

## **Design principles of convergent brain evolution: A case of the most specialized marine invertebrates**

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The evolution of complex brain systems appeared on a common basis or not is currently the subject of debate. A controversial hypothesis proposes that the higher brain centers in insects and annelids have a shared molecular signature with the mammalian cerebral cortex. We examined the connectome of the higher sensory-motor centers and demonstrated a molecular test based on the octopus brains in which many of the vertebrate-like analogical systems have been functionally identified. We found that the territories and a cell type of octopus higher brain centers are uniquely defined by the neural circuitry and a combinatorial expression of transcription factor genes, whereas the lower-order centers particularly the neurosecretory tissues share more features. These findings suggest that developmental regulatory mechanisms of the specialized brain centers are more flexible, and they display both evolutionary divergence and convergence.