of higher organisms. To what extent then are Stiefel and Watt justified in designating their molecule a bacterioferritin?

Ferritin from animal or plant sources is a molecule of potentially high but variable iron content (up to at least 30% by weight or over 4,000 Fe atoms per molecule) held within a protein shell. Its iron is in the form of 'micelles' or microcrystals of hydrous-ferric-oxide-phosphate, which can be seen in the electron microscope without staining or shadowing as particles of about 60 Å diameter. This property of ferritin enables it to be recognised within cells and it has been used as a marker for other molecules tagged to it. It has been shown in several species that iron stimulates the biosynthesis of ferritin: protein subunits assemble to form shells, which accumulate iron. A recent high resolution electron density map of horse spleen apoferritin (Banyard, Stammers & Harrison *Nature* **271**, 282; 1978) shows the molecule as a symmetrical assemblage of 24 subunits each of 18,500 molecular weight with high helix content giving an outer diameter of 130 Å. The structures of several other crystalline ferritins are very similar, but some animal and plant ferritins may be larger. Mössbauer spectroscopy of horse spleen ferritin provides evidence of anti-ferromagnetic ordering within the iron cores at low temperatures, the ordering temperature depending on iron content and particle size.

The 'bacterioferritin-cytochrome' of Stiefel and Watt has an iron content of 13–20% by weight, a subunit weight of 17,000, a molecular diameter comparable to that of animal ferritin and an electron-dense core of 55 Å. Its magnetic susceptibility and temperature-dependent Mössbauer spectra establish it as containing weakly-coupled high-spin Fe^{III} reminiscent of ferritin iron. However, the presence of protoporphyrin IX (one per two protein subunits) is distinctive and the potential required to reduce both forms of iron is more negative than that for horse spleen ferritin. Moreover, the bulk of the Fe^{II} is retained inside the molecule on gel filtration, whereas it is more readily lost from the horse spleen protein, presumably diffusing out of the molecule through channels in the protein shell seen in the electron density maps. Stiefel and Watt have considered the possibility that their 'bacterioferritin' may act as an electron store or as a specific iron-storage depot for the iron-containing protein nitrogenase.

At a recent meeting on Proteins of Iron Metabolism* Bauminger, Cohen, Levy, Ofer and Yariv of the Hebrew University, Jerusalem, described evidence for the presence of a new type of iron-storage compound in *E. coli* grown on ^{57}Fe-enriched media. Mössbauer spectra of packed cells showed the presence of high spin Fe^{III} with evidence for magnetic ordering below 2.6 K. An iron-rich protein, of approximately 300,000 molecular weight containing electron-dense particles was isolated and gave Mössbauer spectra similar to those of the whole cells, but this soluble protein accounted for only about 1% of the iron content of the whole cells grown on the most iron. These workers consider the pure protein from *E. coli* to be quite distinct from ferritin. They report similar ^{57}Fe spectra from *Proteus mirabilis* and *Mycoplasma capricolum*. This suggests that the requirement for an iron-storage molecule may be universal.

A similar molecule may also be present as a minor component of a freshwater magnetotactic spirillum in which most of the iron (1.5% of the cell dry weight) is present in chains of magnetite crystals (each about 100 nm across), which account for the alignment of these organisms in the geomagnetic field (Frankel, Blakemore & Wolfe *Science* **203**, 1355; 1979).

It is not yet clear how similar the *E. coli* protein is to that from *Azotobacter vinelandii*, although the chromophore in addition to the non-haem iron also seems to be present in the *E. coli* protein. Fortunately both proteins have been crystallised and the results of further structural studies are eagerly awaited as well as those of biochemical studies which may more clearly establish their biological roles and their resemblance to and differences from ferritin. □

*Held at Davos, Switzerland on 17–21 April, 1979.

Pauline M. Harrison is a Professor in the Department of Biochemistry at The University of Sheffield.

Errata

In the article 'Acetylcholine receptor clusters' (*News & Views*, **278**, 599; 1979) a line was omitted from the second paragraph, third column, page 599. The sentence beginning on line 12 of that paragraph should read "After the initial stage of cluster formation, the appearance of *new hot spots in the absence of* a nerve fibre has not been observed on morphologically stable muscle cells."

In the footnote to the article 'Membranes and Parasites' (*News & Views* **277**, 12; 1979) it should be noted that the Special Programme for Research and Training in Tropical Diseases is sponsored by The World Bank, The United Nations Development Programme and the WHO.

Actinide magnetism: an extraordinary tale

from Gillian Gehring

SOME intriguing experiments on the magnetic properties of actinide intermetallics containing uranium have produced results which cannot be explained by any of the standard theories of magnetism. The most anomalous material is USb (uranium antimonide) which has been extensively studied by Lander *et al.* (Lander *et al. Phys. Rev.* **B14**, 5035; 1976; Lander *et al. Phys. Rev. Lett.* **40**, 523; 1978; Lander *et al. Phys. Rev. Lett.* **42**, 260; 1979) but the behaviour of UN (uranium nitride) which has been studied by Buyers *et al.* (*Proc. Int. Symp. on Neutron Inelastic Scattering*, Vienna, 1978) is similar. However, all the materials AnX where An is uranium or neptunium and X is nitrogen, phosphorus, arsenic, antimony, sulphur, selenium or tellurium have the same or similar magnetic phases (Aldred & Lam, *The Actinides: Electronic Structure and Related Properties* **I** (eds Freeman & Darby) Academic Press, New York, 1974) so that it is possible that what has been seen in USb and UN is actually characteristic of a whole class of compounds and not just due to some freakish property. The properties of a magnetic material depend on a delicate balance between various interactions and it may be that the particular combination characteristic of the actinides; large spin orbit interaction, variable valance and an apparent tendency for metallic f electrons will call for a totally new theory.

Studies of the magnetic properties of materials have been of great importance in helping our detailed understanding of solid state phenomena. This has been, I think, for two main reasons. The magnetic interactions which are odd under time reversal, split electron degeneracies which cannot be removed by any other means so their explanation is a very critical test of our understanding of a material. Also a very wide variety of experiments may be done. Above the phase transition one can measure the susceptibilities of the system to uniform or varying magnetic fields; close to the transition one sees very pronounced fluctuations in the magnetisation which may exist over large regions of space (that is, involving many crystal sites) and decay only slowly with time; at low temperatures one may study the ordered state and measure the magnetic moment per site as a function of

G. A. Gehring is the Physics Tutor at St Hugh's College and a lecturer in the Department of Theoretical Physics in the University of Oxford.

0028–0836/79/0279—0016$01.00