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Fibroblasts, macrophages, and mast cells may be present throughout the spinal meninges, within the thickness of the three membranes: dura mater, pia mater, and arachnoid. In addition, these cell types are present inside nerve roots, dorsal root ganglia, and peripheral nerves at the endoneurial level, within the perineurial laminae, interfascicular connective tissue, and epineurium [1, 2].

Fibroblasts present among collagen fibers have an elongated shape, and their nuclei are oblong or elliptic and may contain one or two nucleoli. Mitochondria often are located proximal to the nucleus. The amount of rough endoplasmic reticulum fluctuates throughout inactive and active phases; it is scarce during the former and abundant in the latter. Fibroblasts contribute to the production of collagen fibers and glycoproteins in the extra-fibrillar matrix or ground substance, which fill areas not occupied by collagen fibers.

Macrophages are highly specialized phagocytic cells that play an essential role in immune and regeneration processes, as well as in tissue maintenance, acting as scavengers by removing cellular debris and other particles that reach lysosomal enzymes [3–5]. Macrophages have fusiform or stellate shapes and often are present near small blood vessels and perineurial laminae [3].

Macrophages originate from monocytes in the bone marrow; the latter migrate along the bloodstream and cross

through endothelial cells of postcapillary venules to reach connective tissues, where they transform into macrophages [4–8]. These become highly specialized in phagocytic activity, engulfing particles by means of pseudopods or cellular membrane projections that extend and contract. The surface of pseudopods is covered by many microvilli and undulating folds called lamellipodia, where the cytoplasm contains typical heterogenic granules [1, 2].

Among other characteristics, macrophages have an essential lytic function mediated by acid phosphatase and an exceedingly effective phagocytic capability. Macrophages establish special connections with endothelial cells during phagocytic processes, leading to removal of myelin debris [1, 2].

Mast cells are large, 20–30 μm , with a round nucleus, conspicuous granules, and folds of membrane that project from the surface [4]. Mast cells or mastocytes have oval or elliptic shapes and cytoplasmic projections containing vacuoles filled with various types of amines and heparins [9, 10].

Plasma cells are products of B-lymphocyte activation that synthesize and secrete antibodies. These cells have an eccentric nucleus, a well-developed Golgi apparatus, and a cytoplasm packed with dilated rough endoplasmic reticulum (Figs. 2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7, 2.8, 2.9, 2.10, 2.11, 2.12, 2.13, 2.14, 2.15, 2.16) [4].

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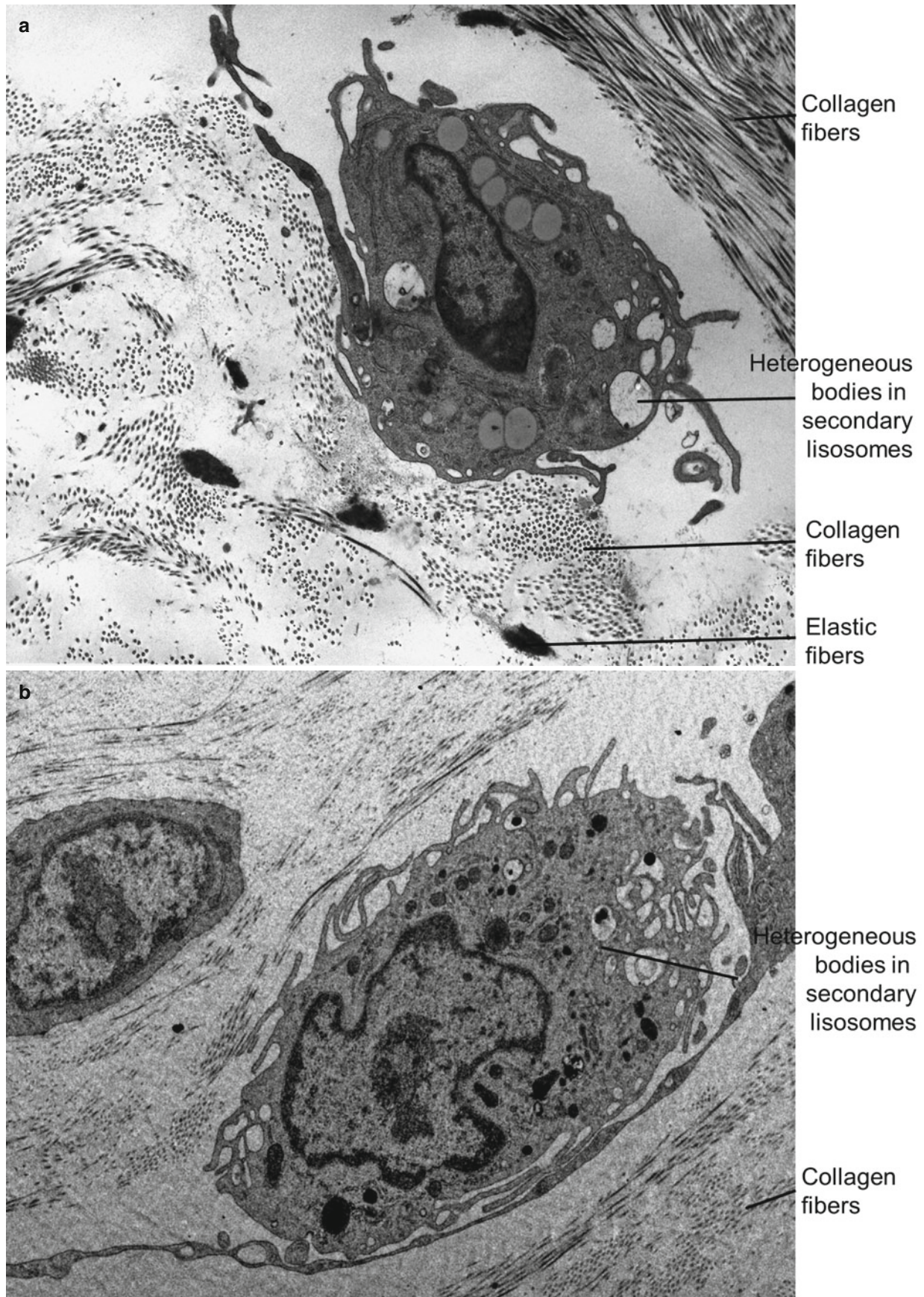


Fig. 2.1 Macrophage (functional form of a histiocyte) within human dura mater. (a, b) The cell has fine pseudopodia lacking organelles. Cisternae from the rough endoplasmic reticulum, mitochondria,

lysosomes, and Golgi complex are identified. Magnification: $\times 7,000$ (Panel a from Reina et al. [6]; with permission)

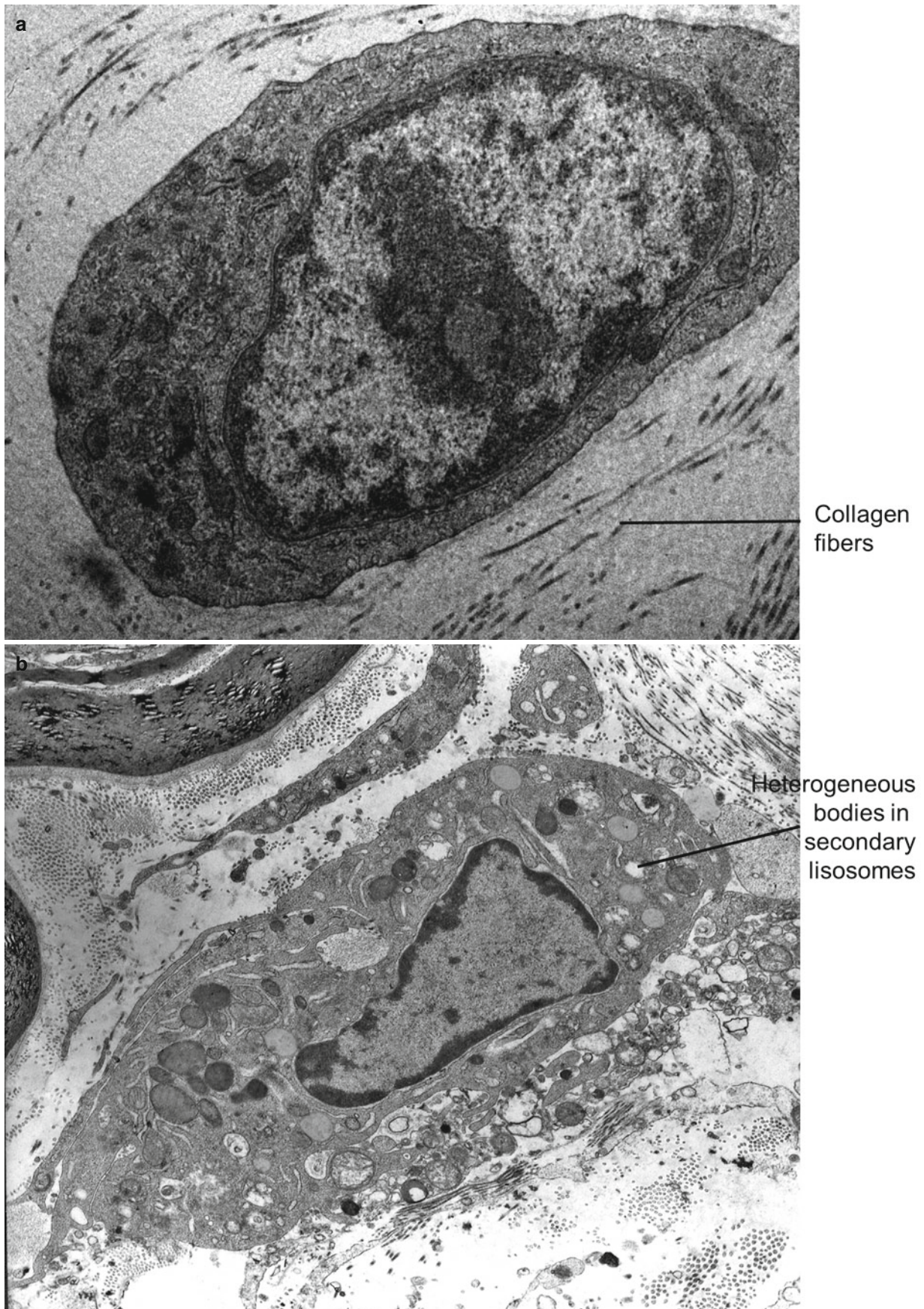


Fig. 2.2 (a) A cell similar to a myofibroblast present in human dura mater. (b) Macrophage located among nerve roots in the cauda equina. Transmission electron microscopy, magnification: $\times 15,000$ (a); $\times 8,000$ (b)

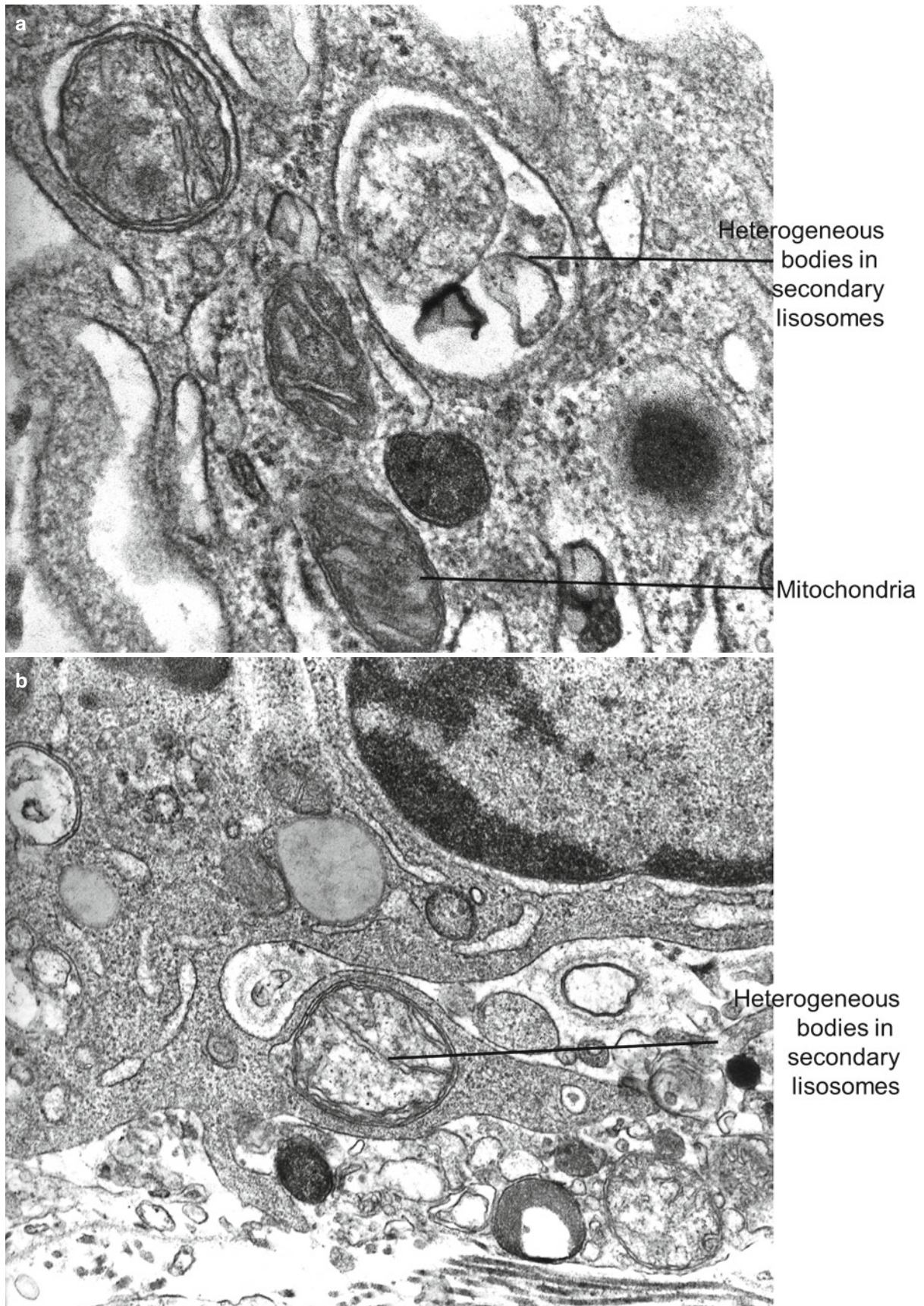


Fig. 2.3 (a) View of the cytoplasm of a macrophage located within the pia mater from a nerve root from the cauda equina. Transmission electron microscopy. (b) Macrophage cell present in a nerve root from the cauda

equina. Electron microscopy (From Reina et al. [8]; with permission) Magnification: $\times 10,000$ (a); $\times 20,000$ (b)

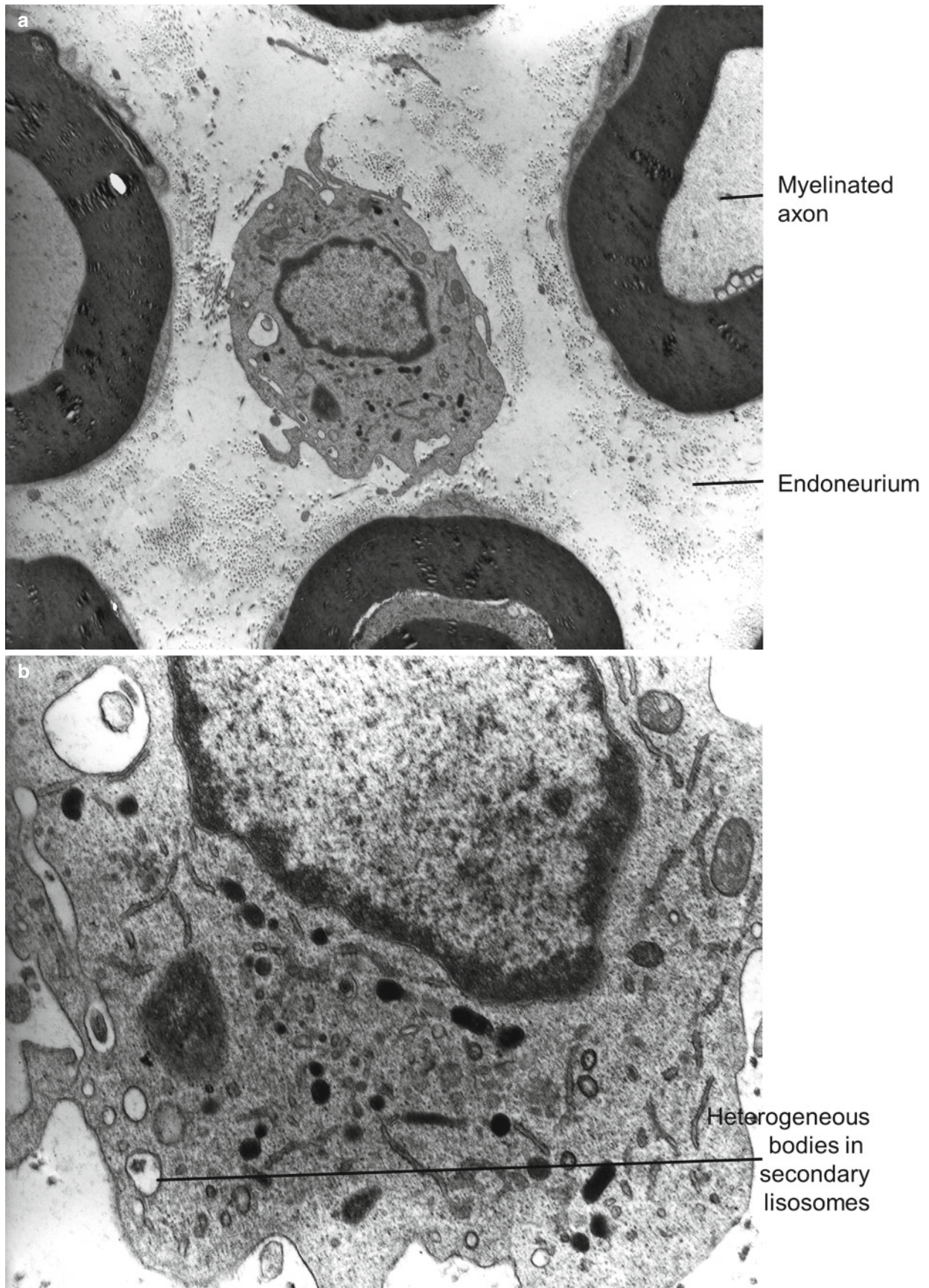


Fig. 2.4 Macrophage in a nerve root from the cauda equina. (a) Cytoplasmic pseudopodia are identified. (b) The same image at higher magnification. Transmission electron microscopy, magnification: $\times 4,400$ (a); $\times 12,000$ (b)

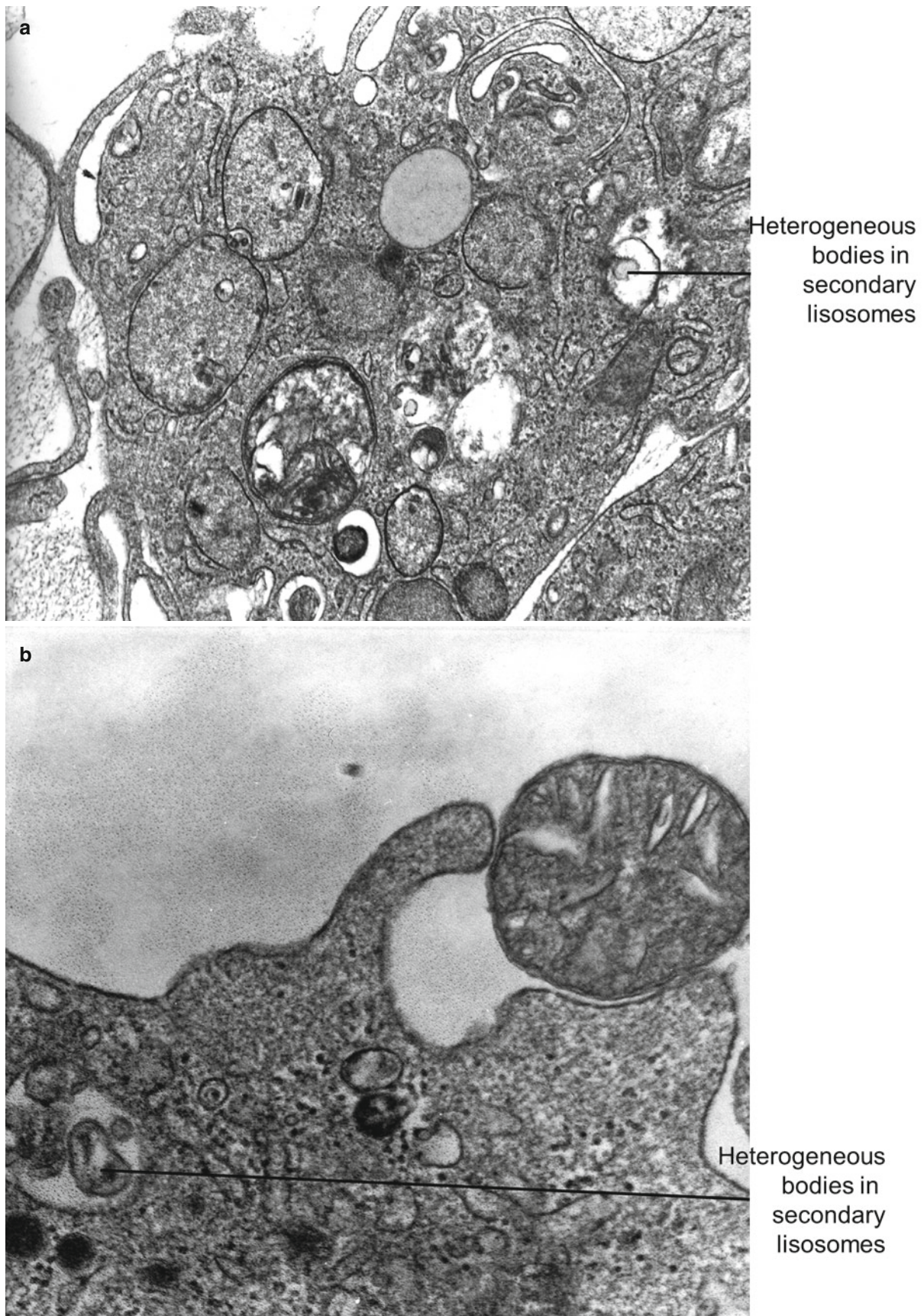


Fig. 2.5 Macrophage in a nerve root from the cauda equina. (a) Detail of lysosomes, smooth endoplasmic reticulum, and mitochondria. (b) Two pseudopods during phagocytosis of a cell particle (From Reina et al. [8];

with permission) Transmission electron microscopy, magnification: $\times 20,000$ (a); $\times 50,000$ (b)

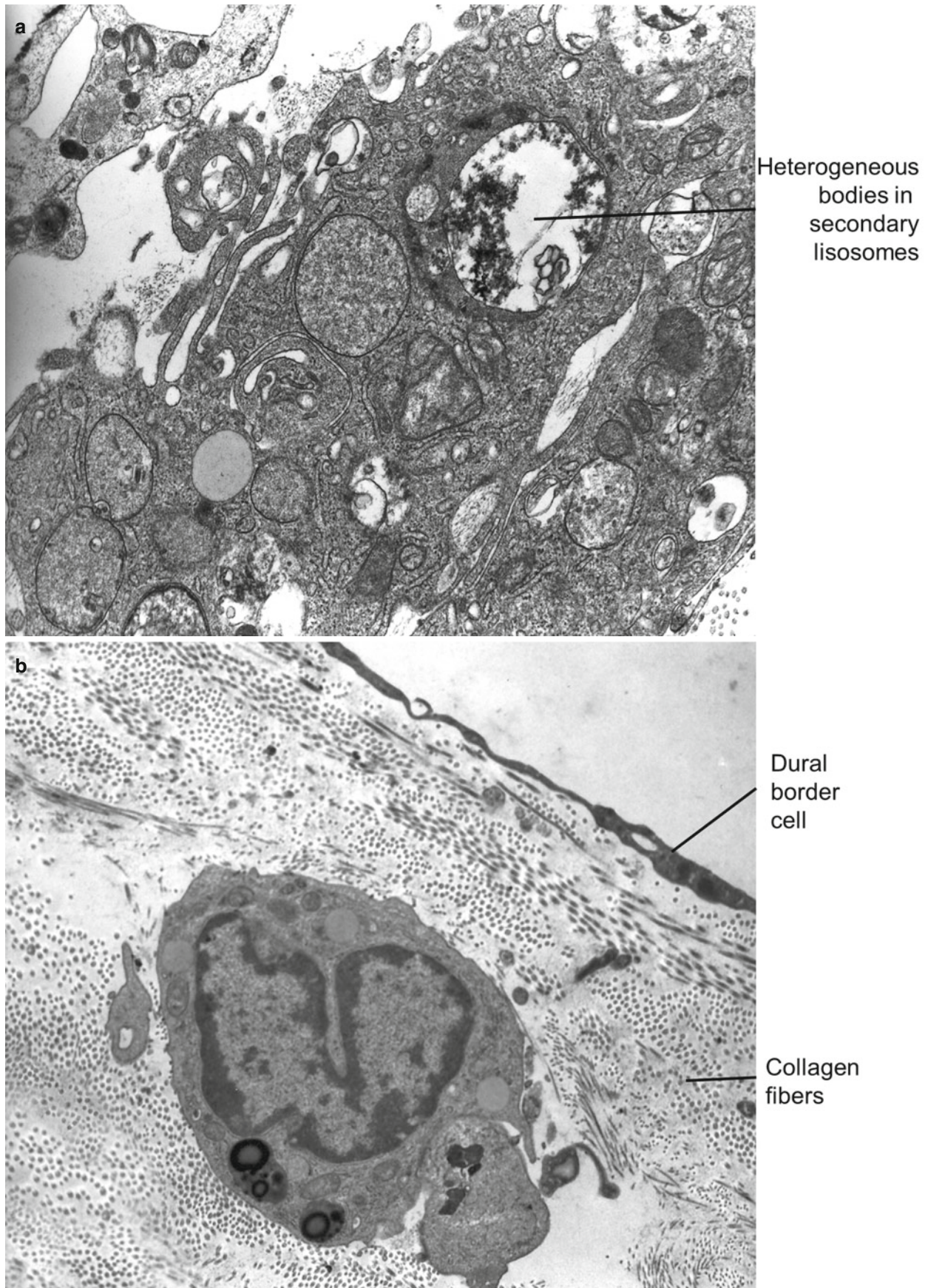


Fig. 2.6 Macrophage. (a) Detail of a macrophage in a nerve root from the cauda equina. Lysosomes are identified. (b) Macrophage located inside a human spinal subdural compartment. Transmission electron microscopy, magnification: $\times 12,000$ (a); $\times 7,000$ (b)

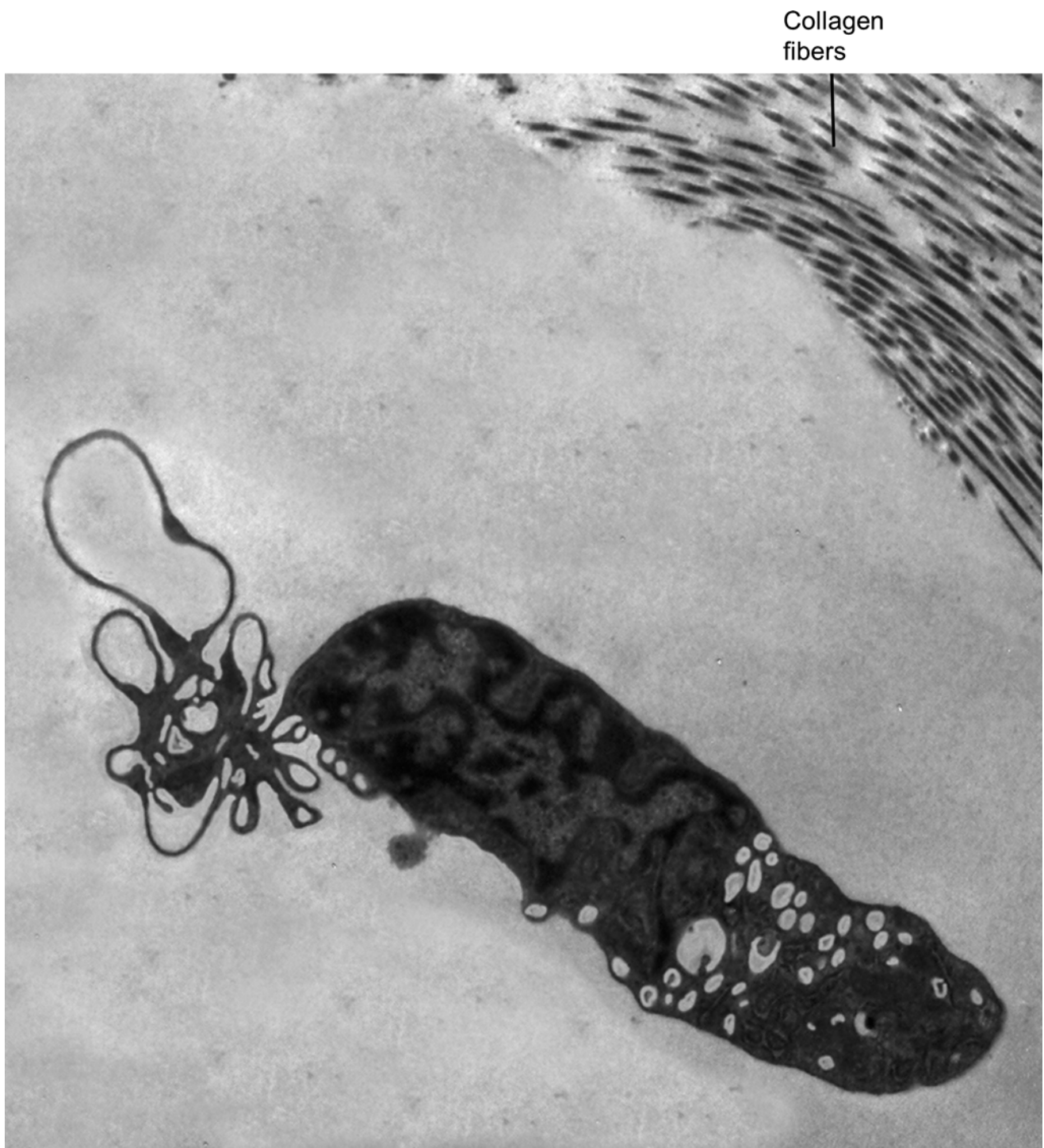


Fig. 2.7 Free cell filled with numerous lysosomes, located inside the human spinal subdural compartment. Transmission electron microscopy, magnification: $\times 7,000$

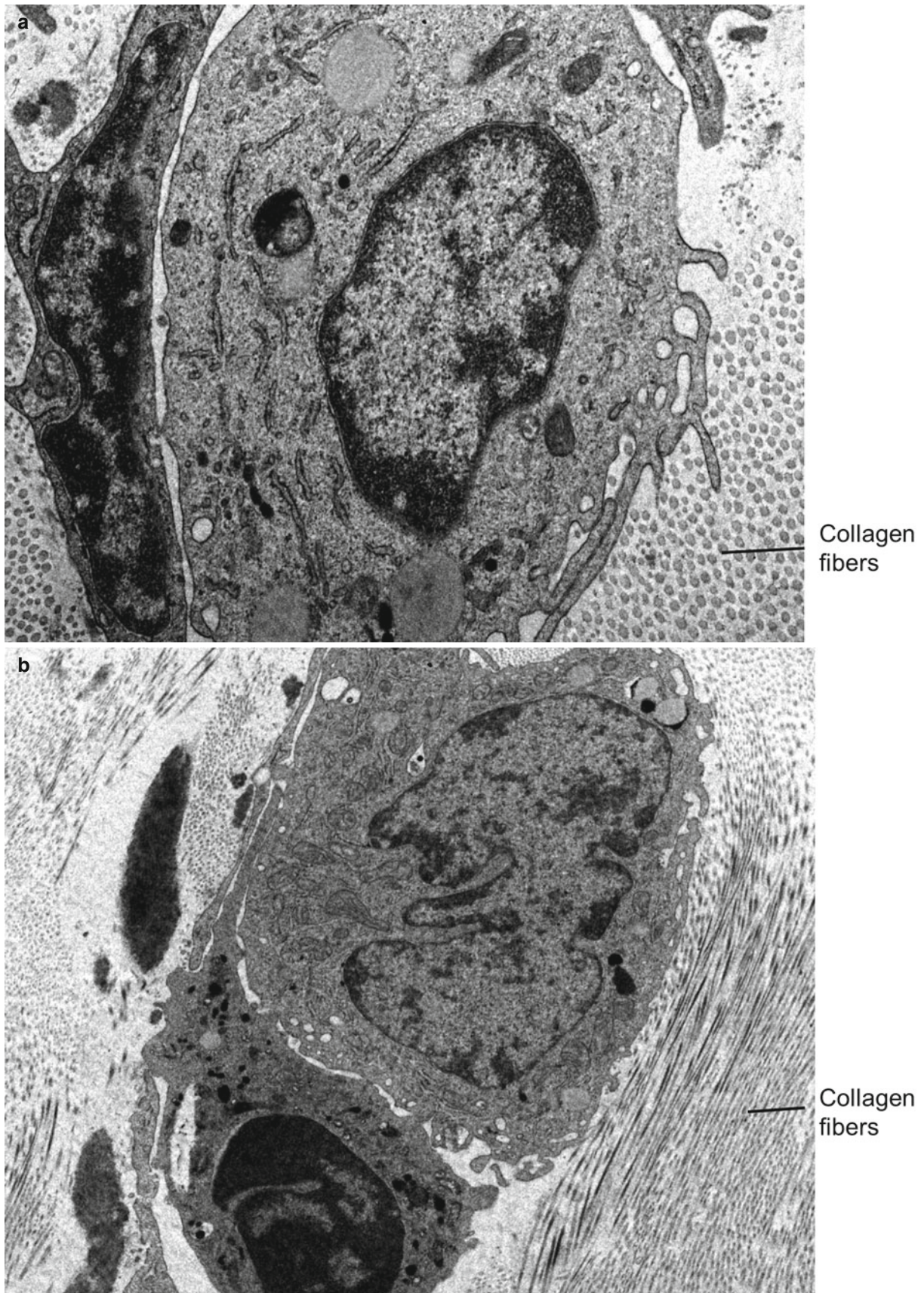


Fig. 2.8 Macrophage located between dural laminae from human spinal dura mater. (a) Several elongated pseudopods lacking organelles. (b) Two adjacent cells in close contact. Above, a macrophage shows pseudopods. Transmission electron microscopy, magnification: $\times 12,000$ (a); $\times 10,000$ (b)

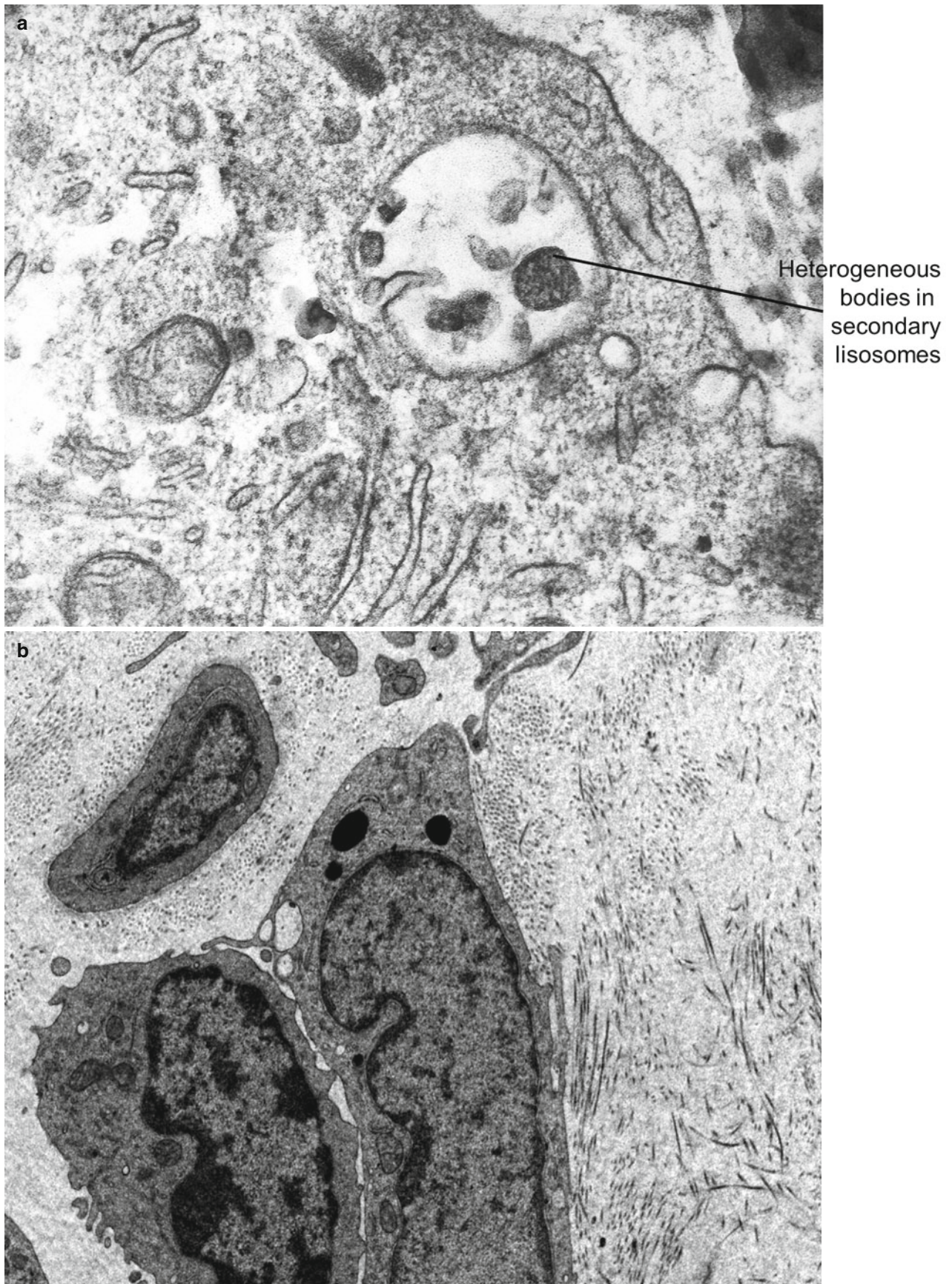


Fig. 2.9 Macrophage and fibroblast. (a) Macrophage in a human spinal subdural compartment. (b) Two cells showing features of fibroblasts between human spinal dura mater. Transmission electron microscopy, magnification: $\times 40,000$ (a); $\times 12,000$ (b)

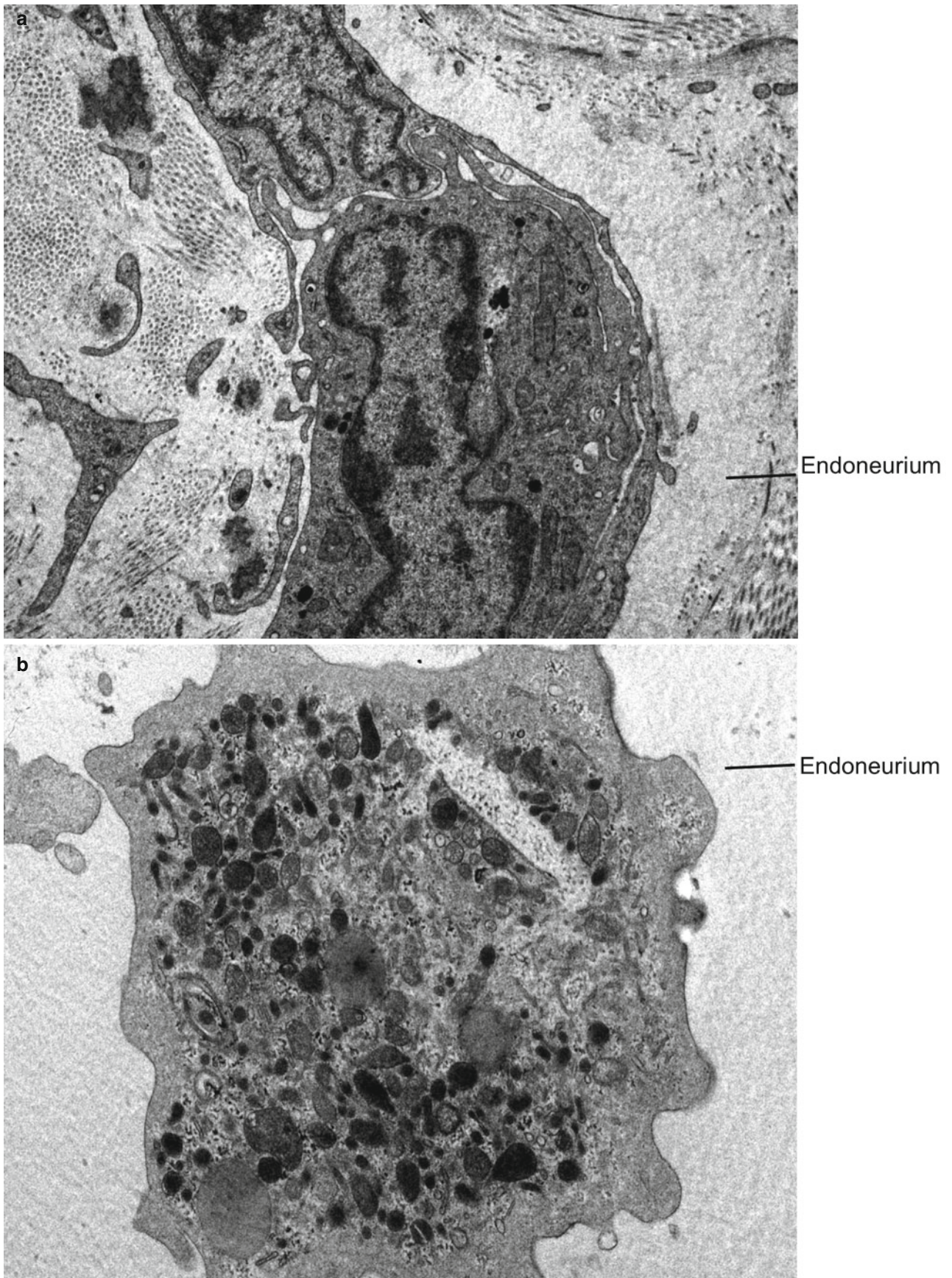


Fig. 2.10 Macrophages and a multinucleated neutrophil. (a) Two adhering macrophages (histiocytes) (From Reina et al. [8]; with permission) (b) Multinucleated neutrophil in a nerve root from human cauda equina. Transmission electron microscopy, magnification: $\times 12,000$ (a); $\times 10,000$ (b)

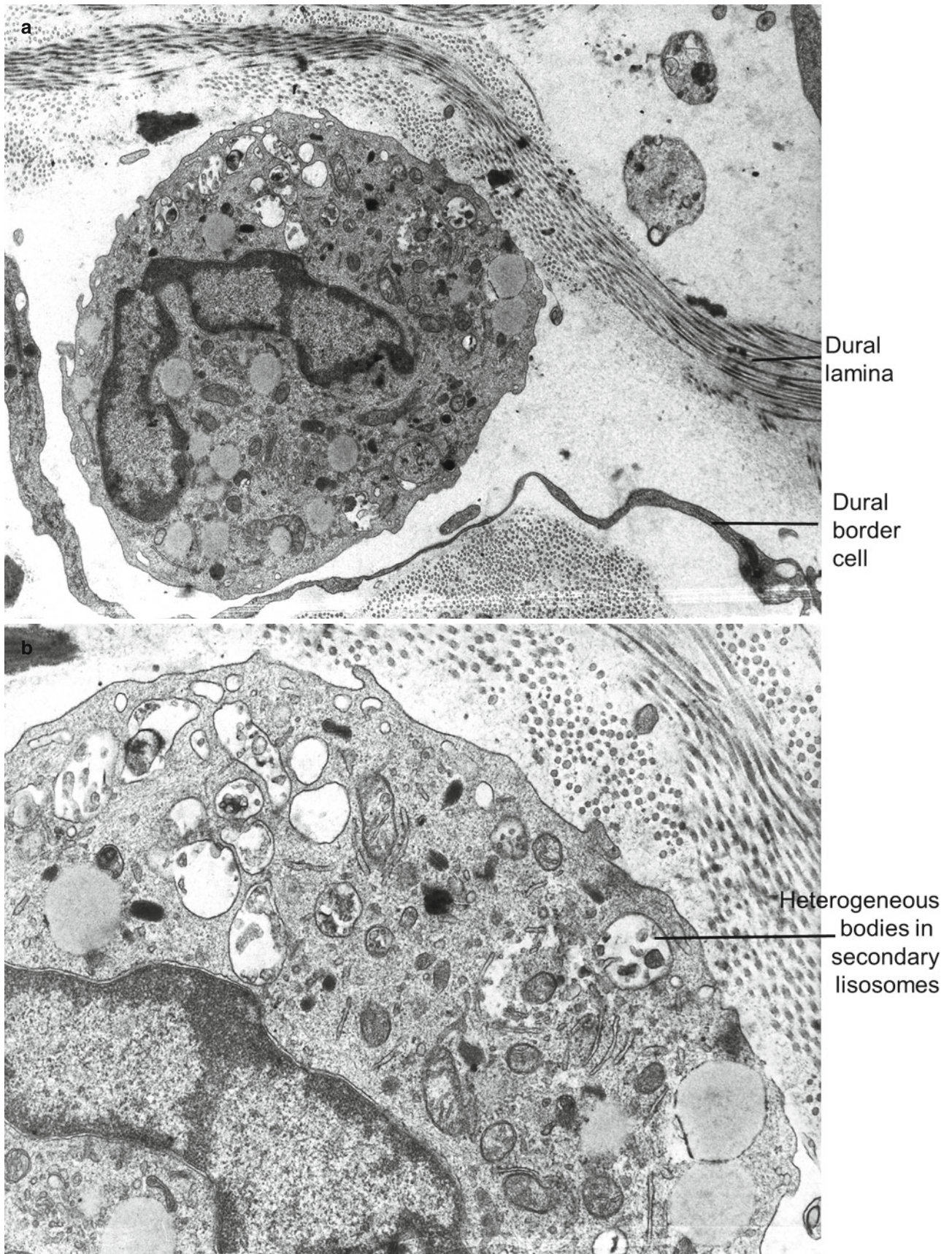


Fig. 2.11 Macrophage located inside a human spinal subdural compartment. (a) Macrophage. (b) Detail of the same image at higher magnification. Transmission electron microscopy, magnification: $\times 5,000$ (a); $\times 12,000$ (b)

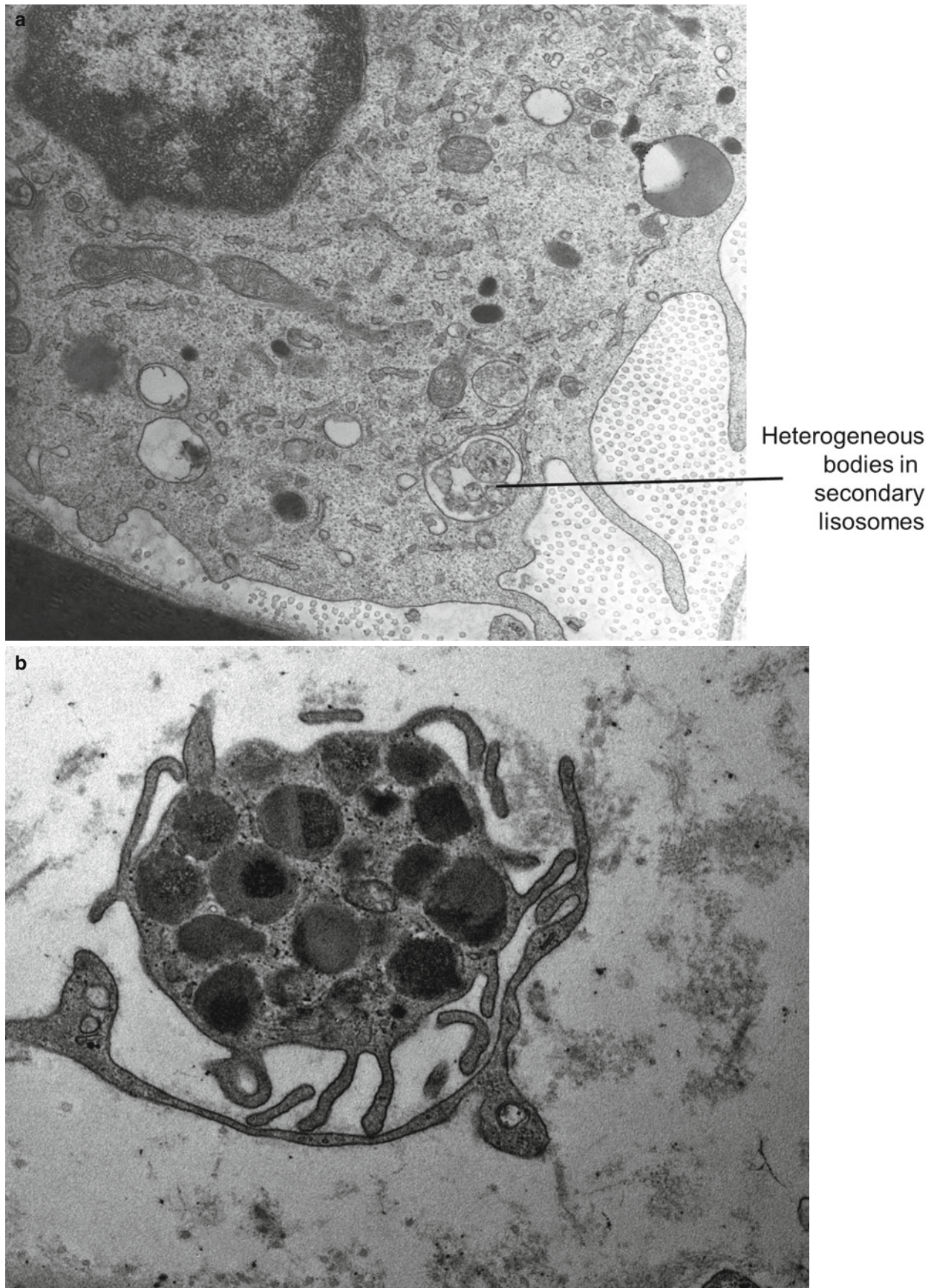


Fig. 2.12 (a) Macrophage inside a nerve root from the cauda equina (From Reina et al. [8]; with permission) (b) Macrophage located inside a human spinal subdural compartment. Transmission electron microscopy, magnification: $\times 12,000$ (a, b)

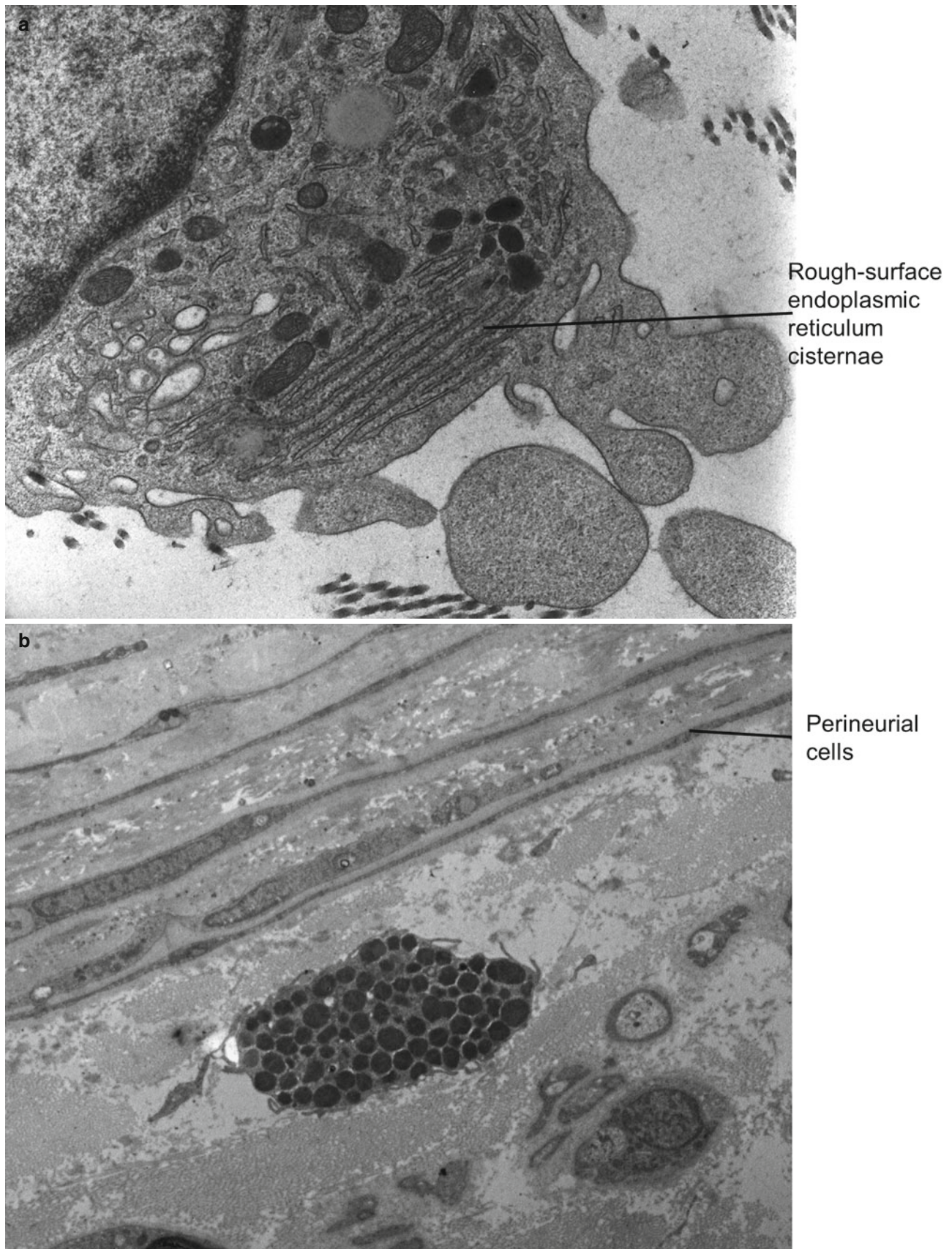


Fig. 2.13 Macrophage and mastocyte. (a) Macrophage located inside a human spinal subdural compartment. (b) Mastocyte located between perineurial laminae of a sciatic nerve. Transmission electron microscopy, magnification: $\times 6,000$ (a); $\times 3,000$ (b)

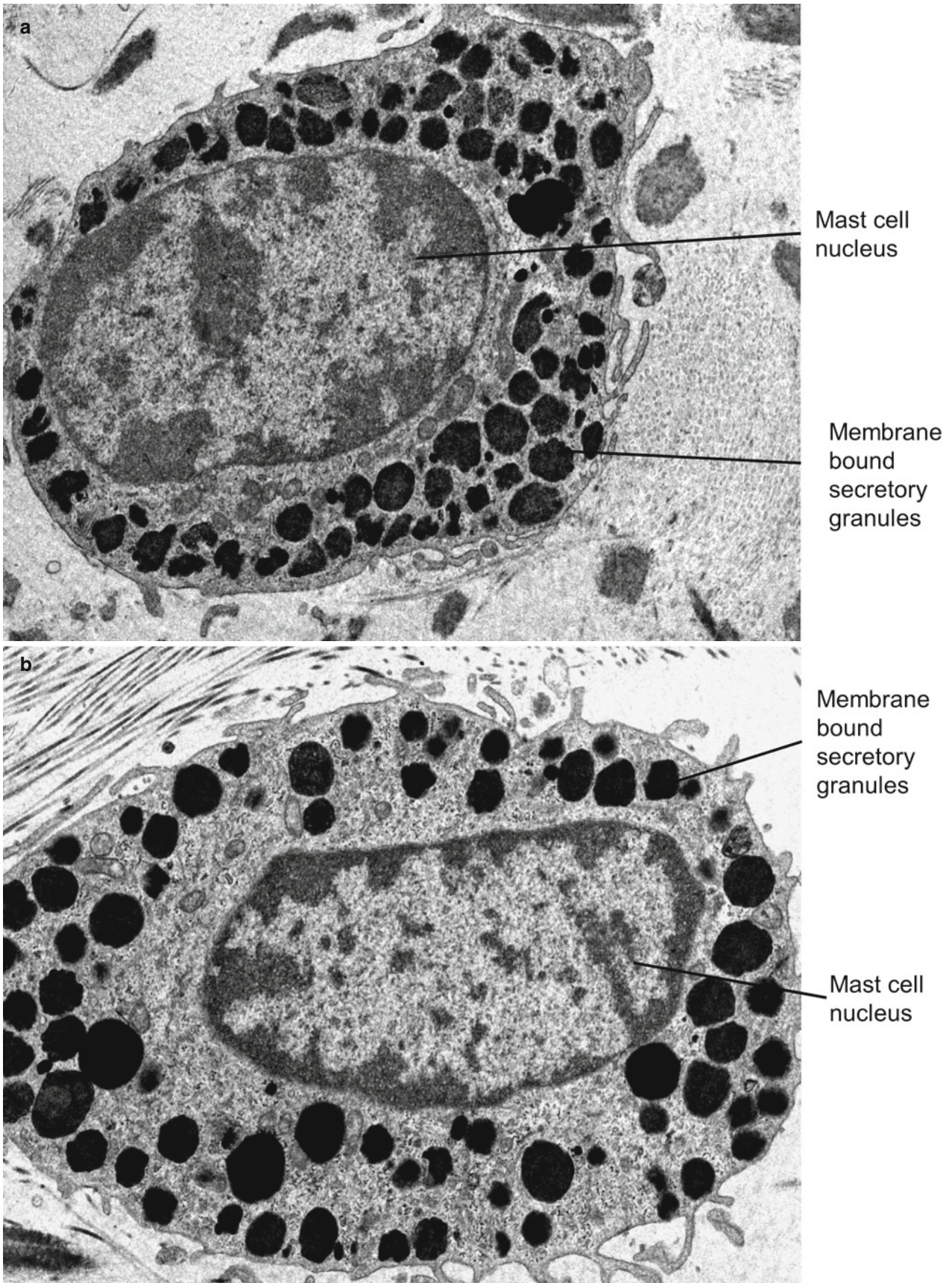


Fig. 2.14 Mastocytes located between laminae of human spinal dura mater. (a, b) Mastocytes. Transmission electron microscopy, magnification: $\times 15,000$ (a, b) (Panel b from Reina et al. [7]; with permission)

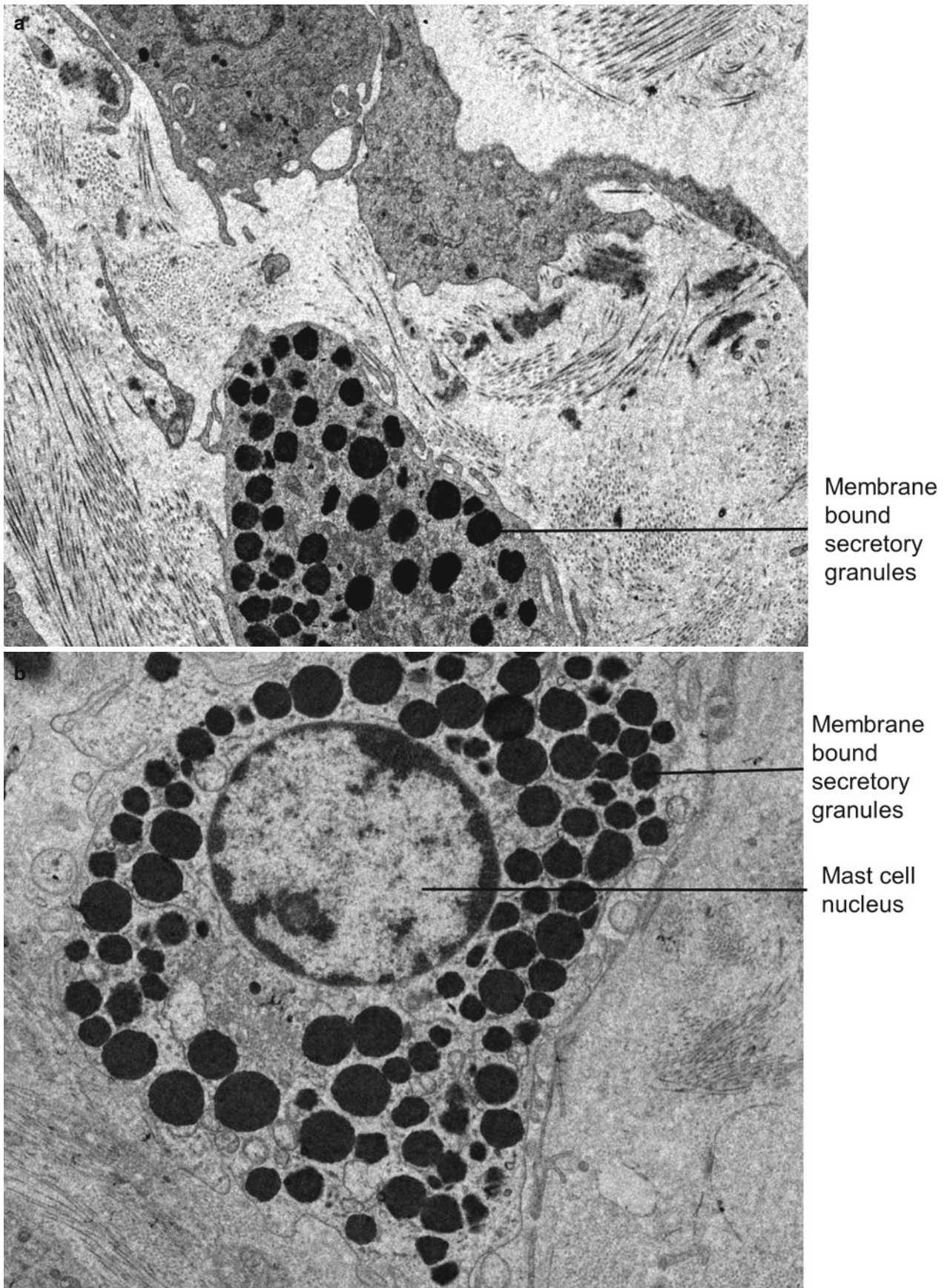


Fig. 2.15 Mastocytes located among laminae of human spinal dura mater. (a) Mastocytes and fibroblasts. Characteristic cytoplasmic granules are identified. (b) Mastocyte with its nucleolus at the center of the cytoplasm. Transmission electron microscopy, magnification: $\times 10,000$ (a, b)

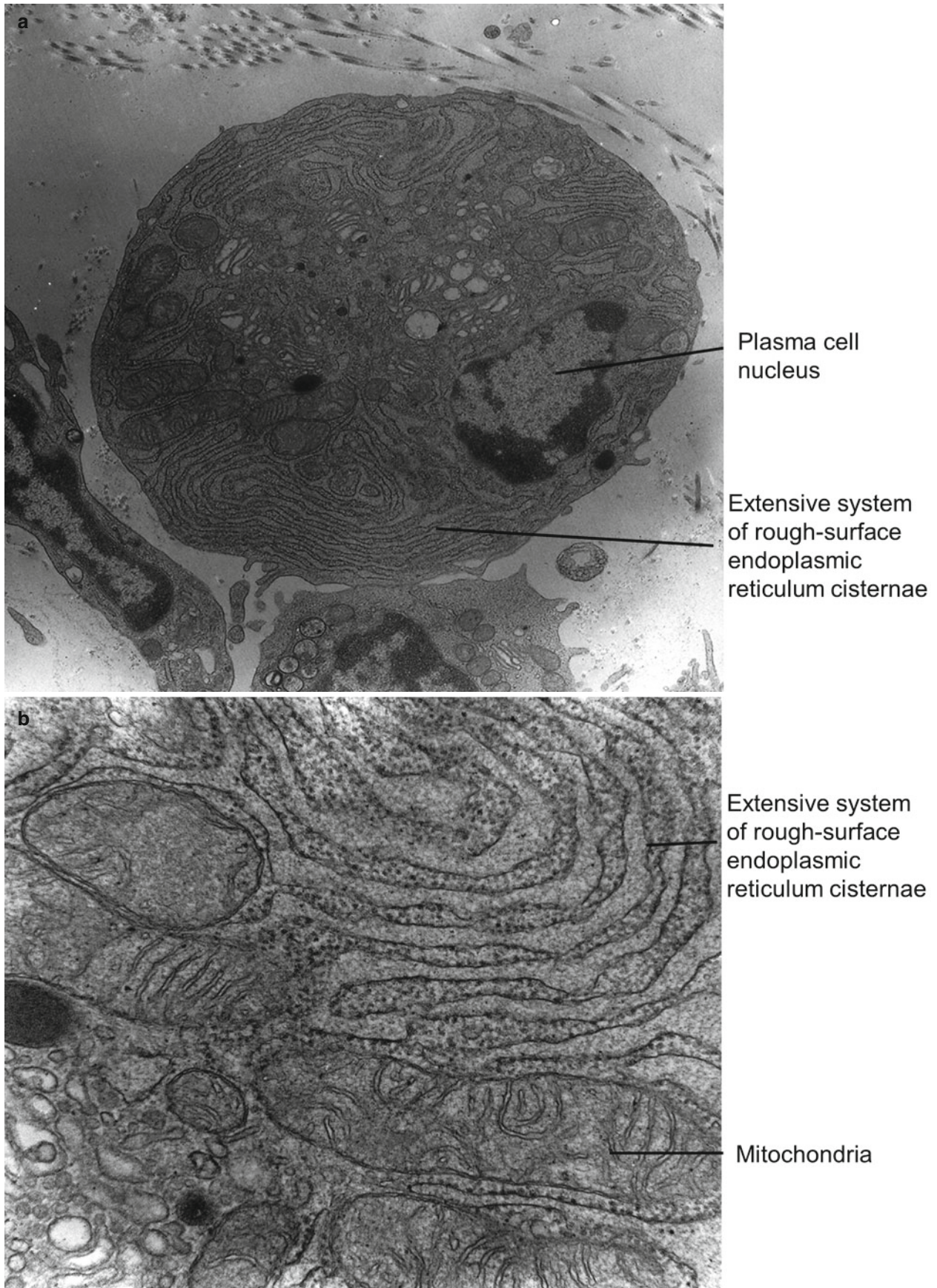


Fig. 2.16 Plasma cell. (a) Plasma cell near the dorsal nerve ganglia. The Golgi complex is located in the central and perinuclear areas. (b) Detail of several rough endoplasmic reticulum cisternae and mitochondria. Magnification: $\times 7,000$ (a); $\times 30,000$ (b)

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