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EDITORIAL

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Editorial overview: Microtubules in nervous system development

The ability of the nervous system to process information depends on the complex and precise organization of highly ramified and polarized cells such as neurons and glia. The microtubule cytoskeleton is crucial for these cells to attain their elaborate morphologies and to maintain the polarized trafficking of cargo that are required for their communication. This special issue of Developmental Neurobiology brings together reviews and original work focused on how neurons and glia build and maintain their polarized, complex microtubule arrays, how they orchestrate the trafficking of organelles and vesicles, and how they remodel their microtubule cytoskeleton in response to injury.

The issue starts with two reviews focused on how microtubule arrays are built and maintained in neurons and glia. These cells pose particular challenges because they need to assemble the microtubule arrays with different morphologies and dynamics in their soma and distal processes and thus rely on decentralized mechanisms of microtubule nucleation. Lüders focuses on recent advances in our understanding of the molecular mechanisms of microtubule nucleation in axons and dendrites to generate arrays with different organization and polarities. This specialization of the microtubule cytoskeleton for transmitting (axon) and receiving (dendrite) information is central to neuronal circuitry (Lüders, 2021). Weigel and colleagues present an overview of microtubule organization of glial cells in the brain—oligodendrocytes, astrocytes, and microglia, and highlight the many outstanding questions that still remain unanswered in the field: the molecular pathways for microtubule nucleation in distal processes, how trafficking is directed and how these cells build unique, complex structures such as the myelin sheet (Weigel et al., 2021). Trafficking is a key process in neurons, where organelles move along microtubules in the axon and dendrites. In their review, Cheng and Sheng describe how mitochondria are transported in the axon during development and maturation. Interestingly, they highlight recent work about how mitochondria motility changes with aging and present links to neurodegenerative, injured and regenerative stages of the nervous system (Cheng & Sheng, 2021).

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While we have reached a good understanding of microtubule dynamics, structure and trafficking events in neurons we still know relatively little about the different tubulin isotypes expressed in the developing brain. The article from the Kneussel lab helps to fill this important gap by presenting the tubulin isotypes that are differentially expressed in the developing mouse brain and cultured primary neurons (Hausrat et al., 2021). Next, Moutin and colleagues focus on the role of tubulin posttranslational modifications that is, the tubulin code in regulating microtubule dynamics, neuronal differentiation, plasticity, and transport and highlight the role of the tubulin code in many pathologies of the nervous system (Moutin et al., 2021).

Cilia are found on almost all neurons, a fact that often gets overlooked when studying these cells. While we traditionally think about neuronal communication as facilitated through axonal–dendritic connections, we now know that cilia also play an important role. Akella and Barr focus on the cilia of *C. elegans* sensory neurons and review recent work that uncovered the importance of the tubulin code in building their specialized architecture, regulating intraflagellar transport, and controlling the release of extracellular vesicles (Akella & Barr, 2021).

One key feature of neurons is their amazing growth when neurons are already integrated in neuronal circuits, that is, upon growth of the whole organism. The cytoskeleton plays a key role in tension-driven axon elongation, which is discussed in the review by (Sousa and Sousa, 2021). Finally, the issue is completed with a review from Rolls and colleagues that describes the microtubule dynamics in neurons (Rolls et al., 2021). By presenting the dynamics found in healthy neurons, the authors highlight clearly how these processes are derailed during injury, and how regeneration can be triggered by microtubule stabilization.

Overall, this collection of reviews provides exciting insights and a timely update into the role of microtubules in the nervous system, a rapidly growing field.

CONFLICT OF INTEREST

H. Witte, A. Ertürk, F. Hellal, and F.B. filed a patent on the use of microtubule-stabilizing compounds for the treatment of lesions of CNS axons (European Patent no. 1858498).

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