LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications

Resistant Peripheral Membranes of the Keratin Fibres

In a number of communications, Alexander and Earland¹⁻³ have claimed to have isolated from wool a new morphological component, a highly resistant continuous membrane lying between the usually recognized cortex and cuticle. In collaboration with Happey⁴, they have further claimed to have demonstrated that the new component is a β -type protein, that is, allied in molecular structure to stretched hair, silk, etc., and that this β -type molecular structure accounts for the stability and resistance of the membrane.

The existence of a subcuticular membrane in animal hairs was suggested by the German workers Lehmann^{5,6} and Elöd and Zahn⁷ several years ago. Their evidence for a subcuticular origin for the tubular residues has already been criticized and the tubes shown to be derived from the external layers of the scaly cuticle, that is, to be cuticular sheaths⁸. To cite merely one convincing experiment: tubes were prepared from fibres which had previously been coated superficially with a thin metal layer by evaporation *in vacuo*. The isolated tubes were found to bear the metal layer which unambiguously labelled the outside surface of the cuticle⁹. Alexander and Earland have merely provided further evidence for a general rule that when the keratin fibres are brought into solution a resistant residue remains which consists of the tubular membranes enclosing a variable quantity of fibrillar cortical fragments¹⁰.

The reason for the separation of the tubes as coherent forms is found by electron microscopy, which shows that the walls of the tubes consist of a very thin, extremely resistant membrane reinforced to a variable degree by the adhesion of granular protein^{8,11}. This thin resistant membrane can be separated in a purer condition by chlorinating wool, when the membrane is inflated as small bubbles (Allworden sacs) and can be rubbed off in fragments by shaking in water^{8,12}. This latter experiment is evidence of the external location of the new membrane, which is seen to form an epicuticle, a thin layer uniformly enveloping the fibre much as if it had been lacquered. This epicuticle is indeed a new morphological component and may be a further example of the peculiarly resistant membranes which electron microscopy has revealed in animal tissues. The epicuticle of hair appears to be chemically the most resistant component of the fibre and remains when the keratin proper is dissolved. Since a certain amount of the rest of the cuticle always adheres to it, we have the possibility of forming more robust sheaths or external casts of the scaly layer, and it is these which mistakenly have been thought to come from beneath the scales.

Some preparations of these sheaths give X-ray patterns of diffuse haloes with β -type characteristics as Happey and others have noted, but one is certainly not justified in concluding from this that the tubes are a β -protein and that wool is molecularly a poly-phase structure. No β -reflexions in original wool were noted by Astbury and Woods¹³, although a β -protein, had it been present to the extent of

7-10 per cent, would have been detected. It is well known¹³, however, that after certain chemical treatments causing fibre contraction, a β -structure does develop due to modifications in the cortex of the fibre¹⁴. An electron microscopic examination of the residue prepared by the method of Alexander and Earland shows, in fact, a considerable quantity of cortical material, which after the chemical treatment it has suffered may be expected to give a β -pattern. In the absence of cortical impurity the tubes give only a most diffuse X-ray pattern from which little can be deduced.

In view of the above criticisms, it may seem unnecessary to comment on the final speculation that the β -structure is the reason for the insolubility of the tubes. Bamford, Hanby and Happey¹⁵ have advanced the hypothesis that the β -structure of certain synthetic polypeptides is the cause of the insolubility of these compounds. There is, however, a considerable difference between synthetic polypeptides and natural proteins, and it is surely better to consider the solubility of actual proteins having a β -structure. We find, in fact, that these are more easily brought into solution than wool keratin; for example, silk in acid or cuprammonium solution and feather in reducing solutions. The suggested explanation is not, therefore, acceptable.

The histological structure of the tubes (epicuticle plus cuticular remnant) shows that the real reason for the separation of the tubes as coherent forms is the insolubility of the epicuticular fraction. The composition of the epicuticle is thus the main problem, and the great difficulty here is to separate it in a pure form and in quantity sufficient for analysis.

E. H. MERCER

Chemical Physics Section,
Division of Industrial Chemistry,
Commonwealth Scientific and
Industrial Research Organization,
Australia.

¹ Alexander and Earland, *Melliand Textilberichte*, **81**, 385 (1950).

² Alexander and Earland, *Textile Res. J.*, **20**, 298 (1950).

³ Alexander and Earland, *Nature*, **166**, 396 (1950).

⁴ Happey, *Nature*, **166**, 400 (1950).

⁵ Lehmann, *Melliand Textilberichte*, **24**, 1 (1943).

⁶ Lehmann, *Melliand Textilberichte*, **25**, 1 (1944).

⁷ Elöd and Zahn, *Naturwissenschaften*, **33**, 158 (1946).

⁸ Lindberg, Mercer, Philip and Gralén, *Textile Res. J.*, **19**, 673 (1949).

⁹ Mercer, *Melliand Textilberichte*, **31**, 694 (1950).

¹⁰ Mercer (forthcoming publication).

¹¹ Lindberg, Mercer and Philip, *Textile Res. J.*, **19**, 678 (1949).

¹² Lindberg, *Textile Res. J.*, **19**, 43 (1949).

¹³ Astbury and Woods, *Phil. Trans. Roy. Soc., A*, **232**, 333 (1934).

¹⁴ Whewell and Woods, *Symposium on Fibrous Proteins*, p. 50 (1946).

¹⁵ Bamford, Hanby and Happey, *Nature*, **166**, 829 (1950).

THE purpose of Dr. Mercer's communication seems to be to establish the following points: (a) that the material isolated by Alexander and Earland is not a subcuticular membrane; (b) that the β -protein contained in their material is not present in the initial fibre; and (c) that the insolubility of their membranes is not connected with the β -structure.

As regards (a) we have no special comment, although we feel that Mercer's view is probably correct. On the other hand, Mercer's arguments against the presence of 7-10 per cent of β -keratin in wool are far from convincing. It is by no means certain that this amount of (partially disoriented) β -keratin, even if it were crystalline, would be detected by X-ray analysis. In fact, Ambrose and