

# Brain anatomy of esophagus-less *Osedax* (Siboglinidae) and organisation of the canonical for annelids supraesophageal commissures

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**INTRODUCTION.** Gutless siboglinid tubeworms (frenulates, *Osedax*, see Fig. A, *Sclerolinum* and vestimentiferans) relying their nutrition on bacterial endosymbionts is an annelid group of uncertain phylogenetic position. Orrhage and Müller compared the brains (a.k.a. supraesophageal ganglion) of a range of annelids and showed the general presence of 4 transverse commissures (though with different level of integration in the adult stage), connecting through their roots and circumesophageal connectives to the ventral nerve cords. Hitherto, brains of siboglinids remain understudied, except for the brain of the large-sized Vestimentifera, exceptionally shown to constitute a fusion of both the supra- and subesophageal ganglia (Fig. B). Studies of other siboglinids are required for tracing the ancestral state of brain and substructures.



Fig. A. *O.* "orange-collar", sister to *O.* "yellow-collar" (Vrijenhoek et al., 2009)

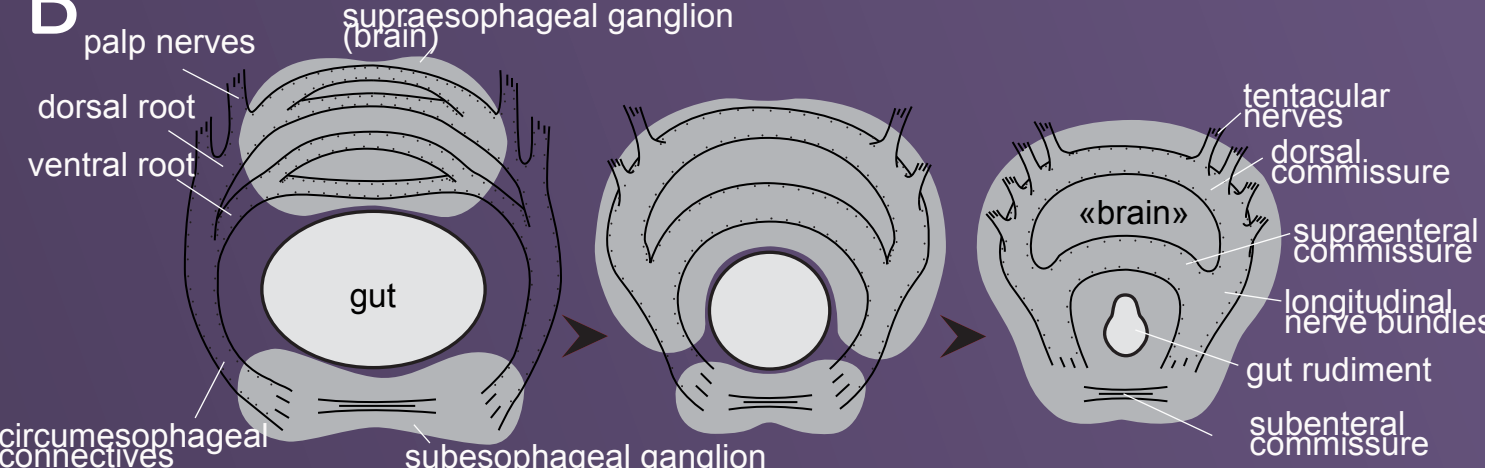
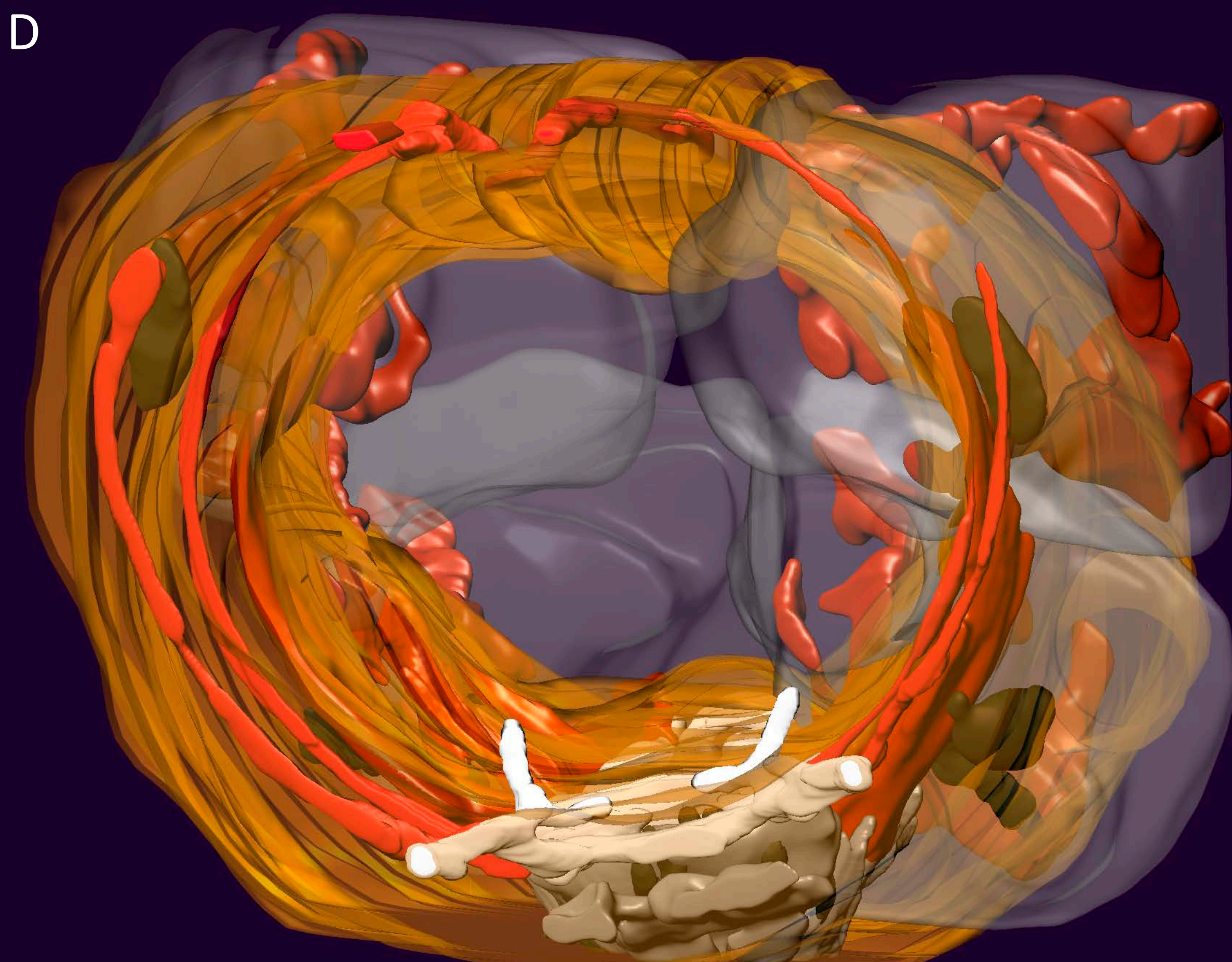
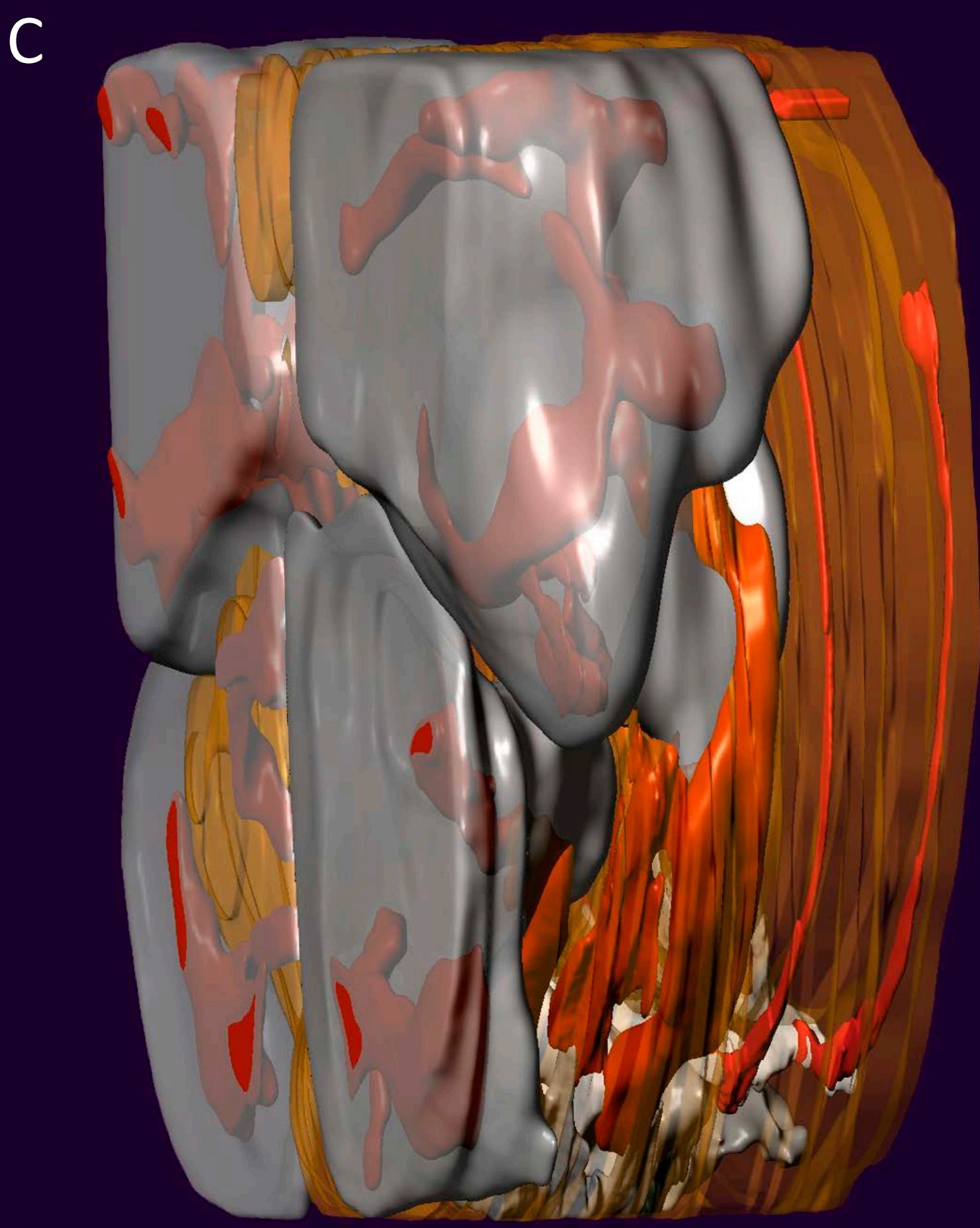


Fig. B. Hypothetical "origin" of the brain of vestimentiferan tubeworms from annelid one (Rimskaya-Korsakova et al., 2012)



Figs. C-E. Brain location and arrangement of peripheral neurite bundles originating from the brain of *O.* "yellow-collar". Overviews of the anterior part of the tubeworm: left (B), posterior view (C), and right (D). Transparent grey – four palps, transparent orange – body and oviduct, red – peripheral nerves (of anterior trunk, oviduct, palps) white – neuropile of the brain, grey – accumulations of perikarya of the brain, green – large cells, presumably also perikarya. Scale bar 20 µm.

**RESULTS.** The brain anatomy of female *Osedax priapus* and *Osedax* "yellow collar" were reconstructed based on histology and 3D modeling (Figs. C-E). In both species there is the same organization of the brain. *Osedax* has a ventral intraepidermal brain, consisting of a large neuropile (Figs. F-K) that ventrally and laterally is covered by densely packed perikarya (Fig. L). The neuropile contains a number of transverse commissures as well as longitudinal and diagonal neurite bundles (Figs. F, J, K, M). In the posteriormost brain are found a dorsal and a ventral commissural bundle with interdecussating fibers, both of which connect with the ventral nerve cords (Figs. F, J, M). A dorsal and a ventral neurite bundle innervating each palp originate from median commissures (diagonal and transverse) and two anterior commissures of the neuropile, respectively (Figs. F, G, N, P). The connection of these commissures to the ventral cords cannot be traced, due to the laterally disguising dense neuropile, also complicating the homology assessment of *Osedax* brain characters. There are three main accumulations of perikarya: posterior, anterior elongated perikarya and anterior round perikarya (Figs. (Fig.H, L, M-P).

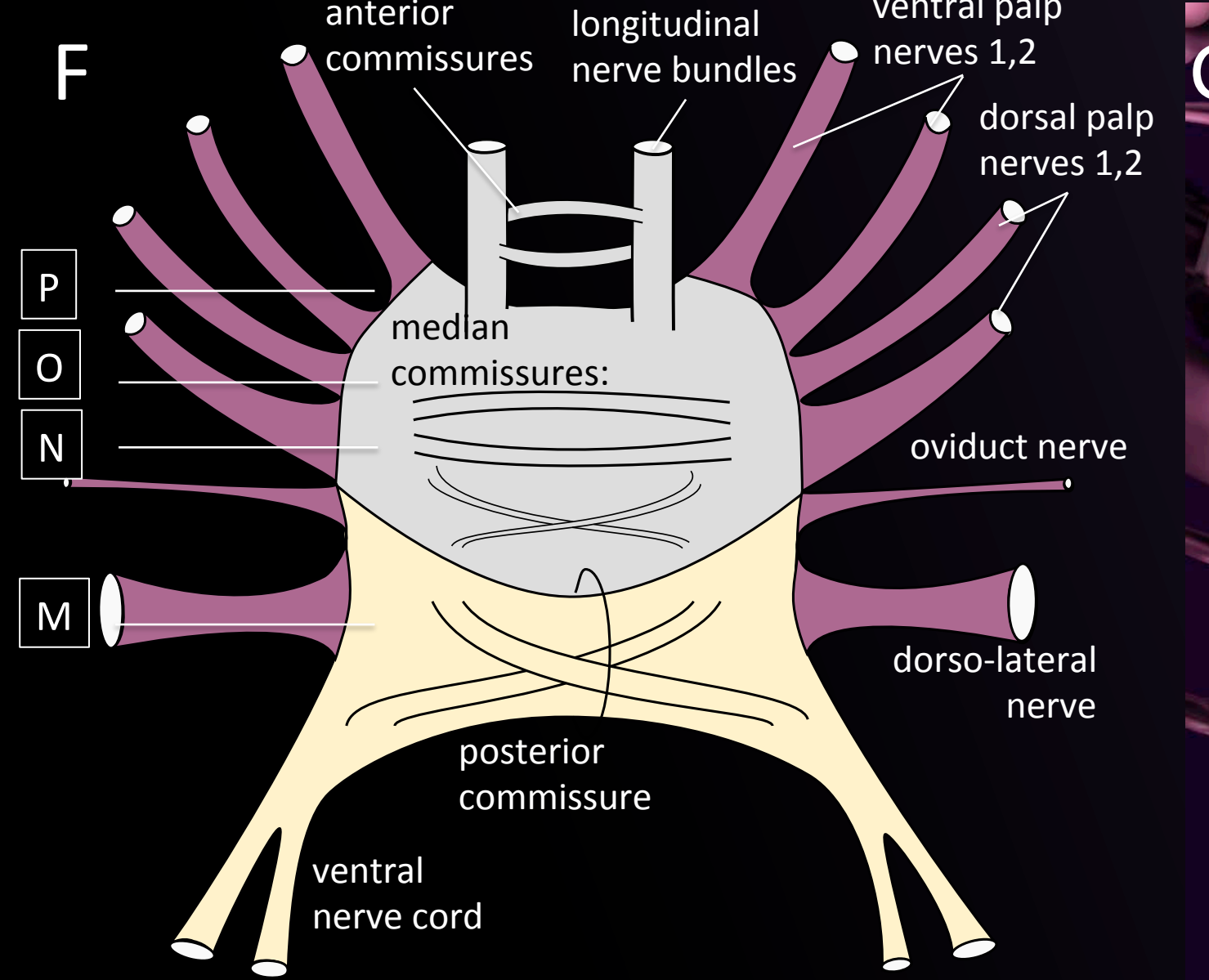


Fig. F. Schematic drawing of the *Osedax* "yellow-collar" brain, based on 3d reconstructions. Letters in boxes show levels at which the histological sections were made (see Figs. L-O).

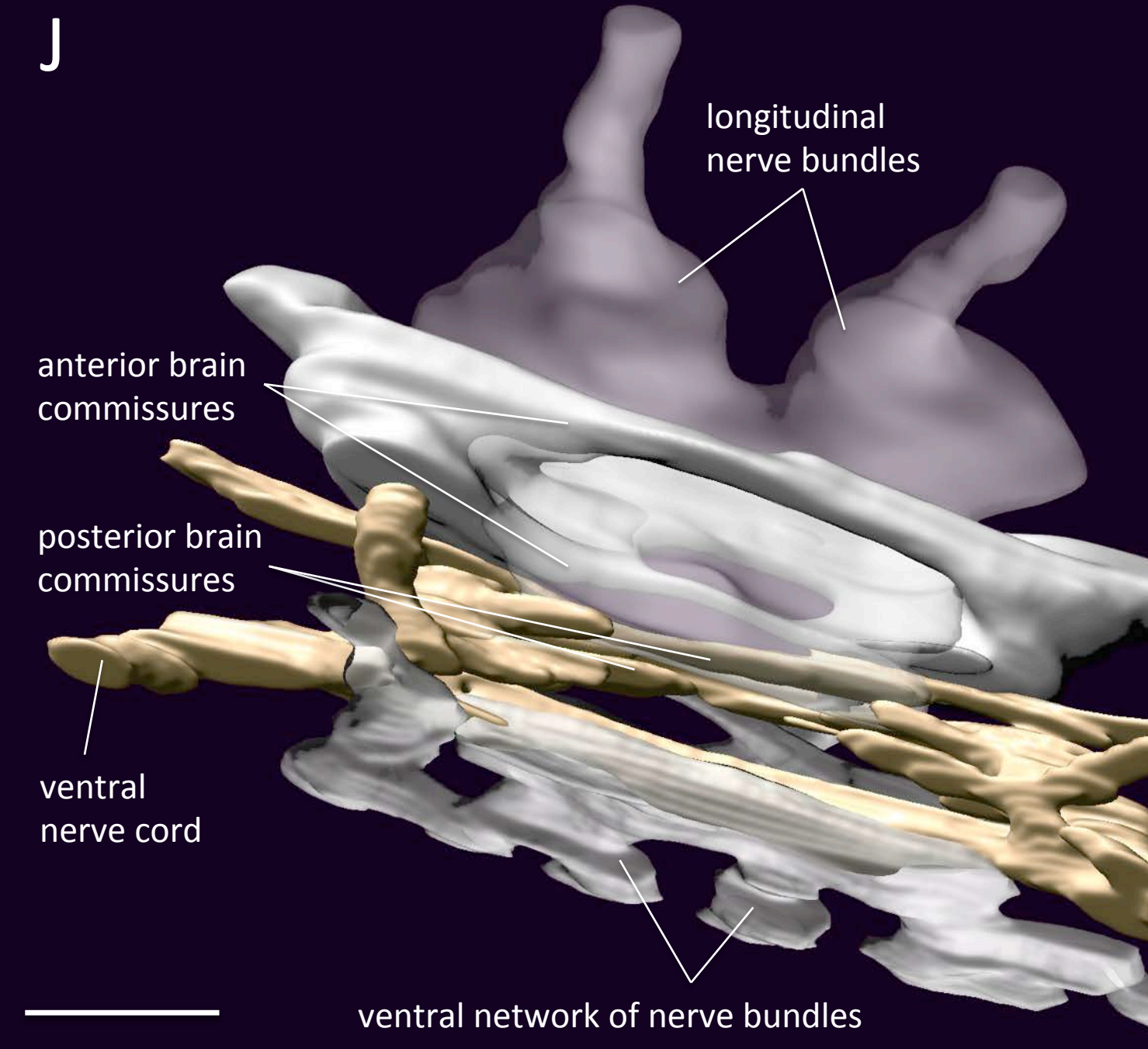


Fig. J. Main nerve bundles of the brain of *O.* "yellow-collar", dorsal view of the 3d model, scale bar 10 µm.

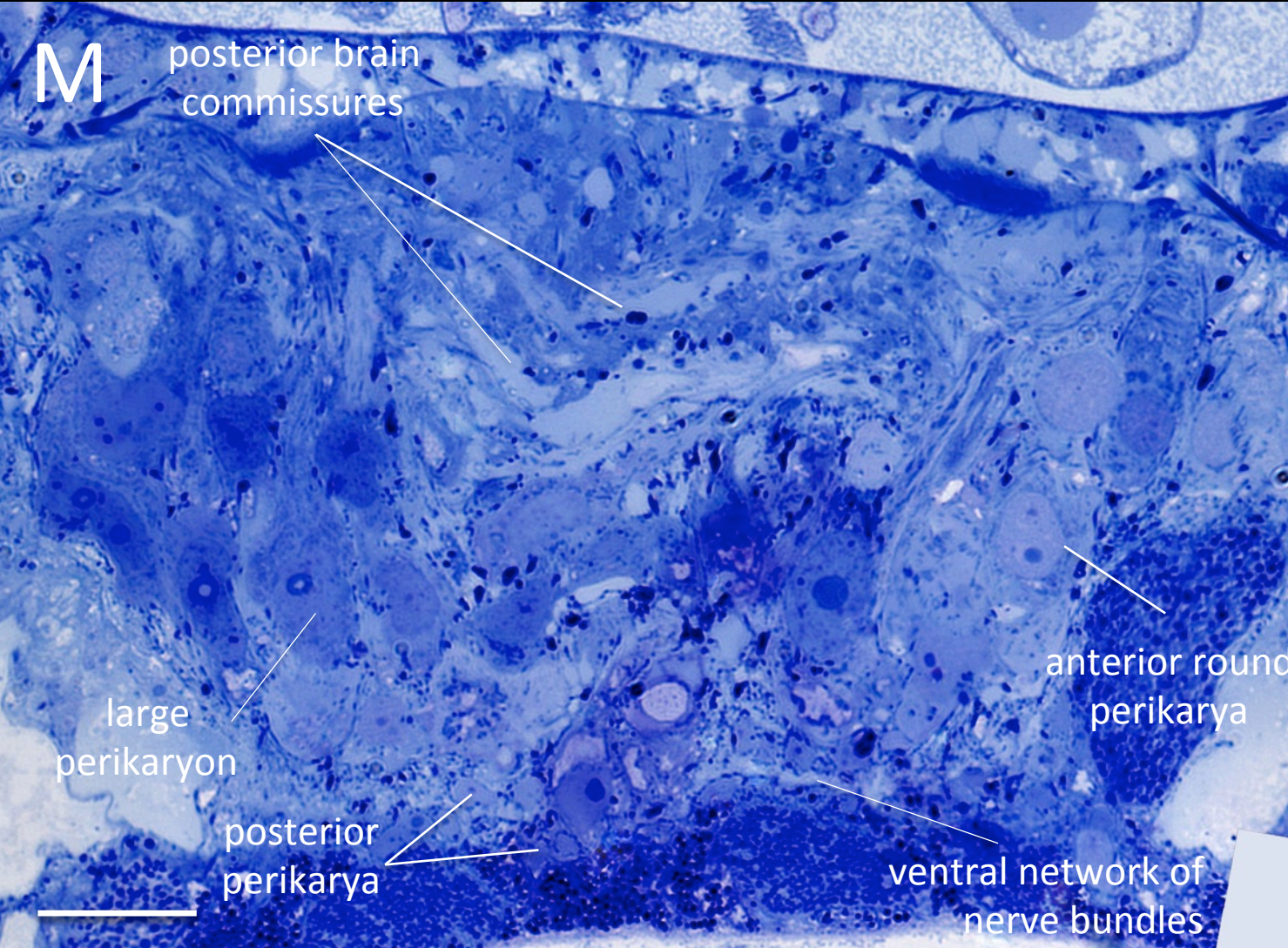


Fig. M. Histological section at the level of the posterior brain commissure in *O.* "yellow-collar". The level showed at Fig. F, scale bar 10 µm.

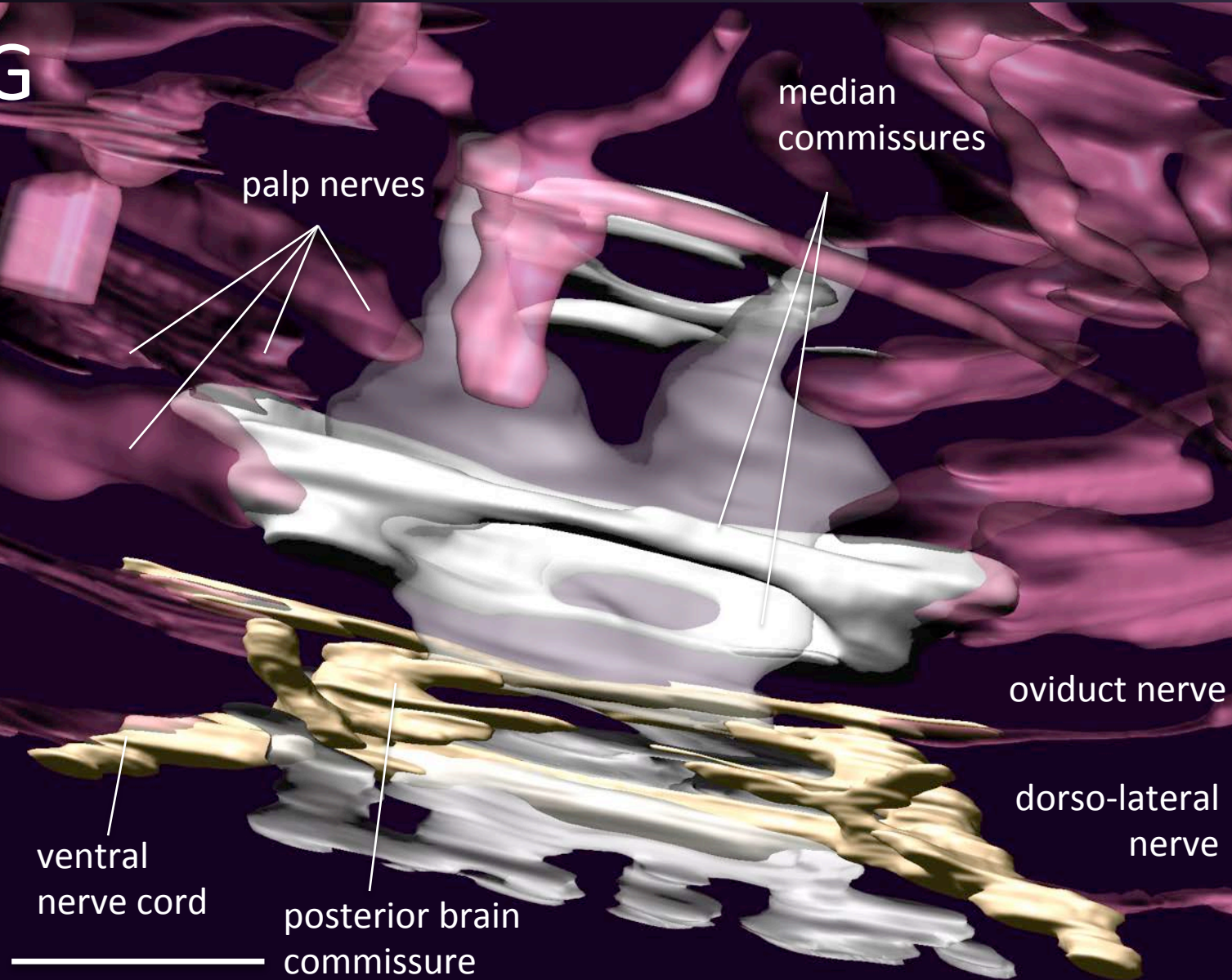


Fig. G. Main commissures and origin of the peripheral nerves in the brain of *O.* "yellow-collar", dorsal view of the 3d model, scale bar 20 µm.

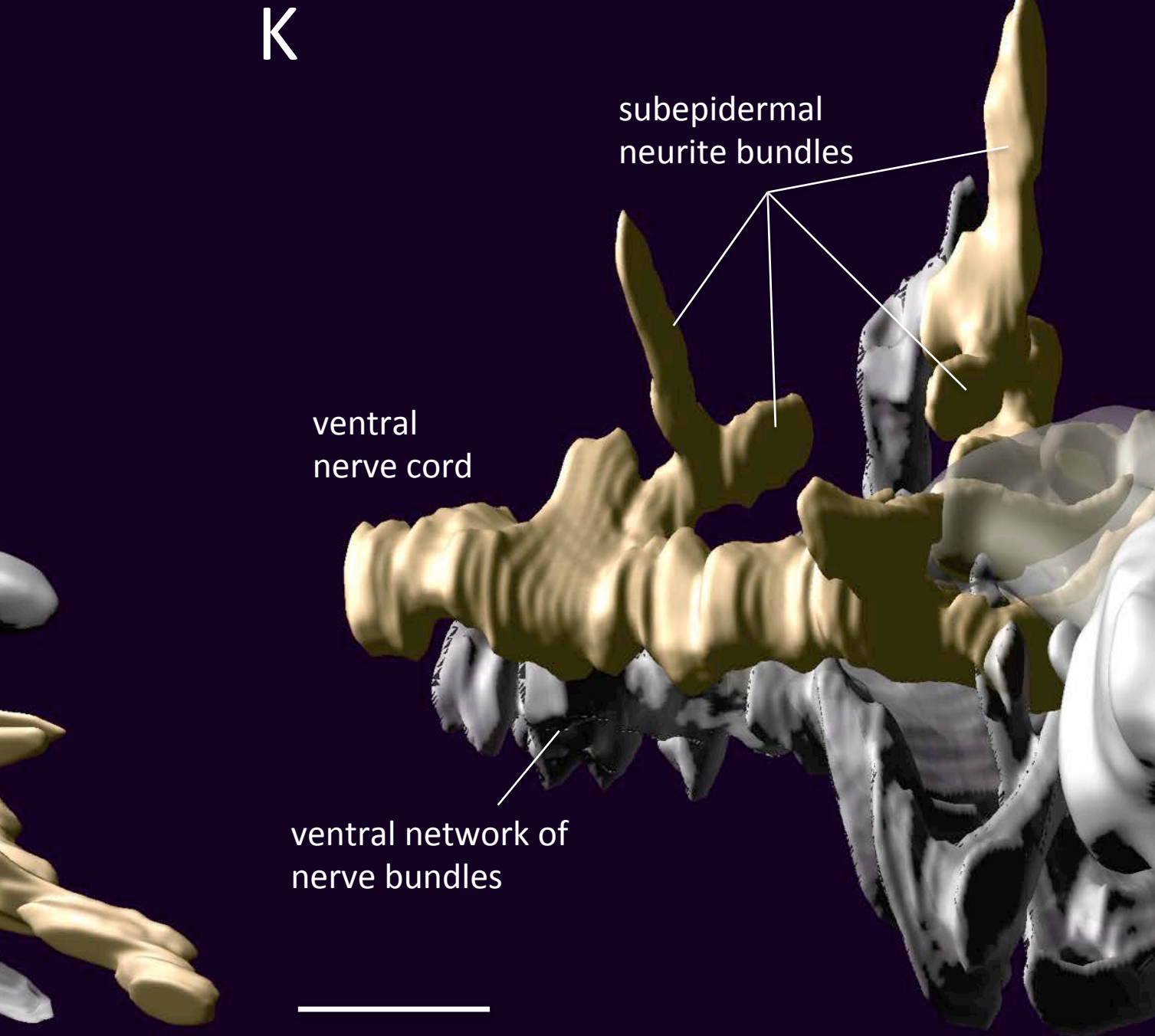
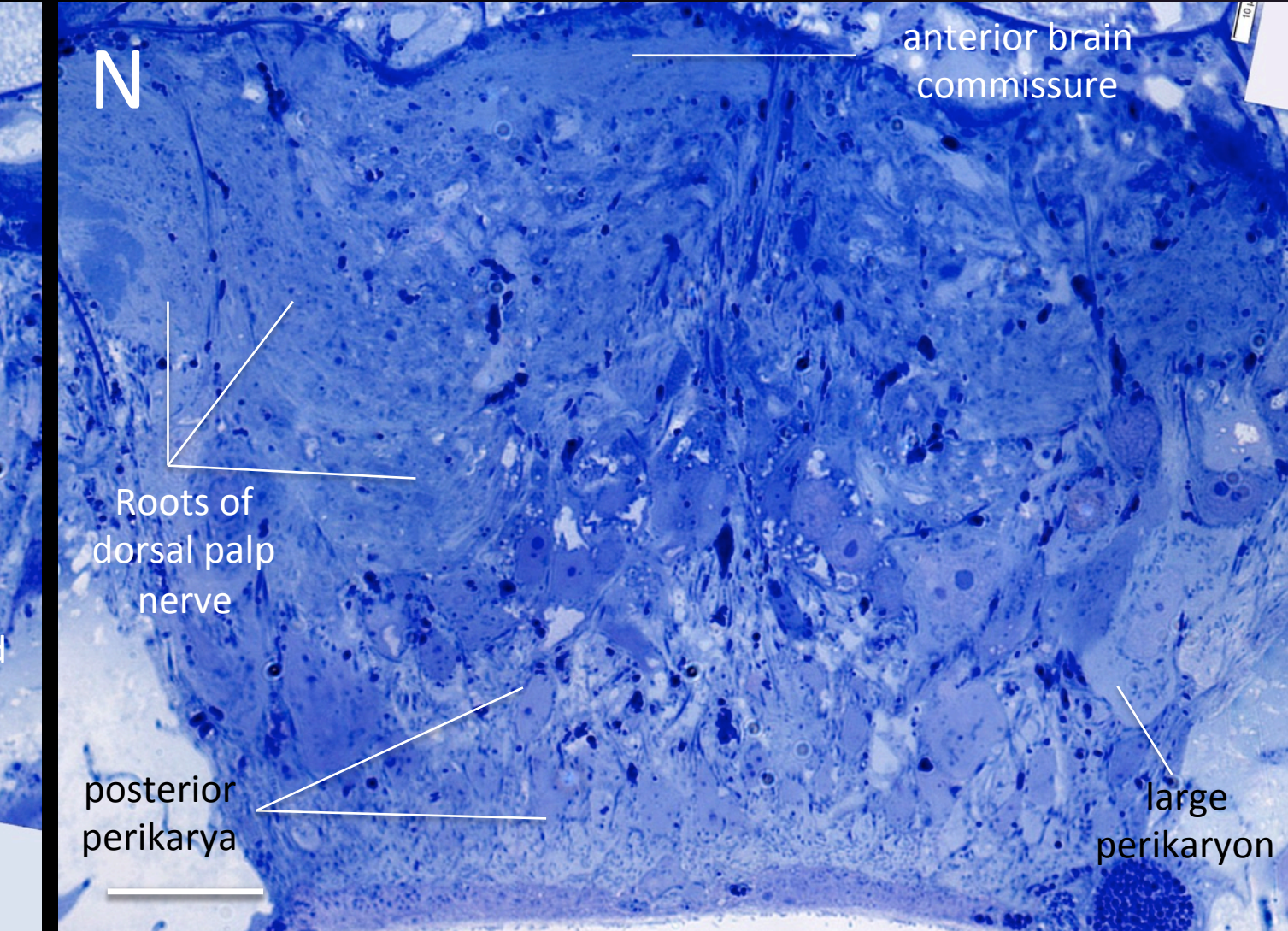


Fig. K. Main nerve bundles of the brain of *O.* "yellow-collar", right lateral view of the 3d model, scale bar 10 µm.



Figs. N, O. Histological sections of the brain of *O.* "yellow-collar" at the level of the anterior brain commissures: dorsal (M) and ventral (N) ones. The level showed at Fig. F, scale bar 10 µm.

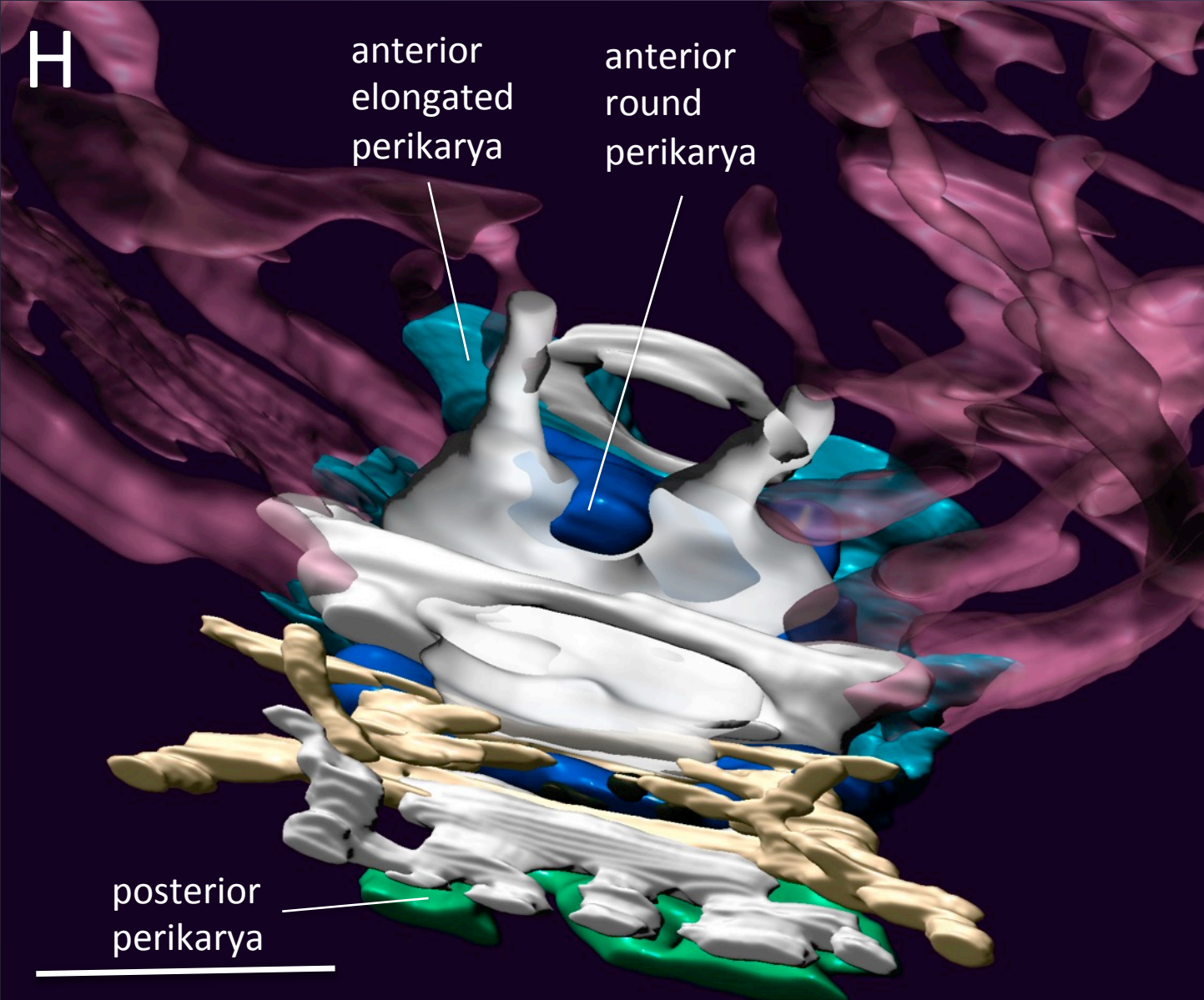


Fig. H. Main commissures and perikarya accumulations of the brain of *O.* "yellow-collar", dorsal view of the 3d model, scale bar 20 µm.

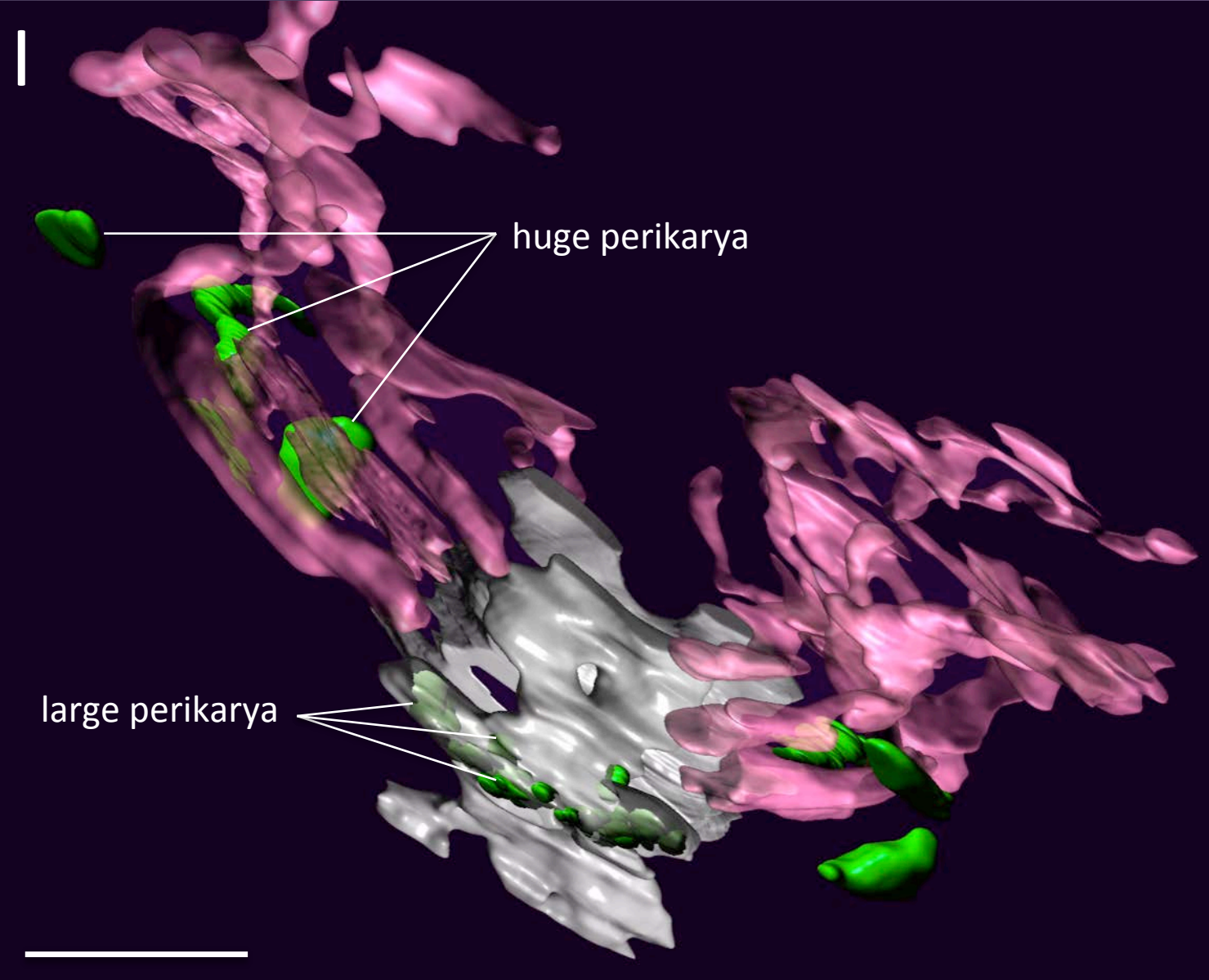


Fig. I. 13 pairs of large perikarya among anterior round perikarya, as well as three pairs of huge cells, presumably perikarya, scale bar 50 µm.

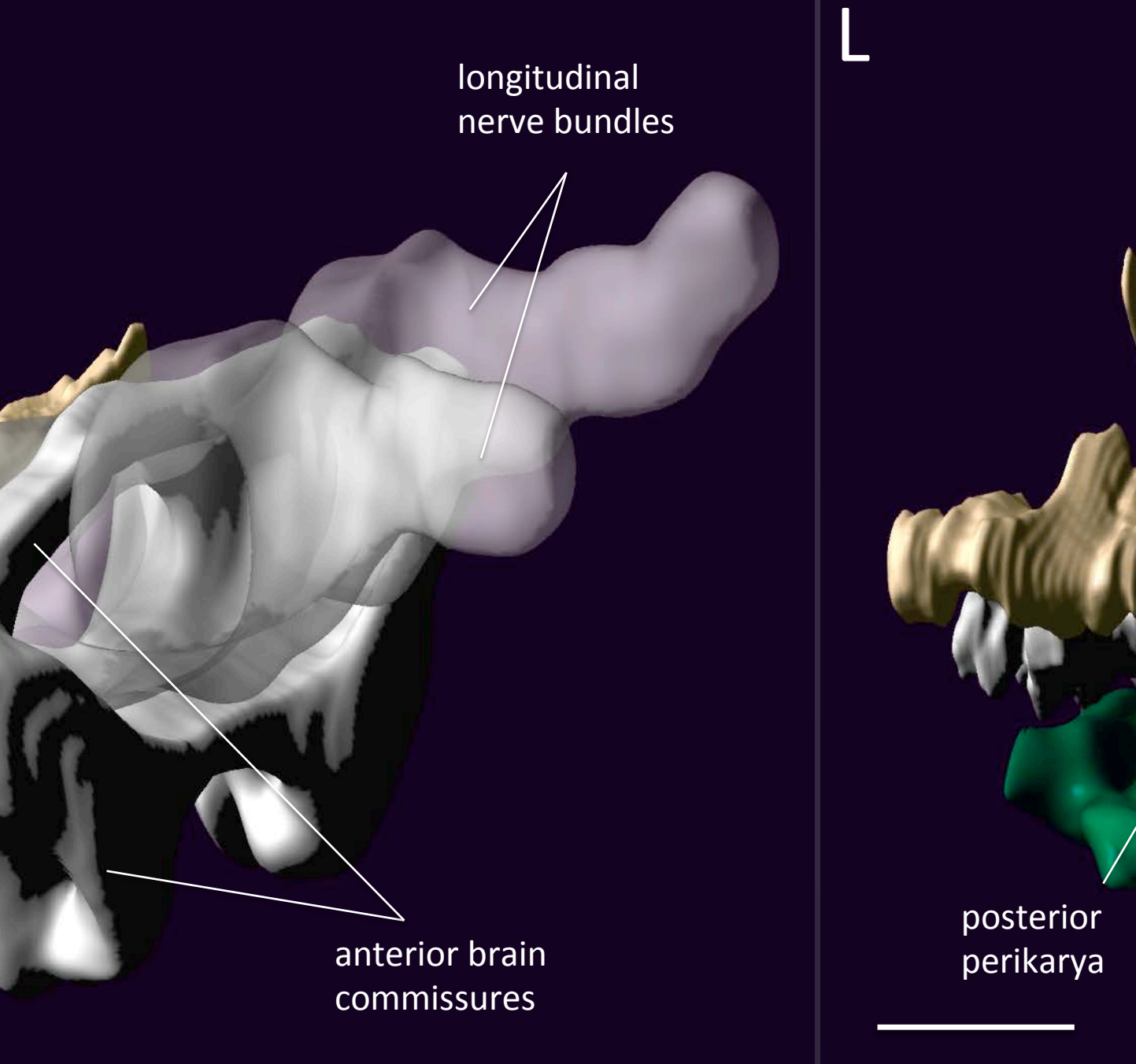


Fig. L. Main nerve bundles and perikarya accumulations of the brain of *O.* "yellow-collar", right lateral view of the 3d model, scale bar 10 µm.

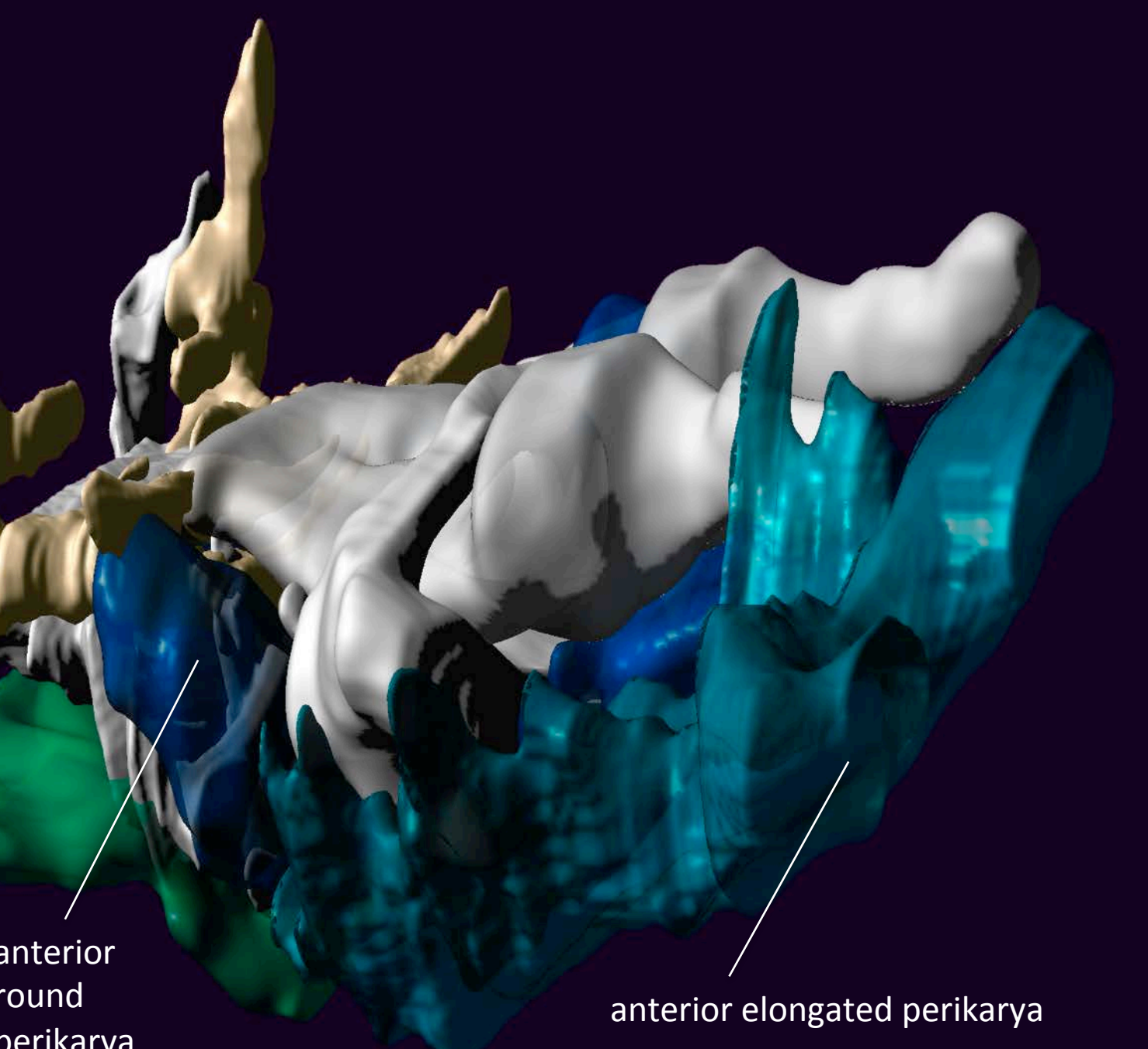


Fig. P. Histological section of *O.* "yellow-collar" brain at the level of the roots of the posterior ventral palp nerves. Level showed at Fig. F, scale bar 10 µm.

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