'Quick' and 'Catch' Adductor Muscles in Brachiopods

THE purpose of this communication is to direct attention to the close analogy between lamellibranch molluscs and articulate brachiopods, in the structure and function of the adductor muscles. In view of the large body of work on the physiology of the adductors in lamellibranchs, it is probable that a similar study in brachiopods would yield interesting comparisons.

Like a lamellibranch shell, the shell of an articulate brachiopod consists of two valves hinged together; but brachiopod valves are placed dorsally and ventrally, are hinged on the posterior side, and have perfect bilateral symmetry. They are closed by two pairs of adductor muscles, attached separately to the dorsal valve but uniting into a single pair of tendonous attachments on the ventral valve; and they are opened not by a ligament as in lamellibranchs but by a pair of divaricator (= diductor) muscles, of which the lines of action pass behind the hinge axis (Fig. 1). The two pairs of adductors differ macroscopically in form and lustre. Microscopically, Hancock¹ noted more than a century ago that the fibres of the posterior adductors are striated and those of the anterior adductors unstriated. This observation has been doubted more recently², but Atkins³ and I have been able to confirm it in several genera. The divaricators are unstriated. It has long been known that brachiopods, like lamellibranchs, snap their valves together for protection when disturbed and at other times for the ejection of pseudofaeces. It has therefore seemed probable that the analogy extends further, and that the striated and unstriated adductors in brachiopods are, respectively, 'quick' and 'catch' muscles. During a recent examination of living brachiopods in New Zealand I was able to confirm this in the terebratuloids *Terebratella* (*Waltonia*) *inconspicua* (Sowerby), *T. (Magasella) sanguinea* (Leach) and *Neothyris lenticularis* (Deshayes), and in the rhynchonelloid *Tegulorhynchia* (*Notosaria*) *nigricans* (Sowerby).

When the valves snap together spontaneously, they do not close completely, and immediately afterwards begin to re-open. If the animal is disturbed (for example, by a vibration of the vessel in which it is contained), the valves snap rapidly until their edges are nearly together, and then close slowly until their edges are tightly in contact (the shell then remains closed for a variable period before re-opening). Thus both quick and slow closing movements can be distinguished in the undissected animal. If the

tendonous portions of the anterior adductors are cut, leaving the posterior adductors undamaged, the valves snap together repeatedly but are unable to close tightly. If a posterior adductor is placed between a pair of electrodes connected to a stimulator, a single pulse will induce a single rapid twitch in the muscle. Thus the striated posterior adductors are clearly the muscles responsible for the rapid snapping of the valves. When an anterior part of the valve and mantle tissue is removed (making the muscles visible through the very thin anterior body-wall) the injury causes a permanent contraction of the anterior adductors, indicating that these are the muscles responsible for slow, tight and prolonged closure of the valves. The relatively slow reopening of the valves after a closure is due presumably to the contraction of the unstriated divaricators when the antagonistic contraction of the adductors has been relaxed.

The functional role of these muscular mechanisms will be described elsewhere, but it is hoped that the physiological properties of these muscles will be investigated more thoroughly by those with access to supplies of living brachiopods. This work was done at Portobello Marine Biological Station during the tenure of a Royal Society and Nuffield Foundation Commonwealth Bursary.

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¹ Hancock, A., *Phil. Trans. Roy. Soc.*, **148**, 805 (1859).

² Hyman, L. H., *The Invertebrates*, **5**, 546 (New York, 1959).

³ Atkins, D., *Proc. Zool. Soc. Lond.*, **131**, 564 (1958).

Paper Electrophoresis of Proteins while preserving the Pattern of their Localization in Tissues

THE composition of protein mixtures extracted from different sources can be found by the usual methods of paper electrophoresis, but the localization of protein fractions in tissues can only be determined with preliminary preparative breakdown of tissues and organs.

I have now succeeded in combining these two functions by using special multilayer columns for electrophoresis made by folding and compressing one or two large sheets of paper and inserting imprints on filter paper of leaves or thin slices of animal tissues or organs. Fig. 1 shows examples of leaf-imprints obtained by a method described in refs. 1 and 2.

Fig. 1. *Terebratella inconspicua*, with valves gaping, cut along median plane of symmetry to show chief muscles (all other organs omitted); dorsal valve above. ($\times 3$)

Fig. 1. Examples of leaf imprints on filter paper