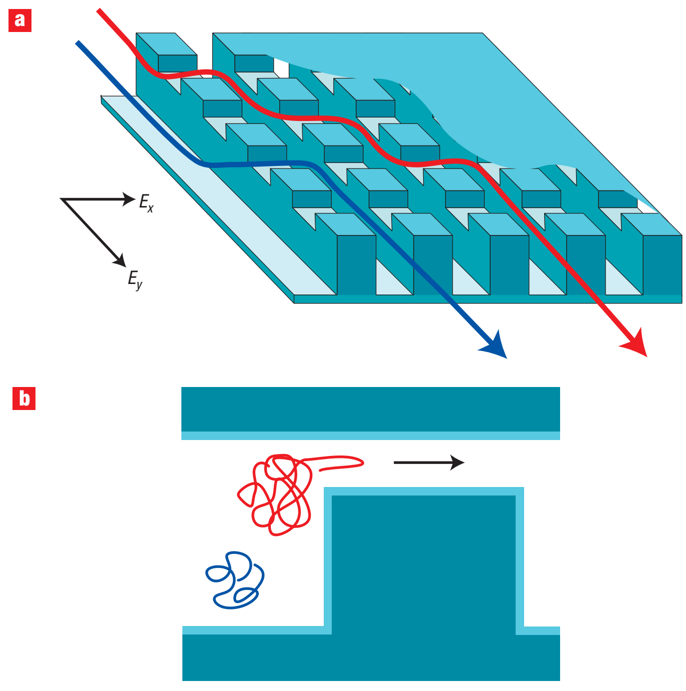

Figure 2 The periodic nanofilter array. **a**, As molecules are driven through the array by the orthogonal electric fields (E_x and E_y) they take different paths depending on how easily they can pass from one deep channel to the next through the narrow channels. In this example, the two paths shown correspond with molecules that have, in relative terms, high (red arrow) and low (blue arrow) probabilities of passing through the narrow gaps. **b**, A cross-section view showing how molecules move from one deep channel to the next through a narrow passage. In this example of an entropic trap, the longer molecule (red) has a greater rate of passage through the constriction than the shorter one (blue) because it has a greater probability of deforming its shape to fit through the gap.

narrower one, the molecules move at angles to the applied field and these deflections are a function of molecular size. This is a key concept: since the molecules fan out as they move, it is possible to run this device in a steady-state mode!

To continue our analogy on how to get to Yogi Berra's house, the side roads can be in various forms of bad shape. They can simply be narrow, and force floppy molecules (like DNA) to be confined. This is the entropic trap. They can be sticky, like a muddy road. This is electrostatic sieving, and charges on the surface of the array walls can be used to sort molecules based on charge. They can be full of potholes that you have to swerve around and this is what we call Ogston sieving, where molecules can be sorted based on their size. Depending on the molecule that one wishes to sort, the side roads can be made to behave in different ways. Because of the rich variety of side roads that can be constructed using nanofabrication techniques, the process described by Han and colleagues can be used to separate a vastly wider range of materials than previous techniques, including proteins.

There is significant potential for further development of this work. In particular, clogging could be reduced dramatically by modifying Han's array to make the size of the asymmetric structures a function of their position on the nanopatterned surface. For example, you could begin with a very coarse asymmetric structure and as you proceed down the flow direction it would only be the smaller objects that are subsequently deflected into ever finer-patterned surfaces. This is a powerful idea.

Although the physics of this concept will be a challenge to develop for all of the objects studied, it is clear that the ideas of broken symmetry, homogenous two-dimensional flow patterns, and generalized entropic forces have been combined to develop a qualitatively new way to separate biological objects over a huge size range in a steady-state manner by fanning them out in space and in time.

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NANOLITHOGRAPHY

Going round in circles

With their unique mechanical and electronic properties, carbon nanotubes are appealing building blocks for the construction of nanoscale devices. Now, in an Olympic feat of nanoengineering, Chad Mirkin, George Schatz and co-workers from Northwestern University in the USA have demonstrated how carbon nanotubes can be bent into circular structures, as shown in this image, using a patterned surface as a template (*Nano Lett.* doi: 10.1021/nl062258e; 2007). Bending nanotubes is of particular interest because it allows their unusual curvature-dependent properties to be studied.

Dip-pen nanolithography was used to coat a gold surface with a monolayer comprising circular islands of hydrophilic molecules surrounded by a sea of hydrophobic ones. When the nanotubes were placed on this surface, they assembled along the boundaries between the hydrophobic and hydrophilic regions, forming circles with diameters as small as 100 nm (although the rings in this image are several micrometres across). The formation process is controlled by two opposing forces — the strain energy involved in bending a nanotube and the van der Waals forces between the nanotube and the molecules on the surface. Although nanotube rings have been made previously, this approach can be used to pattern circles of defined diameters on a surface.

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