RESEARCH HIGHLIGHTS

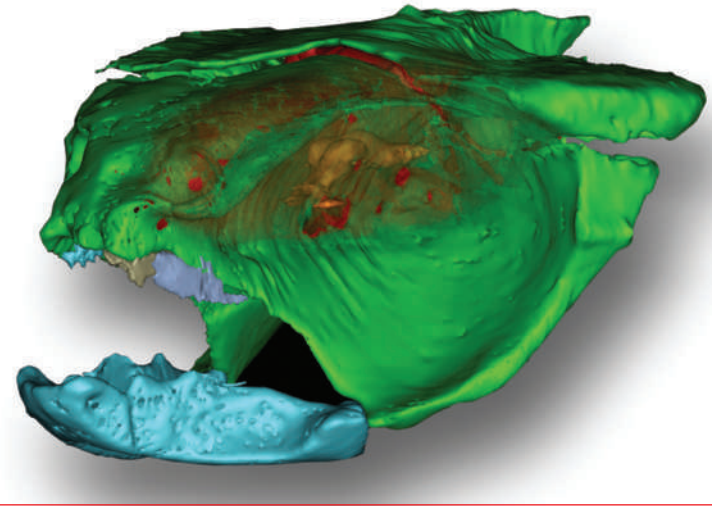
Brain box

Proc. Natl Acad. Sci. USA doi: 10.1073/pnas.0807047106 (2009)

A remarkably well-preserved brain has been discovered in a 300-million-year-old fossil of a fish from Kansas.

Philippe Janvier of the National Museum of Natural History in Paris and his colleagues used X-rays from the European Synchrotron Radiation Facility in Grenoble, France, to peer inside the skulls of iniopterygians, extinct relations of modern sharks and ratfish.

In one skull (pictured), they imaged a dense calcium phosphate structure. Its shape and relationship to nerve locations suggest that it is a brain, mineralized by phosphate-fixing microbes before the soft tissue could decay. The researchers hope that other vertebrates fossilized in similar conditions might yield further preserved organs, potentially throwing light on brain evolution.



PROC. NATL ACAD. SCI. USA/P. JANVIER/CNRS

CHEMICAL BIOLOGY

Sweet disguise

Nature Chem. Biol. doi:10.1038/nchembio.151 (2009)

An analysis of the sugars that cloak HIV-1 indicates that the virus leaves cells by usurping a native pathway used to spit out bits of cell membrane. This may help to camouflage it from the immune system.

When HIV-1 exits a cell, it picks up a coat of proteins decorated with sugars. Lara Mahal of the University of Texas at Austin and her colleagues found that the sugar profile of HIV-1 particles in cell culture matched that of microvesicles — cell membrane fragments thought to modulate immune responses — that are shed by infected cells.

The results raise concern that therapies aiming to block the interaction between HIV sugars and host cells could also interfere with microvesicle function. However, the researchers add that the same process may not be hijacked in all infected cells; they looked only at immune cells called T cells.

PROTEOMICS

Worm versus fly

PLoS Biol. **7,** e1000048 (2009)

The nematode worm *Caenorhabditis elegans* and the fruitfly *Drosophila melanogaster* (pictured, right) produce similar relative amounts of analogous proteins, even though levels of the messenger RNAs that code for these proteins vary widely between the species.

Michael Hengartner at the University of Zurich in Switzerland and his colleagues used mass spectrometry to analyse almost 11,000 *C. elegans* proteins (roughly half of the worm's predicted gene products). Of these, they selected nearly 2,700 for which mRNA data were available and compared their abundances with those of related proteins in the fruitfly. Protein ratios in the two model organisms correlated highly despite the two species' 600 million years of separate evolution, illustrating that regulating protein abundance is more important than maintaining gene-expression levels.

CHEMISTRY

Sprouting tubes

Nature Chem. doi:10.1038/nchem.113 (2009)

Tiny tubes grow spontaneously when small crystals of an inorganic solid are dunked in a solution of an organic ion. The effect could be exploited to build networks of miniature pipes that direct and control fluids.

Leroy Cronin and his colleagues at the University of Glasgow, UK, filmed tubes sprouting at up to 13 micrometres a second; some reached lengths of several centimetres.

The tubes grew from polyoxometalate (POM) crystals in solutions of phenanthridinium-based ions. The dissolving crystals first mingle with the ions to form a membrane, which subsequently bursts, squirting out POM that forms tube walls on contact with more organic ions.

The tubes can be bent with an electric field or the judicious use of obstacles. Their diameters can be customized by altering the concentration of organic ions.

MARINE ECOLOGY

Deadly dusting

Proc. Natl Acad. Sci. USA doi.10.1073/pnas.0811486106 (2009)

Atmospheric aerosols, which supply ocean phytoplankton with nutrients such as nitrates and iron, can have toxic effects too.

Adina Paytan at the University of California, Santa Cruz, and her colleagues found that some species of phytoplankton in Red Sea surface waters suffered when exposed to aerosol samples collected from the Sahara Desert in Africa, whereas they thrived on European aerosols. Copper may be to blame: it was present at much higher levels in African aerosols and can be toxic to phytoplankton.

Although desert dust supplies about two-thirds of atmospheric copper, human industrial emissions of the element are increasing rapidly. The researchers suggest that copper deposition could alter marine ecosystems by damaging phytoplankton in high-aerosol areas such as those downwind of industrial regions of south and east Asia.

MPG/EPA/CORBIS/D. M. PHILLIPS/VISUALS UNLIMITED/GETTY

OPTICS

Beyond the invisibility cloak

Phys. Rev. Lett. **102,** 093901 (2009)

Invisibility shields that cause objects within them to vanish are now well-known. But Yun Lai and his colleagues of the Hong Kong University of Science and

Technology in Clear Water Bay show how such a device might work to hide an object outside its confines.

In their theoretical scheme, the custom-made shield creates an 'anti-object' image that cancels out the light-scattering of the hidden object nearby, so that in optical terms the whole system is replaced by empty space.

The researchers provide a prescription for making anti-objects of arbitrary shape embedded in slabs of metamaterials, which are composed of building blocks that interact with light in unusual, tailor-made ways.

PALAEONTOLOGY

Bird in the hand

PLoS ONE **4,** e4591 (2009)

Prints left by a squatting bipedal dinosaur show clearly that the hands faced inwards, as birds' limbs do now to allow for wing folding. The prints, which are almost 200 million years old, are preserved in Utah sandstone.

The dinosaur was a theropod — one of a group of mainly carnivorous dinosaurs, such as tyrannosaurs and velociraptors, that were the ancestors of modern birds. The prints suggest that theropods exhibited bird-like anatomy and resting postures much earlier than previously recognized.

Andrew Milner, curator at Utah's St George Dinosaur Discovery Site, and his colleagues theorize that the unknown creature's hand orientation was for grabbing or holding prey.

NEUROBIOLOGY

Second fiddle

Science **323,** 1313–1319 (2009)

Ion channels known as AMPA receptors help to transmit fast excitatory nerve impulses in the brain. Changes to their properties, which are regulated by other proteins, are crucial to many processes, including some involved in learning and memory.

TARP proteins were thought to be the only candidates for AMPA-receptor regulation. Yet in the rat brain such proteins associate with only about 30% of AMPA receptors.

Bernd Fakler and Nikolaj Klöcker at the University of Freiburg in Germany and their colleagues have unexpectedly come across what turns out to be the predominant partner proteins, using a quantitative proteomics approach. They found that, in rat brains, about 70% of AMPA receptors associate with cornichon proteins. Cornichons and TARPs regulate the function and expression of AMPA receptors differently, potentially allowing fine-tuning of fast nerve-impulse transmission.

ECOLOGY

Open goal

Proc. R. Soc. B doi:10.1098/rspb.2008.1762 (2009)

A host of grasses, including crops such as maize (corn) and sugarcane, grow well in hot, dry conditions because they have evolved a more efficient type of photosynthesis, the C_4 pathway, which requires less water than the more widespread C_3 pathway.

Some scientists believe that C_4 photosynthesis evolved to cope with drought, but others argue it was originally an adaptation to exposed habitats.

Colin Osborne and Robert Freckleton at the University of Sheffield, UK, have now settled the debate by analysing the habitats of 117 genera of grasses, representing 15 independent C_4 lineages. They provide strong evidence that C_4 plants first arose in open, tree-less environments. Once the pathway had evolved, however, C_4 plants would have been able to adapt faster to dry environments than C_3 plants.

N. CATTLIN/FLPA

MATERIALS SCIENCE

Diaphite domains

Phys. Rev. Lett. **102,** 087402 (2009);
Phys. Rev. B **79,** 054111 (2009)

Graphite, a form of carbon made up of layered sheets of atoms, transforms into diamond — another form — only when subjected to high pressure. But Katsumi Tanimura at Osaka University in Japan, Hiromasa Ohnishi at the Institute of Materials Structure Science in Tsukuba and their colleagues have found that by firing femtosecond (10^{-15} s) laser pulses at a graphite wafer, they can cause five-nanometre-diameter patches of the flat layers to buckle and become three-dimensional.

The patches, which form a structure that exhibits bonding between layers but differs from a diamond lattice, have been termed 'diaphite' domains. The material is stable at room temperature if kept under ultra-high vacuum.

JOURNAL CLUB

Frank Wilczek
Massachusetts Institute of Technology, Cambridge

A theoretical physicist examines exotic particles lurking in new materials.

Axions are very light, very weakly interacting particles, whose existence was posited more than 30 years ago in order to clean up our 'standard model' of particle physics. They close an annoying loophole in Kobayashi and Maskawa's Nobel prizewinning explanation of why the microscopic laws of physics look so nearly the same when running backwards as forwards in time (time reversal symmetry).

Despite heroic efforts — and several false alarms — axions have not yet been detected, but they have become increasingly important. They have been warmly embraced in unified field theories and in string theory. And when we run the equations through Big-Bang cosmology, we find that axions should contribute much of the dark matter that astronomers have inferred to explain the Universe.

Now Shou-Cheng Zhang and his colleagues (X.-L. Qi *et al. Phys. Rev. B* **78,** 195424; 2008) inform us that, all along, axions have been lurking unrecognized on surfaces of bismuth–tin alloys and other materials. To be more precise: the equations that arise in axion physics are the same as those that describe the electromagnetic behaviour of a recently discovered class of materials known, collectively, as topological insulators.

The axion field inside topological insulators is an emergent — and subtle — property of collections of electrons that is connected to their spin–orbit coupling.

These 'quasi-axions' don't improve our standard model, but they do have the charming advantage of being accessible, possibly even useful. There are ideas to exploit their behaviour to make anyons, potential building blocks for quantum computation.

No short summary can do justice to the wealth of ideas synthesized in this paper. Powerful, beautiful mathematics is at play in reality.

Discuss this paper at **http://blogs.nature.com/nature/journalclub**