SCIENCE NEWS

Rise in Oxygen Drove Evolution of Animal Life 550 Million Years Ago

Researchers funded by the Biotechnology and Biological Sciences Research Council (BBSRC) at the University of Oxford have uncovered a clue that may help to explain why the earliest evidence of complex multicellular animal life appears around 550 million years ago, when atmospheric oxygen levels on the planet rose sharply from 3 per cent to their modern day level of 21 per cent.

The team, led by Professor Chris Schofield, has found that humans share a method of sensing oxygen with the world's simplest known living animal — Trichoplax adhaerens — suggesting the method has been around since the first animal emerged around 550 million years ago.

Professor Schofield said "It's absolutely necessary for any multicellular organism to have a sufficient supply of oxygen to almost every cell and so the atmospheric rise in oxygen made it possible for multicellular organisms to exist.

"But there was still a very different physiological challenge for these organisms than for the more evolutionarily ancient single-celled organisms such as bacteria. Being multicelluar means oxygen has to get to cells not on the surface of the organism. We think this is what drove the ancesters of Trichoplax adhaerens to develop a system to sense a lack of oxygen in any cell and then do something about it."

The oxygen sensing process enables animals to survive better at low oxygen levels or 'hypoxia'. In humans this system responds to hypoxia, such as is caused by high altitudes or physical exertion, and is very important for the prevention of stroke and heart attacks as well as some types of cancer.

Trichoplax adhaerens is a tiny seawater organism that lacks any organs and has only five types of cells, giving it the appearance of an amoeba. By analysing how Trichoplax reacts to a lack of oxygen, Oxford researcher Dr Christoph Loenarz found that it uses the same mechanism as humans—in fact, when the key enzyme from

Trichoplax was put it in a human cell, it worked just as well as the human enzyme usually would.

They also looked at the genomes of several other species and found that this mechanism is present in multi-cellular animals, but not in the single-celled organisms that were the precursors of animals, suggesting that the mechanism evolved at the same time as the earliest multicellular animals.

Defects in the most important human oxygen sensing enzyme can cause polycythemia — an increase in red blood cells. This latest work could also open up new approaches to develop therapies for this disorder.

Professor Douglas Kell, Chief Executive, BBSRC said "Understanding how animals — and ultimately humans — evolved is essential to our ability to pick apart the workings of our cells. Knowledge of normal biological processes underpins new developments that can improve quality of life for everyone. The more skilful we become in studying the evolution of some of our most essential cell biology, the better our chances of ensuring long term health and well being to match the increase in average lifespan in the UK and beyond."

(Source: Science Daily Online)

More than 100 New Species Described by California Academy of Sciences in 2010

Global biodiversity surveys over the past few years have provided increasing evidence that our planet is in the midst of its sixth mass extinction. Plants, animals, and microorganisms are disappearing thousands of times more rapidly than they have for more than 65 million years, and for the first time in Earth's history, human activity is the predominant force behind this mass extinction. As governments and conservation organisations around the world attempt to stem this tide of disappearing species, they face a number of formidable challenges, but perhaps the greatest among them is this — we have only documented and described an estimated 10 per cent of the species on Earth, and it's hard to save a species when you don't know that it exists.

In an effort to help address this critical need for data about the diversity and distribution of life on our planet, scientists from the California Academy of Sciences have spent the past year exploring some of the most diverse — and often most threatened — habitats on Earth, searching for new species and creating comprehensive biodiversity maps. In 2010, these scientists have added 113 new relatives to our family tree, including 83 arthropods, 20 fishes, four corals, two sea slugs, two plants, one reptile, and one fossil mammal. The new species were described by a dozen scientists from the California Academy of Sciences along with several dozen international collaborators.

Proving that science still requires a spirit of adventure and exploration, the scientists made their finds over five continents (the Americas, Africa, Asia, and Australia) and three oceans (Atlantic, Pacific, and Indian), hiked through rainforests and dove inside submersibles, and looked everywhere from their own backyards (San Mateo County, California) to the other side of the world (the Seychelles). Their results, published in 27 different scientific papers, come during a year of heightened international interest in the

conservation of life on Earth. The United Nations designated 2010 as the "International Year of Biodiversity" and held a Biodiversity Summit in Nagoya, Japan this October, in which 18,000 participants representing more than 150 countries adopted strategic goals to combat ongoing biodiversity loss compounded by climate change.

"Species loss has been accelerating in the last 150 years due to human activity, with extinction rates estimated to be thousands of times greater than average," says Dr David Mindell, Dean of Science and Research Collections at the Academy. "Scientific exploration and discovery of new species are essential to characterising our planet's ecosystems before they disappear forever. Preserving biodiversity means healthy ecosystems, and healthy ecosystems are crucial to human health and economic well-being."

A recent example of this intimate connection appeared in the December 2nd issue of *Nature*, in which a team of U.S. and British scientists found that the transmission of infectious diseases, such as West Nile fever and Lyme disease, increased in environments where the diversity of wildlife was low. While the exact mechanisms behind this correlation remain unknown, the study illuminated a real danger to humans that results from biodiversity loss.

Below are a few highlights among the 113 species described by Academy scientists this year.

Galapagos Legacy

The Academy sent its first scientific expedition to the Galapagos Islands in 1905 and has since organised dozens of return trips. As a result, the Academy is now home to the world's most comprehensive collection of scientific specimens from these famous islands. Most Academy field work in the Galapagos today focuses on the marine environment, where dozens of new species have been discovered in the last decade. In 2010, scientist John McCosker and his colleagues described a new species of scorpionfish (*Scorpaenodes rubrivinctus*), which was collected by submersible along the islands' steep volcanic slopes 200-400 meters underwater. Submersibles allow scientists to explore a vast part of the Galapagos that was not accessible to Charles Darwin or the first Academy scientists.

Old Spiders, New Family

Although discovering new species is a common occurrence at the Academy, describing a new family of animals is rare. Arachnologists Jeremy Miller, Anthea Carmichael, Charles Griswold, and their colleagues did just that this year, describing a new spider family called Penestomidae. These spiders have been known for 100 years, but they were initially placed in the velvet spider family, Eresidae. Only with the modern techniques of DNA sequencing and scanning electron microscopy did Miller et al. conclude that the penestomids belong in a family of their own. The scientists also added five new species, all from South Africa: *Penestomus egazini*, *P. kruger*, *P. montanus*, *P. prendinii*, and *P. zulu*.

A Wasp Opus 30 Years in the Making

Future entomologists working on the Australian wasp genus *Sericophorus* will have a much easier time identifying species, thanks to a 234-page paper by curator Wojciech Pulawski. A Danish scientist named Ole Lomholdt actually initiated this massive study in the early 1980s. However,

following his untimely death in 1999, Pulawski picked up the mantle and finished this 30-year labour of love. Pulawski conducted additional field work in Australia, studied more than 1,000 specimens, described 30 species unknown to Lomholdt, generated photographs, added distribution maps, and analysed the wasps' evolutionary relationships. The result is the most comprehensive overview of *Sericophorus* ever published, including a key to 100 species.

California Hotspot

Besides hosting a diverse population of people, California is also home to one of the most diverse collections of plant and animal species on the planet. This rich diversity has earned California a title as one of the world's 34 biodiversity hotspots. Four species on this year's list were collected in the Golden State: two sea slugs (*Okenia felis* from Monterey County and *Flabellina goddardi* from Santa Barbara County); a cave-dwelling spider from the Mother Lode region of California (*Archoleptoneta gertschi*); and a sharp-tailed snake from the Coast Ranges and Klamath Mountains in the north (*Contia longicaudae*).

Gigantic Extinct Otter

Ten years ago, anthropology curator Zeray Alemseged initiated the Dikika Research Project to explore the fossil-rich Awash Valley in Ethiopia. While the project has yielded several important discoveries related to early human evolution (including the oldest evidence of tool use and meat-eating in hominins, reported this year in *Nature*), the non-human discoveries provide equally important information about the valley's ancient environment. This year, Alemseged and his colleagues report the only new mammal species on the Academy's list: a gigantic otter (*Enhydriodon dikikae*) from approximately 4 million years ago. Described from part of a skull and lower jaw, *E. dikikae* was more imposing than the cuddly otters familiar to us today. With an estimated skull length of 25 cm and a body weight of 100 kg, the extinct otter was roughly twice the size of a modern sea otter. Its ancient diet is ambiguous, but a battery of robust teeth suggests shellfish, catfish, juvenile crocodiles, turtles, and ostrich eggs as possibilities.

(Source: Science Daily online)

The Birth of Time: Quantum Loops Describe the Evolution of the Universe

What was the Big Bang and what happened before it? Scientists from the Faculty of Physics, University of Warsaw have attempted to answer the question. Within the framework of loop quantum gravity they have put forward a new theoretical model, which might prove useful for validating hypotheses about events prior to the Big Bang. This achievement is one of the few models describing the full Einstein's theory and not merely its greatly simplified version.

Physicists from the Faculty of Physics, University of Warsaw have put forward — on the pages of *Physical Review D* — a new theoretical model of quantum gravity describing the emergence of space-time from the structures of quantum theory. It is not only one of the few models describing the full general theory of relativity advanced by Einstein, but it is also completely mathematically consistent. "The solutions applied allow to trace the evolution of the Universe in a

more physically acceptable manner than in the case of previous cosmological models," explains Prof. Jerzy Lewandowski from the Faculty of Physics, University of Warsaw (FUW).

While the general theory of relativity is applied to describe the Universe on a cosmological scale, quantum mechanics is applied to describe reality on an atomic scale. Both theories were developed in the early 20th century. Their validity has since been confirmed by highly sophisticated experiments and observations. The problem lies in the fact that the theories are mutually exclusive.

According to the general theory of relativity, reality is always uniquely determined (as in classical mechanics). However, time and space play an active role in the events and are themselves subject to Einstein's equations. According to quantum physics, on the other hand, one may only gain a rough understanding of nature. A prediction can only be made with a probability; its precision being limited by inherent properties. But the laws of the prevailing quantum theories do not apply to time and space. Such contradictions are irrelevant under standard conditions — galaxies are not subject to quantum phenomena and quantum gravity plays a minor role in the world of atoms and particles. Nonetheless, gravity and quantum effects need to merge under conditions close to the Big Bang.

Traditional cosmological models describe the evolution of the Universe within the framework of the general theory of relativity itself. The equations at the core of the theory suggest that the Universe is a dynamic, constantly expanding creation. When theorists attempt to discover what the Universe was like in times gone by, they reach the stage where density and temperature in the model become infinite — in other words, they lose their physical sense. Thus, the infinities may only be indicative of the weaknesses of the former theory and the moment of the Big Bang does not have to signify the birth of the Universe.

In order to gain at least some knowledge of quantum gravity, scientists construct simplified quantum models, known as quantum cosmological models, in which space-time and matter are expressed in a single value or a few values alone. For example, the model developed by Ashtekar, Bojowald, Lewandowski, Paw³owski and Singh predicts that quantum gravity prevents the increase of matter energy density from exceeding a certain critical value (of the order of the Planck density). Consequently, there must have been a contracting universe prior to the Big Bang. When matter density had reached the critical value, there followed a rapid expansion — the Big Bang, known as the Big Bounce. However, the model is a highly simplified toy model.

The real answer to the mystery of the Big Bang lies in a unified quantum theory of matter and gravity. One attempt at developing such a theory is Loop Quantum Gravity (LQG). The theory holds that space is weaved from one-dimensional threads. "It is just like in the case of a fabric — although it is seemingly smooth from a distance, it becomes evident at close quarters that it consists of a network of fibres," describes Wojciech Kamiñski, MSc from FUW. Such space would constitute a fine fabric — an area of a square centimetre would consists of 10^{66} threads.

Physicists Marcin Domaga³a, Wojciech Kamiñski and Jerzy Lewandowski, together with Kristina Giesel from the University of Louisiana (guest), developed their model within the framework of

loop quantum gravity. The starting points for the model are two fields, one of which is a gravitational field. "Thanks to the general theory of relativity we know that gravity is the very geometry of space-time. We may, therefore, say that our point of departure is three-dimensional space," explains Marcin Domaga³a, Ph.D .(FUW).

The second starting point is a scalar field — a mathematical object in which a particular value is attributed to every point in space. In the proposed model, scalar fields are interpreted as the simplest form of matter. Scalar fields have been known in physics for years, they are applied, among others, to describe temperature and pressure distribution in space. "We have opted for a scalar field as it is the typical feature of contemporary cosmological models and our aim is to develop a model that would constitute another step forward in quantum gravity research," observes Professor Lewandowski.

In the model developed by physicists from Warsaw, time emerges as the relation between the gravitational field (space) and the scalar field — a moment in time is given by the value of the scalar field. "We pose the question about the shape of space at a given value of the scalar field and Einstein's quantum equations provide the answer," explains Professor Lewandowski. Thus, the phenomenon of the passage of time emerges as the property of the state of the gravitational and scalar fields and the appearance of such a state corresponds to the birth of the well-known space-time. "It is worthy of note that time is nonexistent at the beginning of the model. Nothing happens. Action and dynamics appear as the interrelation between the fields when we begin to pose questions about how one object relates to another," explains Professor Lewandowski.

Professor Jerzy Lewandowski standing by The Kitchen, 1948 by Picasso at the Museum of Modern Art in Manhattan. The lines in the painting are fairly similar to graphs showing the evolution of quantum states of the gravitational field in loop quantum gravity.

Physicist from FUW have made it possible to provide a more accurate description of the evolution of the Universe. Whereas models based on the general theory of relativity are simplified and assume the gravitational field at every point of the Universe to be identical or subject to minor changes, the gravitational field in the proposed model may differ at different points in space.

The proposed theoretical construction is the first such highly advanced model characterised by internal mathematical consistency. It comes as the natural continuation of research into quantisation of gravity, where each new theory is derived from classical theories. To that end, physicists apply certain algorithms, known as quantisations. "Unfortunately for physicists, the algorithms are far from precise. For example, it may follow from an algorithm that a Hilbert space needs to be constructed, but no details are provided," explains Marcin Domaga³a, M.Sc. "We have succeeded in performing a full quantisation and obtained one of the possible models."

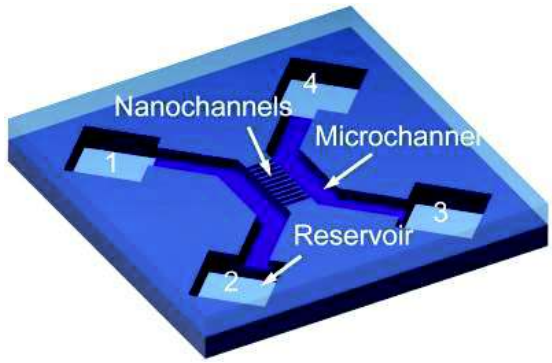
There is still a long way to go, according to Professor Lewandowski: "We have developed a certain theoretical machinery. We may begin to ply it with questions and it will provide the answers." Theorists from FUW intend, among others, to inquire whether the Big Bounce actually occurs in their model. "In the future, we will try to include in the model further fields of the Standard Model of elementary particles. We are curious ourselves to find out what will happen," says Professor Lewandowski.

(Source: Science Daily Online)

Nanotechnology: Tiny Channels Carry Big Information

They say it's the little things that count, and that certainly holds true for the channels in transmembrane proteins, which are small enough to allow ions or molecules of a certain size to pass through, while keeping out larger objects. Artificial fluidic nanochannels that mimic the capabilities of transmembrane proteins are highly prized for a number of advanced technologies. However, it has been difficult to make individual artificial channels of this size — until now.

Researchers with the U.S. Department of Energy (DOE)'s Lawrence Berkeley National Laboratory (Berkeley Lab) have been able to fabricate nanochannels that are only two nanometers (2-nm) in size, using standard semiconductor manufacturing processes. Already they've used these nanochannels to discover that fluid mechanics for passages this small are significantly different not only from bulk-sized channels, but even from channels that are merely 10 nanometers in size.



Schematic of a 2-nm nanochannel device, with two microchannels, ten nanochannels and four reservoirs. (Credit: Image courtesy of Chuanhua Duan)

"We were able to study ion transport in our 2-nm nanochannels by measuring the time and concentration dependence of the ionic conductance," says Arun Majumdar, Director of DOE's Advanced Research Projects Agency — Energy (ARPA-E), who led this research while still a scientist at Berkeley Lab. "We observed a much higher rate of proton and ionic mobility in our confined hydrated channels — up to a fourfold increase over that in larger nanochannels (10-to-100 nm). This enhanced proton transport could explain the high throughput of protons in transmembrane channels."

Majumdar is the co-author with Chuanhua Duan, a member of Majumdar's research group at the University of California (UC) Berkeley, of a paper on this work, which was published in the journal *Nature Nanotechnlogy*. The paper is titled "Anomalous ion transport in 2-nm hydrophilic nanochannels."

In their paper, Majumdar and Duan describe a technique in which high-precision ion etching is combined with anodic bonding to fabricate channels of a specific size and geometry on a

silicon-on-glass die. To prevent the channel from collapsing under the strong electrostatic forces of the anodic bonding process, a thick (500 nm) oxide layer was deposited onto the glass substrate.

"This deposition step and the following bonding step guaranteed successful channel sealing without collapsing," says Duan. "We also had to choose the right temperature, voltage and time period to ensure perfect bonding. I compare the process to cooking a steak, you need to choose the right seasoning as well as the right time and temperature. The deposition of the oxide layer was the right seasoning for us."

The nanometer-sized channels in transmembrane proteins are critical to controlling the flow of ions and molecules across the external and internal walls of a biological cell, which, in turn, are critical to many of the biological processes that sustain the cell. Like their biological counterparts, fluidic nanochannels could play critical roles in the future of fuel cells and batteries.

"Enhanced ion transport improves the power density and practical energy density of fuel cells and batteries," Duan says. "Although the theoretical energy density in fuel cells and batteries is determined by the active electrochemical materials, the practical energy density is always much lower because of internal energy loss and the usage of inactive components. Enhanced ion transport could reduce internal resistance in fuel cells and batteries, which would reduce the internal energy loss and increase the practical energy density."

The findings by Duan and Majumdar indicate that ion transport could be significantly enhanced in 2-nm hydrophilic nanostructures because of their geometrical confinements and high surface-charge densities. As an example, Duan cites the separator, the component placed between the between the cathode and the anode in batteries and fuel cells to prevent physical contact of the electrodes while enabling free ionic transport.

"Current separators are mostly microporous layers consisting of either a polymeric membrane or non-woven fabric mat," Duan says. "An inorganic membrane embedded with an array of 2-nm hydrophilic nanochannels could be used to replace current separators and improve practical power and energy density."

The 2-nm nanochannels also hold promise for biological applications because they have the potential to be used to directly control and manipulate physiological solutions. Current nanofluidic devices utilise channels that are 10-to-100 nm in size to separate and manipulate biomolecules. Because of problems with electrostatic interactions, these larger channels can function with artificial solutions but not with natural physiological solutions.

The next step for the researchers will be to study the transport of ions and molecules in hydrophilic nanotubes that are even smaller than 2-nm. Ion transport is expected to be even further enhanced by the smaller geometry and stronger hydration force.

"I am developing an inorganic membrane with embedded sub-2 nm hydrophilic nanotube array that will be used to study ion transport in both aqueous and organic electrolytes,' Duan says. "It will also be developed as a new type of separator for lithium-ion batteries."

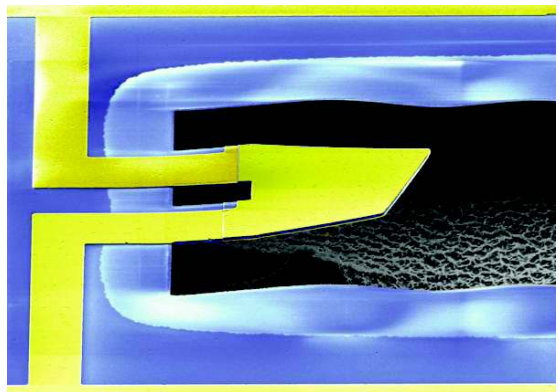
This work was supported by DOE's Office of Science, plus the Center for Scalable and Integrated Nanomanufacturing, and the Center of Integrated Nanomechanical Systems at UC Berkeley.

(Source: Science Daily Online)

Science's Breakthrough of the Year: The First Quantum Machine

Until this year, all human-made objects have moved according to the laws of classical mechanics. Back in March, however, a group of researchers designed a gadget that moves in ways that can only be described by quantum mechanics — the set of rules that governs the behavior of tiny things like molecules, atoms, and subatomic particles. In recognition of the conceptual ground their experiment breaks, the ingenuity behind it and its many potential applications, Science has called this discovery the most significant scientific advance of 2010.

Physicists Andrew Cleland and John Martinis from the University of California at Santa Barbara and their colleagues designed the machine — a tiny metal paddle of semiconductor, visible to the naked eye — and coaxed it into dancing with a quantum groove. First, they cooled the paddle until it reached its "ground state," or the lowest energy state permitted by the laws of quantum mechanics (a goal long-sought by physicists). Then they raised the widget's energy by a single quantum to produce a purely quantum-mechanical state of motion. They even managed to put the gadget in both states at once, so that it literally vibrated a little and a lot at the same time — a bizarre phenomenon allowed by the weird rules of quantum mechanics.



Science's Breakthrough of the Year goes to the first mechanical, vibrating device, which is as long as a hair is wide. The device is the first to reach the quantum ground state, a feat achieved by physicists at the University of California, Santa Barbara. (Credit: Aaron D. O'Connell and Andrew N. Cleland/University of California, Santa Barbara)

Science and its publisher, AAAS, the nonprofit science society, have recognised this first quantum machine as the 2010 Breakthrough of the Year. They have also compiled nine other important scientific accomplishments from this past year into a top ten list, appearing in a special news feature in the journal's 17 December 2010 issue. Additionally, Science news writers and editors have chosen to spotlight 10 "Insights of the Decade" that have transformed the landscape of science in the 21st Century.

"This year's Breakthrough of the Year represents the first time that scientists have demonstrated quantum effects in the motion of a human-made object," said Adrian Cho, a news writer for *Science*. "On a conceptual level that's cool because it extends quantum mechanics into a whole new realm. On a practical level, it opens up a variety of possibilities ranging from new experiments that meld quantum control over light, electrical

currents and motion to, perhaps someday, tests of the bounds of quantum mechanics and our sense of reality."

The quantum machine proves that the principles of quantum mechanics can apply to the motion of macroscopic objects, as well as atomic and subatomic particles. It provides the key first step toward gaining complete control over an object's vibrations at the quantum level. Such control over the motion of an engineered device should allow scientists to manipulate those minuscule movements, much as they now control electrical currents and particles of light. In turn, that capability may lead to new devices to control the quantum states of light, ultra-sensitive force detectors and, ultimately, investigations into the bounds of quantum mechanics and our sense of reality. (This last grand goal might be achieved by trying to put a macroscopic object in a state in which it's literally in two slightly different places at the same time — an experiment that might reveal precisely why something as big as a human can't be in two places at the same time.)

"Mind you, physicists still haven't achieved a two-places-at-once state with a tiny object like this one," said Cho. "But now that they have reached the simplest state of quantum motion, it seems a whole lot more obtainable — more like a matter of 'when' than 'if.'"

Atomic Weights of 10 Elements on Periodic Table About to Make an Historic Change

For the first time in history, a change will be made to the atomic weights of some elements listed on the Periodic table of the chemical elements posted on walls of chemistry classrooms and on the inside covers of chemistry textbooks worldwide.

The new table, outlined in a report released this month, will express atomic weights of 10 elements — hydrogen, lithium, boron, carbon,

Michael Wieser is a scientist from the University of Calgary who is helping to update periodic table. (Credit: Riley Brandt/University of Calgary)

nitrogen, oxygen, silicon, sulfur, chlorine and thallium — in a new manner that will reflect more accurately how these elements are found in nature.

"For more than a century and a half, many were taught to use standard atomic weights — a single value — found on the inside cover of chemistry textbooks and on the periodic table of the elements. As technology improved, we have discovered that the numbers on our chart are not as static as we have previously believed," says Dr. Michael Wieser, an associate professor at the University of Calgary, who serves as secretary of the International Union of *Pure and Applied Chemistry*'s (IUPAC) Commission on Isotopic

Abundances and Atomic Weights. This organisation oversees the evaluation and dissemination of atomic-weight values.

Modern analytical techniques can measure the atomic weight of many elements precisely, and these small variations in an element's atomic weight are important in research and industry. For example, precise measurements of the abundances of isotopes of carbon can be used to determine purity and source of food, such as vanilla and honey. Isotopic measurements of nitrogen, chlorine and other elements are used for tracing pollutants in streams and groundwater. In sports doping investigations, performance-enhancing testosterone can be identified in the human body because the atomic weight of carbon in natural human testosterone is higher than that in pharmaceutical testosterone.

The atomic weights of these 10 elements now will be expressed as intervals, having upper and lower bounds, reflected to more accurately convey this variation in atomic weight. The changes to be made to the Table of Standard Atomic Weights have been published in *Pure and Applied Chemistry* and a companion article in *Chemistry International*.

For example, sulfur is commonly known to have a standard atomic weight of 32.065. However, its actual atomic weight can be anywhere between 32.059 and 32.076, depending on where the element is found. "In other words, knowing the atomic weight can be used to decode the origins and the history of a particular element in nature," says Wieser who co-authored the report.

Elements with only one stable isotope do not exhibit variations in their atomic weights. For example, the standard atomic weights for fluorine, aluminum, sodium and gold are constant, and their values are known to better than six decimal places.

"Though this change offers significant benefits in the understanding of chemistry, one can imagine the challenge now to educators and students who will have to select a single value out of an interval when doing chemistry calculations," says Dr Fabienne Meyers, associate director of IUPAC.

"We hope that chemists and educators will take this challenge as a unique opportunity to encourage the interest of young people in chemistry and generate enthusiasm for the creative future of chemistry."

The University of Calgary has and continues to contribute substantially in the study of atomic weight variations. Professor H. Roy Krouse created the Stable Isotope Laboratory in the Department of Physics and Astronomy in 1971. Early work by Krouse established the wide natural range in the atomic weight of significant elements including carbon and sulfur. Currently, researchers at the University of Calgary in physics, environmental science, chemistry and geoscience are exploiting variations in atomic weights to elucidate the origins of meteorites, to determine sources of pollutants to air and water, and to study the fate of injected carbon dioxide in geological media.

This fundamental change in the presentation of the atomic weights is based upon work between 1985 and 2010 supported by IUPAC, the University of Calgary and other contributing Commission members and institutions.

The year 2011 has been designated as the International Year of Chemistry. The IYC is an official United Nations International Year, proclaimed at the UN as a result of the initiative of IUPAC and UNESCO. IUPAC will feature the change in the standard atomic weights table as part of associated IYC activities.

(Source: Science Daily online)

Antimatter Atoms Stored for the First Time

Atoms of antimatter have been trapped and stored for the first time by the ALPHA collaboration, an international team of scientists working at CERN, the European Organisation for Nuclear Research near Geneva, Switzerland. Scientists from the U.S. Department of Energy's Lawrence Berkeley National Laboratory and the University of California at Berkeley have made key contributions to the ongoing international effort.

ALPHA stored atoms of antihydrogen, consisting of a single negatively charged antiproton orbited by a single positively charged anti-electron (positron). While the number of trapped anti-atoms is far too small to fuel the Starship Enterprise's matter-antimatter reactor, this advance brings closer the day when scientists will be able to make precision tests of the fundamental symmetries of nature. Measurements of anti-atoms may reveal how the physics of antimatter differs from that of the ordinary matter that dominates the world we know today.

Large quantities of antihydrogen atoms were first made at CERN eight years ago by two other teams. Although they made antimatter they couldn't store it, because the anti-atoms touched the ordinary-matter walls of the experiments within millionths of a second after forming and were instantly annihilated — completely destroyed by conversion to energy and other particles.

"Trapping antihydrogen proved to be much more difficult than creating antihydrogen," says ALPHA team member Joel Fajans, a scientist in Berkeley Lab's Accelerator and Fusion Research Division (AFRD) and a professor of physics at UC Berkeley. "ALPHA routinely makes thousands of antihydrogen atoms in a single second, but most are too 'hot'" — too energetic — "to be held in the trap. We have to be lucky to catch one."

The ALPHA collaboration succeeded by using a specially designed magnetic bottle called a Minimum Magnetic Field Trap. The main component is an octupole (eight-magnetic-pole) magnet whose fields keep anti-atoms away from the walls of the trap and thus prevent them from annihilating. Fajans and his colleagues in AFRD and at UC proposed, designed, and tested the octupole magnet, which was fabricated at Brookhaven. ALPHA team member Jonathan Wurtele of AFRD, also a professor of physics at UC Berkeley, led a team of Berkeley Lab staff members and visiting scientists who used computer simulations to verify the advantages of the octupole trap.

In a forthcoming issue of *Nature* now online, the ALPHA team reports the results of 335 experimental trials, each lasting one second, during which the anti-atoms were created and stored. The trials were repeated at intervals never shorter than 15 minutes. To form antihydrogen

during these sessions, antiprotons were mixed with positrons inside the trap. As soon as the trap's magnet was "quenched," any trapped anti-atoms were released, and their subsequent annihilation was recorded by silicon detectors. In this way the researchers recorded 38 antihydrogen atoms, which had been held in the trap for almost two-tenths of a second.

"Proof that we trapped antihydrogen rests on establishing that our signal is not due to a background," says Fajans. While many more than 38 antihydrogen atoms are likely to have been captured during the 335 trials, the researchers were careful to confirm that each candidate event was in fact an anti-atom annihilation and was not the passage of a cosmic ray or, more difficult to rule out, the annihilation of a bare antiproton.

To discriminate among real events and background, the ALPHA team used computer simulations based on theoretical calculations to show how background events would be distributed in the detector versus how real antihydrogen annihilations would appear. Fajans and Francis Robicheaux of Auburn University contributed simulations of how mirror-trapped antiprotons (those confined by magnet coils around the ends of the octupole magnet) might mimic anti-atom annihilations, and how actual antihydrogen would behave in the trap.

(Source: Science Daily Online)

New Device Detects Insects in Stored Wheat

A laboratory milling device for improving stored grain management has been developed by Agricultural Research Service (ARS) scientists and an industry cooperator.

The system, called the "insect-o-graph," can detect internal insects in wheat that are not visible to the eye or that cannot be detected by usual grading methods. The device, built by National Manufacturing, Inc. (NMI), of Lincoln, Neb., was based on ARS-developed technology.

ARS engineers Tom Pearson and Dan Brabec, in the Engineering and Wind Erosion Research Unit of the agency's Center for Grain and Animal Health Research at Manhattan, Kan., developed the device, which uses electrical conductance signals to monitor wheat as it's milled. If a seed containing an insect is crushed, an electrical spike occurs. The software counts the number of insects in a kilogram sample. This system can detect low levels of infestations such as 5 to 10 infested seeds out of 30,000 good seeds.

Tracking insect infestations in stored grain is important to ensure grain quality because insect colonies can multiply rapidly over weeks or months, and consume and damage grain as the colonies grow. Insect damage reduces the grain's value, and the grain also requires additional cleaning to remove the insects and damaged kernels.

Grain companies inspect grain as it comes into their facilities and before storage. Before unloading a truck or railcar of grain, a few minutes are taken to sample the load and inspect the grain. The insect-o-graph can estimate the number of live insects hidden in a one-kilogram grain sample in about one minute.

The device was developed under a formal Cooperative Research and Development

Agreement (CRADA) with NMI, and in collaboration with the food manufacturing company General Mills, as part of efforts by ARS to transfer its technology from the laboratory to the marketplace for the benefit of consumers.

A paper describing this work was accepted for publication in the *Journal of Stored Product Research* in 2010 and will be published soon.

(Source: Science Daily Online)

Everything Evaporates, but How?

Evaporation is a common phenomenon in nature. For the last 130 years, it has seemed that its mechanism was understood well. However, computer simulations carried out by scientists from the Institute of Physical Chemistry of the Polish Academy of Sciences proved that the existing theoretical models were based on false assumptions. Thanks to the simulations, it was possible to learn the mechanisms of evaporation of drops into vacuum or into an environment filled with the vapour of a liquid under examination. However, the mechanism that plays a key role in the case of evaporation into a mixture of gases, for instance into air, is still unknown.

Evaporation takes place all the time in our environment. The phenomenon plays an important role in the formation of Earth's ecosystem and the life functions of many organisms — including humans, who like many other animals use it to stabilise their body temperature.

"The first scientific publication concerning the mechanism of evaporation was written by a famous physicist James Clerk Maxwell. We showed that it contained an error that has been repeated for the last 130 years," says Prof. Robert Ho^{3}yst from the Institute of Physical Chemistry of the Polish Academy of Sciences (IPC PAS) in Warsaw. The computer simulations that have just been completed allowed some of the puzzles connected with the evaporation of a liquid into vacuum or its own vapour to be solved. Currently, in cooperation with the Institute of Physics of the PAS, scientists from the IPC PAS are preparing a series of experiments that will allow them to verify the correctness of the model in the case of the evaporation of drops of water into air.

As much as 71 per cent of Earth is covered by oceans and seas which evaporate continuously. Since the heat of evaporation of water is very high, the evaporation determines Earth's climate. What is more, the content of water vapour — the main greenhouse gas — in the atmosphere changes as a result of evaporation. Its concentration in air may reach as much as four per cent, that is the value over one hundred times higher than that of the infamous carbon dioxide. According to various estimates, if there was no water vapour in air, the temperature on Earth would fall by 20-30 degrees.

Although evaporation is so common and it plays a big role in the environment, little attention has been given to the phenomenon. "Our studies also originated accidentally, as it often happens in science," says Prof. Ho^{3}yst. "Several years ago, in the Institute of Physical Chemistry of the PAS, it was necessary to test a new program for calculations relating to fluid dynamics. We decided to check the simulator using a popular problem. We chose evaporation because we thought that since the phenomenon was so

common and the subject was known for over one hundred years, everybody knew well what happened during the process. However, after we had made calculations using the existing formulas, it turned out that many things simply did not add up."

Polish scientists developed their own theoretical model of the phenomenon and then carried out computer simulations illustrating the process of evaporation of nanodrops into their own vapour or vacuum. The starting point was a drop of liquid closed in a vessel, and in equilibrium with its vapour. In some computer simulations the walls were heated, in some others the vapour was removed, and in the others not only was the vapour removed but the temperature of the system was maintained constant.

During evaporation the most interesting events take place on the border of a liquid and a vapour. The thickness of this interface is more or less equal to the diameter of an atom. The simulation of evaporation in a relatively small cube with faces one meter long would require the calculation of dozens of milliards of points along each of the three dimensional axes. The total number of points would increase to billion of trillions, which exceeds calculation abilities of modern and future computers. In order to deal with this obstacle, scientists from the Institute of Physical Chemistry of the PAS analysed the system of a size of only 1 cm, in which a drop of a diameter of approx. 70 micrometers evaporated. In addition, thanks to the use of symmetry, it was possible to reduce the theoretical description from three-dimensional to one-dimensional. The results of simulation agreed perfectly with the available measurement data.

"Maxwell assumed that evaporation took place at constant temperature. It is so, if we look at the initial state, that is a liquid, and the final state, that is a vapour. It is true that their temperatures are equal. But during the evaporation process itself, the nature acts in a completely different way," explains Ph.D. Marek Litniewski from IPC PAS.

The existing description assumed that the heat transfer in the system was stable and the rate of evaporation was limited by the efficiency of the process during which the particles break away from the surface of drops, i.e. diffusion. However, the simulation carried out in the IPC PAS showed that during the evaporation into vacuum or the liquid's own vapour the system gained mechanical equilibrium very quickly. Particles break away from the surface of a liquid and their mechanical recoil allows the equalisation of the pressure inside the drop. If the rate of evaporation on the surface achieved the maximum value and the system was still unable to equalise the pressures, spaces with new surfaces would open inside the drop and it would start to boil. However, it was observed that the mechanical equilibration of pressure can be insufficient and the temperature on the surface of the liquid decreases: the drop aims at maintaining the pressure equilibrium at the cost of its internal energy. This observation suggests that the factor that is crucial during evaporation is not the diffusion of particles into the environment but the heat transfer and the equality of pressures.

The studies will continue, this time from the point of view of the analysis of evaporation into the mixture of gases, in particular into air. The experimental part will be carried out by scientists from the Institute of Physics of the PAS (IP PAS),

headed by Assoc. Prof. Krystyna Kolwas. Physicists from the IP PAS have already observed the evaporation of microdrops of a liquid into the liquid's own vapour or vacuum. Drops of micrometric sizes were used in the experiments. Since their surface was electrically charged, the drops could be caught by the electric field, lighted by a laser and, while recording changes in interference patterns, it could be observed how their size changed during the evaporation.

Currently, thanks to a new measurement chamber with precisely controlled pressure and chemical composition of the atmosphere, a series of experiments on evaporation into air can be conducted, and consequently, it will be possible to determine which factor has a decisive influence on evaporation in the situation where pressures are equalised from the beginning. The results of the experiments along with computer simulations will allow creating a comprehensive picture of the process of evaporation of water drops in the conditions maximally similar to those that exist in nature.

The deeper understanding of physical mechanisms responsible for evaporation will affect many areas of human activity. Better climate models will allow more precise forecast of weather changes in a short and long time perspective, and more efficient devices for cooling processors and lasers will be developed. Since in engines the evaporation of fuel microdrops injected into a combustion chamber must precede the ignition, the knowledge of evaporation will allow increasing car efficiency in future.

"Our research shows that old formulas are still worth being examined," sums up Prof. Ho^{3}yst.

(Source: Science Daily Online)

Researchers Find Mathematical Patterns to Forecast Earthquakes

Researchers from the Universidad Pablo de Olavide (UPO) and the Universidad de Sevilla (US) have found patterns of behaviour that occur before an earthquake on the Iberian peninsula. The team used clustering techniques to forecast medium-large seismic movements when certain circumstances coincide.

"Using mathematical techniques, we have found patterns when medium-large earthquakes happen, that is, earthquakes greater than 4.4 on the Richter scale," said Francisco Martínez Álvarez, co-author of the study and a senior lecturer at the UPO.

The research, which will be published this month by the journal *Expert Systems with Applications*, is based on the data compiled by the Instituto Geográfico Nacional on 4,017 earthquakes between 3 and 7 on the Richter scale that occurred on the Iberian Peninsula and in the surrounding waters between 1978 and 2007.

The scientists applied clustering techniques to the data, which allowed them to find similarities between them and discover patterns that will help to forecast earthquakes.

The team concentrated on the two seismogenic regions with the most data (The Alboran Sea and the Western Azores-Gibraltar fault region) analysing three attributes: the magnitude of the seismic movement, the time elapsed since the last earthquake and the change in a parameter called the b-value from one earthquake and the other. The b-value reflects the tectonics of the region under analysis.

A high b-value means earthquakes are predominantly small in size and, therefore, the land has a low level of resistance. In contrast, a low value indicates that there are a relatively similar number of large and small seismic movements, which implies the land is more resistant.

"We have discovered the strong relationship between earthquakes and the parameter b-value, recording accuracy rates of more than 80 per cent," Antonio Morales Esteban, another of the co-authors of the study and a senior lecturer at the US highlighted. "After the calculations had been performed, providing the circumstances and sequences we have determined to be forerunners occur, we obtain a significant success probability."

The technique summarises the forecasts in two factors: sensitivity (probability of an earthquake occurring after the patterns detected occur) and specificity (probability of an earthquake not occurring when no patterns have occurred).

The results reflect a sensitivity of 90 per cent and specificity of 82.56 per cent for the Alboran Sea region and 79.31 per cent and 90.38 per cent respectively for the seismogenic region of the Western Azores-Gibraltar Fault.

That is, there is a high probability of an earthquake in these regions immediately after the patterns discovered occur (high sensitivity) and, moreover, on most of such occasions, they only occur after the patterns discovered (high specificity).

At present the team is analysing the same data using their own algorithms based on "association rules," other mathematical techniques used to discover common events or those which fulfil specific conditions within a set of events.

"The results are promising, although I doubt we will ever be able to say that we are capable of forecasting an earthquake 100 per cent accurately," Martínez Álvarez conceded.

(Source: Science Daily online)

Dogs have Bigger Brains than Cats because they are more Sociable, Research Finds

Over millions of years dogs have developed bigger brains than cats because highly social species of mammals need more brain power than solitary animals, according to a study by Oxford University.

For the first time researchers have attempted to chart the evolutionary history of the brain across different groups of mammals over 60 million years. They have discovered that there are huge variations in how the brains of different groups of mammals have evolved over that time. They also suggest that there is a link between the sociality of mammals and the size of their brains relative to body size, according to a study published in the *PNAS* journal.

The research team analysed available data on the brain size and body size of more than 500 species of living and fossilised mammals. It found that the brains of monkeys grew the most over time, followed by horses, dolphins, camels and dogs. The study shows that groups of mammals with relatively bigger brains tend to live in stable social groups. The brains of more solitary mammals,

such as cats, deer and rhino, grew much more slowly during the same period.

Previous research which has looked at why certain groups of living mammals have bigger brains has relied on studies of distantly-related living mammals. It was widely believed that the growth rate of the brain relative to body size followed a general trend across all groups of mammals. However, this study by Dr Susanne Shultz and Professor Robin Dunbar, from Oxford University's Institute of Cognitive and Evolutionary Anthropology (ICEA), overturns this view. They find that there is wide variation in patterns of brain growth across different groups of mammals and they have discovered that not all mammal groups have larger brains, suggesting that social animals needed to think more.

Lead author Dr Susanne Shultz, a Royal Society Dorothy Hodgkin Fellow at ICEA, said: 'This study overturns the long-held belief that brain size has increased across all mammals. Instead, groups of highly social species have undergone much more rapid increases than more solitary species. This suggests that the cooperation and coordination needed for group living can be challenging and over time some mammals have evolved larger brains to be able to cope with the demands of socialising.'

Co-author and Director of ICEA Professor Robin Dunbar said: 'For the first time, it has been possible to provide a genuine evolutionary time depth to the study of brain evolution. It is interesting to see that even animals that have contact with humans, like cats, have much smaller brains than dogs and horses because of their lack of sociality.'

The research team used available data of the measurements of brain size and body size of each group of living mammals and compared them with similar data for the fossilised remains of mammals of the same lineage. They examined the growth rates of the brain size relative to body size to see if there were any changes in the proportions over time. The growth rates of each mammal group were compared with other mammal groups to see what patterns emerged.

(Source: Science Daily Online)

The Puzzle of Biological Diversity

Biologists have long thought that interactions between plants and pollinating insects hasten evolutionary changes and promote biological diversity. However, new findings show that some interactions between plants and pollinators are less likely to increase diversity than previously thought, and in some instances, reduce it.

Findings, published in the *Journal of Evolutionary Biology*, show that local populations of one of the most distinctive plants in the Mojave Desert, the Joshua tree, are not as biologically diverse as would be expected. Joshua trees cannot produce seeds without specialised moths pollinating the tree's flowers. Previous research has shown that biological diversity exists among species of Joshua trees and their pollinating moths: Moths with longer ovipositors, the part of the moth used to lay eggs, favor trees with large flowers, while smaller moth species favor smaller flowers. Thus, biologists would expect the moths would adapt this trait to local flower populations and vice versa in order to reproduce. Yet using a combination of mathematical modeling and field studies,

researchers observed little biological diversity among populations and thus no evidence that local populations of moths adapt to local populations of Joshua trees.

"We had previously observed two species of moths and have shown that the larger moth species uses large flowers and the smaller moth species uses smaller flowers. However, once we account for this difference, there no evidence that moths have adapted to flowers," said William Godsoe, the study's lead author and postdoctoral researcher at the National Institute for Mathematical and Biological Synthesis.

The observation is consistent with recent work from biologists at the University of Idaho who, using a mathematical model, determined that in some cases interactions in nature don't increase diversity but instead reduce it. In a study published in *The American Naturalist*, University of Idaho biologists Jeremy Yoder and Scott Nuismer developed a mathematical model to compare how different interactions in nature affect biological diversity.

"The interactions we stimulated all change the evolution of the interacting species," said Yoder, who also co-authored the study on Joshua trees. "But different interactions can have very different effects — some increase diversity, some don't increase diversity at all, and some can even reduce diversity."

The Joshua tree study is a collaboration of theory and field work. "The patterns we're finding in the Joshua tree and moth data are exactly what we expect from the theory. Coevolution between Joshua tree and its pollinators acts to reduce the variation within species, which creates stronger contrasts between moth species and Joshua tree varieties," Yoder explained.

(Source: Science Daily Online)

Age Estimation from Blood has Immediate Forensic Application

Scientists have devised a method that would allow them to estimate the age of crime suspects or missing persons from blood collected at the scene of a crime.

In principle, the new profiling method could be put to immediate practical use by law enforcement, according to the researchers who report their findings in the November 23 issue of *Current Biology*. They have already begun the required validation of the test, which is designed to assure that quality standards are met.

"We demonstrate that human age can be estimated from blood with reasonable accuracy using a simple, robust, and sensitive test assay," said Manfred Kayser of the Erasmus MC University Medical Center Rotterdam in the Netherlands. "Our method is applicable in situations where only bloodstains are available, which covers a large proportion of crime cases."

The method will be especially useful in forensic cases in which age information is important to provide investigative leads for finding unknown persons, Kayser added. Existing methods for age estimation have limited use for crime scene investigation because they depend on the availability of teeth, bones, or other identifiable body parts having physical features that allow age estimation by conventional methods.

Other proposed genetic or biochemical methods to estimate age from blood samples have suffered from low accuracy and technical problems, Kayser said. The new method takes advantage of a fundamental characteristic of immune cells known as T cells.

T cells play a key role in recognising foreign invaders, an ability that depends on a diversity of T cell receptors, each matching specific molecules (antigens) derived from bacteria, viruses, parasites, or aberrant cells such as tumor cells. That diversity of receptors is achieved through a specific rearrangement of the T cells' DNA, a process that produces small circular DNA molecules as a by-product. The number of those circular DNA molecules (known as signal joint TCR excision circles, or sj TRECs for short) declines at a constant rate with age.

"With our test assay, we quantify the amount of sjTRECs in the total DNA extracted from a small blood sample and use a reference gene not affected by age to compensate for the total amount of DNA in the sample," Kayser explained.

The approach allows accurate estimation of age, give or take nine years, the researchers report, suggesting that it would be highly accurate in placing unknown persons into generational categories spanning about 20 years.

Kayser said that the test currently has the highest accuracy of any test designed to estimate a phenotypic human trait from DNA information. Notably, its prediction accuracies are comparable to or better than those recently demonstrated for predicting brown versus blue eye color from DNA, a test that has already been put to forensic use.

These new tests are harbingers of what's to come as researchers uncover new methods designed to reconstruct the appearance of unknown persons from biological crime scene samples or remains. The hope is that such methods will ultimately mean more crimes solved, the researchers say.

"Conventional DNA profiling applied in forensics can only identify persons already known to the investigating bodies, because the approach is completely comparative," Kayser said. "Hence, every forensic lab is confronted with cases where the DNA profile obtained from the evidence material does not match that of any known suspect tested, nor anybody in the criminal DNA database, and such cases therefore cannot be solved so far. In such cases, it is expected that appearance information estimated from evidence material will help in finding unknown persons."

(Source: Science Daily Online)

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