RESEARCH HIGHLIGHTS

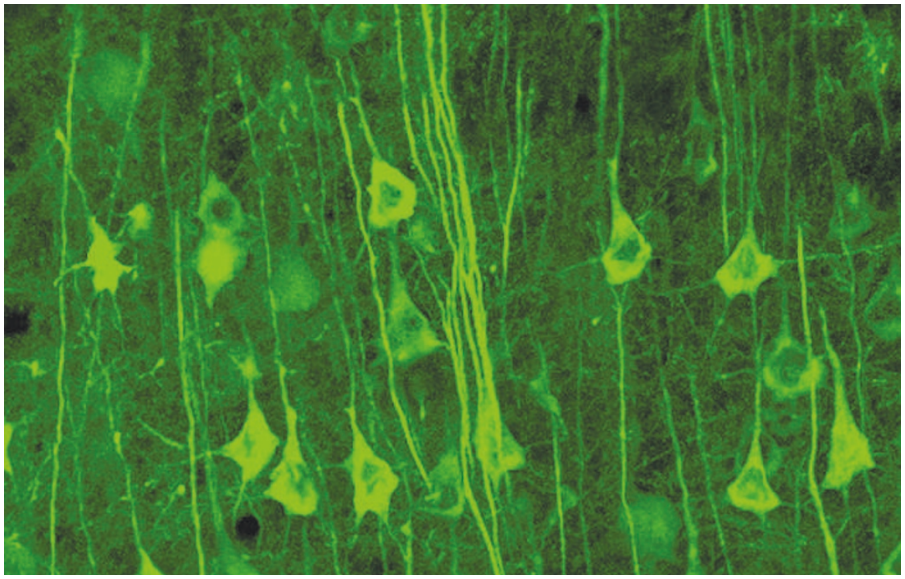
Neurons brought to light

Nature Meth. doi:10.1038/nmeth1009 (2007)

Researchers in Germany have developed a biosensor to image the activity of individual neurons (pictured) in the brains of living mice. The sensor detects the calcium ions involved in neuronal signalling.

Oliver Griesbeck from the Max Planck Institute for Neurobiology in Martinsried and his colleagues made the biosensor by attaching fluorescent proteins to a natural calcium-sensor protein, troponin C. The spectrum of light emitted by the biosensor changes when it binds to calcium.

Previous calcium sensors have performed poorly when engineered into mice, so the team modified the gene encoding this package to ensure that it would express a functional protein. The biosensor was sensitive enough for relatively low levels of electrical activity to be detected.



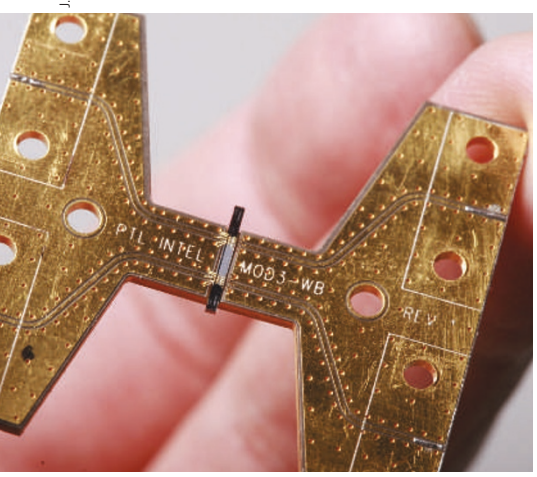
OPTOELECTRONICS

Speedy silicon

Optics Express **15,** 660–668 (2007)

Silicon is the material of choice for computer chips, but has traditionally lagged behind in optics, unable to compete with other materials for speed. That could soon change.

Ansheng Liu and his colleagues at Intel in Santa Clara, California, and in Jerusalem, Israel, have developed an optical device (pictured below) that can write up to 30 gigabits of data per second to a laser beam — three times faster than any previous silicon device. The optical modulator's speed stems in part from a design that transmits the electrical signal carrying the data and the light through a single channel, or 'waveguide'. The researchers claim they can tweak their device to reach data transfer speeds of up to 40 gigabits per second, which rivals the speeds of optical modulators made from more exotic materials.



J. TSENG/INTEL CORP.

NEUROBIOLOGY

Prion symptoms reversed

Neuron **53,** 325–335 (2007)

Early symptoms of the neurodegeneration caused by prion disease can be reversed in genetically engineered mice, report Giovanna Mallucci, of the Medical Research Council's Institute of Neurology in London, and her colleagues.

The researchers monitored the behaviour of mice infected with a prion protein to look for early indicators of the disease. Changes in the way the mice responded to their environment occurred before the onset of obvious signs of neurodegeneration, such as reduced grooming. The mice recovered their normal brain function if production of the naturally occurring protein that propagates the disease was switched off at this stage.

But the implications for treatment of the human prion disease, Creutzfeldt–Jakob disease, are uncertain. It's not clear whether human brains could recover, nor how levels of the prion protein could be lowered.

IMMUNOLOGY

The right kind of help

J. Exp. Med. doi:10.1084/jem.20061839 (2007)

So far they have only tested their hypothesis in mice, but researchers think they have identified a mechanism that could help to explain why men are less prone than women to developing certain types of autoimmune disease, such as mutliple sclerosis.

Lawrence Steinman of Stanford University Medical Center, California, and his colleagues studied a receptor known as peroxisome proliferator-activated receptor-α, which has been implicated in gender differences in lipid metabolism. The receptor is also expressed in the immune system's $CD4^+$ T cells.

The researchers showed that the receptor gene is sensitive to testosterone, and is expressed at higher levels in the T cells of male mice than in those of females.

$CD4^+$ T cells differentiate into different types of 'T-helper' cell. Expression of the receptor seems to direct differentiation away from the type that is associated with certain autoimmune diseases. Knocking out the gene in males made the symptoms of a mouse model of multiple sclerosis more severe.

PALAEONTOLOGY

Could the 'hobbit' hunt?

HOMO — J. Comp. Hum. Biol. doi:10.1016/j.jchb.2006.11.001 (2007)

Debate over the diminutive *Homo floresiensis* — believed to be a hobbit-sized species of hominid — has inspired a team at Washington University in St Louis, Missouri, to develop a method to estimate the size of hominid brain components from fossil skulls.

Researchers have questioned whether the small-brained *H. floresiensis*, which lived on an isolated Indonesian island until at least 12,000 years ago, would have been capable of creating tools, using fire and hunting, as some studies have suggested.

Glenn Conroy and Richard Smith looked at the volumes of 11 different brain components in 45 primate species to set limits on the size of each component as a fraction of overall brain size. The predicted bounds for the brain of *H. floresiensis* are not

consistent with the suggested behaviour, they conclude, unless the brain of *H. floresiensis* was functionally different from that of modern humans or chimpanzees. That possibility would force biologists to rethink how hominid brains evolved.

METAGENOMICS

Invisible communities

Science doi:10.1126/science.1133420 (2007)

Thousands of different microorganisms can share the same habitat, but these populations are hard to study because few individual species survive in cell culture. One way around this is to perform shotgun sequencing of the whole communitiy — an approach known as metagenomics.

Peer Bork from the European Molecular Biology Laboratory in Heidelberg, Germany, and his colleagues present a new bioinformatics approach to digging out biologically relevant details from such data.

They examined 31 'marker genes' — genes that are present in all microbes, but show variation between species — to probe the composition of four communities, including microbes from ocean water and from soil. This allowed them to show, for example, that some communities evolve faster than others and that some microbes have clear and persistent preferences for particular environments.

MATERIALS SCIENCE

Stiffer than diamond

Science **315,** 620–622 (2007)

For hardness and stiffness, it's long been thought that nothing beats diamond. But Roderic Lakes of the University of Wisconsin -Madison and his colleagues have made a material that is almost ten times stiffer, by embedding small particles of barium titanate in a matrix of tin.

Barium titanate can adopt different crystal structures. In the composite, it is trapped in a high-temperature form at temperatures below the usual transition point. This gives the inclusions the strange property of negative stiffness, meaning that they bend in the opposite direction to an applied force.

Warming the composite changes the balance between the mechanical properties of the inclusions and those of the matrix, which responds more conventionally to an applied force. At a particular temperature, these tendencies cancel each other almost exactly, and the material then scarcely deforms at all.

This extreme stiffness is remarkable, given that neither of the materials involved are especially stiff on their own. The composite isn't, however, expected to be particularly hard or strong.

ASTRONOMY

Super-Earth model

Astrophys. J. **656,** 545–551 (2007)

Recently discovered planets in solar systems beyond our own have masses just a few times that of Earth. What might these 'super-Earths' actually look like?

Diana Valencia and her colleagues at Harvard University in Cambridge, Massachusetts, do the maths. They assume that the planets are composed of concentric shells of similar compositions to Earth's layers, and solve equations for the density, gravity, mass and pressure in each as a function of radius.

Varying the proportion of core and mantle, or postulating a surface ocean, produces different solutions for the model planets' mean density and radius that could be compared with future observational data. For instance, if the radius of GJ 876d, the super-Earth reported in 2005, is more than 12,000 kilometres, then it almost certainly contains water, the authors say.

ZOOLOGY

Food poisoning

Proc. Natl Acad. Sci. USA doi:10.1073/pnas.0610785104 (2007)

They say you are what you eat. And that's especially true of the snake *Rhabdophis tigrinus* — zoologists have discovered that it eats poisonous toads and keeps their venom for itself.

R. tigrinus, which is found in Asia, eats a wide range of prey, including toads that secrete defensive poisons known as

D. A. HUTCHINSON

bufadienolides through their skin. When fed a diet featuring these toads, the snakes' venom glands fill up with a poison that seems to have been made from these chemicals, report researchers led by Deborah Hutchinson of Old Dominion University in Norfold, Virginia, and Jerrold Meinwald of Cornell University in Ithaca, New York.

The snakes store the venom in structures known as nuchal glands on the backs of their necks, underlying the ridge visible in the picture above, which they display if confronted by a predator. Snakes with no toads, and therefore no toxin, in their diets make these defensive displays less frequently.

JOURNAL CLUB

Axel Kleidon
Max-Planck Institute for Biogeochemistry, Jena, Germany

A biogeochemist finds inspiration for life on the ocean floor.

My research interests lie in understanding the interplay between the physical and chemical conditions that constrain life, and the feedback processes by which life shapes the Earth's environment.

I want to understand these interactions in terms of a thermodynamic hypothesis that states that systems dissipate as much energy as possible. Can life be seen as an emergent outcome of this tendency for the whole Earth system? To test this, one would need to show that it is possible to predict the emergence of life from the hypothesis, as well as its impact on Earth's early environment.

Two articles (M. J. Russell & A. J. Hall *GSA Memoir* **198,** 1–32; 2006, and M. J. Russell *Am. Sci.* **94,** 32–39; 2006) could provide a starting point. The authors give a detailed picture of the thermodynamics of life emerging at hydrothermal mounds on the ocean floor.

One of the earliest metabolic reactions would have involved the conversion of hydrogen, carbon dioxide and sulphur compounds into organic carbon, acetate and water. This would have happened in the hot, mineral-rich spring water seeping into the hollow mound.

But its influence would have been felt more widely. Removing sulphur from the environment would have changed atmospheric composition and cloud cover, affecting the amount of sunlight reaching the ground. And acetate may have served as fuel for methanogens, methane-producing organisms known to live in vents. Increased methane production would have raised its levels in the atmosphere, resulting in higher surface temperatures on Earth.

Quantifying these interactions should help us to understand whether the evolution of our planet emerged from general thermodynamic trends.