



United Nations Educational,
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Who needs maths
at a time like this?
p. 16

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A World of **SCIENCE**

IN THIS ISSUE

IN FOCUS

- 2 A carbon sink that can
no longer cope?

NEWS

- 6 Multimillion dollar water
project for Iraq
- 7 A strategic plan for
Afghanistan's universities
- 8 Two years to assess
global agriculture
- 8 Asian journalists learn to report
the science of HIV/AIDS
- 9 UNESCO and WMO join forces
to combat flood damage
- 10 The ICTP turns 40

INTERVIEW

- 10 Osman Benchikh on why the age
of renewables has now begun

HORIZONS

- 13 The solar school
- 16 Who needs maths
at a time like this?

IN BRIEF

- 20 Diary
- 20 New releases
- 20 Governing bodies

EDITORIAL

Acid rain, **acid ocean**

Homo industrialis has only walked the Earth for 200 years but, in that time, he has burnt ever-greater amounts of coal and oil, and churned out vast quantities of concrete. Half the carbon produced by this frenetic industrial activity has seeped into the world's oceans.

The oceans have become a sink – and a very effective one at that. A study published in *Science* last July estimates that the oceans have absorbed 118 billion metric tons of carbon dioxide (CO₂) over the past two centuries, about one-third of their long-term potential. As a result, the concentration of CO₂ in the atmosphere has *only* increased by 36% over the same period. Without the ocean carbon sink, the atmospheric concentration of CO₂ would have been higher today and global warming more severe. We owe the oceans a lot.

But, we ask in the current issue, can the ocean continue to cope with being a vast carbon sink? A symposium organized by UNESCO's Intergovernmental Oceanographic Commission last May has concluded that we may yet pay a very high price for this service to humanity. The high concentration of CO₂ in the oceans is making them more acidic and there are signs that this is beginning to affect marine life.

With fossil fuel-burning on the increase rather than the reverse, things are poised to get worse for corals, pteropod molluscs, some plankton and perhaps even some fish, which may encounter a whole range of 'health problems' as the ocean acidifies, including reproductive difficulties and asphyxiation. That would spell catastrophe for the world's fishing and coastal tourism industries.

As the surface waters become more saturated with carbon, the ocean may also become a less efficient sink. With less carbon being absorbed by the oceans, more would enter the atmosphere. That would accelerate global warming.

Most experiments have been conducted in laboratories up until now, so we cannot say for certain at this stage what lies ahead for the marine food chain. But we need to find out. And fast. Hence the resolve of the science meeting last May to fix urgent priorities for studying *ex situ*, and above all long-term *in situ*, the effects on marine life of an acidifying habitat.

W. Erdelen
Assistant Director-General for Natural Sciences

A carbon sink that can no longer cope?

The oceans provide us with a valuable service by absorbing half of the carbon dioxide (CO₂) emitted by the burning of fossil fuels, thereby reducing the impact of this greenhouse gas on climate. A symposium held at UNESCO in May¹ has concluded, however, that we may soon pay a very high price for this service.

When, last May, over 100 of the world's leading ocean carbon scientists from different branches of marine biology and chemistry pieced together some of the best scientific information available, the results were alarming. The compiled research suggests that the increasing acidity of the ocean could seriously harm corals and other calcifying organisms, such as shellfish and some phytoplankton, the base of the marine food chain. If this food chain becomes disrupted, it could lead to the collapse of fisheries industries in many parts of the world, as well as of the billion dollar tourism industry that surrounds healthy coral reefs. These changes may also alter the ocean's ability to absorb fossil-fuel CO₂ in ways that are not yet fully understood.

The May meeting went on to fix urgent research priorities to probe the possible consequences of an acidifying ocean on marine ecosystems and assess the safety of proposed geo-engineering strategies for mitigating the impact on climate by storing excess CO₂ in the deep ocean.

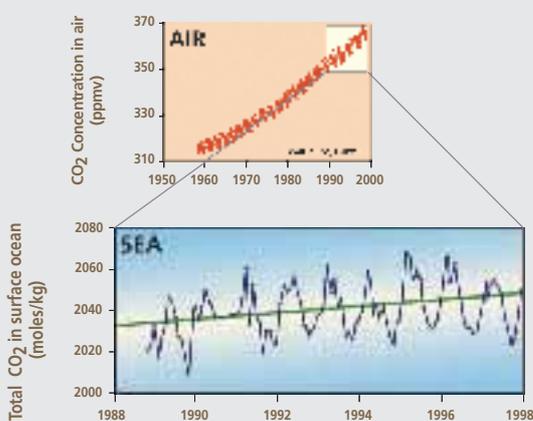
How the carbon-climate connection was made

In the mid-1800s, the hot topic in the scientific world was the ice ages, a new hypothesis that much of the northern land masses had been covered in thick layers of ice tens of thousands of years previously. In investigating how the climate of the planet could change so dramatically, scientists discovered that certain gases in the Earth's atmosphere trap heat from the sun. Calculations showed that the conditions experienced during the ice ages could be brought on by halving the abundance of CO₂ in the atmosphere. But what natural processes might cause such large changes in concentrations of CO₂? This question launched one of the most challenging – and enduring – investigations of earth science: that of understanding the global carbon cycle.

At the beginning of the industrial revolution in the mid-eighteenth century, human activities like the burning of fossil fuels began adding CO₂ to the atmosphere but the amounts were small when compared with the amount of CO₂ naturally present in the atmosphere. Early concerns about the long-term build up of this CO₂ in the atmosphere were not taken seriously because most scientists at the time believed that the oceans would naturally absorb 90% of the industrially produced CO₂ emitted to the atmosphere.

In the late 1950s, geochemists Roger Revelle (the founder of UNESCO's Intergovernmental Oceanographic Commission, IOC) and Hans Suess sounded the alarm. Their calculations showed that ocean uptake of CO₂ was much slower than originally thought and that the oceans could absorb no more than 50% of the CO₂ being emitted annually by fossil-fuel burning. The remainder, they warned, would build up in the atmosphere, where it would increase the atmosphere's ability to trap heat, producing a 'greenhouse effect'. In 1958, Charles David Keeling began taking the first high-quality measurements of atmospheric CO₂ at the Mauna Loa Observatory in Hawaii (USA); he would soon give the world proof of the steady climb in the concentration of CO₂ in the atmosphere. Twenty-five years later, measurements of ocean CO₂ began, in turn, at the Bermuda Atlantic Time Series Station, documenting the slow penetration of this excess CO₂ into the surface oceans.

CO₂ concentrations in the air and at sea



Courtesy C.D. Keeling and N. Bates, U.S. JGOFS Program.

Increases in atmospheric and oceanic CO₂ levels. The dips in the sea curve correspond to seasonal variation

Solving the riddle of the missing carbon sink

Of the fossil-fuel CO₂ emitted globally, only half has accumulated in the atmosphere. The fate of the other half has prompted a decades-long search for the 'missing carbon sink'. The two possible sinks for this CO₂ are the terrestrial biosphere (e.g. via photosynthesis) and the ocean. The ocean represents the largest natural stockpile

1. *The Ocean in a High CO₂ World*. International Science Symposium sponsored by the Scientific Committee on Oceanic Research and UNESCO's Intergovernmental Oceanographic Commission (IOC)

of carbon and has a dynamic interaction with the atmosphere over 70% of the planet's surface. The only direct method of calculating the amount of CO₂ absorbed by the ocean is through direct measurements on a global scale. From 1990 to 1998, a multinational research programme called the World Ocean Circulation Experiment/Joint Global Ocean Flux Study amassed data from nearly 10 000 stations around the world's oceans from 95 separate expeditions and produced the first global survey of carbon distribution in the ocean.

Recent results from the global survey have solved the mystery of the missing carbon sink: the data show that the oceans have taken up approximately 118 billion tons of the CO₂ emitted since 1800, roughly 48% of the total; currently, some 20–25 million tons of CO₂ are being added to the oceans daily, calculates the study, which was published in *Science* in July². Without the ocean sink, atmospheric CO₂ would be much higher and its climatic impacts more severe³. But scientists are now faced with a new question, 'Will the oceans continue to take up almost half of the CO₂ emitted to the atmosphere, even in a warmer climate with changed ocean mixing patterns?' A second global survey and several international research programmes were launched in 2003 to find out.

The oceans have taken up 118 billion tons of the CO₂ emitted since 1800; currently, 20–25 million tons of CO₂ are being added to the oceans daily

Acid ocean?

A second and perhaps more pressing question is, 'How are these higher levels of ocean CO₂ going to affect ocean ecosystems?' Today, there is growing concern that this natural service provided by the oceans may have a steep ecological cost, the acidification of the oceans.

As CO₂ dissolves in seawater, the pH of the water decreases, making it more acidic. Since the beginning of the industrial revolution, the pH has dropped globally by 0.12 pH units⁴.



Experiments in a floating corral (or mesocosm) in this Norwegian fjord help to understand how marine ecosystems will behave in a more acidic environment

While these pH levels are not particularly alarming, the rate of change and the downward trend is cause for concern. To the best of our knowledge, the oceans have never experienced such a rapid acidification. By the end of this century, if concentrations in the atmosphere continue to rise exponentially, we may expect to see changes in pH that are three times greater and 100 times faster than those experienced during the transitions from glacial to interglacial periods. Such large changes in ocean pH have probably not been experienced on the planet for the past 21 million years.

By the end of this century, changes in pH may be three times greater and 100 times faster than during the transitions from glacial to interglacial periods.

Marine ecosystems under threat

Corals, calcareous phytoplankton, mussels, snails, sea urchins and other marine organisms use calcium carbonate (CaCO₃) in seawater to construct their shells or skeletons. As the pH decreases, such as when water is more acidic, it becomes more difficult for organisms to secrete CaCO₃ to form their skeletal material. It is this effect that has marine scientists concerned: since the oceans have never experienced such a rapid acidification, it is not clear how ocean chemistry will change or how ecosystems will adapt.

The penetration of CO₂ into the ocean occurs very slowly but scientists can accelerate this process in the laboratory or in field experiments to study the effects that increasing CO₂ may have on marine ecosystems in the coming decades. One method is to set up floating corrals (mesocosms) in the ocean that encircle natural populations of phytoplankton and to manipulate the CO₂ concentration in the air above the corral to study the effects of varying levels of CO₂ on the ecosystem. Since the lifespan of phytoplankton is of the order of one week, scientists can observe the effects on many generations over a short period of time.

From laboratory and mesocosm experiments conducted to date, almost all calcifying organisms have shown decreased calcification in more acidic environments. This is true for both the smallest single-celled organisms and for reef-building corals. Under such conditions, calcareous phytoplankton, which constitutes part of the basis of the marine food chain, will form thinner skeletons and thus experience difficulties in growth and reproduction. This, in turn, may have profound effects on the marine food web, causing shifts in fish population size or geographic location.

Photos courtesy of Professor Ulf Riebesell, Leibniz-Institut für Meereswissenschaften, IFM-GEOMAR

2. Sabine et al. (2004) *The Oceanic Sink for Anthropogenic CO₂*, *Science*, **305**, 367–371
3. *The cost of avoiding CO₂ emissions is currently US\$40–60 per ton of CO₂ (International Energy Agency Greenhouse Gas Research and Development Programme). By absorbing 118 billion tons of fossil fuel since the beginning of the industrial revolution, the ocean has provided a natural ecosystem service of the order of US\$6 trillion*
4. *The lower the pH, the more acidic the solution. Natural seawater has a range of 7.7–8.2 pH units*

Coral reefs face two challenges from increasing atmospheric CO₂. Firstly, higher CO₂ concentrations in the atmosphere are linked to warmer global temperatures, which in turn lead to warmer water temperatures. Corals are very sensitive to temperature change: a 1–2° C change in local temperature above their normal summer maximum can lead to a phenomenon called ‘bleaching’, whereby the corals expel their vital algal symbionts (algae which live in symbiosis with the coral), leaving the coral tissues translucent. In 1998, a single bleaching event led to the loss of almost 20% of the world’s living coral. Corals can recover from these events but repeated episodes are likely to weaken the coral ecosystem, making them more susceptible to disease and causing a loss of biodiversity. The second challenge faced by corals is the increasing acidity of the water caused by higher CO₂ concentrations. Lowered calcification rates affect the reef’s ability to grow its carbonate skeleton, leading to slower growth of the reef and a more fragile structural support, which makes the reef more vulnerable to erosion. By the middle of this century, the estimated reduction in calcification rates may lead to a situation where we are losing more reef area to erosion than can be rebuilt through new calcification.

Higher marine life forms, such as invertebrates and even some fish, may be affected by lower pH environments through acidosis (an increase in carbonic acid in body fluids) leading to lowered resistance, metabolic depression, behavioural depression affecting physical activity and reproduction, and asphyxiation.

While these projections of our future oceans may seem like doomsday scenarios, we will probably never see dramatic, rapid changes. Instead, there will be slow, progressive shifts in the equilibrium conditions of marine ecosystems over many decades. Scientists will be watching for indications that these ecosystem changes are occurring.

Dodging the impacts

Many scientists believe that stabilizing atmospheric CO₂ concentration at 550 parts per million (ppm) may avoid the worst impacts on climate. Atmospheric concentration of CO₂ is currently ~380 parts per million (ppm) and, if no precautionary action is taken, is expected to reach 550 ppm by the middle of this century. Stabilizing CO₂ at 550 ppm will be a global challenge on an unprecedented scale. According to the Intergovernmental Panel on Climate Change (IPCC), the most authoritative source for scientific assessments of climate change, this may not be achieved through emissions reductions alone but rather through a carefully crafted portfolio of actions that also includes investments to develop low-cost, low-carbon or no-carbon energy sources, improvements in energy efficiency and carbon management options. The latter include storing carbon in the terrestrial biosphere (e.g. planting trees, limiting deforestation), or capturing the CO₂ emitted from an industrial source and storing it in geological formations or in the deep ocean. The IPCC is currently assessing these options for their feasibility, efficacy and safety, and calling for more research wherever information is insufficient to make a sound policy decision.

Invertebrates and even some fish may be affected by lower pH environments, leading to lowered resistance, metabolic depression, behavioural depression affecting physical activity and reproduction, and asphyxiation.

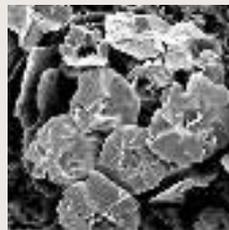
How does phytoplankton react to high levels of CO₂ ?

Today's world
(pCO₂: 280–380 ppm)



Scanning electron microscopy photographs of two calcifying phytoplankton under pCO₂ conditions of today (pCO₂ from 280 ppm to 380 ppm) and under the high CO₂ conditions expected by the end of this century. Experimental results show that increased CO₂ concentrations lead to malformations of calcium carbonate shells

High CO₂ world
(pCO₂: 580–720 ppm)



Calcidiscus leptoporus



Gephyrocapsa oceanica



Scientists participating in the UNESCO symposium were asked to examine the issue of the potential efficiency and ecological impacts of using the ocean purposefully to store atmospheric CO₂. Much relevant research has been conducted in the past decade but the potential effectiveness and risks of ocean carbon sequestration have been neither thoroughly discussed nor assessed. Moreover, the science itself has become trapped in a tug of war between environmental groups and commercial entrepreneurs seeking financial compensation for artificially sequestering carbon in the ocean. Frustrated scientists have asked the IOC to provide a safe-haven

Photos courtesy of Professor Ulf Riebesell, Leibniz-Institut für Meereswissenschaften, IFM-GEOMAR. Adapted and reprinted with permission of Nature (www.nature.com); Riebesell et al. (2000) Reduced calcification of marine phytoplankton in response to increased atmospheric CO₂. Nature 407, 364-367.



Increasing CO₂ and sea temperatures can rapidly change coral reefs from healthy ecosystems (left) into virtual graveyards of bleached and decaying coral (right)

for scientific discussions, free from the influences of special interest groups.

Storage strategies and research requirements

Debate centres on two methods of using the ocean to store excess CO₂. One strategy is to induce and enhance artificially the growth of carbon-fixing plants in the surface ocean. When these organisms die, they sink to the deep ocean, carrying the carbon with them. In many regions, phytoplankton growth is limited by lack of an essential micro-nutrient, iron. Over the past decade, eight small-scale experiments have shown that introducing iron to iron-poor regions can stimulate phytoplankton growth to 20–30 times the natural rate.

Symposium participants agreed that iron fertilization experiments have been, and will continue to be, important for understanding the links between marine ecosystems and the global carbon cycle. However, all available research indicates that iron fertilization would be a very inefficient method for sequestering atmospheric CO₂, both from the viewpoint of the limited amount of carbon that could be sequestered by this method and the likelihood that, even if iron limitations were eliminated, other nutrients and environmental factors would eventually limit growth.

Another method of ocean carbon sequestration is to capture CO₂ from industrial sources, compress it into a liquid and store it in natural reservoirs out of contact with the atmosphere, such as deep geological formations or the deep ocean. Many important questions remain about the efficiency and impacts of injecting liquid CO₂ into the deep ocean and experimental data are extremely limited. The efficiency of this method would depend on the location and depth of the injection, since the goal is to keep the injected CO₂ out of contact with the atmosphere for as long as possible, while minimizing environmental damage around the area of the injection. Reproducing the temperature, pressure and the biological communities found in the deep

ocean in a laboratory is extremely difficult. Carrying out small-scale experiments *in situ* in the deep ocean is no simple matter either, often requiring the use of deep-sea remotely operated vehicles or special instruments that must be lowered to great depths from a research vessel.

To further complicate matters, several attempts to perform experiments *in situ* have been blocked by environmental groups over concerns that these experiments represent the first step towards industrial-scale dumping. This has been a very divisive issue within the scientific community itself, with many strongly opposed to ocean carbon sequestration, even to the extent of suggesting that the community should not pursue research on the subject.

Unfortunately, because of the ocean's large natural capacity to store CO₂, ocean carbon sequestration will continue to interest commercial companies, some of whom may attempt to promote this technique without regard for potential environmental impacts. Symposium participants agreed that, even in the face of strong ethical opposition, investigations into the technical and economic feasibility of implementing this mitigation strategy are likely to continue. The international scientific community must be ready to respond accurately and without bias to questions of potential environmental impacts, long-term efficiency or benefits of this technique, weighing ocean carbon sequestration against other options and the critical need to stabilize atmospheric CO₂ at a concentration that will avoid the majority of impacts on human life and welfare.

Keeping watch

The ultimate objective of the UN Framework Convention on Climate Change is 'to achieve stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system.' Whereas 'dangerous anthropogenic interference with climate' has been widely discussed, no such debate has taken place over acceptable oceanic CO₂ levels. As a result, there are no standards to apply to judge what oceanic CO₂ levels should be considered tolerable for marine life or how proposed carbon management strategies might moderate or exacerbate effects on ocean chemistry and biology.

The IOC will maintain its Watching Brief on ocean carbon sequestration science and will continue to bring together the international and intergovernmental scientific community to develop unbiased policy-relevant scientific information for use by scientists, policy makers and the general public.

Maria Hood⁵

Read the report of the symposium and the IOC Watching Brief :<http://ioc.unesco.org/iocweb/co2panel/>

5. UNESCO-IOC Programme Specialist

Multimillion dollar **water project for Iraq**

UNESCO is to launch a 15-month project in October which will lay the groundwork for a National Water Resources Master Plan for Iraq. The project benefits from US\$3.3 million in funding and comes in response to an urgent request from the Iraqi Ministry of Water Resources.

One of the highest priorities of the new Iraqi government is to rehabilitate the water planning sector. The government considers water security a prerequisite for food and health security, environmental sustainability and socio-economic reconstruction and development. The political situation has, however, deprived the country of the qualified personnel and technical and institutional capacities to attain this objective.

Consequently, the UNESCO project provides for technical training in integrated water resources management. The courses will be run from Amman (Jordan) and Cairo (Egypt), in co-operation with the UNESCO Chair on Wadi Hydrology, University of Jordan and Groundwater Research Institute in Cairo. A second component entails training mid-level and senior officials and experts to formulate, implement and monitor water projects. The project also makes provisions for rehabilitating the training and research centre in the Ministry of Water Resources, in collaboration with higher educational institutions in Iraq. Pilot and research projects will be launched to enable Iraqi water specialists to employ their newfound skills in assessing the country's water problems. The Iraqi specialists will then use their findings to design follow-up projects.

Iraq stretches over 437 072 km², of which 4 910 km² is made up of water bodies. Compared to Jordan, Israel or the Gulf States, Iraq has abundant water resources. According to the United Nations' *World Water Development Report* (2003), the total renewable water resources available per capita per

year amounts to 3 287 m³. Good-quality subterranean water has been found in the foothills of the mountains in the northeast of Iraq and along the right bank of the Euphrates.

Water resources are not spread evenly across the country. Average annual rainfall is estimated at 154 mm but ranges from less than 100 mm in the south to 1 200 mm in the northeast. There is only one river basin, Shatt Al-Arab, formed by the confluence downstream of the Euphrates and Tigris rivers into the Persian Gulf. As much as 90 % of the lakes and marshlands in the lower Tigris–Euphrates has been lost over the past three decades.

The Global Environment Outlook reported in 2000 that groundwater was rapidly deteriorating in Iraq because the water volumes withdrawn far exceeded natural recharge rates. The traditional *Afalaj* systems, which tap into aquifers using gravity-fed underground conduits, have greatly suffered as a result.

In terms of food and health, Iraq is 'slipping back'. Between 1990 and 1992, 1.2 million Iraqis were suffering from undernourishment. By 1999, this figure had doubled. Iraq will have a growing population to feed in coming years; some 41% of Iraq's population of 24 million is less than 14 years old and the population is growing at an annual rate of 2.86.

Iraq has a long history of irrigated agriculture that dates back to the Great Mesopotamian civilization of the Tigris and Euphrates rivers. Today, about 11.5 million ha of land is cultivable. However, the FAO estimates that only 5.5 million ha was under cultivation in 1998, partly due to soil salinity and fallow practices. As much as 64% of cultivated land was irrigated in 1998. Although much of the population is currently dependent on food rations, Iraq's agricultural sector has great potential for supporting economic growth and job creation.

The joint WHO–UNICEF *Global Water Supply and Sanitation Assessment 2000 Report* found that safe water supplies reached 96% of urban areas and 48% of rural areas in 1995 and that 93% of the urban and 31% of the rural populations enjoyed access to sanitation. Yet the International Red Cross/Crescent Society and Christian Relief Fund have noted that these facilities were badly damaged in the 2003 war, a situation which could trigger widespread misery.

A second goal of the UNESCO project is to stimulate regional dialogue on the shared management of the Tigris and Euphrates rivers between Iraq and the other riparian states, Turkey, Syria and Iran. Both rivers originate in Turkey. A Joint Technical Committee on Regional Waters set up in 1980 by Turkey and Iraq to discuss water matters met for the last time in 1992. There have been tensions in the region since Turkey embarked upon a scheme in 1977 to construct 22 dams and 19 hydraulic power plants within its Southeastern Anatolia Project.

UNESCO will be familiarizing Iraqi experts with international norms governing shared water resources and encouraging all four riparian states to exchange water-related information and data on ongoing and planned projects for the shared rivers. Armed with this and a projection of the demand for water for each of the riparian states, the four



Rice planting in Kufa, central Iraq. Agricultural water withdrawals account for 52% of total renewable water use in Iraq

neighbours should be well-equipped to negotiate a regional framework that ensures the rivers are used equitably.

The UNESCO project falls within the Strategic Plan of the United Nations Assistance Mission for Iraq and is funded through the United Nations Development Group Iraq Trust Fund, one of two – together with the World Bank Iraq Trust Fund – which make up the International Reconstruction Fund Facility for Iraq. The Facility was set up at the International Donors' Conference for Iraq in Madrid (Spain) in October 2003 to help donors channel funding and co-ordinate support. At the conference, donors pledged US\$32 billion over a four-year period.

For details, contact: (in Egypt) Radwan Al-Weshah: weshah11@yahoo.com; and (in Jordan): r.fukuhara@unesco.org.jo

A strategic plan for Afghanistan's universities

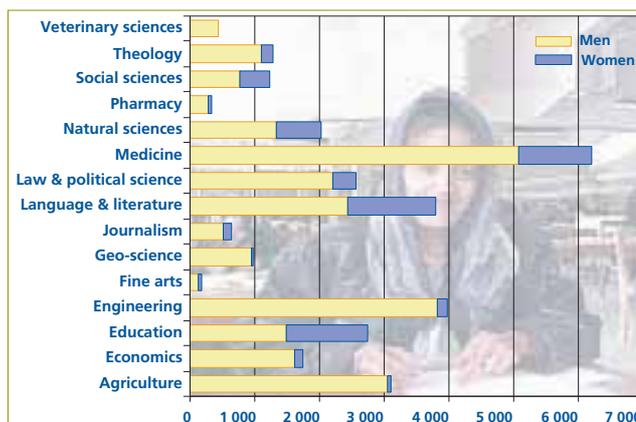
A strategic plan for developing higher education was unveiled at the University of Kabul on 5 July by UNESCO's Director-General. Prepared by a team of experts from the Afghan Ministry of Education and UNESCO's International Institute for Educational Planning (IIEP), the 146-page plan covers the full spectrum of reform, spanning the institutional structure of universities and questions of governance, recruitment and retention of staff and students, the relationship between teaching and research, management, finance and even the procurement of equipment, land and textbooks.

The report notes a current lack of 'geographical equity', which sees some of the country's 17 institutions of higher



A reputed institution in the Soviet era, the Kabul Polytechnic Institute was in a sorry state in August 2002, its corridors strewn with debris. A year after these photos were taken, 1 625 men and 51 women enrolled in the Institute's three faculties of construction, geology and mining, and electro-mechanics. Kabul's four tertiary institutions concentrate half the country's students. The Strategic Action Plan suggests that Kabul Polytechnic could become a Technological Institute offering degrees at all levels and that Kabul University, which has faculties of agriculture, engineering, geology, natural sciences, pharmacy and veterinary science but no faculty of medicine, could merge with the Kabul Medical Institute

Afghan students in 2003 by discipline and gender



Source: Afghan Ministry of Education/IIEP (2004) Strategic Action Plan for the Development of Higher Education in Afghanistan

education located in the same city or close to one another and the remainder spread sparsely around the country. To maximize resources and deter brain drain, the report recommends a policy of consolidation, whereby the regional universities of Balkh, Herat, Kandahar, Khost and Nangahar would be strengthened and encouraged to specialize, and several new institutions envisaged for the under-served southern region concentrating just 1.5% of Afghan students.

Institutions are currently at very different stages of development, the report notes; the University of Kabul counts 14 faculties, for example, but Kandahar University has only three. The rarity of some faculties across the country logically translates into low enrolment in some fields of study. For example, of the 31 200 students across the country in 2003, only 329 were enrolled in pharmacy (1 faculty), 430 in veterinary science (2 faculties) and as few as 72 in computer science (no specific faculty). The highest proportion of students was enrolled in medicine (nearly 20%), followed by engineering, languages and literature, then agriculture.

The report recommends establishing a national system of credentials and credit points to facilitate student movement between universities; it also calls for the development of an electronic network to oil the wheels of scholarly pursuits, including joint research programmes and the link-up of libraries. Measures are proposed to facilitate the access of women to higher education, such as by giving priority to women to attend institutions close to home or the introduction of protected women's dormitories on-campus and on-campus kindergartens. In 2003, barely one-fifth of students were female; in two extreme cases, those of Khandahar and Khost Universities, there were no female students at all.

The team notes two main problems with regard to research. Firstly, Afghan universities conduct very little. Secondly, the tradition established under the Soviet era created a clear division of labour, with the Academy of Science performing research while teaching remained the reserve of universities. Today, half of the research positions

at the Academy of Science remain vacant and, of the 180 academic staff, only 10% have a doctoral degree and a further 40% a Master's degree.

The report recommends a tit-for-tat approach, whereby universities would combine the functions of teaching and research and the Academy of Science's research staff would contribute to teaching in the universities.

Research capacity would be enhanced through the creation of an Afghan Research Foundation, which would set priorities. Both university professors and members of the Academy would be entitled to apply to the Foundation for research funding. Discipline-oriented working groups consisting of academic staff from both the universities and the Academy of Science would conceptualize and negotiate collaboration between the two institutions.

Read the report: www.unesco.org/iiep/

Two years to **assess global agriculture**

An ambitious assessment of the role agricultural science and technology play in development was launched on 3 September at UNEP headquarters in Nairobi (Kenya). Although driven by science, the exercise will have the ultimate goal of informing policy on the future of the agricultural sector. Co-sponsored by FAO, UNDP, UNEP, UNESCO, the World Bank and WHO, the assessment benefits from US\$10.8 million in funding and is expected to take two and a half years.

The six participating organizations will undertake one global and five sub-global assessments of Latin America and the Caribbean; North America and Europe; Sub-Saharan Africa; Central and West Asia and North Africa; East and South Asia and the Pacific.

With more than 840 million people affected by chronic hunger and undernourishment, the assessment will look at how agricultural knowledge, science and technology can reduce hunger and poverty. It will also assess how science and technology used in agriculture facilitate development that is equitable and environmentally, socially and economically sustainable.

Several hundred natural and social scientists from the agricultural sector will participate in designing and implementing the different assessments. This expert work will be complemented by analyses of the history of agriculture and by future-oriented studies which should help us to learn from the past and to conceive plausible scenarios for the next 25–50 years.

The assessment will be guided by a Bureau made up of 30 government representatives and 30 stakeholders from the agricultural and rural development sectors. The Bureau will bring together consumers, governments, NGOs, the private sector, producers, scientists and international agencies to share their views and experiences.

An intergovernmental process launched in Nairobi by 45 governments and 70 inter- and non-governmental organizations, the assessment will kick off with the nomination of experts by governments. Conceptual meetings will take place in the coming months, followed by a series of technical meetings at which scientific evidence will be compiled and analysed.

The different functions of the Secretariat will be divided among the World Bank, UNEP and UNESCO.

For details : www.agassessment.org

Asian journalists learn to report the **science of HIV/AIDS**

According to commentators, one major achievement of the World AIDS Conference in Bangkok (Thailand) last July was to put Asia on the HIV map. Although infection rates are still low in comparison to Africa, even a small increase in Asian countries with a high-population density could spread HIV/AIDS rapidly. Asian media therefore have a crucial role to play in improving public awareness and in ensuring HIV moves up the news agenda. But journalists from Southeast Asia participating in a UNESCO workshop from 6 to 14 July cited media stigmatization of people with HIV and lack of information as problems in their countries.

The third in a series co-organized with the Science and Development Network⁶, the UNESCO workshop covered such topics as microbicide research and vaccine clinical trials. After four days' training at Bangkok's Asian Institute of Technology, the 16 print, television and radio journalists from Cambodia, China, Vietnam, Thailand, Myanmar, Malaysia, Indonesia and the Philippines then used their new skills to cover the AIDS Conference.



Some of the 16 journalists who participated in the Bangkok workshop to improve their skills in reporting on HIV/AIDS

6. www.scidev.net

Adults living with HIV/AIDS in Asia

Source: WHO estimates; population data from UNESCAP

	Total population 2002 (in millions)	Prevalence of HIV/AIDS among adults (%) *
Cambodia	13.5	2.6
China	1 284.9	0.1
Indonesia	211.1	0.1
Malaysia	24.5	0.4
Myanmar	52.2	1.2
Philippines	79.5	<0.1
Thailand	62.8	1.5
Vietnam	79.9	0.4

* Estimates cover both adults who are seropositive and those who have developed full-blown AIDS, all of whom were alive at the end of 2003

Asian journalists face a lack of specific training, according to those who attended the course. 'Few journalists in my country have the necessary skills for specialized science reporting, for digesting scientific data and breaking it down into everyday terms', commented one participant. Yet good reporting on treatments for HIV/AIDS, prevention and research is effective in combating stigma and overcoming taboos.

Participants in the workshop particularly appreciated the introduction to web resources on HIV scientific research and data. The workshop provided 'very practical tools and detailed skills that can instantly improve the quality of HIV/AIDS science reporting', concluded one trainee.

UNESCO will be holding the next workshop in the series in French-speaking Africa in 2005. Earlier workshops trained women journalists from Southern and East Africa, in Kampala (Uganda) in April 2003, and journalists from South Asia in Chennai (India) in November 2003.

Stella Hughes⁷

Download the Multimedia Training Kit containing an open-access training module developed from these workshops:
www.itrainonline.org/itrainonline/mmtk/

UNESCO and WMO join forces to combat flood damage

With the number of people vulnerable to floods expected to mushroom to 2 billion by 2050, out of a projected world population of 9 billion, UNESCO and the WMO have decided to join forces.

The fruit of two years' planning, their new Joint International Flood Initiative will strive to limit flood damage by promoting a more integrated approach to flood management that blends the scientific, operational and

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educational aspects. The social response to flooding has also been incorporated; it covers such areas as advising the public on how to minimize risk or ensuring that rescue operations are able to work unimpeded.

A concept paper was drafted in July by the Task Team composed of three UNESCO and three WMO members. The initiative will develop management tools for flood-prone lands (floodplains) and aim to make forecasts more reliable. It will also strive to improve management of urban floods and the community response to these. Since floodplains are usually highly productive areas, the partners will also be developing strategies for adapting to floods and for maximizing the benefits that can be drawn from them.

The concept paper proposes five guiding principles. The first is 'living with floods'. This recognizes that, while it is not possible to eliminate floods completely, their negative impact can be minimized. The second principle advocates interdisciplinarity, the third a community-based approach in which individuals and communities directly affected by floods are empowered to deal with these through collective decision-making. The fourth principle reasserts the importance of international co-operation for effective flood management, particularly in transboundary watersheds. Last but not least, all areas of scientific knowledge will be harnessed every step of the way, including knowledge drawn from economic and social sciences. Among the new technologies the initiative will be calling upon are those in the field of information and communication. Each activity will involve research, training, information networking, networking for good governance and technical assistance.

So why this growing human vulnerability to flooding? For one thing, extreme weather events are becoming more frequent: from six in the 1950s, the number of devastating floods has climbed steadily, to seven in the 1960s, eight in the 1970s, 18 in the 1980s and 26 in the 1990s. Rising sea levels are in turn causing river levels to rise. Climate variability is another factor. Moreover, the destructive power of floods is being compounded by deforestation and population growth in flood-prone lands.

It was deforestation and the presence of settlements within the floodplains of rivers and in other low-lying areas which were largely responsible for the extent of desolation on the island of Hispaniola last May when torrential rains caused two rivers along the border between Haiti and the Dominican Republic to burst their banks. The floods claimed over 3 300 lives.



A house on the road to Prague (Czech Republic) after floods devastated Central Europe in August 2002

One billion people, the majority of whom figure among the world's poorest inhabitants, are thought to live in the potential path of a 100-year flood. Floods are the most destructive type of water-related disaster. Between 1991 and 2000, more than 665 000 people died in 2557 natural disasters, 90% of which were water-related. From 1971 to 1995, floods affected more than 1.5 billion people. More than 81 million were left homeless. Asia is most at risk, some 228 000 people having perished between 1987 and 1997 in floods that caused economic losses of \$136 billion.

The idea of a joint UNESCO/WMO programme on floods was first raised by the Intergovernmental Council of UNESCO's International Hydrological Programme (IHP) in June 2002. The Council recommended setting up an intergovernmental joint committee on floods to govern the programme. The proposal was welcomed by the WMO, which liaised with UNESCO to establish a joint Task Team in April this year.

The Team was assisted in drafting the concept paper by the United Nations University's new Environment and Human Security Institute and by the International Association of Hydrological Sciences. The United Nations, International Strategy for Disaster Reduction will be invited to collaborate on the initiative, which will achieve outreach through members of the scientific community, civil society, private sector and insurance industry.

The IHP Council approved the concept paper in Paris (France) in September. The WMO's Commission for Hydrology is due to do likewise in Geneva (Switzerland) in October. The initiative will then be announced to the technical community in London, Ontario (Canada), in December at an international workshop on water and disasters. The official launch will take place at the United Nations World Conference on Disaster Reduction in Kobe (Japan) in January 2005.

The Public Works Research Institute in Tsukuba (Japan) has offered to host a small secretariat to manage the day-to-day running of the initiative.

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The ICTP turns 40

The Abdus Salam International Centre for Theoretical Physics (ICTP) celebrates its 40th birthday on 4–5 October with a two-day conference featuring presentations by some of the world's most distinguished scientists, including six Nobel Laureates. The conference will include a roundtable discussion on opportunities for doing science in developing countries.

Over the past 40 years, some 100 000 scientists from 170 nations have passed through the Centre's doors. They have come for varying lengths of time to do research and



ICTP school and workshop on dynamic systems in August 2001

attend activities in the core areas of physics, including high energy physics and condensed matter physics, and mathematics, as well as in such related fields as astrophysics, fluid and plasma dynamics, geophysics, optics, soil physics, synchrotron radiation, and weather and climate. The ICTP sponsors a one-year diploma programme for promising students from the world's least developed countries. In addition, scientists affiliated with the Centre participate in its sponsored off-campus activities both in Italy through the Training in Research in Italian Laboratories Programme and in all regions of the South through the External Activities Programme.

Continual advances in science in the developing world have made the ICTP's task both easier and more difficult; the South is no longer homogeneous, meaning that the Centre can no longer follow a 'one size fits all' strategy.

As the ICTP turns 40, what then is its strategy? Kathepalli Sreenivasan, the ICTP's Director, believes that 'the Centre will no doubt continue to encourage and support individual scientists. However, while the Italian government has been generous in its support of the ICTP, the Centre has neither the physical space nor financial resources to welcome every needy and deserving scientist. So it must nurture strong partnerships with like-minded centres of excellence everywhere, particularly in the developing world, and, at the same time, encourage governments in the South to build new regional centres of scientific excellence based on the example of the ICTP. We should also work closely with the ICTP's UN sponsors – UNESCO and the International Atomic Energy Agency (IAEA) – as well as others to pay more attention to infrastructure, such as fast Internet connectivity and access to scientific literature'. He concludes that 'the ICTP must move beyond its support of individual scientists and lend its considerable prestige to efforts for institutional changes in developing countries. And it must do all of this while remaining true to its enduring principle that scientific progress depends most of all on scientific integrity and pursuit of excellence. These are its core values'.

For details: www.ictp.trieste.it

Osman Benchikh

'The age of renewables has now begun'

With global oil consumption expected to rise by 2.5 million barrels a day this year, largely due to China's growing needs, and with oil production struggling to keep up with demand, last June's conference on renewable energies in Bonn could not have come at a better time.

In his opening remarks, German Federal Minister for the Environment Jürgen Trittin declared that 'the age of renewables has now begun'. Germany has been the undisputed world leader in wind energy since the early 1990s, solar energy being dominated by Japan. In Bonn, Germany reaffirmed its determination to help countries of the South adopt clean forms of energy by pledging to add a further US\$500 million per year for five years in interest-free loans to the US\$1 billion announced two years earlier at the World Summit on Sustainable Development – almost as much as the World Bank. This spectacular initiative is one of many commitments to renewable energy made in Bonn by individual countries, including the Philippines and China, evoked below.

But should we rejoice at a declaration adopted by 154 governments which contents itself with noting the targets individual countries have set themselves rather than fixing any financial targets? Responsible for renewable energy at UNESCO, Osman Benchikh has his own views on the subject.

Neither the escalating price of oil⁸, nor the problems linked to its geostrategic importance seems to have caused an 'electroshock' in the international community in Bonn. Does that make the conference only a semi-success?

Bonn may yet prove to have been a milestone in the history of renewable energy. Representatives of 154 countries, including 120 Ministers and several Heads of State, sat down in Bonn to discuss renewable energy issues. In that sense, the conference did meet its objectives by raising public awareness. Bonn has shown that the international community is now seriously considering renewable energy as a rational and credible alternative. This growing awareness has led the international community, and the developed countries in particular, to make a firm

commitment to renewable energy in recent years. In Europe, wind power grew by more than 35% annually between 1996 and 2003; last year, the photovoltaic sector grew by 33%. Today, the European renewable energy industry has a turnover of 10 billion euros and employs 200 000 people.



Osman Benchikh

It is true that the final outcome of the Bonn Conference – the political declaration – is weak. Concrete commitments are still missing and it sets no targets. I do believe, though, that the history of humanity is a fairly long process and that some countries are simply not yet ready to make a more ambitious commitment.

If I may go back for a moment to the World Summit on Sustainable Development, in order to set targets, the Summit identified five key areas for sustainable development: water, energy, health, agriculture and biodiversity. Two years on, what are we saying? That energy is a key component of development and that, if countries are serious about sustainable development, be they developing or developed, they have no choice but to consider renewable energy as an essential element of sustainable development. The very act of organizing this conference, which has drawn a massive participation by government representatives, makes it a success in my eyes.

Could some of those countries which are not yet ready to commit be thinking of nuclear power as an alternative to oil?

I don't think so. In any case, as much as 56% of oil is absorbed by transportation and you can't propel a plane with nuclear power – at least for the time being. Even if electric buses and cars do exist, they remain a rare sight because they can only operate over short distances.

Don't forget that the technology and use of nuclear energy call for know-how and capital that remain accessible to only a small number of industrialized countries.

8. The price of oil had already climbed to over US\$40 a barrel by the time the Bonn conference took place. By 20 August, it was nudging towards US\$50, a 50% increase since the beginning of the year

Would you say that it was largely the developing countries which set an example in Bonn? I am thinking of China, which committed in Bonn to using renewable energy for 10% of its needs by 2010. China has of course also ratified the Kyoto Protocol.

With a galloping economy, China needs to consume a lot of energy. It is indeed very significant that China should have committed to using renewable energy for 10% of its needs. After all, one in five human beings is Chinese.

In my opinion, we shouldn't link the development of renewable energy systematically to the Kyoto Protocol, even if it is true that mastering energy is the first step towards protecting the environment. If, for the developed countries, renewable energy represents an option for the future which will enable them to diversify their sources of energy, protect the environment and possibly avoid conflicts and tensions linked to the quest for energy, it remains only one of several options.

For the developing countries, on the other hand, it is their only option. That is a big difference. It is their only option at this time if they are to access a minimum of comfort and modernity. Thus, there is a 'converging antagonism' here, with North and South sharing complementary interests.

For the countries of the South, the environmental issue is important but I must stress that there are other priorities for these countries which are equally urgent, if not more so. Nothing is more urgent than giving a minimum of energy to those who have none at all and who unfortunately represent more than one third of the world population.

If renewable energy is so important for the South, why does the World Bank finance renewable energy 20 times less than gas, oil and coal?

The World Bank is first and foremost a bank and a bank acts in its own interests. When making an investment, a bank will endeavour to ensure a return on that investment.

I don't think we should be guided by a purely economic approach. That eclipses any form of solidarity. I am pleased to see that the European Investment Bank has decided that half of the loans it issues between now and 2010 will go to renewable energy.

I should stress that the World Bank is increasingly financing renewable energy projects, further proof, if such were necessary, of the economic viability of renewable energy.

For you, what is the 'ideal' threshold which rich and poor countries should target in terms of renewable energy use?

I don't think there can be an identical threshold for all countries. Even if we confine ourselves to the developing countries, we have to distinguish between those which enjoy fairly good electrification and those which do not. For countries with a large population not connected to the electricity grid, renewable energy represents the most valid option today. African countries are a case in point. In Africa,

circa 72% of the population lacks access to electricity. This proportion can only increase, given that the continent's population is growing faster than the grid's outreach. As I said, for those countries with a large population deprived of the grid, 40% electrification using renewable energy would be an appropriate threshold in my view.

In this connection, I should like to cite the example of the Government of the Philippines, if I may. The government has set itself the goal of raising the share of renewable energies in the total energy capacity by 100%, to 4 700 MW, or around 40% of national energy consumption, by 2013.

As for Europe, the target fixed in 2002 of doubling the share of renewable energies in the European Union energy sector to 12% by 2010 strikes me as a realistic objective. Towards 2050, I think renewable energies should represent a share of around 40% of the energy sector in the industrialized countries.

It could be useful to establish viable scenarios for the medium and long term for the optimum use of renewable energy. An independent group could reflect on the question, in order to define and propose the best energy future possible for our children and their children.

Are you suggesting creating a panel on energy, in much the same way the UNDP and WMO set up the Intergovernmental Panel on Climate Change in 1998?

UNESCO tabled just such a proposal in Bonn. The Organization joined the German Minister of Education and Research in organizing a Science Panel, which consisted of an entire day devoted to science, research, development and human resources. The proposal to create an expert panel to advise and orient States on energy figured among the day's conclusions.

The same Ministry has committed to financing a second UNESCO proposal for the setting-up of an 'open university' on renewable energy. This virtual university would function via existing centres in the North and South. As lead agency, UNESCO will be launching the initiative next year, hopefully with other partners.

I am convinced that these twin initiatives will garner the support they need to get off the ground. During the current wave of consultations of the National Commissions for UNESCO conducted by the Director-General, the regions consulted thus far, namely Africa, Latin America and the Caribbean, and Asia and the Pacific, have all proposed that renewable energy be one of the priorities for the Organization's next Programme and Budget covering 2006–2007.

This leaning towards renewable energy is nothing new. Since its inception, UNESCO has been a pioneer in promoting and developing renewable energy. As far back as the 1950s, UNESCO advocated developing arid zones within a programme by the same name, through the use of renewable energy in general and wind and solar energy in particular.

Interview by Susan Schneegans

For details of the Bonn conference: www.renewables2004.de

The solar school

Alassane Agalassou is one of 26 technicians, engineers and project personnel designated by their governments or institutions to take part in this year's edition of UNESCO's annual summer school organized over a three-week period every July. This year's theme was Solar Electricity for Rural and Remote Areas. In tandem with a series of regional workshops, these annual 'schools' on solar electricity are helping to train skilled personnel, boost public awareness and promote relevant energy policies.

Over the past 15 years, over 500 trainees have 'graduated' from the summer school. They have gone on to become trainers themselves in more than 50 countries situated mainly in Africa but also in Europe and beyond, including Bolivia, Brazil, Canada, Colombia, Germany, Guatemala, Lebanon, Turkey and Vietnam.

Alassane Agalassou is employed by the Agency for the Development of Rural Electrification and Domestic Energy (AMADER) in Bamako (Mali) to give peri-urban and rural populations better access to modern electrical services, such as home lighting, refrigeration, television and radio. 'AMADER is facing the vital challenge of bringing modernity and hope to the majority of Malians through its decentralized electrification programme', Agalassou explains. 'You must understand that, in my country, only about 10% of the 11 million inhabitants live in communities with electricity'.

Agalassou intends to use his new knowledge of the economic and technological aspects of solar photovoltaic conversion to design and implement projects that will improve living conditions and health by making food production and conservation more efficient and more hygienic in a country where temperatures can soar into the forties.



Electrical cabling of solar panels and the installation of solar systems by participants as part of practical field-work organized by UNESCO in Bamako (Mali) in 2003

© Osman Benchikh/UNESCO

The summer school targets men and women with technical or university training who are involved directly or indirectly in decentralized electrification using solar energy. The training programme covers both theoretical and applied aspects of solar energy conversion and is taught both by experts and by representatives of industry and specialized institutions.

Initially, the summer school included visits to research centres, industries and installations in France only. Since 1992, the financial and practical support of external partners has made it possible to venture as far afield as Belgium, Germany, Spain, Italy and Morocco for a series of technical visits which last a week on average. The remainder of the course is taught at UNESCO Headquarters in Paris.



Participants learning to use sizing software to determine the exact energy needed for a given project, during a one-day practical session at this year's solar school

© Osman Benchikh/UNESCO



Practical training to assess solar radiation and simulate a solar installation. This session was organized at the CDER in Morocco during the 2001 summer school

What is solar energy?

Solar electricity is the result of the photo-electric (or photovoltaic) effect discovered in 1839 by the French physicist Edmond Becquerel. Photovoltaic cells convert the luminous energy of the sun into electricity. Most of the solar cells used are actually made of silicon.

Photovoltaic cells produce a voltage of approximately 0.6 volts (V) which is not dependent on the surface of the cell, unlike the electric current produced. To obtain a higher voltage, cells are linked up in a series to make a module which is the sum of the individual cells. The modules produce an unbroken current, the standard voltage for a commercialised module being 12 V. Depending on the installation needs, the modules can be connected in series to obtain a higher voltage. The most frequent voltages used in photovoltaic installations are 12 V, 24 V and 48 V. In general, the power produced by the modules is expressed in Watts (W), which corresponds to 10 W, 50 W, 75 W or 120 W for the commercialized ones.

In the early 1960s, solar conversion took off thanks to spatial applications. Since then, solar energy has expanded to include such applications as rural and decentralized electrification, water pumping and health and telecommunications; in other words, it goes everywhere the electricity network does not.

At isolated sites, the average cost of a complete solar installation (including batteries for storage) varies between 15 euros (excluding TVA) per Watt (for power of 1.5–2 kW) and 40 euros per Watt (for 200–400 W).



© Osman Benachikh/UNESCO

Solar-powered refrigerator used to conserve vaccines in health-care centres in rural and isolated areas. This technology was one of the subjects of this year's solar school

Modules à la carte

The course is structured by modules to enable specialists from different fields to choose the lecture of interest to them *à la carte*. Decision-makers, energy managers and others are thus able to choose whether they participate in a specific aspect of practical work, in a technical visit or in a given roundtable discussion.

Mahamat Oumara from Tchad is grateful to have refined his knowledge of photovoltaic technologies. But for him, the contacts he has made through the summer school are equally valuable. His only regret is that, 'if we had better equipment in our own laboratories to test essential materials, we could do a better job of spreading the technology.'

'One of the greatest obstacles to developing renewable energies in our countries', Oumara adds, 'is the dearth of relevant information at all levels. This affects not only decision-makers and users but also those engineers and technicians who lack the necessary know-how. The local rural population would benefit from well-trained project managers', he notes. 'Good project management extends a system's lifespan and leads to cost-savings, not to mention better use and maintenance of the systems once these are installed. Similarly, a good engineer will design a better project and thereby increase the chances of attracting funding. He or she will also tailor the system better to the needs of the end-user, which can translate into cost-savings for the rural population'.

Demystifying solar energy

Along with three other French industrialists, René Desserrières of French Solar Manufacturers Photowatt has lectured at the school for the past three years. 'We always know about 20% of students,' he says 'which can make for animated discussions about existing installations and component parts between manufacturers and users, who really get down to the nitty-gritty.'

Desserrières explains that the summer school is an excellent complement to other training activities which are more closely linked to specific projects. 'The UNESCO course is given in another spirit,' he says. 'It aims at a higher level of engineer and technician. Despatched by their countries or a local or regional institution, these young people will eventually play an important role in designing and implementing rational energy policies, hopefully avoiding the errors of the past when it comes to planning and project management in particular. The summer school promotes a realistic approach which debunks the myths and demystifies solar energy'. He observes that, 'Both sides need to treat one another like partners. Some experts in developing countries regard us as nothing more than the suppliers of a technology they would like to see transferred without delay.'



Using a platform to simulate a solar system in 2002. This training platform was developed by UNESCO in collaboration with the French agency, ADEME

© Osman Benchikh/UNESCO



Participants visiting a small solar power station on one of several technical visits organized in Spain during the 2001 summer school on the same theme of 'solar electricity for rural and remote areas'

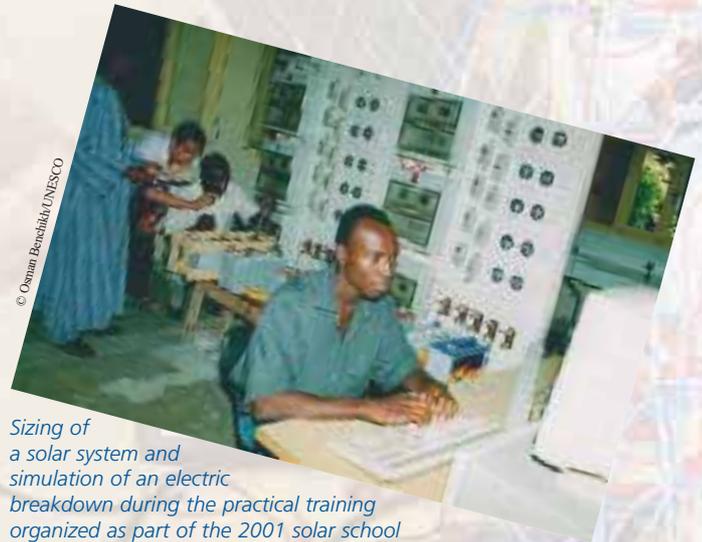
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For Desserrières, the manufacture of photovoltaic cells remains too sophisticated and costly to transfer. 'Nevertheless,' he relativises, 'developing countries can produce other components and, by developing solar electricity, reap 80% of the benefits, create jobs and improve the standard of living in their rural communities.'

Many regional institutions send engineers and technicians to UNESCO's summer school. These include the Centre for the Development of Renewable Energies (CDER) in Algiers (Algeria) and the National Centre for Scientific and Technical Research (CNRST) in Rabat (Morocco). 'For our higher level people,' says Abdelaziz Bennouna, head of the renewable energy laboratory at CNRST, 'the course is excellent from many points of view; it keeps us abreast of what is going on in the field, we meet key people, form contacts with top-level faculty members and, last but not least, meet specialists from other regions'.

People are in the market for energy

Almost two billion people in rural Africa and elsewhere still lack access to basic electrical services. 'It is very sad to see, in this new millennium, most of the rural population in the developing world still using candles and petrol lamps', laments Bennouna. He regrets the lack of technological autonomy in even those countries which use and apply renewable energies on a massive scale. For Bennouna, 'solar cells and silicon are unfortunately not going to be produced and manufactured in the foreseeable future. The industrial process for solar cell production



Sizing of a solar system and simulation of an electric breakdown during the practical training organized as part of the 2001 solar school

© Osman Benchikh/UNESCO

calls for high technological know-how and sophisticated technology that needs a large market to be profitable and economically viable. '

'This said', he adds, 'enormous progress has been made. In some countries today, solar system components are being locally manufactured, commercialized and even exported. In Morocco for instance, solar systems are sold in the market-place by local merchants along with fruit, spices and other goods. Mentalities have changed. People are now in the market for energy; they are purchasing their own 'solar kits' in much the same way they would buy a television set or refrigerator. This is one way in which solar technology is trickling down to the end-user and becoming a household name'.

Osman Benchikh

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Who needs maths at a time like this?

Mathematics may be central to daily life in the 21st century but how many people realize, each time they use a telephone or credit card, listen to a compact disk, drive a car or board a plane, that it is mathematics that makes these apparatus work? Similarly, when people invest in the stock market, check the weather report or admire a work of art, are they conscious of an association between these actions and mathematics? Adults have been heard to proclaim, with a certain degree of pride, that mathematics baffles them. The mathematical support systems of objects and processes that are part and parcel of our daily lives are simply 'invisible' to the person in the street. To show that mathematics is not only indispensable to daily life but can also be fun, a team led by UNESCO has designed a travelling exhibition entitled *Experiencing Mathematics*, which began its world tour last July. Countries everywhere are being encouraged to sign up.

In the aftermath of the terrorist attacks on the USA of 11 September 2001, an Internet forum was inspired to ask, 'Who needs maths at a time like this?' A maths teacher from the State of Ohio came up with this answer, 'Rescue workers digging people out of the rubble of collapsed buildings must be able to calculate how much force they can apply at what angle, in order to lift blocks safely. They must be able to predict which buildings are about to fall and where... Doctors and nurses must be able to calculate how much medicine to give each person in relation to body weight and other factors. They must be able to figure out



Need to move a heavy load? One method involves placing a board on top of two logs. The circular cross-sections of the logs allow these to roll smoothly. The same can be said for rollers whose cross-sections are other figures with constant width, as demonstrated by the non-circular logs above

how many litres of blood the injured need and how much of the supply has already been used...'



Ever wondered why manhole covers are round? A square cover can fall into a square manhole of the same size. This is because the diagonal of a square is longer than the length of its sides. Conversely, a round cover cannot fall into a round manhole of the same size because a circle is of constant width. In other words, the distance between any two parallel lines which are tangent to the circle is constant. Thus, there is no danger with a round manhole of its slipping into the bowels of the city sewers, perhaps taking a pedestrian with it...



The cradle pinball device consists of a board mounted on a curved base which allows the board to tilt in two possible directions. The board has a reservoir at one end for holding balls, pins placed at equal intervals along horizontal lines going towards the opposite end of the board and compartments at the opposite end. A gate holds the balls in place in the reservoir. When the device is tilted in the direction of the compartments and the gate is opened, the balls roll down. The pins are placed at angles, so that a ball rebounding from a pin as it rolls down has equal chances of falling to the left or right of a lower pin. The device can effectively demonstrate several probability distributions; it applies the same principle, for example, as the lottery game of lotto, in which players choose a series of numbers at random in the hope of winning a prize if their sequence comes up

Turning to the fourth civil aircraft hijacked on the same day three others destroyed twin towers in New York and burrowed a hole into the Pentagone (the US Ministry of Defence), the teacher pursued, 'The passengers on [that fourth] plane made a horrible calculation; they decided to crash their plane in a field, rather than take the chance of hitting something bigger and killing thousands of people when the hijackers reached their target.' Close to three thousand people died that day. How many more lives would have been lost, had people not been able to use their knowledge of mathematics?

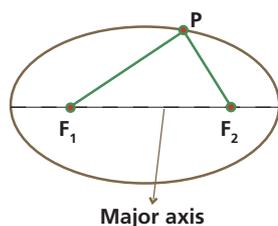
Converting the 'mathophobics'

Ask most people what they think of mathematics and they tend to answer 'boring and difficult'. Mathematics is as unpopular as ever. It has become a monster for many people, a mathophobia, as William Dunham puts it in his book *The Mathematical Universe*. Some people tell of having been turned off by just one bad teacher. Others blame their failure to grasp mathematics on genes. While the fault may not always lie with teachers, they do need to think more deeply about how they present mathematics to their pupils.

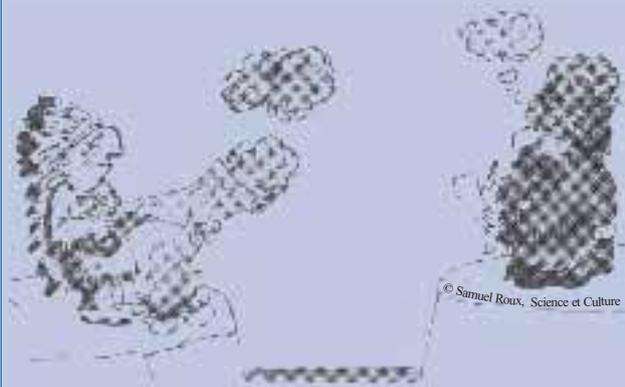
At an expert meeting on Science and Technology Education held jointly last June by UNESCO and the American Association for the Advancement of Science, UNESCO's Director-General underlined the disturbing decline in interest among young people for mathematics, physics and chemistry, as well as all areas of engineering. 'These trends, if not reversed', he cautioned, 'will have dire consequences in the future for capacity-related aspects of development, especially in developing countries.'

This worrying trend should be of concern to both rich and poor countries. The *Guardian* newspaper in the United Kingdom published an alarming 180-page report on mathematics education on 24 February of this year. *Making Mathematics Count* describes the catastrophic, crisis-level shortage of qualified maths teachers and the drastic decrease in student numbers studying maths in UK schools, colleges and universities. It calculates the cost of averting the crisis at £100 million (150 million euros) per year. The report describes a vicious circle, whereby few pupils enjoy maths lessons, inciting few to study maths at university, leading to low numbers of maths graduates and a dearth of well-qualified, enthusiastic maths teachers who will, in turn, be incapable of motivating their pupils.

Here, we have an elliptical pool table, as opposed to the classic rectangular-shaped pool table. When the player hits the ball F_1 with the cue, the ball will rebound from the table frame to hit the other ball, F_2 . This is because the elliptical table makes use of the ellipse: in the diagram on the right, we have a conic section with two foci F_1 and F_2 , such that, for any point P on the ellipse, $\overline{PF_1} + \overline{PF_2} = \text{the length of the major axis}$



Secret codes and cryptography



Most people tend to associate the word *code* with a means of transmitting secret messages. Until the 1940s, this was in fact what codes were used for. A transposition code was used by the Spartans (of present-day Greece) as early as the 5th century BC. The code employed a device called a scytale, which consisted of a staff of wood around which a strip of parchment was wrapped. The secret message was written on the parchment down the length of the staff. The parchment was then unwound and sent. The disconnected letters made no sense unless the parchment was rewrapped around a staff of the same diameter.

Julius Caesar used a substitution code in which every letter of the message was replaced by the letter three places further down in the alphabet. During the Middle Ages and Renaissance (ca 11th–17th centuries AD), complicated codes were used in the papal court and in the courts of the European kings.

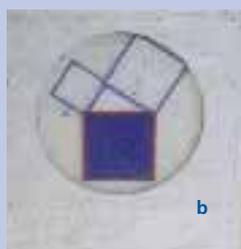
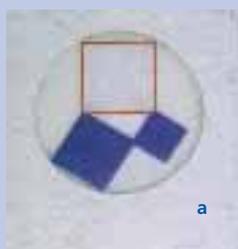
The course of the First World War (1914–1918) was changed when the British deciphered the code used in a telegram from the German Foreign Minister, Arthur Zimmerman, urging the Mexican President to invade America. America subsequently abandoned its policy of neutrality and joined the war on the side of the Allies. Broken codes were to decide the outcome of many battles in the Second World War (1939–1945).

With the phenomenal increase in electronically transmitted information and the extensive development of communications technology, code has come to be understood as a means of translating information into well-defined sequences of symbols for accurate (error-correcting codes), efficient (compression algorithms) and secure transmission (cryptography, through encryption). In the 1960s, when computers became more powerful and more affordable, a problem of standardization arose; America's National Bureau of Standards subsequently developed a standard encryption system, the Data Encryption Standard, which adopted a version of a code created for the company IBM by German emigré, Horst Feistel.

Pythagoras's Theorem

The Greek Pythagoras (6th century BC) was one of the most influential figures in mathematics of his time. He founded a religious community whose philosophy can be summed up in the motto 'All is number'. The Pythagoreans believed they could uncover the secrets of the universe and bring themselves closer to the gods by understanding the relationships between numbers. They developed a substantial body of mathematical knowledge which they kept to themselves, much like a secret society.

One of their most important discoveries is Pythagoras's Theorem: they demonstrated that the square of the longest side of a right-angled triangle (the hypotenuse) is equal to the sum of the squares of the other two sides: $A^2 + B^2 = C^2$. Although the theorem is attributed to Pythagoras, it was known to the Chinese and Babylonians one thousand years earlier; however, whereas the Chinese and Babylonians knew it only for the right triangles they had encountered, Pythagoras was the first to demonstrate its truth for all right triangles.



In this model, the dimensions of the squares are determined by the Pythagorean Theorem. The two smaller containers are filled with water (a). As the circular base rotates, the

water flows from the smaller containers into the larger one, filling it exactly when the smaller two are empty (b).

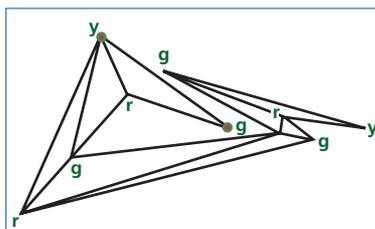
Experiencing mathematics

True to its tradition of promoting international cooperation in mathematics, UNESCO has put together an international mathematics exhibition that will travel to various cities around the world in coming years. The project is being implemented by a working group led by UNESCO and bringing together mathematicians from universities, research institutions and science centres.

Realized by the Science Centre in Orléans (France), Experiencing Mathematics targets children and youth between the ages of 10 and 18, but also their parents and teachers. It features posters and interactive devices placed on nine tables. The experiments are organized around themes which cover everything from shapes in nature, tiling and symmetries, and filling a space, to secret codes and cryptography (see p. 17). One of the manipulative models illustrates the Pythagorean Theorem (see box). Others include the square drill, the cradle pinball device (see diagram p. 16), the tricycle with square wheels, a tree that plays music and the chaotic clock.

Initially, the touring exhibition is being presented in English and French. Its maiden voyage took it to Copenhagen (Denmark) for display on 4–11 July, on the occasion of the 10th International Congress of Mathematics Education (ICME10). The exhibition is currently travelling to France for a formal launch in December and month-long run at the *Maison des Métallos*, in co-operation with the City of Paris. Among the many countries that have expressed interest in hosting or reproducing the exhibition are Canada, Ecuador, Finland, Ghana, Italy, Mexico, Russia, South Africa, United Arab Emirates, USA and Zambia.

Applications to host the exhibition at other venues around the world will be reviewed by the UNESCO-led project working group. The plans for individual exhibition items, and the design of these, have been placed on the Internet to reduce the cost of reproduction. Moreover, all host countries are welcome to add objects and models that would be more representative of their own cultures while remaining true to the mathematical themes of the exhibition. The exhibition organizers are currently seeking financial and technical support to raise funds for countries keen to host the exhibition but unable to cover all costs themselves.



Imagine you have been assigned the task of ensuring the security of the art gallery on the left. How do you assign a coloured light to each vertex (or angular point) of the ten-sided gallery (or decagon), so that, whatever colour of lights are turned on, the entire interior of the decagon will be illuminated?

To find the answer, partition the decagon into triangular regions by drawing diagonal lines. Then assign colours to each vertex in such a way that, in each triangle, the three vertices will have different

colours. You can colour the vertices by using only three colours in such a way that any pair of adjacent vertices has different colours. You now assign the colour of the light set up at each vertex according to the colouring of the vertices. Since each triangle has three different colours on its vertices, each of the triangular regions will be illuminated when a light of any colour is switched on. Therefore, turning on all the lights of any one colour will light up the entire interior of the art gallery. The model shown here is based on the proof of the Art Gallery Theorem

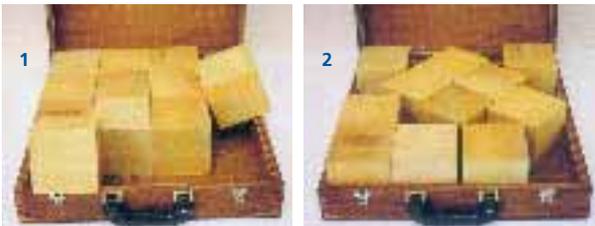


Spirals abound in nature. Here, we have an example of a chambered nautilus, a type of mollusc. A snail's shell is another example of a spiral structure in nature, as are whirlpools, hurricanes and systems of stars in the galaxies. The ammonite, a fossil dating back 300 million years, has a spiral structure. Spiral patterns can also be observed in fruits and flowers. As with our shellfish, the seeds of some fruits, petals of some flowers and leaves of some trees always divide up according to what is known as the Fibonacci sequence of numbers: 1, 1, 2, 3, 5, 8, 13, 21, 34, 55..., where each number after the second is the sum of the two numbers that precede it. Besides its expression in nature, the Fibonacci sequence can be used to analyse stock prices or win combinatorial games.... applications that would have been far from the mind of Leonardo of Pisa (Italy, ca1180–1250) when he discovered the Fibonacci sequence all those centuries ago. At the time, Leonardo of Pisa was attempting to solve a problem on the growth of a rabbit population: how many pairs of rabbits can be produced from a pair of rabbits in a year, if it is assumed that, every month, each pair begets a new pair, which from

*the second month on becomes productive? Leonardo of Pisa was not the first to be intrigued by spirals. The Greek Archimedes discovered a particular spiral in which the distance between successive coils was constant, an observation he recorded in his work *On Spirals* (ca 225 BC)*

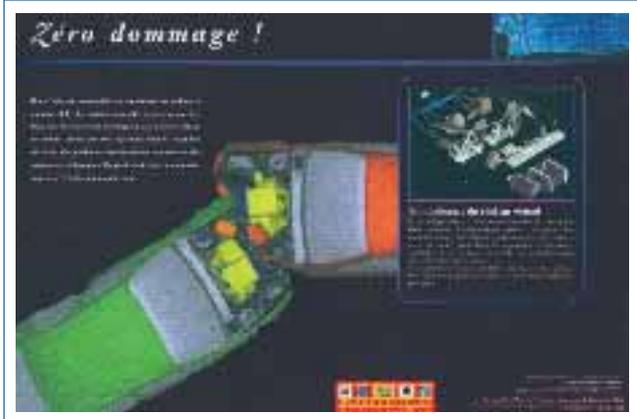
There is no place in the world for ugly mathematics

The exhibition draws inspiration from two successful Japanese and French initiatives organized in 2000. The first was a Mathematical Art Exhibition during the 9th International Congress on Mathematical Education (ICME9). Prof. Jin Akiyama, Deputy-Director of the Research Institute of Educational Development at Tokai University (Japan), had this to say about the event. 'This exhibit celebrates the beauty and the power of mathematics through artistic objects that demonstrate mathematical concepts and formulas, and through models and devices that offer the audience opportunities to experiment, to discover, to gain fresh insights into mathematical truths... We hope the exhibit will bring the audience a sense of wonder and a new appreciation for mathematics'. Akiyama quotes mathematician G.H. Hardy, 'A mathematician, like a painter or a poet, is a maker of patterns... The mathematician's patterns, like the painter's or poet's, must be beautiful; the ideas, like the colours of the words, must fit together in a harmonious way. Beauty is the first test: there is no permanent place in the world for ugly mathematics.'



How often in our daily lives do we encounter the problem of packing things efficiently? Take a look at the suitcases above. How many square boxes with sides of length 1 can be put into a suitcase of sides of length 3.9? Obviously, you can put $3 \times 3 = 9$, as in (1), but a big gap results. It is not so difficult to pack 10 boxes but you can even pack 11 boxes if you do it right (2)

The second influence was one of several activities marking World Mathematical Year in 2000. Led by Prof. Mireille Chaleyat-Maurel, the French Committee for the Year designed and developed a series of posters for display in the underground transport stations of Paris. In 2002, the group



Zero damage, one of the posters displayed in Parisian underground transport stations in 2000. The text on the left reads, 'More and more often in the automobile industry, computer simulations are replacing real-life situation experiments. Engineers are using advanced mathematical methods and sophisticated computers to develop virtual models of cars using mathematical equations. This makes for low-cost vehicle testing'

was awarded the d'Alembert Prize by the French Mathematical Society for drawing public attention to the evolution of mathematics and for showing its connection to contemporary concerns (see *Zero damage* poster).

The exhibition⁹ has been made possible mainly through technical and financial support from the International Commission for Mathematical Instruction, International Mathematical Union, European Mathematical Society, Tokai University (Japan), Japanese Ministry of Education, Université Rene Descartes and Université Pierre et Marie Curie (France), and the Ateneo de Manila University (Philippines).

Minella Alarcon¹⁰

To apply to host the exhibition, contact Prof. Mireille Chaleyat-Maurel of the UNESCO-led working group: mcm@ccr.jussieu.fr

⁹ All exhibits shown here are part of the *Experiencing Mathematics* exhibition, with the exception of the *Art Gallery Theorem* from the ICME9 exhibition

¹⁰ UNESCO Programme Specialist in mathematics and physics; co-ordinator for International Year of Physics beginning in January: www.wyp2005.org

Diary

27 September – 1 October

Hydrology of mountain environments
UNESCO-IHP and UNESCO-MAB/WMO, UNEP, IAHS, MRI, Technical University of Braunschweig, Bavarian State Ministry of Development and Environment etc.
Berechesgaden National Park (Germany):
www.tu-braunschweig.de

6–8 October

Water: a catalyst for peace
2nd intl conf. of UNESCO-IHP/WWAP programme dedicated to shared waters: From Potential Conflict to Cooperation Potential. Will cover co-operative basin management and conflict resolution. Zaragoza (Spain):
www.unesco.org/water/

10–15 October

Bridging space and education

1st in series of sessions in developing countries to promote space education, co-organized by UNESCO and Science Education Institute, Philippines:
y.berenguer@unesco.org

11–15 October

Understanding development strategies for innovation-driven growth models

Awareness-building workshop of S&T Policy Asian Network (STEPAN), co-funded and co-organized by UNESCO Jakarta and S&T Policy Institute of Korea (STEPI): m.nakata@unesco.org

18–21 October

River sedimentation

9th Intl Symposium co-sponsored by UNESCO and IRTCES, covers *inter alia* impact of large hydroprojects, estuarine and coastal works; soil erosion. Yichang, Hubei Province (China): irtces@public.bta.net.cn

18 October – 5 November

Designing sustainable energy systems

ICTP, IAEA workshop. ICTP, Trieste (Italy). Contact B. Stewart: smr1585@ictp.trieste.it

20–22 October

Strengthening the quality and pertinence of policies and programmes for S&T education – a pilot project

Consejo nacional de ciencia y tecnología (CONCYTEC)/UNESCO national workshop. Lima (Peru): www.concytec.gob.pe

10 November
World Science Day for Peace and Development – 3rd edition of Day launched by UNESCO: d.malpede@unesco.org

15–19 November

Co-operation between scientists and educators

Regional CONCYTEC/UNESCO workshop. Lima (Peru): www.concytec.gob.pe

5–7 December

World Academy of Young Scientists

1st General Conference of network, formed under aegis of UNESCO. Morocco: www.waysnet.org; d.malpede@unesco.org

24–28 January

Biodiversity: Science and Governance

Conf. organized by French Ministry for Research and co-sponsored by UNESCO as part of global effort to curb biodiversity loss by 2010. Steering Committee comprised of G8, UNEP, FAO, World Bank, IUBS, IUCN, Diversitas programme, etc. Paris (France). Online registration: www.recherche.gouv.fr/biodiv2005paris; biodiv2005paris@recherche.gouv.fr

New Releases

The Origins of Iron Metallurgy in Africa

New Light on its Antiquity: West and Central Africa
Ed. H. Bocoum. *Memory of Peoples series/UNESCO Publishing*. ISBN 92-3-103807-9, 240 pp. *Exists in English and French*. Until recently, Sub-Saharan Africa was regarded as a mere recipient of iron technology, thought to have come from the Middle East. Sub-Saharan Africa actually invented and developed its own iron metallurgy as far back as the third millennium BC. Here, specialists give a clearer picture of the origins and development of metallurgy in Sub-Saharan Africa, its technological features and the socio-economic and cultural repercussions of this progress.

The Changing Ocean

Its Effects on Climate and Living Resources
By B. Voituriez. *IOC Ocean Forum Series/UNESCO Publishing*. *Exists in English, French and Spanish*. ISBN 92-3-103877-X, 172 pp. The ocean is undergoing perpetual change. Its variations affect the climate, making it necessary for the life sheltered within the ocean to adapt to these changes. For the non-specialist.

Nordic Stone

Edited by O. Selonen and V. Suominen
UNESCO Publishing/LAED/Geological Survey of Finland, ISBN: 92-3103899-0. *English only*, 64 pp. The Nordic countries are famous for granites, soapstones, gneisses and schists, all sustainable building materials; this monograph covers the history and heritage of stone in Nordic countries, describes methods for exploration, extraction and processing and looks at environmental issues in stone production.

Evolution of Village-based Marine Resource Management in Vanuatu between 1993 and 2001

By R. E. Johannes and F. R. Hickey. *CSI papers 15, UNESCO*, 48 pp. *English only*.
Download: www.unesco.org/csi/pub/papers3/vanu.htm or request a copy from Apia: h.thulstrup@unesco.org

...for the young

Community-based Biology

By Anthony J.F. Griffiths. *First in new Bioliteracy Series co-produced by UNESCO Programme on Science and Technology Education and International Union of Biological Sciences via IUBS Commission for Biological Education*. *Written by prominent biologists and biology educators from developed and developing countries*. ISSN 02532069. *English only*, 47 pp. Presents hands-on activities related to the child's neighbourhood, involves parent/teacher/youth leader and child. Children will be weed watching, measuring plant growth, making a plant collection, preserving mushroom spore prints, observing and recording animal behaviour, snail population biology, fungal succession on manure, tree girths, the colonization of rock surfaces in water, etc. Download: www.iubs.org/cbe/; or request a copy via the Editor.

Governing Bodies

At its October session from 4 to 14 October, the Executive Board will be examining a report by the Director-General on UNESCO's contribution to the Joint United Nations programme on AIDS (UNAIDS). UNESCO established an Inter-agency Task Team on HIV/AIDS and Education in March 2002. Composed of all UNAIDS sponsors, bilateral donors, NGOs and experts, the team has published an inter-agency strategy and sponsored both sub-regional training seminars for education ministry staff and strategy papers on relevant issues. In his capacity as current Chair of the UNAIDS Committee of Cosponsoring Organizations (CCO), the Director-General held a CCO meeting in March of this year in Zambia, which saw the launch of 'An AIDS-free Generation in a Generation', a global initiative for HIV/AIDS prevention covering curricula, teacher-training modules, HIV/AIDS workplace policies, education finance mechanisms for orphans and vulnerable children and 'schools as sanctuaries for children'. The UNESCO Strategy for HIV/AIDS Education has been complemented by regional strategies for Europe, Africa, the Arab States, Asia and the Pacific and Latin America.

The Director-General will also be reporting on the UNESCO International Institute for Capacity-Building in Africa, located in Addis Ababa (Ethiopia): www.unesco-iicba.org. The Institute was set up in 1999 to develop networks of teacher-education institutes across the continent.

He will be outlining a plan of action for assessing the impact of the *Universal Declaration on the Human Genome and Human Rights* (1997). This will evaluate five areas: the international scene, national standard-setting sphere, general public information, the education sphere and national capacity-building.

The foregoing will be examined under item 3.2 of the Board's agenda (document 170 EX/5; www.unesco.org/exboard/index.shtml).