

Evolution and Development of Neural Circuits

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The collection of articles on the theme *Evolution and Development of Neural Circuits* explores how brains are built, diversified, and adapted in a variety of species, integrating perspectives from evolutionary biology, developmental neuroscience, and systems neurobiology. Recent advances in molecular genetics, neuroanatomy, physiology, imaging, and computational modeling have enabled unprecedented insights into the mechanisms that shape neural circuits. This collection brings together contributions from leading investigators who examine the architecture and function of neural circuits from multiple angles. Key themes include the evolutionary divergence and convergence of circuit motifs, the conserved molecular and developmental building blocks that underlie connectivity, and the selective pressures that sculpt neural systems to support behavior and cognition. Articles cover topics ranging from retinal mapping and interneuron diversity to thalamocortical connectivity, prefrontal circuit maturation, and the computational modeling of both normal and abnormal circuit development. Collectively, these essays reveal how molecular signaling, cellular variability, and theoretical principles converge to shape the formation and function of circuits across vertebrate and invertebrate brains.

Deciphering the evolutionary and developmental mechanisms that shape the architecture of neuronal circuits promises to reveal the principles by which brains enable behavior and cognition. In recent years, rapid technical and conceptual advances in neuroanatomy, molecular genetics, physiology, and theory have enabled deep insights into these mechanisms across model systems ranging from flies to humans.

This collection brings together perspectives from investigators who have driven these discoveries. A key theme is the leveraging of evolu-

tionary change, both divergent and convergent, across species to provide a larger framework for neuronal circuit design and function (Banerjee et al. 2025; Konstantinides and Desplan 2025). This evolutionary theme is integrated with developmental perspectives, illustrating how conserved molecular building blocks (Chen 2024) and selection pressures have given rise to both shared and divergent circuit motifs across species (Nieder 2023), with a specific focus on thalamocortical connectivity (Molnár and Kwan 2024).



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The collection then leads on to its other major theme with a series of articles covering the mechanisms and principles of circuit assembly. Broad insights from computational modeling (Lakhera et al. 2025; Zavitz et al. 2025) and advances in molecular signaling (Verpoort and de Wit 2024) are discussed, and the role of variability and stochasticity highlighted (Mitchell 2024). How these principles apply to different regional circuits such as the prefrontal cortex (Pöplau and Hanganu-Opatz 2024) and visual system (Kerschensteiner and Feller 2024), as well as specificity and diversity in terms of neuronal cell types (De Marco García and Fishell 2025; Lenherr et al. 2025) is covered. Finally, recent technical advances in studying human development is reviewed (Arichi 2024). Overall, these articles dissect how molecular, cellular, functional, and theoretical approaches have all been used to understand the development of diverse cell types and circuits in the brain, to offer a tantalizing view on a rapidly expanding field of neuroscience.

Together, the articles collected here offer a view of how neural circuits develop, diversify, and function. While no single collection can capture the full breadth of this field, we hope that the contributions assembled here will serve both as a resource for specialists and as an entry point for students and investigators from neighboring disciplines.

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