Back to the chloride channel

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THE product of the gene that is defective in cystic fibrosis may be a chloride channel. This is the implication of new work, reported by Anderson *et al.*¹ in *Science*¹ and by Kartner *et al.* in *Cell*², showing that expression of the cystic fibrosis gene in non-epithelial cells endows them with a plasma membrane Cl^- conductance that can be switched on by cyclic AMP. Activation of epithelial cell Cl^- channels by cAMP is widely recognized as the primary cellular defect in patients with cystic fibrosis. Because the authors demonstrate that such a conductance can be conferred on non-epithelial cells by expression of the cystic fibrosis gene product, they make

the simplest interpretation — that the protein itself is the Cl^- channel activated by cAMP.

The idea that the cystic fibrosis gene encodes a regulated Cl^- channel emerged when it was shown that Cl^- channels in cell-free membrane patches could be activated by protein kinases in normal cells but not in cells from cystic fibrosis patients (reviewed in ref. 3). A defect in the regulation of Cl^- secretion by cAMP had been previously found in sweat gland, airway and intestinal cells from cystic fibrosis patients⁴. The simplest explanation of the single-channel studies was that the cystic fibrosis gene product is a kinase-

activated Cl^- channel. But when the cystic fibrosis gene was eventually cloned and sequenced, it was found that the predicted primary structure of its product, CFTR (for cystic fibrosis transmembrane conductance regulator), did not resemble known ion channels already known. Rather, CFTR shared homology with a group of diverse ATP-driven solute pumps, fuelling speculation that CFTR might actively transport a regulatory molecule rather than serving as a Cl^- channel⁵. This broader view was able to explain alterations in other epithelial cell functions that are associated with cystic fibrosis, such as enhanced airway absorption of sodium ions and changes in mucin chemistry. Indeed, the fact that CFTR did not look like an ion channel even raised doubts about the primacy of the Cl^- channel defect in cystic fibrosis. ►

HIGH-TEMPERATURE SUPERCONDUCTORS

Whorls upon whorls

Laura Garwin

THIN films of the high-temperature superconductor $\text{YBa}_2\text{Cu}_3\text{O}_{7-\delta}$ (YBCO) are packed with spiral structures measuring only a few hundred nanometres across. This observation, reported by C. Gerber and colleagues on page 279 of this issue, and independently by M. Hawley *et al.* in this week's *Science* (251, 1587; 1991), sheds new light on how these films grow, and may also reflect on their ability to carry high electric currents.

Superconducting films, grown epitaxially on a crystalline substrate such as SrTiO_3 , are the raw material for superconducting electronic devices. Film deposition is an energetic affair, in which atoms of the material to be deposited are evaporated or sputtered from a target, and encouraged to land on the substrate. Despite the violence of this process, the films so obtained are highly oriented and have smooth surfaces — at least as seen by the electron microscope.

Gerber *et al.* used the scanning tunnelling microscope (STM) to take a closer look at sputtered films of YBCO, and were rewarded with images like the ones shown here and on page 279. Each spiral staircase reveals the presence of a screw dislocation — a line defect in the crystal lattice that creates a step on the surface of the growing film. The dislocations themselves run down the centre of each spiral, and might be invisible even to the STM, were it not for the fact that they have acted as sites of preferential nucleation for the growing film: each spiral grows by the addition of atoms to the edge of the step.

Beyond their mere existence, the number of screw dislocations observed (over 10^9 per square centimetre) is also of interest. It is paradoxical that, for applications, there is nothing worse than a perfect superconductor. Just about all uses for superconductors involve the presence of a magnetic field, which enters the superconductor in the form

of quantized vortices, or 'lines', of magnetic flux. A flowing current exerts an electromagnetic force on these flux lines — a force that dissipates energy if the lines are free to move through the crystal lattice. Only when the flux lines are pinned in place, at grain boundaries or crystal defects, for example, can the superconductor carry a high current.

Gerber *et al.* show that, in low magnetic fields, the screw dislocations pin flux lines

sufficiently strongly to account for the observed high currents. In higher fields, the number of flux lines per unit area exceeds the number of dislocations, so that some other structure must provide additional pinning. Hawley *et al.* suggest that defects at the boundaries between spiral 'islands' could each pin several flux lines.

Both groups anticipate the objection that the microstructure they have observed might be peculiar to their own films, by presenting arguments for its probable generality. Each will surely be happy to see independent confirmation in the week of publication. □

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Growth spiral at the surface of a 130-nm-thick YBCO film. The black spots at the growth steps are holes over 2 nm deep, which have evidently impeded crystal growth.