RÉSUMÉ

Supersalt

It is alleged that a poached egg, sprinkled with ATP, will contract; this is not to say that a poached egg resembles a muscle but rather that a highly charged ion can exercise large electrostatic effects of a non-specific kind. A striking demonstration of this principle now comes from Y. Goto *et al.* (*J. Biochem. (Tokyo)* **109**, 746–750; 1991). Acidified (therefore cationic) apomyoglobin and cytochrome *c* are unfolded, but enter a compact, structured molten-globule state when salt is added. With ATP, the transition has a mid-point below 1 mM. With adenosine tetraphosphate, it is an order of magnitude down, while ADP pushes it up by a similar factor. A Lys–Leu copolymer will undergo a conformational transition at neutral pH at sub-millimolar ATP concentrations. A powerful charge-condensation phenomenon is evidently at work. Those who work histones, protamines and the like should take note.

Young ones

Larger than Jupiter, smaller than the Sun, brown dwarfs are failed stars that may be numerous enough to account for much of the Galaxy's mass. But, despite some false claims, none has been observed. The answer, according to G. S. Stringfellow (*Astrophys. J.* **375**, L21–L25; 1991), is "to catch them while they are hot and young". Although too light to burn through nuclear fusion as do normal stars, brown dwarfs retain the heat from their initial collapse and radiate faintly in the infrared. For old dwarfs, this glow is pretty indistinguishable from that of feeble, very-low-mass stars. But the distinction is sufficient when the objects are newly formed (less than 100 million years old). The place to look, says Stringfellow, is in young star clusters, such as the Pleiades, where all the objects are of a similar age and the most can be made of the distinction.

Toxin two

Those in pursuit of a safe vaccine against cholera may now have to take into account a newly discovered second toxin produced by the causative bacterium, *Vibrio cholerae* (A. Fasano *et al. Proc. natn. Acad. Sci. U.S.A.* **88**, 5242–5246; 1991). Vaccines based on live attenuated strains should be effective if they are deleted in the gene encoding cholera toxin, the substance believed to be responsible for the intestinal damage that characterizes cholera. But Fasano *et al.* now show that strains negative for cholera toxin produce a protein which disrupts the adherent cellular junctions between the cells of the small intestine, and which can still produce mild diarrhoea in volunteers.

SUPERCONDUCTIVITY

SQUIDs in with applications

John Clarke

Since specialists working on superconducting devices last met in Berlin, in 1985, the discovery of the new family of copper-oxide-based, high-temperature superconductors has given great impetus to the field. Indeed, as became clear at the subsequent meeting last month*, progress towards making devices based on these materials and operating in liquid nitrogen at 77 K has been faster than many had expected. Nevertheless, it is devices based on conventional, low-temperature materials that continue to be used in practical applications and that are available in increasingly sophisticated, multichannel systems.

A unifying element for many of the participants was the Josephson junction, a weak link between two superconductors through which supercurrents tunnel quantum mechanically. Hope seems to be fading (Y. Okabe, Tokyo) for high-temperature Josephson junctions with the hysteretic current–voltage characteristics displayed by their low-temperature counterparts and used, for example, in computer logic and memory elements and in the voltage–frequency standard. But there has been much progress towards making nonhysteretic junctions from $YBa_2Cu_3O_{7-x}$ (YBCO) — just the kind needed for superconducting quantum interference devices (SQUIDs). When the d.c. SQUID — two Josephson junctions connected in parallel on a superconducting loop — is appropriately current-biased, the voltage across it depends periodically on the magnetic flux applied to the loop. The period is the flux quantum, $\phi_0 = h/2e$ (h is Planck's constant and e, the electron charge); with the aid of an electronic feedback circuit one can detect changes in flux as small as $10^{-5}\ \phi_0$.

In the first thin-film high-temperature SQUIDs, the junctions were the naturally occurring boundaries between grains with different crystalline orientations. Today, although many junction types have been investigated, the most successful devices operating at 77 K are based on the controlled growth of grain boundaries. In one method R. H. Koch, IBM Yorktown Heights, M. Kawasaki, IBM) a $SrTiO_3$ substrate is cut and fused to produce a bicrystal with a known misorientation across the interface. A film of YBCO grown with its *c*-axis perpendicular to the bicrystal replicates the grain boundary and, patterned into a narrow strip, produces a junction at a prescribed location. F. C. Wellstood (University of California, Berkeley in collaboration with Conductus Inc., Sunnyvale) described a 'bi-epitaxial' process in which a $SrTiO_3$ buffer layer followed by a YBCO film are deposited on a sapphire substrate on which an MgO seed layer has previously been grown and patterned. This process yields a 45° grain boundary at the edges of the MgO, enabling one to place junctions at will.

SQUIDs are very sensitive to magnetic flux, but, especially with the small effective area allowable for thin-film high-temperature devices, not particularly sensitive to magnetic field (flux divided by area). To make a useful magnetometer one has to couple the SQUID to a thin-film 'flux transformer' — a multiturn coil with dimensions to match the SQUID (say 0.25 mm across) connected to a much larger (say 10 mm) single-turn pick-up loop. Wellstood described our 'flip-chip' magnetometer in which the SQUID and flux transformer are on separate chips that are pressed together. At 77 K, the sensitivity is sufficient to obtain a magnetocardiogram.

Koch also reported flip-chip devices, including a planar gradiometer in which there are two pick-up loops of opposite sense making the flux transformer nearly insensitive to uniform fields. However, flip-chips may soon be *passé*. We (the Conductus/Berkeley group) reported an integrated magnetometer in which the flux transformer and SQUID are deposited on a single chip. The device involves seven epitaxial layers, three superconducting and four insulating, indicating that relatively sophisticated high-temperature circuits may not be far away. Nevertheless, the low-frequency excess noise remains distressingly high in high-temperature SQUIDs. This noise is a significant limitation for biomagnetic applications, for which high sensitivity at frequencies around 1 hertz is required.

The moment of truth for biomagnetic applications of low-temperature SQUIDs may already be at hand. Long regarded as the application most likely to have a substantial commercial impact, magnetic measurements of heart and brain function have been slow to gain clinical acceptance. The main drawback, until recently, has been the absence of the multichannel systems necessary for images of magnetic sources with useful spatial resolution. But no fewer than eight groups — four of them commercial — now produce magnetometers with 24–38 channels, all based on niobium, which has become the preferred low-temperature material. S. Schneider (Siemens) described a study of 20 epileptic subjects in whom the epileptic centre was located magnetically. Of these, 17 were treated with a γ-ray knife and 14 were cured.

Needless to say, SQUIDs were by no means the only practical devices of interest. A high-temperature flux-flow transistor has been devised with a gain and sensitivity that, at microwave frequencies, are competitive with semiconducting devices (Martens, Los

* *SQUID '91*, Berlin, 18–21 June 1991.