MATERIALS SCIENCE

Negative index

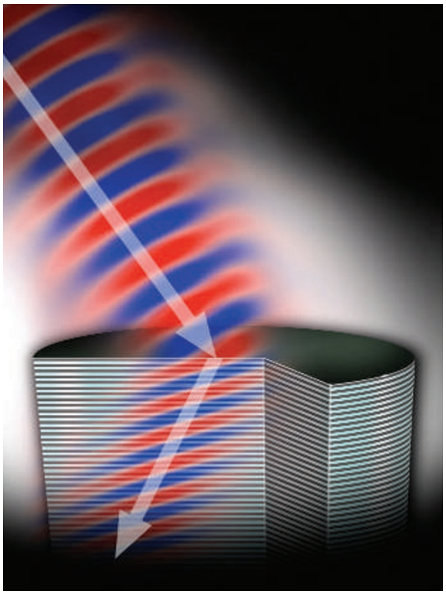
Nature Mater. doi:10.1038/nmat2033 (2007)

Researchers have engineered the first multilayer semiconductor able to bend incoming light in the opposite direction to all known naturally occurring materials.

Anthony Hoffman at Princeton University in New Jersey and his colleagues assembled the material by superimposing many alternating ultra-thin layers of two types of semiconductor. They found that an infrared beam shone into this at any angle was negatively refracted through the material (see picture, right).

Other such 'metamaterials' comprise alternating layers of metals and semiconductors, but can be grown to only limited thickness.

The researchers say that the new material, which is easy to produce, could improve infrared laser devices such as those used in high-speed communication and medical diagnostics, and lead to improved flat lenses to reduce distortion in telescopes and microscopes.



K. DRAKE

IMMUNOLOGY

Nod in the right direction

Immunity doi 10.1016/j.immuni.2007.08.013 (2007)

When pathogens infect a person, they prime dendritic cells to inform another, more specialized, cell of the immune system — the T cell — to tune itself up for defence. Scientists have now identified a key receptor involved in the transfer of information about a bacterial infection.

Martien Kapsenberg, Esther de Jong and their co-workers at the University of Amsterdam in the Netherlands found that a receptor called NOD2 in the cytoplasm of dendritic cells binds to fragments of bacterial cell walls. The activated NOD2 then switches on a set of genes that results in the release of several cytokines. The particular profile of cytokines informs T cells to differentiate into Th-17 T-cells, which are tuned to recognize bacteria and organize their destruction.

Viruses, the scientists showed, did not activate the NOD2 sensor.

MICROBIAL GENOMICS

Toxic genes

Science doi:10.1126/science.1147112 (2007)

Microbes share genes between species so frequently that their evolutionary relationships aren't always clear. Edward Rubin of the Department of Energy's Joint Genome Institute in Walnut Creek, California, and his colleagues say that there are some limits to this horizontal transfer.

Every time a microbe is sequenced, its DNA is transferred by researchers, using plasmids, into the model microbe *Escherichia coli* in what amounts to a large-scale experiment in horizontal transfer. The team took the genes that fail to transfer into *E. coli* from multiple species, and smuggled them into *E. coli* so that they would not be expressed until specifically induced. When induced, the *E. coli* stopped growing, suggesting that the genes were toxic. These transfer-resistant genes could have a future as antibiotics.

QUANTUM PHYSICS

Skipping levels

Nature Phys. doi:10.1038/nphys748 (2007)

Quantum dots are fabricated structures that confine negatively charged electrons and positively charged holes to discrete energy levels.

The rules of quantum mechanics suggest that electrons and holes added to a dot would fill the lowest available energy level before moving up to the next. But Richard Warburton of Heriot-Watt University in Edinburgh, UK, Gabriel Bester at the National Renewable Energy Laboratory in Golden, Colorado, and their colleagues have found an exception to the rule. When five or six additional positively charged holes are crammed into a dot, the researchers find that the newly added holes actually skip an energy level.

The authors say that understanding quantum dots and their unusual behaviour will be important for future applications such as quantum computing.

JOURNAL CLUB

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A spectroscopist tells how the tools of his trade are revealing quantum effects in biological molecules.

In introductory quantum mechanics, one learns that particles can behave like waves, with each particle having a wavelength inversely proportional to its momentum. I am fascinated by recent work that examines how, at the molecular level, life takes advantage of these wave-like properties.

The effects aren't visible when moving biomacromolecules are viewed whole, because their large mass means they have a negligibly small 'de Broglie' wavelength. However, atoms and electrons within a molecule — for example, in active sites, where reactions such as catalysis and light-absorption take place — may interact in a wave-like way.

Researchers are thus investigating what role the wavefunctions of these molecular constituents have during biochemical reactions. And if they do interact, over what distance and for how long does the wavefunctions' phase relationship, or quantum coherence, persist?

Spectroscopists have found evidence for coherences in a few biological systems, thanks to a technique known as multidimensional spectroscopy (A. Nagy *et al. Curr. Opin. Struct. Biol.* **16,** 654–663; 2006). This involves tracking changes in a molecule's configuration over very short timescales with laser pulses that last femtoseconds (10^{-15} s).

Further results reported this year suggest that the energy transfer in a photosynthetic system is wave-like (G. S. Engel *et al. Nature* **446,** 782–786; 2007). For this process, the quantum coherence of the light-excited charges may help the charges search out an efficient pathway through the molecule, by means of a mechanism analogous to a quantum computation.

This observation provokes a question that I look forward to seeing answered. Might biological systems have evolved to use matter's wave-like properties to optimize their efficiency?

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