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Combining Microscopy Imaging and Stochastic Cellular Dynamics to Understand Neural Rosette Formation.

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Neural rosettes are multicellular structures observed in cancer, wound healing, and neurulation—the process leading to neural tube formation. Rosette morphogenesis and structural variations are also linked to neurodevelopmental disorders, such as GNAO1-related diseases, making them an intriguing subject of study. We employ a self-propelled Voronoi model to explore tessellation dynamics, investigating solid-liquid-glass transitions through shape factor, mean square displacement, and static structure factor. By incorporating soft repulsive interactions into the tissue energy function, we assess how nuclear mechanics influence tissue dynamics, identifying a specific parameter space where the balance between fluidity and cell deformability promotes rosette formation. Next, we explore topological defects, showing how they disrupt spatial organisation and drive rosette emergence. To validate our findings, we perform iPSC-based microscopy during differentiation, analysing rosette evolution and extracting quantitative data, such as cell motility, to refine our computational models. Our findings bridge active matter physics, biophysics, and neurodevelopment, providing a framework to understand the role of mechanical interactions in neural tissue organisation and pathology.