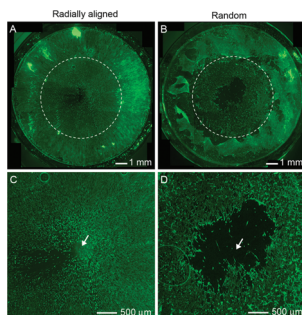


Wound Closure Comes Full Circle for Radially Aligned Nanofibers

Neurosurgical procedures sometimes involve incisions through the dura matter, a fibrous membrane covering the brain and spinal cord. Such procedures necessitate the use of dural substitutes to expand or to replace the resected tissue. However, researchers have had limited success in developing suitable dural substitutes, with problems ranging from formation of scar tissue with autografts to rejection with allografts and xenografts. Biodegradable synthetic polymers have attracted some attention as potential solutions. However, these materials have thus far been tested only in forms such as foils, films, or meshes, which do not promote the cell adhesion or inward migration necessary for effective wound repair and tissue regeneration.

Looking for a better dural substitute, Xie *et al.* (p 5027) developed scaffolds

from the biodegradable polymer poly(ϵ -caprolactone), which was processed into radially aligned nanofibers through a method called electrospinning. The researchers tested this new material's ability



to interface with natural dura and encourage host cell adhesion and migration. After placing the nanofiber-based scaffold over a small hole cut into natural dura, the researchers found that fibroblasts from the dura migrated along the nanofibers toward the center of the scaffold over four days. In contrast, a scaffold made of randomly oriented fibers showed no fibroblasts after the same time period. Further tests showed that a fibronectin coating enhanced the attachment and migration of seeded fibroblasts. Compared to the current clinical gold standard for dura repair, the radially aligned scaffold showed superior cell migration over seven days. The authors suggest that their novel scaffold could offer a high-performing solution for dural repair to the neurosurgical community.

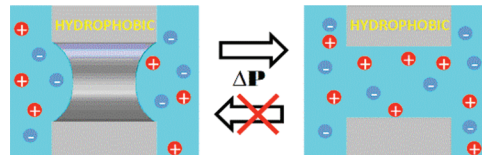
Going with the Flow: Wetting and Drying in Nanopores

Developing materials that mimic biological channels could lead to numerous applications in areas ranging from medicine to fuel cells. Part of this scientific challenge is learning how fluids move through channels on the nanoscale. While this behavior is well understood on the macroscale, theoretical predictions have suggested that it differs substantially in very small channels such as nanopores. For example, some predictions have suggested that water inside a hydrophobic pore spontaneously evaporates if the pore size is sufficiently small.

To understand wetting and drying behavior in very small channels, Smirnov *et al.* (p 5069) used electrical impedance measurements to measure pressure-

induced wetting and dewetting in hydrophobic nanoporous membranes. The researchers used two commercial membranes with 0.2 and 0.02 μm diameter pores and one custom-built 60 μm membrane with 70 nm pores, treating samples of each membrane with one of four types of aliphatic or fluorinated silanes to make their surfaces highly hydrophobic. Tests showed that relatively large pressure, about 3.8 bar, was necessary for water to enter even the largest pores. The researchers found that this pressure substantially increased as pore diameter size decreased. Additionally, the various surface modifiers affected the necessary pressure, with fluorinated surfaces requiring higher pressure than

aliphatic surfaces for water to enter pores. Resistance measurements showed that lowering pressure to atmospheric levels did not lead to water exiting the pores spontaneously except in cases where bubbles were present, caused by situations such as inconsistent cross-sectional diameter or varying quality of hydrophobic modification. The authors suggest that membranes could be engineered to control dewetting behavior.



Patterning Long-Range Nanocrystal Arrays after Nature

Various health and energy applications currently in development have necessitated the search for reliable ways to pattern nanoparticles into two- or three-dimensional nanocrystal assemblies. Composition, size, morphology, and other properties of nanomaterials can be easily tuned, but developing highly reproducible methods to assemble nanocrystals with

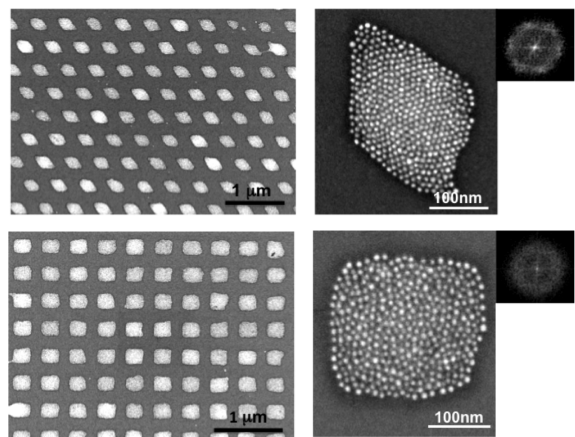
perfect or near-perfect long-range order on substrates has remained a challenge. Though researchers have long relied on kinetically driven evaporation processes to produce highly ordered, close-packed nanocrystal arrays, these methods tend to create local order but not long-range positional order.

Seeking a new way to generate long-range patterns of nanocrystals, Noh *et al.* (p 5076) looked to nature and the way that biomolecules interact. Using a subtraction printing process, the team laid down two-dimensional DNA patterns composed of polyadenine on silicon surfaces, modifying the remaining exposed silicon with hexyltrimethoxysilane to create a highly hydrophobic surface. They then adsorbed gold nanocrystals conjugated with polythymine,

the complementary DNA base to adenine. After thermal annealing for several hours, scanning electron microscopy revealed well-ordered arrays of hexagonally packed nanocrystals on the patterned DNA. The researchers suggest that this packing is due to the surface-bound polyadenosine strands acting as bridging linkers between polythymine strands on neighboring particles because further experiments with random strings of complementary DNA on the surface and nanocrystals led to largely disordered arrays. Significantly more order and sharper boundaries were seen in parallelogram patterns as opposed to square patterns, which the researchers ascribe to energetically favorable hexagonal close-packed orientations being easier to achieve in the parallelogram pattern. The authors note that their new patterning method could eventually achieve more complex nanocrystal arrangements.

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Bright Idea: Light-Emitting Barcodes from Polymer Nanowires

■ The recent explosion of nanotechnology and micro- and nanoscale biotechnology products for both research and commercial uses has led to the need for ways to identify these items quickly and unfailingly. Much like black-and-white barcodes have been used to identify macroscale commercial products, some researchers have pursued inorganic metal-based or magnet-based nanowires as barcodes for nanosized items. However, these barcodes can lack the flexibility needed to tag products with complex physical shapes.

To solve this problem, Park *et al.* (p 5155) developed flexible, light-emitting color barcode nanowires (LECB-NWs) made of various light-emitting polymers. Starting with an anodic alumina oxide nanoporous template, the researchers

fabricated these nanowires by alternating the electrochemical polymerization of three different polymers: poly(3-butylthiophene) (P3BT), poly(3-methylthiophene) (P3MT), and poly(3,4-ethylenedioxythiophene) (PEDOT). The researchers were able to detect differences in photoluminescence between the various polymers using images from a laser confocal microscope and a color charge-coupled device. They were able to enhance photoluminescence by applying a nanoscale Cu metal coating to the nanowires. This coating also extended the stability of the nanowires by protecting them from oxidation. Experiments with a nanopip demonstrated that the polymer nanowires could fold and unfold, showcasing their durability and flexibility. Indi-

vidual nanowires crafted with various colors of light-emitting polymers could be reliably separated in a mixture based on their distinct luminescence characteristics. The authors suggest that such flexible LECB-NWs may eventually be applied to identify products with complex physical shapes at the nanoscale or microscale.

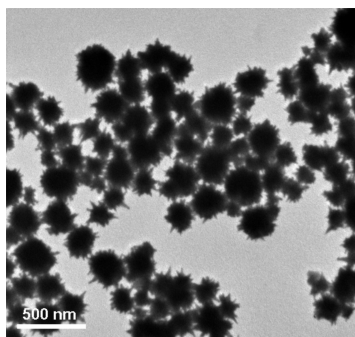


A Gold Star—With a Heart of Iron—For Biomedical Imaging

■ Nanotechnology has brought several promising advances to medicine in recent years, many in the field of biomedical imaging. Both colloidal Au nanoparticles and superparamagnetic iron oxide (Fe_3O_4) nanoparticles are currently being investigated for imaging applications. Au nanoparticles carry high transmissivity through biological tissues and have plasmon resistance at near-infrared (NIR) wavelengths, making them ideal for optical imaging. Fe_3O_4 nanoparticles are useful as contrast agents for magnetic resonance imaging, and they can be steered with magnetic fields to specific sites.

Hoping to take advantage of the qualities of both materials, Song *et al.* (p 5163) created Au nanostars (NSTs) with Fe_3O_4 cores. The researchers synthesized the NSTs using a multistep method, starting

with iron oxide seeds that aggregated into larger particles. Treating these particles with AuCl_3 and an organic solvent formed an ultrathin Au shell on the outside of each particle. Processing these Au-coated particles in a medium



incorporating micellar cetyltrimethylammonium bromide promoted anisotropic growth, leading to nanostars. Using in-plane magnetic pulses while gathering NIR scattering, the researchers showed that both NSTs and the Au-coated nanoparticles generate frequency-selective optical contrast in different ways: the NSTs appear to modulate polarized scattering with minimal lateral displacement, seen as blinking, while the nanoparticles rely on motion for signal modulation. The researchers demonstrated such magnetomotive imaging in a biological system by allowing macrophages to take up NSTs, showing excellent signal quality and low background noise. The authors suggest that hybrid Au- Fe_3O_4 NSTs and nanoparticles could eventually be a useful addition to the suite of contrast materials used for biomedical imaging.

Ultrathin Electronics Covered with Perovskite Nanosheets

■ As electronics continue to decrease in size, new classes of materials are necessary to continue this downsizing trend. Of particular importance to miniaturizing electronics are capacitor components based on thin dielectric films, a central component to integrated circuits. High dielectric constant, or high- κ , oxides are a promising potential component for capacitors, and several current research

efforts are focused on developing new versions of these materials that offer high capacitances and low leakage currents at several nanometer thickness. Some groups have directed their research toward perovskite oxide thin films, but these materials often yield dielectric constants an order of magnitude smaller than bulk material. This problem is typically blamed on a low- κ interfacial dead layer, caused by either degradation of the film/electrode interface or incomplete screening of the dipole charges by electrodes.

Seeking to develop a new high- κ oxide material without this issue, Osada *et al.* (p 5225) created a thin film based on perovskite nanosheets ($\text{Ca}_2\text{Nb}_3\text{O}_{10}$) as building blocks. The team delaminated

layered perovskite and stacked sheets on an atomically flat SrRuO_3 substrate, creating films between 4.5 and 22.5 nm thick. Various microscopy techniques and X-ray diffraction showed highly ordered lamellar structures, and electron energy loss spectroscopy revealed no detectable interdiffusion and strains at the interface between the layers and substrate. Tests showed a high dielectric constant and low leakage current, even in films less than 5 nm thick. The film's superior dielectric and insulating properties suggest that no dead layer exists in this novel material. The authors propose that perovskite nanosheets could open new possibilities for applications ranging from energy storage devices to flexible electronics.

