Giant-Fibre Reflex of the Earthworm

The rapid shortening of an earthworm is co-ordinated by giant fibres located in the nerve cord[1,2]. Though the transmission characteristics and anatomy of these giant internuncials are established, their afferent and efferent connexions are unknown[3-5].

An outstanding feature of the shortening response is its rapid fatigue on repetition. On analysis there are three points in the reflex pathway where failure of transmission might occur. These are : (*a*) between the motor neurones and the muscle cells, the neuro-muscular junction ; (*b*) between the giant internuncial and the motor neurones, the giant-to-motor junction ; and (*c*) between the sensory neurones and the giant internuncial, the sensory-to-giant junction. No evidence has suggested that a physiological junction occurs in the course of the motor nerves, at least for the rapid responses.

The neuro-muscular junction was investigated by repetitively stimulating the central end of a segmental nerve and recording the action potentials produced in the longitudinal muscle of that segment. At a frequency of 4 per sec., each shock, including the first, produces an action potential of which the first two or three show a progressive increase in size. Thereafter the size of the potential is maintained for about 80 shocks after which it gradually decreases in magnitude. The decline, however, is very slow and after 700 shocks the potential is only reduced to half its original size. It requires several hundred more shocks to cause the response to disappear altogether. The recovery time is short, and after a rest period of 2 min. the muscle potential returns to its original size and responds to the first shock. It is therefore clear that the neuro-muscular junction transmits impulses in a one-to-one manner for a considerable time and fatigue of the rapid response must be located elsewhere.

The giant-to-motor junction has proved more difficult to investigate because it is usually stimulated to failure during the dissection. However, action potentials may be recorded from the longitudinal muscle in response to impulses in the median and/or the lateral giant fibres if the operation is performed sufficiently quickly. A short length of the nerve cord was exposed at the posterior end of the worm. The anterior end of the nerve cord was then directly stimulated through the mid-ventral body wall with repetitive shocks and the giant-fibre impulses so produced were recorded from the posterior end. Action potentials were recorded simultaneously from the longitudinal muscle. The results vary greatly from preparation to preparation and also from one region of the muscle to another. Usually accommodation of the giant-to-motor junction was already complete, no muscle potentials being initiated by giant-fibre impulses. However, in favourable preparations the first few shocks are followed by muscle potentials after a delay (25 millisec.) which is so short that the response can only have arisen from the giant-fibre impulses. The junction transmits for a short while in an irregular manner and thereafter no further muscle potentials are recorded unless stimulation is stopped and the preparation allowed to recover. The muscle potentials vary in size as they also do when shocks of varying intensity are applied to a segmental nerve, observations which suggest that in each segmental nerve there are several motor fibres each with its own giant-to-motor junction. Physiological evidence indicates that there are three motor neurones, or groups of motor neurones, innervating the longitudinal muscle in the first segmental nerve, and at least two, probably three, in the 'double nerve' (the second and third segmental nerves). This has not yet been confirmed histologically and the morphological relation between the motor neurones and the giant internuncials is uncertain.

The sensory-to-giant junction also accommodates rapidly and again the operation must be designed to avoid excessive shock. If one of the segmental nerves is stimulated through the ventral body wall at the anterior end, median giant fibre impulses can be recorded from the nerve cord exposed at the posterior end. In the majority of preparations the sensory-to-giant junction accommodates after the first one or two shocks at three per second and remains accommodated for as long as the segmental nerve is stimulated. If, however, stimulation is stopped the junction recovers and is found to transmit again after a period of between one and three seconds. By stimulating the sensory neurones at various frequencies it can be shown that accommodation takes about 1/3 sec. to become fully established, stimulation during this period being effective in exciting the giant fibre.

It appears that rapid adaptation of the sensory endings in the integument does not occur since, long after giant fibre impulses have ceased to be produced, small slow impulses in the nerve cord can be elicited by mechanical stimulation of the body wall.

The existence of these junctions and pathways has not yet been confirmed histologically and this is a problem for future investigation.

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Responsiveness of the Neurosecretory System of Larval Lampreys (*Petromyzon marinus*) to Light

It now seems reasonable to conclude that the brain and in particular the hypothalamus, mediates most endocrine changes, which are responses by vertebrates to changes in their physical environment. The terminal nervous pathway in this integrative system is the hypothalamo-hypophyseal tract which extends from the preoptic (supraoptic) and paraventricular nuclei to the neurohypophysis[1]. The neurones in these hypothalamic nuclei are secretory : the secretory material is stainable, and there is evidence that through special circulatory connexions it may be transported from the nerve endings to the glandular hypophysis to stimulate the release of the trophic hormones[1,2]. Through this neuroendocrine axis, therefore, the environmental regulation of reproduction, behaviour and metabolism of vertebrates may be expressed.

It seemed to us important from the phylogenetic point of view to learn whether such a hypothalamo-