



The Nervous System of a South Australian Giant Earthworm
of the genus Megascolex; a Study of its Anatomy and Physiology.

Submitted as a thesis for the degree of Doctor of Medicine
in the University of Adelaide by William Ross Adey.

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It is my belief that this thesis advances scientific knowledge and practice in the following respects:--

- (1) It is the first detailed account of the connections of the ganglion cells of the cerebral ganglia and ventral nerve cord of an oligochaet worm.
- (2) Significant structural differences have been shown to exist between the nervous system of the worm studied and the closely allied Megascolides australis.
- (3) The giant fibres of the ventral nerve cord have been investigated for the first time in an Australian worm and shown to possess an intra-neuronal system of fibrils. The presence of such a system has been disputed in oligochaets examined by other observers. The special relation of this system to the macrosynapses of the giant fibres has been described.
- (4) Interconnections between the giant fibres have been demonstrated histologically.
- (5) The portions of the worm body innervated by the giant fibres have been shown physiologically to differ significantly from any oligochaet previously examined.
- (6) An accurate mathematical relationship has been achieved between conduction velocity and nerve fibre size for the first time in any annelid giant nerve fibre.
- (7) Variations in conduction velocity in the giant fibres have been shown to occur in different portions of the worm. There is a relationship between length of worm and conduction velocity in the median giant fibre.
- (8) By continued electrical stimulation it has been possible to produce a type of polarity in the giant nerve fibres, which would appear to depend on the presence of macrosynapses within these fibres. This observation is of particular importance in view of the large body of work at present being conducted with a view to elucidating the functions of the synapse.
- (9) The first accurate determination has been made for the annelid giant fibre of the relative proportions of nerve fibre sheath/axon diameter in stained and unstained material. The shrinkage of the giant fibres during formalin fixation and dehydration has been determined in the annelid giant fibre for the first time.
- (10) The electronic apparatus used in this work has been designed and constructed by me and represents new advances in valve application. This applies particularly to the cathode-ray oscilloscope circuit in which it has been possible to use a single-beam and a double-beam cathode-ray tube in conjunction with direct-coupled sweep circuits while maintaining independence of focusing positioning and intensity controls.

SUMMARY.

1. The general anatomy of the central nervous system of Megascolex is described.
2. The dorsal giant fibres of Megascolex are so arranged that the median giant fibre is excited by a tactile stimulus to the anterior 55-60 segments of the body. Stimulation behind this point excites the lateral giant fibres. The point of changeover is relatively constant and bears no relationship to the total number of segments in the body.
3. A tactile stimulus to any part of the worm's body is uniformly sufficient to produce a giant fibre response. A local contraction temporarily diminishes or abolishes the excitability by a tactile stimulus.
4. The conduction velocity in the giant fibres reaches a maximum of 45-55 m./sec. The velocity is a linear function of fibre size and sheath size.
5. The velocity varies in different parts of the worm. In the median fibre it is fastest in the middle of the worm, slower posteriorly, and slowest at the anterior end. The lateral fibres conduct progressively more slowly from behind forward.
6. The maximum velocity in the median giant fibre is approximately a linear function of the length of the worm.
7. Under physiological stimulation an impulse in the giant fibres is conducted equally well in both directions. When fatigued by continued electrical stimulation, a type of polarity appears in the giant fibres at the posterior part of the nerve cord. The lateral fibres cease to conduct posteriorly and the median fibre will not conduct anteriorly.

8. The sheath of the giant fibres has been estimated in stained sections and in fresh preparations under polarized light. It is a linear function of fibre diameter and approximates 5.3% in the stained sections and 6.0% by polarized light. Shrinkage during processing has also been estimated at 10% of the diameter in the fresh state and is not differential for fibres between 20 and 75 μ .
9. The finer structure of the giant fibres is discussed. Each giant fibre appears to possess a single centrally placed neurofibril. The possibility of interconnections between the giant fibres at the anterior end of the nerve cord is considered.