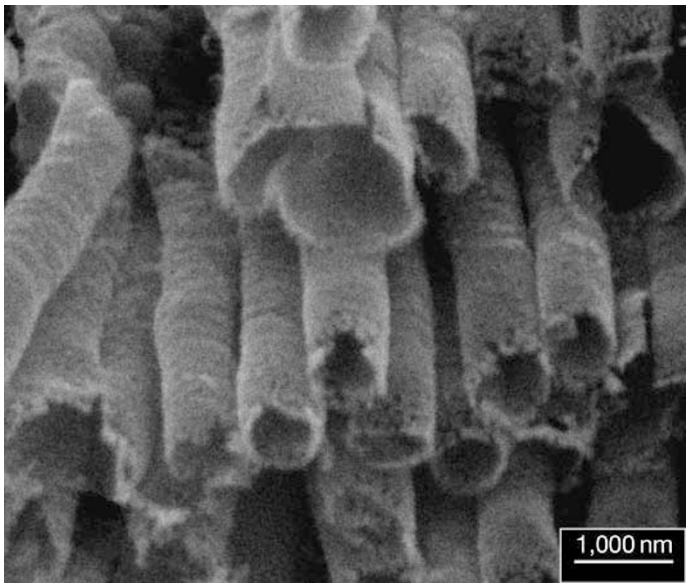

Figure 1 **Going inorganic. Levy and colleagues[1] made these inorganic nanotubes from lanthanum–praseodymium–calcium manganite. The changing electrical resistance of this material in a magnetic field suggests that such nanotubes could be usefully applied in nanotechnological devices, such as fuel cells.**

science also allow the fabrication of inorganic tubular nanostructures. As with the multi-wall carbon nanotubes, no key length scales are probed, but there is, again, the promise of technological applications. Good examples are the piezoelectric nanotubes made from complex oxides such as barium titanate[5,6] and strontium–bismuth tantalate[7]. 'Piezoelectric' means that these polycrystalline tubes can be strained when an electrical voltage is applied, and vice versa. Each tube could be triggered individually to release a small quantity of ink for ink-jet printing, or to deliver drugs into a patient. Sensor, actuator and data-storage applications are also possible.

The excitement generated by piezoelectric nanotubes has now inspired Levy *et al.*[1] to emulate the same growth technique using a different and resurgent class of oxides. Manganites are complex oxides that adopt a pseudo-cubic perovskite crystal structure. Half a century ago, it was found that an applied magnetic field could significantly change the electrical resistance of these materials[8], but it is only in the past decade that these 'magnetoresistance' effects have been studied in detail. The catalyst for this activity was the discovery of colossal magnetoresistance in a thin film[9], just as thin-film magnetoresistance effects were making the transition from the laboratory to application in read heads for computer disk drives.

To fabricate their nanotubes of lanthanum–praseodymium–calcium manganite, Levy *et al.* first made a porous template by chemically etching films of mylar and polycarbonate that had been bombarded with heavy ions. They then introduced a precursor solution into the (wetted) pores, and achieved crystallization by heating the template. Microstructures comprising long, thin-walled nanotubes formed spontaneously (Fig. 1). Through various structural characterization techniques, Levy *et al.* confirmed that each tube is composed of manganite nanocrystals. Moreover, rough estimates of the magnetic properties match those expected for bulk samples of this manganite.

How might manganite nanotubes impact on technology? One possible application is in solid-oxide fuel cells. A fuel cell differs from a battery in that reactants may be continuously fed into it and exhausted. The microstructure demonstrated by Levy *et al.* immediately suggests a means by which gases may be efficiently distributed in such a cell. And as manganites conduct both electrons and oxygen ions, and are resistant to high-temperature oxidizing environments, they make good cathodes.

More speculatively, nanotubes made from metallic manganites could act as highly localized sources of electrons possessing spins of a particular orientation. This is possible because the spins of the conduction electrons in manganites can be aligned perfectly, whereas in ordinary magnetic metals such as cobalt the alignment is only partial. It is possible to imagine the nanoscale engineering of electronic circuits in which the spin of electrons, as well as their charge, could be manipulated with precision — a valuable capability for spin-sensitive scanning probe microscopy, and perhaps, ultimately, quantum computing.

Nanotube structures may also offer a means of tuning the strong interactions that exist between the magnetic, electronic and crystal structures of a manganite. These interactions generate rich phase-coexistence phenomena over a wide range of length scales, as has been revealed by imaging methods[10]. For example, a ferromagnetic metallic phase may coexist with an antiferromagnetic insulating phase. In a nanotube, the delicate balance between the diverse phases could be tuned readily through the stresses associated with the unconventional geometry. Exploring the parameter space of chemical

100 YEARS AGO

Elementary Physiology and Hygiene. **This book has obviously been written to supply the wants of the American schoolchild, and consequently "the subject of alcohol has been treated very thoroughly and in full compliance with the laws of the various States." "Throughout the book the effects of alcohol and other narcotics have been discussed in close connection with the accounts of the functions of the body." The above quotations from the author's preface show that it has been a pleasure to him to comply in his book with the law enjoining that all text-books of physiology used in American State schools must contain a description of the effects of alcohol on the body. So thoroughly has this instruction been carried out that it appears on reading the book as if in many cases the very brief descriptions of the physiology of the different tissues had been written chiefly as introductions in order to make clear the dire effects of alcohol, which are subsequently described in each case… Truly this book must be appalling reading to the American schoolchild whose parents may be in the habit of making even moderate use of alcoholic drinks.**

From *Nature* 21 January 1904.

50 YEARS AGO

For the Seventh Arthur Stanley Eddington Memorial Lecture… Prof H. H. Price, Wykeham professor of logic in the University of Oxford, spoke on "Some Aspects of the Conflict between Science and Religion"… Prof. Price argues that of late the main conflict between science and religion has been over two opposed conceptions of human personality, a materialist and a dualist one. On one side, it is held that all mental processes are produced by and inseparable from bodily processes, or else actually are bodily. According to the religious conception, on the other side, some kind of cognition of the divine is possible, which cannot be supposed to have any ordinary physiological correlates, and also some kind of other-worldly existence distinct from the present bodily one. The systematic investigation of the phenomena of para-normal cognition, such as telepathy, clairvoyance and precognition, has made the materialist conception far less plausible, if not untenable. A dualist type of theory… can no longer be dismissed as unscientific and superstitious.

From *Nature* 23 January 1954.