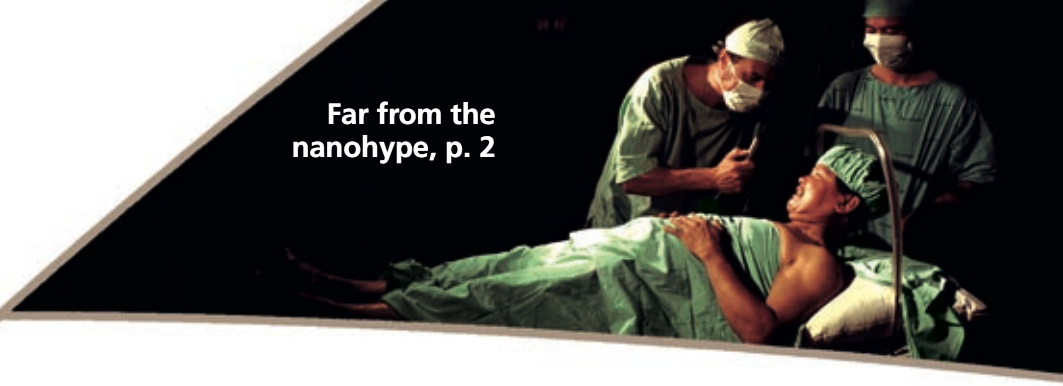
United Nations
Educational, Scientific and
Cultural Organization



A World of SCIENCE

Natural Sciences
Quarterly Newsletter

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IN THIS ISSUE

EDITORIAL

The glass ceiling

A decade ago, UNESCO launched a programme for Women, Science and Technology. Some might be tempted to consider such a programme of secondary importance, in light of such momentous problems as extreme poverty, pandemics, climate change and so on. At a time when the planet is fighting for its survival, does UNESCO have nothing better to do than set up prizes and fellowships for women and promote science education for girls?

Let's examine the situation for a moment. The latest data published by the UNESCO Institute for Statistics, reproduced in this issue, reveal that science and technology are still dominated by men. Women represent just one-quarter of the world's researchers, roughly 10% of university professors and fewer than 5% of members of Academies of Sciences. As for Nobel Prize laureates in science, fewer than 3% have been women.

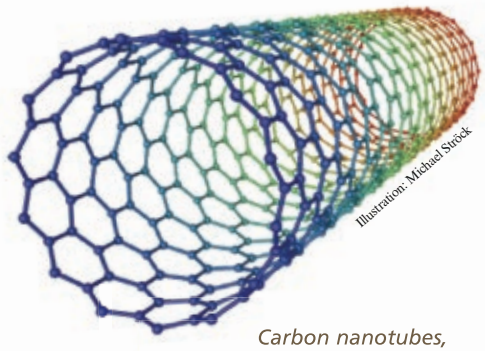
It is true that the life sciences often attract more women than men but, even here, women soon strike a `glass ceiling´ when they try climbing the career ladder. 'Our male colleagues do not readily accept women', regrets Professor Ameenah Gurib-Fakim, one of this year's five L'ORÉAL–UNESCO laureates. 'For a woman to make it, her portfolio has to be ten times heavier than that of her male counterpart.'

Even in countries which have achieved gender parity, such as Argentina, Thailand or Kazakhstan, the glass ceiling remains a common fixture. Yet, like any new population, the influx of women into the profession is slowly but surely changing the face of research. Women are bringing fresh approaches and points of view which can only nurture progress. They are beginning to influence the science agenda, thanks to a growing presence on scientific boards. They are adding value to innovation, not least because they bring 'insider information' on the needs and aspirations of the female consumer to the development of products and services.

The glass ceiling won't shatter overnight. But I am proud to think that UNESCO's partnership with L'ORÉAL, which has already distinguished 350 women scientists around the world in its first nine years of existence, will have helped to put a few chinks in it.

W. Erdelen
Assistant Director-General for Natural Sciences

Far from the **nanohype**



Carbon nanotubes, like this one 'grown' in the laboratory, are approximately 50 000 times smaller in diameter than a human hair but can be several millimetres long. These cylindrical carbon molecules are not only remarkably strong and lightweight but also efficient conductors of heat. These properties make them ideal for reinforced composites and nanoelectromechanical systems. One field of research being explored is that of constructing microspacecraft; carbon nanotubes could also conceivably be used to heat aeroplane wings to keep ice from forming on them.

More than four billion dollars has been spent in recent years on a technology that remains largely hypothetical. 'We stand on the threshold of a new era, that of nanofabrication, where systems and devices will be built in the laboratory atom by atom', remarked Belita Koiller on accepting her L'ORÉAL–UNESCO For Women in Science award in 2005. As we do not yet know how to assemble atoms in practice, much of research and development (R&D) on nanotechnology remains theoretical, via computer modelling and the study of quantum theories. For all their exciting possibilities, nanomachines, nanorobots and the like still remain a promise of things to come for the most part.

Nanotechnology may still be work in progress but it is already raising some important ethical questions. It is also fueling an emotive debate between nanophiliacs and nanophobics. Which of the public's fears are justified and which are unfounded?

Next October, 192 countries will examine *Nanotechnologies and Ethics: Policies and Actions* at UNESCO's General Conference. Prepared by the World Commission on the Ethics of Science and Technology (COMEST) and UNESCO's Ethics of Science and Technology Programme after a wide consultation, the report will outline strategies for regulating the development of nanotechnology around the world to maximize the benefits and minimize the risks of this new technology, far from the 'nanohype' which has taken hold of the debate.

As with any new technology, nanotechnology raises ethical concerns, some of which are common to other technological fields and others more specific. There is currently little public knowledge of this rapidly expanding technology, even if, on the international scene, the debate is raging. Some voices are already predicting uncertain repercussions from the use of this technology and calling for a moratorium on nanotechnology R&D or even a ban. At the other end of the spectrum, nanotechnology is being presented as a panacea to all ills. The truth lies somewhere in-between.

Hospital ward in France. One day, we could see nanomachine-assisted surgery, molecular repair of the human body, the destruction of malignant cells and even the extension of human life

Nanotechnology is developing much faster than the ethical, legal and social debate it has whipped up. Scientists, engineers, and policy-makers need to take the time to confront the ethical and societal implications of both nanoscience and nanotechnology, if they are to avoid running into the kind of difficulties that have hindered other emerging technologies like plant biotechnology.

What is nanotechnology?

The question is not as straightforward as it sounds. Strong controversy surrounds the definition of nanotechnology, since it is not just a technical issue but also a political and ethical one. The simplest definition is that nanotechnology is a general term applied to research and engineering conducted at the nanoscale, in other words at the atomic/molecular level of matter. A nanometre (nm) is one-billionth of a metre or the size of ten hydrogen atoms side by side. Since a single human hair is around 20 000 nm in diameter, objects measured in a few hundred nanometres are invisible to the human eye or even to microscopes that use visible light. That is why new optical technologies like the scanning tunnelling microscope and the atomic force microscope are so important to research in this field.

The applications foreseen in nanotechnology are as ample as those in medicine, environmental management,

manufacturing processes, intelligence and defense, transport and space technology, and telecommunications. Nanotechnology provides innovative tools to work on the molecular level designing and manufacturing nanostructures and nanodevices and assembling them economically into a working system with innovative functional abilities. The term 'nanotechnology' is often reserved for inorganic materials, although combinations with organic molecules are feasible – giving rise to the so-called converging technologies[1] – and can be the source of many potential risks and ethical problems.

A not-so-new technology

Even the birthday of nanotechnology has been the subject of controversy. A consensual idea assigns paternity to Richard Feynman, who described the visionary possibilities of nanotechnology as far back as 1959 in his paper on *Plenty of Room at the Bottom*.

In fact, we owe the word 'nanotechnology' to Japanese scientist Norio Taniguchi, who coined the term in 1974 to describe engineering on a scale smaller than one micrometre (one-millionth of a metre).

The idea would only capture popular imagination in 1986 with Eric Drexler's futuristic book, *Engines of Creation*. Drexler coined the term 'grey-goo' in his novel, in reference to a hypothetical end-of-the-world scenario resulting from an accidental mutation, in which out-of-control self-replicating nanorobots consume all living matter on Earth. The term 'grey-goo' is still used today, if usually in a science fiction context.

Another milestone was the invention in 1981 of the scanning tunnelling microscope by Gerd Binnig and Heinrich Rohrer from International Business Machines' (IBM) Research Laboratory in Zurich (Switzerland), a feat which earned them the 1986 Nobel Prize in Physics. The discovery of carbon nanotubes in 1991 by Sumio Iijima of the NEC Corporation (formerly the Nippon Electric Company) was of no lesser importance.

The next quantum leap would be made by US President Bill Clinton, who announced the National Nanotechnology Initiative in 2000. This would be followed by Japanese and European policies in the same field.

A conventional tennis racquet. Engineers at the Fraunhofer Technology Development Group (TEG) in Germany have come up with a tennis racquet with carbon nanotube inserts that is exceptionally stress-resistant and shock-absorbent. According to Physorg.com (2006), Fraunhofer TEG has also developed a method of processing its tennis racquet on an industrial scale. This is quite an accomplishment, since, as Physorg.com observes, if 'it is no longer difficult to manufacture nanotubes as a raw material, there are still hardly any finished products, for the material has a serious drawback: carbon nanotubes do not bind readily with other materials and stubbornly resist incorporation in the majority of production processes'

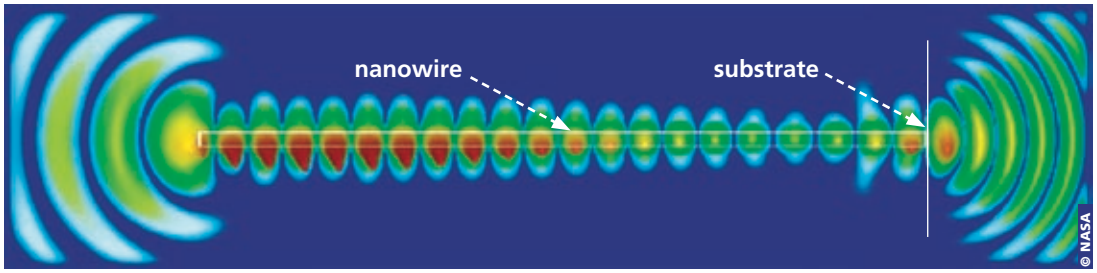
Is nanotechnology already part of our lives?

Nanotechnology may be still in its infancy in terms of applications but its vast potential has made it one of the most promising areas of research, along with biotechnology and information and communication technologies (ICTs).

There are obviously potential benefits for manufacturing of being able to fabricate tiny components – you only need to think back to how the invention of the microchip cleared the way for transistor radios and home computers.

Nanotechnology applications in manufacturing and in areas in which materials are currently being produced remains somewhat speculative for the time being because, although atoms can now be seen and manipulated, they cannot yet be assembled in practice. Among the possibilities currently being explored are precision manufacturing, material reuse, miniaturization and the benefits that the properties of carbon nanotubes offer for the development of light, strong and flexible materials that could be used for instance in spacecraft, safer vehicles for road and rail, or earthquake-proof buildings. Carbon nanotubes could also minimize the production of unwanted or toxic by-products and recycle existing waste; they could also create new biodegradable materials and pesticides.

Improved manufacturing would also reduce the cost of solar cells and energy storage systems, cutting demand for coal and petroleum and in turn reducing pollution.



The complex interaction between light and nanometer structures like wires has possibilities for new technology in the form of devices and sensors. NASA researchers are studying light emission from a semiconductor nanowire which functions as a laser. Lasers made from arrays of these wires have many potential applications in communications and sensing

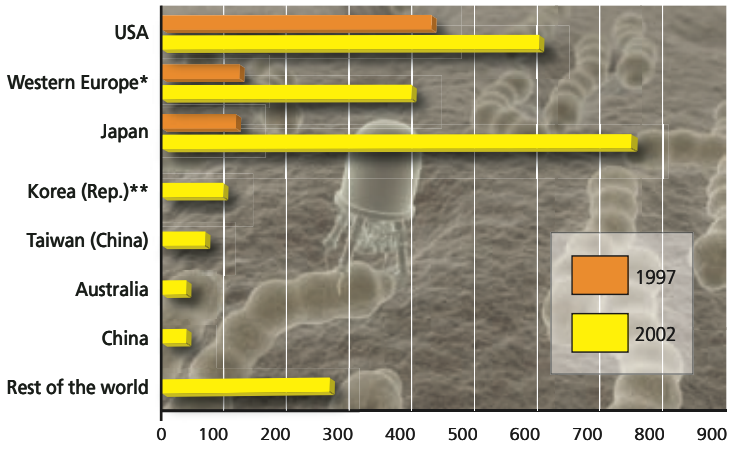
Some of the above applications would obviously also be beneficial for the environment by recycling waste, promoting greater energy efficiency and helping to reduce natural resources consumption. One could also envisage using nanomachines to clean up toxins or oil spills.

Examples abound of potential applications in the medical field. Nanotechnologies could contribute to the development of pharmaceuticals and to disease treatments. We could one day see nanomachine-assisted surgery, molecular repair of the human body, the accurate delivery of drugs, the destruction of malignant cells, the removal of bodily toxins and even the extension of human life. Nanoscale modifications to the surfaces of implants could improve implant durability through better bonding.

Tagged molecules could bind with diseased cells and tissues for early diagnosis and nanoscale delivery of contrast agents could be used in non-invasive diagnostic imaging. Laboratory samples could be screened at high speeds using nanotechnological devices that bind to certain genetic sequences to detect a vulnerability to certain diseases, for example. Scientists have already created a tiny vehicle capable of crossing from the blood stream into the brain to deliver tumour-destroying chemicals efficiently.[2]

If nanotechnology has potential applications in medical biology, it can also help develop ICTs. It is estimated that, by 2015, the miniaturization of the microprocessor will have reached its technical and economic limits. At this point, nanotechnology could allow us to go a step farther. Future transistors might be organic molecules or nanoscale inorganic structures. These would offer very high speeds, low-energy requirements and fewer side effects linked to the heating of materials. Some companies are already producing nanoscale layers on disk drives for higher density data storage and maufacturing affordable carbon nanotubes which could be used as conductors and microscopic probes.[3]

GLOBAL GROWTH IN NANOTECHNOLOGY R&D
in millions of dollars



Source: Mnyusiwalla, A., Daar A.S., & Singer, P.A. (2003). Mind the gap: science and ethics in nanotechnology. *Nanotechnology*. 14 Feb.

**assessment varies between US$350 and US$400 million*
*** per year for 10 years*

Another wedge in the North–South divide?

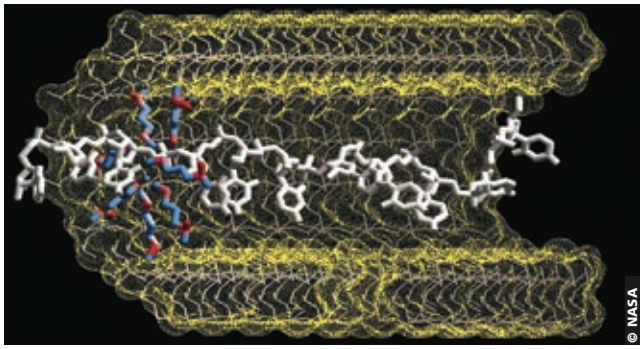
The growth of nanotechnology in the past decade has been intense. By 2003, there were about 500 nanotechnology companies. Research in this field occupied nearly 300 university departments and represented about US$4 billion in investment terms in the USA, Japan and Europe. Global investment in nanotechnology R&D has gone through the ceiling in recent years, even if the number of leading players is restricted to a handful of big spenders.

What about the developing countries? What will nanotechnology do for them? R&D are intertwined with trade in such a way that technological advances frequently exacerbate rather than alleviate global inequalities.

It is crucial to distinguish the different level and nature of risks and benefits between developing and developed countries. Some of these discrepancies include the shift in the existing commodity markets due to the production of new nanomaterials, unexpected exposure to low cost industrial scale products, poor technology transfer and inadequate access to high priced intellectual property.

One could envisage using nanomachines to clean up oil spills like this one in the historic Lebanese port of Byblos last August, after an Israeli bombardment of the Jiyeh power plant during the brief Israeli–Hezbollah war damaged the plant's fuel tanks

The development of new materials could have a strong impact in developing countries whose economies are based on trade in natural resources and minerals. An important shift in the markets for world resources can be expected, since the new nanoproducts will be largely manufactured in developed countries while most of the world's mineral resources are found in developing countries, such as tungsten (China), platinum and gold (southern Africa), aluminium (China, Brazil) and copper (Chile).



Applied voltage draws a DNA strand and the surrounding ionic solution through a pore of nanometer dimensions. By measuring the differences in ion current, scientists can detect the sequence of DNA units. Solid-state nanopores like those pictured here offer a better temporal control of the translocation of DNA and a more robust template for nanoengineering than biological ion channels. The chemistry of solid-state nanopores can be more easily tuned to increase the signal resolution. These advantages will result in real-time genome sequencing. Source: NASA

Some developing countries have flared the danger and are already investing heavily in R&D, such as China, India and Brazil. China's government has announced investments of some US$240 million in nanoscience and nanotechnology between 2003 and 2007. Brazil is investing more than US$25 million between 2004 and 2007, and India US$23 million between 2004 and 2009.[4] Other developing countries such as South Africa, Argentina, Chile and Mexico are also initiating national programmes.

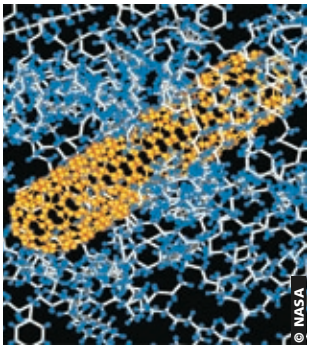
The current pattern is for developing countries to be frequently treated as secondary technology markets for applications designed and built for developed economies. There is a clear need for international policies related to R&D which would enable developing countries to participate fully as real partners, as opposed to simply potential markets. This is even clearer if we take into account nanoscale research addressing the requirements of developing countries, such as in water treatment, energy and agriculture.

Avoiding a public backlash

Conscious of the public resistance to genetically modified foods and of widespread suspicion about other new developments in science, such as cloning and genetic engineering, many governments have chosen to launch independent studies and policies on the benefits and risks of nanotechnology.

In the UK, the Royal Society and the Royal Academy of Engineering have been asked to consider how such a rapidly developing field as nanotechnology should be regulated.

In the USA, the 21st Century Nanotechnology Research and Development Act was signed in December 2004. It established a White House National Nanotechnology Program office authorizing nearly $3.7 billion in spending over four years, effective immediately. The programme also creates a nanotechnology 'preparedness center' to evaluate ethical issues and other issues related to the workforce.



A polymer–carbon nanotube composite. A polymer is a naturally occurring or synthetic molecular compound consisting of large molecules made from a series of linked subunits of molecules. Plastics, adhesives and lubricants are all polymers

In June 2005, the European Commission adopted an Action Plan for 2005–2009 defining actions for the 'immediate implementation of a safe, integrated and responsible strategy for nanosciences and nanotechnologies.'

What is there to be worried about?

The public has no qualms about supporting and encouraging safe medical advances to reduce human physical suffering. The unexpected and uncontrollable effects of such applications do however raise some ethical concerns.

A more controversial aspect of nanotechnology concerns the interface between inorganic molecular engineering and biology. In future, nanodevices could be a combination of biological and physical artefacts, or could interact with biological molecules and genes in unnatural ways. What will the ethical implications be of implantable nanochips in the human body, for instance? How can we make sure that accidents do not create

Examples of potential metal substitutions by nanotechnologies

Nanotechnology	*Metal*
Carbon nanotubes	substitute for high-conducting metals (copper, silver, gold)
Organic semiconductors	substitute for semiconductor elements (gallium, germanium, indium, cadmium, selenium, arsenic, antimony)
Nanostructured ceramics	substitute for tungsten
New catalysts	substitute for precious metal catalysts (platinum, rhenium, rhodium)

Source: Schummer, J. (2005), Identifying Ethical Issues amidst the Nano Hype. In: *Report of the first meeting of the Nanotechnology and Ethics Expert Group*: www.unesco.org/shs/est

What will the ethical implications be of implantable nanochips in the human body? Could these engineered devices interact with genes in unnatural ways?

germ-lines propagating genetic damage, or new virus strains? Nanotechnology may also accelerate existing frontline medical technology, such as gene therapy, that is already controversial from an ethical perspective.

Another impressive possibility of nanotechnology is the use of DNA as computer material. This proposal obviously raises uncomfortable moral questions. Is it ethical to use a basic component of life for the production of an electronic commodity? Are these novel cell–machine interactions acceptable?

Some experts consider that public hype, an unclear definition and the early state of nanotechnology development cloud the ethical issue.[5] Nanohype based on science-fiction, such as the 'grey-goo' scenario, induces misinformation and creates unjustified hopes and fears, disguising political and technical issues of science governance and distracting public perception from these issues.

While some say that a more realistic danger lies in the unknown effects of manipulating molecules at the atomic level, others, based on the scientific fact that the constraints of physics and chemistry are too severe, doubt the thesis of nanotechnological visionaries that nature can be constructed atom by atom.[6]

The questions we should be asking

The real questions we should be asking are what kind of nanoscience and nanotechnology do we need? How should we decide on science policy issues and to whom should the decision fall?

At this early stage in the development of nanotechnology, we cannot yet determine a clear scenario of potential damage. We do not know for instance the level of toxicity of nanoparticles, nor whether these could permeate biological membranes and cause serious damage.

A more technical problem in this regard relates to the lack of international standards and regulations. The fact that we do not even yet know how to measure and classify the toxicity of nanotechnology makes it hard to regulate in this domain. The disposal of nanotechnology waste raises another important environmental concern.

One particular ethical worry about nano-engineered devices concerns the application of ICTs in the military and in intelligence systems. It is impossible for the time being to know whether there are any new radical applications for human enhancement envisaged for military purposes but such a scheme could potentially imply not only environmental pollution and health hazards but also represent a threat to human dignity.

Besides the miniaturization of weapons and explosives (*see table*), other uses of nanotechnology like electronic surveillance monitoring and tracking raise issues of privacy and important civil rights concerns. It is perhaps due to the veil of secrecy that always surrounds R&D of a sensitive nature that only incremental improvement and miniaturization of computing and monitoring devices are detectable at this point.

Where does UNESCO come in?

People would be hard-pressed to deny the potential benefits of nanotechnology. As for putting a stop to R&D in this area, that is not an option. The genie is out of the bottle; nanotechnology has already begun to permeate many fields of research and innovation, as we have seen above.

Examples of potential hazards related to hypothetical military use of nanotechnology

Artificial blood cells that enhance human performance could cause the body to overheat and induce bio-breakdowns; their excretion could add to the environmental load.
Large quantities of smart weapons, especially miniaturized robotic weapons and intelligent, target-seeking ammunition could cause unexpected injury to combatants and civilians, destroy infrastructure and pollute the environment if not equipped with reliable remote off-switches.
Small receptor-enhancers designed to increase alertness and reduce the reaction times of humans could cause addiction and subsequent Chronic Fatigue Syndrome, leading to weakness, neural damage and death.

Source: http://crnano.typepad.com/crnblog/2005/03/military_uses_o.html

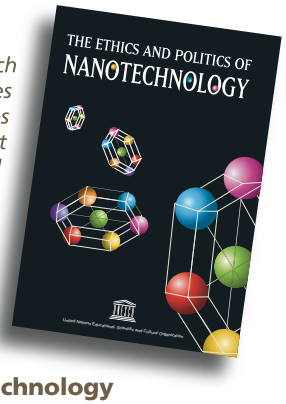
Countries are aware that there is no turning back but they want to have all the facts in hand when it comes to making decisions about nanotechnology. In 1998, they invited UNESCO to launch an Ethics of Science and Technology Programme, which gave rise to COMEST. This decision followed the establishment five years previously of UNESCO's Bioethics Programme.

As one of UNESCO's advisory bodies, COMEST undertakes studies to anticipate questions of ethical concern. It is tasked with formulating, on a scientific basis, ethical principles that can shed light on the various choices occasioned by progress in scientific and technological fields and the impact of this progress. The Commission functions as an intellectual forum for the exchange of ideas and experience, and the detection of early signs of risk. COMEST also fosters a constructive ethical dialogue on values and provides decision-makers with informed counsel.

The Commission is made up of 18 prominent, independent personalities and 11 ex-officio members from various scientific and humanistic disciplines who also represent different regions of the world. COMEST is currently working in several domains: the teaching of ethics, the ethics of environment and the ethics of new and emerging technologies – such as those pertaining to outer space and nanotechnology –, as well as the ethical and social responsibility of scientists.

In 2005, COMEST established a multidisciplinary *ad hoc* group on ethics and nanotechnology. This expert group adopted a two-step strategy: a first phase involving the preparation of a state-of-the-art study on ethics and nanotechnology, followed by a draft policy document indicating the kind of international regulatory action nanotechnology demands. The result, *Nanotechnologies and Ethics,* identifies a need for ethics education, R&D policies and awareness-raising. The document was approved by COMEST at its meeting in Dakar (Senegal) in December 2006. It is the first substantial proposal for global guidance in the field of nanotechnology ever produced. The next step will be to invite representatives of the various sciences involved in the development and application of nanotechnologies to judge the relevance of the strategies and options it proposes. Consultations will follow with major stakeholders as to the political feasibility of the strategies identified in the two previous phases. On the basis of this consultation process, UNESCO will prepare a document for the approval of Member States in October this year.

As a second outcome of this period of reflection, the papers prepared by the *ad hoc* expert group will be published in May, in a book entitled *Nanotechnologies, Ethics and Politics* in the UNESCO series on the Ethics of Science and Technology. The book will appear in Arabic, Chinese, English, French, Russian and Spanish.



In 2006, UNESCO published this outreach booklet to raise awareness of the ethical issues surrounding nanotechnology. The booklet describes nanotechnology and its likely future development in terms of research, potential applications and the vast range of products that it supports now and could support in the future. The booklet also presents some of the ethical, legal and political issues which the international community will have to face in the near future: http://unesdoc.unesco.org/images/0014/001459/145951e.pdf

Society will shape the future of nanotechnology

There are many international initiatives to generate a timely public debate that is both informed and interdisciplinary. A sense of optimism prevails that these public debates will preserve, or even restore, trust in science and technology.

To a large extent, it is the failure to hold this debate which has sparked the criticism and public defiance which other breakthroughs in science have encountered, such as genetically modified organisms and stem cell research. Both governments and the private sector should learn from this experience. The public perception of nanotechnology is of paramount importance. By anticipating the risks related to the development and application of nanotechnology and minimizing these, both governments and the private sector can reassure public opinion. By maximizing the societal benefits that can be expected from nanotechnology, both governments and the private sector can drum up public support for nanotechnology.

A battery of regulations, research, education, ethical reflection and appropriate policies are equally necessary in other fields of science and technology of course but they are particularly relevant for nanotechnology. Ensuring the inclusion of an adequate representation of societal forces – those which will ultimately shape the future of nanotechnology – is thus a must.

Simone Scholze[7]

For details: www.unesco.org/shs/est; h.tenhave@unesco.org

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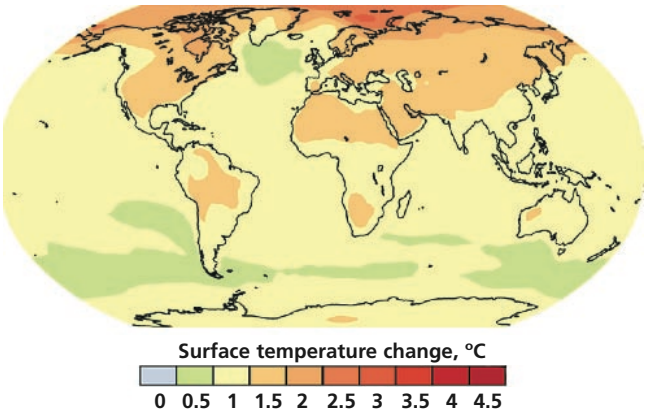
1. *The term 'converging technologies' also goes by the name of NBIC, which stands for the integration of nanotechnology, biotechnology, information technology and cognitive science*
2. *See Fritz, S. (2002)* Understanding Nanotechnology
3. *Idem.*
4. *See Hassan, M. H. A. (2005) Nanotechnology: Small Things and Big Changes in the Developing World.* Science, *vol. 309. no. 5731, pp. 65–66.*
5. *Report of the second meeting of the Nanotechnology and Ethics Expert Group: www.unesco.org/shs/est*
6. *See Schmidt, J. C. (2004) Unbounded Technologies: Working through the Technological Reductionism of Nanotechnology. In: D. Baird, A. Nordmann & J. Schummer (eds.)* Discovering the Nanoscale, *Amsterdam. IOS Press*
7. *Acting Chief of UNESCO's Section on the Ethics of Science and Technology from March 2003 to December 2006*

A global warming on **global warming**

The much-awaited Summary for Policymakers on the physical science basis for climate change was unveiled by the Intergovernmental Panel on Climate Change (IPCC) at UNESCO in Paris on 2 February to a media-packed room.



Source: © IPCC 2007: Working Group I-AR4

Seen here is the projected rise in global temperatures to 2020–2029 for the IPCC's middle-of-the road scenario A1B (2.8°C temp. rise, CO_2 concentration of 850 ppm). Under this scenario, the world pursues rapid economic growth, global population peaks mid-century before declining, new and more efficient technologies are rapidly introduced and there is a balance across all sources of energy (fossil and non-fossil). The highest scenario (4°C temp. rise, CO_2 of 1550 ppm) is identical to A1B except in that it is fossil-fuel intensive. Were concentrations of CO_2 to be held constant at 2000 levels, global warming to 2100 would be limited to 0.6°C

Written by more than 600 scientists and endorsed by the world's governments, the report dissipates any residual doubts about the reality of global warming or the fact that humans are largely responsible for it. Thanks to a growing body of scientific evidence, it is able to confirm the clear trends identified in the previous assessment (2001) and incorporate new findings to achieve an unprecedented level of confidence. 'Warming of the climate system is unequivocal,' it states, predicting that global mean temperatures will rise by 1.8°–4.0°C this century, depending on which of six socio-economic scenarios play out (*see figure*).

'Anyone who would continue to risk inaction on the basis of the evidence presented here,' declared UNEP Executive Director Achim Steiner at the unveiling, 'will one day be considered irresponsible by the history books.'

The report reveals a concentration of carbon dioxide (CO_2) in the atmosphere of 379 molecules per million molecules of dry air (ppm) in 2005. This level 'exceeds by far the natural range over the last 650 000 years (180–300 ppm) as determined by ice cores.' The last time the polar regions were significantly warmer than now for an extended period was about 125 000 years ago, when reductions in polar ice volume led to 4–6 m of sea-level rise. Ice core data indicate that average polar temperatures at the time were 3–5°C higher than today.[8]

Global warming 125 000 years ago was caused by eccentricities in the Earth's orbit around the sun, leading to solar heating of the northern hemisphere in summer that was 10% higher than today. Today's global warming is being caused by a shift in the Earth's energy balance. The main agents of this shift are greenhouse gases, which have a warming effect on the climate system, and aerosols, which have a cooling effect.

Thanks to more comprehensive *in situ* and satellite observations, which have helped to refine a broader range of models, scientists now have a better understanding than six years ago of how changes in the atmospheric concentration of each factor alter the Earth's energy balance (expressed as radiative forcing). Data show that the warming effect of human-driven greenhouse gases (primarily CO_2, nitrous oxide and methane, but also tropospheric ozone and halocarbons) today far exceeds the cooling effect of human contributions to aerosols (generated primarily through burning fossil fuels and biomass) or changes in the amount of sunlight reflected back into space from human changes to land surfaces, such as deforestation or pavement-laying.

A better understanding of natural aerosols helps to explain interdecadal fluctuations in temperature in past centuries. Thus, 'a significant fraction of the reconstructed interdecadal temperature variability over at least the seven centuries prior to 1950 is very likely attributable to volcanic eruptions and changes in solar radiation,' both natural aerosols.

For the next two decades, global warming of about 0.2°C per decade is projected, no matter which socio-economic scenario is followed. The extent to which global surface temperatures rise this century will depend largely on the effectiveness of measures taken to cut back emissions of human-driven greenhouse gases from fossil fuel burning, land-use changes like deforestation and agriculture. There is definite urgency: the radiative forcing of CO_2 in the atmosphere increased by 20% between 1995 and 2005.

Observations since 1961 show that the oceans have been absorbing more than 80% of the heat added to the climate system, causing seawater to expand. This thermal expansion was responsible for about half the estimated 17 cm of sea-level rise last century, the other sources being melt from glaciers, ice caps and ice sheets. The report predicts sea-level rise of up to 60 cm by the end of the 21st century, a prediction which excludes possible changes in the dynamic ice flows in Greenland and Antarctica, judged too uncertain to quantify.

Among other changes we can expect to see this century are shrinking snow cover and sea ice, and thawing permafrost. Warmer oceans will inject a greater amount of water vapour into the atmosphere which the warmer air will be able to hold, fueling intense tropical cyclones and cloud formation. Wind and storm patterns will change and there will be greater episodes of heavy rainfall. High latitudes will become wetter and subtropical regions drier. Days will become warmer and there will be fewer cold days and nights over most land areas. Warm spells, droughts and heat waves will become more frequent.

Already feeling the effects of a substantial increase in precipitation over the past century are eastern parts of North and Latin America, northern Europe and northern and central Asia. Drying has been observed in the Sahel, Mediterranean, southern Africa and parts of southern Asia.

This first volume of the IPCC's Fourth Assessment Report will be followed by a second dealing with *Impacts, Adaptation and Vulnerability*, on 6 April in Brussels (Belgium). The third volume, on *Mitigation of Climate Change*, will be released in Bangkok (Thailand) on 4 May, followed by the *Synthesis Report* in Valencia (Spain) on 16 November. The IPCC is sponsored by UNEP and WMO.

Read the report: www.ipcc.ch; and about UNESCO's 30 climate-related programmes: http://ioc3.unesco.org/unesco-climate/

8. *For the purposes of comparison, a drop in mean global temperatures of 4–5°C would plunge the Earth into a new Ice Age*

ESA and UNESCO to map Mesoamerica's **biological corridor**

Code-named 'Diversity,' a new project coordinated by the European Space Agency (ESA) and UNESCO plans to use remote sensing to strengthen conservation efforts in Mesoamerica.

The project kicked off at a meeting in Frascati (Italy) from 11 to 15 December to define user requirements in the subregion with the help of the Comisión Centroamericana de Ambiente y Desarrollo and the users themselves.

The Mesoamerican Corridor comprises all countries from southern Mexico to northern Panama: Mexico, Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua and Panama. The area hosts a large number of natural and cultural world heritage sites and biosphere reserves.

The two-year Diversity project will monitor protected land areas and changes to these with the help of satellite-derived cartography to evaluate which parts could be linked up to extend the Mesoamerican Biological Corridor. This corridor would respect the migration patterns of endangered species like the jaguar and harpy eagle, which currently live in ecosystems threatened mainly by changes in land use.

During an initial phase to June 2007, large-scale maps will be produced of five selected world heritage sites and biosphere reserves in Mesoamerica. These will include mangrove maps to assess the state of conservation of mangrove forests. Conservation authorities have also suggested selecting areas for use in assessing sources of marine pollution on land.

One unique aspect will be the identification, assessment and definition of a marine corridor between the four world heritage sites of Malpelo, Coiba, Isla de Cocos and Galapagos. The latter is also a biosphere reserve. Models will be derived from satellite imagery to analyse sea surface temperature, water quality, surface currents and other oceanographic conditions of the marine biological corridor. In addition, the health of coral reefs and the quality of ocean water surrounding the reefs will be monitored.

The project will also study the migration patterns of marine species like leatherback sea turtles and hammerhead sharks between the Galapagos and Cocos Islands.

The project will contribute to implementation of the UN Convention on Biodiversity, in which the State Parties vow to 'achieve by 2010 a significant reduction of the current rate of biodiversity loss at the global, regional and national levels as a contribution to poverty alleviation and to the benefit of all life on Earth.' Using various remote sensing technologies and data drawn from space, aerial photography and ground digital images, in coordination with fieldwork, UNESCO will derive biodiversity indicators to determine whether progress is being made towards the Convention's goals.

ESA's contribution of US$250,000 is being distributed directly to the selected consortium of European subcontractors: GeoVille, the Austrian company team leader, responsible for projects on land; France's Collecte Localisation Satellites, specialized in oceanography; Norway's Nansen Environmental and Remote Sensing Centre, responsible for the water-quality component; and the University of Exeter in the UK, specialized in coral reefs.

UNESCO end-users will be the consortium's main beneficiaries. They are represented by Mesoamerica's conservation authorities, themselves supported by NGOs like MarViva which are deeply implicated in local and regional conservation.

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*The isolated Galapagos Islands in the East Pacific Ocean lie 1000 km from Ecuador's mainland. They are known for their wealth of endemic species, like this land iguana measuring 1.2 m in length on average. Both species of land iguana (*Conolophus subcristatus *and* C. pallidus*) are endangered, owing to the introduction of invasive species like pigs and goats which have eaten the undergrowth that used to shield young lizards from birds of prey. Conservation efforts include breeding* C. subcristatus *in captivity and eradicating or controlling invasive species*

A **robot camp** for kids

Dr Sato showing a group of children how to programme a robot's performance on a computer then download the programme from the computer to the robot using a USB cable

Twenty-nine children aged 12–15 years from Malaysia, Japan and Brunei Darussalam spent a week together from 11 to 17 December making robots. They were attending a camp at the University of Brunei Darussalam organized jointly by the Ministry of Education and UNESCO's Regional Bureau for Science in Jakarta (Indonesia).

The aim of the camp was to encourage a "hands-on" (or active learning) approach to teaching science, while showing that science can be exciting and fun.

The original robot kit was designed and developed by Dr Jin Sato and his venture company JS-Robotics which co-sponsored the camp. JS-Robotics has been collaborating with Japan's National Institute of Advanced Industrial Science and Technology to develop small humanoid-type robots. It was Dr Sato who opted to provide 'cutting-edge technology' for the camp in preference to simpler models. The research scientist wished to expose the children to an exciting technology that would leave a long-lasting impression on them. Other sponsorship came from Brunei Shell Petroleum, Royal Brunei Airlines and Japanese Funds-in-Trust.

At the start of camp, the pupils were given lectures on basic robotics, mechanics and computer programming. They were also shown how to use the university's physics laboratories and library for research on the camp theme of science and technology for sustainable development.

After the lectures, the children were divided into five groups of mixed nationalities to begin making robots of their own. About 20 volunteer students were on hand to help from the host university, the Institute of Technology Brunei, Tokyo Institute of Technology and Keio University, along with staff from Japan's Center for Robotics Education for Future Science (CREFUS), who had assisted the Ministry of Education's Science, Technology and Environment Partnership Center (STEP) in designing the camp curriculum. On the last day, the five groups presented their research and their performing robots.

Brunei Darussalam joined UNESCO in March 2005. At the time, the Ministries of Development and Education expressed grave concern at the country's shortage of technical personnel, which severely limits its capacity to explore new technologies. This concern resurfaced in UNESCO's Science and Technology Policy Review of Brunei Darussalam later the same year. Brunei has just one university, with 4917 students in 2004 (15% of youth aged 18–25), less than 10% of whom were enrolled in science (300) and engineering (170) fields.

Two girls with their near-complete robot. Each robot consists of multiple identical modules, enabling the children to make different types of robot using a variety of combinations

'In developing countries, applied science and engineering are usually studied less than theoretical sciences,' explains Masami Nakata from UNESCO's Jakarta office, 'because learning theory does not require costly laboratory equipment. The lack of hands-on science education seems to be one factor accelerating the diminishing interest in science and technology in Asia, causing university rolls to drop in these fields.'

UNESCO's Jakarta office is planning a second robot camp, possibly in Cambodia in collaboration with the Ministry of Education, Youth and Sports and UNESCO's Phnom Penh office. Thailand, Indonesia, the Republic of Korea and Singapore have already expressed interest in participating. UNESCO is seeking collaborators, volunteers, sponsors and robot-kit developers to help organize the camp.

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World water programme to **move to Italy**

The secretariat of the UN-wide World Water Assessment Programme is to move from UNESCO headquarters in Paris to offices near the Italian town of Perugia.

The agreement was signed on 2 February by UNESCO Director-General Koïchiro Matsuura and the Italian Minister for the Environment, Land and Sea, Alfonso Pecoraro Scanio.

Since its inception in 2000, the World Water Assessment Programme has been hosted by UNESCO and funded via Japanse Funds in Trust essentially, although Denmark, Spain and the UK among others have also made contributions.

The February agreement makes provisions for an annual envelope of 2.5 million euros in funds-in-trust for three years and for the transfer of the programme secretariat to Perugia. The agreement will be followed by others, notably with the government of the Umbria Region which has offered to provide premises for the new office.

The new premises will be fully operational within a few months' time to allow the Programme's secretariat to produce the third World Water Development Report, due for release at the Fifth World Water Forum in March 2009 in Istanbul (Turkey). Published every three years by 24 UN agencies, the report represents the most comprehensive evaluation available of the planet's water resources.

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Palestinians gain Chair in **maths and physics**

An agreement was signed on 1 December by Marcio Barbosa, Deputy Director-General of UNESCO, and Nabeel Kassis, President of Birzeit University, for a UNESCO Chair in Mathematics and Theoretical Physics at the Palestinian university. Chairholder Henry Jaqaman will be taking up his post in September. He is currently Professor of Physics at Bethlehem University.

The Chair will promote an integrated system of research, training, information and documentation in mathematics and theoretical physics. It will facilitate collaboration between high-level, internationally recognized researchers and teaching staff of Birzeit University and other institutions in the Palestinian Territories, the Arab States, Europe and elsewhere to enhance the quality of research at Palestinian universities.

In addition to broadening Birzeit University's existing programme in mathematics and theoretical physics, the Chair will provide grants, run workshops and conferences, invite international scholars for lectures and build up a first-rate library with computer facilities. It will also develop research materials and methodologies for secondary education.

High-level training and research in mathematics and theoretical physics is mandatory for modern, technologically oriented societies, and especially crucial in a region that cannot rely on natural resources for its development. The Chair will have a long-lasting effect, as students will be trained in strategic areas of today's and tomorrow's technology-based job markets.

The Chair is a first step towards establishing a centre of excellence in mathematics and theoretical physics at Birzeit University. This project is the brainchild of Professors Ulrich Eckern and Bernd Aulbach from Augsburg University (Germany) and Saber Elaydi from Trinity University in Texas (USA), who in 2003 contacted scientists worldwide, rapidly garnering support for the scheme. Encouraged by UNESCO, a core group of supporting institutions – Birzeit University, University of Augsburg, Trinity University, University of Paris-Sud 11 and the Palestinian/ European Academic Cooperation in Education (PEACE) Network – submitted the proposal for a Chair in April 2006.

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World-famous quantum cosmologist Stephen Hawking expressed support for the Chair during his visit to Birzeit University on 13 December. He gave a lecture there on the Origins of the Universe which drew hundreds of faculty and students.

Africa commits to research

Heads of State meeting on 29–30 January at the African Union's annual summit in Addis Ababa (Ethiopia) have sworn to boost research spending and develop science education on the continent.

The year 2007 is designated a year for championing science, technology and innovation in Africa. It gets off to a flying start with the establishment of a Pan-African Intellectual Property Organization to protect endogenous innovation.

In the final Declaration on Science, Technology and Scientific Research for Development, the Heads of State vow to 'increase funding for national, regional and continental programmes for science and technology (S&T) and support the establishment of national and regional centres of excellence in S&T.'

Regional, South–South and North–South cooperation in S&T will be enhanced. To this end, the Summit backed a proposal by African foreign ministers to equip scientists with diplomatic passports to foster research collaboration by making it easier for them to move around the continent. The AU Commission will now consult individual countries on which scientists to target for the scheme.

Member States are 'strongly urged' to allocate at least 1% of GDP to research and development (R&D) by 2010, a target UNESCO Director-General Koïchiro Matsuura hailed as 'an important step' towards placing African countries in the driver's seat of their socio-economic development.

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Crops irrigated in Mali using a solar-powered pump. The Addis Ababa Summit launched the Green Wall for the Sahara Initiative, a proposal born on the margins of last December's Abuja Summit on Food Security to help over 20 African countries adapt to climate variability and change, arrest soil degradation, slow the advance of the desert frontier, reduce poverty, conserve biodiversity and increase both land productivity and food production

'Is this not too little too late?' challenged Rwandan president Paul Kagame in his own address. He announced that Rwanda would spend 1.6% of GDP on S&T in the current fiscal year and planned 'to increase it to 3% in the next five years.' Rwanda has begun implementing a national policy on science, technology and innovation, he said, that included the goal of increasing the number of science students in tertiary institutions to 70% of the student population.

Member States vowed to revitalize African universities and scientific research institutions so that 'they can play an effective role as loci of science, technology and engineering education and development and also contribute to public understanding of science and technology.' Member States were invited 'to pay special attention to the teaching of science and technology' and undertook to 'encourage more African youth to take up studies in science, technology and engineering.' In this spirit, the Summit approved a Mwalimu Julius Nyerere African Union Scholarship Scheme targeting 50 Bachelor students initially. An African Education Fund will finance the Plan of Action for 2006–2015 adopted by Ministers of Education in Maputo (Mozambique) last September.

'Concerned' that 27% of the African population is undernourished and 'determined to reduce the continent's annual expenditure of US$20 billion on agricultural imports,' governments reaffirmed their commitment in Addis Ababa to allocating at least 10% of national budgets to agriculture and endorsed the African Seed and Biotechnology Programme.

They also endorsed a 20-year Biotechnology Strategy backed by science ministers in Cairo (Egypt) last November. The Strategy is articulated around Pan-African cooperation hingeing on regional strengths: drug manufacture in North Africa, malaria and HIV/AIDS control in southern Africa, agricultural biotechnology in West Africa, livestock research technology in eastern Africa and biodiversity in central Africa.

One of the rare proposals not endorsed by leaders was that for an African Science Technology Fund. The Fund was originally mooted as a means of accelerating implementation of Africa's Science and Technology Consolidated Plan of Action to 2010. Wary that such a Fund might generate unnecessary administrative costs, the Summit decided to mandate an expert panel with more in-depth studies. One solution might be to entrust the Fund to the African Development Bank.

In the Declaration, Heads of State 'recognize the support in S&T by international organizations such as UNESCO' and 'call on UNESCO and other bilateral and multilateral organizations to support the Member States, regional economic communities and the African Union to implement the Summit decision on science and technology.'

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Read Science in Africa*: www.unesco.org/science*

US$30 million loan for **Mayan Biosphere Reserve**

The Inter-American Development Bank approved a US$30 million loan to Guatemala on 14 December for a six-year programme to promote conservation of the Mayan Biosphere Reserve.

Situated in Guatemala's northern-most department of El Petén, the 21 130-km^2 reserve covers 20% of the country's territory and is Central America's largest protected area. It sports a complex system of natural forests, magnificent archeological sites and a unique cultural heritage.

The reserve is coming under assault however from a proliferation of illegal settlements, deforestation, forest fires, oilfields, smuggling of rare woods, wildlife and archeological pieces; unsustainable farming, ranching and logging; and the extreme poverty of a large portion of El Petén's population.

Guatemala's Ministry of the Environment and Natural Resources will implement the new programme, which will counter an outdated model of conservation that largely excluded local stakeholders. The loan will help finance investments in El Petén's protected areas to strengthen participative conservation, as well as in buffer zones to generate alternative sources of income for the population. It will also support investments to improve environmental management and reduce pollution in the Lake Petén Itza watershed.

To promote El Petén as Guatemala's top tourism destination and generate economic alternatives to reduce the pressure of agricultural expansion on the reserve and protected areas in the south, the programme will finance the creation of five tourism circuits backed by the Guatemalan Tourism Institute, involving local communities, and will help to construct and equip museums and a school of community tourism, restore archeological sites and develop a road signage plan for highways and tourism circuits in El Petén.

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Mayan Temple in Tikal National Park, part of the Mayan Biosphere Reserve

Full-time seismic coverage for Europe's seas

Italy is to provide non-stop processing and coverage of seismic data in Europe and the seas around it. Seismic data are essential for detecting earthquakes that potentially generate tsunamis and could significantly boost protection of Europe's heavily developed coastlines, home to about 45 million people.

Italy made the announcement in Bonn (Germany), where delegations from 17 European and North-African coastal countries were meeting from 7 to 9 February to define the Euro-Med Tsunami Warning and Mitigation System (NEAMTWS). An initial detection system is expected to be ready by the end of 2007, with the full system – covering all coasts from the Black Sea to the Mediterranean and North-east Atlantic – available by 2011. The system will be based largely on existing national seismic and sea level monitoring activities which, although extensive, need to be integrated to function as an effective regional system.

The data will be provided by the Istituto Nazionale di Geofisica e Vulcanologia (INGV), one of Europe's largest research bodies in the field of geophysics, seismology and vulcanology. The INGV will thus serve as the system's first hub for immediate data delivery and dissemination. Similar facilities in Europe stand by to extend and intensify the coverage pending government commitments.

About a quarter of all observed tsunamis in the world occur in the Mediterranean Sea. 'The risk of tsunamis in this region might be relatively low,' acknowledges Peter Koltermann, who leads UNESCO's Tsunami Co-ordination Unit in Paris which organized the meeting, 'but if one occurred and we weren't prepared, the damage would be extensive.'

For details: http://ioc.unesco.org/iocweb/disasterMitigation.php

Half a million dollars for top women scientists

This year's laureates of the L'ORÉAL–UNESCO Awards For Women in Science were fêted at UNESCO in Paris on 22 February, where each received a cheque for US$100,000. The previous day, 15 promising young women working in the life sciences on each continent had been awarded research scholarships worth up to US$40,000 each.

The laureate for Africa, Prof. Ameenah Gurib–Fakim, is Professor of Organic Chemistry and Pro-Vice-Chancellor at the University of Mauritius. She made the first-ever full inventory of the medicinal and aromatic plants on Mauritius and neighbouring Rodriguez Island. Prof. Gurib-Fakim and her team have also studied a bitter melon (*Momordica charantia*) and other medicinal plants which act as starch blockers, slowing the release of free glucose into the bloodstream, for their potential in treating diabetes (mellitus). Prof. Gurib-Fakim is a founding member of the Association for African Medicinal Plants Standards, which aims to bring plant remedies that meet international norms to the world market.


Ameenah Gurib–Fakim

The laureate for Asia–Pacific, Prof. Margaret Brimble, is Chair of Organic and Medicinal Chemistry at the University of Auckland (New Zealand). She makes and modifies complex, rare bioactive compounds derived from plants, animal tissues, microbes or marine and salt organisms that exhibit antimicrobial, anticancer or antiviral activity. She has worked extensively on synthesizing shellfish toxins.


Margaret Brimble

The laureate for Europe, Prof. Tatiana Birshtein from the Institute of Macromolecular Compounds at the Russian Academy of Sciences, focuses on the statistical physics of polymers (*see p.5*). Her work has shed new light on the self-organizing properties of many remarkable polymeric systems. Among her contributions: the study of the degree to which macromolecules "stick" on surfaces and the ways in which their structures shift in response to their surrounding environments.


Tatiana Birshtein

The laureate for Latin America, Prof. Ligia Gargallo from the Department of Physical Chemistry at the Pontifical Catholic University of Chile, has set out to demonstrate that polymer behaviour in different states (solid, liquid and interface) is determined by the flexibility of the polymer chain and whether its component monomers (a series of repeating subunits) seek out or avoid water. A better understanding of the ways in which these subunits interact should help researchers to develop applications in technology, medicine and so on.


Ligia Gargallo

The laureate for North America, Prof. Mildred Dresselhaus, is Institute Professor of Electrical Engineering and Physics at the Massachusetts Institute of Technology. Her paper of 1991 showed that a carbon nanotube can behave as either a metal or semi-conductor, depending on its geometry (*see p.2*). Her insights were later confirmed experimentally. Prof. Dresselhaus has described her work as taking a "bottom-up approach", in which she develops new nanoscale systems, characterizes their properties then sees what they can be used for.


Mildred Dresselhaus

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Igor Vasilievich Severskiy

Glacier melt and poor policies behind Central Asia's water woes

Last November, Igor Vasilievich Severskiy was one of 60 experts from 13 countries who called for a regional centre to be established on glacier research, at a workshop run by UNESCO and partners in Almaty (Kazakhstan). Prof. Severskiy heads the Laboratory of Glaciology at Kazakhstan's Institute of Geography, as well as Kazakhstan's National Committee within UNESCO's International Hydrological Programme. He explains why both scientists and policy-makers in Central Asia have a lot to gain from a regional centre on glacier research.

How fast are glaciers retreating in the mountain ranges of Central Asia?

Several studies presented to the international workshop I attended last November show that glaciers in the Central Asian mountain regions of Dzhunghar Alatau and Pamir-Alai are melting very rapidly. Between 1955 and 2000, they lost about 0.6–0.8% per year in surface area and 0.8–1% in volume. These figures leave no doubt that global warming is the main reason for deglaciation and shrinking snow and ice in Central Asia.

Is glacier monitoring satisfactory in Central Asia?

There are too many gaps in monitoring. The November workshop acknowledged that the lack of a monitoring system in Central Asia is responsible for inadequate information on glacier mass dynamics. This is a critical problem in the region, since glaciers are key indicators of global climate change.

There is practically no monitoring system, for instance, for snow cover in the high-mountain belt above 3000–3200 m, even though this is where about half of snow is concentrated, according to our research. It is this snow which is the main source of runoff in Central Asia. Most countries in the region do not even have regular monitoring of permafrost soils. This lack of factual information on processes and natural phenomena at high altitudes in cold mountain regions forces scientists to use secondary data, indirect methods and to make assumptions when constructing forecast models. This explains the lack of consensus among scientists on the impact of climate change on the region's water resources in general and glaciers in particular.

I believe this was why the workshop participants called for a regional centre on glacier research to be established in Central Asia under the auspices of UNESCO. The centre would promote and coordinate monitoring to improve scientific understanding of climate-driven changes in snow- and icepack in glaciers, in permafrost and in the flow system connecting melt water to rivers and lakes in the lowlands.

Is it true that glaciers will disappear by mid-century?

There is tremendous concern in scientific literature that Central Asian glaciers may disappear by mid-century. Yet, our research pens a slightly more optimistic scenario. For example, glacier retreat in Northern Tien Shan reached a climax in the mid-1970s before slowing down in the early 1980s. A similar scenario has played out in the Gissar-Alai mountain range. To take another example, glacier upsurge has even been reported in the Central Karakoram mountains, where the glacier advanced by up to 2.5 km along the valleys between 1990 and 2000.

Long-term monitoring of the average annual temperature of permafrost near the mountain pass of Zhusalykezen (3400 m) in the Zailiyskiy Alatau mountain range (Northern Tien Shan) indicates a constant rise in temperature between 1974 and 1995. Thereafter, the temperature stabilized at around -0.2°C for more than a decade. Moreover, based on our analysis, which takes into account current global warming trends, the glacier area of the Balkhash Basin may shrink by about one-third but will not disappear completely.

These case studies show that glaciers in Central Asia may not disappear as rapidly as predicted. This said, we need updated monitoring systems to improve our understanding before venturing to make any forecast.

Might glacier lakes turn into hazards by overflowing or bursting their banks?

Yes, that is quite a likely possibility. The hazard might be caused by glacier melt forming a new lake nearby by a swollen lake, or even by disturbances in the stability of loose soils. All three processes considerably increase the probability of mud flows.

Is glacier melt to blame for the water shortages the lowlands are experiencing?

Water resources management in Central Asia is a critical problem, especially in the Aral Sea Basin. Melt water from

permanent snowfields and glaciers feeds the two main rivers flowing into the Aral Sea Basin, the Syrdarya and Amudarya. These rivers swell mostly in spring and during the thaw in summer.

As early as the beginning of the 1990s, 150% of the natural runoff from the Syrdarya River and 110% of runoff from the Amudarya River was being used up. You may be curious as to why the percentage exceeds 100; this is because the figures also incorporate return flows from agricultural lands.

It is an interesting fact that runoff from the main rivers has remained practically the same over the past 70–80 years. Despite the considerable shrinking of glacier area, water flow into the river system has not changed. Moreover, the cumulative amount of precipitation and maximal snow reserves has shown practically no change either over the same period. The reason for growing water shortages in the region is thus not a case of a drop in the supply of head water but rather of poor water management downstream

In what way is water being poorly managed?

Poor management of water in the region dates back to the 1960s, when the central Soviet authorities decided to divert unprecedented amounts from the Amudarya and Syrdarya Rivers to irrigate huge cotton plantations. As a result, water shortages in the Syrdarya River Basin rose steeply between 1960 and 1990. In parallel, farmers were encouraged to use more water and dangerous amounts of pesticide and fertilizer.

Yet, even in the 1960s, no more than 25% of the river's natural runoff reached the Aral Sea. This tells us that the human impact on the basin was perceptible long before the so-called "cotton" era. Irrigated farming was well-established in the region as early as the 1930s.

From 1970 to 1989, total water losses in the basin increased by 13.8–14.2 km^3/year. The climate was responsible for less than 5 km^3 of water loss each year (about 35% of the total), compared to 8–9 km^3 for economic activities. This loss was caused by fast-growing irrigated areas and evaporation loss from the many reservoirs constructed in the region. Currently, there are about 100 water reservoirs and 24 000 km of irrigated channels in the Aral Sea basin. A further 6 km^3 was lost each year to evaporation from the Arnasaisk water storage reservoir alone. Water loss from the Priaralje irrigated area in Kazakhstan increased over the same period from 2.5 km^3 to 4.6 km^3 per year. Today, the Aral Sea is just one-quarter its size 50 years ago.

According to forecasts based on general atmospheric circulation models incorporating the most pessimistic climate scenario, water resources in the region may fall by 20–40% by mid-century.

However, as I said earlier, even as glaciers have retreated, annual runoff in terms of volume and yearly distribution has remained unchanged for several decades. This suggests the existence of a possible compensating mechanism, a hypothesis supported by recent research.

What kind of 'compensating mechanism'?

With global warming, rising temperatures have caused underground ice – in the form of buried glaciers, rock-glaciers and ice accumulated in the permafrost layer – to thaw. This has contributed to the compensating mechanism. As a result, the supply of runoff to the river basin has remained unchanged.

Surely, this compensatory mechanism will dry up once the permanent ice has completely melted?

We believe the compensatory mechanism will work for up to a century, despite glacier retreat. This is because the reserves of underground ice in the high mountains of Kazakhstan and the rest of Central Asia are equivalent to the icepack in present-day glaciers. Moreover, in the Chinese mountains, there is twice as much underground ice as ice storage in the surface glaciers. Another consideration is that underground ice melts at a much slower rate than ice in open glaciers.

Hence, we can predict that the ongoing retreat of glaciers will not cause runoff and water supplies to shrink in the region for a few decades yet. However, this optimistic vision needs additional verification, a task which will require monitoring and more scientific studies coordinated at both the regional and international levels. I believe the proposed regional centre on glacier research will help us to predict with greater accuracy the impact of climate change on glaciers and water supplies in the region.

What can central and local governments do to prepare for future water shortages?

The question warrants serious thought. As a matter of fact, a great number of programmes and studies have already tackled these policy issues, including some global projects. Most of their recommendations concern improving the system for managing regional water resources. There have been recommendations, for instance, to substitute cotton and rice for less thirsty crops in irrigated farming, such as wheat and other cereals.

Unfortunately, in spite of the efforts by regional governments and the international community, the situation as regards regional water-sharing remains tense and is even deteriorating. New water reservoirs are still being constructed and irrigated areas continue to grow in the basin. In parallel, population growth remains high.

The situation is further aggravated by internal issues. For one thing, individual countries lack clearly defined water strategies. On top of that, there is no legislative basis for the transboundary management of shared water resources, nor any mutually acceptable criteria for transboundary water-sharing.

Interview by Anil Mishra

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Saving the remaining **wildlife in Darfur**

Radom Biosphere Reserve is situated in the conflict-ridden region of Southern Darfur in Sudan. Over a three-year period, Tagir Tag Elsir Hassan, Ameer Awad Mohammed and Nasir Yousif Gaboush studied the effects of violence and unsustainable practices on wildlife in the reserve, using a grant awarded to Tagir Tag Elsir Hassan within the Young Scientists Award scheme run by UNESCO's Man and the Biosphere Programme.

The survey revealed that the number of wild animals roaming the reserve has dropped from 24 species thirty years ago to just 11 today. Elephants, lions, gazelles and buffalo have all disappeared. Those that have not fallen prey to automatic arms and poisons have fled across the border. Desertification poses another serious threat not only to wildlife but also to the 16 000 people living in the reserve, refugees among them. The three scientists predict that, 'lest serious efforts are exerted by the concerned government authorities', the remaining wildlife will soon be gone. They recommend a series of urgent measures.

Spread over 1 250 970 ha (12 500 km^2), Radom National Park lies close to the border with the Central African Republic (*see map*). The park was designated a Biosphere Reserve in 1979.

Two survey missions assessed the area in the 1970s. The first was undertaken by an expert from the World Wildlife Fund in 1974, the second by a panel of scientists from Sudan's Wildlife Research Centre the following year. The latter made a number of recommendations for conserving and managing wildlife before creation of the national park but this effort attracted little attention from government authorities at the time.

The present survey (*see table*) set out to identify the ecosystems in Radom Biosphere Reserve, quantify flora and fauna, and provide guidelines for involving local communities in managing the park. A total of 42 sample plots covering about 10 hectares each were studied. In addition, 57 questionnaires were prepared for the leaders of the Omad and Sheikh communities, as well as for local inhabitants and government officials (*see photo*). The aim was to obtain a general idea of the socio-economic status of the displaced persons living in nine villages to identify ways of improving their living conditions without compromising the reserve's conservation policy.

Interviewing community members during the survey. The low level of education in the community – one-quarter of the adult population is illiterate and only one-fifth has completed higher secondary school – suggests that the reserve's inhabitants need educating to boost their awareness of the key role they play in environmental degradation

Wild Animal Surveys in Radom Biosphere Reserve, 1975, 1976 and 2003

English name	Scientific name	1974–1975 +	1976 ++	2002–2003 +++
Red-fronted gazelle	*Gazella rufifrons*	5	–	–
White-eared kob	*Kobus leucotis*	50	110	–
Serval	*Felis serval*	1	–	–
Tiang	*Damaliscus korrigum*	414	230	–
Buffalo	*Syncerus caffer*	2	24	–
Lion	*Panthera leo*	1	–	–
Red monkey	*Erythrocebus patas*	*	*	2
African hunting dog	*Lycaon pictus*	14	12	**
Salt's dikdik	*Madoqua saltiana*	36	46	7
Striped hyena	*Hyaena hyaena*	3	–	**
Bushbuck	*Tragelaphus scriptus*	16	2	–
Warthog	*Phacochoerus aethiopicus*	232	159	7
Common jackal	*Canis aureus*	2	**	–
Hippo	*Hippopotamus amphibius*	4	10	–
Bhor reedbuck	*Redunca redunca*	72	12	1
Orebi	*Orebia orebi*	189	26	8
Roan antelope	*Hippotragus equinus*	225	117	–
Common Eland	*Taurotragus oryx*	50	–	–
African elephant	*Loxodonta africana*	12	–	–
Waterbuck	*Kobus ellipsiprymnus defassa*	85	59	–
Ostrich	*Struthio camelus*	–	–	**
Porcupine	*Hystrix cristata*	–	–	**
Colobus monkey	*Colobus abyssinicus*	–	–	6
Green monkey	*Cercopithecus aethiops*	–	–	6
Nile crocodile	*Crocodylus niloticus*	–	–	1

(–) No sighting
(*) Troops or herds
(**) Only traces

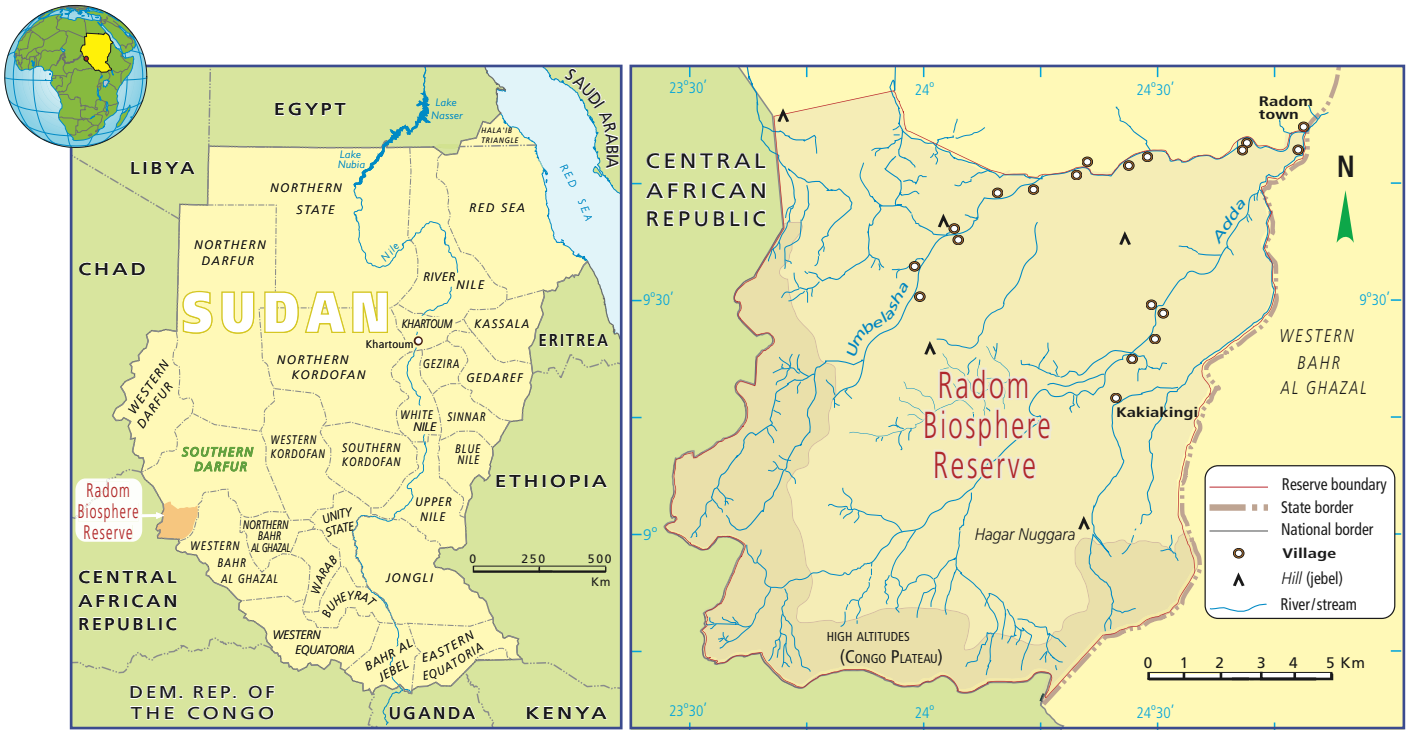
Sources:

+WWF report;

++ Nimir, M. B., Hashim, I. M., Hakim, S. (1976) Wild animals in Southwest Darfur *(in Arabic). Wild Animals Research Unit. Agricultural Research Cooperation. Khartoum; and scientists from Wildlife Research Centre in Khartoum.*

+++ Hassan, T.T. E.; Awad Mohammed, A., Gaboush, N. Y. (2005) Sustainable Utilization of Wildlife Resources in Radom Bisophere Reserve. Final Report. Khartoum.

Note: *One possible reason for the fluctuating numbers of game species from one survey to the next could be the varying duration of the surveys. Also noteworthy is that the 2002–2003 survey was done in the late dry season to circumvent difficulties in accessing certain areas during the rainy season. The deterioration in the security situation also limited the total area targeted by the current study.*



*Located in the Eastern Sahel, Radom Biosphere Reserve is characterized by wooded savannah and grasslands with riverine forests. It is covered in broken hills, most of which rise to altitudes of about 450 m above sea level. The reserve's boundary runs along the Congo Plateau, which forms a watershed (a ridge of land separating waters flowing to different rivers) and divides the Central African and Sudanese water systems. Tributaries from this watershed system head down to Radom town. The reserve's 19 biggest villages are situated along the two permanent rivers, the Adda and the Umbelasha, which represent the main source of water in the reserve. A few small streams (*khors*) flow from the east and south and there are a number of boreholes and pools (*birkas*) in the vicinity of the Adda River. Annual rainfall ranges between 900 mm and 1700 mm, with mean annual humidity from 57% to 65% and a mean annual temperature of 16–27°C. Thanks to the reserve's diverse climate and different types of habitat, a variety of ecosystems remained stable until the mid-1980s*

The devastating reign of automatic weapons

Back in the early 1960s, the park had a good reputation for sustaining a great variety of animal species, particularly once game posts were established. However, the influx of people into the reserve during the famine of 1985 put enormous pressure on game species and trees like mahogany (*Khaya senegalensis*) and sandal el Radom (*Pseudocedrela kotschyi*) used for construction, furniture-making, forage and fires.

As a result, animals frequently observed in the 1970s have since completely disappeared, among them the tora hartebeest (*Alcelaphus buselaphus*) and northern white rhinoceros (*Ceratotherium simum cottoni*), once the park's most outstanding species. Others that used to range the park in good numbers in the rainy season have also vanished, such as the elephant (*Loxodonta africana*) and buffalo (*Syncerus caffer*).

In the past few decades, there has been poaching both in and around the park in the dry season. The proliferation of automatic weapons has decimated game species. The traditional bows, arrows and traps with which villagers used to hunt small game for subsistence have been replaced by modern weapons. Automatic arms and poisons have modified hunting techniques, with many poachers turning to large game. This has been financed and encouraged by local merchants eager to maximize their yields of sun-fried meat, which brings a handsome profit. Game has also been hunted for ivory tusks, leather and other by-products.

In parallel, the security situation has kept deteriorating (*see box on p.20*). By 2001, it had become customary for locals in the adjacent Bahr Al Arab region to purchase automatic weapons and ammunition from open-air markets, both for self-protection and uncontrolled poaching. This has forced many animals to flee across the border. The desperate need for protein in an ever-growing population, coupled with the ease of possessing automatic weapons, has triggered a tragic situation whereby several species are believed to have totally abandoned the reserve.

Animals forced to flee across the border

Animals are usually forced to cross the border into the Central African Republic where there is both efficient protection and vast rangelands. They also flee to Bahr Al Ghazal, which sustains a good number of them when tse tse fly (*Glossina* sp.) infestation recedes in the south.

Radom Biosphere Reserve is also infested with the tse tse fly. This limits the presence of livestock but is a boon for the reserve's wildlife, as their relative tolerance to the tse tse fly lets them enjoy vast areas of rich pasture.

Only ten or so northern white rhinos survive today in the wild, all of them in the DRC

Insecurity and unsustainable practices

The newcomers are held responsible for most, if not all, of the reserve's environmental ills inflicted by humans. The main causes are agriculture, overgrazing, extensive poaching, fishing, mining and security-related problems:

- Trees of economic value are eliminated over large areas in and around the reserve to make way for agriculture. Trees are destroyed either by extensive burning – which impedes natural regeneration of vegetation – or logging. Both eventually trigger desertification.
- Overgrazing by domestic stock competes with the needs of wildlife. On rare occasions, it even facilitates disease transmission between wild and domestic species.
- Extensive poaching using advanced firearms kills massive numbers of animals and nourishes a flourishing trade in weapons which destabilizes the security situation.
- Applying poisons to pools for fishing purposes frequently results in mass mortality in the bird population and kills off micro-organisms in the water which play an essential role in the biological cycle.
- Unreglemented mining operations at Hofrat El Nihas are having devastating effects on wildlife habitat.
- Security problems that necessitate the presence of forces other than game scouts often hinder law enforcement and encourage violations.

Elephants (Loxodonta africana) photographed in west Kenya in 2002

Animals still frequently spotted in the reserve include bushbuck (*Tragelaphus scriptus*), spotted hyena (*Crocuta crocuta*), striped hyena (*Hyaena hyaena*), baboon (*Papioanubis* sp.), warthog (*Phacochoerus aethiopicus*), patas monkey (*Erythrocebus patas*), green monkey (*Cercopithecus aethiops*) and ratel (*Mellivora capensis*).

There are considerable numbers of African wild birds in the reserve. These include tufted guinea fowl, (*Numida meleagris*), the saddle-billed stork (*Ephippiorhynchus senegalensis*), Abyssinian ground horn-bill (*Bucorvus abyssinicus*), secretary bird (*Sagittarius serpentarius*), bustard (*Otis kon*) Marabou stork (*Leptoptilos crumeniferus*), crowned crane (*Balearica pavonina*) and a miscellany of small birds.

Reptilian species frequently observed in the area include the well-known African python (*Python sebae*), tortoise (*Testudo sulcatus*), crocodile (*Crocodylus niloticus*), monitor (*Varanus niloticus*) and small lizards (*Agama* spp).

Settler's summer camp set on fire by a game warden

An influx of human neighbours

Communities in the reserve come from several ethnic backgrounds. They predominantly live in the vicinity of the main seasonal rivers (*see map*), which is why wildlife and plants at the northern end of the reserve come under the greatest pressure. Tribes such as the Kara, Kerish, Ndogo, Bunda, Dinka, Dajo, Berti and Tunjur inhabit the banks of the Adda River. The bulk of the reserve's inhabitants live along the Umbelasha River however, which is home not only to the Kara and Kerish but also to other tribal groups which include the Binga, Youlu, Faur, Massaleet and Tama.

Villages account for most of the damage to the area. They fall into two main groups. The first is made up of residents who inhabited the area before it was recognized as a national park. They number approximately 5170 and are distributed among 13 villages around the Umbelasha River.

The second group is made up of displaced persons who migrated to the area for socio-economic reasons following its designation as a national park. This led to intensive human settlement in the north and northwest of the park. By 1990, the population numbered about 10 500. By 2001, it had climbed to 16 000 and the number of villages had doubled to 28. This second wave is the result of the influx of displaced persons and refugees from Darfur, Bahr Al Ghazal and Chad respectively, due to civil war and the area's attractive reputation for an excellent crop yield.

A third small group is of disproportionate importance: the nomads who cross the area from southern Darfur into Bahr Al Ghazal state twice a year. They are entirely dependent on the reserve for subsistence, even

Digging for water in Kakiakingi. Water is always a primary concern in the dry season

A wooden bridge built to access protected areas during the flooding season

though the infestation of their livestock with tse tse flies frequently drives them out. The nomads frequently cause disturbances, especially when water is in short supply and there are confrontations with locals as the nomads head south across Bahr Al Arab. The trespassing of nomadic groups on the cultivated lands of semi-settled families during their seasonal journeys also gives rise to disputes.

In recent years, families have moved into the buffer zones, which are lands on which subsistence farming is permitted by Sudanese law. These zones extend 5 km inside the reserve's border to enable inhabitants to protect their crops from wild animals, especially primates.

Unfortunately, at the end of the cropping season, these families are not returning to their former villages. Rather, they tend to occupy the new territories permanently for many years to come. This devastating behaviour results in the confiscation of more lands to their advantage and eventually in new crowded villages, leading to the loss of public land and other complications.

Exhausted lands

Land is used essentially for crop- and fruit-growing, honey collection, pastoralism and tree-felling for trading purposes and charcoal. Trees are also felled to enlarge the cultivated area, once the land under cultivation has become exhausted and productivity declines. Another reason is the growing number of mouths to feed in the reserve. The main crops cultivated by local village farmers are sesame, corn and *vetch*, or *Vicia* sp., followed by millet and hot pepper.

Firewood is the main source of energy. In 76% of cases, firewood is used for cooking, lighting and ritual purposes. Previously it was collected from cultivated land around the villages or from forest beyond the reserve. In the past,

Clearing trees for cultivation. Half of the reserve is covered in bare soil (54%) and one-quarter in litters (forest litter is a layer of decomposing plants and animals which enriches the soil by adding nutrients.) The remainder of the reserve is covered in trees and shrubs (11%), stones (3%), rivers (3%) and villages (3%)

Nine remedies for Radom's ills

The fauna of Radom Biosphere Reserve is showing marked depletion and will eventually totally disappear, lest serious efforts are made by the government authorities to reverse the situation. The authors recommend the following remedies:

- Redistribute the smaller villages by adjoining them to bigger tourist villages within the northern and eastern borders of the protected area. These villages should be provided with basic public services such as schools, clinics and communication facilities, and surrounded by a 5-km buffer zone.
- Move farmers north on a voluntary basis to alternative sites on the Umbelasha River under the supervision of the local municipal authorities. Grazing tracks should also be allocated to circumvent the frequent conflicts between farmers and herdsmen.
- In order to combat poaching, intensify surveillance and increase the number of game scout patrolling units in such areas as Bab Elshaweesh and Hagar Nuggara; promote eco-tourism by improving roads and establishing camping facilities.
- Heighten public awareness through programmes targeting semi-organized groups such as students, youth and women. Moreover, it would improve the living conditions of the locals if some were employed at the tourist villages, Forestry Department and Wildlife Conservation Administration.
- Conduct additional research at the higher altitudes of the Umbelasha and Adda Rivers, paying special attention to extinct species, to explain their disappearance, and to migratory species, to determine the extent of their home range habitat.
- Consider areas where mining operations take place at Hofrat El Nihas as a buffer zone, provided that the mining company offers the conservation authorities logistical support and helps to open tracks within the reserve and improve public services in adjacent villages.
- Create mobile veterinary units to deal with livestock problems and survey wildlife diseases within the area.
- Prohibit vehicles from entering the reserve, especially trucks and heavy machinery.
- Form a joint committee of technical experts to address the most challenging issues relating to nature and wildlife conservation. This committee would be responsible for coordinating the efforts of the Wildlife Conservation Administration, Wildlife Research Centre and authorities responsible for fisheries, forestry, soil and water, among other concerned bodies.

Armed game wardens patrolling at Hagar Nuggarra water pool. Pools located alongside the banks of the seasonal rivers, valley beds and narrow water streams (khor) *not only sustain ecosystems but also act as water reservoirs for both domestic and wild animals during the dry season*

this did not affect the reserve's vegetation cover but now 73% of firewood is collected from within the reserve itself. The remainder is collected at market (3%) and from forest beyond the reserve. Preferred trees for firewood include *Acacia seyal, Pseudocedrela kotschyi, Combretum* sp. and *Anogeissus* sp.

Peace is the only way forward

The ongoing strife in Darfur has put great stress on both human beings and the environment. Mass displacement of citizens in the Darfur region has added to those who had migrated earlier from the nearby state of Bahr Al Ghazal. The signing of the first Naivasha agreement served as the basis for the Comprehensive Peace Agreement between the Government of Sudan and the Sudan People's Liberation Army (*see box*). After the signing, resource depletion eased as southerners began returning home to their villages. One can anticipate that a solid peace agreement in Darfur would produce the same happy scenario.

The situation will remain catastrophic, however, unless an efficient and sincere disarmament programme can be agreed upon and implemented by the warring parties, provided a lasting political compromise can be found. The disarmament programme should designate specific areas as weapon-free zones. These zones would serve as 'political asylums' for wild animals, which would be placed under the full protection of the state. Given the numerous remote areas devoid of settlements, the rich vegetation cover and good grazing lands, wild animal populations could also be reintroduced at this point.

Only once the number of uncontrolled weapons circulating drops, strict law enforcement returns and the animal's habitat is given a chance to recover will the reserve's population of wild animals be able to embark on its own long road to recovery.

Tarig Tag Elsir Hassan[10], Ameer Awad Mohammed[11] and Nasir Yousif Gaboush[12]

Half a century of conflict

For all but 11 of the 50 years since independence in 1956, Sudan has been engulfed in civil conflict.

The war that the Government of Sudan and the Sudan People's Liberation Army recently ended erupted in 1983. The root causes which propelled the war included disputes over resources, power, the role of religion in the state and self-determination.

The ensuing 21-year conflict devastated a significant part of Africa's largest country and deprived the rest of stability, growth and development. More than two million people died, four million were uprooted and 600 000 people sought shelter beyond Sudan's borders as refugees.

Under the mediation of the Intergovernmental Authority on Development[9], the Government of Sudan and the Sudan People's Liberation Army signed a series of six agreements between 2002 and 2004, five of them in Naivasha (Kenya). The signing of a Comprehensive Peace Agreement in 2005 led to the formation of a Government of National Unity.

In January 2007, the UN Mission in Sudan handed over a first batch of equipment and supplies to the 7000 soldier-strong African Union Mission in Darfur, a region which has been the theatre of escalating violence (*see box*).

Source: UN Mission in Sudan: www.unmis.org/English/cpa.htm

Read the full report:
www.unesco.org/mab/bursaries/reports.shtml#2007

Apply by 30 April each year for a MAB Young Scientists Award:
www.unesco.org/mab/bursaries/mys.shtml

9. *IGAD covers Djibouti, Ethiopia, Eritrea, Kenya, Somalia, Sudan and Uganda. UNESCO's Addis Ababa office is the focal point for cooperation. Since the signing of an agreement with IGAD on 29 January 2007, UNESCO now has formal ties to seven of the eight regional economic communities recognized by the African Union*

10. *Upper Nile University, Sudan: tarigtagelsir@yahoo.com*

11. *Wildlife Research Centre, Sudan: ameergadour@hotmail.com*

12. *Wildlife Research Centre, Sudan: naboush2@hotmail.com*

Growing insecurity in Darfur

Over the last two years, the efforts of humanitarian agencies in Darfur have saved the lives of hundreds of thousands of civilians caught up in the region's conflict.

Access to people in need in December 2006 was the worst since April 2004. The repeated military attacks, shifting frontlines and fragmentation of armed groups compromise safe humanitarian access and further victimize civilians who have borne the brunt of this protracted conflict. In the last six months alone, more than 250 000 people have been displaced by fighting, many of them fleeing for the second or third time. Villages have been burnt, looted and arbitrarily bombed and crops and livestock destroyed. Sexual violence against women is occurring at alarming rates.

Global malnutrition rates are edging perilously close to the emergency threshold, while some 60% of households in need of food aid cite insecurity as the main barrier to cultivating their land, raising livestock and taking part in other income-generating activities.

The humanitarian community cannot indefinitely assure the survival of the population in Darfur if insecurity continues. The undersigned members of the UN Country Team in Sudan welcome concrete steps from both the signatories, including the Government, and the non-signatories to the Darfur Peace Agreement [*Ed.: signed on 5 May 2006*]. However, such progress must be sustained.

Excerpt from the Joint Statement issued on 17 January 2007 by the UN Country Team (including UNESCO): www.unicef.org/media/media_38055.html

Head counts and headaches
measuring women in science

Statistics-gathering on the participation of women in research remains an obstacle course, as UNESCO's Institute for Statistics found out when it put together a Bulletin on *Women in Science* last November.[13] Although the Institute could pride itself on providing comparable data for 86 countries, some of the world's research hotspots were conspicuous by their absence, among them China, the UK and USA. Why are half the countries in the world missing from the study and what needs doing to improve both the visibility of women in national statistics and cross-national comparability?

The irony is not lost on Ernesto Fernández Polcuch, responsible for science and technology statistics at the UIS. 'Despite the growing demand for cross-nationally comparable statistics on women in science', he laments, 'national data and their use in policy-making often remain limited. Even when data are available, they may not be internationally comparable.'

One problem is that the UIS and other bodies such as the Organisation for Economic Co-operation and Development (OECD) and Eurostat, generally rely upon headcounts of men and women for cross-national comparisons. 'But some of the most developed countries calculate full-time equivalencies (FTE) instead,' explains Fernández Polcuch. 'So they're not actually counting people but shifts.'

This means that, strangely enough, the UIS can report that Myanmar and Lesotho have the world's highest proportions of women scientists, at 85% and 76% respectively (*see graphic overleaf*), but the Institute cannot provide these same statistics for China or the USA.

Another problem is that many low-income countries in particular cannot break down national statistics on higher education and researchers by gender.

Data collected in USA highly detailed

The USA probably collects some of the most detailed information of all on the gender, ethnicity and disability status of its scientists. The National Science Foundation (NSF) isn't just counting the number of women scientists and engineers; it is also keeping tabs on the numbers of patents they receive and even their demographic circumstances.

For example, men on average have 12 subordinates compared to nine for women, among supervisor scientists and engineers in the private sector. The NSF has also found that family responsibilities are cited as the reason for not working by about 27% of women with science and engineering doctorates who are either unemployed or out of the labor force, compared to just 1.5% of men. Women scientists and engineers are also more likely than men to be divorced or separated from their spouses.

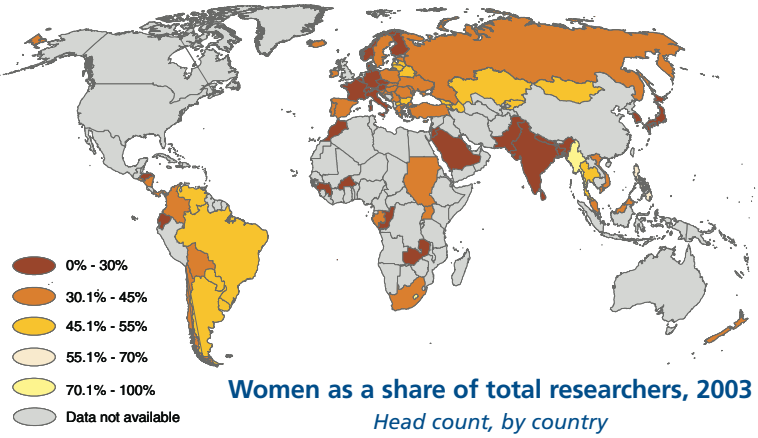
Researcher at the Genoscope, the National DNA Sequencing Centre, in Ivry sur Seine (France) in 2002. According to the UIS Bulletin on Women in Science*, just one-quarter of French researchers are women, close to the EU average. Eurostat notes that, in France, women represent 38% of research fellows, 22% of research directors, 15% of heads of research institutions and 6% of members of the French Academy of Sciences*

When cross-national comparisons become essential

This gold-mine of information can lay the foundations for national policy-making, even if most of the data cannot be compared internationally. But for other countries, like those of the European Union (EU), comparability is critical in efforts to harmonize science policies and put women researchers on the political agenda.

'No statistics, no problem, no policy,' says Dr Hilary Rose of the University of Bradford (UK) in *She Figures*, a report published last year by Eurostat. 'You just get gestures. Statistics help identify problems and can monitor the effectiveness of remedies.'

Rose's comments resonate in countries like Austria, Germany and the Netherlands, where there are low percentages of female scientists and relatively little data on them according to the European Commission's Helsinki Group on Women in Science. In contrast, many of the newer members of the EU and associated countries benefit from the communist legacy of good statistics and high proportions of women scientists and researchers.



Women as a share of total researchers, 2003

Head count, by country

Measuring the thickness of the glass ceiling

Through the Helsinki Group, a network of statisticians is trying to identify and monitor better the factors that bring women in and out of the research field. They are not simply looking at how many women pursue research but how they progress in their careers.

For example, to what extent do women set the scientific agenda? Part of the answer lies in the composition of scientific boards. Only in Finland and Sweden do women constitute more than 40% of board members, followed by the UK and Denmark with more than 30%. But in most EU countries, the share varies from one in five to even less than one in ten, according to *She Figures*.

Another innovative tool is the Glass Ceiling Index, which compares women's and men's chances of reaching a top academic position. Basically, the higher the score, the 'thicker' the so-called ceiling to women's advancement. Romania and Turkey report the most positive results, according to *She Figures*, with 1.1 and 1.4 respectively, compared to the EU average of 2.1. The greatest barriers are found in Malta (11.7), followed by Lithuania (3.2).

At the UIS, Fernández Polcuch dreams of collecting this kind of data internationally. While glass ceilings are beyond his reach, he will soon have a new source of data arising from a joint project between the UIS, Eurostat and the OECD.

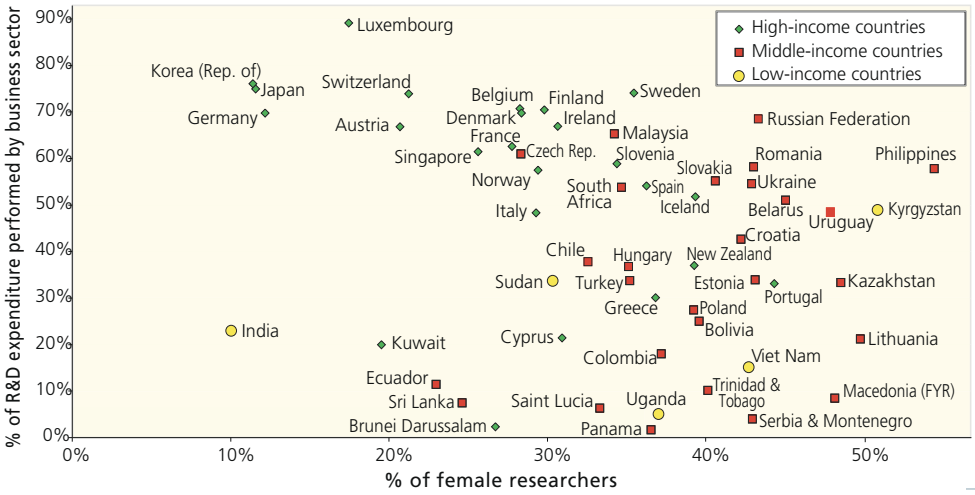
Tracking the careers of doctorate-holders

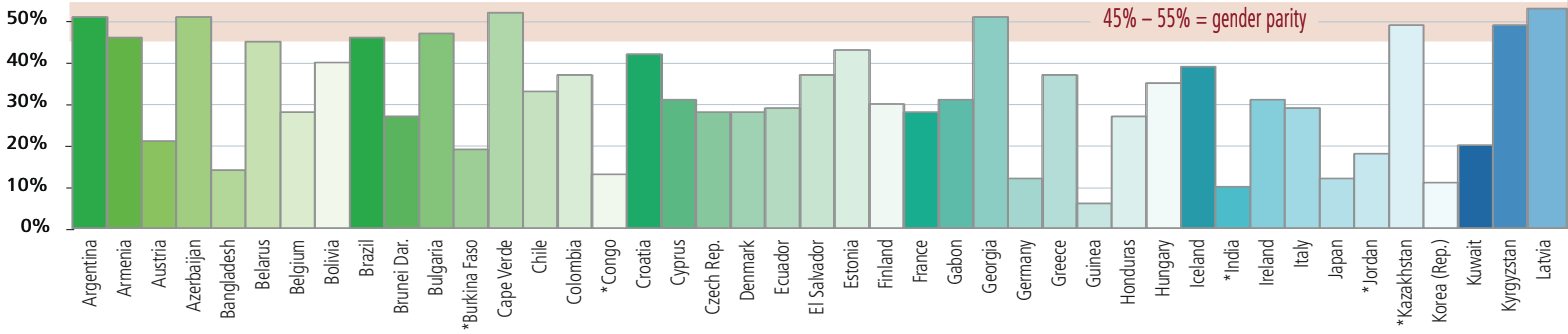
Inspired by a US survey, the UIS, Eurostat and OECD have developed a way to track the careers of doctorate holders internationally. In particular, the UIS designed a model questionnaire to help countries with little experience in this field conduct their own surveys. For the first time, developing and industrialized countries alike will be able to compare the salaries of male and female engineers, for example, or the time it takes them to find jobs in their field.

A number of countries have already piloted the survey, while others are preparing to implement it. Due out next year, the results should considerably expand the global perspective on women in science while shrinking those disconcerting grey zones of 'no data available'.

Relationship between the percentage of women researchers and company R&D expenditure, 2003

as a percentage of total gross domestic expenditure on R&D





Source of graphics: UIS (2006) Women in Science: Under-represented and Under-measured. UIS Bulletin on Science and Technology Statistics, *N°3, November. Montréal, Canada*

Different career paths from the outset

What is clear from available information is that women and men embark on different career paths at university and continue along divergent paths well into their research careers.

The UIS Bulletin on *Women in Science* notes that, in 2003, there was gender parity among students enrolled in Bachelor-degree programmes in science and engineering for just three of the 47 countries for which data were available. 'The fact that, in many countries, there are proportionally more female second-degree graduates than at the first degree level seems to strengthen the hypothesis that women still perform better and drop out less than men, particularly in the early stages of higher education,' the Bulletin observes.

The picture changes at the PhD-level, where males predominate. Only 8% of countries have significantly more women than men graduating from doctoral programmes in science and engineering fields, and just 17% of countries have attained gender parity.

The choice of field of study is also gender-specific. Graduates from engineering schools are 'overwhelmingly men'. Similarly, in computing studies, universities are still 'manning' the information society. The life sciences tell a different story. Some 73% of countries report slightly more women graduates than men in this field, which includes medicine.

Women are less likely than men to be employed in the private sector when it comes to R&D. 'Some have concluded that the significant share of business enterprise in R&D may explain the relatively low percentage of female researchers', notes the Bulletin. Women account for 28% of all researchers in the EU, for example, but 34% of researchers employed by the government and the tertiary education sector, as opposed to 18% in private companies. When it comes to middle and low-income countries, however, there is little correlation between female participation in research and business R&D (*see figure*). The Bulletin notes that 'further studies in this area are clearly needed'.

Pupils at Mahmud Tarzi High School in Kandahar (Afghanistan) in 2007. According to the Ministry of Education, 'the fairer sex' represented one-third of school pupils and one-fifth of university students in 2003, two years after the fall of the Taliban regime opened schools to girls again: 19% of women students were enrolled in medicine, 12% in natural sciences and just 2% in engineering

An overwhelming case for further gender studies

In the 86 countries studied, women represent slightly more than one-quarter of researchers. In one-third of these countries, they represent fewer than 30%. Only 17–18% of countries have achieved gender parity and only a handful of others have more women researchers than men.

The UIS Bulletin concludes that the under-representation of women in research 'can be traced back to education systems, particularly at the higher levels.' It goes on to say that 'it is of utmost importance to further analyse other aspects hindering women's access to, continuity and advancement in research positions. This involves issues related to stereotyping, working conditions – the work/personal life balance – labour market conditions, governance and the role of researchers in society…Decision-makers in the field of higher education and science policy cannot ignore this issue.'

Amy Otchet[14]

Read the Bulletin: www.uis.unesco.org;
For details: e.fernandez-polcuch@unesco.org

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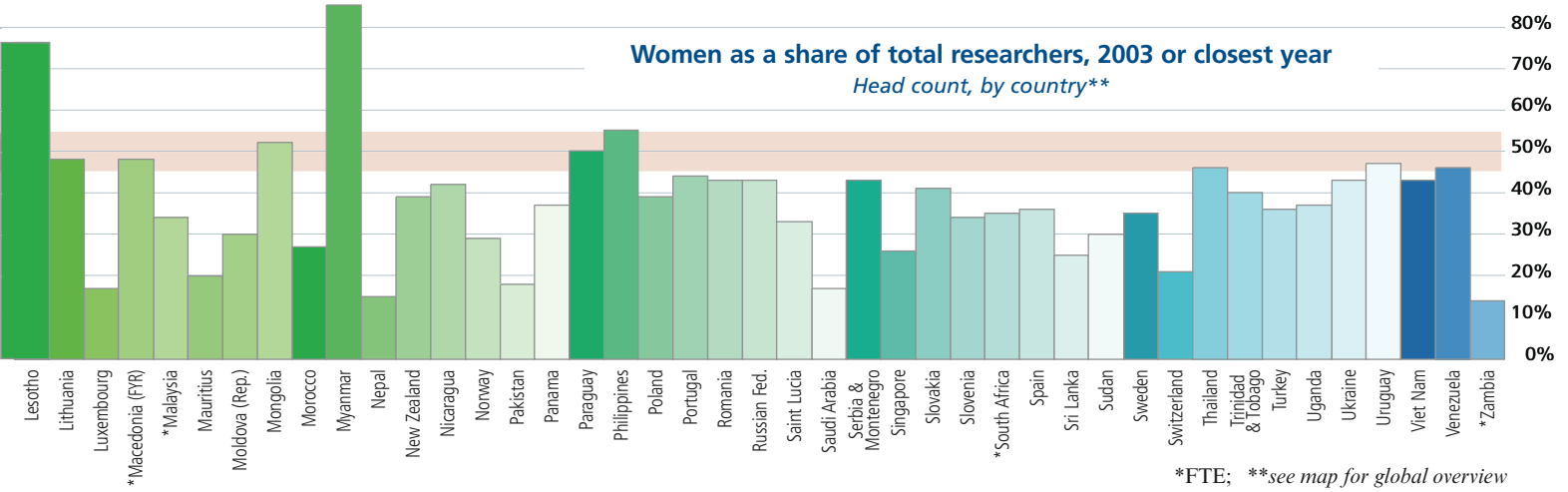
13. In collaboration with the Institut national de recherche scientifique (Montréal, Canada)

14. Communication Officer at the UIS

Women as a share of total researchers, 2003 or closest year
*Head count, by country***



*FTE; ***see map for global overview*

Diary

11–14 April
Surface ocean CO_2 variability and vulnerabilities
Workshop to review current knowledge and enhance intl cooperation. Sponsored by Intl Ocean Carbon Coordination Project, SOLAS, IMBER, GCP. UNESCO Paris: *r.dargaville@unesco.org; www.ioc.unesco.org/ioccp/pCO2_2007.htm*

22–27 April
A Quran botanical garden
Intl Advisory Committee meeting to establish garden in Sharjah, United Arab Emirates. Co-organized by Ruler's Office in Sharjah and UNESCO Doha: *b.boer@unesco.org*

30 April
Deadline
for biosphere reserve nominations (*see 11 June*) and applications for MAB Young Scientists Award endorsed by applicant's MAB National Committee: *mab.awards@unesco.org; www.unesco.org/mab/bursaries/mys.shtml*

2–5 May
Ocean Observations Panel for Climate
Global Climate (GCOS) and Ocean (GOOS) Observing Systems and World Climate Research Programme. UNESCO Paris: *http://ioc3.unesco.org/oopc/meetings/oopc-12/*

3–4 May
Innovation for Development
Intl conf. European Association for Transfer of Technology, Innovation and Industrial Information, and UNESCO. UNESCO, Paris: *unesco.org/science/bes*

11 May
Opening of new WWAP office
Director-General to open office in Perugia (Italy), *see p.10*.

10–12 May
Education, research and innovation: a new partnership for sustainable development
G8/UNESCO World Forum. Themes include: what partnership for university, research bodies and industry? what role for govt? energy; health; S&T and innovation in Africa. ICTP, Trieste (Italy): *http://g8forum.ictp.it/*

23–25 May
Empowerment of women in engineering and technology
Intl workshop organized by WFEO with UNESCO. Tunis (Tunisia): *t.marjoram@unesco.org*

28–29 May
Sustainable use of wetlands
Intl workshop on biosphere reserve management. UNESCO Moscow, MAB National Committee. Hosted by Rostov region. Rostov on Don (Russian Federation): *m.prchalova@unesco.ru*

29–30 May
Mountain areas – ecological problems of cities
Intl scientific conf. organized by Centre for Ecological–Noosphere Studies of National Academy of Sciences with support of UNESCO Moscow and City Hall. Yerevan (Armenia): *IYSC1@rambler.ru*

29–31 May
Integrated Global Observing Strategy
14th session. Hosted by UNESCO-IOC. Paris: *www.ioc-goos.org/IGOS-P-14; hh.lam@unesco.org*

31 May–1 June
Sustainable energy development, science and poverty reduction
Ministerial conf. with Ministers of Energy, UN agencies, in response to G8 recommendations in St Petersburg Plan of Action for Global Energy Security (July 2006). UNESCO Paris: *o.benchikh@unesco.org; www.unesco.org/science/bes*

11–13 June
Advisory Committee for Biosphere Reserves
Meeting to examine new biosphere reserve proposals, extensions to existing reserves, periodic reviews by MAB National Committees: *mab@unesco.org*

13–15 June
50th anniversary of UNESCO-IHE
Anniversary symposium on Water in a Changing World: enhancing Local Knowledge and Capacity. Delft (Netherlands): *www.unesco-ihe.org*

13–17 June
History of water and civilization
5th conf. of IWHA, supported by UNESCO-IHP. Tampere (Finland): *www.iwha.net/; www.unesco.org/water*

18–21 June
S&T in municipal public policies
MERCOCIUDADES exhibition sponsored by UNESCO Montevideo proposing solutions for cities: renewable energies, tech. business incubators, science parks, etc. Montevideo (Uruguay): *orcyt@unesco.org.uy*

19–28 June
IOC Assembly
24th session. UNESCO Paris: *http://ioc.unesco.org*

New **Releases**

Policy Perspectives for Ecosystem and Water Management in the Arabian Peninsula
K. M. Amer, B. Böer (UNESCO), M. Brok, Z. Adeel, M. Clüsener-Godt (UNESCO), W. Saleh (eds). UNESCO/UNU, with Foreword by W. Erdelen and R. Daley, ISBN: 92-808-6001-1, English only, 172 pp.
In recent years, the Arabian Peninsula region has witnessed depletion of water resources, declining fish stocks, deterioration of rangelands, loss of biological diversity and the pollution of water, air and terrestrial ecosystems. A multifaceted perspective on the integrated management of water, land and sea resources so urgently needed in the region. Request a copy from (in Doha): *b.boer@unesco.org*

A Handbook for Measuring the Progress and Outcomes of Integrated Coastal and Ocean Management
Manuals and Guides 46. ICAM Dossier 2. UNESCO-IOC, English only.
Step-by-step guide for users. For details: *p.boned@unesco.org*

Global Geoparks Network
4-page booklet by UNESCO's Earth sciences programme, English only.
Describes the Geopark approach combining conservation, education and geotourism. A Geopark is a nationally protected area containing sites of geological heritage of particular importance, rarity or aesthetic appeal. The Geoparks Network works with UNESCO's World Heritage Centre, UNESCO-MAB, Geological Surveys, NGOs, etc. Request a copy from *m.patzak@unesco.org*

Policy Briefs
New series of 4-page booklets published by UNESCO-MAB and ICSU's Scientific Committee on Problems of the Environment (SCOPE), English only.
The first three booklets address: *Indicators of Sustainability as Reliable Tools for Decision Making*; *The Global Carbon Cycle,* and the *Dialogue between Science and Society in the Case of Global Environment Change*. The next issue, on the impacts of human-induced changes in the global nitrogen cycle, is due out in May: *www.unesco.org/mab/biodiv/biodivSC.shtml#assessments*

News from the Biosphere World Network
E-newsletter quarterly providing a regular overview of web-based information on biosphere reserve activities and UNESCO-MAB. Consult/subscribe for free: *www.unesco.org/mab/publications/newsletter/eng.shtml*

Fishers' Knowledge in Fisheries Science and Management
N. Haggan, B. Neis, I. Baird (eds). Coastal Management Sourcebooks Series 4. UNESCO Publishing, 30 €, ISBN: 978-92-3-104029-0, English only, 440 pp.
Selected chapters from the proceedings of a conference in 2001 on Putting Fishers' Knowledge to Work, which focused on examples of how fishers' knowledge is being used to expand and strengthen fisheries science and management. For details: *www.unesco.org/links*

Communicating Physics/Comunicare la Fisica
M. Armeni, Manager (ed.). Sponsored by UNESCO Venice within Intl Year of Physics (2005) and Pirelli Spa. Zadigroma Editore, 10 €. ISBN: 88-88734-14-7, Bilingual English/Italian.
Describes commonperceptions of physics and how it is communicated via internet and new technologies. Underlines the influence of physics on society, particularly in strategic sectors such as nuclear energy and nanotechnologies. Being distributed to universities and libraries throughout Europe. For details (in Venice): *r.santesso@unesco.org*

African Marine Atlas
Online atlas developed since June 2006 by ODINAFRICA with support from UNESCO-IOC and Flemish community.
First African Marine Atlas, realized by 16 marine scientists and GIS experts from national institutions in Benin, Ghana, Kenya, Mauritania, Mauritius, Mozambique, Namibia, Senegal, Seychelles, South Africa and Tanzania. Indicates areas of intense use along African coastline requiring careful management. All the maps, images and data may be freely consulted by coastal resource managers, planners and decision-makers in Africa, NGOs, hotel managers, teachers, etc. Consult the Atlas: *http://iodeweb2.vliz.be/omap/OMAP/index.htm*; for details (in Nairobi): *m.odido@unesco.org; www.odinafrica.net*

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