THE SCHWANN CELL[1]

In view of the many references to the Schwann cell in articles on electron microscope studies of the nerve lesions in leprosy, the following editorial in a recent issue of the periodical cited is reprinted here. There are passages which do not bear on features of immediate interest, but it is preferred to copy the editorial entire instead of using only excerpts.

Theodor Schwann was born near Düsseldorf, Germany in 1810. The description of the cell that covers the nerve fiber made his name familiar to all first-year medical students in their course on neurohistology. Researches in recent years into the form and function of the Schwann cell may prompt some physicians to reflect upon the contribu-

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[1]Editorial from the *J. American Med. Assoc.* **173** (1960) 1667-1668, copied by permission.

tions of this 19th century anatomist. Schwann was a deeply devout member of the Roman Catholic Church. He never married. Following his studies at the universities in Würtzburg and Berlin, he accepted the professorship of anatomy at Louvain, Belgium at the age of 29. Although the eponymic term is his most popular heritage, his greatest contributions were in fermentation and cellular structure. For more than 200 years the vegetative cells formed during fermentation were considered to be inanimate bodies. Schwann judged them to be living, one of the basic concepts accepted by Pasteur in his earliest investigations in microbiology. Schwann also discussed the cell at some length and believed it to be the basic structural unit of animal tissue.

The Schwann cell, whose cytoplasm enfolds myelinated and nonmyelinated nerve fibers, has been studied in recent years by a number of investigators who have utilized the electron microscope and modern techniques of tissue culture, with rewarding results. The cells have a separate existence and are not syncytial. Furthermore, cytoplasmic discontinuity has been demonstrated, with tiny filaments separating the nerve fiber from the cell wall. Other studies have concerned the mechanism of myelination, the regeneration of injured nerves, and schwannomas, nerve tumors. A monograph on this subject by Causey,[2] currently professor of anatomy in the Royal College of Surgeons in England, details these and other pertinent observations.

The epineurium, perineurium, and endoneurium that we studied in neurohistology need not be redefined. The revelations of the electron microscope, microbiochemistry, and tissue culture seem more exciting. Tissue culture, *in situ*, the regeneration of nerve fibers and their satellite cells (Schwann cell) in the tail of the tadpole, showed that the conjunction of the Schwann cell to the axon of the nerve fiber was a necessary preliminary to myelinization of the axon. Also, tissue culture, *in vitro*, must be maintained for a period of four weeks or longer in order to obtain myelinization. The combination of electron microscopy and tissue culture has shown that maturation of the Nissl pattern within the nerve cell body and the deposition of myelin around its peripheral process proceed concomitantly. Regeneration of Schwann cells in tissue culture was apparent only after previously, freshly cut normal nerve had been crushed and allowed to degenerate for a few days (Wallerian degeneration).

The motor end-plate has been the object of intensive study with the electron microscope. The Schwann cell covers the axon terminally, separating it from the connective tissue in the extracellular space between the end-plate and the nerve fibre. The Schwann cell membrane continues over the end-plate and excludes the cytoplasm around the axon from the narrow space that exists between the axon and the muscle cell. The axon terminal contains mitochondria and a large number of vesicles that contain acetylcholine. The vesicles participate in synaptic transmission and disappear after nerve section at central synapses. The diameter of the vesicle, 500A, seem rather large until it is appreciated that the Angström unit is one hundred-millionth of a centimeter. The resting potentials of glial cells, that have been examined in tissue culture and also *in situ* in the intact brain of the cat, suggest that the potential recorded in electroencephalography may be produced by the electrical activity of the glial cells in addition to the neuronal electrical charges.

The mechanism of nerve regeneration has been an important problem in civilian medicine as well as in military medicine. Schwann's original concept of regenerating nerve fiber from coalescence of his cells has been modified somewhat over the years. The modern concept is based largely upon electron mieroscopy, with some contributions from biochemical studies. The increase in the nucleic acid content of degenerating peripheral nerve has been attributed to the proliferation of Schwann cells. The alteration in total nucleic acid content and the quantity of deoxyribonucleic acid (DNA) appear at an early stage of degeneration, indicating that the nucleic acid proportions begin to alter before cell division. The severing of a nerve is followed by changes identified by electron microscopy within 24 to 48 hours. The cells in the terminal portion of the proximal stump contribute little or not at all to the bridging of the traumatized area of the nerve. Cellular proliferation in the peripheral stump of an injured nerve may be demonstrated after three days and rises to a maximum in three or four weeks. Cellular activity is greater distal to the cut than at the proximal end. It would seem as if the splintered

[2]CAUSEY, G. The Cell of Schwann, Edinburgh and London, E. & S. Livingstone Ltd., 1960.

portion is more concerned with establishing central control than vice versa.

Single cells and portions of cells from nerve tumors, schwannomas, have been investigated with the same tools. An increase in the proportion of nucleus to cytoplasm, in comparison with normal cells, confirms the findings by light microscopy. The cytoplasm in the schwannoma appears to be disintegrating, and there is gross irregularity in the nuclear membrane. The membrane may be markedly convoluted, so that in the cell nucleus, not only is there folding of the membrane generally, but the convolutions of the outer nuclear lamina impinge upon the inner lamina. This constitutes a distinguishing feature in contrast to the regular parallel lines of the nuclear membrane of the normal cell. Several of the studies described by Causey were sponsored by the British Empire Cancer Campaign. If any physician is skeptical of the interest shown and the progress made in the study of the form and function of nerve tissue, reference is made to Causey's monograph on the cell. Much progress has been made since the days of the monocular light microscope and the staining of nervous tissue, described by Weigert and Ramón y Cajal.