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## Letters to the Editor

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NOTES ON POINTS IN SOME OF THIS WEEK'S LETTERS APPEAR ON P. 110.

CORRESPONDENTS ARE INVITED TO ATTACH SIMILAR SUMMARIES TO THEIR COMMUNICATIONS.

### $\alpha$–$\beta$ Intramolecular Transformation of Myosin

SHORTLY after the discovery and investigation by the methods of X-ray analysis[1] of the long-range elastic, intramolecular transformation which takes place when the fibre-substance (keratin) of hair is stretched, the possibility emerged that the elastic mechanism of muscle is similar at least in principle to that of hair[2]. There is a remarkable likeness between the X-ray photograph of washed and dried muscle and that of unstretched hair ($\alpha$-keratin), and there are, moreover, certain striking analogies between their respective elastic properties. Recently, the X-ray and elastic comparison between muscle and hair has been set out in detail[3], and once more the suggestion was made that the normal molecular configuration of the muscle protein myosin—first shown by Boehm and Weber[4] to give, when oriented, an X-ray photograph resembling* that of muscle itself—is that of a folded polypeptide chain system like that of $\alpha$-keratin, which it should be possible, by extension under appropriate conditions, to transform into a fully-extended system like that of $\beta$-keratin (stretched hair). The present writers tried to bring about this transformation two years ago by experiments on the sartorius muscle of the frog, but without success[2].

We have succeeded now in demonstrating the predicted intramolecular transformation by working with the isolated muscle protein instead of with the actual muscle. We have found air-dried myosin films to have the following properties: (1) as in gelatin films, the molecular chains lie roughly parallel to the surface; (2) on moistening with water and stretching, these chains are first pulled into approximate parallelism with the direction of stretching and give rise to an X-ray photograph resembling that of muscle or $\alpha$-keratin; (3) on further stretching, a new photograph appears which closely resembles that of $\beta$-keratin; (4) on exposing the stretched film for a few seconds to steam, the $\beta$-photograph is 'set' and intensified at the expense of the $\alpha$-, exactly as in the case of stretched hair; (5) myosin films can generally be stretched in cold water to about three times their original length and, like keratin fibres, show well-marked long-range reversible elasticity, the $\beta$-photograph disappearing again on contraction provided the film has not been kept stretched in the dry state; (6) when myosin films are made by squeezing the re-moistened protein between glass plates, the $\beta$-photograph is again observed, but this time with the 'side-chain spacing' normal and the 'backbone spacing' parallel to the flat surface, just as when keratin is squeezed laterally in the presence of steam[5]; (7) *unstretched* myosin film, when exposed for a few minutes to steam, contracts spontaneously by about 20 per cent (artificial muscle !), exactly as does keratin that has been brought into the labile state by the action of X-rays on the $\alpha$-form or by the limited action of steam on the $\beta$-form[6].

In brief, myosin films are amazingly similar to the labile, or super-contracting, form of keratin which is produced by the breakdown or modification of certain cross-linkages; and in this comparison the normal contraction of muscle corresponds to the super-contraction of hair[2]. Only very imperfect chemical analyses of myosin and muscle are available—and here the physicist is in very urgent need of help—but, *if we except cystine*, the general distribution of amino-acid types appears to be similar to what has been found for keratin. Does this mean that the method of formation of hair is fundamentally similar to that of muscle, except that the elastic system of hair is more or less stabilised and de-sensitised by the incorporation of relatively large amounts of cystine ? In other words, are we to conclude that the hair protein is roughly speaking no other than 'vulcanised' muscle protein ?

The investigation is being continued in order to try to find out the exact relations between the X-ray photographs and elastic properties of muscle, myosin, and keratin. We wish to express our indebtedness to the Rockefeller Foundation for financing the research, to the superintendent of the Cambridge Low Temperature Research Station for his kind co-operation, and to Dr. E. C. Smith of that laboratory for the invaluable supplies of fresh myosin which have so far formed our exclusive experimental material[7].

W. T. ASTBURY.
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Jan. 7.

* Boehm and Weber claim that the two photographs are indistinguishable, but this is at least doubtful until much more perfect photographs are available. It may be said with equal justification that the photograph of hair is also almost the same as that of myosin.

[1] W. T. Astbury and A. Street, *Phil. Trans. Roy. Soc.*, A, **230**, 75; 1931. W. T. Astbury and H. J. Woods, NATURE, **126**, 913; 1930. *Phil. Trans.*, A, **232**, 333; 1933.
[2] W. T. Astbury, *Trans. Faraday Soc.*, **29**, 193; 1933.
[3] W. T. Astbury, "X-Ray Studies of Protein Structure", Cold Spring Harbor Symposia on Quantitative Biology, **2**, 15; 1934; and "Röntgenoskopie von Proteinfasern", *Koll. Z.*, **69**, 340; 1934.
[4] G. Boehm and H. H. Weber, *Koll. Z.*, **61**, 269; 1932.
[5] W. T. Astbury and W. A. Sisson, *Roy. Soc.*—in press.
[6] W. T. Astbury and H. J. Woods, *Phil. Trans. Roy. Soc.*, A, **232**, 333; 1933. H. J. Woods, NATURE, **132**, 709; 1933.
[7] E. C. Smith, *Proc. Roy. Soc.*, B, **105**, 579; 1930. **114**, 494; 1934.