shuttle Discovery near the completion of the almost 10 day STS-96 mission. The satellite is covered by hundreds of tiny mirrors that reflect sunlight to observers on the ground, to help students study the effects of solar activity on the Earth's atmosphere.
© NASA/courtesy nasaimages.org

From 2012 onwards, ground stations in South Africa, Canary Islands (Spain), Egypt and Gabon will be able to access data from an Earth observation satellite being developed by China and Brazil. This will be the third CBERS satellite designed and launched by the Sino-Brazilian partnership since 1999. Up until now, these satellite images of the changing landscape have been delivered only to users in China and Latin America: more than 1.5 million of them since 2004. Now, thanks to the CBERS Africa initiative, the list of beneficiaries has been extended to Africa. Since a satellite does not stop at borders in its orbit of the Earth, it makes sense to share the collected data with those countries in the satellite's path and thereby forge new partnerships. The space race of the last century has been replaced by a new paradigm, space diplomacy.

This example cited in the newly released *UNESCO Science Report 2010* illustrates a growing trend: the use of space technologies for environmental monitoring within

The full version of this article is published in *Planet Science* January-March 2011 international collaboration. This trend is one consequence of the growing concern at the rapid degradation of the environment and climate change. With recognition of the interconnected nature of the land, water and atmosphere has come the realization that data-sharing among countries and continents will be crucial to improving our understanding and monitoring of the Earth's environment. One motivation for space diplomacy is thus commonality of purpose.

Space diplomacy is itself a subset of a wider phenomenon today: science diplomacy. Science diplomacy can span a wide range of areas, including health, information and communication technologies and clean energy sources. In June 2009, for instance, Sudan inaugurated its first biofuel plant, built in co-operation with the Brazilian company Dedini. A second project in Sudan involving Egypt at a cost of US$ 150 million 'is producing second-generation biofuels from non-edible crops, including agricultural waste such as rice straw, crop stalks and leaves', according to the Report.

Under an agreement signed by the two countries in 2003, Pakistan and the USA now 'contribute to a common fund which is jointly managed by the National Academy of Sciences in the USA and by the Higher Education Commission and Ministry of Science and Technology in Pakistan,' writes Tanveer Nair, who, as Chair of the Pakistan Council for Science and Technology, played a pivotal role in securing this landmark agreement. 'Each year, proposals for research collaboration are invited with at least one US and one Pakistani scientist as principal investigators,' she explains. 'The proposals undergo peer review in both countries and are selected on merit. This programme has resulted not only in capacity-building of Pakistan's laboratories', she says, 'but also in the joint discovery of a vaccine to prevent a deadly disease caused by tick bites which afflicts those working with animal herds in the southern region of Sindh in Pakistan.'

Cost-sharing

Around the world, countries are developing partnerships in science, technology and innovation within a wider policy to forge political alliances and enhance their presence on the world stage. But international collaboration is of course also motivated by the more pragmatic desire to pool resources in the face of the escalating costs of scientific infrastructure. The bill for one international project to develop a clean energy source by mastering nuclear fusion has been estimated at no less than 10 billion euros. This is 'the most ambitious collaborative project in science ever conceived', writes Peter Tindemans, a consultant who used to be responsible for co-ordinating research and science policy in the Netherlands. The project is building an International Thermonuclear Experimental Reactor (ITER) in Cadarache, France, by 2018.

That the project should involve not only the traditionally dominant scientific powers of the European Union, Japan, the Russian Federation and the USA but also China, India and the Republic of Korea is a reflection of the growing economic and technological might of these countries. China, for instance, 'will assume 9.09% of the cost of construction and spend over US$1 billion in total,' writes Mu Rongping, Director of the Chinese Academy of Science's Center for Innovation and development, in the report. 'Some 1000 Chinese scientists will participate in the ITER project [and] China will be in charge of developing, installing and testing 12 components,' he explains.

Winning new markets

The business sector has also been quick to weigh up the advantages of international scientific collaboration. In addition to cost-sharing, international consortia offer a tempting opportunity to conquer new markets. The hugely successful Airbus consortium is the result of the merger of the formerly independent aircraft manufacturing companies of four European countries – France, Germany, Spain and the United Kingdom – and is a shining example of what pan-European co-operation can achieve.

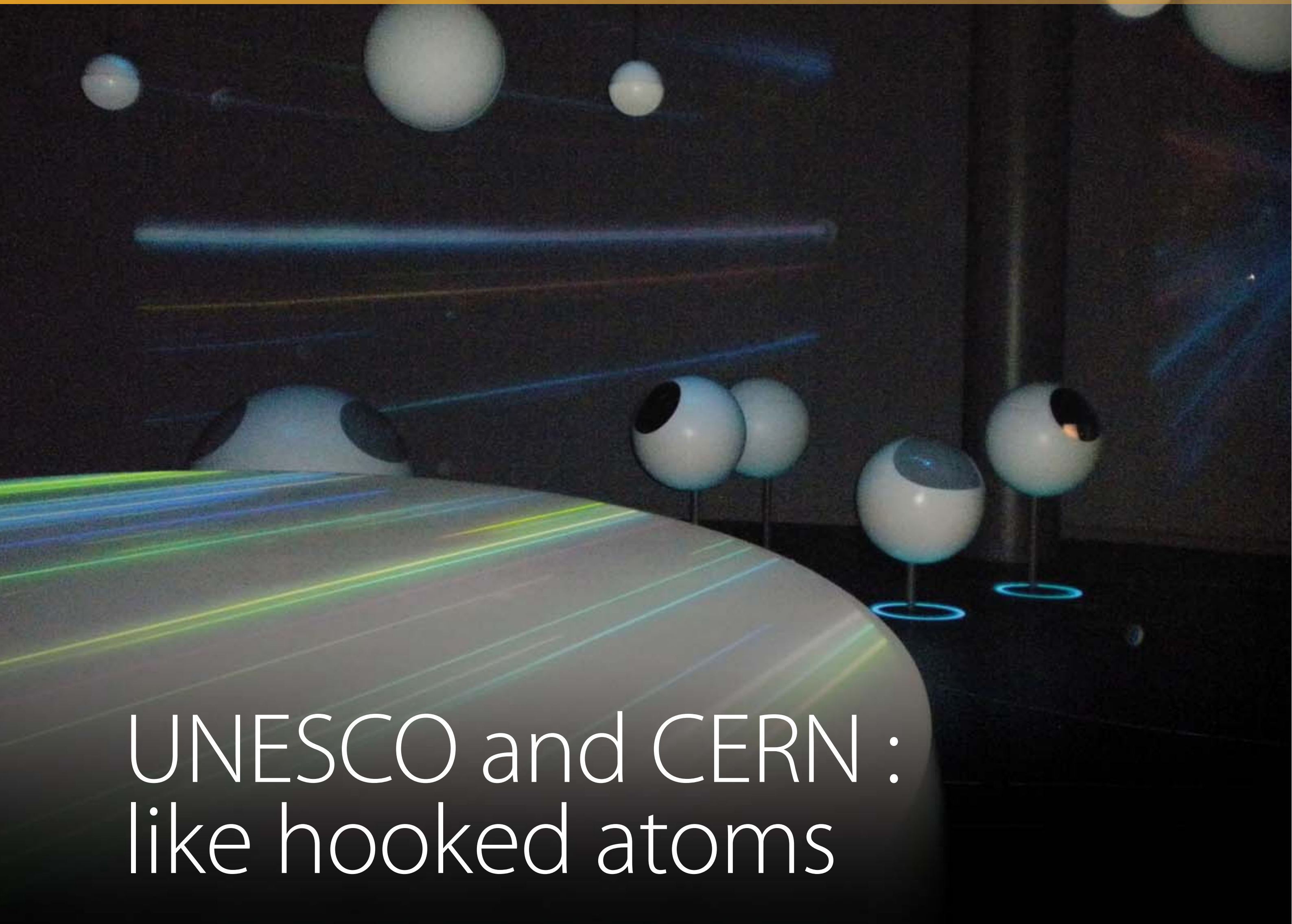
Two decades after the fall of the Iron Curtain, the Russian Federation is witnessing a growing volume of commercial contracts and joint ventures in science and technology involving both Russian and foreign companies. In 2010, the joint-stock enterprise comprised of the French company Alcatel-Lucent RT and state corporation Russian Technologies began investing in the development, manufacturing and marketing of telecommunications equipment for the Russian market and those of the countries of the Commonwealth of Independent States. Meanwhile, the jointly owned US–Russian company IsomedAlpha has begun producing high-tech medical equipment like computer tomographs.

International co-authorship

In addition to such factors as evolving geopolitics and financial considerations, the growth of international scientific collaboration in recent years owes much to the rapid spread of ICTs: Internet access doubled between 2002 and 2008 from 11% to 24% of the global population and even tripled in the developing world from 5% to 17% of the population.

The past few years have not only witnessed a surge in international co-authorship but also a diversification of research partners. One of Australia's top three partners for scientific co-authorship between 1998 and 2008 was China, along with traditional partners the United Kingdom and USA. In the Philippines, top billing went to the USA and Japan, followed by China. China was even the number one partner for Malaysia, ahead of the United Kingdom and India. There are signs that the growing role of China and India in scientific authorship as a consequence of their growing global influence is already reshaping the scientific landscape in Southeast Asia.

The closest neighbours do not always make for the closest partners. India, Iran and Pakistan all publish 20–30% of research articles with scientists abroad but most of their co-authors live in Western countries. Just 3% of research articles are published in collaboration with scientists working in South Asia. In Brazil, where international scientific collaboration has remained steady for the past five years at about 30% of the total, 'US scientists are the main partners' write Carlos Henrique de Brito Cruz and Hernan Chaimovich, respectively Scientific Director of the São Paulo Research Foundation and CEO of the Butantan Foundation in Brazil. They cite a 2009 study which 'found that 11% of scientific articles written by Brazilians between 2003 and 2007 had at least one co-author in the USA and 3.5% a co-author from the UK. Argentina, Mexico and Chile combined represented just 3.2% of co-authors of Brazilian articles.' ■



UNESCO and CERN : like hooked atoms

Fostering scientific cooperation, making science education more attractive, facilitating access to scientific knowledge for a fairer world – these are common objectives being pursued by UNESCO and the European Organization for Nuclear Research, better-known by its historic acronym, CERN. The two organizations have been closely linked for 60 years.

Jasmina Šopova meets ROLF-DIETER HEUER, Director-General of CERN

Few people today remember that the idea of creating a European Council for Nuclear Research (CERN) was mooted in 1950, in Florence (Italy), at the fifth session of the UNESCO General Conference. At that time, the world was still licking its wounds after the still recent Second World War. European intellectuals, men and women of the arts and scientists had all understood one thing – that cooperation was essential for the construction of peace. What was needed was a common project around which European researchers could join together, coming from both Allied countries and the Axis powers.

The Florence project was to enter into force three years later, with the signature of the final Convention on the creation of CERN (the 'Council' having metamorphosed into 'Centre'). The Convention was ratified by 12 countries[1] in 1954 and the first stone of the building was laid, just outside Geneva (Switzerland), in 1955.

1. Belgium, Denmark, France, Germany, Greece, Italy, Netherlands, Norway, Sweden, Switzerland, United Kingdom, Yugoslavia.

Today, beneath the buildings of the European Organization for Nuclear Research, which has kept its historic acronym, is the world's largest particle accelerator. Some 27 kilometres in circumference, the Large Hadron Collider (LHC) is a gigantic instrument, equipped with 9300 magnets.

On 30 March 2010, news coming out of CERN set the world talking – LHC had succeeded in colliding beams at close to the speed of light. "With this experiment", says Rolf-Dieter Heuer, CERN's Director-General, "we got to within a fraction of a second of the Big Bang. "It's a new step forward, opening areas of research into the Creation of the universe that we could never have imagined before."

The historical discovery of 30 March was made possible through the "Atlas Collaboration" which brings together around 3000 physicists (including 1000 students) from 40 countries, and belonging to over 170 universities and laboratories. This an entire "virtual nation", to use an expression often

The Universe of Particles exhibition aims to help visitors to CERN understand the major issues in contemporary physics. © UNESCO/J. Šopova

heard at CERN. "Motivation – and this alone – can explain the success of this gigantic undertaking. Although we come from different regions of the world, we're all moving in the same direction – towards knowledge," says the Director-General. If, one day, we discover the famous Higgs boson – a hypothetical particle dubbed The Grail by physicists, because they've all been searching for it for half a century – it will be thanks to the Atlas. "We know everything about this particle, except whether it exists," he says, smiling.

CERN is not alone in pursuing this quest, though. There is also Fermilab, just outside of Chicago (USA). "Today, CERN has the most powerful accelerator in the world, but until recently it was Fermilab, and they have amassed a huge quantity of data over 25 years, whereas we have just begun. LHC was only launched in September 2008. But, having said this," confides Rolf-Dieter Heuer, "I think that, with it, we have a good chance of beating them to the discovery of the Higgs boson." Do the two organizations collaborate? "I call it competitive collaboration or collaborative competition. Fermilab helped us a lot when the LHC went down, [shortly after it opened]." And do they exchange data? "Not for the moment. Come back in a few years and ask me that question again."

There is no progress without competition – nor without cooperation.

"There is no progress without competition," says Rolf-Dieter Heuer. "Nor without cooperation." This was at the origin of the birth of CERN and remains its driving force, but it is also one of the permanent ideals of UNESCO. And one of the Organization's recent projects is to support the Synchrotron-light for Experimental Science and Applications in the Middle East (SESAME) centre in Allan (Jordan). In terms of international scientific cooperation, SESAME is the Middle East's equivalent of CERN. It brings together Bahrain, Cyprus, Egypt, Iran, Israel, Jordan, Pakistan, the Palestinian Authority and Turkey. "We don't have the same fields of expertise," explains CERN's Director-General, "but the idea of using science for peace underlies both projects. And CERN has not shied away from helping create SESAME, especially in terms of expertise."

In the framework of common initiatives (SESAME, virtual libraries in African universities, training teaching staff, etc.), CERN puts its expertise at the disposal of UNESCO, while UNESCO's International Basic Sciences Programme (IBSP) offers the European Organization a framework for cooperation with researchers from countries that are not its members. Indeed, CERN has 20 Member States, but its projects include 10,000 associate experts from 85 different nationalities.

We never know when or how a result of basic science will be applied. But it always is, in the end, either directly or indirectly.

CERN also counts on UNESCO to help it promote the idea of a new approach to teaching physics and mathematics on an international scale. "We can no longer continue to teach physics starting with theories developed in the 18th century!" protests Rolf-Dieter Heuer. "Current research on the universe, for example, is very appealing to young people. Schools should start by stimulating their curiosity and then gradually move on to the basics. CERN cannot develop a method that would suit all countries, but it can raise awareness and train teaching staff from all over the world. And UNESCO can convince political leaders that we absolutely have to make science subjects more attractive to pupils in secondary school, so that they are not turned off." The struggle could be a long one. "I know, the battle is not going to be a walk-over. But if we don't start with a battle, we have already lost!"

Basic science is another area where the objectives of the two organizations coincide. Decision-makers often perceive basic science as too abstract, because there may be no immediate applications for its results. But for Rolf-Dieter Heuer, this is nonsense.

"I define basic science as open research with a focus on results, but not with a focus on application. Imagine if you had asked Wilhelm Röntgen to invent a machine to photograph your skeleton! He would never have come up with radiation. And yet, without any preconceived ideas, he discovered, in 1895, the X-rays that still underlie modern radiography." There is no lack of examples to illustrate Heuer's conclusion – "We never know when or how a result of basic science will be applied. But it always is, in the end, either directly or indirectly." ■

Three years after the idea for CERN was first conceived, the Convention for its creation is signed on 19 July 1953, at UNESCO.
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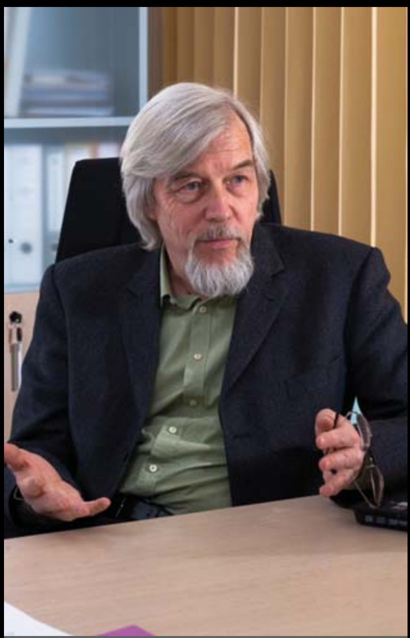

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Rolf-Dieter Heuer, a German physicist, took over as Director-General of CERN on 1 January 2009. He took up his post just as the Large Hadron Collier (LHC) started operating.

Essential UNESCO science publications

UNESCO SCIENCE REPORT 2010
The Current State of Science around the World
'What effect is the current global economic recession having on national science systems?' 'How fast are the national innovation systems developing in the BRIC countries (Brazil, Russian Federation, India, China)? Which new players are emerging in an increasingly multipolar world?' and 'which countries are experiencing difficulties in maintaining their current status in an increasingly competitive global environment?' 'What new R&D priorities are emerging in a world confronted with climate change and growing food, water and energy insecurity?' The report answers all these questions and more. It is divided into national and regional chapters, each written by experts who hail from the same country or region they are covering.

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The dramatic environmental and social transformations due to climate change that Arctic is undergoing have ramifications for the entire planet. Today, the central preoccupation of scientists is the exploration of strategies for responding and adapting to climate change. A truly interdisciplinary approach is required. This book brings together the knowledge and visions of leading Arctic scientists in the natural and social sciences, prominent community leaders from across the circumpolar North, and international experts in education, health and ethics.

376 pages, colour photographs, figures, tables, references, annex, 24 x 18 cm · ***€22.00*** *· 2010*

WATER AND PEACE FOR THE PEOPLE
Possible solutions to water disputes in the Middle East
Jon Martin Trondalen
A clarification of the complexity of the water conflicts in the Middle East, practical and objective solutions. Unless the countries involved co-operate, the consequences will be devastating. The lack of plentiful and clean water for the people will not only result in severe human suffering, but could also have grave geopolitical consequences.

The book covers four critical areas: the Euphrates and Tigris Rivers, the politically sensitive Golan Heights, the Hasbani water dispute between Lebanon and Israel, the longstanding water resource dispute between the Israelis and Palestinians.

246 pages, maps, tables, figures, photographs, annexes, index, 24 x 19 cm · ***€38.00*** *· 2008*

CLIMATE CHANGE
Guy Jacques and Hervé Le Treut
The basic scientific background and information essential for understanding the complex processes that bring about climate change. The authors explain the difficulties involved in making realistic climate predictions. They examine the Kyoto protocol from different points of view, shedding new light on the challenges at stake and the need to foster international cooperation. Finally, they outline the work ahead needed to both develop effective climate prediction models and to come up with countermeasures to cope with the dangers facing our Earth and society.

176 pages, figures, appendix, glossary, 23.7 x 15 cm · ***€14.80*** *· 2005*

EXPLAINING THE EARTH
Philippe Bouysse
The *Discovering the World* series proposes in a few pages all you need to know about a subject. Aimed at a young readership, parents and teachers, the books are concrete and richly illustrated.

Explaining the Earth outlines the basic geophysical aspects of the Earth and traces its dynamic and ever-changing surface properties and topographic evolution. A better understanding of how our planet functions is the key to learning how to better respect the fragile and complex ecological equilibriums that reign over the globe and thereby guarantee the survival of future generations.

48 pages, illust., photographs, glossary, 21.7 x 15.5 cm · ***€8.00*** *· 2007*

WORLD HERITAGE N° 56
Heritage and Biodiversity: synergies and solutions
- Synergies between World Heritage sites and Key Biodiversity Areas
- Marine World Heritage: the time is now
- Climate change and a natural solution
- Cultural diversity, biodiversity and World Heritage sites
- Western Ghats: biodiversity, endemism and conservation
- Kew Gardens and the conservation of biodiversity
- Funding for biodiversity: implications for World Heritage sites

88 pages, photographs, 28 x 22 cm · ***€7.50*** *· 2010*

ENGINEERING: Issues, Challenges and Opportunities for Development
UNESCO Report
Engineering is as international as science. The Report reviews the role of engineering in development, and covers poverty reduction, sustainable development, climate change mitigation and adaptation. It presents the various fields of engineering around the world. It also discusses engineering issues, applications and innovation, infrastructure, capacity building, engineering education.

A platform for the better understanding of engineering, and of the roles and responsibilities of engineers.

396 pages, photographs, tables, figures, index, 28 x 21.5 cm · ***€26.00*** *· 2010*

Art as a bridge between cultures

Stephen Humphreys

Since cultures have existed, they have mixed, interacted and given birth to new, hybrid cultures. Yet, at the same time, they have a tendency to split themselves off, and to reject neighbouring cultures. Taking as examples North American and Arab/Muslim cultures, Stephen Humphreys highlights the role of literature and the arts as special means for rapprochement.

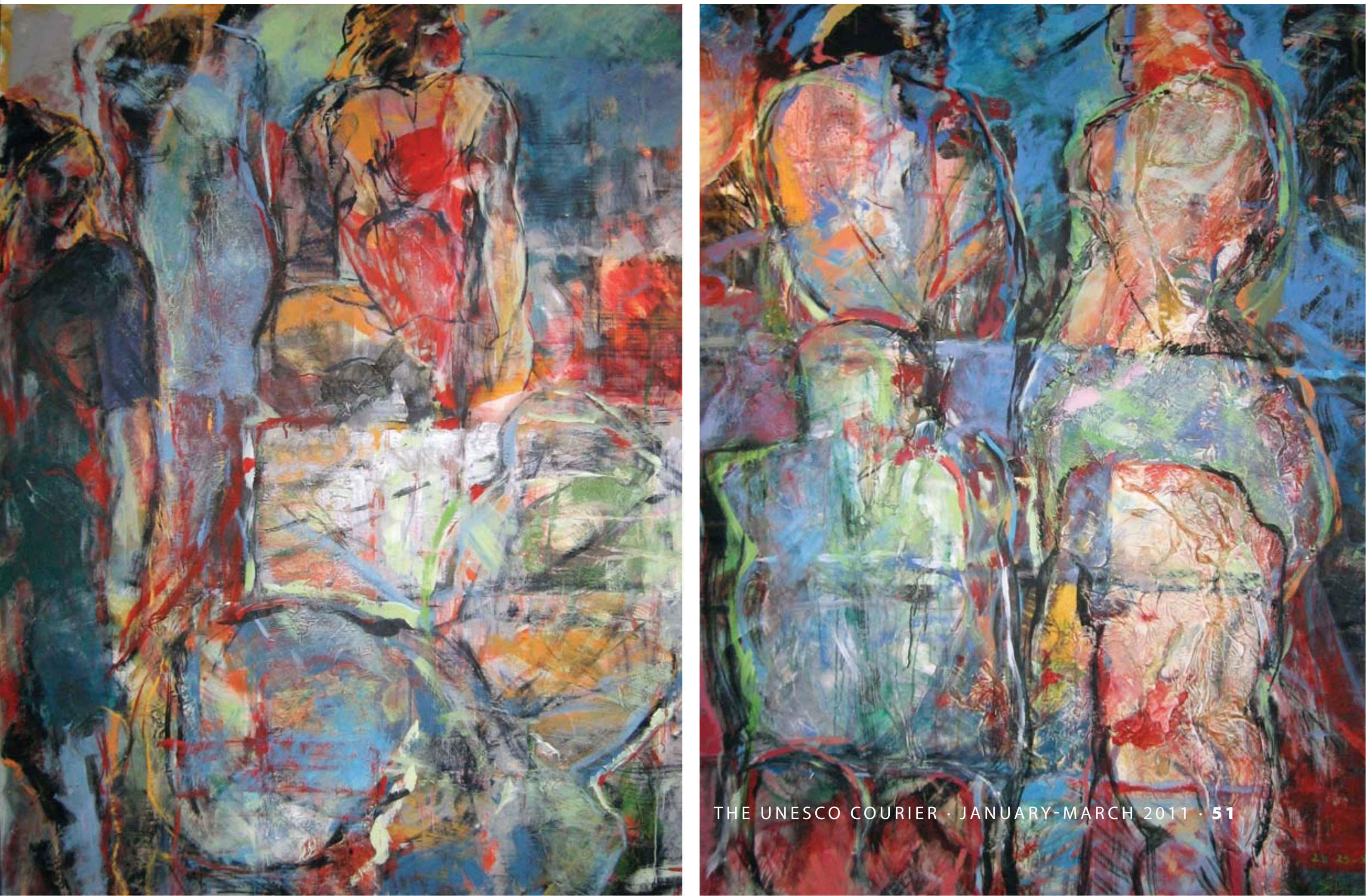
Any discussion of cultures in intimate contact with one another—whether this contact manifests itself as tension, as overt conflict, or as a search for rapprochement—ought to begin with some effort to define culture. In this presentation, I follow a perspective developed by the American anthropologist Clifford Geertz nearly forty years ago. Culture, he argued, does not lie in patterns of behaviour and social structures in themselves, but rather in the ways we create and express meaning within these patterns and structures. A culture is thus the body of ideas, beliefs, gestures, rituals, and practices by which a society comes to see itself as a coherent, meaningful whole—in effect, as a people apart, with a distinctive identity of its own.

Cultures are not hard-shelled; only rarely can they shield themselves from the pressure and influence of others. Rather, cultures are permeable, capable of engaging in processes of interpenetration and hybridization. Cultures can exist side-by-side or be interwoven with one another in a state of equilibrium. Each interacts with neighbouring cultures in a limited, pragmatic way but has no trouble retaining its sense of itself and maintaining its core identity.

Conflict arises when two cultural systems come to seem threatening to each other. This sense of threat often arises out of the violent intrusion of one cultural system into the space occupied by another—"imperialism" on a small or large scale, which is a constant and pervasive feature of human history. However, fear of the other is most powerful and insidious when it emerges out of a situation of rapid, pervasive, uncontrollable hybridization. Such hybridization creates an acute sense of loss of control. All the old rules of behavior, symbols, beliefs, and rituals dissolve and begin to seem foreign. One feels that he is becoming a stranger in his own home. This anxiety of hybridization is what we confront everywhere in the world today. Almost every culture is infected by it. The question we face is whether it is possible to heal or ameliorate this anxiety. If so, how, and to what extent.

Meeting at the heart of painting: diptych by Helga Shuhr (Germany) and Youssef Fatis (Libya).

Photo : UNESCO/R. Fayad



Beyond stereotypes

In trying to answer this question, I will focus on the U.S. response to Arab and Muslim societies. No one will be surprised to hear that this response is confused. In general Americans do want to understand and even accept cultural difference, but have a deeply rooted belief in the superiority of "the American way". The American response focuses on fears—specifically, of "Islamic terrorism"—rather than on a comprehensive and nuanced engagement with the diverse and complex cultures of Arab and Muslim societies. A comprehensive engagement of the kind required can be found in the United States, but only in boutique environments—in colleges and universities, rather than the grand public square defined by the mass media and the internet.

Inevitably, stereotypes about Arabs and Muslims reign supreme. The problem is how to get a broad spectrum of Americans to question stereotypes, to confront their fears, and to engage with Arab and Muslim cultures in a serious way.

At this point we need to be honest with ourselves. Even if we succeed in this task, there will surely remain cultural differences that are too stark to be absorbed, that challenge and offend deeply held American values and ways of life. A single example will suffice. To the American eye, the *burqu`* and *niqab* symbolize—indeed they epitomize—the degradation and depersonalization of women. Almost no amount of discussion and explanation will get rid of this almost instinctive response.

Another caution. One can come to understand cultural differences and still reject them as valid or acceptable alternatives. Does such a rejection inevitably lead to conflict? I have no immediate answer to this question, but it must be confronted thoughtfully and honestly.

The mirror of suspicion

Cultural engagement requires selectivity. One cannot know everything about everything. But then what aspects of Arab and Muslim cultures should we focus on? What groups will we choose to represent these cultures to us? To this point Americans have tended to fix their attention on two groups, to the near exclusion of all others: militant religious radicals and women. The fear and anxiety they engender are bound to distort discussion and analysis.

In regard to the first group, let us say simply that among Americans, Islam is viewed through the prism of September 11 and Arabs through the prism of the the Israel/Palestine conflict. The converse is also true, I think: for Arabs both in the Middle East and the diaspora, the United States is also viewed through the prism of Israel/Palestine. We are the mirror image of each other's suspicion, fear, and resentment. It is a perfect recipe for mutual tension, distrust, and even cultural repugnance.

As regards women's rights activists, some are informed and culturally sensitive, some are not. In either case, however, interventions in this arena strike at the most intimate and bitterly contested dimensions of Arab and Muslim societies. In this case, concern and engagement may sometimes increase rather than diffuse cultural tension.

A translator's work, like a performing musician's, is perhaps not creative, but it is re-creative. It is an essential element in the process of cultural rapprochement.

Culture as a go-between

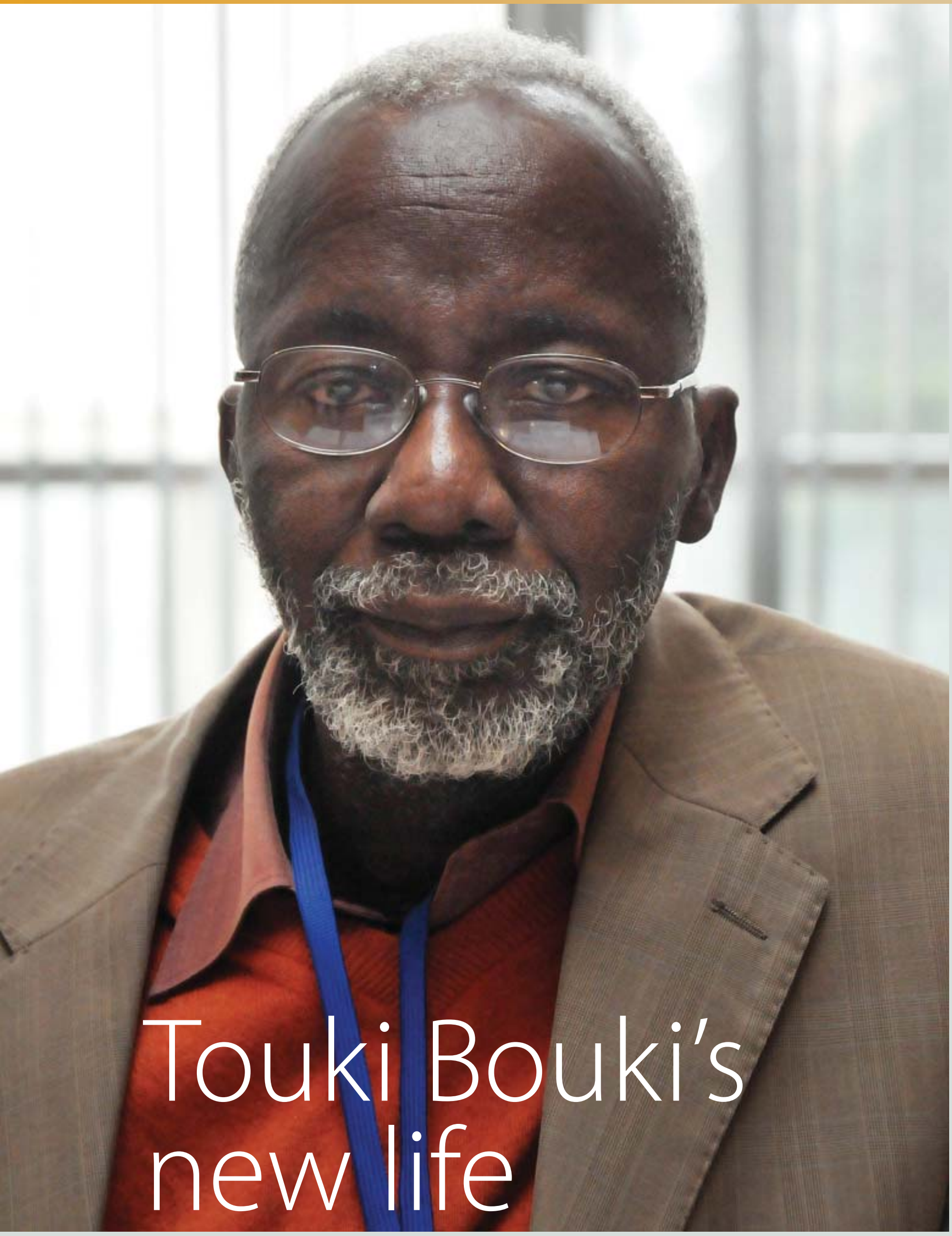
Literature and the visual and performing arts are a compelling means to get to understand Arab and Muslim cultures. An article in the *New Yorker* by Claudia Roth Pierpont makes a telling statement: "Arabic novels offer a marvelous array of answers to questions we did not know we wanted to ask." Precisely. The only problem is that so little of the Arabic literature published over the last twenty years is available in English.

While novelists construct their own worlds, which are not a simple mirror of their cultures and do not speak for their societies, but only for themselves, their work is a direct, authentic product of the societies and cultures within which they live. Much the same could be said of musicians, painters, and sculptors.

In spite of all limitations and reservations, literature and the arts are the best way for outsiders to get inside another culture. They give us the broadest and most varied perspectives on the self-understandings of Arab cultures and on the myriad ways they try to define themselves. On the other hand, in order to serve as a bridge between cultures, these arts require translators, performers, and interpreters. Such cultural brokers are often regarded with some condescension, as simple conduits by which the original creative efforts of others can be transmitted to new audiences. Plainly that view does not do justice to the depth of knowledge and understanding required to make the products of one cultural system intelligible, meaningful, and even usable to the members of another, very different culture. A translator's work, like a performing musician's, is perhaps not creative, but it is re-creative. It is an essential element in the process of cultural rapprochement.

In closing, I will argue that Americans will only be able to come to terms with the complex realities of Arab cultures when the United States develops a much larger body of translators and interpreters than it now has, and—even more critically—when these brokers become integral members, rather than marginal players in the country's intellectual and cultural life. This will not happen anytime soon, and in any case it will not resolve all the tensions and hostilities between such very disparate cultures. But it would at least allow Americans to move toward seeing Arabs and Muslims as they really are, in all their complexity. In return, of course, one hopes that Arab intellectuals and scholars will make a similar effort to make sense of American life and thought—no easy task, I admit, but one that must be undertaken if we are ever to move beyond the mutual confusion and suspicion in which both cultures are so deeply entangled. ■

R. Stephen Humphreys is Professor of History and Islamic Studies at the University of California, Santa Barbara (USA). This article is taken from his paper, *Reflections on the Problem of "Rapprochement des Cultures"* presented at UNESCO on 9 February 2010, as part of the Forum held on the occasion of the award of the seventh UNESCO/Emirate of Sharjah Prize in Arab Culture.



Souleymane Cissé at UNESCO, at the launch of the International Year for the Rapprochement of Cultures, on 18 February 2010. © UNESCO/A.Wheeler

Touki Bouki's new life

Filming in their own languages, helping African film-makers, promoting their work, supporting contemporary film and television, safeguarding Africa's cinema heritage — these are some of the objectives that the Malian director, Souleymane Cissé, has set for himself. Here is a man of spirit, with ambitions for his continent.

Interview with **SOULEYMANE CISSÉ** by **Gabrielle Lorne**, journalist from Martinique

Do you see cinema as a space for dialogue between cultures?
Yes, cinema has made the world a smaller place. It's part of the idea of the global village – I might even say 'global emotion'. Whatever the director's nationality, and no matter where a film was made, it is a means of sharing a vision. And the viewer has the feeling of being transported to a universe where the sounds and accents are unfamiliar. I feel that one of the virtues of cinema is to bring people together.

You talk about the global village. But at the same time there is a growing trend for societies to turn in on themselves, and for misunderstanding to increase.
This kind of ambivalence is there, there's no doubt about it. In the past 30 years I have seen the major distributors gradually turn away from African films. The distributors seem to be afraid of difference. In 1987, my film *Yeelen* was shown in all the mainstream cinemas in France and Navarre and won over audiences from every social class! I don't think that would be possible today. But I don't think the audiences have changed. It's the decision-makers who won't take risks any more. Neither the risk of showing differences, nor the risk of discovery. And even less so, financial risks. And paradoxically, in the South, we only go to see Western films.

Can this imbalance be put right?
There has to be real political determination to overcome this tendency to turn inwards. Poor ticket sales have an impact on both the quality and the quantity of our work. And, as African film-makers, we have to draw the right conclusions, such as turning towards our own natural audiences, in our own countries. But no matter how many people go to see our films, the public can't pay enough to finance them. This is why, in Mali, film-making is poorer today than 20 or 30 years ago.

Why do you always film in Bambara, Mali's national language?
I have often been criticized for not filming in French, the only official language in Mali. I have chosen to film in Bambara, because it's the main language spoken by 80% of Malians. It is understood by over 20 million people in West Africa. It is the language used for business. This carries a lot of weight and is not a mere detail.

At the same time, having directed dozens of actors, I can assure you that you don't get the same results when the dialogue is in French as when it is in Bambara, which is the language of intimacy for us… We have often been told that no-one will understand our films outside of Africa, and that puts us at a disadvantage, but I think that's not true. Language is there to serve the story of the film. How could I have made *Yeelen* is in French, when it is about the esoteric knowledge passed down from one generation to another!

You go even further and say that African States should renounce colonial languages in favour of national languages, which are not officially recognized.

National languages bring citizens together, they are indispensable for nation building. In Mali, we have 13 national languages, but just one official language – French. I've said it before and I'll say it again – national language won't kill off English, French or Spanish. But I do believe that if Mali does not look after its own languages, the civilization that they have been carrying for thousands of years will finally disappear.

And if I may make one political observation, since the State has chosen to become independent, it has to go the whole way, and not be afraid of upsetting the Administration. There is still time to take up the task again of codifying a written form of each of our languages and to respect the ideograms left to us by our ancestors.

You are also very committed to promoting African cinema.

Yes, since *Waati*, my film about Apartheid in South Africa, came out in 1995, I realised that financial support for African films started to disappear, especially in Europe. African States do not have the money to invest in our films, but they can at least help film-makers and the film industry by creating an appropriate legal framework.

It was time that we, as professional film-makers, took a stand together to protect our work. So, in 1997, I set up the West African Union of Film-makers and Producers (UCECAO). Our aim is to promote African cinema and to encourage those in Africa who have the means – the private sector, for example – to support it.

You also set up film festivals?

In 1998, UCECAO launched the Bamako Film Festival (RCB). Then we started the Nyamina International Festival (FINA), in the countryside, because culture cannot just be reserved for those living in towns. FINA is not just for young directors, but also for video makers and even photographers.

Poster for the film, Touki Bouki *by Djibril Diop Mambéty in 1973. The film was recently restored by WCF.*
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You are now involved with Africa's film heritage.

That is true. In 2007, in Cannes, I had the pleasure of participating in the launch of Martin Scorsese's World Cinema Foundation (WCF). A few months later, UCECAO invited Scorsese to Mali and he decided to invest in preserving our film heritage. At the following Cannes Festival, I was able to show the restored version of Touki Bouki, by Djibril Diop Manbety, from 1973. It had been 20 years since anyone had seen the film, as it had become very damaged by time and poor storage conditions.

Touki Bouki was the first film from sub-Saharan Africa to have been granted a new life. I was delighted with this choice, because, for me, it is a prophetic film, about emigration, since it tells the story of a young couple fascinated by the West. ■

Souleymane Cissé is the first African film-maker to have received an award at Cannes (in 1987) for his feature film, Yeelen. He is one of the great names of world cinema. Now, at 70, with some 30 films to his name, he is a member of the High-level Panel on peace and dialogue among cultures set up by UNESCO in 2010. The Panel's first meeting, on 18 February 2010, marked the launch of the International Year of the Rapprochement of Cultures, which comes to an end in March 2011.

Intangible cultural heritage

The *"Parachicos* in the traditional January feast of Chiapa de Corzo" (Mexico) were inscribed in 2010 on the Representative List of the Intangible Cultural Heritage of Humanity.

The word *Parachicos* refers to both the dances and the dancers in this traditional Great Feast, which takes place every year from 4 to 23 January. This celebration of music, dance, handicrafts, gastronomy, religious ceremonies and feasting embraces all spheres of local life, promoting mutual respect among communities, groups and individuals.

The dancers move throughout the city, each wearing a carved wooden mask with head-dress, *serape*, embroidered shawl and multicoloured ribbons. They are led by the Patron, who wears a severe mask and carries a guitar and whip, while playing a flute, accompanied by one or two drummers. As they dance, he intones praises to which the *Parachicos* respond with cheers.

The Convention for the Safeguarding of Intangible Cultural Heritage, was adopted at UNESCO in 2003, and came into force on 20 April 2006. It recognizes the importance of intangible cultural heritage, which resides not so much in the cultural manifestation itself as in the wealth of knowledge and skills that it passes down from generation to generation.

To date there are 213 elements on the Representative List of the Intangible Cultural Heritage of Humanity, while the List of Intangible Cultural Heritage in Need of Urgent Safeguarding, numbers 16.

Les guerres prenant naissance dans l'esprit des hommes, c'est dans l'esprit des hommes que doivent être élevées les défenses de la paix. Since wars begin in the minds of men, it is in the minds of men that the defences of peace must be constructed. Puesto que las guerras nacen en la mente de los hombres, es en la mente de los hombres donde deben erigirse los baluartes de la paz. **Мысли о войне возникают в умах людей, поэтому в сознании людей следует укоренять идею защиты мира.** **لما كانت الحروب تتولد في عقول البشر، ففي عقولهم يجب أن تبنى حصون السلام** **战争起源于人之思想，故务需于人之思想中筑起保卫和平之屏障.** Les guerres prenant naissance dans l'esprit des hommes, c'est dans l'esprit des hommes que doivent être élevées les défenses de la paix. Since wars begin in the minds of men, it is in the minds of men that

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和平

65

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