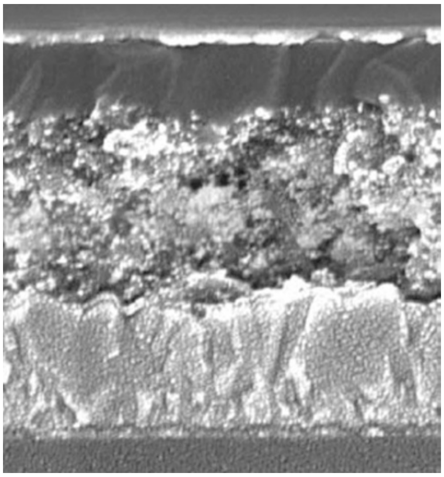
research highlights

Perovskite photovoltaics

Science **338,** 643–647 (2012)



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Dye-sensitized solar cells show some of the highest power-conversion efficiencies of all solution-processable photovoltaic devices, but the use of liquid electrolytes can limit their long-term stability. Recent research has hence explored the replacement of the liquid electrolyte by a polymeric hole conductor and the sensitization of the mesoporous TiO_2 electrode with a thin inorganic semiconducting absorber layer. Henry Snaith and colleagues now report an improved architecture for such hybrid solar cells that leads to efficiencies of up to 10.9%. The key component is the perovskite $CH_3NH_3PbI_2Cl$, which is stable in air and suitable for solution processing. The compound is deposited onto mesoporous insulating Al_2O_3 instead of TiO_2, which leads to an enhanced open-circuit voltage and high internal photoconversion efficiency across wide parts of the visible solar spectrum. The researchers attribute this enhancement to charge transport through the perovskite coating and suggest that increased absorption in the infrared range could further improve the performance of such hybrid solar cells. *CM*

Molecular energy transfer

Phys. Rev. Lett. (In the press); http://arxiv.org/abs/1110.0457 (2012)

Since the early work of Edward Purcell it has been recognized that the electromagnetic environment affects the spontaneous emission rate of individual excited atoms and molecules. Much less studied is the effect that the environment has on the energy transfer rate between pairs of closely spaced molecules. Previous studies indicated that this rate depends strongly on the environment, while others reported weak or no dependence at all. In an elegant work, Christian Blum and colleagues now provide strong evidence that the energy transfer rate between molecules is not affected by the nanophotonic environment. The researchers attached energy donor and acceptor molecules at the two ends of a DNA strand of a precisely defined length (6.8 nm). The energy transfer pairs were then positioned with nanometre precision close to a metallic mirror. The researchers found that although the environment did not seem to affect the energy transfer rate, it could dramatically change the efficiency of the transfer, essentially between 0 and 100%. *KT*

Quantum rattling

Nature Commun. **3,** 1124 (2012)

Collective excitations such as phonons, the quantized lattice vibrations that occur in crystalline solids, are a central concept in condensed-matter physics. On the one hand they determine the physical properties of a crystal, such as the heat capacity, and on the other hand, they provide a framework for reducing the many-body phenomena that occur in complex systems into tractable theoretical models. Adam Aczel and colleagues find a beautiful example of this correspondence in uranium nitride, a rock salt-like structure that has recently been put forward as a possible fuel for next-generation nuclear reactors. Using a time-of-flight neutron scattering approach they observe, in addition to the usual phonon modes, a set of clear and equally spaced high-energy vibrational modes. This spectrum is best explained by assuming that each nitrogen atom behaves as an independent harmonic oscillator trapped within an octahedral cage of heavy uranium atoms. The researchers therefore conclude that uranium nitride is an ideal experimental realization of a quantum harmonic oscillator, one of the few quantum mechanical models that can be solved analytically. *AT*

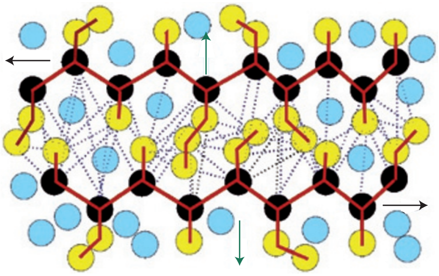
Spheroid survival

Angew. Chem. Int. Ed. http://doi.org/fz8rxc (2012)

The therapeutic potential of mesenchymal stem cells (MSCs) is known to be enhanced by their formation into enlarged spheroids of cells. In the centre of these spheroids, as a consequence of a reduced supply of oxygen and nutrients, however, hypoxic conditions can be present. These conditions decrease MSC survival and lower the efficacy of MSC-based therapy involving spheroid transplantation. Now, Younan Xia and colleagues show that the anti-apoptotic activity of human MSCs (hMSCs) can be enhanced by the intracellular delivery of polyplexes composed of the biodegradable polymer, branched poly(disulphide amine) (PDA), and Fas-silencing small interfering RNA (Fas siRNA). These Fas-silenced hMSCs are cultured as enlarged spheroids under hypoxic conditions and the gene-silencing efficiency of the polyplexes is about 1.5 times higher than hMSCs treated with polyplexes formed from Fas siRNA and polyethylenimine. Also, the expression of angiogenic and anti-apoptotic growth factors is increased in the spheroids treated with the Fas siRNA–PDA polyplex. *AS*

Folding and jamming

Nature Commun. **3,** 1161 (2012)



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Vigorously shake a pack of grains that are stuck, and they will 'unjam'. Heat a glass to a sufficiently high temperature, and it will flow. These apparently disconnected behaviours are usually expressed as a universal jamming phase diagram that depends on temperature, density and external force. Now, Prasanth Jose and Ioan Andricioaei show that the mechanical behaviour of folded proteins is similar to that of granular materials and glasses. Using molecular dynamics simulations, the researchers pulled the ends of protein chains in their native states, or increased the temperature. They found that the distribution of normalized forces per protein atom in the resulting trajectories fell on a universal shape (with a characteristic peak at low forces) common to force distributions measured on jammed grains and droplets. They also show that the stress relaxation of folding proteins slows down with respect to that of unfolded ones, a dynamic signature resembling the viscous slowdown of jammed grains and glasses. These results suggest that protein folding can be mechanically interpreted as a jamming transition. *PP*

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