During the past few years, the manganites have undergone a second renaissance. These perovskite oxides of manganese first rose to prominence in 1994 when it was discovered that large changes in electrical resistivity could be brought about by an applied magnetic field, a phenomenon known as colossal magnetoresistance. Unfortunately, magnetoresistance effects in the manganites are strongly temperature dependent. This, together with several other factors, has prevented the commercial exploitation of manganites in devices such as disc-drive read-heads. But fundamental and practical interest in the manganites is resurgent once more, because modern imaging techniques have revealed that the electronic and magnetic properties possess spatial variations over a wide range of length scales. These magnetic and electronic textures are poorly understood at present, but by considering the accompanying strain textures, Ken Ahn and colleagues report in *Nature* the basis of a convincing theoretical model for the observed complexities

The occurrence of magnetic and electronic texture in the manganites is exciting because it is unusual for such variations to occur in a continuous crystal lattice. A single crystal of a simple metal such as aluminium, for example, is homogeneously metallic throughout. But, in the manganites, valence electrons associated with manganese can become mobile and spin-aligned in some regions of a crystal, yet immobile and anti-aligned with each neighbour in other nearby regions of the same crystal. Consequently, within the same crystal there can be regions that are conducting and ferromagnetic, juxtaposed with regions that are insulating and antiferromagnetic. When the distances over which such variations occur is somewhat below a micrometre, this behaviour is referred to as phase coexistence (much like the coexistence of water and ice at $0^\circ$C). But, when these variations occur over much smaller distances, measured in nanometres, such behaviour represents mesoscopic texture within a single thermodynamic phase.

Figure 1 Three ways of creating nanoscale features. a, In a top-down process, material is removed from a monolithic entity resulting in the nanostructure. The example shown relates to a lithographically patterned resist mask that protects parts of a thin film during ion-milling. When the mask is later dissolved, the protected regions of the film remain. b, In a bottom-up process, building-blocks organize to form the nanostructure. The example shown relates to functionalized molecules coming out of solution to bind with a lithographically defined template such as gold. c, In a ‘Third Way’ process, the nanostructure is created within a homogeneous medium. The example shown describes how one might write patterns by locally addressing a film with electromagnetic radiation. This is reasonable given that an X-ray beam can alter the magnetic and electronic structure of a manganite.

**The third way**

The emergence of nanoscale features — such as magnetic and electronic patterns — in materials that are otherwise homogeneous provides a potential alternative to conventional top-down and bottom-up fabrication techniques. The way these features arise in manganite crystals is contentious, but could be explained using elasticity theory.

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**NEWS & VIEWS**

The interest in mesoscopic texture in the manganites is more than academic. To continue to miniaturize transistors beyond the limitations of silicon for the computers of tomorrow, it is necessary to look at nanostructures based on alternative materials to silicon. The manganites provide an interesting test-bed for this purpose, because by controlling the mesoscopic textures one can dream of a nanotechnology in which self-organized functional structures are fabricated within homogenous media. This approach would contrast existing top-down and bottom-up syntheses (Fig. 1).

The model constructed by Ken Ahn and colleagues captures a key aspect of manganite physics by creating an energy landscape based on spatially varying short- and long-range strain fields that are explicitly coupled to each other. Tracking the evolution of various initial strain-field configurations (towards lower-energy states) yields a rich tapestry of behaviour in which distorted regions coexist with undistorted regions. The electronic structure of the system can be plausibly inferred from this energy landscape, with distorted regions being electrically insulating and undistorted regions being metallic. Moreover, the length scales spanned by these coexisting regions can be controlled to match those observed experimentally.

In any given run of the computer simulations of Ahn et al., the length scale of the resultant texture is controlled by varying an elastic constant in the expression for the energy landscape. This varies the depth of the local energy minimum associated with the locally undistorted state. If the elastic constant is small, then the locally undistorted state occupies a shallow minimum resulting in mesoscopic texture, as seen experimentally using scanning tunnelling microscopy (Fig. 2a). However, if the elastic constant is larger, the locally undistorted state will occupy a deeper minimum resulting in submicrometre texture, as seen experimentally using magnetic force microscopy (Fig. 2b) and transmission electron microscopy (Fig. 2c). In this latter scenario, phase coexistence was not automatically forthcoming in the simulation by Ahn and colleagues because of a lack of nucleation events. This may be a consequence of the theorists’ crystals being too clean in comparison with real-world samples, which always contain some impurities that can seed nucleation events.

Intriguingly, the images generated by the strain-based model bear striking similarities to their experimental counterparts. The atomically sharp phase boundaries generated by the simulations are seen in scanning tunnelling microscope images of a single crystal of (Bi,Ca)MnO$_3$ (Fig. 2d). And the nanoscale droplet pairs with opposing strain fields that arise during nucleation are reminiscent of the micrometre-sized magnetic domain pairs seen in epitaxial 

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How do you make a parcel on a nanoscale, wrapping a molecule up in a robust package that will somehow unwrap itself when the molecule is needed? This is a trick that would be very useful for drug and gene delivery. As is often the case, nature has perfected some impressive ways of doing this, not always with benign results. For example, in viruses, delicate nucleic acids are wrapped up in a robust protein coat, which releases them at the correct moment to infect cells. In this issue of Nature Materials, Enrico Bellomo et al. report a synthetic approach to molecular delivery that mimics some aspects of these biological mechanisms.

The starting point for synthetic molecular delivery systems are the liposomes—the prominent selling-point of many implausibly expensive beauty creams and lotions. The building unit for a liposome, or lipid vesicle, is a lipid bilayer. Lipids are amphiphilic molecules like soaps, in that one end of the molecule is hydrophobic, with the other end hydrophilic. The geometry of a lipid molecule is such that they self-assemble into bilayer sheets. A liposome is the roughly spherical bag that is obtained when a lipid bilayer folds back on itself to make a closed surface. The water inside the closed surface is completely cut off from the outside world, and a molecule trapped inside the liposome is effectively isolated.

Lipid vesicles are well known, and relatively easy to make from cheap ingredients (despite what cosmetics companies would have us believe). But they are not very robust; their walls are as thin and insubstantial as a soap bubble. An altogether more useful product is obtained if the lipid is replaced by a block copolymer. A block copolymer is the polymeric analogue of a lipid, with two or more blocks having different water affinities covalently linked together: if the architecture is correct, copolymers will self-assemble, like lipids, into sheets, and these sheets can be persuaded to fold over into bags or vesicles. The walls of these polymer vesicles

![Figure 1](https://example.com/figure1.png)

**Figure 1** Smart drug carriers. a, The block copolymeres synthesised by Bellomo et al. self-assemble into a trilayer vesicle structure made of hydrophobic helices (in blue) exposed to the water outside and inside the vesicle, and hydrophilic helices (in red) in the middle. If the pH is lowered, the hydrophobic groups become positively charged and they change their conformation from helical to random coil. b, This perturbs the close packing of the vesicle wall and disrupts it, allowing drug molecules (the green spheres) to escape. Drug release can therefore be easily controlled through a change in pH.