I. Introduction

Muscle is a device for producing the mechanical work necessary for movement and is, therefore, a tissue which must change its shape. Whereas flagella and cilia – the simplest motile organelles – perform a complex elastic movement, the muscle simply changes its length either actively during contraction, or passively during stretch or during release from an extended length. In fig. 1a 1) an electron micrograph of vertebrate striated muscle (VStM) shows the characteristic disposition of filaments in the fibrils of a muscle cell. The attached fig. 1b (1) shows the commonly accepted diagrammatic representation of this structure, the sliding filament model, as proposed by H.E. Huxley. The thin dark transverse lines are called “Z lines”; between pairs of Z lines lie the “I bands” (where there are thin filaments only), the “A bands” (where there are both thick and thin filaments) and the “H bands” (where, according to Huxley’s model, should be thick filaments only).

If the fibril is examined under higher magnification [fig. 21), a most instructive picture can be found in (3)], both the presence of arrays of thin filaments extending from the Z lines into the spaces between the thick filaments, and of cross-bridges between the overlapping filaments can be detected. Both types of filaments can interact to produce a contraction of the muscle, probably by the sliding of adjacent filaments over each other.

Two proteins make up the bulk of the muscle tissue, myosin and actin. If muscle is extracted with a salt solution the A bands disappear, and, as myosin is soluble in salt solution, it is thought that the A bands contain the myosin located in the thick filaments. In Huxley’s model the cross-bridges form a permanent part of the myosin filament being represented by the H-meromyosin subunit of the myosin molecule (fig. 3). The thin filaments contain the actin, which can exist in two forms, as G-actin (a globular protein) or F-actin (a fibrous protein). Even after isolation from the muscle a mixture of myosin and F-actin retains the ability to contract.

In VStM the myosin-containing filaments are spaced out in a hexagonal lattice some 450 Å apart, with the actin-containing filaments in between them at the trigonal positions of the lattice (fig.1b, vid. also fig.4). The space between the filaments is occupied by sarcoplasm (a dilute aqueous solution of salts – among them 5 mmol/l Mg++, 5 mmol/l ATP, 5·10⁻³ mmol/l Ca++ – and of other proteins). For further details see particularly (4, 5, 6).

II. The meander model of muscle

Although we are not very familiar with the molecular biology of muscle it seems to us that progress in this field today is mainly due to the work of biochemists. The physics of muscle contraction for instance has not achieved any final quantitative success in spite of some interesting theoretical attempts e.g. (7, 8, 9, 10), 11, 12). The sliding filament model requires further development to account quantitatively for all experimental results known today. In this connexion one may recall the critical engagement of Ernst in his booklet (13).

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1) By kind permission of Dr. G. J. Steiger and Dr. G. Beinbrech, Bochum (2).
2) In Volkenshtein’s paper (10) an excellent review on the Physics of Muscle is available.
Fig. 1. Upper part (a) electron micrograph of a myofibril (rabbit proas). Lower part (b) diagrammatic representation of Huxley's sliding filament model.

Fig. 2. Part of the myofibril at higher magnification (insect fibrillar flight muscle), upper part at rest, lower part in rigor.