



Colloquium

Numerical studies of the morphodynamics of dynamic cell assemblies

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Venue: S4-625

Time: 14:00

Abstract :

One of the biggest distinctions between living-cell assemblies and nonliving aggregates such as colloids may be that the cells themselves are the sources of their dynamism, including processes such as cell migration and cell proliferation. In the main part of this talk, I plan to talk about our numerical studies on the morphodynamics of growing complex cell assemblies. Growing cell assemblies cultured in vitro, such as organoids and epithelial cysts, serve as powerful systems for investigating the mechanisms that determine the morphology of complex cellular structures in nature, such as organs. However, a comprehensive understanding of the generic mechanisms linking simple cellular behaviors to emergent morphology of such growing cell assemblies remains elusive. In the talk, I will introduce our recent numerical studies in which, based on a multicellular phase-field model, we simulate the morphology and morphodynamics of a cell assembly containing a fluid-filled cavity (lumen) grown from a few cells in vitro, as observed in certain organoids and epithelial cysts, with particular emphasis on lumen dynamics [1,2]. Our theoretical model accounts for multiple proliferating and growing cells, as well as lumens formed by these cells. It incorporates essential conditions such as timing and volume thresholds for cell division, rules for lumen nucleation, and luminal pressure. We will present results demonstrating that simulations based on this model, starting from a small number of cells with no lumen, autonomously generate a diverse range of lumen morphologies depending on luminal pressure and the minimum time required between successive cell divisions. We will also compare some simulation results with experimental observations of organoids and epithelial cysts [3].

Overall, our results highlight the importance of continuous cell proliferation accompanied by lumen formation and the maintenance of luminal pressure in the dynamic emergence of complex morphologies in growing cell assemblies and their lumen.

References:

[1] S. Tanida et al., "Predicting organoid morphology through a phase field model: insights into cell division and luminal pressure" *PLOS Computational Biology* 21, e1012090 (2025).

[2] K. Fuji et al. "Computational approaches for simulating luminogenesis" *Seminars in Cell & Developmental Biology* 131, 173 (2022).

[3] L. Lu et al. *Nature Communications* 16, 6307 (2025); B.-H. Lee et al. *Nature Cell Biology* 28, 113 (2026).