OBSERVATIONS ON THE ELECTRON MICROSCOPIC STRUCTURE OF INSECT MUSCLE*

by

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We wish to publish four electron micrographs of sections of insect muscle. The muscles were fixed *in situ* in buffered[1] osmic acid, embedded in a mixture of (1:3) methyl and butyl methacrylate, and sectioned with a glass knife on the microtome described elsewhere[2].

Fig. 1 is a longitudinal section through a fibril of the thoracic (wing) muscle of the house-fly. The dark lines close to the ends of the picture are Z lines. The following points deserve attention: A and I bands are absent; the very thin light area in the immediate vicinity of the Z membranes is probably an artifact since it is missing on other sections and may be due to the absorption of the staining material by the Z membrane; there is no continuous M membrane; the darker cross line in the middle of the sarcomere can be resolved into a slight thickening and darker staining of the protofibrils; and the series elastic component is missing entirely[3]. These peculiarities are evidently connected with the nature of the function of the insect wing muscle and may contribute towards the understanding of these missing structures. It is known that in cultures of embryonic heart muscle the cross striation is developed only after the fibers have begun to beat; thus the development of the A and I band may be caused by contraction. Insect wing muscle, as compared with mammalian muscle, shortens but very little, a few per cent only, and so the lack of striation would be understandable if this should develop as a secondary consequence of shortening. It is possible that the globular proteins located between the protofibrils are, so to speak, hammered together into a compact sheet by the shortening of the muscle. This assumption is supported by studies of G. DE VILLAFRANCA, conducted at present in this laboratory, which indicate that the protein which lies between the protofibrils in the A band, and lends to this band its higher density and double refraction, is fibrous while it is *in situ* but readily disintegrates into globules on extraction. Similarly, the absence of the series elastic component can be linked with the fact that this muscle performs several hundred contraction cycles per second. If it had a series elastic component it could not move the wings at all, and the sole result of contraction would be a stretching of this elastic component**. Similar sections have been published by G. B. CHAPMAN[4]. His pictures showed the same structure but he failed to point out the above features.

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** No series elastic component is needed in very fast and very slow muscle. Accordingly, this component is entirely missing also in the muscles of the lobster claw, which is a "slow muscle".

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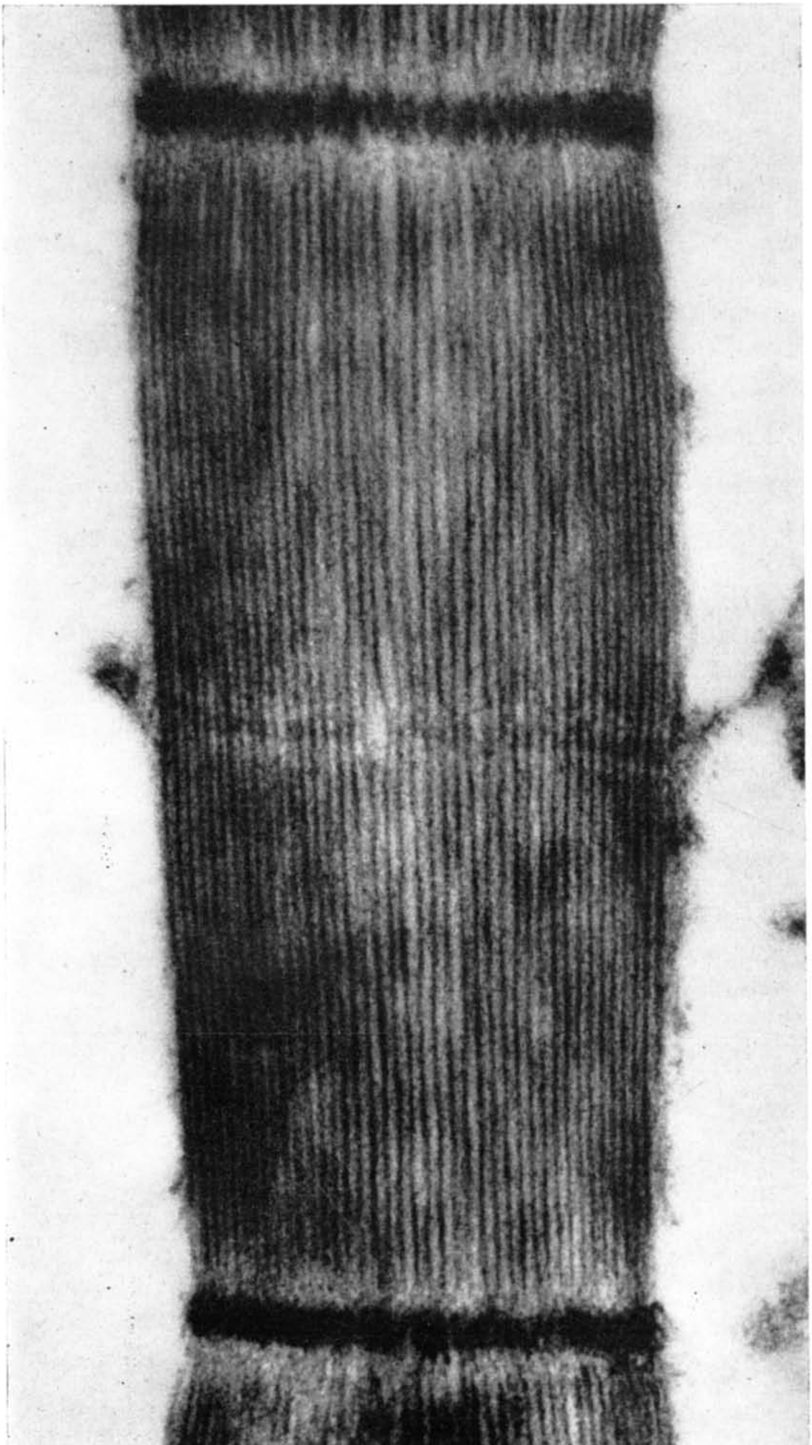

Fig. 1. Longitudinal section of a fibril from the wing muscle of the house-fly. Distance from Z to Z membrane, 3.3 microns.

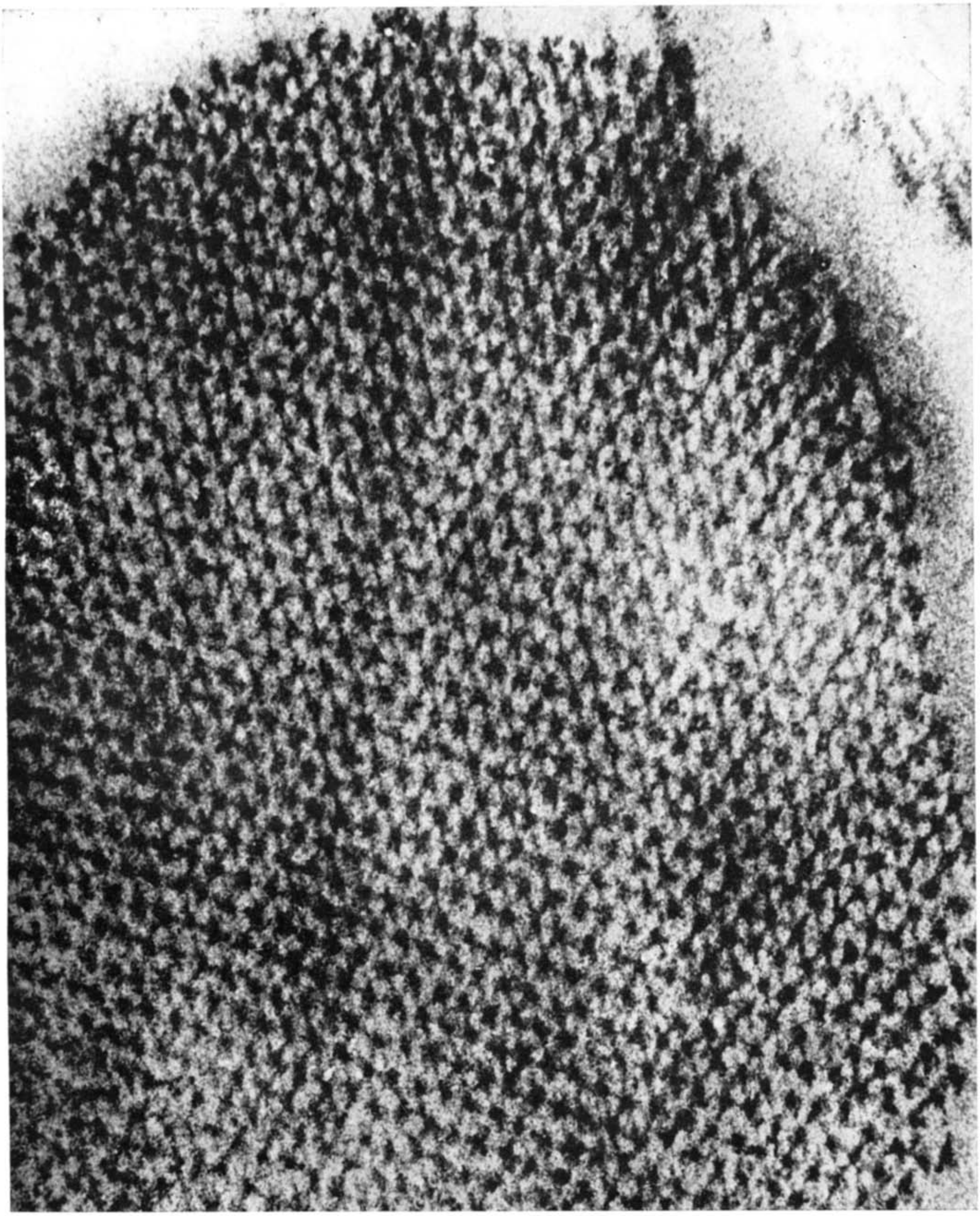

Fig. 2. Cross section from a fibril as shown in Fig. 1. The shorter side of the picture is one micron.

Fig. 2 shows the cross section of a similar fibril. The big dots are, evidently, cross sections of the protofibrils. The regularity of their hexagonal arrangement is conspicuous, and deserving of special mention are the dark lines connecting every protofibril with each of its six neighbors. We shall not attempt to give an interpretation here.

The space between the fibrils in the wing muscle of the house-fly is occupied by

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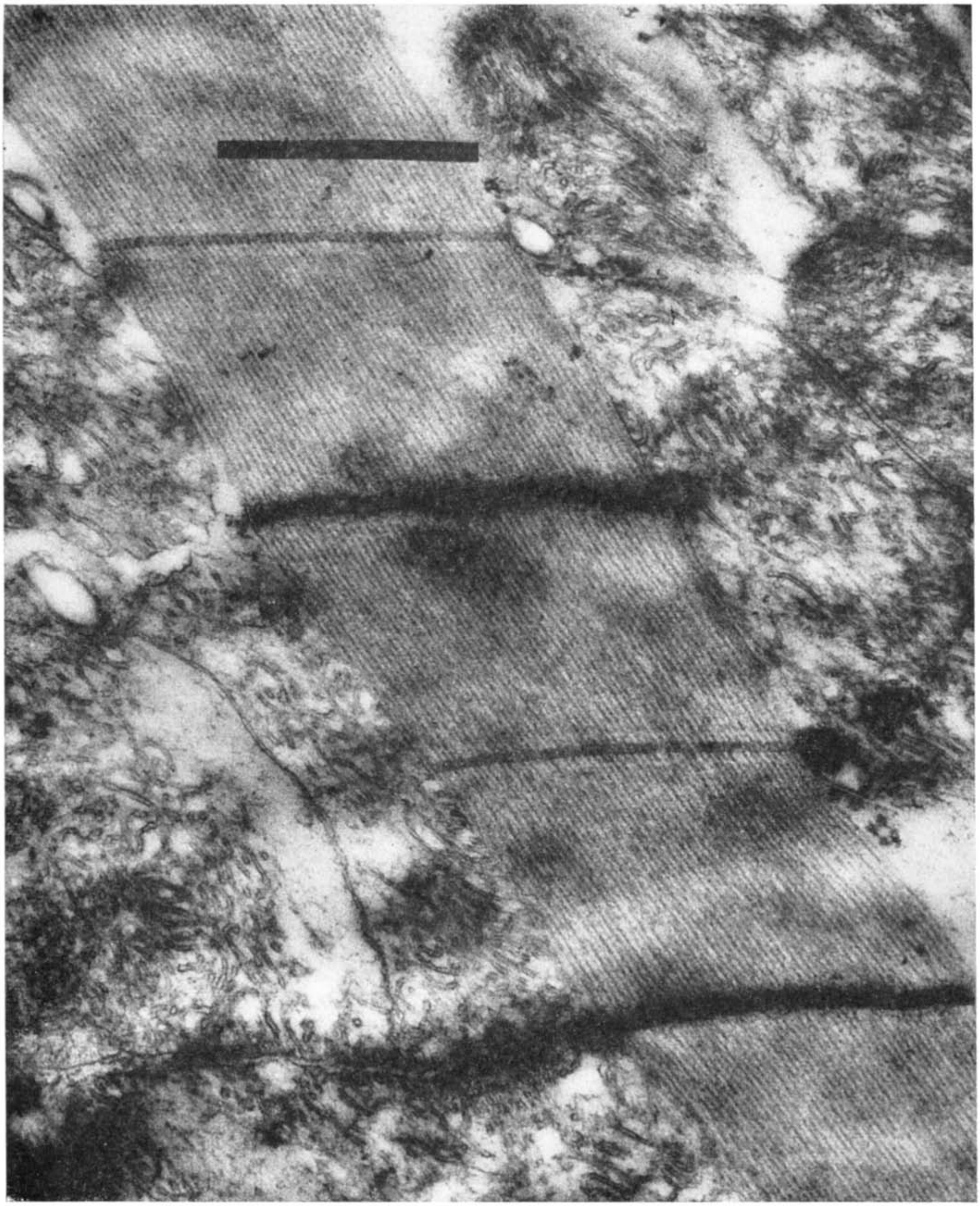

Fig. 3. Section from the wing muscle of the bumble-bee. Black line = 1 micron

the giant mitochondria which do not show the laminated internal structure described in the mitochondria of the kidney by PALLADE[5]. We have been unable to resolve their finer inner structure. However, in extra thin sections of the wing muscle of the bumble-bee the structure of the mitochondria could be resolved into a closely packed mass of tubules, as shown in Fig. 3. The middle of the picture is occupied by a muscle fibril.

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Fig. 4. Section from a leg muscle of the bumble-bee. Black line = 1 micron.

The fibril is seen embedded in a mass of mitochondria, of which the tubules can be clearly discerned. Most of these tubules can be followed for some distance which makes it probable that they are flat, though at places round cross sections can also be observed. The tubules seem to end freely at the surface of the mitochondrium. At the right hand side of the upper Z membrane one sees the narrow split separating two mitochondria and one can also see a number of tubules ending in it. Tubules ending at the fibril can also be seen at its right hand side at the level of the upper M line. On this side of the fibril one finds the mitochondrium in register with the sarcomere, the Z membrane lying opposite the split separating two mitochondria, which is in agreement with the observation of earlier histologists.

However, tubular structure is not necessarily characteristic of insect mitochondria. SPIRO[6] has found laminar structure in the flight muscles of the blow-fly. Mitochondria may have a laminar structure in the one muscle while having a tubular structure in other muscles of one and the same animal. This is evidenced by Fig. 4, a section of the leg muscle of the bumble-bee, whose wing muscle was shown in Fig. 3. The mitochondria show here a laminar structure.

SUMMARY

Four electron micrographs are reproduced. The longitudinal section of the wing muscle of the house-fly shows the absence of the series elastic component and of the A and I bands. The possible bearing on the genesis of these bands is discussed.

Mitochondria of the wing muscle of the bumble-bee show a tubular inner structure, while the mitochondria of the leg muscle show laminar formations.

RÉSUMÉ

Quatre micrographies électroniques sont reproduites. La section longitudinale du muscle alaire de la mouche domestique ne présente ni séries de constituant élastique, ni bandes A et I. Les conséquences possibles pour la genèse de ces bandes sont discutées.

Les mitochondries du muscle alaire du bourdon possèdent une structure interne tubulaire, tandis que celles du muscle de la patte sont formées de lames.

ZUSAMMENFASSUNG

Vier Elektronenmikrographien werden reproduziert. Der längliche Querschnitt eines Flügelmuskels der Hausfliege zeigt die Abwesenheit der elastischen Serienkomponente, sowie der A- und I-Streifen. Die Möglichkeit eines Zusammenhanges mit der Entstehung dieser Streifen wird erörtert.

Flügelmuskelmitochondrien der Hummel zeigen eine schlauchartige Innenstruktur, während Beinmuskelnmitochondrien lamellenartige Bildungen aufweisen.

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