MUSCLE

# Regulating the Scallop

from our Molecular Biology Correspondent

ONE of the most interesting developments in muscle biochemistry in recent years is the partial resolution of the regulatory machinery, which enables the myosin ATPase to respond to small changes in the concentration of calcium supplied by the sarcoplasmic reticulum. In the mammalian systems, on which most of the work until just now has been done, the site of regulation is in the thin filaments, the effect of the calcium, which binds to one of the troponin subunits, being transmitted by way of the other troponin components and tropomyosin to the actin. This causes a change in the affinity of the actin for the myosin heads, reaching out towards it from the thick filaments. Szent-Györgyi and his colleagues have been looking at the muscles of more primitive creatures, and here it seems that regulation is encompassed in a totally different manner, and operates not at the thin filaments but rather the myosin heads. Szent-Györgyi, Szentkiralyi and Kendrick-Jones (*J. Mol. Biol.*, **74**, 179 ; 1973) now unfold a remarkable story concerning the mechanism of regulation of scallop muscle.

Fortune has to an extent favoured them, for the wily scallop has incorporated a regulatory subunit into its myosin, which, unlike the minor chains of numerous other myosins that have been looked at, can be removed without reducing the protein to an enzymatically inert porridge. The myosin extracted from scallop muscle is superficially indistinguishable from that of mammals: its hydrodynamic and optical rotatory properties are the same, and so is its length in the electron microscope, as well as the segment long spacing in fibres. When exposed to proteases under the right conditions it gives rise to enzymatically active soluble fragments, corresponding to heavy meromyosin and subfragment-1 (or isolated heads). Also like rabbit myosin, it contains light chains, which in SDS-gel electrophoresis come out at a molecular weight of about 18,000, and in a ratio of three chains per myosin molecule.

There are, it turns out, two types of light chain in the scallop, one of which contains cysteine and is present in a ratio of two copies per myosin. The other, of which there is only one copy per myosin molecule, is dissociated when EDTA is added to sequester divalent metal ions. It is this molecule which is the "regulatory subunit", in that it confers calcium response on the myosin. Thus, the ATPase activity is unaffected by the addition of calcium ions when the critical light chain has been stripped off, whereas the ATPase of intact myosin with its complement of light chains is strongly inhibited by removal of calcium. When the preparation of light chains is added back to the stripped myosin, the calcium sensitivity is restored. The stripped myosin still binds calcium, but binding plots indicate that probably one site has been lost. The light chain is not of itself, however, capable of taking up calcium. The other (cysteine-containing) light chains remain firmly stuck to the myosin, and their removal by more drastic methods leads to irreversible denaturation.

The independence of the thick and thin filament-dependent regulation mechanisms is spectacularly demonstrated by the interaction of the desensitized scallop myosin, denuded of its regulatory light chain, with the rabbit actin-tropomyosin-troponin system, with which it combines just like rabbit myosin to give a fully calcium-regulated actomyosin. This points again to the evolutionary stability of actin compared with myosin, at which evolutionary pressures are evidently mainly directed. Rabbit myosin will induce a high and calcium-independent ATPase activity in a mixture of actin with excess scallop myosin. It seems therefore that when there are no calcium ions about, the scallop myosin does not combine with actin, so that the actin filaments are available for reaction with a competing species. Neither, in consequence, is the ATPase of the scallop myosin stimulated by actin in the absence of calcium. Like the regulatory protein system of mammalian thin filaments, then, the sensitizing subunit of the scallop myosin blocks the interaction with actin. The oddest aspect of this engrossing story is the stoichiometry. In principle it is possible, with the aid of some allosteric hand-waving, to explain the calcium response of a system bearing a regulatory subunit on only one myosin head. The authors eschew such intellectual contortions, and postulate instead that the regulatory chain physically links the two heads, and functions only when so located. In support of this kind of scheme is the finding that active isolated heads (8–1) from the scallop myosin contain the regulatory light chain, but have no calcium sensitivity.

A curious twist to the picture of regulation in mammalian muscle emerges from an observation by Bailin and Bárány (*J. Biol. Chem.*, **248**, 373 ; 1973), who find that rabbit myosin, dinitrophenylated to the extent of 1.5 modifying groups per molecule, displays no calcium sensitivity in its complexes with actin, tropomyosin and troponin. Partial removal of the dinitrophenyl groups leads to reappearance of calcium sensitivity. This seems to indicate that the myosin when modified no longer recognizes the difference between the inhibiting and non-inhibiting states of the thin filaments.

SOLAR SYSTEM

# Primordial Field

from our Geomagnetism Correspondent

THE strength of the interplanetary magnetic field is now of the order of tens of gammas. But has it always been so? And in particular, was it quite so low at the time of the origin of the Solar System? In the absence of any other information, it is often taken as axiomatic that the interplanetary field has always been negligible ; but Sonnet *et al.* (*Astrophys. Space Sci.*, **7**, 446 ; 1970) have postulated otherwise, and primordial magnetic fields of the order of 1 oersted ($10^5\gamma$) are apparently required by the cosmological theories of Fowler *et al.* (*Geophys. J.*, **6**, 148 ; 1962).

In principle, it should be possible to determine the intensity of the primordial interplanetary field from carbonaceous chondritic meteorites, for Banerjee and

# Drag Reduction for a Rotating Disk

ALTHOUGH drag reduction in turbulently flowing liquids containing small amounts of polymers like polyacrylamide is fairly well investigated, both practically and theoretically, it is the possibility of drag reduction under conditions of laminar flow that is in many ways of particular interest. For one thing laminar flow is more commonly encountered than turbulent flow.

In next Monday's *Nature Physical Science* (March 12) Kale, Mashelkar and Ulbrecht show that drag can be reduced when a disk rotates under laminar conditions in an appropriate polymer solution. What they have done is to investigate the relationship between torque and angular velocity for disks between 7.5 and 15 cm in diameter in solutions of carboxy methyl cellulose—an inelastic fluid—and in three solutions of polyacrylamide of varying strength. It turns out that for a given angular velocity (plotted by Kale *et al.* as a moment coefficient) the torque is significantly reduced in the case of the polyacrylamide solutions.

Kale and his colleagues draw attention to the fact that others have shown drag reduction in laminar flow to be possible in situations like flow in a curved tube and flow round a sphere, but they place their own work firmly on a practical footing when they say that "for centrifugal pumps with enclosed disk-type impellers there is likely to be a better pumpability with viscoelastic liquids".

Hargraves (*Earth Planet. Sci. Lett.*, **10**, 392; 1971) recently showed that some such chondrites contain a moderately strong and stable natural remanent magnetization (NRM). In this branch of geophysics, of course, the gap between principle and practice can be quite wide, as the difficulties in obtaining palaeointensities from even very young terrestrial rocks prove. Nevertheless, both Banerjee and Hargraves (*Earth Planet. Sci. Lett.*, **17**, 110; 1972) and Butler (*Earth Planet. Sci. Lett.*, **17**, 120; 1972) have independently succeeded in determining at least minimum intensities of the primordial field and find them to be several orders of magnitude higher than commonly supposed.

Banerjee and Hargraves have used the Orgueil, Murchison and Allende meteorites which are carbonaceous chondrites representative of Wiik's (*Geochim. Cosmochim. Acta*, **9**, 279; 1956) Types I, II and III respectively. The principal field determination was carried out using a modified form of the Thellier method (backed up by thermomagnetic, opaque mineralogy and electron probe microanalysis studies) to assess stability and identify the magnetic carriers. The Allende chondrites proved to be the most stable magnetically (thus giving the most reliable data), the magnetic carriers being very fine single-domain grains, probably of NiFe. Even so, only temperatures up to 135° C could be used for the intensity determination because of thermally-induced chemical changes at higher temperature. The result of four determinations on two samples was an average palaeointensity of 1.09 oersted. The Murchison and Orgueil chondrites were relatively less stable, the usable temperature ranges being lower. Average palaeointensity values from these were 0.18 oersted and 0.67 oersted, respectively.

Butler has concentrated solely on the Allende meteorite and finds an average ancient field strength of 1.1 oersted. In a situation fraught with so many practical problems, such agreement is startling and, as Banerjee and Hargraves admit, must be regarded as fortuitous. The order of magnitude agreement is, however, important. Moreover, there are other reasons for regarding exact values with some caution. For example, the intensity determination methods used are based on the assumption that the NRM of the samples is TRM (thermoremanent magnetization). In the case of the Allende chondrite there is convincing evidence that this assumption is warranted, although in the other examples the validity is less secure. The point to bear in mind here is that TRM is the most effective magnetization process, so that if other processes were responsible for the magnetization the obtained palaeointensities would be underestimates. In other words, the values derived by Banerjee and Hargraves and Butler are at least minimum values.

Because there is no evidence to suggest that the Allende chondrite has been reheated since its formation (indeed, there is evidence to the contrary), the conclusion must be that magnetization took place in a field at least $10^4$ times higher than the present interplanetary field and of the order of magnitude of the present terrestrial surface field. This presumably refers to $4.44 \times 10^9$ yr ago, the potassium-argon age of the chondrules in the Allende meteorite. As Butler points out, however, alternative interpretations are possible. The strength of about 1 oersted only applies to the ancient interplanetary field if the Allende was actually magnetized in that field. It could, of course, have acquired its magnetization in the field of its parent body. In this case, the parent planet would have required an extremely high magnetic moment at a very early stage in the formation of the Solar System.

SEMICONDUCTORS

# What is New?

from a Correspondent

THE opportunity for asking this question was afforded by the celebrations in connexion with the twenty-fifth anniversary of the transistor and, in particular, in a symposium held by the Institution of Electrical Engineers in London on February 14. A small exhibition of the development of the transistor is open at IEE headquarters and is worthy of a visit.

The symposium did not forget the social aspects of the invention of the transistor, which were reviewed by Professor W. E. Farvis (University of Edinburgh); but the technical contributions and the lively discussion which followed concentrated rather on the question of the next step in the field of electronic devices. The five invited speakers were all members of research laboratories attached to leading British semiconductor manufacturers and they were all clearly adept at presenting the potential profitability of their ideas for new developments to their financial managers. They thus had an interest in presenting at least an appearance of hard-headedness. Although this rather limited the distance of the look forward and inhibited the range of an otherwise lively discussion, it allowed a firm and highly informal contemplation of the next stages in silicon technology.

The first talk was perhaps an exception to this generalization. Dr J. Evans (Standard Telecommunications Laboratories) talked about new materials and the new electronic functions which they might perform in the future. He began with an account of the versatility of gallium arsenide, which was at first used as a material for bipolar transistors but has now unexpectedly found application in light-emitting devices and as a microwave oscillator and a field-effect transistor. He held this up as an example of how to pick new materials

# Soft X-ray Structure of Cassiopeia A

OBSERVATIONS of Cas A from Copernicus are reported in next Monday's *Nature Physical Science* (March 12) by Fabian, Zarnecki and Culhane. The diagram shows an X-ray contour map of the source in the energy range 1.4 to 4.2 keV, superimposed on the Uhuru error box for the source 2U2321 + 59. Clearly, the two objects are the same, as was already suspected.

The detail shown in the contour map is reminiscent of the first radio contour maps obtained of this source, and the overall distribution of X-rays is best explained by an annular source of outer diameter $5.5 \pm 1.5$ arc min and inner diameter $2.0 \pm 2.0$ arc min—this is definitely not a compact source of X-rays, even though it might have been expected that a collapsed object would have been left at the centre of this supernova remnant, which is only about 300 years old. "The data are suggestive", say Fabian *et al.*, "of a shell source" in which X-ray generation occurs either through thermal bremsstrahlung from a blast wave or through the synchrotron process.

Much remains to be discovered from further detailed studies of the source; it is particularly interesting to compare the present X-ray observations with early radio maps of Cas A and with the best detailed map now available, made at 2.7 GHz, which the MSSL team reproduce in their article. If the accuracy of X-ray astronomy proceeds at the present pace, it may not be long before comparable high resolution X-ray maps of Cas A and other extended objects are available.