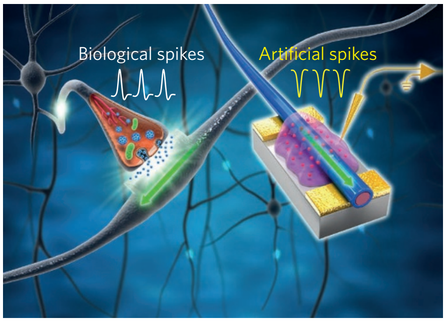
NEUROMORPHIC NANODEVICES

Rivalling biology

Sci. Adv. **2,** e1501326 (2016)



AAAS

The highly interconnected network of neurons in the human brain consumes only tens of watts of power to perform highly complex algorithms. Since a reasonable estimate for the number of synapses transmitting signals between neurons approaches 10^{14}, this remarkable efficiency is made possible by the tiny amount of energy required by each synaptic event, on the order of a few femtojoules. Artificial synapses must have comparable performance to their biological counterparts if neuromorphic hardware architectures are to be used in future novel computational approaches. However, the efficiency limits set by nature are as yet unequalled.

Now, Tae-Woo Lee and co-workers at the Pohang University of Science and Technology in Korea report on artificial synapses that outperform the energy efficiency of their biological counterparts. The researchers grew devices based on core–shell organic nanowires to mimic a nerve fibre. The synapse's functionality was reproduced in a transistor with an ion gel to provide signals analogous to both inhibitory and excitatory presynaptic pulses. The resulting differential dynamics of anions and cations inside the gel and their interaction with the nanowires allowed neuronal signal propagation, mimicking the different specific synaptic functions. Through device optimization, the researchers achieved an average energy consumption of around 1 femtojoule per synaptic event. *GP*

EDUCATION

Thinking ahead

ACS Nano **10,** 5595–5599 (2016)

Many indicators show that nanoscience and nanotechnology are some of the fastest-growing fields in scientific research and are poised to have a major impact on the world economy. To unleash the full potential of nanotechnology in society and its contribution to tomorrow's workforce, researchers in the US, Singapore, Korea and Denmark reflect on the education and training required to nurture the next generation of scientists and equip them with strong technical backgrounds and the business know-how to operate across related cultures and disciplines.

While various aspects of learning design and the curriculum of nanotechnology education and training have been discussed previously, Paul Weiss, Nam-Joon Cho and colleagues propose that long-term strategies for educating future scientific leaders are now needed. The researchers recommend a set of considerations for those responsible for planning education and training in nanotechnology. First, inspire students and capture their imagination by highlighting how nanotechnology impacts our world through courses on the applications of nanotechnology, hands-on laboratory experiences that align with taught concepts, and better communication of nanoscience to the public. Second, promote successful role models and create opportunities for students to interact with them. Third, nurture teamwork by encouraging international collaboration through partnerships and student exchanges. Fourth, show the many possible ways to be involved in nanotechnology — from research and education to entrepreneurship and manufacturing — and promote learning through experience. *ALC*

METAL–ORGANIC FRAMEWORKS

Enzyme pretenders

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Metal–organic frameworks (MOFs) are used for a range of applications, including gas storage, sensing and catalysis. While some post-synthetic modifications of MOFs are known, this concept has now been taken significantly further. F. Dean Toste, Omar Yaghi and colleagues from the University of California, Berkeley, and the National University of Cordoba, Argentina have introduced short peptides into the framework's pores in a step towards using these materials as enzyme-like catalysts.

The authors first made post-synthetic modifications to functionalize the organic struts of the MOF. Using classical peptide couplings, up to 7 modifications were made while still retaining the crystalline and porous scaffold. These peptide additions reduced the pore space, indicating the potential applications for molecular confinement. One of the MOFs was found to catalyse the stereoselective chlorination of butyraldehyde, giving the product in 20% e.e. The authors then attempted sequence-specific peptide cleavage. Inspired by the active site of the tobacco etch virus, a MOF with a Cys–His–Asp chain was designed as a synthetic endopeptidase. This selectively cleaves the Ser peptide bond of a short peptide in 5% yield after 24 h.

While the reported catalytic activities and selectivities are quite low, they are averaged values of the system, which, at this stage, does not contain uniformly functionalized pores. However, these results suggest that MOF-based strategies could be optimized further for selective transformations. *BLB*

OPTOMECHANICS

Measurements with a kick

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Optically trapped nanoparticles experience at least two types of interaction: collisions with gas particles in the nearby environment, and collisions with the photons of the trapping field. Both of these interactions contribute to noise in the measurements of these systems. While collisions with other particles can be minimized under ultrahigh-vacuum conditions, the individual kicks from the photons represent a fundamental limit to the degree of precision of such measurements: low laser energies decrease the noise but also increase the uncertainty of the particle's position, and at high laser energies the reverse is observed. Now, Lukas Novotny and collaborators from ETH Zürich, the University of Vienna and ICFO in Spain describe an experiment in which the contribution of photon shot noise can be measured directly.

A nanoparticle of ~50 nm diameter was confined in an optical trap and an ultrahigh vacuum applied. The particle was then cooled to mK temperatures and kept there under steady-state conditions. Under these conditions, the interaction with the laser field was the only source of heating. The researchers could measure this interaction directly by watching the trajectory of the levitated particle (an indication of how much it has heated up) as soon as they turned off the cooling mechanism. They found that the photon shot noise heats the nanoparticle at a rate of 10,000 oscillator quanta per second. This value sets a lower boundary for the sensitivity of levitated nanoparticle measurements. *AM*

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