'Tubular and undulated profiles' in the myelin sheath of axons in the goldfish spinal cord[1]

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Summary. We observed 2 unusual structures in island of oligodendrocyte cytoplasm included in the myelin sheath of large axons.

The myelin sheath surrounding the axons of the vertebrate central nervous system consists of closely apposed myelin lamellae, loosened only near the node of Ranvier and at the Schmidt-Lantermann's clefts where cytoplasm of the oligodendrocyte is trapped between the lamellae. In both regions, this cytoplasm contains vesicles, microfilaments and microtubules[3-5] and occupies a space derived from a partition of the 'major dense line'. Studying transverse sections of the spinal cord of 3 normal young goldfishes, we have sporadically observed 2 peculiar structures within the myelin sheath of some axons.

The spinal cord of 4 cm long goldfishes was fixed in 1% osmiumtetroxyd in cacodylate buffer at a temperature of 1 °C. After dehydratation in a series of ethanols and propylenoxyd, fragments of the cords were embedded in Epon. Transverse sections were mounted on 'single hole grids' and stained with uranyl acetate and lead citrate.

The compact myelin sheath of a minority of axons near the midline of the ventral spinal cord is found to widen locally through the splitting of a 'major dense line' (figure 4). The resulting clefts contain concentric inclusions (figures 1, 2 and 4). Identical structures were, in addition, observed at the inner and outer surface of myelin sheaths. These structures consist of rather large 'tubular profiles' oriented both longitudinally and transversely with respect to long axis of the axon involved (figures 1, 2, 4, 5) and 'undulated profiles' (figure 3).

These 'tubular profiles' are often clustered (figure 4) and intermingled with ill-defined round or oblongated, filamentous or lamellar structures (figures 1 and 4). The diameter of a single 'tubular profile', including its wall, varies between 0.1 and 0.3 µm.

It consists of a round, electron translucent central space which has a diameter varying between 0.05 and 0.2 µm and often contains unidentifiable structures (figures 2, 4 and 5). This space is surrounded by lamellar structures which might be described as 'pseudomyelin'. The 'pseudomyelin' is composed of intercalated lamellae of varying density which are coiled spirally around the central space. The periodicity of the 'pseudomyelin' measures 7 nm as determined from the center of 2 adjacent dense lines (figure 5). The dense line measures approximately 3 nm in thickness; the line of intermediate density approximately 3.5 nm. The 'undulated profiles' shown in figures 1-3 are usually observed in association with 'tubular profiles', but they occur less frequently. They are sometimes bounded by a membrane and consist of parallel, electron dense undulated layers (thickness approximately 30 nm) enclosed in a matrix of medium osmiophilia. The layers contact each other at intervals; sometimes, fusion of these contact points occurs giving rise to round structures (figure 3). Furthermore transition between 'undulated profiles', 'pseudomyelin' and the 'normal' myelin are observed.

The 'tubular and undulated profiles' described here are unusual differentiations of the oligodendrocyte cytoplasm, which are located at an unusual site. They may represent regressive or reactive alterations of the myelin sheath, or structures having a specific function. The pseudomyelin of the 'tubular profiles' shows also a periodicity of 7 nm, but differs from the accumulations of myelin-like membranes called 'myelin bodies'[6,7] in possessing a well-defined structure. The 'tubular profiles' show many analogies with a myelinated axon. It cannot be excluded that they represent fine, 'pseudomyelinated' collaterals crossing the myelin sheath of the mother axon. The 'undulated profiles' do not consist of lamellar structures but of homogenous osmiophilic stripes. We compared their structure with the regressive alterations found in tissue exposed to Triparonol (an inhibitor of cholesterol synthesis[8]) as well as with the annulated lamellae described by Kim and Boatman[9] as reactive changes in cells infested by *Rubella* virus. The adaxonal tubular lattice[10], a differentiation in the myelin sheath of the crayfish ventral nerve roots representing part of a conduit system permitting rapid solute flow across the sheath, shows many similarities with our 'undulated profiles'.

However, the 'undulated profiles' described in this paper differ in size and position, and their configuration appears to be unique.

1 Acknowledgments. The author wishes to express his appreciation to PD Dr G.S. Kistler (Anatomy) for the use of electron microscopic facilities and helping in preparing the manuscript, to Prof. G.M. Yasargil (Physiology) for constant support and to Prof. R.L. Friede (Pathology) for critical discussion. I thank Mr W. Scherle for excellent technical collaboration. The study was supported by the Swiss National Fund, grant No. 3.9050.72.

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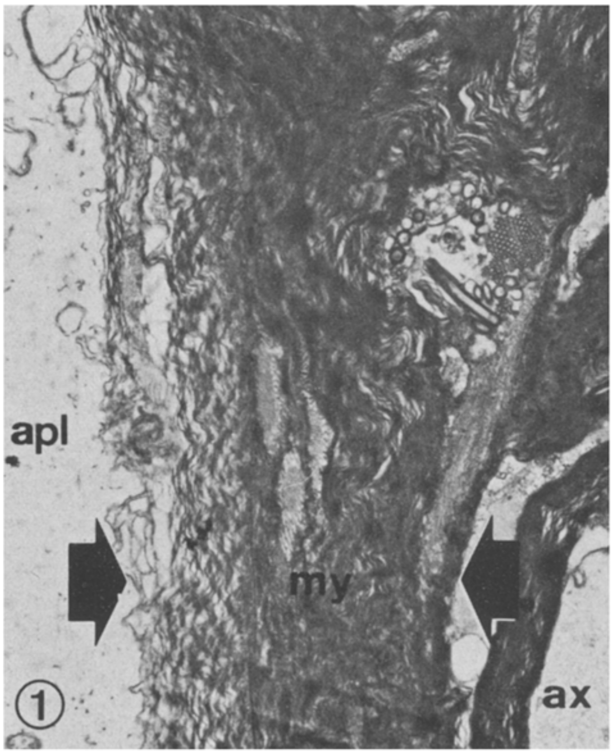
Fig. 1. Transverse section through the myelin sheath of the Mauthner axon (my). The boundaries of the myelin sheath are marked with 2 big arrows. The myelin sheath widens to accomodate some circulary arranged structures. apl: axoplasm of the Mauthner axon. Ax: other contiguous large axon. ×9600. Fig. 2. The circulary ordered structures in the myelin sheath of figure 1 are composed of 'tubular' (tu) and 'undulated profiles' (pe). Structures with slightly rounded or oblong form (black arrowheads) and empty regions (asterisk) are also present. 'Tubular profiles' contain a structure similar to the inner tongue of usual myelin sheath (white arrowhead). ×28,000. Fig. 3. 'Undulated profiles': some contact points between 2 parallel undulated stripes are marked with an asterisk. A round structure is pointed out by 3 black arrowheads. ×140,000. Fig. 4. Transverse section through an axon of the ventral part of the spinal cord. The compact myelin sheath widens through the splitting of a 'major dense line' (arrow; magnificated in the inset). tu: 'tubular profiles'. White arrowhead marks a 'tongue'-like structure. ×44,000. Fig. 5. 'Tubular profiles' with central core (Nu) and 'pseudomyelin' (pmy). The difference in periodicity between the latter and the 'usual' myelin (my) is remarkable. ×100,000.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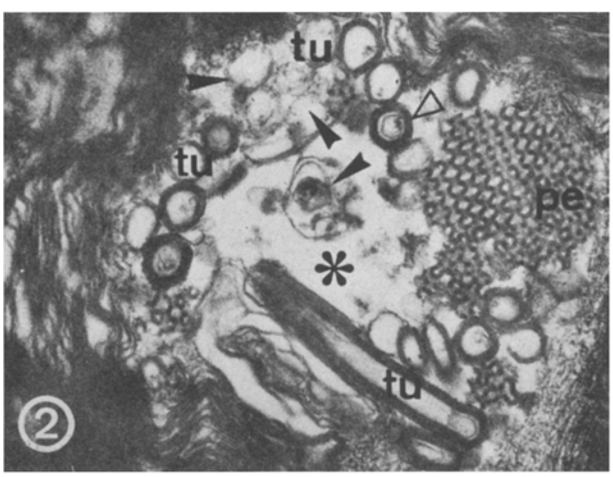
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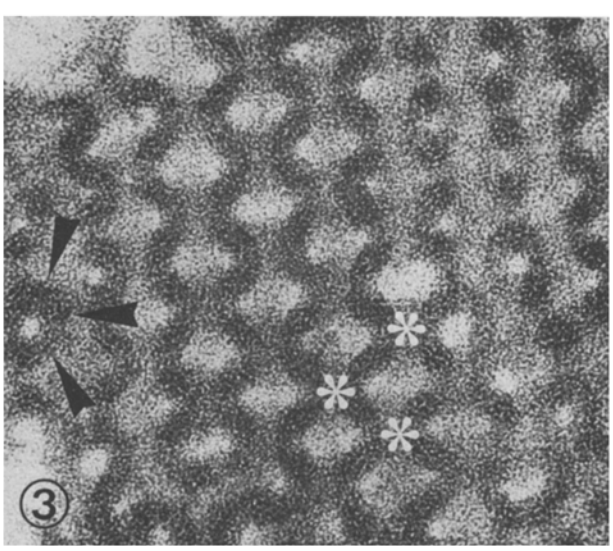
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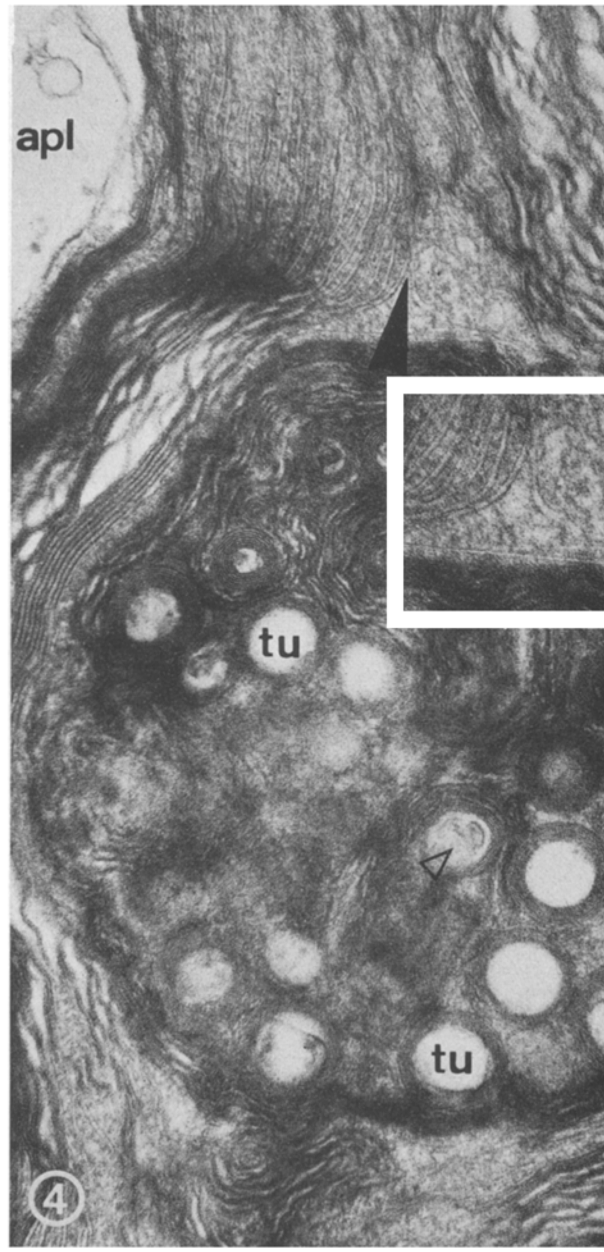
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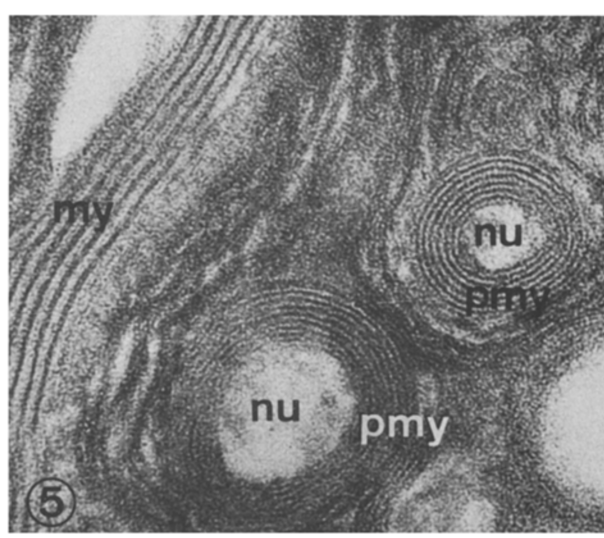
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