not think that there is any experimental evidence that the supraconducting metals form a separate group of elements like the ferromagnetic group or are exceptional in some other ways. We find the supraconducting metals in four groups of the periodic table. They have either a cubic or most irregular lattice, some of them belong to the transition group of elements, and we have amongst them the metals of the highest and lowest melting point. All the special relations between resistance and temperature for supraconductors pointed out by Mr. Bartlett are found by a more minute analysis of experimental data to apply also to some non-supraconductors. The special significance which Mr. Bartlett attaches without any theoretical justification to the fact that all supraconductors have a characteristic temperature below 243° *K.*, probably is no more significant than the fact that the atomic weight of every supraconductor is higher than the 115 of indium, because this happens to be the lightest supraconductor.

Finally, the very important recent discovery made by de Haas (NATURE, Jan. 26, p. 130) that the eutectic alloy of gold and bismuth can become a supraconductor, must be considered very carefully. The details of the experiment are not yet known, but from the point of view which I am defending, the explanation of the phenomenon may be that in a mixture of gold and bismuth one of the metals absorbs more readily the impurities of the other, and this purification may be of such a nature that it allows one of the components to become a supraconductor.

All these considerations, no doubt, cannot be regarded as final proof of my suggestion, but they offer a definite application of the hypothesis and give a quite fresh experimental line of attacking the problem of supraconductivity.

P. KAPITZA.

The Cavendish Laboratory
(Magnetic Laboratory),
Cambridge.

Mass and Size of Protein Molecules.

BY means of a method which utilises the measurement of sedimentation equilibrium and sedimentation velocity in strong centrifugal fields at constant temperature, a systematic study of the mass and size properties of the molecules of various proteins has been carried out in this laboratory during the last five years. Our work has been rewarded by the discovery of a most unexpected and striking general relationship between the mass of the molecules of different proteins and the mass of the molecules of the same protein at different acidities, as well as of a relationship concerning the size and shape of the protein molecules.

It has been found that all stable native proteins so far studied can with regard to molecular mass be divided into two large groups: the hæmocyanins with molecular weights of the order of millions and all other proteins with molecular weights from about 35,000 to about 210,000. Of the group of the hæmocyanins only two representatives, the hæmocyanin from the blood of *Helix pomatia* with a spherical molecule of weight 5,000,000 and a radius of 12·0 $\mu\mu$, and the hæmocyanin from the blood of *Limulus polyphemus* with a non-spherical molecule of weight 2,000,000, have been studied so far.

The proteins with molecular weights ranging from about 35,000 to 210,000 can, with regard to molecular weight, be divided into four sub-groups. The molecular mass, size, and shape are about the same for all proteins within such a sub-group. The molecular masses characteristic of the three higher sub-groups are—as a first approximation—derived from the molecular mass of the first sub-group by multiplying by the integers *two*, *three*, and *six*. The molecules of the first and fourth sub-group are spherical, with a radius of 2·2 $\mu\mu$ and 4·0 $\mu\mu$ respectively, while the molecules of the second and third sub-group are non-spherical. Ovalbumin and Bence-Jones's protein belong to the first sub-group; hæmoglobin and serumalbumin belong to the second sub-group; serum globulin belongs to the third sub-group; Rhodophyceæ-phycocyan, Cyanophyceæ-phycocyan, Rhodophyceæ-phycoerythrin, edestin, excelsin, amandin belong to the fourth sub-group in the neighbourhood of their isoelectric points.

The molecules of most of the proteins of the fourth sub-group are easily disaggregated with increasing *p*H. Thus R-phycocyan at a *p*H of 4·6 belongs to the fourth sub-group, but at a *p*H of 6·8 belongs to the third sub-group, that is, its molecules are disaggregated into halves and have lost their spherical symmetry. C-phycocyan at a *p*H of 4·6 belongs to the fourth sub-group, but at a *p*H of 6·8 about one-third of its molecules are disaggregated into halves, at the same time losing their spherical symmetry; at a *p*H of 12·0 the molecules of this protein are probably all reduced to the mass and shape of the protein molecules of the first sub-group, thus regaining their spherical symmetry. R-phycoerythrin at a *p*H of 4·6 belongs to the fourth sub-group, but at a *p*H of 11·0 about one-fourth of its molecules are reduced to the first sub-group. Edestin belongs to the fourth sub-group from its isoelectric point *p*H 5·5 to about *p*H 10. At a *p*H of 11·3 a considerable amount of molecules belonging to the second and third sub-group are present, together with the normal molecules belonging to the fourth sub-group.

Although not more than 11 different proteins belonging to the group which displays these regularities have as yet been studied, it would seem very improbable that the relationship between the molecular masses and sizes were incidental. Perhaps the most striking proof of the close relations between the different proteins is the fact that one and the same protein may, according to the *p*H to which it is brought, appear with the molecular mass, size, and shape of another protein.

When looking for an explanation of these unexpected regularities, it would be well to bear in mind the fact already brought out by many bio-chemical experiences, namely, that Nature in the production of organic substance within the living cell seems to work only along a very limited number of main lines. The great variety appears in the specialisation of details. Thus it would seem that the numerous proteins are all built up according to some general plan which secures for them only a very limited number of different molecular masses and sizes when present in aqueous solution. By varying the constituents of the different proteins (different percentage of different amino-acids, etc.) the chemical and electro-chemical properties may be varied sufficiently to enable the cells to make use of them for their different purposes.

The experimental data upon which the above conclusions are based have to a large extent been published in the *Journal of the American Chemical Society*. Part of the material is unpublished. The investigations have been carried out in co-operation with R. Fåhraeus, J. B. Nichols, N. B. Lewis, E. Chirnoaga, F. Heyroth, B. Sjögren, T. Katsurai, A. J. Stamm.

THE. SVEDBERG.

Laboratory of Physical Chemistry,
University of Upsala,
Upsala, Sweden.