Mechanical feedback and incompatibility in size regulation

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Abstract

In this presentation, we explore the complex relationship between growth, stress, and size regulation in biological systems, focusing on how cells control their growth as they near the final size of the organ. Our approach is twofold: examining the energetic costs of growth and investigating the concept of growth incompatibility.
First, we introduce a modified morphoelasticity framework that accounts for an energetic penalty due to growth. This model provides a size control mechanism, in addition to the usual models of collapse and uncontrolled expansion present in classical Eshelby-driven growth. It aligns with residual stress profiles observed in experiments with multicellular spheroids, offering a thermodynamics-based perspective with testable predictions about organ growth mechanics.

Second, we delve into the concept of incompatibility, the geometric 'seed' of residual stress, as a crucial determinant of growth termination. We explore this both at the cellular and tissue levels, showing that incompatibility-driven growth, measured via the Ricci curvature of the growth tensor, enables a final size for the growing body. This is consistent with behaviors observed in Drosophila wing discs and multicellular spheroids, suggesting that controlling incompatibility at the cellular level can regulate overall properties like stress and size.

In conclusion, in this presentation we will reveal that the dynamic interplay between growth, stress, and incompatibility proposes mechanisms of how organs may regulate their growth to achieve specific sizes, in coherence with experimental data in growing spheroids and Drosophila wing discs.
References
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