United Nations
Educational, Scientific and
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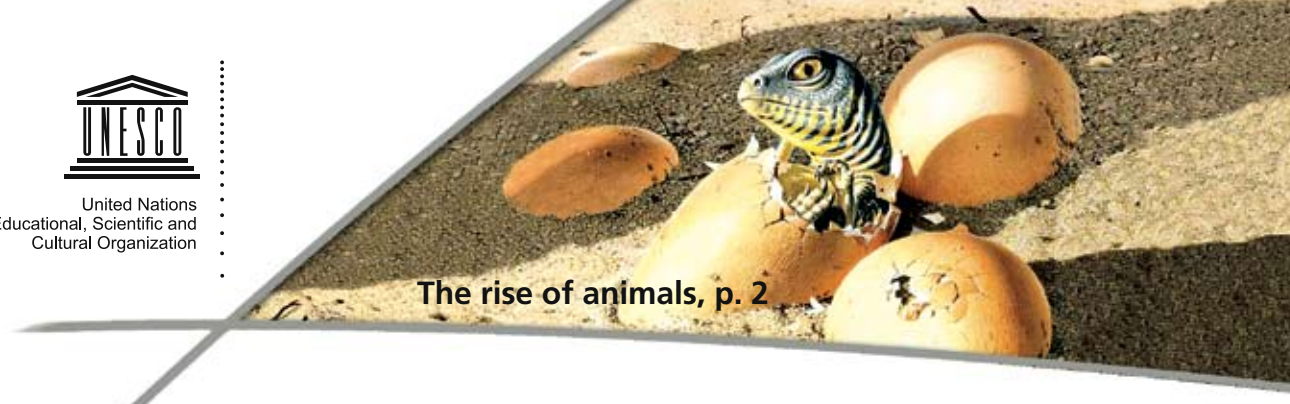

The rise of animals, p. 2

A World of SCIENCE

Natural Sciences
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IN THIS ISSUE

EDITORIAL

Trend-setting in sustainability

For years, actors in nature conservation and business went their separate ways, convinced they lived in separate worlds. UNESCO's Man and the Biosphere (MAB) programme was one of the first to make the connection between underdevelopment and environmental neglect. In 1995, the adoption of a new strategy at the 2nd World Congress of Biosphere Reserves in the Spanish city of Seville consecrated this new mindset.

The new strategy set out to make biosphere reserves model regions for sustainable development via rural economic development. As eco-tourism had the dual advantage of generating local revenue while teaching the public to value nature, incentives were put in place to encourage local entrepreneurs to develop wildlife-watching, snorkelling, desert safaris, mountain treks and the like.

Biosphere reserves were urged to develop eco-industries, organic agriculture, ecological animal husbandry, apiculture, wine- and fruit-growing and so on. Rhön Biosphere Reserve in Germany has never looked back. Thanks to the decision to focus on marketing quality local produce, Rhön has created jobs and preserved farms at a time when much of the country is experiencing a rural exodus. The case of Rhön is all the more inspiring in that one-third of the biosphere reserve is situated in what was formerly East Germany. As we shall see in this issue, Rhön is as much a symbol of newfound German unity as of economic revival.

Suk Kyung Shim of the South Korean Commission for UNESCO sees a parallel between Rhön and the situation closer to home. She believes 'the demilitarized zone separating North Korea from South Korea since the ceasefire in 1953 resembles the former inner-German border. The [4 km-wide by 248 km-long] area has not been exposed to human influence of any kind for more than 50 years,' she explains in *UNESCO Today*, the journal of the German Commission for UNESCO, 'and is today a natural treasure trove that is home to many rare species. This makes the demilitarized zone unique and particularly worth protecting.'

Could a transboundary biosphere reserve offer a solution one day to the two Koreas? 'The Republic of Korea has looked at various international programmes,' says Suk Kyung Shim, and 'a biosphere reserve appears to be particularly suitable,' even if 'the political situation makes it improbable that the biosphere reserve can be established in the near future.' There are now several transboundary biosphere reserves in the world and even one intercontinental biosphere reserve linking Morocco and Spain.

UNESCO's MAB programme has often been a 'trend-setter.' Some say it was practicing sustainable development long before the term was coined. So, where do biosphere reserves go from here? The 3rd World Congress of Biosphere Reserves may well provide the answer; it is being hosted by the Government of Spain in Madrid from 4 to 9 February on the theme of …Biosphere Futures. After analysing implementation of the Seville Strategy over the past decade, the Congress will be elaborating the Madrid Action Plan for 2008–2013.

W. Erdelen
Assistant Director-General for Natural Sciences

Fossil of a trilobite about 8 cm in width facing this way. Trilobites were able to see; they had compound eyes like the fly. They had a segmented external skeleton, with the body being divided into head, thorax and tail

The rise of **animals** (Part II)

Taking up our story where we left off in October, we now find ourselves at the dawn of the Phanerozoic Eon 542 million years ago (Ma), when the continents were flooded by shallow seas. The first 20 million years of this era see an 'explosion' of biodiversity. The world changes dramatically. Animals gain eyes, favouring the emergence of true predators. The reaction of much of their prey is to burrow into the seabed and/or 'cloak' themselves in protective armour: vertebrates gain skeletons, invertebrates gain shells.[1] Even plants develop their own protective armour.

Animals and plants will need to 'devise' ingenious stratagems to survive, for the Phanerozoic Eon we still live in today will be punctuated by sweeping temperature swings from Icehouse to Greenhouse worlds, periods of great aridity, growing competition, meteor strikes and mass extinctions. Incredibly, some species will come through all of these ordeals to become living fossils, like the lungfishes and the little brachiopod *Lingula*. Others exist today only in the fossil record. On a 24-hour clock of geological time, our own ancestors, the first hominids, will not make an appearance until just before midnight.

Trilobites were among the first animals to develop hard parts. These joint-legged arthropods rapidly diversified and, together with the bivalved brachiopods, dominated the oceans for much of the early Palaeozoic, along with a myriad of other animals, some of which still lacked hard parts. A handful of soft-bodied Ediacarans may have survived into the Early Cambrian and an even smaller number may have given rise to such groups as the molluscs (remember *Kimberella* from Part I!).

The Cambrian 'explosion' of biodiversity

New life forms included pelycypods – today represented by the clam, oyster, scallop and mussel – as well as the monoplocophorans and the gastropods, today's sea snail and slug, and the nautiloids.

There was also a variety of short-lived forms, such as the reef-forming archaeocyathids (probable relatives of the sponges), helicoplacoids and other spiny-skinned echinoderms, today represented by the starfish and sea urchin.

The earliest record of vertebrates may be Early Cambrian and certainly dates from the Late Cambrian and Early Ordovician about 500-475 Ma. These were probably not the first vertebrates though. Most ancient fish were equipped with external armour in the form of bony plates and scales. They lived in shallow seas in parts of the world that include North America, Bolivia and Australia. Their hard parts were made of apatite, the mineral constituent of bone, which includes fluorine and phosphorous. Most of their remains are only a few millimetres square and less than a millimetre thick but a few have larger bony plates fused into head and body armour.

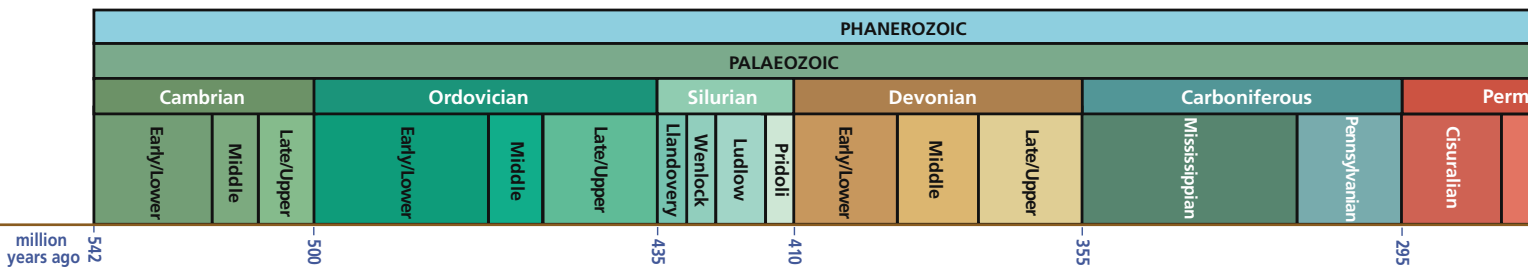
Courtesy of Natural History Museum Vienna, Austria

Eurypterus, pictured here in a Silurian reef 435–410 Ma, is an arthropod, a group which includes scorpions, spiders and trilobites. Eurypterus *is characterized by a pair of forceful pincers (chelae) extending from the head and a paddle-like pair of legs for swimming. Some species grew up to 2 m in length, but most were no longer than 20 cm.* Eurypterus *hunted prey such as trilobites and fishes, which lived in the tropical seas, brackish ponds and freshwater lakes.* Eurypterus *became extinct during the late Permian. A living relative of this prehistoric animal is* Limulus*, the Horseshoe Crab*

Australia and Bolivia, two Gondwanan fragments, provide the first glimpses of what these early vertebrates looked like as whole fish. *Sacabambaspis* from 470-million year old, brachiopod-bearing sediments in Bolivia and somewhat younger *Arandaspis* from central Australia in the early Middle Ordovician are both of simple design, having no fins other than a tail fin and no moveable jaws; they were essentially filter-feeding organisms.

Where did jaws come from?

After the development of hard parts, primarily external skeletons, the next major innovation for vertebrates was the development of an internal bony skeleton, followed by jaws.



The first jawed fishes don't appear in the fossil record until the early Silurian however, about 435 Ma, up to 90 million years after the first vertebrates. Jaws allowed the first truly predatory vertebrates to develop and a variety of herbivorous forms to specialize in a more diverse diet.

Where did jaws come from? Living primitive sharks may provide some clues and embryology sheds further light on the origins of jaws. One theory contends that the core of the upper and lower jaws of primitive sharks and other primitive fishes may have been derived from the most anterior gill arch. However, they may have developed totally independently, perhaps in a process associated with the formation of the sclerotic bones around the eye.

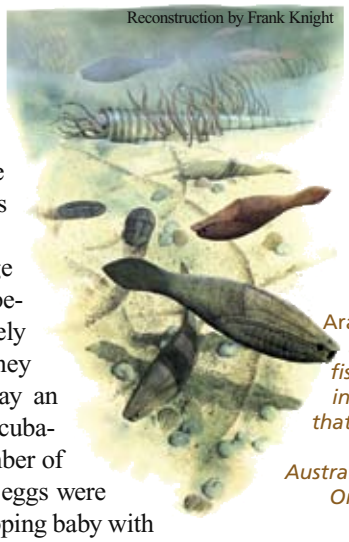
With jaws came two other major innovations: paired fins (both pectoral in front and pelvic behind) and a braincase similar to that of modern fishes. The combination of these characteristics endowed their owners with greater feeding opportunities, greater maneuverability and often greater speed, as well as better coordination and better protection for vital organs. In many cases, such new developments were important for gaining mates and protecting the young.

Invasion of the land

Amphibians were the first vertebrates to take to the land, a territory already inhabited by plants and a variety of invertebrates. The 'labyrinthodonts,' with their crocodile-like appearance and somewhat similar lifestyle, were the earliest vertebrate land-dwellers. They appear in the fossil record in the Devonian and are best-known from the spectacular remains of *Ichthyostega* and *Acanthostega* from about 375 Ma found in East Greenland. *Ichthyostega* was an intermediate between fish and amphibian. It had legs but probably still used them as paddles. Its wrists and ankles were weak and thus ill-adapted to a terrestrial lifestyle.

Life on the land encouraged independent motion of the head from the body, leading to the loss of some bones and the fusion of others. This strengthened the skull and protected the braincase. Lungs and structures associated with intake and expulsion of air developed. Heavy scales aided in water retention. But though moving on land and likely feeding there, labyrinthodonts still had to return to water in order to reproduce. Apparently, their eggs were not self-sufficient on land.

Labyrinthodonts arose during Greenhouse times but survived through the Icehouse conditions of the late Palaeozoic. It was during such dynamic times that true terrestriality was attained by reptiles. Extensive swamps laid down the biomass from decaying animals and plants which would form the massive coal deposits which fuelled the Industrial Revolution in Europe and North America in the late 18th century. The Carboniferous swamps probably formed in the temperate to tropical zones but the Permian coals of Australia were definitely laid down in cool temperate swamps, just as peat forms under similar conditions today.



Arandaspis, a jawless fish, swims in the seas that covered much of Australia in the Ordovician

Reptiles had an advantage over the labyrinthodonts in being able to reproduce in entirely terrestrial environments. They were the first vertebrates to lay an amniote egg, a new kind of incubator with a hard shell and a number of embryonic membranes. These eggs were capable of providing the developing baby with nutrition, waste collection and protection against dehydration. The oldest amniote egg fossil is Permian in age.

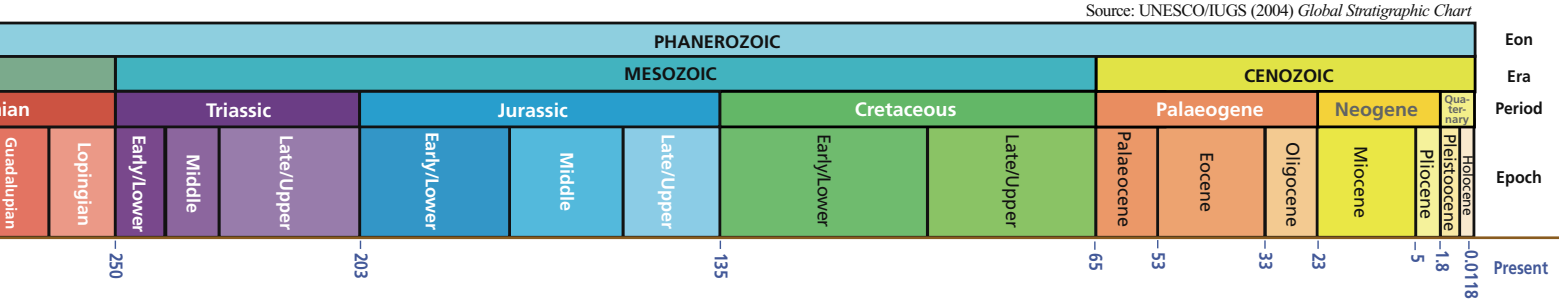
Labyrinthodonts and reptiles co-existed into the early Mesozoic when Greenhouse conditions returned, even if vast areas were actually quite arid during this time. Both reptiles and labyrinthodonts had survived the cataclysm of the Late Permian, where upwards of 90% of life appears to have expired around 250 Ma.

Again, at the Triassic–Jurassic boundary around 200 Ma, another cataclysm affected large numbers of terrestrial vertebrates, as well as a great variety of both marine and non-marine organisms. Only a few labyrinthodonts survived into the Jurassic and only one into the Early Cretaceous of Australia about 110 Ma.

Just what caused the Triassic–Jurassic cataclysm is not clear. There was a major change at this time from the older seed fern-dominated *Dicroidium* flora to a more modern flora dominated by gymnosperms – whose unenclosed seeds are today associated with needles, cones and the like – and the first appearance of flowering plants, the angiosperms. Elements of the *Dicroidium* flora show adaptations to aridity, such as their spike-like leaves and thickened cuticle, both specializations for preventing water loss. Many other hints, such as the global abundance of evaporate (salt) deposits, also point to severe aridity during the time leading up to the Jurassic.

The reconstructed skeleton of a labyrinthodont amphibian from the Triassic, from remains near Sydney in Australia. This specimen of Paracyclotosaurus davidi *is 2.25 m long.* Paracyclotosaurus *was a large carnivore for its time*

Source: UNESCO/IUGS (2004) *Global Stratigraphic Chart*



The waltz of the continents

Since the break-up of Pangaea 250 Ma

Late Triassic (210 Ma)

- At the beginning of the Mesozoic (250 Ma), all the continents formed a single supercontinent, Pangaea. Some 40 Ma later, the east side of Pangaea is indented by a large gulf called Tethys.
- In the Tethys, the main accretionary ridge lies off the coasts of Arabia, India and Australia, which form the southern Tethyan margin. It is a stable, passive margin with no evidence of volcanism. Conversely, the northern ridge of the Tethys is an unstable, active margin that is in the process of swallowing the Tethyan oceanic crust. This subduction in the north and accretion in the south will eventually lead to the collision of the Mega Lhassa block, later to become the northern Tibetan plateau, with Southeast Asia.

Late Jurassic (145 Ma)

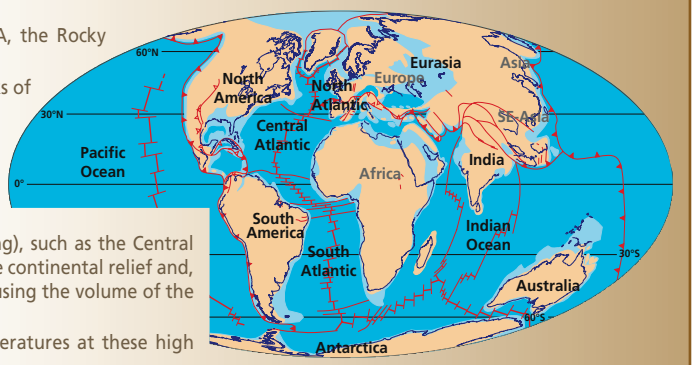
- The westward progression of the Tethys has now extended right through to the Pacific, dividing Pangaea into two parts: Laurasia to the north and Gondwana to the south. The Mega-Lhassa block is now entering into collision.
- Florida in the USA has drifted up from the Equator to 15°N. This will have important consequences for the future because the latitude of continents affects the sedimentary characteristics of their deposits. Reefs for example, with their proliferation of flora and fauna, are potential sources of major oil deposits but only develop in the intertropical zone (30°S– 30°N). Thus, Florida, neighbouring Texas and Arabia all currently occupy a favourable position for oil deposits, at a time when great quantities of tropical biomass are decomposing and being incorporated into the sediments. The Caspian Sea has just reached this intertropical zone.
- A few million years from now, the deposition of bauxite in parts of the Mediterranean Rise (MR) will indicate a warm and humid tropical environment, the deposits of East Gondwana a temperate climate, evaporate deposits (salt, gypsum, …) in Western Europe a semi-arid climate. Arabia, Florida (USA) and Yucatan (Mexico) will be dominated by salt lakes.

Middle Cretaceous (95 Ma)

- The east–west trending of the oceans (Tethys), in a tropico-equatorial position, is a thing of the past. We are witnessing the early formation of a south–north trending Atlantic Ocean. The South Atlantic Ocean has been opening up between South America and Africa for 15 million years. Gondwana has split up and East Gondwana is now divided into two plates: India and Australia–Antarctica.
- The continents have been invaded by the sea. The oceanic ridges have become more active (swelling), causing sea level to rise and displacing water which floods onto the land. In Africa, the Saharan Sea (SS) links the Mediterranean Rise (MR) and the South Atlantic. In North America, a basin borders the west of the Rocky Mountains, linking the Arctic Sea with the Gulf of Mexico. Eastern Europe is submerged.

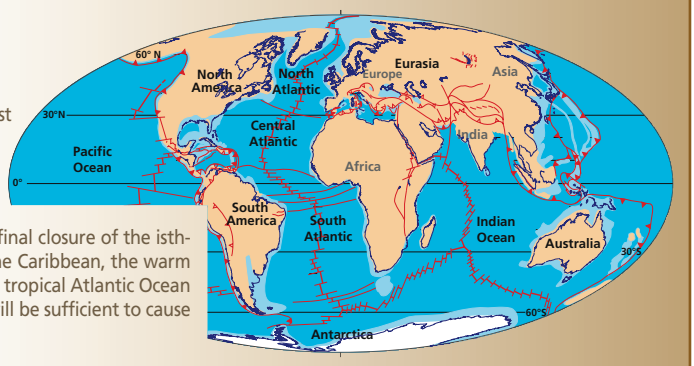
Eocene (45 Ma)

- Greenland has broken away from North America then from Europe. In Canada and the USA, the Rocky Mountains are rising, as also the Sierra Madre in Mexico.
- India is impacting with Eurasia but is not yet locked into it. This movement will push aside blocks of Southeast Asia and enable the uplift of Tibet.
- In the Caribbean, the Greater Antilles is colliding with Florida and the Bahamas Shelf. The isthmus of Panama is beginning to take shape but is far from being completely emerged.
- An active accretionary ridge between Antarctica and Australia is causing the latter to move northwards towards Asia.
- There is a significant decrease in the accretion rate of certain ridges (and thus of their swelling), such as the Central Atlantic ridge and those displacing India. In parallel, the formation of mountains is increasing the continental relief and, at the same time, reducing the continental area through thrusting. These dual processes are causing the volume of the oceanic basins to increase and thus global sea level to drop.
- It is now possible for ocean currents to circulate around Antarctica; this causes ocean temperatures at these high southern latitudes to fall.



Miocene (10 Ma)

- The configuration of the continents and oceans is now similar, and the pattern of the plates almost identical, to that of today. The Arabian plate is still forming however: a rift, marked by major volcanic activity, is forming in the Red Sea and in East Africa: the future Great Rift Valley, home to some of the first hominids 5–6 Ma later.
- An ice sheet has formed over Antarctica. Only at about 2.7 Ma, shortly before the onset of the Quaternary, will an ice sheet form over the circum-Arctic region. This event will coincide with the final closure of the isthmus of Panama: with circulation no longer possible between the Atlantic and Pacific Oceans via the Caribbean, the warm water of the Atlantic will have no outlet. During the Quaternary glaciations, warm waters from the tropical Atlantic Ocean will lap the shores of the cold continents located around 50–60°N. The difference in temperature will be sufficient to cause heavy snowfalls that will progressively form the Arctic ice sheets.



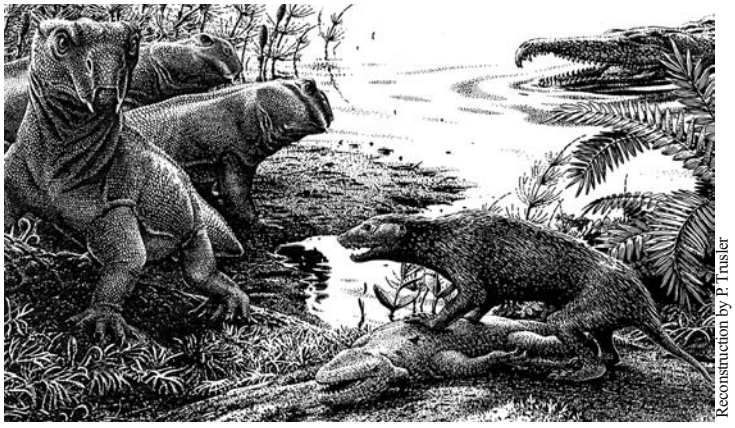
Source: Vrielynck, B. and Bouysse, Ph. (2003) The *Changing Face of the Earth*. UNESCO Publishing/Commission for the Geological Map of the World. Paris.

When life nearly died

The Palaeozoic–Mesozoic transition was a time of immense crisis for terrestrial and marine organisms alike. Early in the Carboniferous, cyclicity gripped the world. Great global glaciers waxed and waned, seas grew and shrank, flooded the land then retreated, leaving behind the shells and skeletons of marine and non-marine organisms as fossil reminders of a very dynamic time.

But something went terribly wrong at the end of the Permian, arguably the greatest mass extinction in Earth history. Not just one but several pulses of extinction occurred. The extinction of animals of large body size is most visible, but many smaller forms suffered a similar fate. New forms evolved from some of the smaller survivors.

Just what went wrong is still under debate but most researchers would agree that a distinct rise in temperature was the culprit. This came about when massive outpourings of volcanic material – the Siberian Traps – and very likely a massive 'methane burp' caused by the release of gas hydrates from the oceans combined to add great quantities of CO_2 to the atmosphere, thereby heating it and causing extinctions on a gargantuan scale. As Michael Benton notes in his book *When Life Nearly Died*, the Triassic was a time of misery. Ocean waters were low in oxygen and ocean circulation was very slow or even at a standstill. All this certainly affected life on land, where vegetation was sparse. Coals were not forming at this time in most places – one exception being Australia – for lack of preservation of decomposing organic matter. Soils were poor and temperatures high. The few surviving land animals, such as the mammal-like reptile *Lystrosaurus*, were some of the only successful forms. Even forms known as disaster taxa – the bivalves *Claraia* and *Eumorphotis* – had disappeared by the middle of the Triassic. It would take some time for both marine and terrestrial animals to recover. Many never would.



Reconstruction by P. Trusler

A predaceous therapsid by the name of Thrinaxodon *stands atop the anapsid reptile,* Procolophon*, which it has just dispatched. The skeleton and skull of* Thrinaxodon *were very mammal-like and the animal may have been covered in hair. On the left, three other therapsids, tusked mammal-like reptiles by the name of* Lystrosaurus*, stand at the water's edge while, in the background, the gavial-like* Chasmatosaurus *bides its time in the water. During the Triassic, Antarctica pictured here and many other parts of Gondwana were dominated by reptiles, particularly the mammal-like therapsids and crocodile-like thecodonts*

Diversity in a Greenhouse world

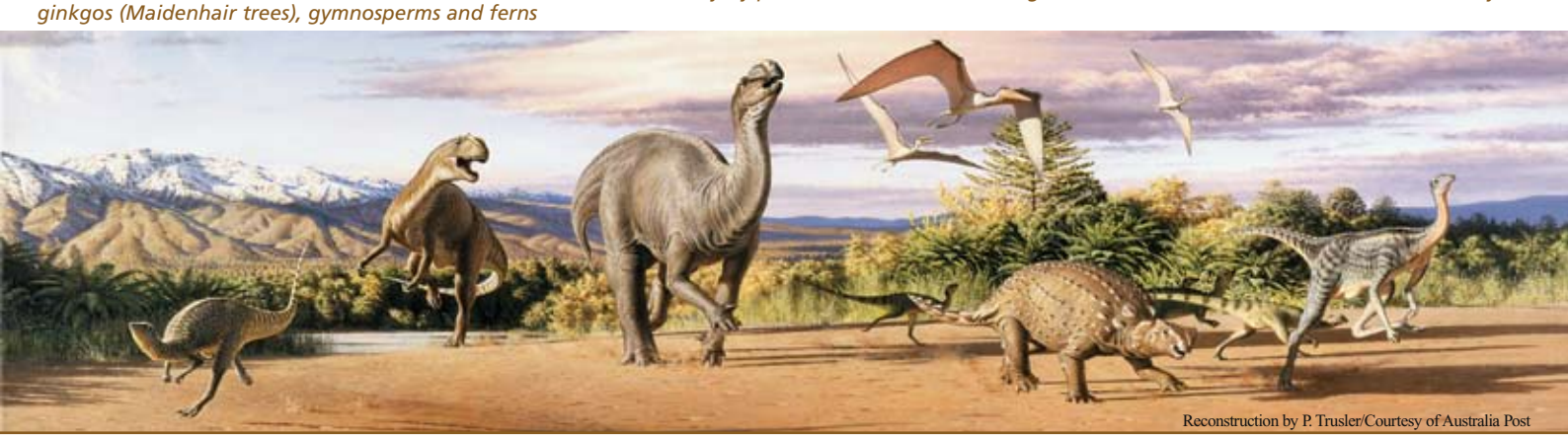
After the disaster of the Permo–Triassic, the world became a much more pleasant place. Dinosaurs, which had emerged during ecosystem recovery from the miserable times of the early Mesozoic, along with other large reptiles, expanded and prospered, on land and in the sea.

Dinosaurs were the lords and ladies of the land. Plesiosaurs, ichthyosaurs and mosasaurs were dominant reptilian predators of the seas. Bony fishes expanded, sharks held their own. Ammonites diversified, as did a myriad of other invertebrates. The flowering plants turned the land into a fragrant garden and insects co-adapted as their pollinators. Greenhouse conditions had returned.

Mammals were present but not diverse. They were also smaller than their reptilian neighbours. They lived in the shadow of the mighty, successful saurians, especially the dinosaurs.

Abundant palaeoclimatic evidence for the Mesozoic all points to a warm world, initially arid but increasingly humid, until, in the Jurassic and for much of the Cretaceous, the climate remained unseasonably wet and mild. This was a time of higher concentrations of CO_2 in the atmosphere, which would have nurtured plant growth. Atmospheric moisture and cloud cover increased, resulting in a sluggish, humid greenhouse climate. The cause of these conditions may have

About 110 Ma, dinosaurs thrived near the South Pole, in what is now southeastern Australia. They lived in a widening rift valley as Australia began to separate from Antarctica. The area was cold and lay south of the Antarctic Circle: in winter, darkness lasted at least three months and the ground froze. Left to right in this reconstruction are: the hypsilophodont Leaellynasaura amicagraphica*, a flesh-eating* Allosaurus*,* Muttaburrasaurus*, an armoured dinosaur* Minmi *and the ornithomimosaur,* Timimus hermani*. In the sky fly pterosaurs. The forests that grew in this area at the time were dominated by ginkgos (Maidenhair trees), gymnosperms and ferns*



Reconstruction by P. Trusler/Courtesy of Australia Post

Gyronchus macropterus *measured 10 cm. It is a typical bony fish, a member of a group that was widespread in the warm, shallow seas of the Mesozoic and remains so today. This fossil was preserved in limestones of southern Germany about 150 Ma. The same limestones also yielded* Archaeopteryx, *the famous bird-like form considered a link between reptiles and birds.* Gyronchus *had a round, laterally compressed body. The tail fin and long dorsal and anal fins were effective for precise coordination. These fishes were well-adapted to living on coral reefs: the downward-pointed mouth formed an excellent tool for picking food from the reef surface; cobblestone-like teeth were ideal for crushing hard prey: corals, echinoderms and bivalves.* Gyronchus *and its relatives disappeared about 50 Ma, probably due to an increase in competition. The fossil here is similar in basic morphology to modern coral reef fishes, such as the butterfly fishes (Chaetodontidae) and doctor fishes (Acanthuridae). These modern fishes, however, are only remotely related to* Gyronchus

Bavarian State Collection for Palaeontology and Geology, Munich, Germany

Natural History Museum Senckenberg, Frankfurt/Main, Germany

Also known from the Eocene of Messel, Kopidodon *belongs to the extinct mammal family Paroxyclaenidae. This specimen of* Kopidodon *is exceptionally well-preserved, displaying many details of its body, fur and bushy tail. Similar to modern squirrels,* Kopidodon *lived in trees; it used its claws to cling to twigs and branches, and its bushy tail for balance. With a total length of up to 115 cm,* Kopidodon *is one of the largest tree-dwelling mammals known to date. This animal was an omnivore, possibly filling a niche similar to that of racoons today; it was equipped with sharp teeth that may have been effective in warding off predators*

Hessisches Landesmuseum Darmstadt, Germany

Many fossil mammals are known exclusively from isolated teeth, articulated skeletons being generally rare in the fossil record. The excellently preserved fossils of Heterohyus *from Eocene deposits (40–34 Ma) in Messel thus came as a real surprise. The fossils demonstrate that two fingers on the hand of* Heterohyus *are distinctly elongated. Only two extant mammals show this morphological modification: the Aye Aye (*Daubentonia*) from Madagascar and the Striped Possum (*Dactylopsila*) from New Guinea. Both species display similar feeding habits: they remove the bark of trees with their powerful teeth to gain access to the borings of insect larvae, which they then adeptly pull out using the elongated fingers as tools. Relatives of* Heterohyus *occurred in North America several million years prior to this genus. This suggests that this group of mammals likely evolved in North America and eventually migrated to Europe. The Atlantic was already present at the time and the only remaining land bridge between North America and Europe was in the Arctic, north of Greenland. Fossil evidence tells us that this land bridge was frequently used by North American animals to migrate to Europe and vice versa*

Natural History Museum Senckenberg, Frankfurt/Main, Germany

Eurohippus *lived in the Middle to Late Eocene in the tropical forests of Europe, where it could easily hide from predators. This horse stood just 30–50 cm high. In contrast to modern horses, the forelegs of* Eurohippus *were equipped with four toes and the hind legs with three. The fossil pictured was discovered in the oil shale mine of Messel (Germany), a World Heritage site. The black portions of the fossil are traces of skin and fur. The stomach contents of this fossil demonstrate that the diet of* Eurohippus *consisted of leaves and fruits. Horses evolved in North America and Europe; the earliest forms were very similar to* Eurohippus. *Over more than 50 Ma, they adapted to life in open grasslands: body size increased, legs lengthened and the number of toes reduced. Horses developed large eyes, fine senses, alertness, speed and the ability to sleep without lying down, so as to be ready to flee predators. In response to a diet that included ever-more grasses with a high silica content, horses also developed high crowned teeth with complex enamel patterns that were longer-wearing*

Reconstruction by P. Trusler

Dromornis stirtoni *was a large, flightless bird which lived in central Australia about 10 Ma. These birds were first thought to be related to emus and cassowaries but new fossil material found in the past decade, particularly of skulls, shows that its nearest relatives are the Screamers (Anhimidae) of Latin America and the primitive Magpie Geese of northern Australia, in the Anseriformes, a group which also includes ducks and swans. The dromornithids formed a large part of the herbivore stock in a land whose large mammalian herbivores were marsupials like the kangaroo in the background here. The vegetation in this reconstruction shows how lush central Australia was at the time. Nowadays, this area is more characterized by sand dunes and profound deserts*

The giant goanna, Megalania prisca, *approaches a nest of the dromornithid bird,* Genyornis newtoni, *in Pleistocene central Australia more than 60 000 years ago. Both species are now extinct. As* Megalania *is known only from fragmentary material, it has been reconstructed using scaled-up bones of the living Komodo Dragon from Indonesia. Like the Komodo Dragon, it was probably an ambush hunter and scavenger.* Genyornis *was the last survivor of the family Dromornithidae and became extinct when Australia's climate changed from humid to arid. The final blow was probably dealt by the arrival of humans on the Australian continent more than 40 000 years ago, who brought with them the Dingo, a type of wild dog, and rats*

Reconstruction by P. Trusler

been heightened by volcanism – which produces CO_2 – forced by plate tectonic activity ripping Pangaea apart.

The consequences of this climate on the biomass of the time is of economic importance, for there was a build-up of coal in the extensive swamp forests and an accumulation of hydrocarbons in the thick, organic-rich muds characteristic of the oxygen-starved marine basins. This was accompanied by massive upwelling of water masses along continental margins, which in turn nurtured large biomass production. Today, this is the source of a significant part of the world's oil, including that of Libya, the Gulf and the Gulf of Mexico.

The fall of most of the dinosaurs

Conditions changed dramatically and rapidly about 65 Ma, around the Cretaceous–Palaeogene boundary. This brought about the demise of most of the dinosaurs and gave mammals the opportunity they needed to thrive. One group of dinosaurs which had emerged in the Jurassic actually survived: the birds! Dinosaurs took to the air.

For the past century, the cause of the Late Cretaceous catastrophe has been the subject of fierce debate among geologists and palaeontologists. Some geologists have suggested that heightened volcanic activity during the Cretaceous led to a nuclear winter, with the masses of particles in the atmosphere blocking incoming radiation from the Sun.

Another school of thought marshals an impressive array of evidence to suggest that an extraterrestrial visitor was the culprit. According to this theory, the impact of a comet or an asteroid would have first heated the Earth to unthinkable temperatures (from a biological point of view) in some places, with much of the planet being swept by firestorm before a time of intense acid rain.

Evidence supporting this theory includes a concentration of iridium, an element rare on Earth but common in meteorites which is present in clays of around 65 million years of age found in many parts of the world, including Italy, New Zealand and western North America. Iridium would have been part of the particles thrown into the air by the asteroid impact then deposited globally. Even the ground-zero site for the extraterrestrial bolide seems to have been found, a 300-km diameter circular depression in the northern part of the Yucatan Peninsula in Mexico and in the adjacent Caribbean Sea. All around this area, the iridium-rich boundary clay is excessively thick and there are massive tidal wave deposits on adjacent shores of North America, as well as indications of massive firestorms in the sediments. Moreover, sediments in nearby Haiti, Cuba and Texas (USA) contain abundant quantities of telltale shocked quartz, another product of high-pressure impact.

In fact, the cataclysm may have been a combination of vulcanism and bolide impact. Whatever happened, it brought about the extinction of upwards of 50% of life on Earth.

The reign of mammals and birds

At the end of the Cretaceous, mammals and birds became the new, dominant vertebrate groups on land. Those reptiles which did survive were diminutive in size in comparison to many of their Mesozoic precursors. Some lizards, crocodiles and snakes did however reach gargantuan sizes in places like Australia where mammalian predators were small and rare. Two examples are the varanid *Megalania*, thought to have reached over 7 m in length, and the equally gigantic saltwater crocodile of north Queensland, the world's largest surviving reptile.

The angiosperms diversified immensely and turned the lands into colourful, fragrant realms. These flowered plants 'challenged' the birds and insects to a co-evolutionary contest culminating in such complex brilliance as the elaborate orchids.

In the seas, the bony fishes in general and the actinopterygians in particular ruled, together with the molluscs and crustaceans. The tiny foraminifera and diatoms provided a major food source for the largest of mammals on Earth, the baleen whales. Antarctica and Australia finally separated some 55 Ma and the Circum-Antarctic Current was set in motion. Whales took advantage of this opportunity to become masters of the marine realm.

The Australian continent began a long period of isolation; this led to the development of a strange, endemic fauna of monotremes, such as the platypus and echidna, survivors from an old Gondwana connection. Other forms, such as kangaroos and the dromornithid birds, developed entirely on the drifting Australian continent. As Australia approached Asia, biotic exchange saw the entry of such forms as the acacias (a plant) and the cuckoo (a bird).

The survivors of the Cretaceous crisis had before them vast opportunities but their lot was not an easy one. Gradual cooling overall, albeit in fits and starts, was followed by a test of their metal: the development of permanent ice caps both north and south, most severely during the last two million years, with massive glaciations which swept equatorward on the northern continents several times, lowering temperatures and sea levels.

Most continents became more arid from about 20 Ma onwards. Widespread grasslands opened up, to which the terrestrial fauna adapted in tooth and limb (*see primitive horse fossil on facing page*). Plants developed spines, small leaves and thick cuticles to retain water and fend off possible ruminants. However, in other places, massive reefs developed. As Australia drifted north into the tropics, the Great Barrier Reef came into its own and plants of the old, cool temperate forests evolved into the rainforests of North Queensland.

By the end of the Mesozoic, the major groups of mammals still alive today had appeared: the monotremes; the marsupials, which suckle their young in a pouch, such as kangaroos and opossums; and the placentals, which incubate their young via a placenta, allowing the mother to nourish her unborn young in the womb for a considerable time.

Many placentals became very large during the Cenozoic. These include *Smilodon*, the 'sabre-toothed tiger' from the Americas; the mammoth, a relative of the elephant which inhabited North America, Europe, Asia and Africa until only a few thousand years ago; primitive elks and rhinoceroses; giant armadillos and ground sloths.

Marsupial carnivores were able to develop in Latin America and Australia during the early Cenozoic because of the

absence of advanced placental carnivores. When the placentals invaded these two continents late in the Cenozoic, the marsupial carnivores there were doomed.

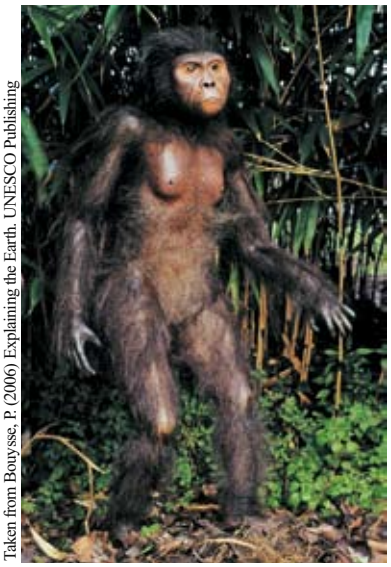
The making of modern man

Among the early placentals were the primates, a group to which we modern humans, *Homo sapiens*, belong. The first definite primates show up in the early Cenozoic, though some suggest that they were present as far back as the Cretaceous. The oldest primate may be *Altiatlasius* from the Late Palaeocene of Morocco, a very small beastie weighing in at only about 100 g. Certainly, by the early Eocene, mammals – including primates – had greatly diversified.

The oldest member of the family to which humans belong, the Hominidae, may belong to the subfamily Kenyapithecinae, known from fossils found in many parts of Africa, as well as in Turkey and Europe. These fossils range in age from 20 Ma to 14 Ma. Within this family, humans, chimpanzees, bonobos and gorillas have their own subfamily, the Homininae – a group distinct from the Ponginae: the orang-utans and their ancient cousins. Humans are distinguished from the rest of the subfamily by their very large brains (1400 cm^3 on average) relative to body size and their habit of walking upright (bipedalism), a function that dates back 6–4 Ma.

Evidence drawn from bones, teeth and molecular biology points to a split between humans and their nearest relatives, the chimpanzees and bonobos, in the late Miocene or early Pliocene. There are many names given to these oldest 'humans': *Australopithecus* and more recently *Orrorin*, *Sahelanthropus* and *Praeanthropus afarensis*.

Fossils of the oldest member of the genus to which we belong, *Homo*, were first exposed in 1960 at Olduvai Gorge in Tanzania. The skull had a brain cavity of 630–700 cm^3 and the hands of these fossils reflected an ability to manipulate objects and make tools. This inspired the name of *Homo habilis*, or 'handy man.' Dates on these fossils and another form, *Homo rudolfensis*, range from 2.4 to 1.5 Ma; both were contemporaries of *Australopithecus*.



Taken from Bouysse, P. (2006) Explaining the Earth. UNESCO Publishing

H. habilis and its cousins were African forms. By 1.9 Ma, 'humans' may well have been moving out of Africa. Finds in China and Georgia have revealed *Homo erectus*-like forms dated at 1.9 and 1.7 Ma respectively. *H. erectus* survived for a long time. One of the richest sites for this species is Zhoukoudian Cave near Beijing in China: the site of Peking Man dated 600 000–200 000 years ago. There is a possible even younger date for *H. erectus* of 50 000 years in Java. The brains of these later *H. erectus* may have reached 1100 cm^3, according to Benton, and these forms were beginning to make fairly refined hand axes.

Our own species *Homo sapiens* makes its appearance in Africa and the Middle East at least by 160 000–100 000 years ago. Alongside us lived *Homo neanderthalensis*[2], which was separate from *H. sapiens* at least 500 000 years ago and a more heavily-built hominine with a brain size of 1500 cm^3. *H. neanderthalensis* had a sophisticated toolbox, with refined spearheads, scrapers and hand axes. Neanderthals used fire, made clothes and practiced burial rituals. They seem to have completely disappeared by about 30 000 years ago. Just why is a point of anthropological controversy.

After that, *H. sapiens* ruled. Australia and southern Latin America were most likely the last destinations of modern man, with arrival dates in Australia now pushed back to more than 40 000 years ago and those in southern Chile to 19 000 years ago. The 'settlers' were aided and abetted by the lowered sea levels, which made it possible to walk from Siberia to Alaska across the Bering Land Bridge at the height of development of an enormous ice sheet over much of North America and Europe during the ice ages of the Pleistocene. Even in the warmer Southern Hemisphere, which had no real continental glaciers, the lowered sea level made it possible to walk from Papua New Guinea to Australia, or to sail from Asia to Australia across only short stretches of ocean.

The end of the last Ice Age and the beginnings of agriculture about 10 000 years ago heralded the start of a population explosion among *H. sapiens*. Today, the influence of this highly 'successful' species in evolutionary terms is unprecedented. Human activities are polluting the air, sea and land, decimating biodiversity and changing the Earth's climate. How this story will end, no-one knows. Humans certainly have the brain capacity to plan for a sustainable future – but can they act in unison to make this happen?

Patricia Vickers–Rich,
with Peter Trusler and Draga Gelt

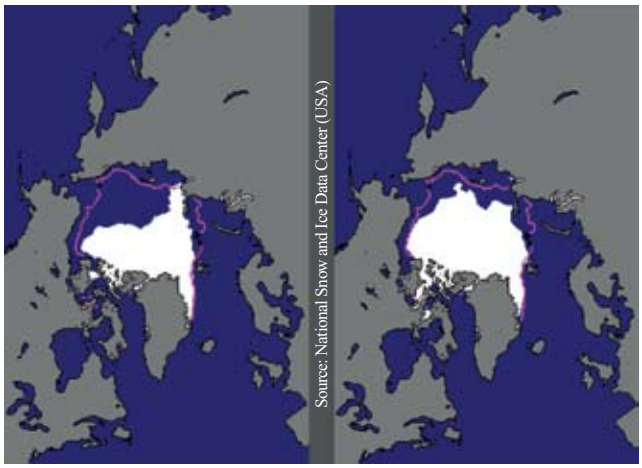
With thanks to Bettina Reichenbacher (Ludwig Maximilians University), Michael Krings (Bavarian State Collection for Palaeontology and Geology) and Wighart von Koenigswald (University of Bonn) for supplying the fossil images and text on page 6 and the reconstruction of Eurypterus.

1. *Skeletons and shells have other advantages for their bearers. Muscles can be attached to them, resulting in a more efficient use of energy in locomotion and opening new avenues of feeding*
2. *One school of thought considers the Neanderthals to have been so similar to modern man that the two should be described as* Homo sapiens sapiens *and* Homo sapiens neanderthalensis. *Others prefer to label the two as separate species*

Praeanthropus afarensis *is the name given to 'Lucy' (reconstructed here), found in the Rift Valley in Ethiopia in 1974. Lucy is the skeleton of a young girl which is about 40% complete. She has been dated at 3.2–2.9 Ma. Lucy and her relatives were only around 1.0–1.2 m tall with a brain size of around 400 cm^3 and an apparently ape-like face. Their limbs had curved fingers and toes, suggesting they were still quite capable of climbing; their wrist structure suggests they may have walked on their knuckles*

Arctic sea ice a record low

Summer sea ice in the Arctic has shrunk to a record low. For the month of September, it extended 4.28 km^2 million on average, shattering the previous absolute minimum of 5.32 million km^2 measured on 20–21 September 2005. In a race against time, UNESCO and several of its sister agencies are working with countries to put in place an Arctic Observing System to ensure that neither the Arctic environment, nor Arctic societies are the losers in a 'wild west-like' scramble for resources that would compromise universal access to the Arctic Ocean and universal benefit from it.



The extent of Artic summer sea ice in September 2007 (left) and the previous record low in September 2005, from satellite microwave measurements. Last year, the Northwest Passage was open for the first time

As the ice cover of the Arctic erodes, formerly inaccessible areas are becoming valuable economic and strategic resources. The fabled Northwest Passage, a potentially lucrative shipping route, is the subject of an ongoing territorial dispute between Canada and nations including the USA which argue that the passage lies in international waters.

In 2007, the most direct Northwest Passage was open for the first time since records began. It will certainly soon be used for commercial shipping. This would shorten the journey considerably for vessels traveling to northern Europe from the west coast of Canada, for example. A Northwest Passage route would also cut thousands of kilometres off the journey for many of the vessels which normally transit via the Panama Canal, for which Panama charges a right of passage.

Even the North Pole itself and its potentially rich sub-sea oil, gas and mineral resources are a growing target of various national interests. Last August, the Russian Federation planted a rust-proof titanium national flag on the seafloor at the North Pole, arguing that an underwater mountain range known as the Lomonosov Ridge, which stretches across most of the Arctic basin, was an extension of its continental margin and thus potentially within its territorial waters. In October, Russia announced it would be filing a claim with the United Nations by the end of the year. Under the UN Convention on the Law of the Sea, any state with an Arctic coastline wishing to stake a territorial claim must lodge its submission with the UN Commission on the Limits of the Continental Shelf. Nations with Arctic interests are presently all busy mapping the topography of the seafloor to bolster their own positions and claims under the Convention.

As sea ice melts, the dark waters of the Arctic will become exposed to light and air for the first time in millennia. This will have an immense environmental impact, as the darker surface of the sea will reflect less light back into space and exchanges of heat, moisture and greenhouse gases between the air and sea will increase considerably.

UNESCO and its Intergovernmental Oceanographic Commission (IOC) are working with national and international partners to build and sustain an Arctic Observing System to monitor these changes. This system will be a contribution to the Global Ocean Observing System (GOOS) sponsored by the UNESCO-IOC.

A sustained Arctic Observing System is critical to understanding the underlying climatic variability of the Arctic, adapting to the consequences of change and mitigating these. The system is also critical to protecting the Arctic Ocean and Arctic natural and cultural heritage as part of the global commons we hold in stewardship for future generations. GOOS may have been designed originally purely to address the impact of scientific processes on the environment but that hasn't prevented it from being used increasingly to assess also the socio-economic impact of a warming Arctic Ocean.

At the GOOS Intergovernmental Committee[3] meeting at UNESCO headquarters last June, Member States agreed 'to promote actions towards establishing' an Arctic Observing System in the near future, as a sustained observational legacy of the International Polar Year, which got under way in March last year.

European nations are moving ahead quickly on this. Several European institutes have already signed a Memorandum of Understanding as a prospective contribution to an Arctic Observing System. These same European partners will be holding a first official meeting on 18–19 December within the Arctic Circle in the city of Lulea (Sweden).

At the same time, the oceanographic community is working towards a fully international system as its contribution to the sustained Arctic Observing System, via a series of international workshops being hosted by Canada, Finland and Sweden. The first of these workshops took place in Stockholm on 12–14 November.

For details (IOC): k.alverson@unesco.org; www.arcticobserving.org

3. *Made up of the UNESCO-IOC, WMO and UNEP. On GOOS, see A* World of Science, *January 2006*

Ocean observing flotilla hits **3000 mark**

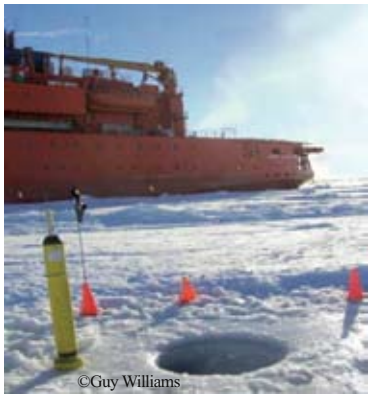
Seven years after the launch of the first robotic Argo float, the Argo ocean observing array has reached its initial target of 3000 operating floats worldwide, the Group on Earth Observations heard on 30 November at its Ministerial Summit in Cape Town (South Africa).

By systematically measuring the temperature and salinity of the ocean from the surface to a depth of 2000 m, Argo has already improved estimates and forecasts of sea-level rise caused by thermal expansion (warming oceans). It is also playing a key role in improving forecasts of seasonal climate variability and in tracking the pathway and intensity of hurricanes.

The most obvious benefit from Argo has been a marked reduction in the uncertainty surrounding ocean heat-storage calculations. These are a key factor in determining the rate of global warming and sea-level rise, and in projecting future trends. The steady stream of Argo data, coupled with global scale-satellite measurements from radar altimeters, has also made possible huge advances in the representation of the oceans in coupled ocean–atmosphere models, leading to seasonal climate forecasts and the routine analysis and forecasting of the state of the subsurface ocean. These are advances that could only have been dreamed of a decade ago. They also have practical applications, such as predicting the impact of oil spills in the open ocean and as an aid to building sustainable fisheries.

Argo data are being used in an ever-widening range of research applications that provide fresh insights into how the ocean and atmosphere interact under both extreme and normal conditions. Two examples are the processes in polar winters when the deep waters that fill most of the ocean basins are formed and, at the other temperature extreme, the transfer of heat and water to the atmosphere beneath tropical cyclones. Both conditions are crucial to global weather and climate and could not be observed by ships.

The next challenge will be to sustain the system over the long term – the current generation of floats has a lifespan of four years – and to learn from this success to complete the other elements of GOOS. These include an observing system for the Arctic (*see previous page*), an array of moorings in 'tropical' seas – critical for El Niño prediction – and the GOOS coastal module to facilitate adaptation to sea-level rise and coastal inundation, as well as mitigation.


©Guy Williams

An Argo float equipped with ice-detection software about to be lowered into the 1.5-m wide-hole drilled in the ice for the purpose. It is mid-October and the deployment team is in the Indian Ocean sector of the Southern Ocean (100° E, 65° S). 'The floats can store profiles collected while under the ice and transmit all of the data during the austral summer, after the ice has melted,' explains Prof. Steve Riser from the University of Washington

For details: http://ioc.unesco.org/jcomm/; k.alverson@unesco.org; on the floats, see: A World of Science*, January 2006; on the Group on Earth Observations, see* A World of Science*, July 2004*

Report confirms **science still dominated by men**

A report released by UNESCO in October confirms that science is still dominated by men. Although the participation of women in science at the higher levels of education has increased in the past decade in most parts of the world, three out of four researchers are still men.

Ernesto Fernández Polcuch of the UNESCO Institute for Statistics notes that, 'whereas Central Asia and, in general, the post-Soviet countries, have good gender parity, as do many countries in Latin America, the same cannot be said of Africa (31%), the rest of Asia (17%, including 12% in India but excluding China) and Western Europe (28%). In the case of Western Europe, this can be explained by the fact that many researchers work for industry, where the percentage of women is low.' Even in some countries with gender parity, like Argentina (51%), women are under-represented in the higher echelons.

Science, Technology and Gender notes that there are multiple causes for the widespread gender imbalance, including problems of discrimination and the fact that work days do not accommodate family life. In the USA for example, 35% of women doctorate-holders not in the workforce 'cite family responsibilities as the reason, compared with 2% of men.'

In the workplace, stereotypes can affect a woman's place in a team and the recognition of her abilities. The report cites the cautionary tale of Englishwomen Jocelyn Bell and Rosalind Franklin, 'who received no formal credit for their parts in Nobel Prize-winning scientific work.'[4]

'Women's employment options are often restricted by rules and laws, many of which were constructed to protect them. Employer or worker association regulations or other legislation can keep women out of S&T jobs – particularly in engineering – by setting inappropriate physical requirements for jobs that do not actually require heavy lifting. Restrictions on working at night can keep women out of well-paid shift work.'

Gender discrimination practices are particularly detrimental for the many developing countries with low numbers of researchers overall. These 'practices truly limit the ability of many developing countries to grow and reduce poverty.' The report notes that 'much talent is being wasted as girls turn away from S&T careers and women in S&T become discouraged by discriminatory treatment.'

Science, Technology and Gender has been coordinated by UNESCO's Division for Science Policy and Sustainable Development. It marks the start of an initiative to spur serious discussion and action in national and international scientific and academic communities, in order to increase women's participation in S&T careers, enable sex-disaggregated data collection and rigorous research, and build public awareness of gender issues.

Also in October, UNESCO's Science Education Programme released a training module for teachers and their pupils. *Girls into Science* sets out to debunk the myths and motivate girls to study science and pursue scientific careers.

For details, see page 24.

4. *Jocelyn Bell (1943–) determined that the position of four pulsating radio sources (pulsars) remained fixed with respect to the stars, meaning they were beyond our Solar System. (These pulsars turned out to be rapidly rotating neutron stars.) The Nobel Prize for this discovery went to her male supervisor. Rosalind Franklin (1920–1958) was the first to recognize the helix shape of DNA. Her work was passed on to Francis Crick and James Watson who, along with Maurice Wilkins, a coworker of Rosalind's, shared the Nobel Prize for the discovery of the double helix*

Children follow in gorilla's footsteps

A teaching kit that comes in a trunk begins a 12-month tour of 30 primary and lower secondary schools in Uganda in January then in Gabon in March. The trunk on The Great Apes and their Habitat is the fruit of a partnership between UNESCO, the French Museum of Natural History and the Coopération française within the Great Apes Survival Project (GRASP).

The kit alerts children living in the 21 great ape range states in Africa and those of Indonesia and Malaysia to the plight of the great apes. It provides them and their teachers with up-to-the-minute knowledge of the anatomy, behaviour, ecology, number and location of great apes. Via a series of fun activities, the children and their entourage come to understand the importance of preserving great apes and their habitat, and what can be done to help them for the benefit of their own community but also for the sake of humanity. The chosen schools all lie in proximity to forests inhabited by great apes.

Part of the trunk has been set aside for each country to personalize the content and add material about national or regional initiatives and programmes, and provide data.

Project coordinator Sabrina Krief from the French Museum of Natural History and educational advisor Christine Avril accompanied the first trunk to Uganda in September to help with recruiting and training the local teachers who will be touring schools with the trunks.

A national committee was put in place, comprised of the Uganda Wildlife Club, Uganda Wildlife Authority, Uganda Wildlife Educational Center, Association des professeurs de français en Ouganda, Allliance française, Coopération française and Newspapers for Education.

Training sessions were organized first at the local French Lycée and Uganda Wildlife Educational Center then at Kasiisi School near Kibale National Park in September. Starting in October, the English-speaking teachers were given three months of French lessons by the Alliance française in Kampala to make sure they could interact with classes in both English and French, the two language versions of the trunk.

The trunk begins touring Ugandan schools after a two-day workshop in Kampala for school principals. The trunk will spend one week in each school for three consecutive terms, with the school holidays offering a chance to organize public outreach activities at the Uganda Wildlife Educational Center and elsewhere.

The project's impact on children and their teachers will be assessed in both Uganda and Gabon.

For details: krief@mnhn.fr; s.mankoto@unesco.org; see also the interview of Sabrina Krief in A World of Science*, January 2006*

Photos: Jean-Michel Krief

On this rug, children learn to knuckle-walk by literally following in the footsteps of a great ape or Australopithecus *to imitate its gait. This boy is wearing a soft reproduction of a gorilla's hand to stimulate role-playing. Children can also make a plaster cast of a chimpanzee's hand, or complete a puzzle of the silhouette or skeleton of a great ape*

On a giant board game, children play at being female chimpanzees in a forest filled with obstacles and surprises. Children can also create a fresco for their classroom wall, from among 100 illustrations of the flora and fauna of African and Asian forests. A third sheet pinpoints the world's forests and the geographical distribution of great apes

Girls comparing plaster casts of modern and fossilized human skulls with gorilla and chimpanzee skulls. The skulls all come in the trunk, which also contains 'knowledge' sheets, an illustrated booklet, photographs, interactive CDs and DVDs, and a computer

The new biosphere reserves

AFRICA	
SOUTH AFRICA	**Cape Winelands –** A mosaic of diverse ecosystems, including the world-renowned Cape Winelands viticultural landscape; part of the Cape Floral Kingdom with some of the most outstanding diversity, density and endemism of flora in the world. Complementary part of the planned Fynbos Cluster Biosphere Reserve Network. Home to more than 300 000 people.
ARAB STATES	
LEBANON	**Jabal Al Rihane –** Represents a green island among wide extensions of bare lands of the semi-arid Bekaa valley to the east and the dry plains to the south. The site, whose name means 'mountain of basil,' shelters a number of eco-zones. Besides its ecological values, this landscape of peaks and basins is of particular aesthetic value as it offers wonderful limitless views and more than 500 year-old oak trees.
QATAR	**Al-Reem –** First in Qatar. Particularly important for the protection of terrestrial and marine areas and wildlife of great value. Other notable features include elevated limestone formations along the west coast, under which lies the Dukhan oil field. Communities use modern technology to maintain their pastoral and agricultural traditions. Breeding centres are reintroducing native fauna like the Arabian oryx and desert gazelle alongside modern oil and gas pumping stations to combine conservation and economic development.
UNITED ARAB EMIRATES	**Marawah –** First in UAE; of particular importance for the protection of marine and costal ecosystems and fragile habitats, such as sea grass beds, coral reefs and mangroves. The world's second-largest population of Dugongs finds shelter and food at this site. The area also counts more than 20 sites dating back to the 16th century on the various islands.
ASIA–PACIFIC	
AUSTRALIA	**Noosa** – Covers freshwater/tidal and terrestrial areas and straddles two eco-regions: Eastern Australian Rivers and Streams; and Eastern Australian Temperate Forests. Considered a 'biodiversity museum.' Noosa communities endeavour to manage urban growth in a sustainable manner and to develop ecotourism strategies in the buffer and transition zones.
CHINA	**Chebaling** – In the south, contains relatively well-preserved sub-tropical evergreen broad-leaved forests. Home to the endangered Chinese tiger (Panthera tigris) and the recently rediscovered white-eared night heron (*Gorsachius magnificus*). Ecotourism is being developed.
	Xingkai Lake – Includes the Chinese part of the largest freshwater lake in Eastern Asia characterized by a mosaic of inland wetland ecosystems with lakes, swamps, plains, and hills supporting a high biodiversity, particularly of fish and bird species. The local population relies on fishing, paper and rice production – 'Xingkaihu' is one of China's green brands – and growing tourism.
FED. STATES OF MICRONESIA	**And Atoll** – Spread over a seascape more than half the size of the USA, the 607 islands and surrounding reefs of the FSM house mangroves, more than 1000 species of fish, 350 species of coral and thousands of species of sponges. And Atoll is one of the last relatively intact seabird rookeries in the region and provides crucial nesting grounds for rare sea turtles. It has the only healthy population of giant clams and aggregations of grey reef sharks and barracuda. With great vistas and beaches, And Atoll has great potential for eco-tourism and is already reputable for diving and snorkelling. There is potential for the production of black pearls, giant clams, sponges and soft coral. The main threats are overfishing and hunting.
MONGOLIA	**Mongol Daguur** – In the northeast near the borders of the Russian Federation and Chinese Mongolia. Features a temperate grassland ecosystem with plains, rolling hills and wetlands. A nesting and breeding ground for migratory birds along the Northeast Siberia–South Pacific migration corridor.
VIET NAM	**Western Nghe An –** A remote site bordering the Laos People's Democratic Republic. Remarkably high biodiversity ranging from lowland monsoonal evergreen forests to elfin cloud forest at altitudes of 2300m. This site could play an important role in developing the economy and raising the standard of living of the numerous ethnic groups living in the area.
EUROPE	
PORTUGAL	**Corvo Island –** The smallest of the Azorean Islands situated in the extreme northwest of the archipelago, off the coast of Portugal. The island is the emerged part of a volcanic cone (rising 718 masl) that dominates the landscape, creating a diversified morphology that supports many endemic species. The biosphere reserve includes the island's entire emerged land mass and surrounding marine area. Centuries of agriculture and cattle-breeding have formed a landscape of high cultural significance.
	Graciosa Island – Part of the Azores archipelago. Encompasses the entire island and surrounding marine area. Exceptionally geo-diverse: the central volcano (Caldera Volcano) is distinguished by slag and spatter cones, surtseyan cones, basaltic lava flows, sub-volcanic forms, volcanic depressions, caves and algares (gas-originated domes). Includes coastal habitats and evergreen forests. Home to numerous species of endemic birds, bats, molluscs, and arthropods. Agriculture, wine production and cattle-farming are traditional livelihoods. Its mild climate, thermal springs and landscapes give Graciosa great potential for eco- and cultural tourism.
SPAIN	**Rio Eo, Oscos y Terras de Buron –** Located in the northwest on the scenic Cantabrian coastline between Asturias and Galicia. Encompasses four distinct landscape units: the estuary and mouth of the Eo River, the Cantabrian coastline, fluvial channels and the Cantabrian mountain range. The Eo River estuary is an internationally recognized wetland under the Ramsar Treaty and has plans for its rational management. Livestock, forestry and tourism drive the economy.
LATIN AMERICA	
ARGENTINA	**Andino Norpatagonica –** Of great importance for the protection of mountain ecosystems, temperate forests, pastures and the sub-Andean steppe. The easternmost example of Argentine/Chilean temperate rain forests. Recognized by the World Resources Institute and WWF as a Global 200 Site. Also listed as a biodiversity hotspot by Conservation International. The neighbouring population centres benefit from adventure tourism such as sport fishing, skiing and trekking.
	Pereyra Iraola – Constitutes the last remaining natural habitats along the Rio de la Plata. Counts the highest biodiversity and largest green area in the Buenos Aires Province, home to 12 million people. The watersheds recharge the overexploited subterranean aquifers and provide clean drinking water to the densely populated areas surrounding the reserve. The reserve also protects Buenos Aires' cultural heritage; its long-time inhabitants still practice traditional dances and produce leather and wool handicrafts.
CHILE	**Bosques Templados Lluviosos de los Andes Australes –** Located in the south, includes critical high mountain ecosystems and water resources. The coastal temperate rainforests of Chile and Argentina represent one-third of this type of ecosystem in the world. The area is recognized by the World Resources Institute and WWF as a Global 200 Site and as a hotspot by Conservation International. Local populations are engaged in ecotourism like trekking. As the reserve is contiguous to Argentina's Andino Norpatagonica Biosphere Reserve (*see above*), there is potential for a transboundary biosphere reserve.
COSTA RICA	**Agua y Paz –** Located in the San Juan River watershed, near the Caribbean Sea and the border with Nicaragua. Its humid tropical lowland forests are rich in biodiversity and provide habitat for rare species like jaguar and manatee. In addition to Agua y Paz's mosaic of lakes and navigable rivers, it has wetlands and rafia palm bogs, including the Caño Negro wetland, a Ramsar site considered the nucleus of the reserve. The reserve ensures ecological continuity between Costa Rica's Cordillera Volcánica Central Biosphere Reserve and Nicaragua's Indio Maiz Biosphere Reserve.
ECUADOR	**Podocarpus–El Condor –** Located along Ecuador's border with Peru. Conserves important tropical forest ecosystems and water resources. A biodiversity hotspot, due largely to its location at the crossroads of the Amazon, the high Andes and the Paramo converge. Dramatic altitudinal ranges (700–3790 masl) create 48 distinct ecosystems and provide critical habitat for many endemic species. Owing to recent scientific discoveries, is one of the highest priority areas for scientific research in the Neotropics. The Podocarpus tree is native to the region's cloud forests. The El Condor mountain range represents Ecuador's great multiculturalism, ecological and mineral diversity. Opportunities for organic agriculture and sustainable forestry.
EL SALVADOR	**Apaneca–Llamatepec –** El Salvador's first biosphere reserve, in the west. Conserves zones of primary succession mountain vegetation over lava fields. A key ecosystem for filtering water that drains into aquifers, benefiting not only the protected area but the entire country. Santa Ana, or Llamatepec, is the country's largest volcano (2381 masl) and the nucleus for various neighbouring 'parasitic' volcanoes. Shade-grown coffee is a key economic activity and the reserve shows potential for sustainable coffee production through its innovative participatory practices.
	Xiriualtique Jiquitizco – Its name translates as 'place in the bay of stars.' Sports the largest extension of mangroves in El Salvador and covers transition zones from coastal mangroves to freshwater ecosystems. Includes some of the country's largest and least fragmented forests. The inhabitants have developed an environmental consciousness translating into sustainable production, protected area and risk management, and recovery of traditional ecological knowledge. Sustainable development is based on ecotourism and the harvest of mangroves, coconuts and sugarcane, fishing and animal husbandry.
MEXICO	**Sierra de Alamos – Río Cuchujaqui –** Of great importance for the conservation of the fragile desert ecosystems of the Western Sierra Madres and the Northwestern Coastal Plains. Its altitudinal gradient contributes to rich diversity, from low tropical deciduous forests to dense evergreen forests. The mountain range runs parallel to the Pacific Ocean and has many deep ravines that have been excavated by rivers flowing to the Pacific. The Cuchujaqui River is home to rare felines such as pumas, jaguars and ocelots. About 400 inhabitants.
NORTH AMERICA	
CANADA	**Manicouagan Uapishka –** Lies between Saint Laurent River in the south and Manicouagan Reservoir in the north. Visible from outer space in the shape of an eye. Baie–Comeau is the site's biggest city with 22 613 inhabitants. Numerous rivers cross the territory. Traditionally, mining was a main activity of this highly forested area. An in-depth participatory process led to a shared vision for the region's sustainable development.
	Fundy – Some of the earliest colonial settlements in North America were established here. Aboriginal artefacts found in the Bay of Fundy date back more than 6000 years. With a total area of 432 000 ha, including 9940 ha of estuarine coastal habitat, it features a highly diverse topography ranging from towering cliffs to broad sweeping salt marshes at the head of the bay. The Fundy Biosphere Regional Network stakeholder group has launched innovative practices for sustainable development.

View of Cape Winelands, the new biosphere reserve in South Africa

23 new biosphere reserves in countdown to Congress

III World Congress of Biosphere Reserves Madrid, Spain 2008

The Man and the Biosphere (MAB) Programme's International Coordinating Council (ICC) has added 23 new sites in 18 countries to the World Network of Biosphere Reserves. This means that the global network will count 529 sites in 105 countries at the time of the World Congress on Biosphere Reserves in Madrid on 4–9 February.

The ICC Bureau also extended the biosphere reserves of Frontenac (Canada) and Great Volzhsko-Laùslu (Russian Federation) when it met at UNESCO headquarters in Paris from 18 to 20 September. In parallel, Germany withdrew the Bayerischer Wald Biosphere Reserve from the network because it no longer met the criteria established by the Statutory Framework for biosphere reserves adopted in 1995.

The Bureau also selected 11 young scientists for MAB Young Scientists Awards of up to US$5000 each towards their respective research projects in biosphere reserves: (Ms) Anahí Jael Miner and (Ms) Adriana Luzmila Szymanski (Argentina), Bing-Wan Lui (China), (Ms) Gertrude Lucky Aku Diame (Ghana), (Ms) Giulia Wegner (Italy), Douglas Ndambuki (Kenya), (Ms) Aida Kaptagaeva (Kyrgyzstan), (Ms) Mirvat Al-Wali (Palestinian Territories), (Ms) Tatyana Yashina (Russian Federation), (Ms) Salma Abdeshafar Hassan Elamin (Sudan) and (Ms) Pham Thi Thuy (Viet Nam).

For details: www.madrid2008mab.es/; www.unesco.org/mab
m.clusener-godt@unesco.org

Water institute to train 2100 Iranians

The UNESCO-IHE Institute for Water Education signed an agreement in November with the Iranian National Water & WasteWater Company and the Power and Water University of Technology in Teheran, for the training of 2100 Iranian water professionals in 2008–2009.

The UNESCO-IHE will develop and run 59 one-week training courses with the Power and Water University of Technology in Iran in the areas of water supply and wastewater technology, operation and maintenance, management and finance.

In addition, 20 study tours to European water and wastewater companies will be organized for senior managerial and technical staff.

Financed by the Iranian government, the project sets out to make sure that professionals working for water and wastewater companies are better prepared in future to face growing challenges. Topics will include water demand management, the design of innovative water and sanitation systems, integrated water management, emergency planning and response, environmental assessments and the operating and maintenance of water treatment plants.

The project will conclude with an expert group meeting to draft a plan for ongoing human resources development in the Iranian water and wastewater sectors.

For details: www.unesco-ihe.org; c.gonzalez@unesco-ihe.org

Environment prized at Forum

The Sultan Qaboos Prize for Environmental Preservation and the Great Man-Made River Prize for Water Resources in Arid and Semi-Arid Areas were awarded by UNESCO Director-General Koïchiro Matsuura at the World Science Forum in Budapest (Hungary) on 10 November, on the occasion of World Science Day for Peace and Development.

The biennial Great-Man Made River Prize has been attributed to two research teams in the USA, the first from the Centre for the Sustainability of Semi-Arid Hydrology and Riparian Areas at the University of Arizona and the second from the Centre for Hydrometeorology and Remote Sensing at the University of California.

The biennial Sultan Qaboos Prize, worth US$30,000, is shared by the Institute of Biodiversity Conservation (IBC) in Ethiopia and Dr Julius Oszlányi (Slovakia), as recommended by the MAB's ICC Bureau last September. The prize recognizes the Institute's efforts to establish effective systems for the conservation and sustainable use of Ethiopia's biodiversity, and to provide for equitable sharing of the costs and benefits derived from it. Dr Julius Oszlányi is Director of the Institute of Landscape Ecology of the Slovak Academy of Sciences and a member of the Scientific Committee of the European Environment Agency.

For details: www.unesco.org/mab/prizes/sq.shtml;
www.unesco.org/water

Jacob Palis

An Academy of Sciences for the Developing World

The Academy of Sciences for the Developing World (TWAS) is a UNESCO-affiliated body. Headquartered in Trieste (Italy), TWAS receives its core funding from the Italian government. To mark the Academy's 25th anniversary this year, we talk to its fourth president, Jacob Palis. A renowned international expert in dynamical systems and differential equations, Jacob Palis directed the Instituto Nacional de Matemàtica Pura e Aplicada (IMPA), Brazil's leading research centre for mathematics, between 1993 and 2003. He has also served as President of the International Mathematical Union (1999–2002). He was elected President of TWAS in September 2006.

What are the most critical challenges facing the developing world?

We live in an era that places a premium on both global knowledge and global competition. That makes the role of S&T more critical than ever. I don't want to sound too grandiose but the main challenges TWAS faces today are common to all humanity: how to devise and sustain broad-based strategies for socio-economic growth based on endogenous systems of science, technology and innovation, and how to ensure that such strategies benefit as many people as possible.

Another big challenge, closely related to those above, is how to increase substantially the participation of women in science. Greater female involvement will help ensure that the global scientific community is drawing on the largest possible pool of talent. It will also help shift the focus of science to issues more directly related to critical socio-economic needs.

How is TWAS addressing these challenges?

TWAS has worked hard to identify the best scientists in the developing world and elect them as members of the Academy. Earning membership of TWAS has become highly competitive. Five years ago, the Academy received some 100 nominations. Last year, it received more than 200.

In developing countries without merit-based science academies, election to TWAS serves another important function. By casting a spotlight on a nation's most eminent scientists, it helps to identify those who can be called upon at the earliest stages of a science academy's development. That's one reason why TWAS has diligently sought nominations not only from developing countries with growing scientific capabilities, such as Brazil, China and India, but also from poor developing countries with lagging scientific capabilities.

Beyond our roster of 880 Academy members, I think one of TWAS's most significant programmes is the South–South fellowship programme we operate in partnership with the governments of Brazil, China, and India and, most recently, Mexico and Pakistan. The programme is open to young scientists from developing countries who are pursuing doctoral degrees and postdoctoral studies in a wide range of scientific disciplines. TWAS pays the cost of travel and provides a small stipend; local universities and research centres hosting the students cover the cost of food and lodging. More importantly, these institutions open their classrooms and laboratories to participating students from other developing countries. This programme is one of the largest and most effective programmes for South–South cooperation in science. With more than 200 fellowships available each year, it represents an unmatched channel for collaboration between more scientifically proficient and less scientifically proficient developing countries.

TWAS also oversees a research grants programme largely for young and mid-career scientists in the developing world and visiting scientist programmes that foster South–South and South–North scientific exchanges. The Academy has worked closely with other international organizations, including UNESCO, UNU's Institute for Advanced Studies and the International Council for Science, to advance these efforts.

In 2002, under the leadership of my predecessor, C.N.R. Rao, the Academy launched a programme targeting funds for scientific groups and research centres in sub-Saharan Africa and the least developed countries. The programme offers annual grants of up to US$30,000 for three consecutive years. It is designed to provide significant resources to research groups and institutions in very poor developing countries that are doing excellent work under trying conditions. TWAS will be extending this programme substantially this year, thanks to a generous grant from the Swedish International Development Agency (SIDA).

TWAS also provides small sums of money for scientific meetings in the developing world. It also holds a general meeting once every two to three years for several hundred high-level scientists, science administrators and public officials. These gatherings, which are supported almost entirely by the host country, have become signature events in assessing the

state of science in the developing world. Brazil, China, India, Iran, Kuwait and Senegal are among the countries that have hosted Academy general meetings. The next one is scheduled to take place in Mexico in November 2008.

The Academy also supports scientific capacity-building at the regional level, largely through its offices in Brazil, China, Egypt, India and Kenya. A key focus of these regional offices is the organization of symposia for young scientists and the awarding of prizes to young scientists who have displayed much promise in their fields of research. Recently, the TWAS secretariat in Trieste established a new category of affiliated membership for young scientists that will permit those selected to be associated with the Academy for a five-year period. This is part of our larger campaign to encourage university students to pursue careers in science.

Lastly, I would like to mention that TWAS provides administrative support for several other international scientific institutions that share its interest in scientific capacity-building and science-based development. These organizations include the InterAcademy Panel on International Issues, a global network of merit-based science academies, and the InterAcademy Medical Panel, a global network of medical academies or medical divisions within science academies. We are particularly proud of our support for, and affiliation with, the Third World Organization for Women in Science (TWOWS). With more than 3200 members, TWOWS is the world's largest organization of women scientists. Its fellowship programme for young women scientists from sub-Saharan Africa and the least developed countries, which is funded by SIDA, is helping young women scientists earn advanced degrees in a broad range of scientific fields.

We are looking forward to the concrete establishment of the Consortium on Science, Technology and Innovation for the South (COSTIS), which was born in September 2006 at the TWAS general meeting in Brazil. COSTIS is a joint initiative of the Group of 77, the largest advocacy group in the United Nations for issues of concern to the developing world, and the international scientific organizations located in Trieste. While it has yet to take full shape, the core of COSTIS' mandate calls for addressing the critical challenge I mentioned earlier: the need for every nation to build sufficient S&T capacity to pursue science-based development successfully.

What new trends do you see emerging in South–South cooperation?

The sense of kinship shared by many developing countries drives them to pool their efforts, wedded by comparable levels of skill and circumstances. This cooperation has been enhanced by the increasing number of developing countries that have recently experienced rapid growth in scientific competency. These countries now find themselves in a position of effectively cooperating not only with other developing nations at similar levels of scientific competency but also with developing countries that, for any number of reasons, have not kept pace with global advances in S&T. In such an environment, 'cooperation' replaces 'aid' as the primary driver of development.

Science is universal. For this reason, South–South co-operation does not in any way preclude South–North cooperation. In fact, South–South cooperation could well improve the effectiveness of South–North cooperation through the successful creation of trilateral arrangements in which developing countries with less scientific capacity interact with developing countries with greater scientific capacity, especially in the same region. The more scientifically proficient developing countries, in turn, can interact with developed countries. A variety of critical issues, for example, climate change, energy research and development, and curbing the spread of infectious diseases, could lend themselves to such an approach, creating truly global networks of scientific research.

You have been a key player in transforming Brazil's scientific enterprise. What accounts for the success of these reforms?

Science in Brazil is growing rapidly but its roots are not very deep. Brazil's most prominent universities – the University of São Paulo and the University of Brazil in Rio de Janeiro – were created in the first half of the 20th century. The nation's main national agencies for the promotion of scientific research and training – notably, the National Scientific Council (CNPq) and the Coordination for the Upgrading of University Professors (CAPES) – were launched in the early 1950s. The nation's scientific enterprise is decades, not centuries, old.

The pace of change, in fact, began to accelerate rapidly in the 1960s. That is when the National Bank for Development decided to invest 2% of its annual budget in S&T and the Ministry of Education began building a comprehensive and innovative national framework for postgraduate studies to increase both the number and quality of Master's and Doctorate degrees.

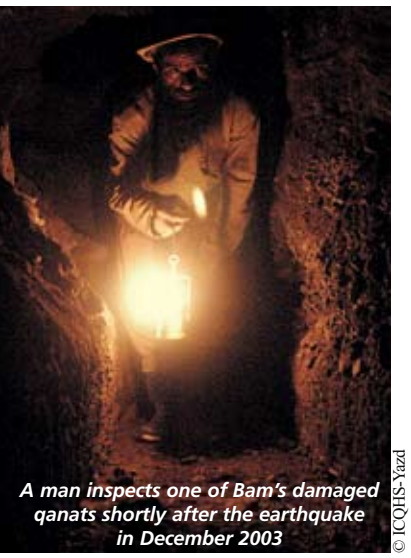
These efforts have reaped enormous benefits, creating an impact over time that is now easy to see. Brazil's S&T communities are much stronger and more diverse, and the nation's S&T infrastructure has improved enormously. Perhaps most importantly, as the value of S&T to society has become increasingly obvious, so too has the government's commitment.

The critical remaining challenge in Brazil is to spread scientific excellence beyond São Paulo, Rio de Janeiro and other major urban centres to less privileged regions, such as the Amazon, the Northeast and the Centre West, and to encourage greater interaction between the public research community, especially in universities, and the private sector.

I believe there is a great deal to learn from Brazil's experience, as well as from the experience of other developing countries that have made enormous strides in building S&T capacity and applying it to development. If such experiences are shared in meaningful and effective ways, it could mean that relatively less developed countries will be able to build their own scientific capacity rapidly.

Daniel Schaffer[5]

5. *TWAS Public Information Officer. On TWAS: www.twas.org*



A man inspects one of Bam's damaged qanats shortly after the earthquake in December 2003

The fall and rise of **Bam's qanats**

Iran is located in an arid and semi-arid region where average rainfall amounts to just 252 mm per annum, one-third the world average. Approximately 90% of the country suffers from water scarcity. Over the centuries, Iranians have learnt to deal with this. They have mastered various techniques that enable them to harness their limited water supply for domestic needs and irrigation. One of the most efficient of these techniques is the qanat system, which may have been invented in Bam thousands of years ago.

The Bam District in southeastern Iran is desertic and heavily reliant on qanats. Ever since a tragic earthquake flattened the city four years ago, UNESCO's Tehran office has been bolstering the country's efforts to reconstruct Bam's qanats and ensure these are better protected in future.

Qanats are a water supply system consisting of an underground tunnel connected to the surface by a series of shafts. They tend to be dug in areas where there is no surface water. By putting the majority of the channel underground, qanats reduce water loss from seepage and evaporation. By using the force of gravity to carry water downstream, they eliminate the need for pumps.

Qanats occupy a special niche in Iran's cultural, socio-economic, political and physical landscapes. Although life has changed radically over the centuries, qanats have conserved their importance for community well-being and even survival in many parts of the country. Despite this, there has been a decline in recent years in the number of experts for managing such systems.

Bam's qanats among the earthquake's structural casualties

The Bam District is a typical desert oasis with an average annual rainfall of about 60 mm. Even that has dropped in recent years. Around 70% of the people living in Bam and the surrounding villages are directly or indirectly engaged in agriculture, which is based mainly on the discharge from qanats. Until the day a 6.5 magnitude earthquake struck the ancient city on 26 December 2003, these qanats provided over 50% of the area's annual water requirement.

The earthquake hit the district at 05:28 am local time, an hour when almost all of the city's 90 000 residents were still in bed; one-third were killed and most of the remainder

A brief history of qanats

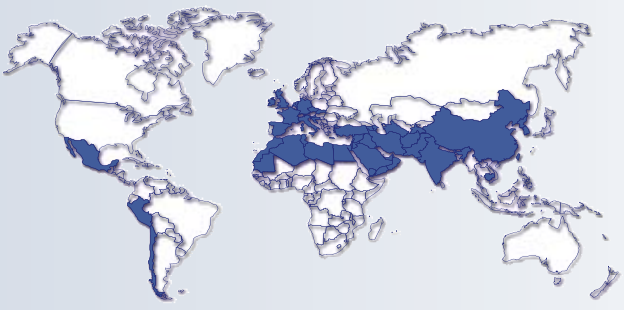
Iran is thought to be the original homeland of qanats, some of which date back over two thousand years. They supplied water for the historical expansion of the Persian Empire across the region.

According to Henry Gubler, coal miners in northeastern Iran improvised the first series of canals around 800 BC in the Western calendar, in order to extract water from coal mines. The technology was gradually applied by farmers and spread all over the Iranian plateau.

During the period 550–331 BC, when Persian rule extended from the Indus to the Nile, qanat technology spread throughout the empire. To the west, qanats were constructed from Mesopotamia to the shores of the Mediterranean. By about 525 BC, the technology had reached Oman and Saudi Arabia via Persian campaigns and Egypt by 500 BC.

To the east of Persia, qanats were constructed in Afghanistan, in the Silk Route oasis settlements of Central Asia and in Chinese Turkistan.

During the Roman–Byzantine era (64 BC–660 AD), many qanats were constructed in Syria and Jordan. From here, the technology appears to have diffused north and west into Europe. There is evidence of Roman qanats as far away as Luxembourg.

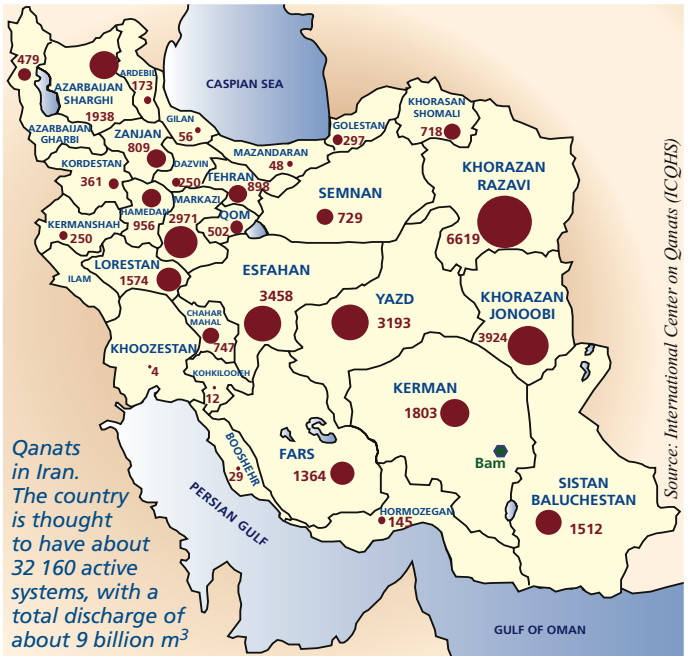


Distribution of qanats around the world
(in blue)

Qanats were introduced into Africa by Muslims. In about 750 AD, the Arabs were responsible for the construction of the first *yafuga* (qanat) in Madrid. In turn, the Spanish went on to introduce qanats into Mexico in 1520 AD. From there, the technology was carried to Los Angeles in the USA and on to Chile.

Some 60% of the world's qanats are based in Iran, which has exported expertise to about 36 countries, including: Afghanistan, Algeria, Bahrain, Cambodia, Chile, China, Cyprus, Czech Republic, Egypt, France, Germany, India, Iraq, Jordan, Libyan Arab Jamahiriya, Mexico, Morocco, Oman, Pakistan, Peru, Qatar, Russian Federation, Saudi Arabia, Spain, Sudan, Tajikistan, Turkey, Turkmenistan, the United Arab Emirates, UK and Yemen.

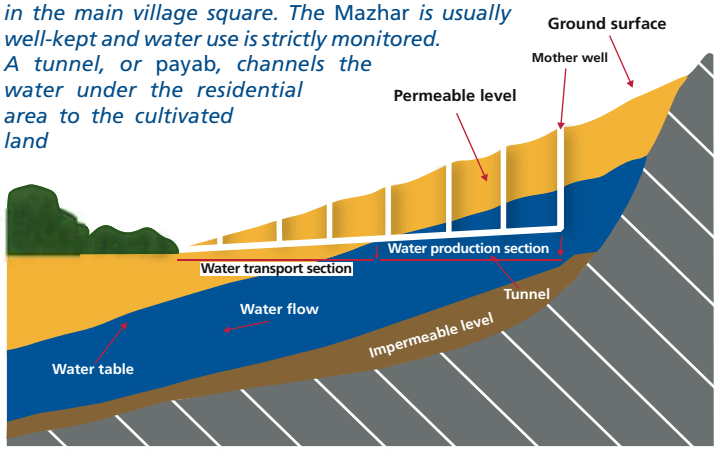
Sources: International Center on Qanats and Historic Hydraulic Structures: www.qanat.info/en/index.php; www.waterhistory.org/histories/qanats/



Qanats in Iran. The country is thought to have about 32 160 active systems, with a total discharge of about 9 billion m³

Source: International Center on Qanats (ICQHS)

A typical qanat system. The main (or mother) well is generally excavated in the mountains, penetrating deep into the water table. Water from this mother well runs down a slightly sloping tunnel, gradually increasing in volume until it emerges near farms or communities. Water is brought to the surface where the soil has been enriched by sediments from alluvial fans. Cultivated land and settlements are situated downwards from the point where the water surfaces. People draw water from the immediate outlet, the Mazhar, *which is generally located in the main village square. The* Mazhar *is usually well-kept and water use is strictly monitored. A tunnel, or* payab, *channels the water under the residential area to the cultivated land*



were left homeless. The catastrophe brought more than 80% of the city buildings crashing to the ground. These included ancient constructions like the Citadel and historic hydraulic structures valued as cultural heritage like the qanats. The earthquake created blockages in many of Bam's qanats and caused others to collapse (*see geological report overleaf*). In some cases, the damage caused water to seep into other qanats, increasing their discharge.

An unexpected archaeological find

Studies undertaken soon after the earthquake revealed thousands of hectares of archaeological remains. These had not been uncovered by the convulsions of the earthquake but rather scattered across the surface and abandoned for years. Ongoing archaeological investigations reveal that the area is even more important than archaeologists had previously thought when preparing the Bam dossier for submission to UNESCO's World Heritage Centre. The Bam District seems to contain some of the oldest extant qanats in Iran and perhaps in the world.

The technical advantages of the natural setting of Bam, which is located in a plain between two mountain ranges showered in both rain and snow, go some way to explaining why Bam seems to have played a significant role in the invention and development of qanats. Bam's geographical situation was ideal for the construction of shallow wells and qanat systems. The district has the oldest qanats in Iran and one of the greatest densities of qanats in the entire country, with some 375 lines of old traditional qanats and 950 wells of different depths in various parts of the district.

Bam's qanat system reached its peak in the early Islamic period before losing its lustre by the end of the 12th century, a casualty of the wars that scarred the period. Although somewhat damaged by warfare, the qanat system did survive, even if the city never recovered its former glory. Nevertheless, Bam's status as a garden town in a semi-arid region has lost none of its fascination.

Impoverished farmers struggle to rehabilitate the qanats

Qanats have long contributed to the development of the social structure in the Bam area. Owing to the arduous, expensive work required to build them, it has always been a collective activity, involving different beneficiaries and communal

Before and after views of the ancient Arg–e Bam Citadel. In 2004, Bam and its Cultural Landscape were inscribed simultaneously on the List of World Heritage and the List of World Heritage in Danger

Report reveals 40% of Bam's qanats devastated by earthquake

According to the Geological Survey of Iran, the Bam fault scrap has greatly contributed to the trapping of groundwater in the upper terrace, where Bam City is located, as it forms a sort of underground dam that keeps recharge water in the aquifer.

The geological report reveals that the 2003 earthquake did not result in significant displacement of the fault scrap and is not expected to have changed the groundwater status in the region.

It observes that qanats near the main rupture suffered greater damage than others due to the direction of seismic waves. A preliminary evaluation showed that about 40% of qanats had collapsed or been severely damaged by the earthquake.

Earthquakes affect the linear structure of the qanats in two ways, via tremors and groundwater failure. Tremors refer to a vibration of the ground that produces seismic waves. Any underground tunnel shape structure is affected by this. The damage to the structure depends on its overall design, strength, ductility and flexibility. General failure includes various types of instability.

The best way to mitigate the risk of structural damage is to avoid areas prone to earthquakes. However, since qanats are often several kilometres long, it is almost impossible to overcome this problem.

Workmen repairing one of Bam's qanats

Tips for protecting qanats

Among the recommendations contained in the report submitted by UNESCO and its partners to the Government of Iran are:

- ✓ When planning the reconstruction of qanats after an earthquake, take into consideration newfound faults.
- ✓ Carry out detailed studies on the geotechnical and engineering properties of different horizons near qanats.
- ✓ Map old qanats which are still yielding water to help avoid damage to newer structures and channels.
- ✓ Keep construction near qanat systems to a minimum.
- ✓ Provide additional structural support when building near the access wells and galleries of qanats.
- ✓ Impose restrictions on digging deep wells to avoid excess water extraction which could lead to a drop in the water table and reduce the performance of qanats.
- ✓ New wells should be dug only when absolutely necessary, within a distance of at least 3 km from the existing qanat.
- ✓ Document traditional knowledge of qanat practitioners and preserve the expertise.
- ✓ Ensure a compatibility between traditional and new management systems to fulfil all economic, social and technical needs of communities and qanat users.
- ✓ Establish a comprehensive groundwater monitoring network.

ownership. Access to qanats and management of qanat water is regulated by a water-user group, whose members are the water-share owners. Many of these users are farmers.

The earthquake impoverished these same farmers, making rehabilitation of the qanats much harder. In parallel, prices rose sharply, owing to a combined shortage of skilled labour and materials.

UNESCO steps in

In the aftermath of the earthquake, UNESCO's Tehran office offered to support the Iranian efforts to reconstruct those qanats that had been either damaged or completely destroyed by the earthquake. The aim was also to ensure that the qanats were better protected and better managed in future. Six teams of experts were commissioned to prepare comprehensive technical reports on the current status and future prospects of the qanats. Some of their many recommendations are highlighted on these pages.

In the first project phase in 2004, each team examined a different aspect of the problem: the International Centre on Qanats and Historic Hydraulic Structures studied Bam's qanats from an engineering perspective; the Ministry of Jihad-e Agriculture from an agricultural perspective;

Every newcomer to the central plateau of Iran will encounter rows of wells like these crossing arid landscapes like stitches on a piece of cloth. These are qanat shafts, the visible segment of subterranean canals which convey groundwater from a main well generally excavated in the mountains, down a slightly sloping tunnel to the point of use

A maintenance worker descends into a qanat shaft from the surface

the Iranian Cultural Heritage and Tourism Organization from a cultural perspective; two UNESCO consultants from an archaeological perspective; the Geological Survey of Iran from a geological perspective; and the UNDP from a socio-economic perspective.

Each partner prepared a report for presentation to a workshop run by UNESCO's Tehran office on the qanats of Bam in June 2005. The various reports were compiled and submitted to the Iranian government in the second half of 2005. The Ministry of Jihad-e Agriculture then launched the second phase of the project covering the reconstruction and rehabilitation of the qanats. This process is still under way today.

Since June 2005, UNESCO's Tehran office has run two short training courses on qanats in tandem with the International Centre on Qanats and Historic Hydraulic Structures in Yazd, which operates under the auspices of UNESCO. The first took place in Bam itself and the second in Yazd in July 2007. It is planned to hold further training courses in countries around the region.

UNESCO also supports a training centre on qanats established by the Ministry of Higher Education in 2003 to ensure the qanats are properly managed over the long term. The centre is situated in the city of Taft near Yazd, well-known for its qanats. Students study different fields in relation to qanats, including geology and hydrogeology, history, archaeology, the classification of qanats, traditional methods of constructing and maintaining qanats, the workings and water distribution of qanats, and socio-economic aspects of qanats.

Afghanistan is one of the four cluster countries[6] covered by UNESCO's Tehran office. It has prepared a desk report on an ongoing project supported by UNESCO to inventory its own qanats. UNESCO's Tehran office plans to replicate this project in other countries in the cluster where qanats remain the unique means of supplying water in many places.

Bam's catastrophic earthquake has drawn attention to a sophisticated culture of rational resource allocation that was previously largely overlooked. It has shone the spotlight on an ancient method of groundwater management which provides an excellent demonstration of human ingenuity in coping with water scarcity that is of timeless utility for arid and semi-arid zones everywhere.

Abdin Salih[7] and Alireza Salamat[8]

On the International Center on Qanats and Historic Hydraulic Structures: www.qanat.info/en/index.php;

On Bam, read: After the Earthquake, in the April 2004 issue of A World of Science

6. *The others are the Islamic Republic of Iran, Pakistan and Turkmenistan*
7. *Former Director of UNESCO's Tehran office (until September 2007)*
8. *Programme Specialist at the Regional Centre on Urban Water Management in Tehran, a centre operating under the auspices of UNESCO*

Children living in a temporary settlement shortly after the Bam earthquake wait in single file to fetch a glass of water from a nearby cistern. Within a month of the earthquake, 30 000 survivors were living in tents like the ones pictured here and other emergency shelters. Within eight months, 30 000 temporary homes had been built. By 2007, these had been replaced by permanent homes with steel-braced frames, in addition to 25 000 rural homes. An estimated 98% of residents have been rehoused.UNESCO participated in the construction of the Arg-e Bam Model School Complex near the Citadel, together with the Ministry of Education and the International Federation of Red Cross and Red Crescent Societies. Completed in February 2007, the school has 17 classrooms for a roll of 400 covering the pre-primary, primary and lower secondary levels. This and other schools have been rebuilt in Bam with international donor funding

Rhön's **gastronomical ambassadors**

© Lutz Möller

Peace memorial at the former East–West border. Visible on the panel is the Russian word for peace

Tourists call it 'the land of wide open spaces.' Rhön Biosphere Reserve in central Germany offers a sprawling landscape of rolling hills covered in meadows and grasslands. Straddling the three federal states of Bavaria and Hesse, formerly in West Germany, and Thuringia, formerly in East Germany, Rhön is a product of German reunification. Once a 'hot spot' of Cold War confrontation[9], the territory was designated as a biosphere reserve in 1991, just two years after East and West Germany embarked on the reunification process. If the biosphere reserve is a symbol of unity and economic upswing today, the project initially sparked controversy. The decision to focus on regional development, with an emphasis on marketing local produce, was a decisive factor in bringing the population round.

Rhön Biosphere Reserve boasts a variety of landscapes: the Hohe Rhön is a plateau which traditional forms of sheep farming have kept open; it is covered by 'neglected grasslands'. The Hessian Rhön is characterized by striking cone-shaped mountains and a park-like appearance; the Thuringian Rhön by unique lime neglected grassland connected over large areas, where agriculture is dominated by large concerns. The Bavarian Rhön is synonymous with open, unsettled meadows; here, the predominant occupation is also farming but more often than not as a secondary occupation.

The core zone is made up of beech forests and raised bogs. The diversity of species in the protected habitats is very high, thanks to the favourable living conditions many threatened species enjoy there, including such birds as the black grouse, corncrake, black stork and kingfisher. In the case of the black grouse for example, its territory has been kept open thanks to landscape planning, enemies like the red fox and the marten have been hunted down and tourists have been taught to respect the bird's privacy.

'Protection through utilization'

The three state administrations running the biosphere reserve focus on different aspects but together have succeeded in making the Rhön a 'role-model' for biosphere reserves. Several of their priority projects focus on the economic dimension of sustainable development. These set out to invigorate the marketing of local products, revive regional economic cycles and forge close cooperation with local farms.

Close cooperation across the three federal states was agreed upon right from the start. In parallel, local sponsoring agencies, which exist for most of Germany's biosphere reserves, have accompanied the local government players. This is especially true in Hesse, where the local sponsoring agency Natur und Lebensraum Rhön was founded as early as 1991. With its mission statement of 'Protection through utilization', the agency has consistently attracted European Union subsidies for regional development to this day.

Each of the three federal states administers its own territory within Rhön Biosphere Reserve, which altogether spans around 1850 km². The strictly protected core area (42 km²) is surrounded by a buffer zone (675 km²) where conservation is emphasized but where people also live and work

In the beginning, there was the Rhön sheep

Looking back, one of the first truly exemplary schemes for marketing local produce in the biosphere reserve has been the Rhön sheep project.

In the 18th century, hundreds of thousands of sheep could be seen grazing in the Rhön. However, when the industrialization of farming accelerated in the aftermath of the Second World War from the 1950s onwards, the country breeds were unable to compete with the modern

meat breeds and traditional sheep farming went into decline. By the end of the 1970s, the Rhön sheep was almost extinct.

In the 1980s, both private concerns and the Bavarian nature conservation NGO Bund Naturschutz began looking into the studbook breeding of this robust country breed, particularly appropriate for landscape conservation. There were also enthusiasts in Thuringia who managed to secure the survival of local Rhön sheep, despite the adverse regulations in force in the former East Germany.

Over the past 16 years, Rhön Biosphere Reserve has organized an extensive marketing campaign for Rhön sheep. This has been accompanied by culinary events for gourmets and excursions for shepherds. Early on, a dialogue was established with retailers. Little by little, the stock of Rhön sheep has grown to about 4000 ewes today. The Rhön sheep has become the local mascot once more and is used as an advertising icon.

Rhön sheep

In all three federal states, Rhön sheep flocks are put out to pasture to preserve the landscape. Locally produced lamb and mutton are marketed for their 'bio-quality', via baby-food manufacturers and chain stores. Nor is the Rhön sheep the only breed to have done well out of a long-standing marketing collaboration with the regional supermarket chain Tegut. In 2006, 5000 animals were marketed through this partner, including other sheep breeds in the Rhön.

Today, there are 20 000 ewes of various breeds in the Rhön. Those shepherds who have committed to practicing ecological animal husbandry have been able to find major, trustworthy partners via the marketing initiative.

The apple of Rhön's eye

Nobody in their right mind would refer to the rather rough mountain range of the Rhön, with altitudes of up to 950 masl, as an apple-growing region. Nevertheless, many traditional types of fruit have survived. Pomologists talk of around 400 apple varieties.

In Rhön Biosphere Reserve, the potential for marketing locally grown apples was recognized very early on. In the mid-1990s, the Rhön Apple Initiative, an association of apple-growers, began harvesting apples from traditional Rhön orchard meadows and marketing them for their bio-quality. Local fruit-crushing and pressing plants, like the medium-sized Elm plant, have specialized in the production of top-quality apple juices, cider and sparkling apple wine.

Rhön apple beer is produced by the Rother-Bräu ecobrewery. Antoniusheim, a local home for the disabled, produces apple chips. Smaller producers focus on top-quality jellies. The Rhönsprudel company runs huge advertising campaigns around Hesse for its mineral water and apple drink, marketed under the brand name 'Biosfere.'

These products generate revenue for the entire region. All are now standard fare on the shelves of regional supermarkets. Several Rhön products are even listed in the delicatessens of the capital, Berlin.

The considerable distance to major urban agglomerations, the firmly rooted agricultural tradition and the territory's natural features have all combined to create a cultural landscape in Rhön Biosphere Reserve which is, for the most part, still intact today

Parade through the streets in traditional costume in the Hesse part of Rhön Biosphere Reserve

Protecting European crayfish from crayfish plague

The Rhön Biosphere Reserve crayfish project started out as a species protection scheme in 2000 but the scope has since been extended to include marketing for the benefit of the local catering industry.

The first task was to plot and analyse the crayfish in water courses. European crayfish were counted in ten streams but it was found that American signal crayfish had invaded four of these. As American signal crayfish can spread crayfish plague, there were fears they might endanger the stocks of European crayfish. The American signal crayfish were thus separated from their European cousins and the varieties were bred in separate ponds.

In 2004–2005 alone, more than 5000 European crayfish were returned to the wild, leading to a stable population in eight local water courses. Volunteers are involved in this part of the project, which is being implemented in close cooperation with fishing clubs, the local fishing authority and fish farms.

There is currently a move to upscale marketing of both varieties of crayfish by introducing them into the local crayfish trade.

A carpenter's workshop in the Thuringian part of Rhön Biosphere Reserve

Top-quality gastronomy with the Rhön Umbrella Brand

Marketed under the 'Rhön umbrella brand' many products from the biosphere reserve are certified organic, meaning they have been grown without the use of standard pesticides or artificial fertilizers and without being genetically modified; in other cases, the Rhön products are certified as meeting conventional quality standards.

'Rhön biosphere cattle' and 'Rhön goats' have not only turned out to be excellent gastronomical ambassadors for the biosphere reserve but are also helping to preserve the landscape. An important market potential is foreseen for these top-class food products. As for Rhön's own brown trout, it has already established itself as a top-quality product within the local catering industry. Rapeseed oil and honey produced in the biosphere reserve are another target of marketing initiatives.

It has taken up to ten years for each new Rhön product to establish its market niche. Such a long-term investment would be impossible without motivated partners, creative staff and a great deal of patience. A UNESCO biosphere reserve provides the appropriate framework for long-term marketing projects, in contrast to other schemes which tend to offer only short-term support for regional development projects in Europe today.

Quality breeds content

If the local population has embraced the idea of living in a biosphere reserve, it is mainly thanks to the successful marketing of regional products and the resultant safeguarding of local farms and jobs.

Today, economic and demographic development is better in Rhön Biosphere Reserve than in comparable parts of Germany. The population has remained stable over the past decade, belying a trend in other regions towards a rural exodus. Numerous companies have sprung up; these have created jobs and, in many cases, gone on to become highly successful. One example is a company producing an organic soft drink by the name of BIONADE, which can be found today in just about any trendy bar in Germany.

The high level of public acceptance of the biosphere reserve is reflected in representative surveys. One opinion poll carried out in Rhön by Allensbach

Rhön shop selling organically grown local produce

in 2002 revealed that 47% of people were 'very familiar' with the biosphere reserve concept; of these, 72% felt there were more advantages than disadvantages to living in a biosphere reserve, compared to 6% who thought the contrary.

Today, there is even a strong interest among many stakeholders in expanding the territory deeper into Bavaria and Hesse.

In 2003, Rhön received a positive evaluation from the German National Committee for the Man and the Biosphere (MAB) Programme. Seven years earlier, the committee had drawn up a catalogue of criteria for designating and evaluating UNESCO biosphere reserves in Germany, thereby implementing the MAB Programme's International Guidelines at the national level. The committee published a revised catalogue of 40 criteria last year. All 13 existing German biosphere reserves have to fulfil these criteria, including those designated before the change in focus in 1995 with the adoption of the Seville Strategy.

Martin Kremer[10]

This article is a slightly modified version of that published in the latest issue of UNESCO Today *(2007) on the theme of UNESCO Biosphere Reserves: Model Regions with a Global Reputation.* UNESCO Today *is published by the German Commission for UNESCO and can be downloaded from: www.unesco.de/uh2-2007.html?&L=1*

9. *Ed.: This confrontation opposed two military alliances: the North Atlantic Treaty Organization (NATO), established in 1949 by the USA, Canada and Western European countries, and the Warsaw Pact established in 1955 by Central and Eastern European countries. The Cold War is so-known because there was never any direct military engagement, although tensions fuelled a forty-year nuclear arms race until the fall of the Berlin wall (dividing the city into two), in 1989*

10. *Head of the Biosphere Reserve and Nature Park Department in the Hessian Rhön and Manager of the Association Natur und Lebensraum Rhön*

Governing **bodies**

With the official return of Singapore to UNESCO in October after an absence of two decades, some 193 Member States were concerned by the adoption of UNESCO's Medium-Term Strategy for 2008–2013 and Programme and Budget for 2008–2009 at UNESCO's General Conference in Paris from 16 October to 3 November.

Science tightens its belt another notch

The approved biennial budget amounts to US$631 million. Of this, US$20,857,600 (3.3%) is allocated to activities in Natural Sciences – US$1,015,000 of which will go directly to the Abdus Salam International Centre for Theoretical Physics. The budget envelope for staff costs in Natural Sciences amounts to US$35,416,700 (5.6%). The second (category 1) UNESCO science institute, the UNESCO-IHE Institute for Water Education, is funded exclusively from extrabudgetary resources.

Within the first biennial priority for science, there is to be stronger coordination between the International Hydrological Programme, the UNESCO-IHE and other water-related centres, as well as with UNESCO Chairs. Biosphere reserves are to be used increasingly as learning platforms for sustainable development, including ecotourism, and for environmental management and monitoring. In tandem, UNESCO's role in geosciences and in Earth observation is to be developed to monitor changes in land, water and oceans, and improve understanding of climate change and its impact. UNESCO will continue to foster a culture of disaster preparedness, including via implementation of the Global Tsunami Warning System.

Within the second biennial priority for science, the programme will develop a culture of science education at all levels that is inclusive of girls; it will foster capacity-building in science, technology and innovation (STI) via collaboration with scientific networks, centres of excellence and NGOs, encouraging South–South and triangular North–South–South cooperation. Countries will continue to receive assistance and support in formulating and implementing STI policies. Access to knowledge and basic services via cutting-edge technologies will be promoted and energy policies for sustainable development devised.

New science centres

The General Conference endorsed the establishment of the following (category 2) science centres under the auspices of UNESCO: Regional Centre for Shared Aquifer Resources Management (Libyan Arab Jamahiriya); International Groundwater Resources Assessment Centre (Netherlands); Regional Centre for Water Management Research in Arid Zones (Pakistan); International Centre for South–South Cooperation in Science, Technology and Innovation (Malaysia); International Centre on Hydroinformatics for Integrated Water Resources Management (Itaipú Binaciónal: Brazil–Paraguay); Sustainable Energy Development Centre (Russian Federation); International Research Centre on Karst (China); Institute on a Partnership for Environmental Development (Italy). The establishment of an International Centre of Water for Food Security at Charles Sturt University (Australia) was approved in principle, the final decision on the terms of the agreement being delegated to the Executive Board.

Ministers outline their priorities for science

A Ministerial Roundtable on Science and Technology for Sustainable Development: the Role of UNESCO brought together 48 Ministers and 25 Vice-Ministers of Science and Technology on 26 and 27 October. Among its recommendations, the call for UNESCO to: broker knowledge banks to facilitate the sharing of information and data; develop an enabling platform for affordable and accessible technologies; promote a better understanding among decision-makers of the positive role that science, technology and their commercial application play in economic development; and to create international fora on the teaching of science and science curriculum. Read the communiqué: www.unesco.org/science/document/communique_Final_E.pdf

Diary

7–8 January
Water and cultural diversity
Expert group meeting to advise on directions for new UNESCO project. UNESCO Paris:
http://typo38.unesco.org/en/themes/ihp-water-society;
contact: l.hiwasaki@unesco.org

13–18 January
Agricultural S&T for development
Last Bureau and Intergovernmental Plenary of Intl Assessment (IAASTD) co-sponsored by FAO, GEF, UNDP, UNEP, UNESCO, WHO, World Bank, to consider for approval final text of IAASTD. UNESCO and IICA coordinated Latin American and Caribbean component. Nairobi (Kenya); contact: *g.calvo@unesco.org.*

14–18 January
Mathematics and S&T education in Southern Africa
16th annual conf. of Southern African Assn for Research in Mathematics, S&T Education, on role of research in promoting relevance, quality and access. With UNESCO support. Maseru (Lesotho), contact: *molapo@lesoff.co.za*

21–25 January
Oceanographic data management and exchange standards
1st Session of IODE/JCOMM Forum. Attendance by invitation. Oostende (Belgium), contact: *p.pissierssens@unesco.org*

28 Jan – 1 Feb
Harmful algal bloom research
2nd Asian GEOHAB meeting on future focus of research and cooperation., Nha Trang City (Viet Nam): *www.geohab.info; www.ioc-unesco.org/hab/; contact: h.enevoldsen@unesco.org*

31 January – 1 February
UN Intl Strategy for Disaster Reduction
1st meeting of Scientific & Technical Committee involving UNESCO, ISDR, UNEP, IUCN, etc., chaired by UNESCO. The committee is linked to the Global Platform for Disaster Risk Reduction. UNESCO Paris (Room XVI),
contact: k.tovmasjana@unesco.org

4–9 February
Biosphere futures
3rd World Congress of Biosphere Reserves. See Editorial and pages 12–13. Madrid.
www.madrid2008mab.es/;
contact: m.clusener-godt@unesco.org

12–13 February
Launch of International Year of Planet Earth
UNESCO Paris, contact: *r.missotten@unesco.org;*
www.unesco.org/science/earth/igcp.shtml

14–15 February
IGCP Board meeting
UNESCO Paris: *r.missotten@unesco.org;*
www.unesco.org/science/earth/igcp.shtml

3–7 March
L'ORÉAL-UNESCO awards week
For women in science; 15 research scholarships (5 March) and 5 prizes (6 March) to be awarded in the life sciences. Includes conf. on Changing the Face of Science (6 March): UNESCO Paris, contact: *r.clair@unesco.org;*
www.unesco.org/fellowships; www.unesco.org/science/bes

3–7 March
Science with Africa
Conf. on methodologies for improving level of participation by African-based scientists and science-based organizations in intl collaborative R&D projects. UNECA and African Union, with the company Intelligence in Science and UNESCO. Addis Ababa (Ethiopia): *www.sciencewithafrica.com;*
Contact: *s.nair-bedouelle@unesco.org; m.miloudi@unesco.org*

10–12 March
Integrated water resources management
Intl conf. on lessons learned from implementation in developing countries. Also, 2nd Africa Regional Meeting of IHP National Committees. Water Research Commission of South Africa, Dept of Water Affairs and Forestry; UNESCO-IHP, Water Institute of Southern Africa. Cape Town.
Contact: *wbv@dwaf.gov.za; www.wrc.org.za*

12–14 March
Tsunami and other coastal hazards warning system
For the Caribbean Sea and Adjacent Regions. 3rd session of Intergovernmental Coordinating Group. Panama:
Contact *p.koltenburg@unesco.org*

Deadline extended for photo contest
The deadline for entries in the photo contest on the theme of The Changing Face of the Earth has been extended to 30 June 2008. Moreover, a second category has been added for those aged 21 years and over, in addition to the original category for 15–20 year-olds. There are 40 book prizes to be won and cameras for the best entries.
See A World of Science, *July 2007*
For details: www.unesco.org/science or photocontest@unesco.org

New Releases

Science, Technology and Gender
An International Report
Coordinated by UNESCO's Division for Science Policy and Sustainable Development. UNESCO Publishing, € € 25.00, ISBN: 978-92-3-104072-6. Exists in English, with Arabic, Russian and Spanish versions under preparation.
For details, see page 10. *For background: e.martinez@unesco.org; www.unesco.org/science/psd; see also* A World of Science, *April 2007.*

Girls into Science
Training module produced by UNESCO's Science Education Programme. Exists also as a CD-ROM..In English, French and Portuguese, 132 pp.
Targets teachers and their pupils. Examines the pressures on young female learners to conform to traditional roles and how this affects their choice of subjects and performance. Examines how pre-service programmes can alert new teachers to the issues. Analyses how career advice programmes might be better organized. *Download: http://unesdoc.unesco.org/images/0015/001548/154837E.pdf; Request a copy from j.heiss@unesco.org*

The Future of Arid Lands – Revisited
A Review of 50 Years of Drylands Research
By Charles F. Hutchinson and Stefanie M. Hermann. Man and the Biosphere series. UNESCO Publishing, €€ 32.00, ISBN: 978-92-3-104053-5, English only, 238 pp.
Commissioned by UNESCO in 2005, this work considers how scientific understanding of the processes governing arid lands has evolved since *The Future of Arid Lands* was published in 1956. Extracts lessons from these comparisons that may guide current and future arid land managers and speculates on what the future may hold for arid lands. Reflects the shift in drylands thinking from a piecemeal or 'magic bullet' approach to a systems-based approach that considers people as an integral part of problem-solving.
For a summary of the content, see A World of Science, *October 2006.*

Hidden Assets: Biodiversity Below-surface
UNESCO–SCOPE Policy Briefs, no 5. English only, 6 pp.
The Earth's soils and sediments are habitats for millions of species but these habitats are being damaged at an unparalleled rate. To sustain the productivity of our lands, freshwater and oceans, it is essential to learn how these below-surface species provide vital ecosystem services and to integrate this information into management and policy decisions.
Download this and previous policy briefs: www.unesco.org/mab/biodiv/biodivSC.shtml.
For background: a.persic@unesco.org

Quito Newsletter
Quarterly newsletter produced by UNESCO's Quito office. Covers UNESCO's work in Bolivia, Colombia, Ecuador and Venezuela in education, science, culture, communication and information. Spanish only, 8 pp.
Download: www.unesco.org/quito or write to info@unesco.org/ec.

International Geoscience Programme
In the Service of Society
Booklet produced by the co-sponsors of the IGCP: UNESCO and the IUGS. English only, 16 pp.
Describes the five current themes for IGCP project proposals for basic and applied research, many of which mirror those of the International Year of Planet Earth: global change and the evolution of life: evidence from the geological record; geohazards: reducing risks; Earth resources: sustaining society; the geoscience of the water cycle; how the deep Earth controls our environment. Targets potential research applicants, partners and potential sponsors.
To request a copy: m.patzak@unesco.org; igcp@unesco.org

Natural Disaster Preparedness and Education for Sustainable Development
Produced by UNESCO's Bangkok office, English only, 79 pp.
Draws together the work completed under a project to develop educational materials for natural disaster preparedness in Asia–Pacific. Includes reports for the countries most affected by the earthquake and tsunami of 26 December 2004: Maldives, India, Indonesia and Thailand. In Indonesia, for example, the in-country project team developed a folding picture kit and the Disaster Master, a simulation game of natural disasters, after discovering that secondary school pupils were more responsive to well-illustrated information and preferred comics to books.
To download: http://unesdoc.unesco.org/images/0015/001504/150454e.pdf;
for details: Bangkok@unescobkk.org; www.unescobkk.org

Sustainable Island Living
Produced by UNESCO's Coastal Regions and Small Islands Platform. English, French & Spanish. 48 pp. – An overview of UNESCO's recent activities in support of the Mauritius Strategy adopted in 2005 to foster sustainable development in the world's small island developing states. Challenges include: alleviating poverty, developing knowledge societies, strengthening S&T, keeping traditional knowledge alive, providing a space for islanders to air their views on sustainable living (via Small Islands Voice), gender equality and developing eco-tourism. *Download: www.unesco.org/csi/B10/mim2007.htm or request a copy from sids@unesco.org; dar-es-salaam@unesco.org, kingston@unesco.org or apia@unesco.org*

Urban Water Cycle Processes and Interactions
By J. Marsalek, B. Jiménez-Cisneros, M. Karamouz, P.-A. Malmquist, J. Goldenfum and B. Chocat. Urban Water series (New). UNESCO Publishing / Taylor & Francis, ISBN 978-92-3-104060-3, € €0.00, English only, 152 pp.
The fruit of an UNESCO-IHP project, introduces the urban water cycle concept and the need for integrated management. Goes on to explore the manifold hydrological components of the cycle, the diverse elements of urban infrastructure and water services, and the various effects of urbanization on the environment, from the atmosphere and surface waters to wetlands, soils and groundwater, as well as biodiversity. Includes recommendations.

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Cover image: reconstruction by P. Trusler of a hatchling Qantassaurus, a polar dinosaur from the Cretaceous of Southern Australia. (Courtesy of Australia Post)