United Nations Educational,
Scientific and Cultural Organization

A World of SCIENCE

Natural Sciences Quarterly Newsletter

Vol. 3, No. 4
October – December 2005
1st edition revised

IN THIS ISSUE

EDITORIAL

Not business as usual

The Cuban Ministry of Science and Technology (S&T) and UNESCO are organizing a regional conference on Science, Technology and Innovation for Sustainable Development from 1 to 3 December in Havana. The organizers are deliberately departing from a business-as-usual approach. Rather than aiming for the adoption of a set of recommendations – the more usual outcome of conferences of this kind – they will be putting on the table a series of projects for regional co-operation that participants will be invited to criticize, improve upon and possibly approve. These operational projects will include such areas as disaster risk reduction, science education and science popularization. UNESCO will then assist Member States in identifying project funding. The rationale behind this approach is that projects are an effective way of stimulating intra-regional co-operation in areas of common concern.

UNESCO has long been a proponent of South–South co-operation throughout the developing world. In Latin America and the Caribbean, its Regional Bureau for Science in Montevideo (Uruguay) has been involved in regional projects for technical co-operation for decades. UNESCO has also played a major role in creating regional scientific networks; the two most recent ones were launched in 1998: the network of research and development (R&D) and science programmes in the Caribbean (Cariscience) and the network of R&D for postgraduates in science in Central America (Red-CienciA).

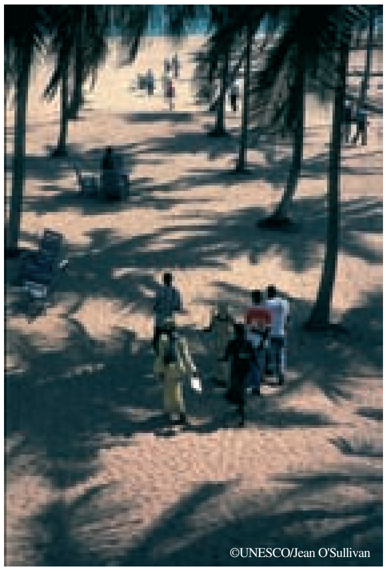
Financial and political instability in recent decades has taken its toll on S&T in Latin America. Today, the region represents 8.3% of the world population and 8.9% of world GDP but just 3.2% of world expenditure on R&D and 2.6% of scientific articles. Countries have come to realize that, if their region is to take its rightful place on the international scene, they are going to have to pull together. That will entail strengthening intra-regional ties.

Latin America and the Caribbean is a highly diverse region. Countries devote from as little as 0.1% to 1.0% of GDP to R&D. Seven states account for 92% of scientific articles published in mainstream journals: Brazil (40%), Argentina and Mexico (a combined share of 20%) and, in equal parts, Chile, Colombia, Cuba and Venezuela.

In the Caribbean, Cuba is a unique case. Contrary to its neighbours, which still hesitate to embrace a 'science culture', Cuba has invested heavily in biotechnologies and is today reaping the dividends. In this issue, we take a closer look at the research situation in both Cuba and the countries of the Caribbean Common Market.

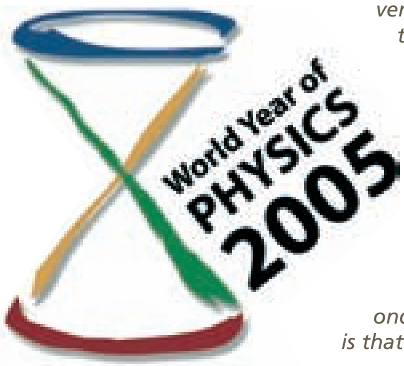
W. Erdelen
Assistant Director-General for Natural Sciences

The miracle of light



There may be more to celebrate in the International Year of Physics than meets the eye. Indeed, the Year marks not only the centenary of Einstein's miraculous year but also the millennium of the founding of modern optics by physicist Ibn Haitham (Iraq, 965–1040). Among a number of major contributions, Ibn Haitham put experimental science on the map by decisively settling the heated debate over the basics of vision, through a remarkable series of experiments. Having pioneered the pinhole camera, he successfully explained sight in terms of light travelling into the eye rather than the other way round. This finally discredited the now absurd emission theory of Plato and Ptolemy[1], effectively rewriting centuries of scientific thought.... Here, we voyage through one thousand years of the physics of light, with a special focus on optics.

The organizers of the International Year of Physics 2005 (originally labelled the World Year of Physics) could hardly have chosen a more elegant logo than a colourful sketch of a light-cone diagram, reminiscent of Einstein's seminal work of 1905. Light-cones, as the famous Oxford physicist Roger Penrose put it, 'represent the most important structures in space-time.' What a light-cone shows is simply how a pulse of light spreads out in space as time passes, just like ripples spread out on the surface of a pond.



The Year of Physics logo: a colourful sketch of a light-cone diagram. The upper-cone is called the future light-cone, showing how a pulse of light spreads out in space (represented horizontally) as time passes (represented vertically). The lower-cone is called the past light-cone and is simply an extension of the future light-cone into the past. There are two basic properties of light underpinning a light-cone diagram. The first is that light travels in straight lines, which was experimentally proven by Ibn Haitham using the pinhole camera 1000 years ago. The second, also proposed by Ibn Haitham, is that light has a finite speed

The reason why light lends itself to such elegant geometry in the first place is because of two basic properties. The first is that light travels in straight lines (ignoring the curvature of space-time), the second that light has a finite speed. These two properties lead us to the 11th century Arab physicist Alhasan Ibn Haitham, more commonly known to the West by his Latinized first name Alhazen, the founding father of modern optics.

Ibn Haitham's light beam

In order to settle the long-standing debate over how vision worked, Ibn Haitham pioneered an experimental set-up of surprising simplicity: the pinhole camera, or *camera obscura*[2], the principle behind all photography from the earliest cameras to modern-day digital ones. His pinhole camera consisted simply of a tiny hole that led to a dark room. He placed several lamps outside the room and observed that an identical number of light spots appeared inside the room on the opposite wall. Upon placing an obstacle between one of the lamps and the hole, he observed that one of the light spots disappeared and, when he removed the obstacle, that the light spot reappeared. Crucially, he observed that each lamp and its corresponding light spot were always aligned perfectly in a straight line passing through the hole.

Thus, using the pinhole camera, Ibn Haitham proved that light travels in straight lines. Further, by observing that light from different lamps did not get mixed up in going through the hole, he drew a parallel, concluding that vision occurred by means of light travelling into the eye and forming an ordered point-for-point image of the visual scene. The pinhole camera was in fact the climax of a series of observations and experiments, which meant that the eye could be studied as an optical instrument. Indeed, Ibn Haitham studied the anatomy and physiology of the eye in great detail, giving many eye parts their present-day names, for instance: the cornea, the lens and the retina.

By defining a beam of light, he was able to describe the propagation of light in a way which perfectly fitted the laws of geometry, highlighting a unique relationship between physics and mathematics. But for him, unlike his predecessors, theory had to be supported by experiment. Therefore,

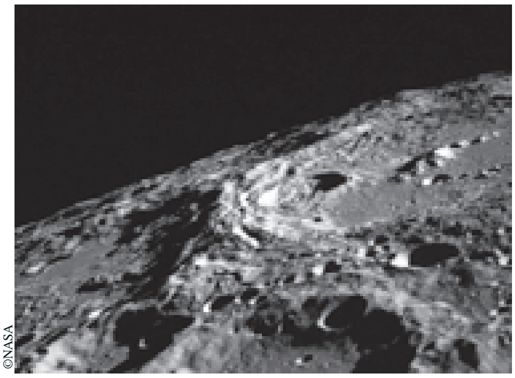
1. *The philosopher Plato (Greece, 427–347 BC) and astronomer Ptolemy (Egypt, 90–168) were both legends in their time. From measuring the position of stars, Ptolemy realized that light is refracted by the atmosphere*
2. Camera *is the Latin word for 'room' and* obscura *means 'dark'*

in order to prove his theories, he invented devices of varied complexity which were designed not merely to test qualitative assertions but also to obtain quantitative results. Regarding the phenomenon of diffuse reflection, essential for understanding vision, he showed by experiment that reflected light from each point on the surface of an illuminated object radiates in all directions in straight lines. In particular, reflected light from a visible object forms a cone of rays with its base at the object and its tip at the eye. This is the principle behind linear perspective, the foundation of Renaissance art. Artists like the Italian Leonardo da Vinci (1452–1519) used linear perspective masterfully to achieve a realistic three-dimensional sense in their paintings. Yet Ibn Haitham's influence on the development of science in Europe was still more profound. Following the revival of logic by Spanish polymath Ibn Rushd (1126–1198), the transmission into Europe of Ibn Haitham's theory of light and vision played a singular role in illuminating the European Dark Ages.

Science through the pinhole camera

Before we turn to the second property of light underpinning a light-cone diagram, let's take a closer look at the impact of the pinhole camera, an invention which has powered centuries of scientific thought. The pinhole camera became a standard method for generations of physicists after Ibn Haitham. Isaac Newton, for example, used it to conduct his famous prism experiment in which he analysed white light into basic colours, 'The Sun shining into a dark chamber through a little round hole in the window-shut and his light being there refracted by a prism to cast his coloured image upon the opposite wall...,' Newton explained in *Opticks* (1704). Referring to his discoveries in optics, Newton wrote in a letter to his arch-rival Robert Hooke, 'If I have seen further, it is by standing on the shoulders of giants.'

Two and a half centuries later, photographs of stars taken from the island of Principe, off the west coast of Africa, provided the proof needed to convince the international scientific community once and for all of the soundness of Einstein's general theory of relativity. Einstein had predicted that light passing near a massive object like the Sun would be deflected by an amount given by his new theory of gravity. The 1919 solar eclipse provided an opportunity for a British expedition led by Arthur Edington to test Einstein's prediction. Edington compared photographs of stars from the Hyades star cluster, seen in the vicinity of the eclipsed Sun, with photographs of the same stars when the Sun was off the visual field. The photographs confirmed the predicted shift in the stars' apparent position, turning Einstein into a celebrity.


©NASA

The Moon's surface. Ibn Haitham showed geometrically that moonlight can only be adequately explained using the phenomenon of diffuse reflection – that is, reflection from a rough surface

Speed of light infinite or finite?

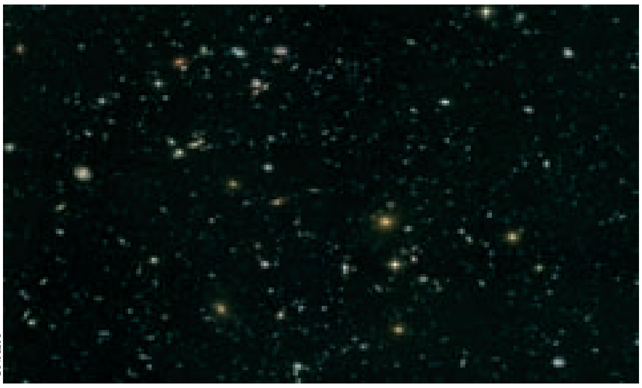
Two of the most fundamental phenomena in optics are reflection and refraction, both of which Ibn Haitham investigated through countless experiments. In explaining refraction (the bending of light as it enters or leaves a denser

How to make a pinhole camera

Simple to make (see below), the pinhole camera helps us understand how light travels. To use the camera, simply point it towards the object you wish to observe and look at the image projected onto the screen of your camera. It is best to observe either a very contrasted or bright light, such as the filament of a lightbulb in a dark room. To avoid being temporarily blinded by the glare, simply follow the example of the first photographers and place a piece of thick, dark cloth over your head. You will see that the image projected onto the screen is upside down, which will tell you that light travels in a straight line.

To make the camera, you need a sheet of thin cardboard measuring 22 cm x 28 cm (for the rectangular body of the camera) and two sheets of waxed paper or a sheet of tracing paper measuring 5 cm x 5 cm for the screen (Step 1). With the help of a sewing needle, pierce a hole 1 mm in diameter in the centre at one end of the camera (Step 2). Once you have glued the sheets of waxed or tracing paper onto the frame of the screen, glue the screen onto the open end of the camera (Step 3).

With the kind permission of Claire Deschênes and Judith Sévigny, CRSNG/Alcan Chair for Women in Science and Engineering (Canada): Opus programme (Useful teaching tools for science/Outils pédagogiques utiles en sciences)


©NASA

This view of nearly 10,000 galaxies by the Hubble Space Telescope is the deepest image of the visible universe ever achieved. Hubble's Advanced Camera for Surveys captured galaxies billions of light-years away, going back to 'within a stone's throw of the Big Bang.' This achievement comes almost 1000 years after Ibn Haitham pioneered the pinhole camera, the principle behind photography

medium), he went against the accepted wisdom by arguing that light has a finite speed, which is the second property of light underpinning the light-cone diagram of the Year of Physics' logo. In a flash of insight, he realized that refraction was caused by the slowing down of light as it enters a denser medium. He characteristically based his proposition on an experimental model.

Quantum Electro-Dynamics (QED), the climax of the quantum revolution which Einstein kick-started in 1905, tells us that light always takes the path of least time in travelling between two points. Within the same medium, this path is simply a straight line. But because the speed of light is slower in a denser medium, the path of least time for light crossing between two mediums is no longer a straight line, causing light to bend. The theory of QED developed by Paul Dirac, Richard Feynman and others fantastically explains a wealth of optical phenomena.

Why does it not suddenly get dark when the Sun sets? The phenomenon of the twilight is so common that one hardly stops to ponder. In his book, the *Balance of Wisdom*, Ibn Haitham calculated on the basis of the duration of the twilight that the Sun is actually 19 degrees below the horizon when the twilight ends, due to the reflection of sunlight by the Earth's atmosphere. In a spectacular feat, he ingeniously used the onset of the twilight to calculate geometrically the approximate height of the atmosphere from the Earth's radius, opening a new chapter in the quest to unravel the mysteries of the universe.

Optics masterpiece

An in-depth analysis of reflection and refraction appears in the second half of Ibn Haitham's masterpiece *Kitab Al-Manazir*, or *Book of Optics*, translated into Latin as *Opticae Thesaurus* – a revolutionary work firmly based on geometry and experiment, reforming the established optical tradition of Ptolemy. Here, Ibn Haitham decisively distinguished the study of optics (both physical and geometric) from that of visual perception, experimentally establishing optics and more generally physics as an independent science. It was in optics, rather than mechanics, that the concept of experimentation as systematic and ordered proof was first born. Ibn Haitham's *Book of Optics* must rank alongside Newton's *Principia Mathematica* as one of the most influential books ever written in physics.

'He was the greatest Muslim physicist and student of optics of all times. Whether it be in England or faraway Persia, all drank from the same fountain. He exerted a great influence on European thought from Bacon to Kepler,' wrote George Sarton in his *History of Science* (1927). There is a unique copy of *Opticae Thesaurus* in the archives of the Institute of Electrical Engineers in London, which once belonged to the celebrated French physicist André Ampère (1775–1836).

Designing the perfect lens

According to legend, Archimedes (Greece, 287–212 BC) set invading Roman ships afire by focusing sunrays onto them using huge mirrors. Whether or not the story is true, the quest to construct a perfectly focusing mirror has inspired much research in optics since antiquity. Ibn Haitham's predecessor, 10th century Baghdadi mathematician Ibn Sahl, redefined the goal of this research more generally as constructing a perfectly focusing optical device. He pioneered the study of the lens, formulating the first geometric theory for lenses. Unfortunately, Ibn Sahl's work was lost for centuries.


©NASA

The lower atmosphere illuminated orange during the twilight. Why does it not suddenly get dark when the Sun sets? Reflection of sunlight by the Earth's atmosphere means that the Sun is well below the horizon when the twilight ends. Ibn Haitham ingeniously used the onset of the twilight to geometrically calculate the approximate height of the atmosphere, using the Earth's radius. Natural phenomena like the twilight interested Muslim scientists for yet another reason. The movement of the Sun across the sky defines prayer times, whereas the birth of the new Moon marks the beginning of each month and determines annual celebrations

Optics: an optimal focus for active learning

UNESCO runs an Active Learning in Optics and Photonics* programme for physics teachers from developing countries. The aim is to equip university and high school teachers better to teach the optics part of the introductory physics course by using active learning and hands-on techniques and by drawing on examples from local research.

Why the focus on optics? Because optics is an area of experimental physics that is both relevant and adaptable to research and educational conditions in many developing countries. Optics has been termed an 'enabling science' because it forms the basis of many modern advances in high technology, such as the laser, optical fibres, photodetectors and sensors. Improving education in optics and photonics education will result in a skilled and well-educated workforce for emerging industries in Africa and elsewhere.

Courses have been run by UNESCO so far at the University of Cape Coast in Ghana, in September 2003 and November 2004, and at the University of Monastir in Tunisia, in April 2005. Each course attracts about 30 participants. The next course is planned for Tanzania in 2006.

The courses are run by a working group co-ordinated by UNESCO which includes UNESCO's Abdus Salam International Centre for Theoretical Physics, the International Society of Optical Engineering (SPIE), Swinburne University of Technology (Australia), the Ateneo de Manila University (Philippines), University of Oregon (Eugene, USA), University of Missouri-St. Louis (USA) and the University of Tunis (Tunisia).

For details: m.alarcon@unesco.org

* *Also known as fibre optics and opto-electronics, photonics is the technology used to transmit, control and detect light (photons)*


©M. Alarcon/UNESCO

Here, young Tunisian university instructors at UNESCO's April workshop are modelling and observing how the eye works, as well as the refractive anomalies of the eye and their correction. They are using different types of lenses supported on an optical bench

However, recently discovered manuscripts of his work, analysed by French historian of science Roshdi Rashed, leave no doubt that Ibn Sahl was the first to discover the elusive sine law of refraction. This makes the law of refraction, together with the law of reflection – first given in full by Ibn Haitham – probably the oldest dynamic laws formulated for nature. Armed with this discovery, Ibn Sahl achieved a centuries-old goal by deriving the geometric shape of a perfectly focusing lens, otherwise known as an 'anaclastic'. What's more, he designed elaborate mechanisms for drawing his lenses and mirrors.

Yet, the basic understanding of lenses took on a whole new dimension after Ibn Haitham launched the study of their visual and magnifying properties with his *Book of Optics*. It was undoubtedly this new understanding of the lens, based on geometry and experiment, which underpinned the craft of the Dutch spectacle-makers (makers of eye-glasses) who, by holding one lens in front of another, invented the first microscope and telescope, two instruments crucial to the subsequent development of science.

Light's dual nature: simply miraculous

Three centuries after Ibn Haitham, the Persian physicist K. Al-Farisi (1267–1319) wrote an important commentary on the *Book of Optics*, in which he set out to explain many natural phenomena. For example, by modelling a water drop using Ibn Haitham's study of double refraction in a sphere, he gave the first correct explanation of the rainbow. Al-Farisi also proposed the wave-nature of light. By contrast, Ibn Haitham had modelled light using solid balls in his experiments on reflection and refraction. Now the question presented itself: is light wave-like or particle-like?

Despite the wave theory of light becoming very dominant by the start of the 20th century, it could not account for certain experimental observations, most notably the phenomenon of the photo-electric effect, the subject of Einstein's first paper of his Miraculous Year. Einstein reintroduced the idea of light particles, now called photons, successfully explaining the photo-electric effect and thus initiating the quantum revolution. We now have to think of light as being wave-like and particle-like at the same time: light's paradoxical wave–particle duality.

In fact, duality was a key concept in Einstein's thinking at the beginning of the last century. In what is considered to be his most important work of 1905, the special theory of relativity, he showed that mass and energy are two aspects of the same thing. Indeed, stars including the Sun shine by converting mass into energy in gigantic nuclear-fusion explosions. Einstein expressed the mass-energy duality elegantly in the famous equation $E = mc^2$, where E is energy, m is mass, and c is the speed of light – a universal physical constant.

Alhazen's Billiard Problem

The recent proof of Fermat's Last Theorem[3], hailed as one of the biggest mathematical triumphs of the 20th century, left perhaps the last of the great problems in classical geometry half-solved: Alhazen's Problem. This mathematical puzzle named after Ibn Haitham has a colourful history dating back to the time of the Greek geometricians. In his *Book of Optics*, Ibn Haitham tackled the problem in terms of optical reflection in spherical, cylindrical and conical mirrors.

It is also known as Alhazen's Billiard Problem, since it can be formulated as 'finding the point on the boundary of a circular billiards table at which the cue ball must be aimed, if it is to hit the black ball after one bounce off the cushion.' Ibn Haitham was the first to find a solution for this geometric riddle, solving it using conic sections. Indeed, mathematics was his passion, with half of all his surviving works on pure mathematics. But Ibn Haitham's mathematical genius is a story for another occasion.

©NASA

Solar explosions. Stars including the Sun, seen here, shine by converting mass into energy in gigantic nuclear-fusion explosions. The mass–energy duality was famously expressed by Einstein as $E=mc^2$, where E is energy, m is mass, and c is the speed of light

The brilliant mathematician Al-Khwarizmi (Iraq, 780–850) is said to have invented algebra while writing a book on how to divide inheritance based on the Quran. Al-Khwarizmi's mission as a mathematician was simple: he set out to make mathematics more systematic. Indeed, the very word 'algorithm' is derived from his name. Successive generations applied algebra to the existing branches of mathematics, giving rise to new mathematical branches. This is why algebra is considered by many as the foundation of modern mathematics.

While it became possible to express geometric problems in terms of algebra, Alhazen's Problem defied an algebraic solution for many centuries. Finally, an Oxford professor of mathematics solved it algebraically one thousand years after Ibn Haitham penned his geometric solution, drawing the curtain over a rich chapter of mathematics in time for the new millennium.

Science's oldest puzzle

Have you ever wondered why the Moon looks much bigger when it is near the horizon? This intriguing phenomenon, known as the 'Moon illusion', is arguably the oldest unsolved scientific puzzle today. A similar effect is observed for the setting and rising Sun. The ancients wrongly attributed the illusion to the magnifying properties of the atmosphere. But is this a physical phenomenon anyway?

Surprisingly, the answer is no. The Moon illusion was correctly redefined by Ibn Haitham as being to do with visual psychology rather than physics. As has been mentioned, this clarity of thinking was key to establishing physics as an independent science. On a slightly different note, there is a famous quote in which Einstein expressed his discontent with the haziness of quantum mechanics by asking a friend: do you really believe that the Moon exists only when you

3. *Pierre de Fermat (France, 1601–1665) would intrigue mathematicians for centuries by scribbling in the margin of his copy of Diophantus's* Arithmetica '*I have discovered a truly remarkable proof which this margin is too small to contain*'. *Fermat claimed to have discovered a proof that the Diophantine equation $x^n + y^n = z^n$ had no non-zero integer solutions for x, y and z when $n > 2$. This came to be known as a 'theorem' on the strength of Fermat's scribbled note, even though no other mathematician was able to prove it for centuries*

©NASA

Two beautifully shaped spiral galaxies in near collision. Since it is gravity which determines the large-scale structure of the universe, many physicists today seem to give special prominence to the laws governing gravity look at it? The Moon illusion gives Einstein's rhetorical question a touch of irony.

One can easily test the Moon illusion by taking pictures of the Moon near the horizon and comparing them with pictures of the Moon near the zenith. Most people are astonished to find that the size of the Moon in the photographs remains almost exactly the same!

A mind-bending explanation for the Moon illusion was given by Ibn Haitham in his *Book of Optics*. First, he proposed what is now called the Size–Distance Invariance Hypothesis (SDIH), basically explaining why an object would appear to be larger if it is perceived to be further away, an effect purely to do with visual processing in the brain. Indeed, most present-day explanations of the Moon illusion are based on some version of Ibn Haitham's SDIH. Second, he explained why the dome of the sky appears flattened; in other words, why the stars near the horizon seem to be further away than the stars directly above. Paradoxically however, most people say that the large horizon Moon actually seems closer; that's why little children are sometimes seen to jump in an attempt to catch it! It is precisely this paradox which many present-day researchers are trying to resolve.

©NASA

Seen from the Moon, the Earth shining 'moonlike'. It is a fitting coincidence that, on the Moon, Alhazen crater lies in the east, whereas Einstein crater lies in the west

The search for quantum gravity

One of the intended goals of the International Year of Physics is perhaps to inspire another paradigm shift, which might well be needed in order to solve the central problem in physics today: finding a theory for quantum gravity. That theory needs to unify quantum mechanics with general relativity (the theory of the very small and the theory of the very large). If we reflect on the last 1000 years of science, comparing Einstein's paradigm shift at the beginning of the 20th century, which established modern physics, with Ibn Haitham's paradigm shift at the beginning of the last millennium, which established physics on experimental grounds, one thing strikes us: the central theme for both was light, not gravity.

Interestingly, many physicists today seem to give special prominence to the laws which govern gravity, since, as famous Cambridge physicist Stephen Hawking explains, 'it is gravity which determines the large-scale structure of the universe.' We can still ask however: does the curious similarity between the paradigm shifts in physics of 100 years ago and 1000 years ago give away any clues about the nature of the paradigm shift which might solve today's central puzzle of quantum gravity?

Over the Moon!

Today, in celebration of Ibn Haitham, who correctly explained the nature of the Moon's surface, a lunar crater has been named after him. Alhazen crater lies near the eastern rim of the Moon's near side (Latitude: 15.9° N, Longitude: 71.8° E). Another lunar crater celebrates Einstein: Einstein crater lies along the western limb of the Moon (Latitude: 16.3° N, Longitude: 88.7° W). It is a fitting coincidence that, on the Moon, Alhazen crater lies in the east whereas Einstein crater lies in the west, beautifully reflecting their birth places back on Earth – Basra in Iraq and Ulm in Germany.

Einstein once said, 'It has always pained me that Galileo did not acknowledge the work of Kepler.' But has the work of Ibn Haitham, which established experiments as the norm of proof in physics, been properly acknowledged? Let's make the centenary of the miraculous year a celebration of one thousand years of physics – from Ibn Haitham to Einstein – and a celebration of light, the universal metaphor for knowledge.

H. Salih, M. Al-Amri and M. El Gomati[4]

The historical content of this article is based primarily on original writings of Ibn Haitham, as well as on the analysis of Roshdi Rashed, recipient of UNESCO's Avicenna Gold Medal.

For details, contact: M. El Gomati: mmg@ohm.york.ac.uk

4. *H. Salih is affiliated to York Probe Sources Ltd at the University of York (UK), M. Al-Amri to the Department of Physics, King Khalid University in Abha (Saudi Arabia) and M. El Gomati to the Department of Electronics at the University of York. All three authors are affiliated to the Foundation for Science Technology and Civilisation (UK). The authors are grateful to those who made valuable suggestions during the preparation of this manuscript, especially David Wilkinson of Central Science Laboratories in York*

Ten years to develop **centres of excellence in Africa**

The African Union (AU), its New Partnership for Africa's Development (NEPAD) and UNESCO are to oversee a programme for developing up to 30 regional centres of excellence on the African continent over the next ten years, at a projected cost of US$3 billion.

The AU has placed the development of a regional network of centres of excellence at the heart of *Africa's Science and Technology Consolidated Plan of Action* adopted by the Second African Ministerial Conference on Science and Technology[5] in Dakar (Senegal) on 30 September.

The concept was also a focus of a Commission for Africa report published in March, *Our Common Interest*, which specifically recommended that AU/NEPAD and UNESCO set up a high-level working group to complete a detailed programme on centres of excellence. The report further recommended that the programme build on the NEPAD mapping of S&T capacity over the past two years.

The report's recommendations were subsequently endorsed by the G8 group of industrialized countries at their July summit in Gleneagles (UK). The G8 committed a total of US$8 billion in funding over the next ten years to Africa's development: US$ 3 billion for a programme to develop a regional network of centres of excellence; and US$5 billion for a programme to revitalize the continent's institutions of higher education.

The Second African Ministerial Conference on Science and Technology decided that the NEPAD Secretariat would establish an AU/NEPAD/UNESCO high-level working group to prepare a comprehensive programme for establishing and funding centres of excellence, in accordance with the Commission for Africa's recommendations.

The Conference also approved the creation of an African Science and Innovation Facility to provide the pan-African mechanism necessary to sustain the networks of excellence and promote technology-based entrepreneurship. Among other tasks, the Facility will mobilize technical expertise and funding for project development and implementation.

The composition of the working group is yet to be decided but the group is expected to identify existing centres of excellence, like the African Biosciences Facility for Central and Eastern Africa hosted by Kenya, and propose new ones in the environmental, physical, medical and social sciences. Developing institutes of technology will be a core part of the programme.

The regional centres of excellence will not only foster endogenous development but also combat the continent's 'brain haemorrhage'. The cost for Africa of recruiting 100 000 skilled expatriates to replace those who leave each year has been estimated at US$4 billion annually.

Centres of excellence will be encouraged to set up the public–private partnerships or innovation hubs that are critical to fostering innovation, entrepreneurship and technology diffusion. They will also be urged to engage with local communities, the government, the diaspora and international partners to ensure that science extends beyond the laboratory into everyday life.

Africa's Science and Technology Consolidated Plan of Action states that 'one of NEPAD's overall objectives is to bridge the technological divide between Africa and the rest of the world'. The Plan lays out a number of specific targets, such as that of doubling 'teledensity' to two lines per 100 people by 2005.

The *Plan* identifies four programme clusters: biodiversity, biotechnology and indigenous knowledge; energy, water and desertification; material sciences, manufacturing, laser and post-harvest technologies; and ICTs and space science and technologies. Within each of these programme clusters, an African network of centres of excellence will be developed. In biosciences, for example, this network will provide overall institutional leadership on cereal-related genomics and proteomics research.

For details: sc.nepad-ldc@unesco.org; www.nepad.org; www.commissionforafrica.org

Time to **regulate deep-sea gold rush**, experts say

Unexplored until recently, the deep seabed is home to organisms found nowhere else on Earth. The enormous commercial and scientific potential of this 'new' stock of genetic resources is sending bioprospectors rushing to one of Earth's last frontiers. In the absence of a specific international regime addressing deep seabed bioprospecting in international waters, a report released on 9 June warns that the deep seabed could be permanently damaged if countries do not agree on ways to regulate access to those parts of the deep seabed which lie beyond national jurisdiction.

Over the past twenty-five years, scientific and technological advances have allowed for new and unprecedented exploration of the oceans. We are now able to reach the depths of the ocean seabed, which is home to unique ecosystems such as hydrothermal vents, cold seeps and seamounts. The extreme environmental conditions in these areas, in terms of pressure, temperature and toxicity, make the organisms inhabiting these ecosystems of growing interest from both a scientific and a commercial point of view. Many have become the object of bioprospecting: the search for

5. *For background on the first of these conferences, see* A World of Science*, January 2004*

Orange-coloured bacterial mat living at oil and gas seeps in the Gulf of Mexico

potentially valuable genetic resources in the Earth's commons.

But there is widespread concern among the international scientific community about the potential for severe and perhaps permanent damage to these unique and sensitive ecosystems. Several patents have already been granted to inventions based on the use of deep seabed genetic resources and compounds based on deep seabed organisms have already been isolated and developed for commercial application. Some are already available on the market and others may soon be commercialized.

The growth in bioprospecting in the deep seabed begs a number of scientific, legal and policy questions. How vulnerable are these ecosystems to human impact? Should access to the deep seabed be regulated, and if so, how? Who should reap the benefits—monetary or otherwise—of these prospecting activities, and how can these benefits be distributed?

Co-authored by Salvatore Arico of UNESCO and Charlotte Salpin of the International Institute for Sustainable Development, *Bioprospecting of Genetic Resources in the Deep Seabed* is published by the United Nations University. It examines the current scientific and commercial explorations occurring in the deep seabed, and offers an in-depth analysis of the relevant legal instruments–and the gaps in these laws.

Bioprospecting in the seabed within territorial limits is currently regulated by the UN Convention on the Law of the Sea, which determines states' jurisdiction, rights and obligations in the oceans, and by the UN Convention on Biological Diversity governing access to genetic resources and benefit sharing.

Whereas most countries have regulations on marine scientific research undertaken in their waters and seabed, only a few have adopted legislation regulating access to, and exploitation of their genetic resources, including marine resources. Moreover, beyond national jurisdiction, these regulations break down, for there is currently no specific international regime addressing deep seabed bioprospecting in international waters. Thus far, no international co-operation has been organized at government level.

Source: http//oceanexplorer.noaa.gov

Large chemosynthetic mussels in the deep sea off the USA's Georgia Coast

An article outlining the report's findings in greater detail will feature in the next issue of *A World of Science*.

Report at: www.ias.unu.edu/binaries2/DeepSeabed.pdf

Fellowships for African physicists

UNESCO has launched the Mori Fellowships scheme to enable 20 PhD candidates per year from Sub-Saharan Africa to finalize their doctoral research at UNESCO's Abdus Salam International Centre for Theoretical Physics (ICTP) in Trieste, Italy. The first 20 Fellows travelled to Trieste in September to begin one of two six-month stints over a period of two years at the ICTP.

The scheme was announced by the Director-General during the visit by President Olusegun Obasanjo of Nigeria to UNESCO Paris as part of celebrations to mark Africa Day on 25 May. President Obasanjo is currently Chair of the 53-member African Union. 'We recognize that scientific research is an area of priority need', the Director-General told the President. 'While there is enormous talent in Africa in this area, the lack of scientific networks both on the continent and with other continents is a major handicap.' The fellowship scheme has been launched to help overcome this handicap.

The ICTP will provide Mori Fellows with research support and training in mathematics and physics, broadly defined to include, for example, climate, fluid dynamics, oceanography and seismology. The scheme is expected to have a multiplier effect by enabling African physics and mathematics students at home to receive expert university instruction from the returning Fellows.

During the 1970s, Sub-Saharan Africa had some of the finest institutions of higher education in the developing world: Dar-Es-Salaam in Tanzania, Ibadan in Nigeria, Khartoum in Sudan and Makerere in Uganda. Decades of neglect, political uncertainty and violence have taken their toll on these institutions and forced a large number of the region's 'best and brightest' to pursue their careers elsewhere. The result has been a chronic crisis in higher education and academic research.

Named after a former Japanese Prime Minister, the Mori Fellowship scheme draws upon a fund established by the Japanese government and has been allocated close to half a million dollars to cover the first two years of operation.

Qualified doctoral or post-doctoral students from Sub-Saharan Africa wishing to apply for the scheme need to fill out an application form detailing their educational background and research interests and accomplishments. A review panel appointed by the ICTP, consisting of scientists from both within and beyond the Centre, will select the successful applicants.

For details: schaffer@ictp.trieste.it; www.ictp.trieste.it

21 projects **help to engineer a better world**

The development projects of twenty one teams of young engineers have won Mondialogo Engineering Awards worth a total of €300,000. The awards were presented in Berlin on 30 May by the two partners in the initiative, DaimlerChrysler and UNESCO.

Over the past year, young engineers from developed and developing countries have been working together on project proposals addressing the UN Millennium Development Goals, particularly those of eradicating extreme poverty and promoting environmentally sustainable development.

The award money of €14,000 per team will help the winning teams to realize their projects. In the category of emergency and disaster response and reconstruction, for example, the winning team of engineering students from Ryerston University in Canada and the American University of Beirut in Lebanon will be deploying an unmanned aerial vehicle (UAV) they have designed for remote-controlled landmine detection. The UAV is due to go to Afghanistan, Cambodia and Lebanon. There are an estimated 110 million functional landmines around the world; these can cost as little as US$3 a piece to manufacture but as much as US$1000 a piece to detect and disarm, at great risk to the demining personnel. The automated UAV is able to move and hover over a minefield. It will clear urban and rural centres of landmines, thereby curbing the number of landmine-related fatalities and injuries and helping countries return to economic stability in the process by reclaiming previously unsafe farmlands and clearing roads. The easy-to-use UAV will also diminish the risk to demining personnel, speed up the demining process and reduce its cost.

Winning designs in other categories include the provision of solar power to health centres in rural areas of Mali by a Germano-Malian team (see photos); a project involving engineers from Myanmar and Singapore to develop a sustainable centralized sanitation system for new townships around Yangon in Myanmar; a plastic waste management system designed by a British-Kenyan team to deal with the substantial quantities of plastic bags affecting the Pumwani environment in Kenya, with the parallel goal of contributing to economic development through product sale; an Americano-Indian project to provide arsenic-free water to remote villages in West Bengal in India; and the treatment and recovery of waste whey in the Palestinian dairy industry, designed by a Canadian-Palestinian team.

This first edition of the Mondialogo Engineering Awards originally involved 412 teams of 1700 young engineers and students from 79 countries, whose projects were examined by an international jury.

For details: www.unesco.org/science/bes; www.mondialogo.org/

©Jobogo Mirindi

Posing solar panels on the roof of a health centre in the Malian village of Mamisan. These panels will be used to generate electricity for lighting and to power an emergency radio. Other equipment provided by the Mondialogo team of young Germano-Malian engineers for village health centres includes refrigeration systems for drugs. It is also possible to link battery chargers to create an additional source of income for the local community. Equipping a health centre in rural Mali costs approx. €8000. Crucially, a learning package comes with the installation; at a solar training centre, villagers learn how to manage and maintain the system

GRASP vows to **curb great ape loss** by 2010

The First Intergovernmental Meeting on the Great Apes Survival Project (GRASP) has adopted a strategy and work plan for protecting the great apes and their habitat. Hosted by the Democratic Republic of Congo from 5 to 9 September and attended by government representatives from all 23 range states, the Kinshasa meeting also formalized the GRASP Executive Council, responsible *inter alia* for liaison with donors.

In point of fact, the meeting produced not one but several strategies adapted to the specific circumstances of each range state or region. Uganda, Indonesia, Ghana, Côte d'Ivoire and Angola each outlined their national and regional great ape survival strategies, underscoring their awareness of the danger of extinction of the great apes. They highlighted the importance of collective action through the GRASP partnership. Many states emphasized that solutions should take into account poverty alleviation in the communities living alongside great apes; others stressed the need for better law enforcement and capacity-building.

The *Kinshasa Declaration* and *Strategy* reflect these concerns. In the *Kinshasa Declaration*, participants set themselves the target of securing a constant and significant reduction in the current rate of loss of great ape populations and their habitats by the year 2010 and securing the future of all species and sub-species of great apes in the wild by 2015.

Fourteen DRC park rangers pose proudly after a training course in Virunga National Park in 1998, home to gorilla and chimpanzee populations. Five years later, all but two of the rangers pictured here had lost their lives in the line of duty. UNESCO is working with local rangers to help improve law enforcement and monitoring in all five of the DRC's World Heritage Sites

As a means to this end, the signatories undertake to ensure the integrity of sites supporting the key wild populations that would conserve the genetic, ecological and cultural diversity of all great apes for all time and to protect these from further degradation and habitat loss. The signatories pledge to ensure interconnectivity of protected areas, such as by establishing corridors where necessary, in order to avoid isolation of protected great ape populations.

The signatories undertake to work with local and indigenous communities to ensure that any human use of habitats is ecologically sustainable and consistent with maintaining healthy, viable great ape populations. This will entail developing ecologically sustainable local poverty-reduction strategies.

The signatories also pledge to 'demonstrably improve' where necessary the quality and enforcement of relevant laws, as well as the capacity of law-enforcement agencies to protect individual great apes and their habitats.

Among the signatories of the *Kinshasa Declaration* were Ministers from Angola, Cameroon, Congo, Central African Republic, Democratic Republic of Congo, Ghana, Guinea-Bissau, Uganda, United Republic of Tanzania, the Ambassador of Côte d'Ivoire and donor countries like the United Kingdom, as well as representatives of the European Commission and of the Central African Forestry Commission (Comifac). Klaus Töpfer and Walter Erdelen signed the *Declaration* on behalf of the GRASP Secretariat run jointly by UNEP and UNESCO.

The meeting was attended by state environment, forestry or tourism ministries and departments from great ape range states, national wildlife and parks agencies, donor government officials and other non-range state representatives, international and local NGOs and representatives of local communities and of the private sector, including eco-tourism and timber companies.

In Kinshasa, Walter Erdelen announced a new initiative in favour of great apes. UNESCO is to award scholarships worth a total of US $100 000 per biennium to young scientists from 16 great ape range states wishing to devote their studies to the great apes, their habitat and the relationship between great apes and local communities. The allocation is administered by UNESCO's Man and the Biosphere (MAB) Programme within its Young Scientists Awards Scheme.

As current funding levels remain insufficient to achieve the declared targets, one the first tasks of the GRASP Council will be to negotiate additional donor funding. In June, the European Union pledged €2.4 million for UNEP's GRASP activities.

To apply for a scholarship: mab@unesco.org;
Kinshasa Declaration*: www.unesco.org/mab/grasp.htm*

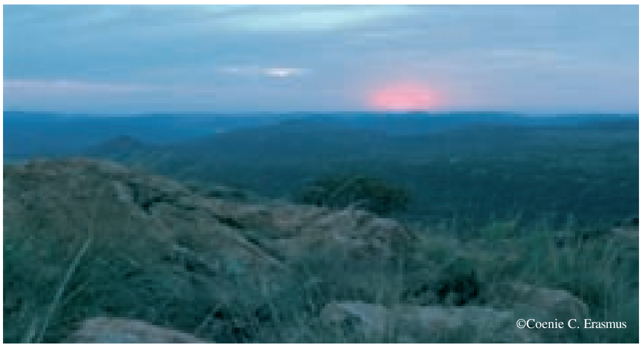
Seven natural sites enrich World Heritage

Vredefort Dome in South Africa is one of seven natural sites inscribed on the UNESCO World Heritage list on 14 July, bringing the total to 160 natural sites and 24 mixed sites of outstanding universal value.

The second new site inscribed by the World Heritage Committee is Wadi Al-Hitan (Whale Valley), in the Western Desert of Egypt, which contains invaluable fossil remains of the earliest, and now extinct, suborder of whales, the archaeoceti. These fossils represent one of the major stories of evolution: the emergence of the whale as an ocean-going mammal from a previous life as a land-based animal with limbs.

The other five sites are Shiretoko Peninsula in Japan; the West Norwegian Fjords Geirangerfjord and Nærøyfjord; a site comprising 244 islands, islets and coastal areas in the Gulf of California in northwestern Mexico; the rugged mountainous area of Dong Phayayen: Khao Yai Forest Complex spanning 230 km between Ta Phraya National Park on the Cambodian border in the east and Khao Yai National Park in Thailand in the west; and Coiba National Park and its Special Zone of Marine Protection off the southwest coast of Panama.

For details: http://whc.unesco.org



Situated 120 km south-west of Johannesburg, Vredefort Dome is the only example on Earth of a full geological profile of an astrobleme (a larger meteorite impact structure) below the crater floor. This is because geological activity on the Earth's surface has led to the disappearance of evidence from most impact sites. Dating back 2023 million years, Vredefort Dome is not only the oldest astrobleme found on Earth so far but also the largest, with a radius of 190 km, and the most deeply eroded. Vredefort Dome bears witness to the world's greatest known single energy release event, which caused devastating global change, including, according to some scientists, major evolutionary changes

New or extended biosphere reserves

BARKINDJI BIOSPHERE RESERVE (AUSTRALIA) North of the Murray River in New South Wales, comprises several important wetlands, home to waterfowl and migratory birds. Local farmers and NGOs promoted it to foster both environmental conservation and sustainable development.

WIENERWALD BIOSPHERE RESERVE (AUSTRIA) On the outskirts of Vienna, a landscape with small hills, thermal springs, watercourses, wet and dry meadows and large-scale forest, as well as extensively farmed open areas. The Biosphere Reserve has 200 000 inhabitants and is the congested capital's principal recreation area.

SERRA DO ESPINHAÇO BIOSPHERE RESERVE (BRAZIL) Covers 3 million ha of the Espinhaço Mountains in the state of Minas Gerais with cerrado and Atlantic forest vegetation. Family agriculture, harvesting of natural resources and popular art contribute to regional economic development; contains 18th century colonial cities like Ouro Preto, a UNESCO World Heritage Site.

SHOUF BIOSPHERE RESERVE (LEBANON) The first in Lebanon, covers about 5% of the country and extends along the ridge of Mount Lebanon's western chain at an altitude of 1000–2000 m; includes 24 villages and two protected areas, Al-Shouf Cedar Reserve and the Ammiq Wetland.

CABO DE HORNOS BIOSPHERE RESERVE (CHILE) In the south next to Cape Horn, comprising marine areas, islands and forested coast. It has very low population density and major potential for tourism.

UTWE BIOSPHERE RESERVE (FEDERATED STATES OF MICRONESIA) The first in Micronesia, has high biodiversity with tropical rain forests, mangrove forest, sea grass beds and coral reefs. The nomination was prepared by Kosrae State communities, which have a long tradition of natural resource conservation through customary laws.

DORNOD MONGOL BIOSPHERE RESERVE (MONGOLIA) In eastern Mongolia bordering China, a sparsely populated temperate grassland and steppe ecosystem, home to some of the largest remaining herds of Mongolian gazelles and to several rare and threatened bird species.

NGAREMEDUU BIOSPHERE RESERVE (PALAU) The first in Palau, South West Pacific, covers a large bay and coastal area with dense mangrove swamps. Marine core areas protect economically important crab, fish and clam species. Populations of three states in Palau prepared the nomination using a community approach.

EL CHACO BIOSPHERE RESERVE (PARAGUAY) Named for the Chaco region's dry forest ecosystems, ecologically diverse but under great pressure to be converted into grazing lands. The Biosphere Reserve designation will also help protect local indigenous communities' homeland and cultural identity.

BIALOWIEZA BIOSPHERE RESERVE (POLAND) (EXTENSION) Adds a vast area to the original site, a national park on Poland's eastern border, a remnant of ancient central European forest with European bison.

KHANKA LAKE (RUSSIAN FEDERATION) One of the largest freshwater lakes in Eastern Asia. The site is composed of wetlands, swamps, steppe and lacustrine areas; also designated a Ramsar site*, particularly noted for its variety of bird and fish species; avoiding pollution from agriculture and industry is a major concern.

SERALI BIOSPHERE RESERVE AND RAIFA BIOSPHERE RESERVE (RUSSIAN FEDERATION) Two units of a future large-scale Biosphere Reserve to be established along the River Volga next to Kazan, a World Heritage city, with innovative arrangements for regional land and water resources management.

THE DELTA DU FLEUVE SÉNÉGAL TRANSBOUNDARY BIOSPHERE RESERVE (SENEGAL AND MAURITANIA) The second Transboundary Biosphere Reserve in Africa, covers a mosaic of deltaic and coastal ecosystems at the mouth of the River Senegal that forms the international border. One of the most important sanctuaries in West Africa for migratory birds, it comprises five Ramsar wetland sites and two World Heritage sites, including the city of Saint Louis. Co-ordinated sustainable management of the river is a central issue for the two countries.

ALTO DE BERNESGA BIOSPHERE RESERVE, LOS VALLES DE OMA_A Y LUNA BIOSPHERE RESERVE AND LOS ARGÜELLOS BIOSPHERE RESERVE (SPAIN) Three new units of a large-scale Biosphere Reserve that will encompass the entire sparsely-populated Gran Cantabrica mountain range in northern Spain; the project aims to provide an 'umbrella' enabling co-ordination of land uses to ensure conservation of large rare mammals such as wolf and bear while favouring quality ecotourism and responsible industry.

AREA DE ALLARIZ BIOSPHERE RESERVE (SPAIN) In Galicia, is particularly important for cultural values and sustainable land-use enabling local flora and fauna conservation. Adjoining sites are expected to be nominated soon, to connect the area to the future Gran Cantábrica Biosphere Reserve.

GRAN CANARIA BIOSPHERE RESERVE (SPAIN) Covers 40% of the island, including entire water catchment basins from the top of the island's mountains through valleys used by agriculture to beaches and finally to marine areas. The site is likely to be extended to include additional areas in the near future.

SIERRA DEL RINCON BIOSPHERE RESERVE (SPAIN) Close to Madrid, characterized by pine and oak forests, rocky hillsides and valleys with pastures and a large variety of species associated with a long history of agriculture and cattle raising; a major challenge is to revive the dwindling economies of the small villages to enhance natural and cultural values.

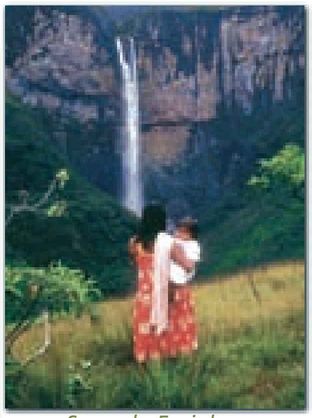
BUNDALA BIOSPHERE RESERVE (SRI LANKA) Southeastern area marked by lagoons, inter-tidal mud flats, beaches, sand dunes, grasslands and forests; an important bird sanctuary and Ramsar site since 1991, home to elephants, sea turtles, flamingos and rare black-necked storks.

KRISTIANSTAD VATTENRIKKE BIOSPHERE RESERVE (SWEDEN) In densely populated southernmost Sweden around the town of Kristianstad, surrounded by agricultural lands, forests and water meadows of international importance for bird life; innovations to avoid conflict of interests have been sparked, such as the 'Haymaking project', in which a local farmer developed new equipment to harvest hay even in very wet areas; a pilot site for fostering economic and human development.

CAMILI BIOSPHERE RESERVE (TURKEY) In the Karçal Mountains on the border with Georgia, is home to brown bear, wolf and lynx and incorporates a significant bird migration route; this first Biosphere Reserve in Turkey will generate income opportunities for inhabitants of its six villages (e.g. organic agriculture, honey production, ecotourism).

MOUNT ELGON BIOSPHERE RESERVE (UGANDA) On the Kenyan border, in a major regional water catchment area critical for the livelihoods of local communities; discussions are ongoing to unite the site with the existing Mt Elgon Biosphere Reserve in Kenya, forming a potential Transboundary Biosphere Reserve and facilitating cross border co-operation.

Ramsar sites are areas recognized as Wetlands of International Importance under the 1971 Ramsar Convention promoting their conservation and wise use



Serra do Espinhaço Biosphere Reserve (Brazil)

23 new Biosphere Reserves

Twenty-two new sites in 17 countries, as well as one transboundary site shared by Senegal and Mauritania, have been added to the World Network of Biosphere Reserves of UNESCO's Man and the Biosphere (MAB) Programme, bringing the network to 482 sites in 102 countries. The Bialowieza Biosphere Reserve in Poland has also been extended.

The additions and changes to the World Network of Biosphere Reserves were approved by the Bureau of MAB's International Co-ordinating Council between 27 and 29 June at UNESCO Headquarters in Paris. In addition, the MAB Bureau discussed a change in zonation of the Dunaisky Biosphere Reserve (Ukraine). The Bureau has requested more information from the Ukrainian authorities on the controversial project to construct a navigation canal across the Danube Delta, designated as a Transboundary Biosphere Reserve with Romania.

For details: www.unesco.org/mab; mab@unesco.org

Saudi Arabia gives boost to Palestinian higher education

The Saudi Committee for the Relief of the Palestinian People committed US$15.2 million on 14 September to a UNESCO programme for the benefit of Palestinian universities and students in need. The programme is to be implemented immediately out of UNESCO's office in the Palestinian city of Ramallah.

The programme will provide direct financial support to all Palestinian universities and to Palestinian students in need enrolled in those universities and in leading post-secondary colleges. The Saudi grant will also be used to assist the Palestinian Ministry of Education and Higher Education in creating a student aid system.

Some 25% of young Palestinians were enrolled in the universities of the West Bank and Gaza in 2003, compared to a 15% average for the Arab region. The number of students enrolled in the 11 universities, four university colleges and 24 community and technical colleges in the Palestinian Territories more than tripled between 1995 and 2003 to 136 000.

For details: www.unesco.org/education

Stephen Hill

Why recovery is taking so long

Nine months after a tsunami with the force of 1000 Hiroshima atomic bombs devastated the Indian Ocean, rehabilitation efforts are only just starting to make a visible impact in Aceh, the Indonesian province hardest-hit by the disaster[6]. Why is recovery taking so long and what lessons have been learned for the next time disaster strikes?

Stephen Hill is Director of UNESCO's Regional Bureau for Science in Jakarta. He has assumed the dual role of Resident Co-ordinator of the United Nations and Co-ordinator of Humanitarian Relief in Aceh on a number of occasions. Here, he describes his experiences and answers the critics.

In recent months, the United Nations has been criticized for its perceived inefficiency in responding to the tsunami tragedy. Is this criticism justified?

Not really. In fact, the United Nations (UN) as a whole has done a good job. In co-operation with the Indonesian government and foreign military forces, immediate humanitarian relief in the form of food and medical support programmes, in particular, was delivered very efficiently, even though some communities were very hard to reach. Remember that the infrastructure along the coast had been annihilated: 400 damaged bridges (120 of which were totally destroyed) and 1900 km of damaged local roads; there were no ports for coastal access; and many of the affected communities were in a previously 'closed' zone of conflict between the rebel Free Aceh Movement (GAM) independence fighters and the Indonesian military[7]. Conditions were pretty tough. However, though it took some days to reach some remote communities, people did not die from starvation and there were no serious outbreaks of disease.

Where the UN and other agencies are being criticized now is mainly for perceived delays in the subsequent reconstruction, particularly of housing. When you look at the situation on the ground, you can understand why there have been delays.

You have to understand the sheer magnitude of the disaster. The tsunami was not just a big wave; somewhere near one-third of a billion km^3 of ocean was displaced by the 26 December earthquake, invading the land at the speed of a jumbo jet with power equivalent to 1,000 Hiroshima atomic bombs.

The impact was not only one of physical destruction. There was also serious trauma among the survivors, virtually all of whom lost close relatives or many members of their wider family. Women were killed at three times the rate of men: the tsunami hit early on a Sunday morning when many women were on the beaches with their children and the men mostly out on the ocean fishing. Nearly 40 000 children died; government officials and university professors, who tended to live in the better suburbs by the ocean, were killed in disproportionate numbers, thus seriously weakening the recovery effort; the media and communications systems were destroyed …. society was torn apart!

Meanwhile, there was an outpouring of world sympathy, generosity and a will to be involved. While the generosity of the private donor community was of enormous importance, the activities of NGOs and volunteers were not always helpful. A total of 164 NGOs arrived in Aceh, some well experienced in emergency relief, like Oxfam, World Vision, Care International and the International Red Cross; these moved quickly into the role of implementing 'arms' of UN programmes, delivering food, tents and so on. Others were literally falling over each other in an unco-ordinated way. The UN, as an international agency, is not constitutionally mandated to co-ordinate NGOs. This is the task of government, which in this case was still reeling from the shock and magnitude of the response needed.

Many volunteers, quite frankly, had no language or relevant skills. They arrived at the flaps of the temporary tent accommodation the UN had to operate from, demanding to be used but basically getting in the way, taking up scarce food and accommodation. Or the skills they brought with them required an infrastructure which did not exist. For example, a team of four highly specialized neurosurgeons arrived but for them to operate required a backup

6. Aceh was martyred by the underwater earthquake off Sumatra and the successive tsunami waves: of the estimated 227 000 dead, 126 000 were Acehnese. A further 93 000 Acehnese are still missing. Half a million Acehnese were displaced by the disaster, which reduced 127 000 homes to rubble

7. The Aceh Peace Agreement was signed by the Indonesian government and the GAM on 15 August in Helsinki (Finland) team of other surgical specialists, established hospital facilities, nurses, etc. in a triage environment where people were being saved from death by surgery delivered in field tents. Or the NGO jumped in, doing its own project decided upon before coming, with a local group identified through personal contacts rather than on government advice; it then went about delivering fishing boats or nets designed for different coastal conditions and fishing practices or building houses in zones the government had already declared unsafe for future habitation. The government has now taken action to channel and connect those NGOs, who are permitted to continue operating, but this took several months.

The UN – and the government – therefore moved into the rehabilitation stage of recovery in a context of a seriously traumatized population and considerable confusion from the enormous range of voluntary and funded support flooding in. What was needed was a new government agency based in Aceh with overarching power to co-ordinate and direct response. The Agency for Rehabilitation and Reconstruction (BRR) was duly established in April but it took another couple of months before the agency was assuming full control over co-ordination of recovery operations.

The UN is assisting the government, facilitating recovery efforts towards government-set objectives and helping to bolster the government's own decision-making capacities. BRR is now directing resources towards mainly the physical rebuilding programme, constituting 70% of the $US 1 billion worth of approved projects at the start of August. With the UN assisting, we can expect a fairly solid kick in the curve of reconstruction activity.

Most important however were the secondary impacts of the trauma. Nearly all the records of land ownership were washed away or seriously damaged. In an environment of total destruction with so many previous owners killed, it was very hard to establish who really owned the land, particularly when only their extended kin were left, arriving at the coastal community from a village some distance away in the mountains.

The only way of establishing legitimacy of ownership is to develop community consultations led by the local government official responsible, many of whom had been killed. However, as the head of one UN agency involved in rebuilding housing said to me, 'unless we take the time to generate full agreement and commitment to the decisions on land ownership, there will be serious problems a year or two down the track, with land disputes tearing the community apart again. This is particularly true in cases where survivors have to move from their previous location because the land has been seriously affected by the tsunami, such as through salination, or because their home lies in an area delineated by the government as being unsafe in the face of another possible tsunami.

Stephen Hill

Are there any gaps in the recovery process?

Most energy is being devoted to rebuilding the physical infrastructure, with a secondary focus on re-establishing livelihoods and jobs. Much less attention is being paid to rebuilding the human culture, communications and social infrastructure needed for people to generate the collective strength to take over the rebuilding enterprise themselves. Just 1% of approved projects at the start of August, for example, were devoted to social affairs: legal support for women and internally displaced people, trauma recovery and so on. There was virtually nothing for recapturing the strength of the culture of the Acehnese. These people have a very strong and individual culture and sense of their identity as an Islamic community, a strength that dates back to the 9th century. But with its heart torn out and many traditional carriers of the society's culture now gone, this potential strength is in danger of erosion. Yet, as UNESCO has found out through a fairly successful project utilizing cultural performance and community in the healing process for traumatized children, this community power is of enormous importance.

Donors also pay most attention to the physical things which demonstrate clear results to their benefactors. We at UNESCO are finding it much harder to generate funding for projects we are currently implementing on the 'softer' things, for example, for rebuilding the media system and communications, for re-building the longer-term capacity of the province's higher education system which lost so many senior academics, for looking after the out-of-school youth who 'drop through the cracks' of the formal system and are as yet unable to get to the newly rebuilt schools, for strengthening and supporting the heart of the society's cultural expression and performance before its remnants end up in the marketplace of immediate economic necessity.

The rush of activity has also tended to sweep past the scientific and technical (S&T) knowledge that is essential for the recovery process to be sustainable. To take an example: having committed funds to activities for which they had technical competence, a number of the large NGOs then moved into areas in which they lacked competence. Planting mangroves along the coast to mitigate against another potential tsunami became a popular movement, even though there is still limited evidence of how to do this. Relatively wealthy agencies therefore moved into mangrove replanting operations. However, without their own technical experts, their mode of operation was to fund local communities to do the job: people without any experience or technical knowledge who were unsupervised by experts. This often resulted in failure, perhaps simply because there had never been mangroves in that particular location and mangroves were extremely unlikely to find it habitable in the future.


©UNESCO/J. Steffen

A ship originally anchored 1 km offshore to supply Banda Aceh with electricity now provides the same services from its resting place 2 km inland. To the right of the photo stands UNESCO Jakarta's junior hydrologist, Georgia Pelli, who is assessing salt intrusion and groundwater quality in the area

Are there any lessons to be learned about how to handle recovery from such a catastrophe next time? You mention inadequate attention to knowledge and scientific support, for example.

The first and probably most important lesson is that, in a complex emergency like the one we confronted in Aceh, aid does not always translate the generous good intentions of kind, caring hearts into precisely what is needed on the ground; and managing the flood of goodwill can be a nightmare. What is essential is connectedness to real knowledge of local needs.

The second lesson is that we need to look at rehabilitation as a coherent physical and human recovery enterprise and to link knowledge about both. Rebuilding media and communications and strengthening the S&T bases on which communities make decisions is not something to be left for later. That is why UNESCO lost no time in rebuilding the Nikoya radio station in Banda Aceh, for example. Culture is not a luxury either.

The third lesson is that science and the scientific capacity of the affected community are not a distant 'luxury' to be thought of later either but an immediate necessity. The Aceh disaster proved that we needed immediate scientific assessments of the damage both in the water and above the water line before the evidence was lost, in order to be better prepared next time. UNESCO conducted a series of such surveys and supported those of government scientists towards overall assessment of environmental damage.

We needed the immediate support of scientists to work with communities and government in making choices about where people should live in a context of salinated or damaged land and potential dangers from the ocean.

We needed scientific training of communities in planting mangroves or developing other biological or physical barriers to mitigate the possible effects of a future tsunami event. UNESCO itself developed a community-based pilot project in Aceh targeting habitats conducive to mangrove propagation, including the provision of direct expert technical support to the planting communities; with attention to these parameters, the planting programme was a success.

With many park rangers and environmentalists having been killed, we needed to train their replacements to conserve established forests and coastlines against the potential encroachment of both illegal and legal economic exploitation. UNESCO has been working with the Ministry of Forestry on these issues and is currently seeking funding for support of government capacity in the Leusser World Heritage park.

We needed to rebuild the scientific base of the main local institutions providing tertiary education, as it was these very institutions which would be called upon to provide technical backing for the recovery programme itself.

Lastly, 'preparedness' for dealing with future disasters requires expert S&T inputs into both educative materials and the actions communities practice in escaping and coping. UNESCO has taken a lead role in developing these materials for disaster preparedness in Indonesia.

UNESCO's experience in confronting the need for disaster response across a broad range of areas has highlighted a fourth lesson. The difficulty of response to such a disaster – as for that matter, the response in the USA to the Hurricane Katrina tragedy in late August – demonstrates the need to tune up disaster preparedness across the whole country and not just where tragedy last struck, building a stronger, well-prepared government and community able to handle natural hazards. S&T knowledge is central to this broader objective. UNESCO is now in a good position to take a lead here in promoting a stronger 'science preparedness'.

For the experts think more may come. Off the coast of Sumatra, the island of Simeulue has risen and the island of Nias has tilted as the Earth continues to adjust and the pattern of major earthquakes moves down the coast from Aceh to the south. The Earth's crust underneath is highly unstable. These are not good signs.

Interview by Susan Schneegans

Caribbean science under the microscope

As Latin American and Caribbean nations prepare for a major conference on Science, Technology and Innovation for Sustainable Development, organized by UNESCO and the Cuban government from 1 to 3 December, just how much of a 'science culture' is there in the Caribbean? The countries of the Caribbean Common Market (Caricom) would be the first to acknowledge that they need to make a lot of progress in absorbing and applying science and technology (S&T) if they are to improve their populations' standard of living. The problem is that, up until now, little attention has been paid to how this might be done.

The conference is being held in Havana. Since Cuba is not a member of Caricom and since no study of Caribbean science would be complete without profiling the unique experience of this small, yet dynamic country, Cuba is the subject of a separate article beginning on page 20.

The Caribbean is an archipelago of small and relatively young island nations in the Caribbean Sea, combined with a few neighbouring countries on the contiguous coast of Latin America. The island nations range from a size of 103 km^2 (Montserrat) to 10 000 km^2 (Jamaica).

The countries of the Caribbean are largely English-speaking, with the exception of Dutch-speaking Suriname, French-speaking Haiti and Spanish-speaking Cuba and the Dominican Republic. The English-speaking island nations have developed strong cultural, economic and educational ties through institutionalized mechanisms. For example, the University of the West Indies (UWI), founded in 1948, is pivotal to tertiary education for many of these island nations, whereas Caricom – not to mention the game of cricket – provide the 'glue' that binds the Caribbean people together.

Caribbean nations do however have diverse natural resources, economic policies and political strategies which have produced a considerable variety of economic, educational, industrial and cultural achievements.

Wasted opportunity

All Caribbean nations, both individually and through Caricom, recognize they will have to make major progress in absorbing and applying S&T to improve their populations' standard of living. Little attention has been paid to how this might be done or to the roles played by different levels of scientific research: curiosity-driven versus application-targeted basic research and applied research directed towards problem-solving.

There seems to be no mechanism for setting research goals and priorities, judging whether any research goals have been met or evaluating research results from within and beyond the Caribbean for their potential beneficial impact on the lives and economies of the region. This is a very serious policy and management deficiency which must be remedied quickly if S&T and innovation are to become entrenched in the Caribbean culture and the productivity of the scientific enterprise is to grow to optimal levels. The lack of a conceptual framework for understanding and evaluating innovation in the region has meant that many research programmes have been established and maintained without any evaluation of how well they perform or of the requisite infrastructure, financial and human resources to complete their mission.

For this reason, bananas, sugar, alumina, tropical rainforests and other resources of vital economic interest to the region have remained poorly understood and their diverse potential is largely unexplored. What is most distressing is that there are significant earnings to be gained from economic activity in

The university scene

The student body in the Caricom universities comes to about 42,000; of this, some 27,000 students are enrolled at the University of the West Indies (UWI), which has three main campuses in Barbados, Jamaica and Trinidad.

Besides the UWI, the Caribbean counts the University of Guyana with its two campuses, the University of Technology (Jamaica), the University of Suriname and, of more recent vintage, the University of Trinidad & Tobago, which came on stream in 2004. All are publicly funded.

The UWI has established postgraduate programmes leading to MSc, MPhil and PhD degrees. Enrolment in higher degree programmes in 2002/2003 amounted to 4638, of which 38% were in S&T disciplines.

The University of Technology, University of Guyana and University of Suriname are also expanding and consolidating their postgraduate programmes. The University of Trinidad & Tobago is initially offering only science and engineering programmes, at both the undergraduate and graduate levels, to meet the human resource needs of this highly industrialized country.

©UWI

UWI students working on a lap-top computer

these areas but there is no endogenous research and development (R&D) capacity to sustain them. There are of course bright spots of excellent achievement in research in the region but this is largely a result of determined individual effort and initiative rather than a planned and sustained cultural movement towards regional or national scientific excellence in the economically vital fields.

Research is conducted in universities, national and regional publicly funded special research institutions and, to a limited extent, in the private sector. Examples of national research institutes are the Scientific Research Council in Jamaica, the National Agriculture Research Institute in Guyana and the Institute of Marine Affairs in Trinidad & Tobago.

Modest R&D expenditure

Gross expenditure on R&D (GERD) is modest (see table). Statistics show that the amount of funds actually available to R&D is proportionate to the tiny size of the Caribbean economies. In Jamaica, the Environmental Foundation of Jamaica, with normal funding of up to US$ 100 000 per project selected from peer-reviewed applications, is the most significant single source of substantial research funding. The Foundation supports environmental conservation, sustainable development and closely related research projects and promotions for which it has approved over US$ 8 million in support of 421 projects since 1994[8]. The Commonwealth Caribbean Medical Research Council also provides small grants. Success in competitive funding awards from external sources is modest.

Commercialization of research results is a potential source of revenue and the region is active in intellectual property developments. Some encouraging examples are the sale of licenses in educational software by UWI to an international company, new food products turned out by the Scientific Research Council and the Small Business Incubators at the University of Technology in Jamaica. The Centre for Resource Management and Environmental Studies in Barbados has been responsible for developing sources of renewable energy, which were meeting 15% of the island's needs in 2003.

Recently, the region's academic institutions have attracted international companies to operate resident R&D activities. Funds earned from such arrangements are ploughed back into research infrastructure. In one case, this took the form of a significant contribution to a new 500 MHz NMR at the UWI in Jamaica. There is a similar arrangement at UWI's Cave Hill campus in Barbados with the company Biochem Pharma.

Still a long way to go in scholarly output

The scholarly publication rates of research institutions outside the academic sector are insignificant. Of the research papers published by academic institutions between August 1999 and July 2000, approximately 92% originated from the regional research facility, the UWI, which has recorded significant growth in publication rates in the past decade or so. Overall, the region's 6.4 million inhabitants (excluding

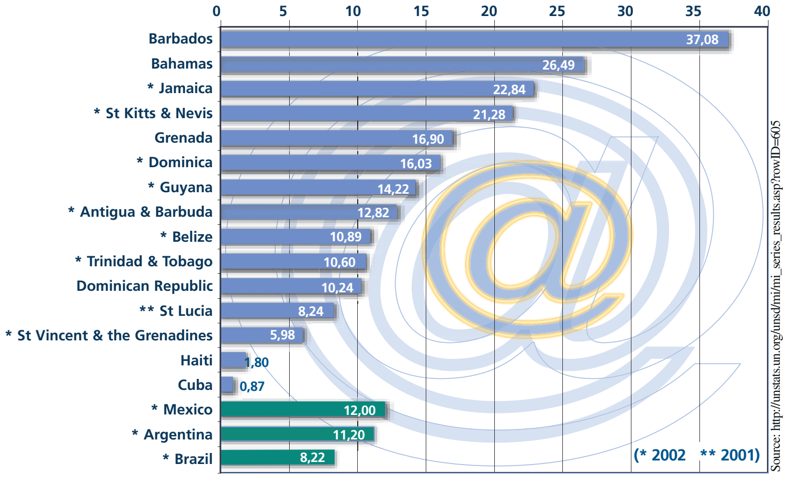
Key indicators for the Caricom* countries

	Population (thousands) 2001	Human Development Index**, 2002	GNP average annual growth (%), 1998–2001	GNP per capita PPP US$, 2001	Public expend. on education as % of GDP, 2001	Public expend. on tertiary education as % of total education, 1999–2001	GERD as % of GDP 2002
Antigua & Barbuda	72	55	3.3	9550	3.5	15.1	–
Bahamas	307	51	–	15680	–	–	–
Barbados	268	29	5.1	15110	6.7	29.9	–
Belize	245	99	6.6	5150	6.8	16.2	–
Dominica	78	95	-1.3	4920	5.6	–	–
Grenada	81	93	–	–	4.5	–	–
Guyana	762	104	-1.2	4280	4.5	–	–
Haïti	8111	153	-0.1	1870	1.1	–	–
Jamaica	2603	79	0.4	3490	6.8	19.2	0.08
Montserrat	3	–	–	–	–	–	–
St Kitts & Nevis	42	39	6.5	10190	8.5	21.2	–
St Lucia	147	71	2.4	4960	7.7	–	–
St Vincent & Grenadines	118	87	2.9	4980	–	5.2	0.15
Suriname	429	67	-12.9	–	–	–	–
Trinidad & Tobago	1294	54	13.1	8620	4.3	3.7	*** 0.10

* Neither Cuba nor the Dominican Republic is listed here because neither is a Caricom member ** 1–55 equals high development *** 2001

Source: UNESCO (2005) Education for All*: the Quality Imperative. EFA Global Monitoring Report; UNESCO Institute for Statistics; UNDP (2004)* Human Development Report

8. *Disbursements for 1999/2000 amounted to US$ 1.8 million for 52 projects, according to the Planning Institute of Jamaica*



Internet users in the Caribbean in 2003 (%)
Argentina, Brazil and Mexico are given for comparison

Monitoring water flow of the Layou River on the volcanic Caribbean island of Dominica

Haiti) published 460 papers in refereed journals: at 71 papers per million inhabitants, the figure is encouraging. It compares favourably with figures for Latin America identified in UNESCO's *World Science Report* 1996, which showed fewer than 50 research papers per million inhabitants for all but Argentina and Chile in 1993. Only the latter country, with a figure of 90, boasted a better publication rate than the Caribbean. Cuba in 1990 had a rate of 14 per million. This said, the figures for Singapore and Taiwan of China for the same year were 375 and 200 respectively, which means we have a long way to go.

Among the peer-review journals in which the region's papers appeared are periodicals from the region. These are concentrated mainly in five science journals, three of which are based at the UWI. First published in 1924, *Tropical Agriculture* is the region's longest surviving journal. The *West Indian Medical Journal* is the region's premier scientific journal; today, it reaches over 75 countries with about 700 individual subscribers and a circulation of over 2000. Like *Tropical Agriculture*, it is published quarterly. Published biannually by the Faculty of Engineering at the Trinidad Campus, the *West Indian Journal of Engineering*, which first appeared in 1967, has a very impressive list of international advisors/reviewers. Its contents though, are local to a large extent. The *Jamaican Journal of Science and Technology*, containing peer-reviewed papers in many fields, is published twice a year by the Scientific Research Council. The Bahamas *Journal of Science* is also published twice a year, in this case by Media Enterprises Limited.

Special difficulties for R&D

The most serious difficulties are lack of funding, inability to attract and keep quality staff, and poor working conditions, including with regard to salaries, maintenance of equipment and staff development opportunities.

In Guyana and Suriname, these problems are acute, owing mainly to the very weak economies of these countries. In the UNDP's *Human Development Report* 2004, Guyana for example was ranked 104th out of 177 countries under the Human Development Index (see table).

Very limited funds are available for research and the purchase and maintenance of equipment; weak infrastructure – including an unreliable supply of electricity – tests the patience of researchers. Moreover, only a few scientific journals are available to researchers.

Scientists at the universities in Guyana and Suriname also carry very heavy teaching loads, leaving them little time for research. To compound the problem, staff income is anything but attractive; this is reflected in the countries' inability to attract highly qualified scientists and the scholastically unproductive phenomenon of moonlighting. In the Faculty of Natural Sciences at the University of Guyana, out of 33 full-time staff, only six have PhDs and some only a first degree. A paltry five international papers were recorded at this university last year. The situation in these two countries calls for intervention by the international scientific community.

The hub of scientific activities in Barbados, Jamaica and Trinidad & Tobago centres around the campuses of the UWI. Scientists here are much more fortunate than their counterparts in Guyana, Suriname and in most countries of the Caribbean and Latin America. They enjoy better salaries and working conditions, as well as such fringe benefits as travel grants and access to limited internal research grants. The major need encountered here is mainly that of adequate research funding and better management of the scientific enterprise to match the productive potential of the academic staff and the science infrastructure.

Brain drain expected to rise

The challenge of migration affects the Caribbean greatly. For example, in the years 1991–2000, Jamaica saw some 20 000–25 000 (close to 1% of the population) emigrate each year, according to the Planning Institute of Jamaica (2000). Some 11–15% of those migrating have skills or professions which might include S&T fields.

Emigration rates of professionals and skilled Caribbean people can be expected to rise unless working conditions and the state and productivity of the scientific enterprise itself improve in the near future.

Lack of motivation unchecked for too long

There are also minor problems, such as poor staff retention, lack of a systemic approach to staff development, lack of short-term research attachments, recruitment difficulties in competitive areas like information technology and a seeming lack of motivation among some researchers which has gone unchecked for too long.

Substantive evaluation of research programmes and researchers themselves is lacking, as is action from management to combat mediocrity or a collective will to award differential benefits for highly productive researchers. This has stalled the development of an endogenous research culture.

Making the Caribbean's voice heard

There are three regional scientific organizations in existence: the Caribbean Academy of Sciences, Cariscience (see box) and the Caribbean Council of Science and Technology. The latter was created by governments in 1981 with limited members drawn from policy makers and scientists. One of its first activities was to develop a S&T policy document for the Caribbean. Unfortunately, not much seems to have been done in the way of subsequent implementation.

There are a few well-established, active scientific associations, such as the Caribbean Chemical Engineering and Chemistry Association, the Caribbean Congress of Fluid Mechanics and the Caribbean Solar Energy Society.

The Caribbean Agriculture Research and Development Institute and the Caribbean Environmental and Health Institute are two of the better-known regional institutes. Guyana boasts a unique centre for research into international forest conservation, *Iwokrama*, which encompasses 3600 km^2 of lush pristine tropical rainforest in central Guyana. The centre receives research grants from a number of countries, as well as from international donor agencies, but has no core funding.

A Renewable Energy Centre in Barbados is on the cards. Speaking at the Caricom Task Force meeting on Regional Energy Policy in October 2003, Barbados Minister of Energy and Public Utilities Anthony Wood was quoted by the *Barbados Advocate* as saying that, 'a regional energy policy that focuses on sustainable development must be our objective for the development of the energy sector in the long term'. He stated that the Government of Barbados would like to have renewable energy contribute 30% of the island's primary energy by 2012.

The creation of a Regional Research Council to fund research of interest to, and focus on, regional problems has been proposed to the Heads of Caribbean governments, as reported by the Caribbean Academy of Sciences in 1998. At their annual meeting in 1999, these same governments endorsed a proposal by the UWI to establish a Caribbean Regional Research Agency. The Agency is not yet a reality.

Some of the region's leading scientists are now playing a major role in creating a science culture and developing a strong capacity in S&T. This is evidenced by a number of recent workshops and symposia in science education and a major Caricom conference on Harnessing S&T for Caribbean Development planned for 9–13 May 2006 in Trinidad & Tobago.

Ishenkumba Kawha and Harold Ramkissoon[9]

Adapted by the authors from a chapter on the Caribbean they contributed to the UNESCO Science Report 2005.

---

9. *At the UWI, respectively Prof. of Supramolecular Chemistry (Mona Campus in Jamaica) and Prof. of Mathematics (Trinidad campus). Prof. Ramkissoon is also Executive-Secretary of Cariscience and former President of the Caribbean Academy of Sciences*

Cariscience

Launched in Jamaica in 1998, Cariscience is a UNESCO network of R&D and post-graduate programmes in the basic sciences in five Caribbean countries: Barbados, Guyana, Jamaica, Suriname and Trinidad & Tobago.

Organized *by* active researchers *for* researchers, its main objective is to promote academic excellence and improve the quality of scientific research in the region by assisting scientists and encouraging co-operation. As part of this effort, Cariscience launched the Caribbean Young Scientist Fellowship Programme in January 2004 and has established links with the diaspora.

The Caribbean Academy of Sciences and UNESCO have created a website on scientific activities in the Caribbean: www.cariscience.org


©UWI

©UNESCO/S. Acao

Cuban science: a jewel in the Caribbean crown

It is a widely held view that science and technology (S&T) are a necessary tool for development in any society. What is lacking in most developing countries is a vision for an effective science policy and, most importantly, the political will to implement this policy. My visit in 2000 to Cuba's research institutes in biotechnology, medicine, agriculture and the basic sciences, and my meetings with Cuban scientists, left absolutely no doubt in my mind that Cuba's progress in science has not been achieved overnight. Rather, this progress is the result of a vision and of planning and implementation involving the political directorate, technocrats and scientists.

One year after the Cuban revolution in 1959, it was decided at the highest political level to link the future of Cuba to the future of science in Cuba. Biotechnology was selected as the focus, reportedly by President Fidel Castro himself. The rationale behind this decision was that, given the limited financial and human resources at the time, S&T had to be development-oriented. Biotechnology was an area of great potential, as it could be used for improving health, mainly through the development of new vaccines; increasing crop yield and enhancing animal production; and for earning hard currency through the marketing of biotechnology products.

Measures were then put in place to create new institutions and train a critical mass of scientists. The Cuban Academy of Sciences (founded in 1861) was reorganized in 1961, 13 institutes were created within the Ministry of Health and the National Centre for Scientific Research (CENIC) was founded in 1964. CENIC's initial role was to train and prepare scientists to staff a number of research institutes still on the drawing board at the time, of which the most internationally renowned is the Centre for Genetic Engineering and Biotechnology (CIGB), founded in 1986.

©CENIC

The Cuban National Centre for Scientific Research (CENIC), founded in 1964

Biotechnology, the heart of Cuban science

In 1981, Cuba fell prey to a serious epidemic of dengue fever. The National Centre for Scientific Research summoned a Meeting of Directors from 12 research centres to deal with the crisis. They recalled a suggestion made by Prof. Clarke, a US Scientist who had met with President Fidel Castro in 1973, concerning the use of interferon in viral infections. It seems that two major decisions were taken at this Meeting of Directors, the first being to start work immediately on the production of interferon and the second to build the necessary scientific research capacity for the development of biotechnology. That very year, Cuban interferon was effectively used in the treatment of dengue. This heralded the beginning of accelerated research in molecular biology and genetic engineering that would ultimately lead to the opening of the CIGB.

Today, the CIGB is regarded as the flagship in biosciences in the entire so-called Third World. It is the pride of all Cubans and very much the heart of Cuban science.

Located west of Havana, the CIGB is very much a self-contained centre with state-of-the-art equipment, production facilities and with over 1000 employees involved in the dual functions of research and production. The staff includes 700 highly skilled researchers, some of whom are housed in a neighbouring high-rise apartment building. Those I happened to meet seemed highly motivated and very dedicated. Many of them received training abroad in such countries as France, Germany, the UK and Canada.

The main building contains well maintained air-conditioned laboratories, administrative offices, service areas, an auditorium with translation facilities and seating capacity of 400, lecture rooms, language laboratories, a library and a gymnasium. The research facilities include five greenhouses and a biotherium equipped for different animal species. The CIGB counts a number of divisions with specific orientations and goals. Among these are the Vaccine

Source of commentary: Granma International, *Cuba*

The monoclonal antibody CIMAher, seen here, is used in Cuba on brain and neck tumours, in combination with radiotherapy, and is patented in 17 nations. CIMAher has been developed by the Centre for Molecular Immunology (CIM) in Havana, which signed an agreement on 15 July 2004 with CancerVax Corporation in California for the transfer of biotechnological technology from Cuba to the USA for the co-operative production of anti-cancer vaccines. A plant has been constructed at the CIGB to manufacture the batches for the first clinical trial in the USA, that of a therapeutic vaccine against lung cancer developed at the CIM. The vaccine is based on epidermal growth factor (EGF), a protein closely related to cellular growth. The CIGB's other new plant, in operation since August 2004, is producing the active pharmaceutical ingredients for the Cuban vaccine against Type B Hemophilus influenzae, *a bacterium responsible for a large percentage of meningitis, pneumonia and otitis cases, responsible for the deaths of half a million children worldwide every year; in 2003, Dr Vicente Vérez Bencomo, the vaccine's principal author, explained that Quimi-Hib 'will permit the country to save US$2–3 million a year from imports used in the National Immunization Programme'. The new plant is capable of producing 10 million doses a year.*

Division, Pharmaceutical Division, Plant Molecular Biology Division, Mammal Cell Genetic Division and the Quality Assurance Division.

A company by the name of Heber Biotec was established in 1991 to market the CIGB's 160 products. Among the products available in over 50 countries are a Hepatitis B vaccine, human alpha interferon, certain enzymes, diagnostic kits which include one for HIV and a cattle tick vaccine. Work is being done on an HIV/AIDS vaccine, a meningitis vaccine, a Hepatitis C vaccine, pharmaceuticals, transgenic fish production and in plant molecular biology (insects and fungal diseases, papaya, coffee, potatoes and tomatoes). The HIV/AIDS vaccine is currently being tested.

Like other scientific organizations in Cuba, the CIGB does not work in isolation. It forms the core of a network of institutions involved in biotechnology research and development (R&D). This network includes:

❏ the **Centre for Molecular Immunology**, the focus of which is cancer and the production of pharmaceuticals;

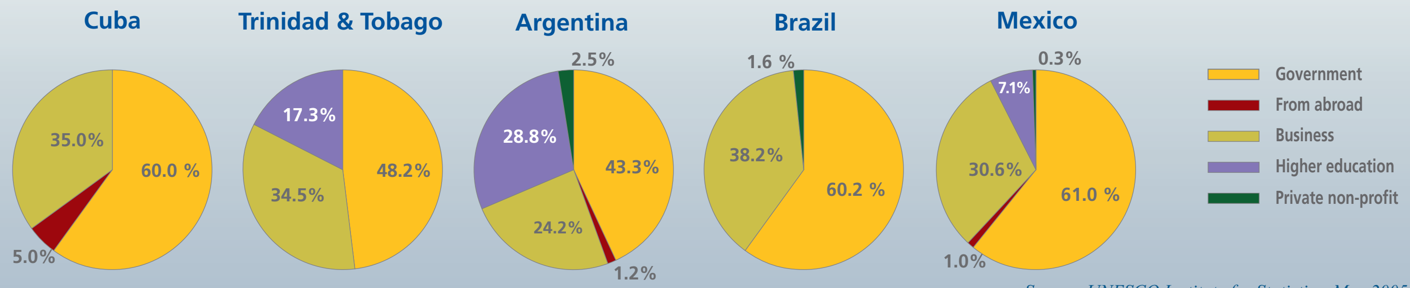
❏ the **National Biopreparations Centre**, the main focus of which is the production of Hepatitis B vaccines. The centre also produces media and vaccines in Cuba that were initially developed elsewhere;

❏ the **Finlay Institute**, named after national hero Dr Juan Carlos Finlay (1833–1915), whom Cubans claim deserved a Nobel Prize for discovering that yellow fever virus was transmitted by mosquitoes (he was nominated but did not win). The main research at this 112-year old institute fitted out with modern facilities centres on producing new vaccines by combining existing vaccines such as those against influenza and cholera. The meningococcal type B vaccine used to fight meningitis was produced at this institute and earning from the export of this vaccine have netted Cuba US$40 million;

❏ the **National Centre for the Production of Laboratory Animals** meets the growing needs of the country's various research centres. The centre produces a variety of animals ranging from mice to monkeys, as well as their food.

GERD in Cuba by source of funds, 2002

Other countries are given for comparison



Source: UNESCO Institute for Statistics, May 2005

© Cécile Nirrengarten/UNESCO

Street scene in Havana in 2003

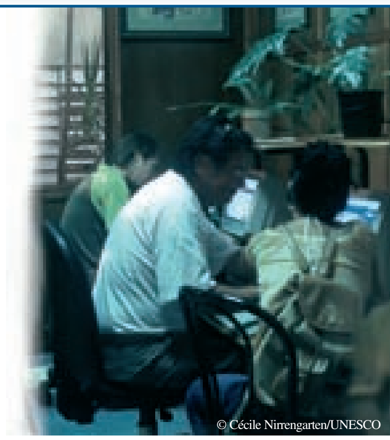
Undoubtedly, the greatest strength in Cuban S&T is biotechnology but this has not been achieved without sacrifice; approximately US$1 billion was invested in biotechnology from 1990 to 1997.

In the past five years, two new institutions have opened their doors, the Centre of Medical Genetics and the Centre of Bio-informatics.

The best health in the developing world

In the late 1950s, a Cuban infant had a one chance in ten of dying, mainly from diarrhoea and respiratory diseases. There were just over 6000 doctors and one medical school at the time. The health system, I was told, was in a state of rapid decline in those days with medical care beyond the reach of the average Cuban. Along with education and S&T, health was therefore given top priority in the1960s.

Today, UNICEF places Cuba just four notches behind the USA and ahead of all developing countries in terms of children's health. There are 14 medical schools and 60 000 doctors for a population of 11.2 million; this translates into one doctor for approximately every 200 persons. Cuba has the lowest mortality rate (8 per 1000 compared to 11 per 1000 in Great Britain) and the highest life expectancy (73) in Latin America.



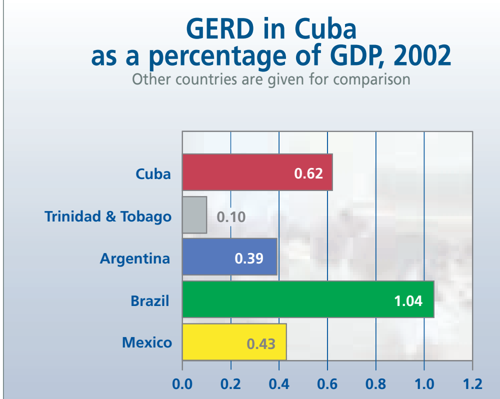
© Cécile Nirrengarten/UNESCO

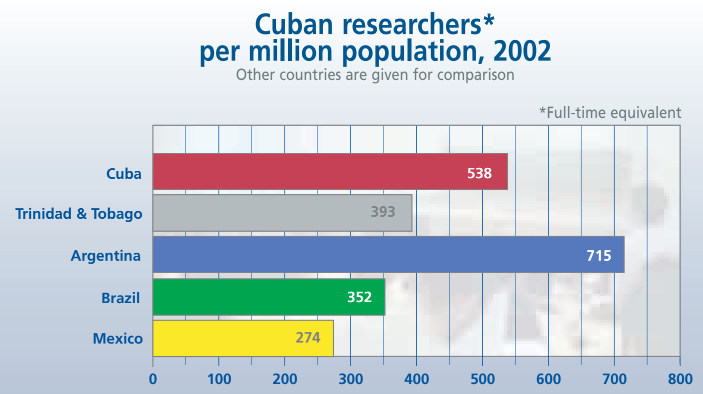
Cybercafé in Havana in 2003

Mass immunization has resulted in the almost total eradication of several contagious diseases. Cuba was declared by the Pan-American Health Organization (PAHO) to be the first polio-free country in the Americas. In 1997, no cases of whooping cough, infantile tetanus, poliomyelitis measles, mumps, rubella or yellow fever were diagnosed. The reasons for Cuba's outstanding health programme are many, among which the fact that medical care, including the supply of drugs, is free to all; the health of mother and child is given priority; the family doctor programme puts doctors and nurses in every neighbourhood to provide primary care. (The family doctor's home is already in existence: a three-story building with a clinic on the first floor, the doctor's living quarters on the second and the nurse's quarters on the third); the availability of 12 vaccines (PAHO recommends seven), including a pneumococcal vaccine developed in Cuba to combat pneumonia, which used to kill thousands of children; and the testing of expectant mothers to avoid abnormalities in newborns. Last but not least, Cuba has an active and effective surveillance and prevention programme. For example, the first cases of a dengue outbreak in December 1996 were detected in January 1997 and circumscribed to just 15 cases thanks to the effectiveness of the Cuban surveillance system.

The emphasis placed on health is borne out by the fact that Cuba's first success in producing a biotechnology product came in 1984 when, with the help of US cancer specialist Randelip Lee Clarke, insulin was produced. More than two million Cubans suffer from diabetes.

In addition to my discussions with medical scientists and doctors, I visited the Pedro Kouri Institute for Tropical





Source: UNESCO Institute for Statistics, May 2005

Medicine (IPK) established in 1937 and now under the directorship of Gustavo Kouri, grandson of the founding father. The stated goal of the institute is the pursuit of excellence in R&D in such areas as tropical medicine, microbiology and communicable diseases. One focus of microbiology is tuberculosis, as the number of cases augmented recently. The institute is also involved in a number of nature control and eradication programmes, including one for the prevention of AIDS. The institute is also working with the CIGB to produce a dengue vaccine. Great emphasis is placed on preventative medicine – and wisely so, as this reduces health care costs. The institute has a 170-bed hospital which houses mainly AIDS patients. There is also an educational component. A number of courses, mainly postgraduate, are offered for the training of national and foreign professionals. Some of these courses have been sponsored by UNESCO and PAHO. The institute provides advisory services to several countries and has a very active exchange programme.

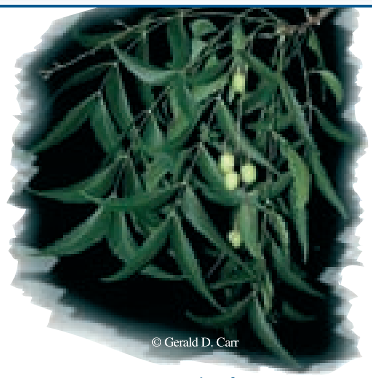
Of tobacco, sugar and neem

Cuban S&T is intimately linked to development and the agricultural sciences are no exception. Research focuses on crops that generate substantial foreign exchange, such as sugar and tobacco, and those that will enable Cuba to feed itself and meet the requirements of the expanding tourism industry. Cuba grows about two-thirds of its own rice requirements. The country has been encouraging organic farming for environmental and economic reasons.

At the Institute of Basic Research in Tropical Agriculture, I was somewhat surprised by the amount of research being done on neem[10] to create a natural pesticide. Neem culture got under way in 1991; by 2000, there were over 500 000 neem trees in Cuba. There is a joint proposal with the Caribbean Agriculture and Research Development Institute (CARDI) to produce the technology for the agro-industrial exploitation of the neem tree to obtain pesticides and veterinary products. In point of fact, the proposal goes further, suggesting a pilot programme in St Kitts & Nevis for the production and marketing of the neem pesticides.

Street scene in Garagüey

Other projects of the Cuban institute include pest management utilizing vegetable residues – only tobacco residue to-date has been used as an insecticide –, a maize hybrid and an integrated management of papaya culture to improve yield.



Branch of a neem tree (Azadirachta indica)

Basic research confined mainly to universities

Research in the basic sciences is conducted primarily at the universities. It seemed to me during my visit that the state of the economy and the country's commitment to biotechnology meant that the basic sciences, though certainly not neglected, could not be afforded the same level of research support.

This does not necessarily mean that the scientists working in these areas are less active or motivated. They attend international conferences and undertake frontier work with researchers abroad. In fact, members of The Institute of Computer Science, Mathematics and Physics host a major international conference every two years. At a meeting with the Head of the Institute and some other members, interest was expressed in establishing links with the rest of the Caribbean. I believe there is potential here for co-operation.

Since my visit in 2000, the government has defined three new priorities for S&T, in consultation with the Cuban scientific community, one of which is basic sciences; the other two are information and communication technologies and social sciences. All three are to be reinforced.

New avenues for co-operation have opened up: in capacity-building in basic and pedagogical sciences – Cuba hosted the XIIIth Inter-American Conference on Physics Education in July 2003, for example – , in climate change research, hurricane forecasting, renewable energies, science popularization and, last but not least, gender issues: women make up 65% of human resources in S&T in Cuba.

Harold Ramkissoon[11]

---

10. The neem tree belongs to the mahogany family (Meliaceae). Cultivated over wide areas of Asia, Africa, Australia, the Americas and the south Pacific, the neem tree has been dubbed 'the village pharmacy' for its medicinal properties (against diabetes, high cholesterol, cancer, etc.). Neem oil is used for preparing body cleansing products and cosmetics, such as soap, shampoo and skin creams. The tree also acts as an insecticide: many of the tree's secondary metabolites have biological activity, such as azardirachtin present in the tree's seeds, which breaks the insect's lifecycle. Source: http://Wikipedia.org

11. For Prof. Ramkissoon's affiliation, see p. 19

Diary

25–29 September
UNESCO resource kit on S&T education in 21st Century
Regional workshop on Arabic version of kit. Kuwait City: *www.unesco.org/beirut*

1–5 October
Global change in mountain regions
Open Science Conf. Culmination of four GLOCHAMORE thematic workshops. Perth (UK): *www.unesco.org/mab/mountains/news.htm*

3–7 October
Integrated ecosystem management: pursuing a quality economy in biosphere reserves – Workshop of MAB-ECOTONE and meeting of SeaBRnet MAB regional network. Hosted by Govt of PDR Laos in co-operation with UNESCO. Thematic session on applying the biosphere reserve concept to large Asian wetland areas: *www.unesco.org/mab*

5 October – 30 November
Experiencing mathematics
UNESCO-driven exhibition visits Maputo (Mozambique), after touring South Africa from 20 June to 26 September: www.*mathex.org*

13–14 October
The basic sciences: the science lever for development – Ministerial roundtable during UNESCO's General Conf. (3–21 October) Paris: *www.unesco.org*

18–20 October
Education for sustainable development: new approaches for the future
Organized by UNESCO Kingston (Jamaica), University of West Indies and others. In Kingston: *u.miura@unesco.org*

25–27 October
Conserving internationally designated areas: biosphere reserves, world heritage and Ramsar sites in Iberoamerica
Intl conf. Institute of Ecology A.C., MAB-Mexico and UNESCO/MAB. Support from CONACYT, DIVERSITAS-México, Natl Comm for Protected Areas (Mexico), Govt of Spain. Xalapa, Veracruz, Mexico: *m.clusener-godt@unesco.org; halffter@ecologia.edu.mx; cskarez@unesco.org.uy;*

31 October – 2 November
Physics and sustainable development
500 physicists and policy-makers from around the world to discuss how physics can better benefit the developing world in economic development, health, energy, environment and education. Planned outcome: agenda for action for Intl physics community. Co-sponsored by UNESCO and its ICTP, South African Institute of Physics, Intl Union of Pure and Applied Physics: *m.alarcon@unesco.org; www.wyp2005.org*

1–7 November
Science city governance
Workshop covering policy development for S&T parks, co-operation between industry, academia, research institutes and government, co-operation among local governments, etc. World Technopolis Association and UNESCO. Daejeon (Rep. Korea): *qqhong@metro.daejeon.kr; y.nur@unesco.org*

9–12 November
Training for research managers and administrators
Regional training seminar organized within UNESCO's Strategy for Enhancing Scientific Co-operation in South-East Europe by UNESCO, Austrian Science and Research Liaison Office. Ljubljana (Slovenia): *www.unesco.org/venice*

10 November
World Science Day
www.unesco.org/science/index_wsd_2005.shtml

10–12 November
World Science Forum
Intl roundtable on the role of parliamentarians in S&T policy, organized by UNESCO, ISESCO and others at World Science Forum hosted by Hungarian gov. Budapest: *d.malpede@unesco.org*

22–24 November
Combating desertification
Regional workshop organized by UNESCO Chair of Desertification Studies (Sudan). Will analyse research and national action plans, design sub-regional projects and create research network of institutions from participating countries. Khartoum : *www.unesco.org/water/water_events/Detailed/1051.shtml*

29 November – 1 December
Understanding, extinction and prevention of spontaneous coal seam fires
Conf. of programme of Ecological Research for Sustaining the Environment in China (ERSEC) run by Chinese Min. of Education, German Min. of Education and Research, UNESCO. Beijing: *x.han@unesco.org; g.schoning@unesco.org; coalfire@nrscc.gov.cn*

1–3 December ***(see p.16)***
Science, technology and innovation for sustainable development
Regional conf. organized by Govt of Cuba and UNESCO: *f.ortiz@unesco.org.cu; montevideo@unesco.org/uy*

New **Releases**

Biodiversité et distribution de la mégafaune
Published in two volumes by UNESCO-IOC within its Technical Series (n° 69). French only. English version due out in 2006. Vol. 1: Ecosystème de nodules polymétalliques de l'Océan Pacifique Est-Equatorial, 134 pp. ; Vol. 2: Atlas photographique annoté des échinodermes de la zone de Clarion et de Clipperton, 65 pp.
Describes the biodiversity and distribution of megafaunal assemblages, based on 200 000 underwater photos and 55 hours of underwater film. (Here, megafaunal refers to animals on the seabed 1–4 cm or more long.) The first volume studies the ecosystem of the Abyssal Nodule Province of the Eastern Equatorial Pacific. The second volume is an annotated photo atlas of echinoderms (in Greek, literally "spiny skins", echinoderms are radially symmetrical animals like starfish found only in the sea) of the Clarion-Clipperton Zone. Copies are being sent to all UNESCO-IOC Member States. Request a free copy: p.boned@unesco.org or download: http://ioc.unesco.org

Food Engineering
G. V. Barbosa-Canovas (Ed.) UNESCO Publishing and EOLSS Publishers. ISBN: 92-3-103999-7, 858 pp. English only.
Multi-author work on the fundamental aspects of food processing, preservation and production, as well as consumption. Discusses the basics underlying food transformation from both the standpoint of food technology and food engineering. For educators, university students, professional practitioners and specialists (including policy analysts) wishing to acquaint themselves with technical and systems management knowledge; and for researchers seeking to learn about innovations and new approaches to problem-solving. Taken from the *Encyclopedia of Life Support Systems*, a dynamic virtual library equivalent to 200 printed volumes, published on-line by EOLSS Publishers in collaboration with UNESCO, with discount rates for universities from developing countries: *www.eolss.net*.

Towards Knowledge Societies
UNESCO World Report. UNESCO Publishing. ISBN: 92-3-104000-6, 240 pp. Available November in Arabic, Chinese, English, French, Russian, Spanish.
A future-oriented overview of the upheavals through which we are living, with a focus on education, science and culture. Advocates the pooling of knowledge rather than its partition. Tackles issues currently the subject of global debate: digital solidarity between North and South; the scope and extension of the knowledge commons; intellectual property; ethics; safeguarding of cultural and linguistic diversity, etc.

UNESCO Science Report 2005
UNESCO Publishing. ISBN: 92-3-103967-9, 288 pp. Available in English as of November. French to follow in 2006.
The fourth in a series of periodic reviews of the state of science around the world, seen through the eyes of independent experts. Looks at what has changed since its predecessor, the *World Science Report*, was published in 1998. Who is performing R&D today, where and with what means? What are the new priorities? Each essay describes how R&D are organized in a given region or country and identifies and discusses emerging trends in research and higher education, including those which are region- or country-specific.

Science, Technology and Economic Development in South-Eastern Europe
UNESCO Regional Bureau for Science in Europe. First in series of Science Policy Studies. English only, 72 pp. Request a free copy: roste@unesco.org

A World of Science is a quarterly newsletter published in English and French by the Natural Sciences Sector of the United Nations Educational, Scientific and Cultural Organization (UNESCO), 1, rue Miollis, 75732 Paris Cedex 15, France. All articles are free of copyright and may be reproduced providing that A World of Science is credited. ISSN 1815-9583
Director of Publication: Walter Erdelen; Editor: Susan Schneegans; Lay-out: Yvonne Mehl; Printed by: Eric Baudry, GRAPH 2000, MP GRAPHIC, (eric.baudry@club-internet.fr) – This issue was printed in 8,000 copies.
Register for free e-subscription: y.mehl@unesco.org – Free print subscription for libraries and institutions: s.schneegans@unesco.org, fax: (331) 4568 5827