Seeing the matrix

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In animal tissues, the extracellular matrix (ECM) is, as inferred by its name, the area outside cells that forms a framework for connective tissue. It is largely made up of proteins, gives support to cells, and has a vital role in processes such as cell migration, stem cell differentiation and cancer metathesis. Established methods to observe the ECM have tended to focus on components within it; however, Klaus Müllen and colleagues have now designed a fluorescent macromolecule that can specifically stain animal tissue so that the microstructure of the matrix can be visualized at high resolution. The dendritic macromolecule has a core of aromatic groups surrounded by a flexible polymer shell with multiple amine functions at the chain ends. As it is positively charged, the molecule binds directly to the negatively charged ECM. When bound, the emission intensity of the dye increases significantly. Müllen and colleagues show that the method can be used alongside antibody staining, making it a promising way to label and monitor the ECM.

Look very carefully

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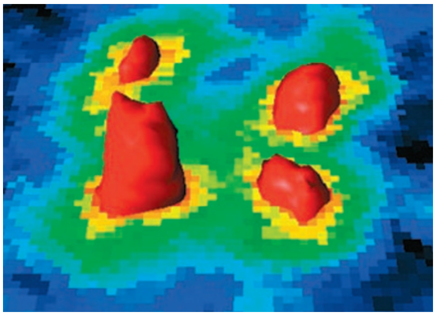
The origin of room-temperature ferromagnetism in oxides is still a matter of debate. Is ferromagnetism an intrinsic feature of these materials or does it arise from small ferromagnetic portions (secondary phases)? Various theoretical studies and conflicting experimental results have produced considerable confusion. Tiffany Kaspar and co-authors have now shown how difficult and misleading the interpretation of experimental results can be. Their Co-doped ZnO films become weakly ferromagnetic after annealing in Zn vapour. Standard characterization, including X-ray absorption and diffraction techniques, do not reveal any secondary phase. But a more careful analysis by X-ray photoemission spectroscopy actually shows the presence of 3% of the Co as part of the intermetallic phase CoZn. The amount of CoZn is not detectable by standard crystallographic techniques. And yet, the magnetic signal that it generates is comparable to the one measured, implying that the ferromagnetism is not at all intrinsic in the annealed films. The message is clear: look very carefully for secondary phases before concluding that a ferromagnet is intrinsic.

A coupling, indeed



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One of the most intensively studied multiferroic materials is $BiFeO_3$, mostly because it shows room-temperature multiferroic coupling with a large spontaneous electric polarization. Although the material has been known to be magnetoelectric since the 1960s, actual evidence of multiferroic coupling in bulk material has been missing, mainly owing to the lack of suitable high-quality crystals. Having achieved the growth of high-quality $BiFeO_3$ crystals, Delphine Lebeugle and co-workers now report on a neutron diffraction study into the coupling between magnetic and ferroelectric properties of $BiFeO_3$. They find that although the material has no linear magnetoelectric effect, the antiferromagnetic moments form a low-pitch spiral that creates an efficient multiferroic coupling. However, a more efficient switching of magnetic properties can be achieved not through a direct multiferroic coupling but if the antiferromagnetic moments of $BiFeO_3$ are used to switch the magnetic moments of a ferromagnet through the exchange interaction at the interface between the two materials. Therefore, an electric field applied to $BiFeO_3$ indirectly switches the ferromagnetic state of the adjacent layer, as has been demonstrated recently.

DNA sensor

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The potential for a label-less and portable DNA detector is described by Andrew Price and Daniel Schwartz. The DNA is sensed by monitoring the birefringence — differences in refractive index of light parallel and perpendicular to the bulk molecular orientation — of liquid crystals (LCs) on hybridization of DNA to a cationic surfactant adsorbed at the LC/aqueous interface. This results in the LCs orienting to form a homeotropic (untilted) alignment. When DNA hybridizes to the cationic surfactant, the LCs realign to an intermediate tilt angle. This change in orientation of the LCs, and therefore the birefringence, results in an optical signal that can be monitored using polarized light microscopy. The cationic surfactant is thought to neutralize electrostatic repulsion and allow hydrogen bonding between DNA molecules. The response of the LCs to the DNA was such that a concentration as low as ~50 fmol could be detected; the system could even differentiate a mismatch of one base-pair in a 16-base-long DNA.

Building bones

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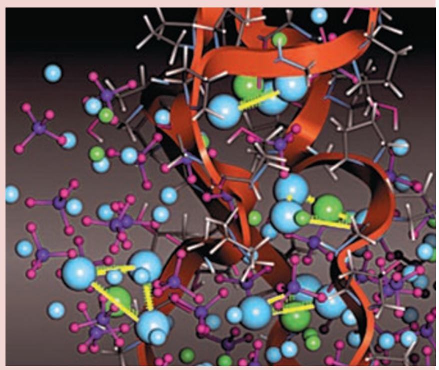

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Bones and teeth are made from composites of the calcium phosphate mineral apatite and the protein collagen. The mechanism by which these complex materials are formed in nature is not well understood. Although electron microscopy has revealed insights on the mesoscale, information on the atomic scale is still required. Dirk Zahn, Rüdiger Kniep and colleagues from the Max Planck Institute for Chemical Physics of Solids, Dresden, have now used atomistic simulation to study the phenomenon. In spite of the computational complexity — modelling 160 ions took several 'computer years' — Zahn and co-workers discovered that collagen aids in the formation of a particular Ca_3F motif. None of these structures were formed during simulations that did not contain collagen. Further evidence for the importance of the protein–motif interaction comes from the fact that collagen helices align in the direction of apatite's *c*-axis, where the many Ca_3F triangles are staggered. There are many other possible motifs that can be adopted by the ions that make up apatite, but nature's choice of Ca_3F triangles leads to controlled collagen–apatite composites.