World Science News In Review

[Archeology]

Evolving Whales

The general evolutionary origins of whales have long been known: large mammals called pakicetids turned to the sea between 50 and 35 million years ago. However, the details were hazy—until now. Newly discovered fossils from the Indian subcontinent have revealed how many of the necessary aquatic adaptations took place, particularly the crucial ability to hear underwater.

As a few minutes spent in a swimming pool will attest, the ears of humans and other land mammals are poorly suited to detecting noise underwater. Water fills the outer ear canal, preventing the eardrum from transmitting sound. The ready transfer of sound from water to the animal's body creates distortions that cause it to reach both ears simultaneously, so what little the eardrum does transmit is of an unknown direction. Uncorrected, these shortcomings would have crippled early whales' efforts to locate food and therefore allowed the numerous aquatic predators of the Eocene period to approach them undetected.

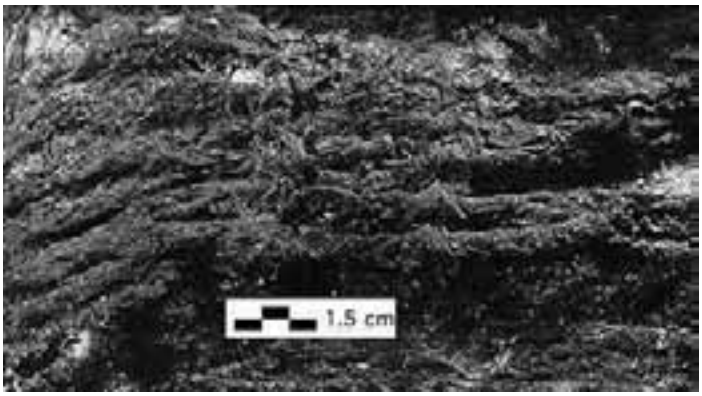
A research team led by Hans Thewissin of the Northeastern Ohio Universities College of Medicine analyzed new fossils from early, intermediate, and late stages of whale development. The ears of early pakicetid fossils exhibited few differences from their terrestrial counterparts, indicating that for their first few million years, whales had only minimal auditory capacity. The intermediate fossils, however, showed that by about 45 million years ago, whales were able to transmit sound vibrations to the ear by means of a newly developed pad of fat within the jaw, although they continued to possess an air-filled outer ear canal. Five million years later, these were discarded in favor of air-filled insulatory sacs that allowed sound to enter only on the sides of the head; the direction of sound was determined in a manner similar to that of modern-day whales. Unfortunately, if you're planning on sneaking up on a whale, you're about 40 million years too late. —D. Barclay

Source: http://news.nationalgeographic.com/news/2004/08/0811_040811_whale_evolution.html

The Fabric of Early Society

Technology for analyzing prehistoric organic artifacts has been stuck in the Stone Age; while inorganic materials such as clay and rocks are naturally well-preserved, more fragile textiles have a tendency to decay over a period of 20,000 years. Prehistoric humans presumably wore clothing, but such assumptions are difficult to confirm when a typical archaeological site yields only a few singed fibers of fabric.

Recent improvements in chemical analysis have enabled these fibers to become more than sub-par museum displays. Textiles buried near copper artifacts that absorb some of the element are less biodegradable, allowing experts to determine the type of plant used and the structure of its assembly. These facts in turn "tell us about the knowledge prehistoric people had of the resources available to them in their environment—it shows a remarkable amount of skill and technical know-how to go out and locate plants, figure out what time of year to collect them, and how to extract fiber from plant stems to create very fine yarns," said textile sciences professor Kathryn Jakes of Ohio State University. Fiber from a plant non-native to its area could provide clues to early human migration patterns.



Twined textile from an ancient U.S. site. New technology allows scientists to examine fragments of cloth found in burials and other archaeological sites to learn more about the lives of ancient civilizations.
Photo / Kathryn Jakes, Ohio State University

In the case of charred textiles, the chemical analysis advances can also detect the presence of dyes or paints. Based upon this, the North American Hopewell civilization probably used a plant called bedstraw to serve as a red dye, even though "nothing about bedstraw suggests it would create a color. It doesn't look red," said Jakes. "Instead it had to have been discovered in a prehistoric 'science experiment' that the rots of this plant will impart a red color. It gives you a lot of respect for what these people knew." —D. Barclay

Source: http://news.nationalgeographic.com/news/2004/08/0823_040823_ancient_textiles.html#main

[Biology]

Omega-3 Fatty Acids May Work Against Alzheimer's

Omega-3 fatty acid, commonly found in fish and canola oil, has been observed to prevent memory loss in laboratory mice afflicted with a disease similar to Alzheimer's. This research, published in the September issue of *Neuron*, hints at the preventive power of omega-3 fatty acids against the onset and degeneration of Alzheimer's disease. In a recent study headed by Greg M. Cole, a neuroscientist at UCLA, docosahexaenoic acid (DHA) was shown to be a key fatty acid in memory function. The study involved older mice, about 17 months on average, which had been genetically engineered to develop β-amyloid plaques, similar to the plaques that Alzheimer's patients develop.

Over a period of 103 days, Cole and colleagues gave one group of mice food with DHA, and a second group food without it. Not only did the second group of mice lack a concentration of DHA in the brain at the end of the period, but they had deficiencies in concentration of two

other proteins that are critical to transmitting messages across synapses.

The research group also proceeded to test memory in two groups of elderly mice, as before dividing them into consumers of ordinary food and food enriched with DHA. The mice were taught to swim on a platform in a water tank, but the water level was raised in later trials to submerge the platform. The mice had to use spatial memory to find the platform. The mice who received the DHA-enriched food found the submerged platform in about twenty to thirty seconds, while the second group took fifty or more seconds, demonstrating the fatty acid's effectiveness. Nutritionist Julie A. Conquer, of the University of Guelph in Ontario, pointed to the significance of the findings: "This is spatial memory... that's the memory you lose in Alzheimer's disease."

Conquer said that the research is now diverging into the two disparate fronts: investigating the effect of fatty acids on brain function and the more applied task of monitoring Alzheimer's patients who are taking fatty acid supplements. The biggest question facing researchers, however, is the role of the waxy plaques of β-amyloid protein, a hallmark of Alzheimer's disease and many other diseases. Cole hypothesizes that β-amyloid accumulation might damage DHA through oxidation, but the answer is still unclear. The current evidence showing the benefits of omega-3 fatty acids in the prevention of Alzheimer's is a step toward a solution. —P. Mulligan

Source: http://www.sciencenews.org/articles/20040904/fob3.asp

New Hottest Life-Form Discovered

Researchers from the University of Massachusetts last year isolated a microbe, unofficially called Strain 121, that can thrive in temperatures up to 121 degrees Celsius, 8 degrees hotter than any other known life-form. The microbe was found residing 1.5 miles (2.4 kilometers) below the surface of the Pacific Ocean, on the walls of a hydrothermal vent that emits mineral-enriched and scorching hot water.

University of Washington scientists led by oceanographer John Delaney pulled up the sample about 200 miles off Washington State in Juan de Fuca Ridge using a remotely operated submersible. They sent the chunk of vent to Professor Derek Lovley and postdoctoral researcher Kazem Kashefi of the University of Massachusetts. The isolated Strain 121 was placed in an autoclave, where the strain continued growing and reproducing. The strain survived at temperatures up to 130 degrees Celsius.

In order to formally name the new strain, Lovley and his colleagues need two cultures of the strain that are accessible for peer-review. However, Craig Cary, a University of Delaware expert on thermophilic microbes, pointed out that "extremophiles are very difficult to grow. They are living under very specific constraints."

The thermal vents that give rise to heat-resistant microbes.
Photo / Derek Lovley

Like other Archaebacteria, which split from the evolutionary tree of life right at its beginning, Strain 121 is accustomed to extreme environments because it has adapted to its harsh environment after so many years. Strain 121 is indeed a unique type of organism, one that reduces ferric iron to ferrous iron to replace oxygen in its respiration process.

The current research drift is sequencing the genome of Strain 121. Cary said that the biggest question about microbes like Strain 121 is how their DNA functions at such extreme temperatures. He also suspects that microbes living in more extreme conditions have yet to be found. "This is not a needle in the haystack, this is a needle in the whole haystack of Kansas—there's got to be others out there."

—P. Mulligan

Source: http://news.nationalgeographic.com/news/2004/05/0521_040521_extremeheat.html

[Earth, Atmospheric, and Planetary Sciences]

In Search of Planets

The long quest to locate extrasolar planets similar to Earth received a boost recently, as astronomers located the three lightest such planets thus far. Most extrasolar planets are gaseous giants similar to Jupiter and incapable of supporting life, while smaller bodies' weaker gravitational fields prevent the accumulation of toxic levels of gas.

Artist's depiction of a newly discovered Neptune-size planet orbiting the red dwarf star Gliese 436, which lies 30 light-years from Earth.
Photo / NASA

The search has mostly uncovered "those in the Jupiter- and Saturn-mass range," says R. Paul Butler of the Carnegie Institution of Washington, as their large size enables them to be detected at such a great distance. Recent technological advances, however, have refined the quality of detection instruments to permit the hunt to expand to smaller and more interesting planetary bodies. The improved devices check for miniscule signs of wobbling in the parent star, induced by the planet's gravitational field.

One such star, the red dwarf Gilese, was found by Butler's research team to harbor a planet between 21 and 25 times the mass of Earth, with a year of 2.81 days. A second star contained no less than four planets, including a "small" Earth analogue—the closest resemblance to our solar system yet. With a similar methodology, another team from the University of Lisbon located a planet in the mu Arae system with a mass about fourteen times that of Earth. It doesn't seem terribly habitable, but seems more hospitable than Jupiter. —D. Barclay

Source: http://www.sciencenews.org/articles/20040904/fob1.asp

To Go Low, Aim High

Investigations deep below the Earth's crust might seem necessary to study earthquakes. The developers of the Global Earthquake Satellite System, however, believe that high-resolution satellite imagery of the crust's surface deformations can predict imminent seismic activity. Based on the theory that sudden large changes could indicate a future

earthquake, a recent technology known as interferometric synthetic aperture radar (InSAR) tracks tiny changes in surface deformations.

Despite an altitude of tens of thousands of feet, the InSAR method can monitor deformations in increments of only a few inches by comparing multiple radar images of the same location taken from slightly different angles. The redundancy involved is time-consuming, and a large number of satellites would be required to monitor the earth's major fault zones. A 2000 space shuttle mission used elements of the InSAR procedure to successfully develop a global topographic map, and advocates of the program are encouraging NASA to launch one or more full-time InSAR satellites to extend the work, an effort hindered by the lack of a realistic ability to predict earthquakes in the near future.

Even so, the information could still be used to clarify the distinction between damaging and benign seismic shifts, according to geophysicist Carol Raymond of the Jet Propulsion Laboratory, and "allow us to test our knowledge of the physics of the earthquake process by comparing the observed motion of the Earth's surface with realistic models of fault system behavior." Some GPS satellites have already contributed to this model-building process by monitoring surface deformations—the relative success or failure of which may determine whether the InSAR initiative will gain a satellite of its own.

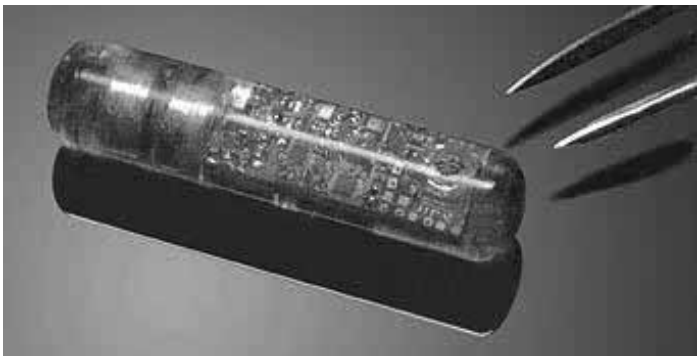
—D. Barclay

Source: http://news.nationalgeographic.com/news/2004/07/0720_040720_earthquake.html

[EECS/Biology]

Complete Biological Analysis on a Chip

Researchers have developed a microfluidic device capable of performing integrated biological analysis on a single computer chip. Sample preparation, PCR, microarray detection, and other supportive functions that are currently performed separately can now be incorporated into the device, potentially improving the efficiency of biological research.



Integrated biological analysis is now possible on a single chip.
Photo / Robin Lui

Researchers at the Microfluidics Laboratory of Motorola Labs recognized a long-standing frustration in the necessity of frequently interrupting fieldwork to return to the lab and finish analyzing particularly complex samples. Heterogeneous substances like whole blood can be handled by the microfluidic device's new chip, in addition to its traditional role of back-end DNA detection. The research team successfully performed single-nucleotide polymorphism analysis on diluted blood and detected pathogens in millimeter whole blood samples. "This is the first time that a fully integrated device has been demonstrated to perform the whole sample preparation, PCR, and DNA microarray detection from a complex biological sample such as whole blood," said lead author Robin Hui Liu.

Even for researchers who do not conduct fieldwork involving heterogeneous input samples, the new device still has something to offer. Less complicated homogenous samples can be prepared through integrated cell purification, DNA amplification, target-cell capture, and cell lysis capabilities. While these functions can be easily performed off the chip, maintaining a central location could have a greater convenience. A completely self-contained system would also drastically reduce the likelihood of contaminating a sample, as contamination is usually incurred during the transfer from the chip to the off-site location.

—D. Barclay

Source: http://www.reactivereports.com/38/38_3.html

[Materials Science]

Purification and Separation of Semiconducting and Metallic Carbon Nanotubes

Oxford University physicists have found a more efficient way to purify carbon nanotubes and developed a method of separating semiconducting nanotubes from metallic nanotubes. Carbon nanotubes are small (one-tenth the width of a human hair), strong (their sp^2 bonds are stronger than that of diamond's sp^3 bonds) cylindrical structures that exhibit electrical properties ideal for applications in optoelectronics and nanotechnology. However, the nanotubes often contain impurities such as the ferromagnetic additives necessary for synthesis that can adversely affect their electronic properties. This places a premium on the development of reliable separation techniques.

Purification techniques call for taking advantage of magnetic properties innate to the nanotubes to separate out the semiconducting nanotubes by diameter. Diameter screening is used for choosing the proper nanotube to react with a specific substrate. Researchers Malcolm Green and Shik Tsang have also developed a method using oxidizing agents to open and fill the ends of nanotubes with other materials. Filled nanotubes exhibit different electronic and magnetic properties and are potentially useful as shape-selective catalysts. Ironically, purification can best take place by introducing yet another material into the system!

—C. Lin

Source: http://chemistry.about.com/gi/dynamic/offsite.htm?site=http://www.acdlabs.com/webzine

Room-temperature Operable Magnetic Plastics

British researchers led by Naveed Zaidi of the University of Durham have created plastic magnets that operate at room temperature, while previous versions of plastic magnets have only been demonstrated to work below 10 Kelvin. The required new polymer to accommodate the higher temperature was created using emeraldine base polyaniline (PANi) and tetracyanoquinodimethane (TCNQ) whose components possess ideal properties—PANi is conductive and stable in air, while TCNQ forms free radicals, which are charged particles.

Researchers imitated conventional magnetism, but instead of aligning electron spins, they aligned free radicals. Initially, the polymer did not exhibit magnetic properties. However, just as the researchers were about to give up, the three-month old polymer began picking up iron

filings. X-ray diffraction confirmed an increase in polymer chain alignment occurred over time. Currently, the plastic magnets are not only weaker than metal magnets, but also inconsistent in strength throughout the polymer. However, since they are operative at room temperature, scientists believe the breakthrough plastic magnet will have practical applications in dentistry, coating computer hard discs, or acting as transducers in cochlear implants. —C. Lin
Source: http://www.newscientist.com/news/news.jsp?id=ns99996326

[Mathematics]

Unraveling Archimedes's Puzzle

Mathematicians are trying to piece together Archimedes's thoughts 2,200 years ago, using a parchment that Danish mathematical historian Johan Ludwig Heiberg found in Istanbul at the beginning of the twentieth century. The parchment describes the Stomachion, a puzzle which contains fourteen pieces of triangles, quadrilaterals, and pentagons that fit together to make a square and other shapes, such as elephants and sailboats. Though it was probably a children's toy, the theory behind it is anything but simple.

Classicists speculate that Archimedes counted the number of different ways these puzzle pieces can be rearranged to make a square.
Image / E. Roell

Using high-tech digital-imaging techniques, Netz and Wilson were able to decipher a word that had eluded Heiberg—"plethos," or quantity. This suggests that what intrigued Archimedes about the Stomachion was not what shapes could be made, but rather, the number of ways the pieces could be arranged to make a square. Netz followed this lead, and had Stanford mathematicians Persi Diaconis and Susan Holmes determine this number. With the assistance of Ron Graham and Fan Chung of the University of California, San Diego, they studied the puzzle for months and determined that the pieces could form a square in no fewer than 268 ways.

By translating the puzzle into a network, Chung and Graham discovered other intriguing properties of the puzzle. For example, when the puzzle is placed on a 12 by 12 grid, all the tile corners lie on the grid's lattice points, regardless of how the tiles are arranged to make a square. Wilson comments, "I wouldn't put it past Archimedes to recognize this was a special puzzle."

Some believe that Archimedes, while surely unaware of the puzzle's network relationships, may have used the Stomachion to study geometric theorems and even help prove the Pythagorean theorem. Others, like Netz and Wilson, believe that Archimedes used the Stomachion to explore combinatorics. The full powers of the puzzle have yet to be revealed. —E. Liu
Source: http://www.sciencenews.org/articles/20040515/bob9.asp

[Physics]

Making Maps Using the Physics of Diffusion

Researchers Mark E.J. Newman and Michael T. Gastner of the University of Michigan in Ann Arbor have developed a new way of making cartograms derived from the physics of diffusion. Cartograms, which are maps in which the sizes of geographic regions are in proportion to its populations, are usually difficult and time consuming to construct. Distortions are usually inevitable as densely populated states are enlarged and sparsely populated ones are reduced.

Gastner and Newman applied the diffusion equation in physics to the population density for a given map to create an algorithm that results in a map with uniform population density and no overlapping boundaries. Newman and Gastner demonstrated the viability of their method by creating cartograms for lung cancer rates among males in the state of New York, distribution of wire service news stories by state, and the results of the 2000 U.S. presidential election.

Newman and Gastner are now looking forward to increasing the method's speed and expanding its application to an international scale. Earth's curvature presents a challenge in creating such a large-scale map because the approximation method used to flatten the United States would clearly fail to be effective for the entire globe. Though Newman says that creating cartograms on a larger scale would require rewriting their computer codes, large maps are feasible, and there is still room for more elaborate research in this field. —E. Liu
Source: http://www.sciencenews.org/articles/20040828/bob8.asp