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A World of SCIENCE

IN THIS ISSUE

EDITORIAL

To your telescopes!

Some governments feel there are too many International Years. It is true that the new century has already shone the spotlight on mountains, freshwater, physics and desertification; the International Union of Geological Sciences is presently gearing up for the International Year of Planet Earth in 2008.

Although governments propose International Years to the United Nations, it is in fact largely the scientific community which implements them, with the support of the media.

At UNESCO's last General Conference in October 2005, Member States endorsed Italy's proposal for an International Year of Astronomy in 2009. The next step will be for at least one of these same Member States to bring the proposal before the United Nations General Assembly within the next few months.

In my view, an International Year of Astronomy would have numerous benefits. For one thing, the International Astronomical Union (IAU) is very committed. It is already planning star-gazing nights for the general public. As the IAU has national members in just 62 countries however, UNESCO's involvement will be crucial to ensuring the Year benefits all Member States.

One aim of the Year would be to foster the introduction of astronomy into school curricula. This is precisely the goal of UNESCO's Space Education Programme. As part of this effort, the programme donates portable telescopes to schools and organizes 'rocket launching' workshops for children, as you will discover in this issue.

The Year would also encourage amateur astronomy clubs. The sky is an open-air theatre which everyone can contemplate, with or without instruments. You don't need a telescope to admire a shooting star or comet. Mercury, Venus, Mars and Jupiter were all known two thousand years before the invention of the telescope.

The Year would be an opportunity for clubs to help one another. A number already have webpages explaining how to make a telescope. These telescopes can be modest affairs. Let's not forget that Galileo discovered Jupiter's four moons in 1609 using a telescope just a few centimetres in diameter.

Astronomy is not only one of the oldest sciences in the world, it is also on the cutting edge of research. Remember the excitement last month when NASA published photos of bright new deposits in two gullies on Mars which suggested that water had carried sediment through them sometime in the past seven years, thereby reviving speculation about the potential for microbial life on Mars? The event made the headlines around the world.

What better way to reconcile children with science and improve the population's general scientific culture than via astronomy? What better occasion to do so than via an International Year of Astronomy in 2009?

W. Erdelen
Assistant Director-General for Natural Sciences

Secrets of the night sky

In 2009, we hope to celebrate the 400th anniversary of a revolution: the first use of instruments for astronomical purposes. Galileo Galilei may not have invented the telescope but he was the first to point it heavenwards, in 1609. Moreover, Galileo's initial observations of the Moon's surface and Jupiter's four moons enabled him to confirm the Copernican theory that placed the Sun – and not the Earth – at the centre of our Solar System. Since then, the rate of discoveries has accelerated at an ever-quickening pace. Most of the planets in our Solar System have now been explored and we know of nearly 200 planetary systems beyond our own.

UNESCO and the International Astronomical Union (IAU) are calling for 2009 to be proclaimed International Year of Astronomy. This is because such a Year would afford a unique opportunity to recall an obvious, if overlooked, fact: the sky belongs to everyone. Star-gazing provides not only a magnificent spectacle but also a window to reflection on the meaning of existence that should be accessible to all.

The Crab Nebula (pictured here) is a cloud of gas which is expanding at a rate of about 1000 km/s. It is a powerful source of X-rays. The Crab Nebula was born of the explosion of a supernova (an exploding star), an event observed by Chinese astronomers on 4 July 1054

Throughout history, people everywhere have admired the sky and been awed by its beauty. Ever since antiquity, we have been putting names on constellations, categorizing stars according to their brightness and scrutinizing the sky for comets, solar eclipses and unusually bright stars. Stonehenge is obviously an ancient astronomical observatory (*see photo*).

The ancient Egyptians believed there was a link between the onset of flooding of the Nile each year and the return of Sirius to the sky at dawn. Seen from Earth, Sirius is the brightest star in the sky after the Sun. For a short time, however its position in relation to the Sun and Earth is such that it disappears from sight.

Stonehenge, the largest megalithic complex in England. Historians of astronomy agree that the position of the standing stones, which form a large circle, is based on observations of the sky made between 2000 and 1500 BC

In 1054, Chinese astronomers recorded the particular intensity of a 'guest' star they could see even in plain daylight for a week. This was the famous supernova (exploding star) known as the Crab Nebula, part of the constellation of Taurus (*see photo*).

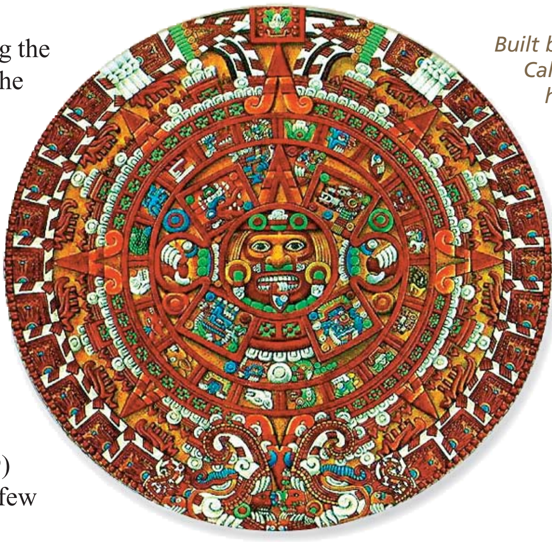
The religion of the Incas was based on Sun worship. Part of the famous Incan city of Machu Picchu in Peru is illuminated by bright light every year at the summer solstice. Farther north, in Central America, the Aztecs had their own Sun Stone (*see photo*).

The Arab civilization has produced great astronomers and magnificent observatories, such as those in Samarkand, Jaipur (*see photo*) and Delhi. It has also bequeathed to posterity a large number of terms, including the names of stars such as Betelgeuse and Aldebaran, and the words zodiac, zenith and nadir. The early calendars were based on observation of the apparent movement of the Sun and the Moon.

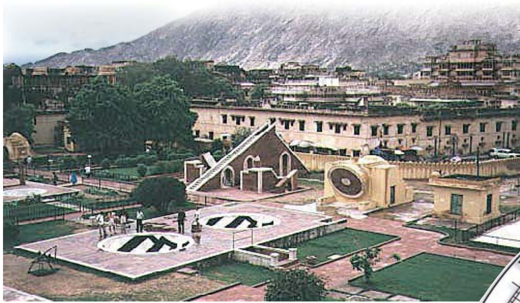
The dates of Easter, celebrated by Christians and Jews, and of Ramadan are determined in relation to the phases of the Moon.

In short, astronomy appears to be one of the very first disciplines to have acquired precocious scientific status. The 'scholars' in each of the civilizations mentioned above drew up tables and sky charts showing the positions of stars and planets. The Arabs invented the astrolabe, an instrument used to find your position by measuring the height of the celestial bodies above the horizon (*see box*).

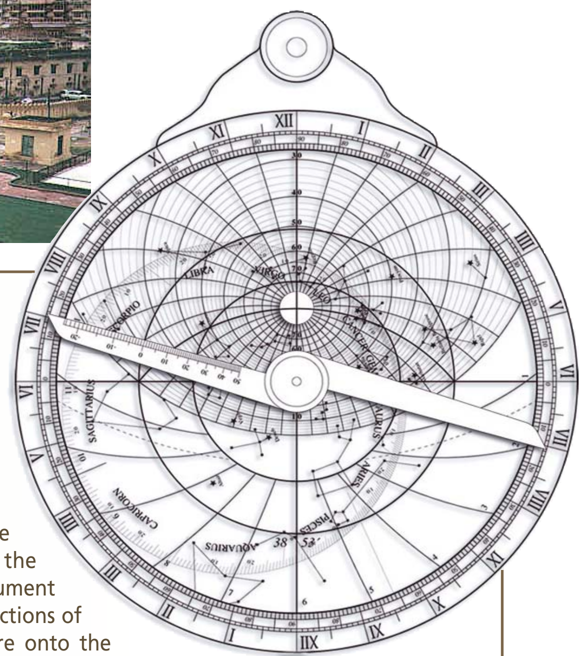
The science of orientation and cartography is based on the observation of celestial bodies. Given the obvious economic and military utility of cartography, it is hardly surprising that Jean-Baptiste Colbert, minister of King Louis XIV of France, and Charles II of England decided to build the first two major observatories, in Paris (1669) and Greenwich (1675), within just a few years of one another.



Built by the Aztecs in the 15th century, the Calendar Stone (or Sun Stone) pictured here was placed atop the main temple in Tenochitlan, the Aztec capital. Rays emanate from the Sun god in the centre, Tonatiub. The Aztec priests used the calendar to fix the hours of the day, the period of solistices and equinoxes, and the point at which the sun was at its zenith; the stone divides the solar year into 18 months of 20 days each, for a total of 360 days, plus five days to make the calendar correspond to the solar year



The Jaipur Observatory was built in the 1720s by the Maharaja Jai Singh II and is a contemporary of the observatories built in Delhi, Mathura, Ujjain and Vârânasî. It remains one of the jewels of this superb city



The astrolabe

The astrolabe is an astronomical instrument used to find one's position, a task which would otherwise require considerable mathematical calculations.

The principles of the astrolabe projection were known to the Greeks before 150 BC and true astrolabes were being made before AD 400. The astrolabe was not invented by a single individual but evolved over several centuries.

Astrolabes were used to tell the time of the day or night, to find the time of sunrise and sunset, and thus the length of the day, and to locate celestial objects in the sky. Islamic prayer times are astronomically determined.

The astrolabe was refined and highly developed in the Islamic world by 900 AD; it was introduced into Europe from Islamic Spain (Andalusia) in the 11th century. It was the most popular astronomical instrument until it was replaced around 1650 by more specialized and accurate instruments. Astrolabes are nevertheless still appreciated for their unique capabilities and their value for astronomy education.

The astrolabe is intended for both observation and computation. For observation, it is fitted with a ring so that the instrument can be hung vertically while the position of the Sun or a star is measured using moveable sights and a scale on the back of the instrument.

©Anthony Dunn

18th century Persian astrolabe in the Whipple Museum(UK)

The planispheric astrolabe works because all of the components on the front of the instrument are identical projections of the celestial sphere onto the face of the instrument.

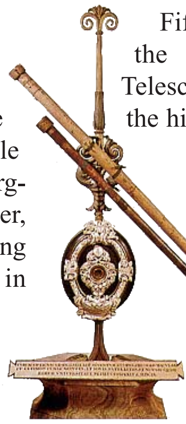
Most astrolabe problems were solved using the front of the instrument, which has both fixed and rotating parts: the former represent time scales and a view of the sky as seen from a specific latitude; the latter simulate the daily rotation of the sky. To use an astrolabe, you adjust the moveable components to a time and date. Once set, much of the sky, both visible and invisible, is represented on the face of the instrument.

In the sketch of an astrolabe above, the hours of the day run full circle (2 x 12 hours) on the rim. The Sun's daily longitude (Aquarius, Capricorn, etc, according to the zodiac) is marked on the ecliptic circle.

Text and drawing of a European version reproduced with the kind permission of James Morrison:www.astrolabes.org/

Increasingly powerful telescopes

In 1609, Galileo adapted an optical instrument for astronomical observation that was probably invented in the Netherlands. 'Galileo's telescope' was the first veritable instrument for astronomical observation; it used a converging lens 37 mm in diameter for the objective and a smaller, diverging lens for the eyepiece (*see photo*). The diverging lens would later be replaced by a converging eyepiece in subsequent telescopes.



Galileo's telescope was a simple tube

In the latter half of the 17th century, Englishman Isaac Newton and Frenchman Nicolas Cassegrain perfected the first telescopes with a concave mirror rather than an objective lens. The mirrors in the first telescopes measured just a few dozen centimetres in diameter.

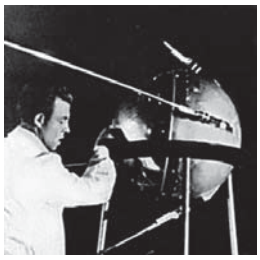
By the early 20th century, Californian astronomers were using a telescope 2 m in diameter at the Mount Wilson Observatory to the north of Los Angeles (USA). It was this telescope which was used by Edwin Hubble in 1929 to prove that the universe as a whole was expanding (*see box overleaf*). He then decided to install on Palomar Mountain north of San Diego a 5-metre telescope which remained the 'champion' until the late 1990s.

The Paranal Observatory in northern Chile consists primarily of the Very Large Telescope of the European Southern Observatory. There are four telescopes in all, each measuring 8 m in diameter, or the equivalent of a large 16-metre telescope. The VLT is arguably the most sensitive instrument in the world. For the past three to four years, it has been making observations of unprecedented quality

Fifteen years ago, Californian astronomers installed the first 10-metre telescopes – known as Keck Telescopes after their wealthy patron – on Mauna Kea, the highest point on Hawaii's main island (USA).

Since the turn of the 21st century, European and Chilean astronomers have been using a very large telescope in Chile which is equipped with four mirrors measuring 8 m each in diameter (*see photo*). In about a decade from now, there will be instruments with an equivalent diameter of 30–100 m. There is a reason for this race to create giants: the bigger the telescope, the more sensitive it is; in other words, the bigger the telescope, the greater its capacity to detect less luminous celestial bodies and the higher its resolution, meaning that it can distinguish objects separated by ever-smaller angles.

An increasingly specialized field



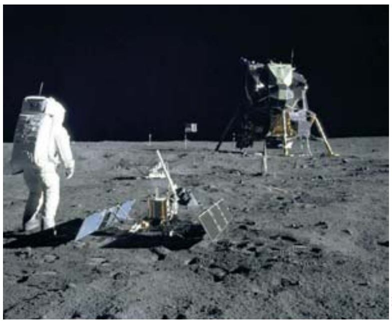
Final preparations before the launch of the first artificial satellite, the Sputnik, by the Union of Soviet Socialist Republics in October 1957

Three main factors account for the amazing boom in discoveries in recent years and the growing specialization of astronomers, a trend which is driving a wedge between the professionals and the many communities of amateur astronomers.

The first reason is the enormous progress in 'instrumentalization' since 1609. This has led to the construction of increasingly large, sophisticated and powerful telescopes, equipped with increasingly effective light detectors.

The second reason lies in the development of information technology (IT), which astronomers use for at least two purposes. Firstly, they use IT to process observations, a task which is becoming infinitely more rapid and more reliable. In the 1960s, it took a team of five technicians a month to interpret the light emitted by a star; today, the

This image of Mars was taken in October 2006 by NASA's robotic rover Opportunity on the rim of Victoria Crater, which the rover was about 800 m in diameter near the equator of Mars; it is bigger than any crater Opportunity has explored during its long Martian trek.Within two form long ago. Scientists hope that the rover's exploration of exposed geological layers in the cliff-like portions of Victoria's inner wall will Orbiter spacecraft will help guide the rover's exploration of Victoria from above.The rover will be recovering geological samples from the



Two American astronauts walking on the Moon for the first time in July 1969. 'That's one small step for a man; one giant leap for mankind', said Neil Armstrong, who took this photograph of Buzz Aldrin. The third man on NASA's Apollo 11 mission, Michael Collins, remained on board Columbia in lunar orbit. As the Moon has no atmosphere, the footprints left by the men's boots should still be visible on the Moon's surface today

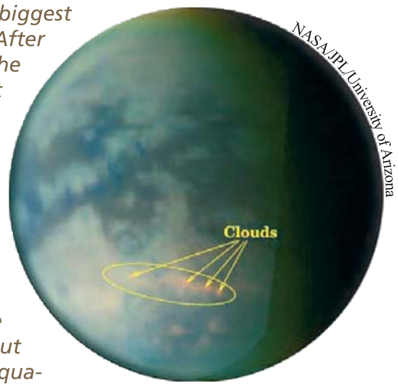
same operation can be completed in about 10 minutes by a novice astronomer. Astronomers also use IT to develop adaptive optics – optics which are continually corrected by the computer. This has further refined the performance of telescopes.

The third reason is that astronomers, along with the rest of the scientific community, have had access to space since the flight of the first Sputnik in 1957 (*see photo*). This allows them to observe all forms of celestial radiation, from the strongest forms such as ultraviolet rays, X-rays and gamma rays, to the weakest, which include infrared rays, radio waves and micrometric rays. This is because the Earth's atmosphere 'lets through' only visible radiation, in other words that which can be seen with the naked eye, and radio waves. All the other forms of celestial radiation are more or less absorbed by the atmosphere. In the case of ultraviolet rays, this is because of the stratospheric ozone layer.

Most of the planets in our Solar System have been visited

For the three reasons outlined above, to which may be added advances in physics and particularly those in the microscopic world of elementary particles, modern astronomy has made many wonderful discoveries. For example, most of the planets in our Solar System have been 'visited' by countless space missions. To cite only two, the European probe Huygens, carried by the American satellite Cassini, gently touched down on the surface of Titan, Saturn's biggest Moon, in January 2005 (*see photo*).The most recent missions to Mars like Mars Express have detected the presence of water, most of which has now disappeared (see photo). Future missions should be able to ascertain whether 'biological' molecules exist on the planet's surface.

In observing the stars in our galaxy, my colleague Michel Mayor of the Geneva Observatory in Switzerland and all those who have followed in his footsteps since have discovered nearly 200 planetary systems beyond our own. Jean-Philippe Beaulieu of the Institut d'astrophysique de Paris and his team have even detected a distant 'telluric' planet just five to eight times the size of Earth. A telluric planet has a solid surface similar to that of Mercury, Venus, Earth and Mars.



Clouds over Titan, Saturn's biggest satellite, on 22 July 2006. After a journey of seven years, the Cassini–Huygens spacecraft reached Saturn in July 2004. The spacecraft is now on a four-year mission to explore the planet. With its stunning rings and many moons, Saturn is an intriguing planet. It has a huge magnetosphere and a stormy atmosphere with winds clocked at about 1800 km per hour near the equator. These super-fast winds, combined with heat rising from within the planet's interior, cause the yellow and gold bands visible in its atmosphere. Like Jupiter, Uranus and Neptune, Saturn is a gas giant. It is made up mostly of hydrogen and helium. Cassini will complete 74 orbits of Saturn, 44 close flybys of Titan and numerous flybys of Saturn's other icy moons. In April 2006, the mission revealed mountains and river channels near Titan's equator. Contrary to popular belief that liquid methane and ethane oceans would collect on its surface, no evidence has been found so far for large lakes of liquids (Source: NASA)

to begin exploring. (The rover has been superimposed on the image to give an idea of scale.) Victoria is an impact crater about
months of landing on Mars in early 2004, Opportunity had found geological evidence for the presence of water in liquid
provide new clues about the history of water on Mars. Photos taken by the high-resolution camera onboard the Mars Reconnaissance
crater for analysis back on Earth (Source: NASA)

Travelling to the origins of the universe

The Big Bang theory on the origin and evolution of our universe postulates that, 12–14 billion years ago, the portion of the universe we can see today was only a few millimeters across. The universe has since expanded from this hot dense state into the vast and much cooler cosmos we currently inhabit. As the universe expands, the gas and radiation within it cool. The universe should thus be filled with radiation that is literally heat left over from the Big Bang, what is called cosmic microwave background (CMB) radiation.

The universe is expanding

The Big Bang model was a natural outcome of Albert Einstein's General Theory of Relativity as applied to a homogeneous universe. However, in 1917, the idea that the universe was expanding was considered absurd so Einstein invented the cosmological constant that allowed for a static universe.

In 1929, astronomer Edwin Hubble announced that his observations of galaxies outside our own Milky Way showed they were systematically moving away from us at a speed proportional to their distance from us: the more distant the galaxy, the faster it was receding from us. The universe was expanding after all!

Taking the temperature of the universe

CMB radiation still pervades the universe. It was first observed inadvertently in 1965 by Arno Penzias and Robert Wilson at the Bell Telephone Laboratories (USA) when the radiation acted as a source of excess noise in a radio receiver they were building.

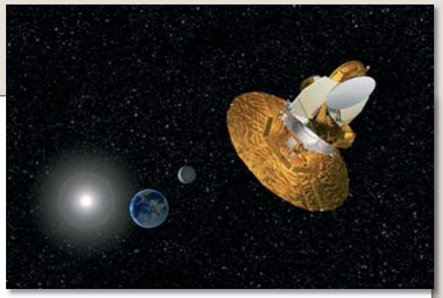
CMB radiation is visible to microwave detectors as a uniform glow across the entire sky. The temperature of this radiation is currently being measured by NASA's Explorer Mission (*see illustration on facing page*). This is because CMB radiation can tell us a lot about the age of the universe. It can also tell us a lot about how matter and energy have evolved over the past 13.7 billion years.

How the 'microwave sky' tells us about the universe

There were no atoms in the hot early universe, only free electrons and nuclei. (Nuclei are made up of neutrons and protons.) Eventually, the universe cooled sufficiently for protons and electrons to combine to form neutral hydrogen. This is thought to have occurred roughly 400 000 years after the Big Bang when the universe was about 1/1100th its present size. This was when CMB radiation was emitted for the first time, long before stars or galaxies ever existed.

By giving us insights into the expansion of the universe, CMB radiation can also help us to estimate the age of the universe. When the visible universe was half its present size for example, the density of matter was eight times higher and CMB was twice as hot. When the visible universe was 1/100th its present size, CMB was a hundred times hotter.

In this sequence from a film called The Universe, ***Frame one*** *depicts temperature fluctuations (shown as colour differences) in the oldest light in the universe, as seen today by WMAP.* ***Frame two*** *shows matter condensing as gravity pulls matter from regions of lower density onto regions of higher density.* ***Frame three*** *captures the era of the first stars, about 400 million years after the Big Bang. Gas has condensed and heated up to temperatures high enough to initiate nuclear fusion, the engine of the stars.* ***Frame four*** *shows more stars turning on. Galaxy chains form along those filaments first seen in frame two.* ***Frame five*** *depicts the modern era, billions upon billions of stars and galaxies... all from the seeds planted in the infant universe*



An artist's depiction of the WMAP. Since being launched by NASA in 2001, this spacecraft has made discoveries relating to the shape of the universe, dark matter and early galaxy formation. It has maintained an orbit 1.6 million km from Earth

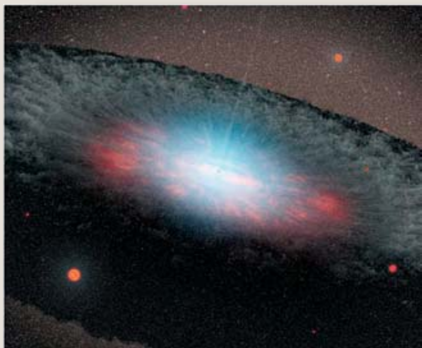
Travelling through time and space

By studying the physical properties of CMB radiation, we can learn about conditions in the universe on very large scales, since the radiation we see today has travelled a great distance.

We can also learn about conditions in the universe at very early times. Since light travels at a finite speed, astronomers observing distant objects are looking into the past. Most of the stars that are visible to the naked eye in the night sky are 10–100 light years away. We thus see them as they were 10–100 years ago. We observe Andromeda, the nearest big galaxy, as it was about 2.5 million years ago. Astronomers observing distant galaxies with the Hubble Space Telescope can see them as they were only a few billion years after the Big Bang.

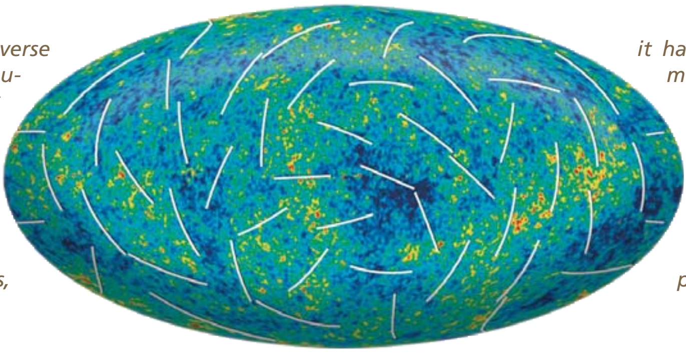
The universe is expanding at a rate which appears to be accelerating. The question is, will the universe continue to expand forever or will it eventually collapse?

This page is a compilation of media-related resources provided by NASA and the California Institute of Technology: http://map.gsfc.nasa.gov/; www.galex.caltech.edu



Black holes (here an artist's impression of one) are monstrous heaps of dense matter at the centre of galaxies. Over time, a black hole and its host galaxy will grow in size but not always at the same pace. Since bigger galaxies are known to have bigger black holes, astronomers believe the black holes are responsible for the lack of youthful stars in these galaxies. According to this theory, the growth of a black hole slows the development not only of stars but of the entire galaxy. How? There are two theories: jets being blasted out of black holes could blow gas (potential star-making fuel) out of the galaxy centre, where stars tend to arise; or the phenomenon could be due to the fact that black holes drag surrounding gas onto them, which heats the gas. The gas could become so hot that it could no longer clump together and collapse into stars. Here, only the old red-coloured stars that make up the galaxy can be seen. There are no new stars. The findings described here were published in Nature *in August 2006*

A map of the infant universe showing spatial distribution of inhomogeneity of celestial background radiation observed in 2001 by NASA's satellite, the WMAP. This is the most accurate map available to astrophysicists today; among other things,



it has enabled them to determine accurately the 'age' of the universe as being 13.7 billion years. In early 2008, European astrophysicists will launch the Planck–Surveyor satellite, which should provide maps ten times more precise (see also box)

Coming to grips with how galaxies are formed

Astronomers have also proved that there are more than 200 different molecules in interstellar gas. Most of these are carbon-based and thus organic in nature. Some are highly complex shapes, such as fullerenes ('bucky-balls'), which can be represented as structures in the form of a sphere. Other astronomers have become interested in the great structures of the universe, the galaxies and their clusters.

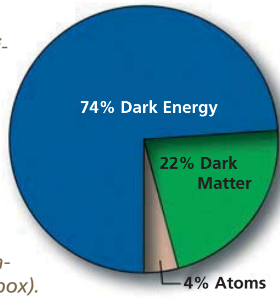
Launched by NASA in 1990, the Hubble Space Telescope measures 2.4 m in diameter. Its astigmatism was repaired in 1993. The telescope is 85% American and 15% European and continues to supply some of the most beautiful images of the universe (see an example overleaf)

We owe our better understanding of the way in which galaxies are formed (by the assemblage of smaller structures rather than fragmentation) to the Hubble Space Telescope. It has also enabled us to determine when the birth rate of galaxies peaked, some 2 billion years after the 'birth' of the universe.

A recent space mission, the *Wilkinson Microwave Anisotropy Probe* (WMAP), has been producing results since 2001. WMAP has made it possible to determine with precision the basic parameters of the universe as a whole, within the framework of the Big Bang theory. According to the latter, the universe has been expanding for more than 10 billion years and has emerged from an infinitely denser, hotter phase (*see box*).

These parameters reveal the universe's 'age', that is, the time that has elapsed since history began 13.7 billion years ago. Thanks to the findings of the WMAP mission and the observations of the most remote supernovae made using the Hubble Space Telescope, we are now convinced that the matter of which we are made and which we can see represents at most just 10% of the material content of the universe. (The matter we are made of is called 'nuclear' because we are made of atoms and almost all the mass of these atoms is included in their nuclei.) Most matter consists of non-nuclear particles which astrophysicists and particle physicists are presently working hard to find. As concerns the energy–matter content of the universe, there is apparently twice as much free energy as matter.

WMAP data reveal that the contents of the universe include 4% atoms, the building blocks of stars and planets. Dark matter comprises a further 22% of the universe. Different from atoms, this matter neither emits nor absorbs light and has only been detected indirectly by its gravity. Three-quarters of the universe is composed of 'dark energy' that acts as a sort of anti-gravity. This energy, distinct from dark matter, is responsible for the present-day acceleration in the expansion of the universe (see also box). Source: NASA



Perfect amateurs

The growing specialization of professional astronomers is quite regrettable, as amateur astronomers are the natural link between society and the professional community. The fact that amateurs also use small-diameter telescopes with a broader field of vision and frequently know the sky better than the professionals often gives them a headstart when it comes to spotting something new, be it the appearance of a comet, the explosion of a nova or – extremely rare in the life of a galaxy – the explosion of a supernova.

Artist's impression of our galaxy. It contains the planets in our Solar System (see page 9) and the stars which can be seen with the naked eye

Most countries have amateur clubs. These clubs tend to use instruments between 10 cm and 40 cm in diameter, either individually or collectively, which are smaller than the telescopes used by professionals. Clubs meet to organize and attend conferences, build up libraries of books and journals and encourage the installation of planetarias of differing sizes and sophistication. Some even set up Internet sites to disseminate striking images and valuable information to amateur astronomers, such as sky maps or instructions on how to make a telescope.

There is no lack of arguments for forming and running an astronomy club. For one thing, you learn to work with other people in a climate of mutual respect.

A second argument is that you will share powerful emotions. In my opinion, nothing is more rewarding than using a small telescope to observe Saturn, or the planetary nebula in the constellation of Lyra or a beautiful globular cluster such as can be observed in the constellation of Hercules (*see also photo opposite*).

There is a third argument which is at least as important as the first two. Education can nourish a love for science in the young that may one day lead them to opt for a scientific or technical career.

The Omega Nebula photographed here by the Hubble Space Telescope is about 5000 light-years from Earth. It is visible with binoculars in the constellation of Sagittarius. It contains glowing gas, dark dust and some unusually massive stars that haven't yet had time to self-destruct. Until they do, these stars will continue to sparkle and emit light so energetic that it breaks up the surrounding gas and dust

Getting the message across

Teaching astronomy has many 'virtues'. For one thing, the subject is intrinsically interesting and can be taught in a very basic way so as to attract even those who might be put off by mathematics. Astronomy also draws on a number of disciplines which include all the branches of optics as well as computer science, electronics, basic physics and chemistry. It is a great pity that astronomy has still not found its place in primary and secondary education in so many countries, including France.

UNESCO could make it a priority to incite countries to introduce astronomy into the curriculum from the primary to tertiary levels of education, to encourage the founding of amateur clubs everywhere and the installation of numerous planetaria, which provide such an

Preparing the next space generation

Not all children may dream of growing up to be astronauts, astronomers, robotic engineers or physicists but what child has never wondered what it would be like to explore outer space?

Since 2002, UNESCO's Space Education Programme * has been striving to make science lessons more exciting for children and their teachers by incorporating space-related subjects into the curriculum. The twin goal is to develop a scientific culture and to prepare the next generation of the space workforce. As part of this effort, UNESCO runs workshops for pupils and their teachers in different parts of the country. The workshops include rocket launching demonstrations (*see photo*), astronomical observations and talks by an astronaut and other experts on subjects like lunar and Mars exploration missions.

UNESCO has also been providing schools with state-of-the-art technology like portable telescopes (*see photo*) donated by Meade Instruments Inc. At the end of a series of workshops in the country, a pilot national space programme is defined with expert advice and forwarded to UNESCO for assistance in building partnerships.

Workshops have been organized in the Philippines (2004), Nigeria and Colombia (2005) and Vietnam (2006); the next ones will be held in Ecuador, Morocco, Syria and Tanzania in 2007

Vietnamese boys discovering their school's new telescope in March 2006

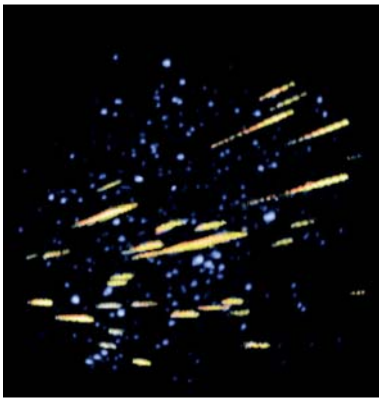
Girls and their teachers learning how to 'launch a rocket' in Ile-Ife, one of three Nigerian cities which hosted a workshop in May 2005

Although the programme puts special emphasis on teacher training and the development of educational materials, it also organizes or sponsors outreach activities like space contests and events for the public.

Countries interested in hosting workshops are invited to contact: y.berenguer@unesco.org; See also: www.unesco.org/science/earth

** Partners include the Armagh Planetarium, Centre national d'Études spatiales (France), European Space Agency, EURISY, Instituto Nacional de Pesquisas Espaciais (Brazil), International Space University (France), Japan Aerospace Exploration Agency, NASA (USA), National Space Society (USA), Norwegian Space Centre and the UN Office for Outer Space Affairs. UNESCO is also a member of the working groups on education and capacity-building of the Committee of Earth Observation Satellites, Committee on Space Research, International Astronautical Federation, Sociedad de Especialistas Latinoamericana de Percepción Remota y Sistemas de Información Espacial and the Global Earth Observation System of Systems*

Shooting stars like these are not stars at all but cosmic dust particles known as meteoroids which leave a fleeting trail of light as they break up upon entering the Earth's atmosphere. A meteoroid which makes it to Earth is known as a meteorite. Every August in France, a night is designated 'Star Night'. At this time of the year, when a shower of shooting stars are visible in the sky, a thousand clubs go sky-gazing, with or without instruments



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A globular cluster orbiting the Andromeda Galaxy. A globular cluster groups several million very aged stars which occupy a relatively small volume that is a near-spherical shape. There are some 200 globular clusters distributed fairly symmetrically around the centre of our galaxy, the Milky Way, which lies in the direction of Sagittarius

entertaining introduction to the beauty and mysteries of the sky.

For my part, I belong to a small association by the name of Uranoscope France which helps groups in countries as diverse as Algeria, Egypt, India, Morocco, Panama and Syria to obtain small telescopes. Professional astronomers have an essential role to play at both the country-level and internationally in promoting astronomy. Be they amateurs or youngsters, people will be all the more eager to embrace astronomy if the professionals are prepared to spare them a little of their time.

The goals of the International Year of Astronomy advocated by UNESCO and the IAU are obvious. First and foremost, we hope to convince people to turn their eyes heavenwards. To this end, we plan to organize a number of star-gazing nights.

Professional astronomers would also like to seize this opportunity to speak out against light pollution at night, which affects the quality of observations. One idea might be to choose a night in 2009 when countries and communities would be invited to turn down the lights.

Our second goal is to cater to the young. We are planning a host of events for them, including drawing competitions and visits from professional astronomers, whom we plan to bring into the classroom.

Our third goal is to draw up a list of groups in every country who are keen to practise astronomy on an amateur basis. With 191 Member States, UNESCO has a special role to play here, as professional astronomy is practised only in the 62 countries which are national members of the IAU.

Jean Audouze[1]

1. *Director of Research at the Centre national de la recherche scientifique, Vice-President of the French National Commission for UNESCO. See also page 15*

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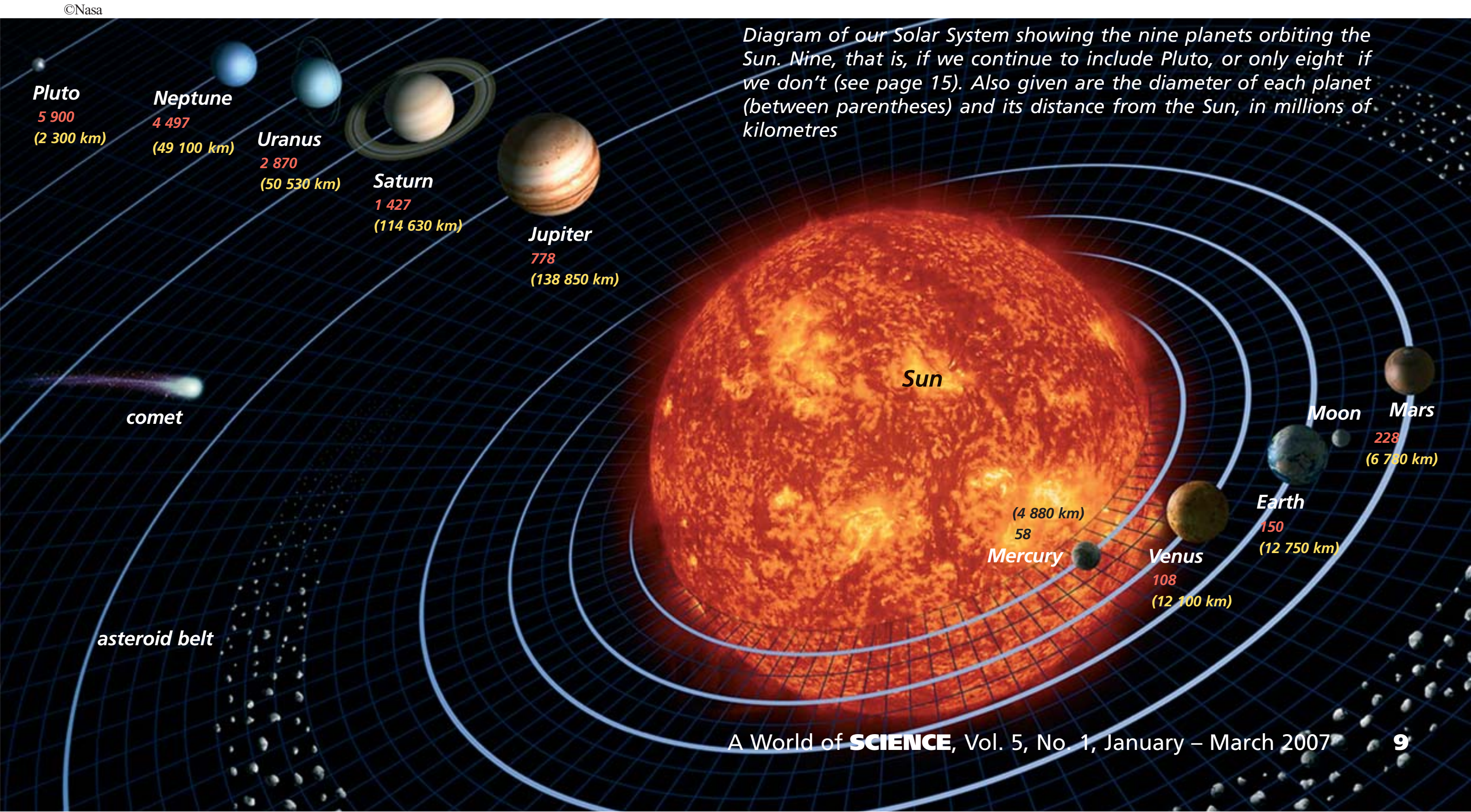


Diagram of our Solar System showing the nine planets orbiting the Sun. Nine, that is, if we continue to include Pluto, or only eight if we don't (see page 15). Also given are the diameter of each planet (between parentheses) and its distance from the Sun, in millions of kilometres

Experts call for **glacier research centre** for Central Asia

Sixty experts meeting in Almaty (Kazakhstan) on 28–30 November to discuss glacier retreat and its impact on water resources in Central Asia have called for the creation of a regional centre for glacier research in Central Asia.

Central Asia is one of the world's water-stressed areas. Studies presented to the workshop show that the glaciers in the region are melting rapidly: between 1955 and 2000, they lost 0.6–0.8% of their volume per year

Mountain ranges in the region include the Altai, Tian Shan, Pamir, Karakoram and the Himalyan and Tibetan Plateaus; these ranges stock the largest volume of ice outside the polar regions. The ranges serve as water towers by providing a continuous supply of fresh water to the lowlands for irrigation, domestic and other purposes. As many of the rivers and glaciers cross national boundaries, water shortages could potentially create not only socio-economic problems but also political instability in the region.

In the Almaty Declaration, the experts also call for a review of the ongoing and completed research in Central Asia on the hydrological impact of glaciers, snow and permafrost. They recommend developing a regional network of benchmark basins to investigate the impact of glaciers and snow cover on the hydrological cycle and on the associated socio-economic system.

The workshop was organized by UNESCO's Man and the Biosphere (MAB) and International Hydrological Programmes (IHP), together with the Regional Environmental Centre for Central Asia (CAREC), the European Commission and the Institute of Geography of the Academy of Sciences of Kazakhstan.

Situated 30 km south of Almaty, Tuyuksu Glacier (pictured here in August 2006) has been monitored by Kazakh scientists for nearly a century. Tuyuksu glacier has receded nearly 1 km since 1923, according to Stephan Harrison from Oxford University in the UK

International experts had travelled to Almaty from Canada, China, Germany, Japan, Jordan, Kazakhstan, Kyrgyzstan, Nepal, the Russian Federation, Switzerland, Tajikistan, Uzbekistan and the USA.

Among the NGOs present were the World Conservation Union (IUCN) and the Mountain Research Initiative, a key partner in UNESCO's Global Change in Mountains (GLOCHAMORE) project funded by the European Union (see *A World of Science*, January 2006).

For details (in Almaty):
www.unesco.kz/science; a.mishra@unesco.org

Launch of **first centre for water law**

The UNESCO Centre for Water Law, Policy and Science was given its European launch in Brussels (Belgium) on 28 November. Brussels was chosen for the launch to give the centre greater visibility and link to it up to the institutions of the European Union on water issues.

The UNESCO centre is hosted by the University of Dundee in the UK. It will be the first centre in the world to develop legal frameworks for managing the world's water resources at the local, regional and global levels. The new centre will develop policies to bridge the gap between science and law in conflicts over water both within and between countries. It will also fulfill a key role in developing transparent, responsive water policies that are also enforceable.

The Dundee centre has been established in collaboration with UNESCO's Hydrology for the Environment, Life and Policy (HELP) Programme, which seeks to build bridges between hydrology and the needs of society around river catchment basins. HELP seats scientists, managers, legal and policy experts and stakeholders around the same table to tackle locally defined water-related issues. Since its inception in 1999, the programme has established a network of 67 basins involving 56 countries.

'While water is an important priority on the international development agenda and policy is evolving rapidly in this area', notes UK Ambassador to UNESCO Tim Craddock, 'the international community has not yet established a global action plan, including policy and legal frameworks for water management and the delivery of clean water to populations in need around the world along the lines of the Education for All plan. The Dundee Centre could contribute to this global action plan by developing the legal and policy aspects.'

The UNESCO Centre for Water Law, Policy and Science was formally approved by UNESCO at its General Conference in October 2005.

©UNESCO

The construction of a series of dams by Turkey like this one on the Tigris River has created tensions in the region since the scheme was launched in 1977. The Tigris originates in Turkey before flowing through Syria, Iraq and Iran. A UNESCO project launched in 2004 to lay the groundwork for a National Water Resources Master Plan for Iraq is also promoting dialogue among the four riparian states on the shared management of the Tigris and Euphrates rivers

For details: www.dundee.ac.uk/water/ ; www.unesco.org/water/ihp/help

UNESCO and Korea to foster **science parks in South**

The Korean International Cooperation Agency (KOICA), Daejeon Metropolitan City and UNESCO have set up a scheme to help developing countries manage science and technology parks, or 'technopolises'. The tripartite agreement was signed on 29 September at UNESCO headquarters.

Under the scheme, KOICA and Daejeon Metropolitan City will contribute US$1 million in funds in trust over the next five years to UNESCO's programme for University-Industry-Science partnerships (UNISPAR). UNISPAR seeks to overcome the problems many developing countries face in commercializing research by fostering partnerships between academia and industry. The project will foster innovation in information and communication technologies, biotechnology and other high-tech fields.

To launch the fund, KOICA has donated US$120 000 and Daejeon City a further US$80 000. These initial funds will be used to run an annual international training workshop in Daejeon, as well as a series of regional workshops in Africa, Asia, the Pacific, Latin America and the Caribbean.

The project will also develop a regional network and pilot project in Africa, the Arab States, Asia and the Pacific and Latin America and the Caribbean, in close cooperation with the World Technopolis Association.

For details:
www.unesco.org/science/psd; y.nur@unesco.org

Grid computing **links Africans to diaspora**

UNESCO and Hewlett-Packard launched a joint project on 20 November to provide grid computing technology to universities in Algeria, Ghana, Nigeria, Senegal and Zimbabwe.

The project will connect scientists at home to their colleagues abroad, as well as to research networks and potential funding bodies. Faculties and students at beneficiary universities will also be able to work on major collaborative research projects with other institutions around the world.

'This new African project builds on the success of a similar initiative with UNESCO launched in 2003 to alleviate brain drain in South East Europe that now includes eight countries,' said Bernard Meric, Senior Vice-President of External Affairs at Hewlett Packard, who was in Paris for the launch (see A *World of Science*, July 2005).

The African project was developed by UNESCO's Education Sector in response to requests by Member States. UNESCO and the Education Ministries of the countries concerned will choose the beneficiary universities. Preference will be given to university departments with important information technology components.

Hewlett Packard will provide equipment, including servers and grid-enabling technologies, and local human resources to the universities, as well as training and support, until the projects become self-sustaining. It will also donate personal computers and monitors and fund research visits abroad and meetings between beneficiary universities. UNESCO will be in charge of overall coordination and monitoring, as well as administration and project evaluation.

For details: www.unesco.org/education

A first **intercontinental** biosphere reserve

The world's first intercontinental biosphere reserve was approved by MAB's International Coordinating Council (ICC) on 27 October, along with 24 other biosphere reserves. Four existing biosphere reserves were also extended.

The Intercontinental Biosphere Reserve of the Mediterranean straddles Morocco and Spain, two countries separated by a stretch of water less than 15 km wide in parts at the mouth to the Mediterranean. Connected by this marine transition area, the sites in both countries have much in common in terms of geology, ecology and cultural heritage, and can thus benefit from one other's experience.

The 25 new biosphere reserves

Malawi	
Lake Chilwa	164 bird species are specifically associated with the Lake Chilwa wetland, a Ramsar site; natural habitats and land cover types include the lake itself, marshes, swamps, five major rivers, islands, a cultivated floodplain and grasslands; communities live off fishing, bird hunting and rice-growing
Mexico	
Cumbres de Monterrey	of particular interest for the economic value of some plant species and its role in ensuring a water supply to the nearby urban areas of Monterrey; important for preservation of bird species and its abundant oak forests
Huatulco	on the Pacific coast of the Oaxaca Province in the south of Mexico; ranges from tropical dry forests to coral reefs; of value for the protection of turtles, dolphins, *púrpura caracol* (purple snail), etc.
La Encrucijada	on the Pacific coast of the State of Chiapas; 11 rivers and their tributaries merge with sea water to form lagoons where shrimp fishing is widely practiced; the Mexican authorities have created the reserve to protect the wetlands and coastal areas from human pressures
La Primavera	in the State of Jalisco; features mainly pine and oak forests of value for supplying water and wood to the city of Guadalajara; a genetic reservoir and biological corridor between the area's various ecosystems
La Sepultura	in the Chiapas in the south; of interest for the rich variety of its forests and land-use; home to eight of the Chiapas' 18 primeval vegetation types; features remnants of pre-Colombian cultures like the Olmec
Laguna Madre and Rio Bravo Delta	in the Northeast on the Caribbean shoreline; a high variety of tropical and coastal forests, including mangroves; dunes and wetlands with endemic turtle species; a natural corridor for migrating water fowl; an ecological management plan was needed to mitigate stress caused by human impact
Los Tuxtlas	wet tropical rainforests stretching over three volcanoes in central Mexico, in the State of Veracruz on the Caribbean coast; indigenous Popolucas and Nahuas
Maderas del Carmen, Coahuila	its altitude, geographic particularities and interconnections sustain numerous flora and fauna species typical of the Chihuahua desert and Eastern Sierra Madre; should encourage transboundary cooperation with the Big Bend National Park and Biosphere Reserve on US side of the border
Mariposa Monarca	of value for protection of the Monarch butterfly (*see photo*)
Pantanos de Centla	in the State of Tabasco, the protection of water resources is the fruit of millennial cultural practices; villagers are closely involved in management and highly aware of the reserve's wealth, as they use 200 plant species
Selva El Ocote	in the Chiapas ; home to large tropical rain forests; features numerous cave formations with many endemic species; has karstic aquifers that constitute a fresh water reservoir of 600 million m^3
Sierra de Huautla	in the State of Morelos, 700–2240 m above sea level; features large fir forests and interesting butterfly species, relicts from more humid and warm periods; local participation in managing the site is important
Volcan Tacana	in the Chiapas on the Guatemalan border; of value for local participation in managing fragile ecosystems and for rural development; contiguous to national park on Guatemalan side, which should facilitate transboundary cooperation
Arrecife Alacranes	largest coral reef in Gulf of Mexico and only coral reef in Yucatan; of value for its biological diversity, fishing potential and for the wealth of historic shipwrecks and monuments
Barranca de Metztilan	in the dry central area of the State of Hidalgo, considered a Pleistocene refuge of the Mexican desert biota and its relationship with the Chihuahuan and Sonora deserts; a landscape marked by cacti several metres tall; five indigenous Otomi communities
Chamela–Cuixmala	on the Pacific coast of Mexico; features variety of tropical forests with strong ties between island, marine and terrestrial activities; home to five species of marine turtles, the green iguana lizard and river crocodile
Cuatrocienagas	in the ecoregion of the Chihuahua desert of the Mexican Highlands; features close to 500 pozas, pools whose turquoise waters come from underground; a wealth of endemic species
Sistema Arrecifal Veracruzano	consists of numerous islands near the Caribbean coast grouped in a national park of value for protecting coastal and island resources in the vicinity of the town of Veracruz
Morocco/Spain	
Intercontinental of the Mediterranean	shared by Spain and Morocco (*see previous page*)
Russian Federation	
Middle Volga Integrated	150 000-ha 'island of nature' formed by loop of Volga River within industrial area of Samara–Togliatti agglomeration; consists of national park and municipal areas; rich biodiversity, notably 30 moss, 130 lichen and 300 vertebrate species, some living close to agricultural land and urban buildings
Spain	
Os Ancares Lucenses y Montes de Cervantes, Navia y Becerrea	important for protecting the Cantabric bear, *Ursus arctos*; complements existing biosphere reserve complex of Gran Reserva de la Biosfera de la Cordillera Cantabrica; borders Terras do Mino Biosphere Reserve; together with Los Ancares Leoneses (see next entry), extends future Gran Cantabrica Biosphere Reserve to more than 900 000 ha
Los Ancares Leoneses	complements existing complex of Gran Reserva de la Biosfera de la Cordillera Cantabrica and neighbours Muniellos Biosphere Reserve; links two separate areas of Cantabrica Biosphere Reserve; stepping stone towards future Gran Cantabrica Biosphere Reserve
Las Sierras de Béjar y Francia	near the border with Portugal; notable in ecological and cultural terms; contributes to revitalizing the local economy with programmes to mitigate the rural exodus
Viet Nam	
Kien Giang	covers coastal and marine ecosystems with islands, swamps, mangroves, coral reefs and primary tropical forest patches; noted for its dugong (sea cow) habitats; great potential for ecotourism

The majority of the other new biosphere reserves (*see table*) are located in Mexico. The remainder are in Malawi, the Russian Federation, Spain and Vietnam. These additions bring the World Network of Biosphere Reserves to a total of 507 sites in 102 countries.

Four biosphere reserves have either been extended or undergone changes in zonation:

- in Mexico, the **Región de Calakmul Biosphere Reserve** (formerly the Calakmul Biosphere Reserve) now includes more protected areas of the Yucatan Peninsula, which has among the highest biodiversity of tropical forests in Mexico. The reserve also features important Maya ruins and is an important part of the Mesoamerican Biological Corridor.
- in Ukraine, the **Shatskyi Biosphere Reserve**, in the western part of the largest European swamp–lake–forest complex, the Polesie Region, has been extended to the Polish border in the southwest and to the Belarus border in the north to form a more complete unit for future transboundary cooperation.

- in France, the **Commune de Fakarava Biosphere Reserve**, (formerly the Atoll de Tairo Biosphere Reserve of French Polynesia) has been extended to encompass a group of seven atolls: Aratika, Fakarava, Kauehi, Niau, Raraka, Taiaro and Toau. Most of these atolls are inhabited and local communities were heavily involved in designing its zonation.
- Also in France, the **Camargue in the Rhône River Delta Biosphere Reserve**, has been extended to cover 193 000 ha between Port St Louis du Rhône and Fos-sur-Mer to the east and Grau du Roi/Port Camargue to the west. The new structure facilitates coordination of rice cultivation, hunting, fishing and other human activities, which should ensure the collective management of water resources and maintain key natural ecosystems. This Ramsar site is renowned for its bird population, which includes pink flamingos, eight heron and six seagull species.

The Monarch butterfly, or Danaus plexippus *(pictured), migrates from North America to the new Mariposa Monarca Biosphere Reserve in Mexico every year, attracting large numbers of tourists and generating considerable income for the locals. There is close cooperation with the Canadian and US authorities responsible for key sites along its migratory routes*

For details: www.unesco.org/mab

Research grants for 25 young scientists

At its meeting in Paris from 24 to 27 October, the ICC selected 25 researchers for MAB Young Scientists Awards.The annual awards of up to US$5,000 each encourage young scientists to carry out interdisciplinary research on ecosystems, natural resources and bio diversity.

This year's laureates are: Lucía Souilla (Argentina), Mingyong Chen (China), Ri Un Hyang (Republic of Korea), Nisrin Benayad (Morocco), Joanna Adamczyk (Poland), Dmitry Gorshkov (Russian Federation), Ndeye Astou Niang (Senegal), Jeevani Manishka De Mel (Sri Lanka), Lulu Tunu Kaaya (United Republic of Tanzania) and Anuttara Nathalang (Thailand).

In addition, 15 young scientists have been awarded a research grant of up to US$5,000 each within the Great Apes Survival Project. They are Charles Rugerinyange (Burundi), Barthelemy Doui, Yvette Lakoue and Marc Yagueme (Central African Republic), Geoffroy Guichard and Abraham Mayoke (Congo), Bila-Isia Inogwabini, Innocent Masiala Mabialo and Josué Mbonekube (Democratic Republic of the Congo), Carine H. Nzotekoumie (Gabon), George Oweyesigira, Richard Muhabwe Rugyendo and Annette Mirembe (Uganda), Djibril Diouck (Senegal) and Jared Sylvister Bahuza (United Republic of Tanzania).

Birgit Reutz-Hornsteiner from Austria is the first laureate of the biennial Michel Batisse Grant for biosphere reserve management worth US$6,000. The award has been created in memory of UNESCO's Assistant Director-General Michel Batisse, one of the founders of MAB and the 1972 World Heritage Convention.

For details: www.unesco.org/mab

Sixty years of science at UNESCO

A history of science at UNESCO was launched at headquarters on 10 November, at a ceremony marking both World Science Day for Peace and Development and UNESCO's 60th anniversary.

Written by historians and scientists, including former and active staff members, *Sixty Years of Science at UNESCO 1945–2005* traces the fortunes of the agency since it rose from the ruins of the Second World War. The book includes a list of milestones and a chapter on Looking Ahead. The following are a few highlights from the first 30 years.

In 1950, the UN Economic and Social Council entrusted UNESCO with coordinating 'research and the development of international scientific laboratories.' The first and arguably most famous of these was the European Organization for Nuclear Research (CERN) in 1954. Half a century later, CERN would serve as the model for a synchrotron laboratory in the Middle East by the name of SESAME, the construction of which is currently nearing completion in Jordan under the auspices of UNESCO.

Another UNESCO project to found an International Institute of the Hylean Amazon in 1948 would not turn out so well. The plans for the institute included research laboratories and 'an international museum to house collections of plants, animals, mineral and rocks.' It was noted that 'no inventory has yet been made of Hylea's natural wealth.' The authors comment that 'to the modern reader, these quaint objectives smack of the self-serving interests of scientists from outside the region.' Brazil never ratified the institute and its leading Brazilian proponents 'were accused of

Young researcher at the Indian Institute of Technology (IIT) in Bombay, shortly after it was founded in November 1958 with UNESCO assistance. 'In December 1956, the first team of UNESCO experts arrived: eight from the Soviet Union and one each from the USA and Yugoslavia. They stayed two years', recalls Professor S. P. Sukhatme, Director of the IIT in Bombay

compromising the national security of the country.' Years later, some of the plans for the doomed institute would nevertheless inspire Brazil's Instituto Nacional de Pesquisas da Amazônia. The project hailed the beginning of UNESCO's concern for the environment.

In 1948, UNESCO, the French government and the Swiss League of Nature convened a conference 'which gave birth to the International Union for the Protection of Nature and Natural Resources.' This intergovernmental body has since become the NGO known as the World Conservation Union (IUCN), a close partner of UNESCO.

After UNESCO's proposal that the UN set up an international institute for arid zone studies was not retained in 1947, UNESCO went on to launch its own Arid Zone Research Programme in 1951. The programme devoted a particular year to a specific area: hydrology (1951), plant ecology (1952), wind power and solar energy (1953), human and animal ecology (1954) and arid zone climatology (1955). A 'resounding success', the programme produced the first global map of arid zones in 1951 and created or strengthened research institutes in arid zones in Egypt, India, Israel, Mexico, Pakistan, Tunisia and Turkey.

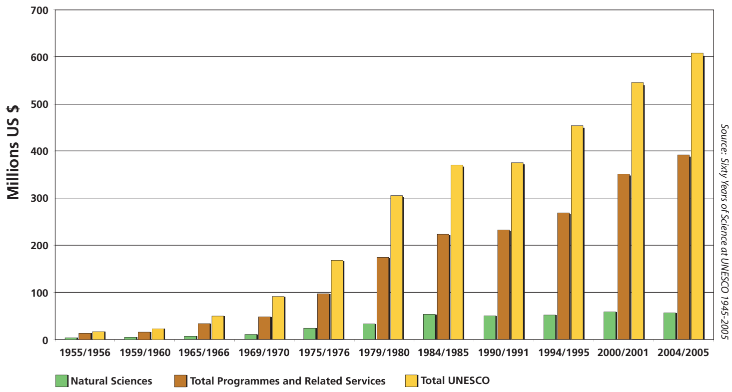
By the early 1970s, UNESCO had four intergovernmental environmental programmes: the Intergovernmental Oceanographic Commission (1961), the Man and the Biosphere (MAB) programme (1971), which advocated the ecosystem (or holistic) approach from the outset, and the International Geoscience Programme (1972) as it is known today. The end of the International Hydrological Decade would usher in UNESCO's International Hydrological Programme in 1975.

The biosphere reserve concept was just a few months old when it gained a high political profile overnight. At their 1974 summit in Moscow, the Soviet and American Presidents Brezhnev and Nixon issued a joint statement 'desiring to expand cooperation in the field of environmental protection … and to contribute to the implementation of the MAB programme of UNESCO, both sides agree to designate, in the territories of their respective countries, certain natural areas as biosphere reserves.'

UNESCO's early years are indissociable from the gradual thaw of the Cold War. Wary of the West, the Union of Soviet Socialist Republics (USSR) would only assent to join UNESCO in 1954, a year before a conference on the peaceful uses of atomic energy and three years before the newly founded International Atomic Energy Agency took over this role from UNESCO. In 1957, the USSR would seize the occasion of UNESCO's International Geophysical Year to launch the first artificial satellite, Sputnik, and with it the space age (*see also page 4*).

History has invited itself into UNESCO in other ways. 'The end of colonialism represented a major turning point for science at UNESCO', note the authors. This had the effect of orienting science away from 'helping Europe catch up to the USA', in molecular biology in particular, and towards helping the developing countries. The first UN Conference on the Application of Science and Technology for the Benefit of the Less Developed Areas was held in 1963 – although just 16% of delegates to the conference hailed from developing countries.

UNESCO Science Budget, 1955–2005
Regular Programme



Another consequence of the end of colonialism was the decision in the 1960s 'to raise science to the same priority level as education' at UNESCO. The resultant hike in budget was to be short-lived however, as UNESCO's science budget has stagnated at around US$56 million ever since 1984 when the UK and USA pulled out of UNESCO for over a decade (*see figure*).

The *International Recommendation on the Status of Scientific Workers* adopted by the General Conference in 1974 is still pertinent today. Only last October, UNESCO's Executive Board invited the Director-General to analyse the ethical principles in the original *Recommendation*, together with the ethical aspects of the *Declaration on Science and the Use of Scientific Knowledge* adopted by the UNESCO–ICSU World Conference on Science in 1999, to encourage their use by Member States.

To order a copy: www.unesco.org/publishing, see also page 24.

Jean Audouze

When is a planet not a planet?

The International Astronomical Union's (IAU) General Assembly got off to a flying start in Prague (Czech Republic) last August when it proposed including three new stars in the category of planet. This would have carried the number of planets in our Solar System from nine to twelve, a veritable revolution. The reaction was not slow in coming. After a lively debate, the astronomers voted on 24 August to create a new category of planet, the dwarf planet or pluton in reference to the smallest of the planets in our Solar System, an icy, desertic star just 2300 km in diameter. That is how Pluto found itself downgraded to a dwarf planet and our Solar System dropped from nine planets to eight.

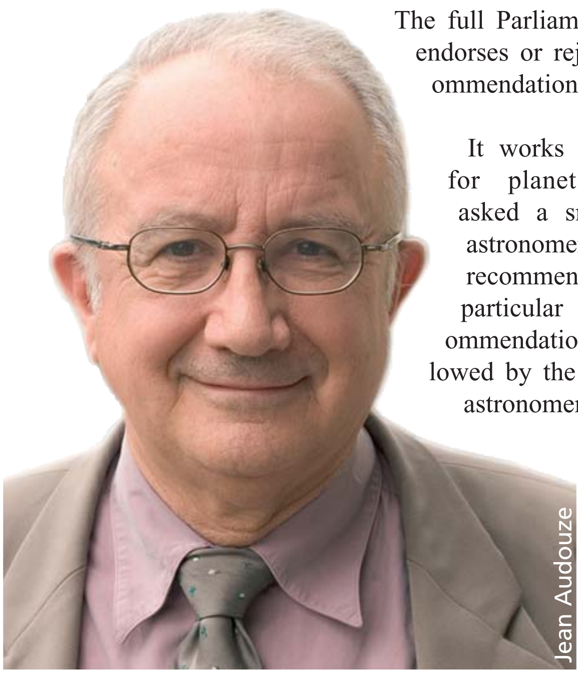
Director of Research at the Institut d'astrophysique de Paris, Scientific Advisor to the President of the French Republic from 1989 to 1993 and laureate of the Kalinga Prize for the Popularization of Science awarded by UNESCO in 2004 for his role at the head of the Palais de la découverte in Paris, Jean Audouze explains why defining the notion of planet is no easy task, even for the experts.

In early August, our Solar System counted nine planets, in mid-August twelve and by the end of August just eight? What happened?

Two factors entered into play. The community of astronomers meets every three years. This year, they were in Prague, in 2009 they will be in Rio de Janeiro in Brazil. Major ongoing projects are presented at these meetings but they are also an occasion to codify the nomenclature and put a bit of order in our classifications.

Astronomers tackle questions concerning the planets in much the same way a Parliament functions. In Parliament, you have a Commission made up of a group of parliamentarians who examine a bill and make recommendations on it. The full Parliament then either endorses or rejects these recommendations.

It works the same way for planets. The IAU asked a small group of astronomers to submit a recommendation. In this particular case, that recommendation was not followed by the community of astronomers.



Jean Audouze

Is it the discovery of Xena in 2005, a star on the outer edges of our Solar System like Pluto, which put the cat among the pigeons?

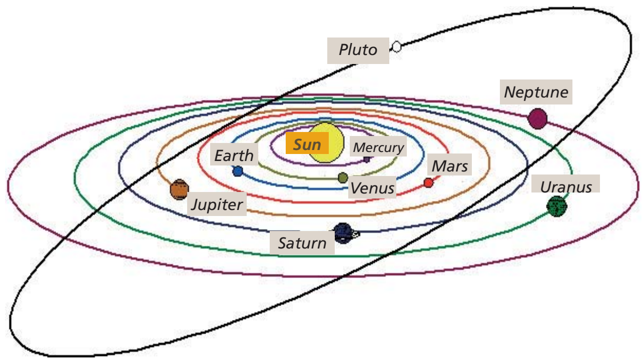
Of course. After a team of astronomers discovered the star you describe, which has since been named Eris, they said, 'here's a new object which orbits the Sun. We propose that it be the tenth planet.' At the time, people were not yet talking about adding two others but I shall come back to that.

Is it true that Eris measures 100 km in radius more than Pluto?

Yes, 110 km more to be exact. It also lies three times farther from the Earth than Pluto, at a distance of 16 billion kilometres. This compares to a gulf between Pluto and Earth of just 6 billion kilometres. Eris possesses characteristics which are fairly comparable to those of Pluto in terms of chemical composition. However, Eris reflects the Sun's light much more effectively than Pluto and this light irradiates Eris like any other planet.

Let's move on to the first stage, shall we. The group of seven experts convenes. The group is keen to add Eris then thinks, 'but if we want to include Eris, we shall have to add Charon, Pluto's only known satellite, as well as Ceres, a massive asteroide lying between Jupiter and Mars.' The group of experts thus proposes moving from nine to twelve planets.

When this proposal is presented to the full contingent of astronomers, other voices clamour, 'Let's take a less permissive definition. Let's say that, on the one hand, the planets of our Solar System have to orbit the Sun and that, on the other hand, they have to follow the same trajectory. As none of the four candidates – Pluto, Charon, Ceres and Eris – satisfies these restrictive criteria, we prefer moving



from nine to eight planets.' When it comes to the vote, the majority of astronomers follow this reasoning. There you have the story.

What differentiates the eight planets from Mercury to Neptune from the other four?

Firstly, they vary in size, these four being smaller than the other planets. Secondly, the Sun is not the only cause of their movement. Remember that the eight planets orbit the sun in an ecliptic plane. They follow an elliptic movement in line with Galileo's theory. We have known for ages that Pluto follows an orbit that is completely out of line with the ecliptic plane (*see diagram*). It has been common knowledge since 1932 when Pluto was discovered by an American amateur astronomer by the name of Percival Lowell.

Is it true that, according to the definition adopted by the IAU on 24 August, any celestial body moving in the orbit of a planet, like Charon, cannot lay claim to the title of planet?

Yes, that's right. According to this new definition, the main agent of a planet's movement must be the Sun. According to one hypothesis, Pluto used to be one of Neptune's satellites, until it steered off course; having left Neptune's orbit, it then began orbiting the Sun. This is another reason why Pluto has been downgraded. The new definition excludes the celestial bodies in the asteroid belt between Mars and Jupiter from the category of planet (*see page 9*), as well as the more distant celestial bodies in the Kuiper belt, one of which is Pluto. This is more convenient, since new celestial bodies are being discovered in these two belts every year.

Is it also because Pluto is the only icy planet in our Solar System that it has been downgraded, when the other planets are either telluric like Mercury, Venus, Earth and Mars, or gaseous like Jupiter, Saturn, Uranus and Neptune?

I don't honestly think so, especially since Pluto and Eris are both telluric bodies. That is to say, both are stars which possess solid ground like Earth that is surrounded by an atmosphere.

There is one point I would like to stress. Pluto is no less interesting for having lost its planet status. It is not the name we give a star which necessarily determines its degree of interest. We have just explored Titan, even though Titan is not considered a planet. This hasn't prevented Titan from being the object of a major spatial mission called Cassini–Huygens. Titan is Saturn's principal satellite. Titan is bigger than either Mercury or Pluto and has an atmosphere which is fascinating to study because it could resemble that of Earth at the beginning of our own planet's history *(see page 5)*.

Coming back to Pluto, we shall continue studying it. NASA has already dispatched a satellite which should fly over Pluto in 2015. It boils down to a question of nomenclature. It is as if we were botanists trying to categorize a flower. As we keep discovering planets around other stars though, the word 'planet' has to have a precise meaning.

In that case, should we set about revising school textbooks without delay or is it possible that, in a year or two, a new discovery will come along which throws everything into doubt again?

It is true that things are moving very fast. At the same time, for the teacher, books need to last a while. To avoid having to revise the list of planets with each new discovery, I would proceed with a mini-revision of school books. As there is no need to redraw the diagrams of the Solar System, I would simply add a mention at the bottom of the page to the effect that Pluto has been considered as a planet up until now but that, from now on, it belongs to the new category of dwarf planets like Eris. This new definition simply gives the notion of planet a more precise meaning. Even if school textbooks are not modified, it will make little difference to our conception of the sky and the universe.

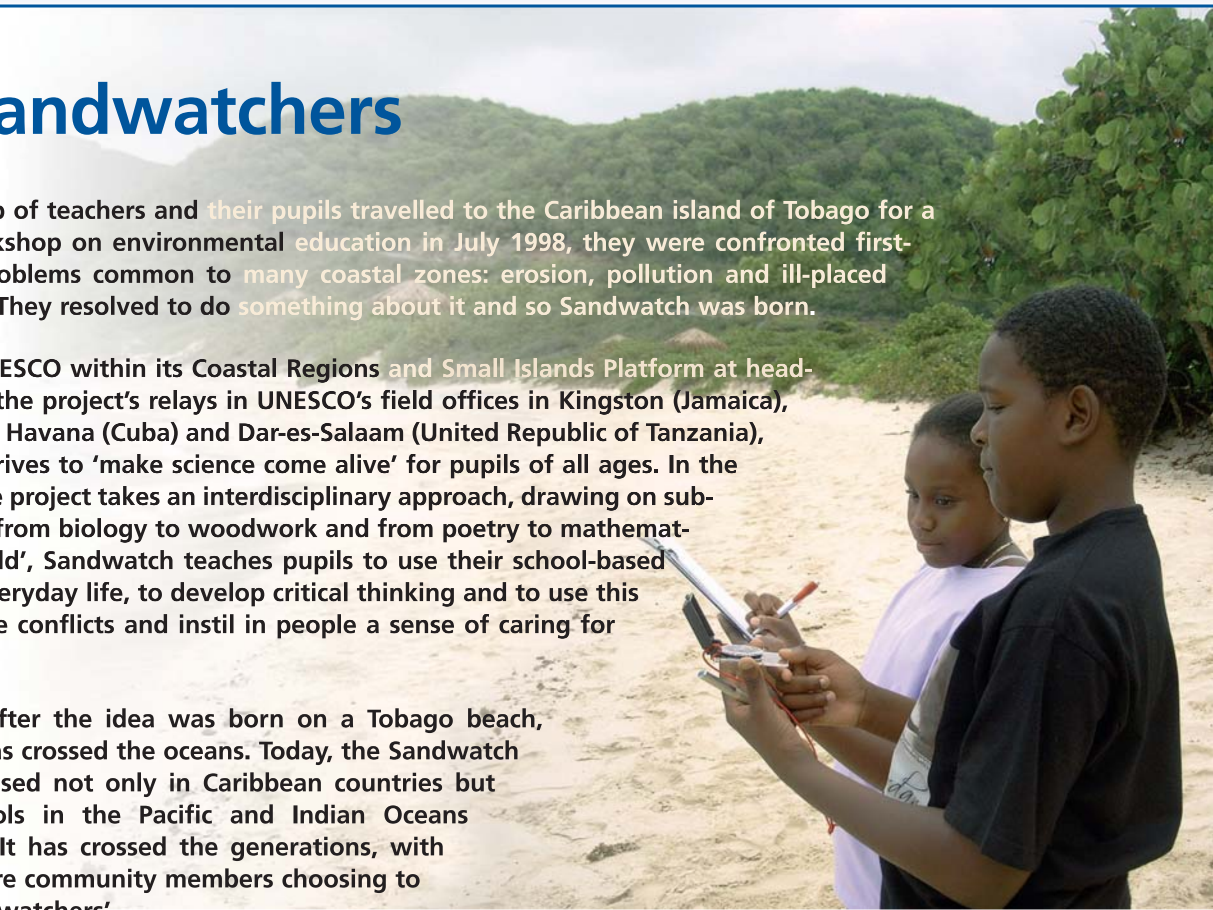
But if a teacher quizzes the class on the number of planets in our Solar System, what answer should the pupils give?

In my opinion, teachers should accept both eight and nine as being the correct answer. The right answer is for a pupil to say that there are eight planets in a strict sense but that there is also a ninth which astronomers consider for the time being as 'a planet with a difference'. That's nothing new. I could have said that Pluto was a planet with a difference 20 years ago. What is new is that Pluto has been classified in another category.

You are totally right on one point. I would not be surprised to see us return to 12 planets in two or three years' time. Teaching needs long lapses of time, unlike research. School books should change as little as possible. If we can avoid confusing young minds, so much the better. All we need to tell youngsters is that Pluto is a special type of planet which astronomers classified differently in 2006.

Interview by Susan Schneegans

The **sandwatchers**



When a group of teachers and their pupils travelled to the Caribbean island of Tobago for a UNESCO workshop on environmental education in July 1998, they were confronted first-hand with problems common to many coastal zones: erosion, pollution and ill-placed construction. They resolved to do something about it and so Sandwatch was born.

Piloted by UNESCO within its Coastal Regions and Small Islands Platform at headquarters and the project's relays in UNESCO's field offices in Kingston (Jamaica), Apia (Samoa), Havana (Cuba) and Dar-es-Salaam (United Republic of Tanzania), Sandwatch strives to 'make science come alive' for pupils of all ages. In the classroom, the project takes an interdisciplinary approach, drawing on subjects ranging from biology to woodwork and from poetry to mathematics. In the 'field', Sandwatch teaches pupils to use their school-based learning in everyday life, to develop critical thinking and to use this skill to resolve conflicts and instil in people a sense of caring for their beaches.

Eight years after the idea was born on a Tobago beach, Sandwatch has crossed the oceans. Today, the Sandwatch approach is used not only in Caribbean countries but also in schools in the Pacific and Indian Oceans and beyond. It has crossed the generations, with more and more community members choosing to become 'sandwatchers'.

Photo courtesy of Paul Diamond, British Virgin Islands

Pupils from the British Virgin Islands reading a compass to determine wave direction

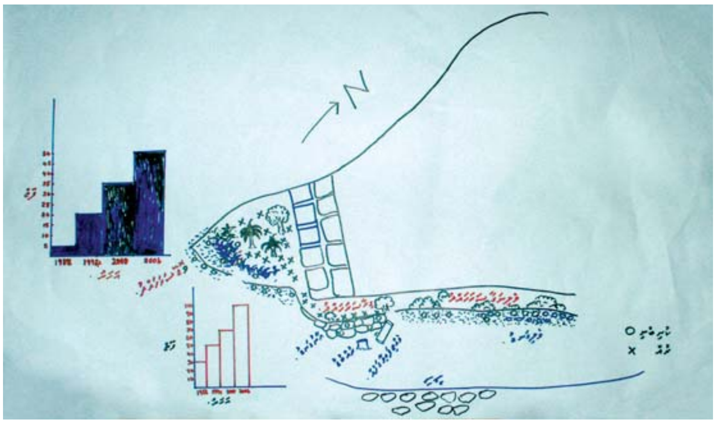
The first thing Sandwatch teaches children is the scientific method. They learn that observation and recording is the starting point for any scientific investigation. Using the UNESCO manual, *Introduction to Sandwatch: an Educational Tool for Sustainable Development*, and basic equipment like tape measures, magnifying glasses and simple water-quality test kits, pupils learn how to make observations, conduct simple measurements and repeat these over time.

Getting started

The starting point for Sandwatch is to observe and record as much detailed information about the beach as possible and to use the data to make a sketch map (*see photo*). This map provides a basis for discussion about problems at the beach and for deciding which characteristics to monitor. One teacher in Mauke (Cook Islands) also suggested making a sound map of the beach; pupils were asked to close their eyes and identify the different sounds they heard over several minutes.

If equipment is available, classes may use disposable or digital cameras to take 10 photos of things they like about the beach and 10 photos of things they dislike. Making a mural with the photos helps to focus discussions on beach problems and what to do about them.

To find out how the beach has changed over time, pupils can interview members of the community and local officials or study aerial photographs and topographic maps.



Sketch map of a beach made by community members in Kalaidhoo, a small, low-lying sandy island on the northeastern side of Laamu Atoll in the Maldives. During a meeting organized by Live and Learn Environmental Education, community members expressed concern at the serious erosion of their beach, which was causing more frequent flooding of their village by high waves. The community suspected that the mining of sand from a nearby beach was causing the erosion. After visiting and observing conditions at the site of each beach, they prepared sketch maps and timelines. When all the information was compiled, it became apparent that, while sand mining was contributing to the erosion, it was not the sole cause; other factors like coral reef destruction were also to blame

In addition to studying the composition of the beach, Sandwatchers assess water quality, wave characteristics and currents, and observe plants and animals. They measure beach erosion and the opposite phenomenon, accretion

Photo : G.Cambers

Teachers measuring the size of grains of sand in the Maldives. If a grain is smaller than 0.004 mm, it does not qualify as sand but as clay; if smaller than 0.08 mm, it qualifies as silt ; if bigger than 4.7 mm, it is not sand but gravel. With Sandwatch, pupils learn how to record the variety of material found along different sections of the beach, such as seaweeds, seagrasses and stones, and to label it accurately

(*see box*). They also observe human activities like jogging and assess beach debris and litter.

They then learn how to compile, analyse and interpret the collected data and to prepare reports, graphs, stories, poems and artwork depicting the results. In the classroom, teachers integrate these activities into different subjects ranging from science to language and from mathematics to social studies. In the Bahamas for example, 10-year olds at Hope Town Primary School have learnt how to use pie graphs to show mathematically the different types of boats they have observed at the beach.

Pupils from Dublanc Primary School in Dominica have made decorative vases and pencil holders with some of the debris they have collected from the beach; they have also drawn pictures, written poems and participated in a march around their village to raise community awareness. At Bequia Community High School in St Vincent and the Grenadines, pupils have used their woodworking classes to make wave measurement poles and their water quality measurements have become part of their chemistry lessons.

Tackling beach-related problems

If acquiring the scientific method is the first component of the Sandwatch approach, addressing beach-related sustainable development issues is the second. Armed with their measurements, pupils use critical thinking to identify beach-related problems then implement projects to remedy these.

Projects implemented so far have shown tremendous diversity and originality. Pupils from an environmental club in Barbados for instance conducted an opinion poll of beach users to see if they viewed animal droppings on the beach as a serious health risk or simply a nuisance factor. Another group in Cuba tried to change the habits of beach users by working with the local community to clean up a heavily polluted beach, install rubbish containers and design a beach mural.

The Sandwatch competition

In an effort to find out whether Sandwatch was actually benefiting communities, an International Community Sandwatch Competition was run in 2004–2005. Schools belonging to UNESCO's Associated Schools network were

Measuring beach width for signs of erosion

Activity for pupils

1) measure and record the distance between the vegetation line and the high water mark on the beach once a month for a year;

2) calculate the average value for the winter months (for example in the Caribbean region from October to April) and do the same for the summer months (May to September);

3) pursue this exercise the following year to build up measurements over time which make it possible to detect signs of erosion.

Case study

In the hypothetical example on the right, variation remained within a normal range between 2003 and 2005. There was considerable erosion in 2006 however, with a very low winter average and a low minimum value. If similar figures are obtained for 2007, it may be necessary to envisage sea defence options at this site before the situation gets out of hand.

Among the options which promote beach build-up are: planting deep-rooting trees, positioning new buildings a 'safe' distance behind the beach and beach nourishment, the process of replenishing a beach with material from another source inland or offshore.

Photo : G.Cambers

Live and Learn Environmental Education, a regional NGO that works with UNESCO, measuring beach width in Fiji

Year	Average winter distance (m)	Average summer distance (m)	Minimum distance (m)	Maximum distance (m)
2003	13.9	16.1	10.2	18.5
2004	13.5	17.0	9.0	21.0
2005	14.2	15.3	11.9	18.2
2006	8.2	16.4	6.0	15.8

Source: adapted from Cambers, G. (1998) Coping with Beach Erosion. Coastal Management Sourcebooks 1. UNESCO Publishing, Paris.

asked to plan, design, implement and evaluate a community-based beach enhancement project using the scientific beach monitoring methods they had learnt. The quality of the 52 entries was so outstanding that these have been made available on the web.

At the primary level, first prize went to Nikao Maori School in the Cook Islands for a project that included planting trees behind the beach to control the erosion, installing signs and containers to help people recycle their litter, and instilling a caring attitude towards the beach by providing rakes for beach users to clean up after enjoying their picnics.

I have been involved in collecting data on wave intervals. It was the first time I used a stopwatch. Since then, many mathematical problems have become clearer to me and I have begun to enjoy maths. I have a better appreciation and understanding of geography and science.

Allana Stanley, secondary pupil, Trinidad and Tobago

Pupils from Castries Comprehensive Secondary School in St Lucia won first prize in their category. Having identified pollution from the nearby Choc River as a major problem, they used school assemblies to ask pupils to reach out to their parents and neighbours about indiscriminate rubbish disposal in the river and on the beach; their subsequent litter surveys showed a significant decrease in the amount of rubbish on the beach.

Photo courtesy of Maria Mercedes Brito-Feliz

Secondary pupils in the Dominican Republic learning to measure wave height

Schools from Cuba submitted several entries. A combined entry from a school for pupils with special needs, an art school and a secondary school worked to educate the community about the benefits of keeping the beach clean and showed how pupils with autism could participate in Sandwatch.

Networking across the waters

As Sandwatch grew from a regional Caribbean initiative into a global project, it became apparent that there was a need to keep partners in touch and motivated, as well as to inspire new groups. UNESCO commissioned Paul Diamond, a teacher from Robinson O'Neal Memorial Primary School in Virgin Gorda (British Virgin Islands), to develop a website where each participating school could display its contact details, activities, data and photos.

Studying beach ecology

At a glance, beaches may appear to be barren stretches of sand. In reality, they are diverse and productive transitional ecosystems that serve as a critical link between sea and land. The sandy beach is an unstable environment for plants and animals, largely because the surface layers of the beach are in constant motion from the waves and wind.

Organisms living on beaches are especially well-adapted to survive in this type of environment. Many burrow into the sand for protection from waves or to prevent drying-out during low tide. Others are simply passing by, such as birds and fishes.

Activity for pupils

1) ***observe, collect and record:*** the pupils are given plastic bags and asked to collect 10 different objects from the beach and to record where each object was found.

2) ***identify the collected items:*** back in the classroom, the pupils separate biological from non-biological items and plants from animals. They then identify the items. Each pupil then selects one of the plants or animals and describes its shape, colour and size; draws a picture; then studies its habits with regard to diet, movement, reproduction and self-protection; any unusual or interesting features are also studied, such as ways in which it might be affected by humans;

3) ***build a food chain:*** using the plants and animals collected, the pupils build a food chain to show how the various organisms interact within the ecosystem and how energy passes from one organism to another.

Case studies

The endangered iguanas

Sixteen -year old pupils from the Instituto Preuniversitario Vocacional de Ciencias Exactas Comandante Ernesto Ché Guevara in Santa Clara (Cuba) ran their Sandwatch project at Los Ensenachos, a large cay on the north coast of Cuba targeted for tourism development. They visited the cay monthly over an 8-month period to record the numbers and different types of birds, reptiles and molluscs, as well as the amount of litter; they also interviewed residents. The pupils shared their results with construction workers to ensure that certain species were protected when the site was cleared for the construction of a hotel. Part of their project involved capturing as many iguanas as possible and relocating these on another undeveloped cay with similar characteristics for their own protection.

Photo : C.Boyce

The debris-choked swamp

After their beach was eroded repeatedly by hurricanes between 2000 and 2005, pupils at Hope Town Primary School in the Bahamas cleaned out a debris-choked swamp so that water and fish could enter the wetland. They also recorded the different species present in the mangrove and measured water temperature, salinity and depth. Their studies extended to the pine forest ecosystem behind the mangrove and beach.

Measuring water quality

The quality of coastal waters is very important for health and safety reasons, not to mention visual appeal. Disease-carrying bacteria and viruses associated with human and animal waste contaminate seafood, drinking water and swimming areas. Excessive quantities of nitrates and phosphates from sewage discharge, household and commercial waste, detergents and fertilizers, can all cause marine plants to proliferate and result in algal blooms .

Simple water quality test kits are available to measure these indicators in either fresh or brackish water. A simple kit providing enough chemicals for several tests of each indicator costs around US$40. The kits are safe and easy to use.

Pupils can use the following simple indicators:

- ***faecal coliform bacteria***: naturally present in the human digestive tract but rare or absent in unpolluted water;
- ***dissolved oxygen***: needed by all aquatic organisms for respiration;
- ***biochemical oxygen demand***: a measure of the quantity of dissolved oxygen used by bacteria as they break down organic wastes in the water;
- ***nitrate***: a nutrient needed by all aquatic plants and animals to build protein;
- ***phosphate***: also a nutrient, needed for plant and animal growth;
- ***pH***: a measure of the acidic or alkaline properties of the water;
- ***water temperature***: affects many physical and biochemical processes, including the amount of oxygen available in the water and metabolic rates of animals and plants;
- ***turbidity***: a measure of the amount of suspended matter and plankton in the water.

Case study

The blocked drain

When pupils from Bequia Community High School in St Vincent and the Grenadines investigated a blocked drain in the Paget Farm area, they began by conducting extensive tests for coliform bacteria, dissolved oxygen, pH, nitrates, phosphates and biochemical oxygen demand. The results showed the presence of coliform bacteria (*see photo*), a cause for concern, since local fishermen cleaned their fish in the drain; the area was also a holding place for lobsters prior to market and a favourite bathing spot for children. The pupils engaged the fishermen in a one-on-one dialogue about the dangers of improper disposal of waste. They also cleared the drain of debris, set up mesh guards to prevent it becoming blocked again and landscaped and replanted the area adjacent to the drain.

Photo : P.Diamond

There is a separate section for each country with schools being encouraged to personalize their country's pages. A forum where teachers can write in with new ideas is another feature of the site. Only recently, an audio section was added where recordings of pupils discussing Sandwatch or interviewing environmentalists and community leaders can be posted.

Bringing more schools on board

Over the past fifteen months, the Sandwatch manual has been distributed to thousands of schools in coastal regions around the world, including via UNESCO's network of Associated Schools. As Sandwatch grows, the challenge will be to bring more schools on board. Some islands have been particularly innovative. The Ministry of Education in the Cook Islands for example has used funding from the UNESCO Participation Programme to integrate Sandwatch into teaching units on landscapes, recycling, tourism and ecosystem studies.

One of the main strengths of Sandwatch is that it puts schools in many small and isolated islands and communities in real contact with each other. It lets them know that they … can actually make a difference to the well-being of their local environments.

Paul Diamond, British Virgin Islands

Combining efforts with interested partners is another way of maximizing the impact of Sandwatch, as UNESCO's work with the regional NGO Live and Learn Environmental Education demonstrates. In Mauritius, the Centre for Documentation, Research and Training on the South West Indian Ocean, another NGO, is about to embark on a project inspired by Sandwatch to enhance the knowledge and understanding of beach management, climate change and related issues among residents of two coastal communities in the island.

Sandwatch has been very successful with the pupils, as it is their work. They enjoy studying their own environment rather than reading about someone else's.

Gail Townsend, Curriculum Development Unit, Cook Islands

Nearly two years into the UN Decade of Education for Sustainable Development (2005–2014), Sandwatch is of special relevance. With its participatory approach and focus on 'learning by doing', the project is an exemplary educational tool.

Gillian Cambers[2] and Fathimath Ghina[3]

For details: csi1@unesco.org; www.sandwatch.org
Discover the Sandwatch competition entries:
www.unesco.org/csi/smis/siv/inter-reg/sandw1entries.htm
Download the Sandwatch Manual :
www.unesco.org/csi/pub/papers3/sande.htm

2.Former UNESCO Consultant

3.Consultant with UNESCO's Coastal Regions and Small Islands Platform, Paris

Helping **Africa's 'best and brightest'** lift science at home

©ICTP

Students following a lecture at the ICTP

A three-year fellowship programme is enabling African postgraduate students to study abroad and remain affiliated with institutions in their home countries.

Funded by the Japanese government via UNESCO Funds-in-Trust, the programme is run by UNESCO's Abdus Salam International Centre for Theoretical Physics (ICTP) in Trieste (Italy). The scheme was launched by UNESCO Director-General Koïchiro Matsuura in May 2005.

As endless reports have shown, a large number of native-born Africans with advanced degrees in mathematics and science have abandoned their homeland to pursue their careers elsewhere. Equally disturbing, only a small percentage of students in Africa over the past few decades have pursued advanced degrees in mathematics and science in the first place.

'No one doubts that there's a crisis,' says ICTP Director K.R. Sreenivasan. 'In fact, analysts have been lamenting the chronic shortfall of well-trained professors and students in science and mathematics in Africa for some time.'

'The critical question,' adds Sreenivasan, 'is not what's happening – that's painfully obvious – but what to do about it. That's why we are so pleased to have received generous funding from Japan to launch the Mori Fellowship programme for young scientists and mathematicians from sub-Saharan Africa.' Named after Yoshiro Mori, a former prime minister of Japan, the scheme receives US$440,000 in funding.

Specifically, the Mori Fellowship programme provides 10 fellowships each year over a three-year period to qualified students in a broad range of fields in mathematics and physics. Its ultimate goal is to strengthen the human capacity of sub-Saharan Africa by offering high-level educational and research opportunities to students pursuing advanced doctorate and postdoctoral studies in such areas as condensed matter physics, the physics of weather and climate, fluid dynamics, oceanography and seismology, as well as in pure and applied mathematics.

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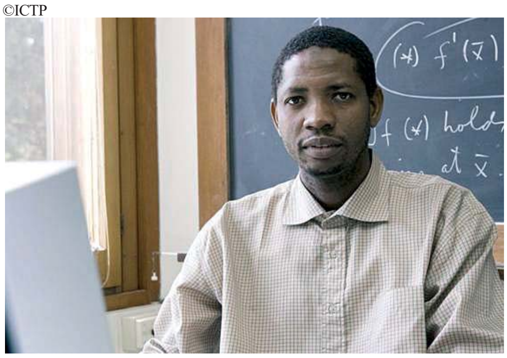

Ali Bashir in his office at the ICTP was the first Mori Fellow to arrive in Trieste in February 2006. Bashir lectures in mathematics at Bayero University in Kano (Nigeria), the institution which awarded his master's degree. His area of specialty is functional and nonlinear analysis. He hopes that his three extended visits to ICTP over the next three years – each for about six months – will enable him to obtain his PhD degree from the University of Nigeria by 2009

Each application for a Mori Fellowship is examined by a review panel appointed by the ICTP and made up of scientists from both within and beyond the centre.

Eight Mori Fellows are currently sharing their time between the ICTP and their home institution to complete an advanced degree (*see photos and box*).

Fighting brain drain while fostering excellence

'During the 1970s,' says Gallieno Denardo, special advisor to the ICTP Director and the past head of the Centre's Office of External Activities, 'sub-Saharan Africa had some of the finest institutions of higher education in the developing world, including Dar-Es-Salaam in Tanzania, Ibadan in Nigeria, Khartoum in Sudan, and Makerere in Uganda.'

'Decades of neglect, political uncertainty and violence,' Denardo laments, 'have left these institutions in a poor state and forced a large number of the

From earthquakes to blood flow

In all, eight Mori Fellows are currently working at the ICTP towards an advanced degree. They are profiled on these pages. Another six students are scheduled to become Mori Fellows this year. Among the current Fellows:

Paulina Ekua Amponsah is a lecturer at the Department of Geology within the University of Ghana in Legon and principal seismologist at Ghana's Geological Survey Department in Accra. She examines earthquake hazards and mitigation strategies in Africa by developing ground motion simulation models that help to determine potential seismological behaviour on the continent.

Oluwayomi Peace Faromika is an assistant lecturer at the Federal University of Technology in Akure (Nigeria). Faromika specializes in fluid dynamics and, more specifically, the development of mathematical models and computational simulations as tools for blood flow analysis.

Folsade Mayowa Olajuyigbe is likewise an assistant lecturer at the Federal University of Technology in Akure. He applies laser technology to biological studies, especially to obtain a better understanding of the enzyme structure, function and dynamics of soil-bound micro-organisms.

Mohammed Khalil Salih Saeed is a medical physicist at the Radiation and Isotopes Center in Khartoum (Sudan). He examines dosage levels and improved quality control mechanisms for radiotherapy to ensure better protection for patients and medical personnel.

Abdulrafiu Tunde Raji was born in Nigeria and is now an instructor at the University of Cape Town (South Africa). Raji specializes in solid state physics. More specifically, he develops computer simulations to study the ways in which stress, temperature and pressure effect materials and particularly metals.

©ICTP

Uguette Flore Ndongmouo Taffoti in her office at the ICTP. This Mori Fellow obtained her PhD in November 2005 from the Institute of Mathematics and Physical Sciences in Porto-Novo (Benin). The focus of her study is molecular dynamics, particularly as it relates to water absorption of icy surfaces

region's most able mathematicians and scientists to pursue their careers elsewhere.'

The problem, as many observers see it, is that professors have been unable to engage in the kind of research and teaching that their colleagues in many other parts of the world take for granted. Meanwhile, students have been unable to enrol in courses or conduct laboratory experiments that would allow them to gain the knowledge and skills they need to become successful mathematicians and scientists.

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Brice Rodrigue Malonda Boungou in his office at the ICTP. Born and raised in the Congo, this Mori Fellow is working towards his PhD at the University of Douala's Centre for Atomic Molecular Physics and Quantum Optics in Cameroon. Malonda Boungou's research focuses on condensed matter physics and, more specifically, the electronic and magnetic properties of nanostructures

'Studies show,' adds Denardo, 'that when a mathematician or scientist from a developing country, particularly a least developed country, stays away from his or her country for several years, he or she is unlikely ever to return on a permanent basis.' To stem this phenomenon of chronic brain drain, institutions have turned to a strategy that requires students to remain enrolled in universities in their home countries, or affiliated to these, while still enjoying access to state-of-the-art science facilities elsewhere.

UNESCO applies the same principle at the intra-regional level. The Organization's Regional Bureau for Science in Nairobi (Kenya), for example, has been awarding grants to senior African academics for the past 15 years to enable them to undertake short-term teaching and/or research at a sister institution in Africa (*see box*).

The 'Sandwich' programme

'The strategy we have adopted for the Mori Fellowship programme works like this,' says Sreenivasan. 'Participants matriculate in institutions in their home countries but can visit the ICTP and other scientific institutions in Trieste for extended periods over three successive years to participate in research and training activities and engage in discussions with eminent scientists. In fact, all students will be assigned two supervisors, one from their home country and another from a Trieste-based scientific institution.'

'Beyond the immediate benefits it provides to participating students,' Sreenivasan continues, 'we anticipate that the programme will have a substantial "multiplying effect" as those who earn their degrees assume teaching responsibilities in their home countries. Over time, more and more young African students interested in science and mathematics will benefit.'

The ICTP is no stranger to such a strategy, which has come to be called a "sandwich" programme. Charles Chidume, a staff member in the ICTP's mathematics group, launched an ICTP-supported "sandwich programme in mathematics" at the University of Nigeria in Nsukka. The programme has since provided support to 10 students, who have spent roughly half of their time at their home institutions and half at the ICTP.

Similarly, the International Atomic Energy Agency (IAEA) in Vienna (Austria) joined the ICTP in launching a Sandwich Training Educational Programme (STEP) in 2004 to provide research and training opportunities in a wide variety of fields in physics and mathematics to students from developing countries. Under the STEP programme, students spend part of their time at home and part of their time at institutions in Italy. At present, approximately 50 STEP students are enrolled.

'The experience acquired by the ICTP through its "sandwich" programme over the past few years,' says Chidume, 'has enabled us to implement rapidly the Mori Fellowship programme.'

The ICTP is hardly a novice when it comes to student training. Founded 40 years ago by Abdus Salam, a Pakistani physicist and Nobel laureate in 1979, the centre trains 4000 students each year.

Daniel Schaffer[4]

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

4. *Public Information Officer at the ICTP*

African scientists working for African science

The African Network of Scientific and Technological Institutions (ANSTI) was set up in 1980 by UNESCO, which hosts the ANSTI secretariat in Nairobi (Kenya).

UNESCO mobilizes extrabudgetary resources both within the institutions themselves and from other sources to train young scientists at the postgraduate level and broaden the experience of senior scientists.

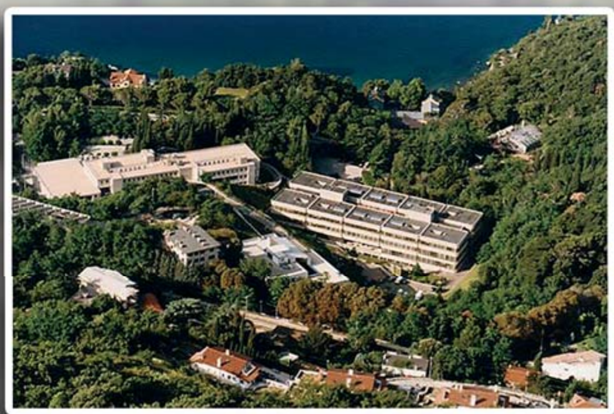
ANSTI membership is open to the faculties of science and engineering in all sub-Saharan universities and other institutions of higher education. Every year, the grants awarded to senior African academics from ANSTI member institutions enable them to undertake teaching and/or research at another ANSTI institution. These take the form of postgraduate training fellowships, staff-exchange fellowships or travel grants.

A total of 248 grants have been awarded in the past 15 years. The grant beneficiaries subsequently return to their home institutions, bringing with them their newly acquired knowledge and skills.

In parallel, UNESCO facilitates the dissemination of research results across Africa through a grant to the online *African Journal of Science and Technology* published by ANSTI.

For details (in Nairobi): www.ansti.org; Joseph.Massaquoi@unesco.unon.org

Aerial view of the ICTP



Diary

15–19 January
Caribbean tsunami and other coastal hazards warning system
Intl Coordination Group (ICG). Organized by UNESCO-IOC. Venezuela (in Cartagena): *c.toro@unesco.org*

22–25 January
Landslide risk analysis and sustainable disaster management
Symposium of Intl Programme on Landslides. In parallel, 1st session of Global Promotion Committee. UNU, Tokyo (Japan): *b.rouhban@unesco.org; www.unesco.org/disasters*

24–30 January
Scientific research, technology & innovation for Africa's socio-economic development
African Union Summit. Addis Ababa (Ethiopia): *Joseph.Massaquoi@unesco.unon.org; m.el-tayeb@unesco.org; www.nepadst.org*

26 January
Conditions favouring epidemic emergence of respiratory infections
Meeting of UNESCO, European Academy for Arts, Sciences and Humanities, Trace Element Institute for UNESCO, WHO, French Association for Advancement of Science, European Society for Emerging Infections. UNESCO Paris (Room IX): *susan.gamon@trace-element.org; trace.elem.for.unesco@wanadoo.fr*

29 January – 1 February
Climate change 2007
WMO–UNEP Intergovernmental Panel on Climate Change (IPCC) Working Group to finalize assessment of state of knowledge of physical science basis of climate change, a contribution to upcoming 4th Assessment Report. UNESCO Paris (Room II) : *a.fischer@unesco.org*

5–9 February
North-Eastern Atlantic, Mediterranean tsunami early warning system
ICG meeting. Bonn (Germany): *p.kolterman@unesco.org*

14–16 February
IGCP Scientific Board
Meeting. Request booklet on IGCP's new priorities: *r.missotten@unesco.org; m.patzak@unesco.org*

15–16 February
Business in sustainable development of cities
Workshop with industrial enterprises and business communities of Yaroslavl, Cherepovets, Vologda, Kostroma and other Russian cities, state and municipal authorities, scientific bodies, within project for Cooperation Along a Big River: the Volga Basin. UNESCO Moscow is a consortium partner. Yaroslavl: *www.unesco.ru;m.prchalova@unesco.ru*

19–23 February
Indian Ocean tsunami early warning system
ICG meeting. Nairobi (Kenya): *r.j.cunneen@unesco.org*

20–21 February
Volga delta project launch
Launch of UNESCO project supported by Coca-Cola HBC Eurasia to enhance environmental awareness of Volga River, its wetlands and biodiversity. Targets local authorities, communities and schools. 1st meeting of Steering Committee. Moscow: *www.unesco.ru; m.prchalova@unesco.ru*

22 February
For Women in Science Awards
Annual L'OREAL–LUNESCO Award ceremony. UNESCO Paris: *r.clair@unesco.org; www.forwomeninscience.com*

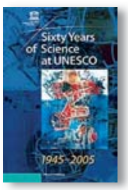
10–15 March
Diagnostic analysis of coastal and marine issues in ROPME Sea Area
Training course for government-designated experts from Bahrain, Iran, Iraq, Kuwait, Oman, Qatar, Saudi Arabia and United Arab Emirates. Organized by UNESCO Doha, with UNESCO offices in Iraq and Tehran, UNEP, Regional Organization for Protection of Marine Environment (ROPME), also University of Bahrain. Doha: *b.boer@unesco.org*

23 March
50th anniversary of space age
Celebrates 50th anniversary of Sputnik launch (*see page 4*), also 40th anniversary of Outer Space Treaty. Organized by Intl Astronautical Federation in cooperation with UNESCO: *r.missotten@unesco.org; www.iafastro.com*

New Releases

Earthquake Spectra

W. Iwan (Technical Ed.) UNESCO Earth Sciences series, UNESCO Publishing/ Earthquake Engineering Research Institute, 43.00, ISBN 92-3-104037-5, English only, 916 pp.
Reconnaissance report on the Great Sumatra Earthquakes and Indian Ocean Tsunamis of 26 December 2004 and 28 March 2005. Conceived as a definitive reference work on this catastrophe, this special issue of the journal Earthquake Spectra addresses: Seismology; Geology and Geophysics; Tsunami Field Surveys and Analyses; Performance of Structures and Lifelines; Preparedness; Societal Impacts; and Recovery and Reconstruction. Also features individual tsunami field surveys from 12 countries, discussions of the seismologic and geologic aspects, and analyses of the impact on communities in the region.

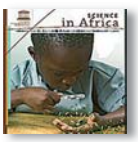


Sixty years of Science at UNESCO, 1945–2005

UNESCO Publishing, 30,00 , ISBN : 978-92-3-104005-4, English only, French version planned, 696 pp. (see also page 13)

Lesotho Science & Technology Policy 2006-2011

Science Policy Studies Series. Published by Division of Science Policy and Sustainable Development, English only, 92 pp
Developed by UNESCO in tandem with UNECA, UNIDO and UNCTAD and UN Commission on S&T for Development. Reviews current socio-economic and S&T environment, including pool of S&T personnel and institutional assets. Proposes policy measures and an implementation strategy in three phases. Download: *www.unesco.org/science/psd/thm_innov/country_stud.shtml*



Science in Africa

UNESCO's contribution to Africa's Plan for Science & Technology to 2010
Division for Science Policy and Sustainable Development. Exists in English and French, 32 pp.
Describes UNESCO's programmes, networks and projects in Africa. Includes list of UNESCO Microbial Resource Centres, Chairs, World Heritage sites and Biosphere Reserves in Africa. Due to be distributed to Heads of State and Government at the African Union Summit on 24 January (*see Diary above*). Request a copy from: *s.schneegans@unesco.org; a.candau@unesco.org;* or download: *www.unesco.org/science/science_africa.shtml*

Exit from the Labyrinth

Integrated coastal management in the Kandalaksha District, Murmansk Region of the Russian Federation
Coastal Regions and Small Island papers 21. UNESCO in collaboration with Ministry of Education and Science of the Russian Federation and Russian State Hydrometeorological University. Exists in English only with Foreword and Summary also in Russian, 76 pp.
The Russian coastline is the longest in the world (60 000 km). The centralized political system, planned economy and absence of market mechanisms in the former Soviet Union meant that Russian coasts were administered differently from the rest of the world, which was moving towards integrated coastal management. Even today, Russian Federation legislation does not recognize the coastal region as a whole; each resource is dealt with by specialized legislation. An exception to the rule, the Kandalaksha District provides a 'blue print for how integrated coastal management could be applied to other northern coastal regions. Download: *www.unesco.org/csi/pub/papers4/lab.htm*

Biodiversity and Stakeholders

Biosphere Reserves Technical Notes 1–2006, MAB Programme, English and French, 80 pp.
Aims to stimulate discussion about the challenges of reconciling conservation and development within biosphere reserves. Request a copy from: *m.bouamrane@unesco.org*

Groundwater for Emergency Situations

Vrba and B. Verhagen (Eds). IHP –VI Series on Groundwater 12, English only, 94 pp.
Describes IHP project of same name (2002 –2007) which identifies in advance potential safe, low vulnerability groundwater resources which could temporarily replace damaged supply systems. For details: *a.aureli@unesco.org; a.lipponen@unesco.org*

For the Young

Explaining... the Earth

By P. Bouysse, Discovering the World series, UNESCO Publishing/Éditions Nouvelle Arche de Noé, 8,00 , ISBN-10: 92-3-104015-4, Exists in English, French and Spanish, 48 pp.
Targets 11–16 year-olds. Presents basic aspects of the Earth sciences: our planet's place in the Universe and in our Solar System, the structure of the Earth, plate tectonics, the role of the atmosphere and hydrosphere, the formation of reliefs, the ice ages and natural hazards. Highlights the immense difference in scale between geological time and human time.

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