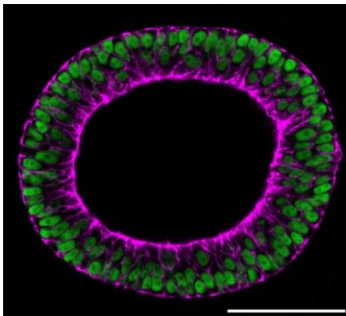
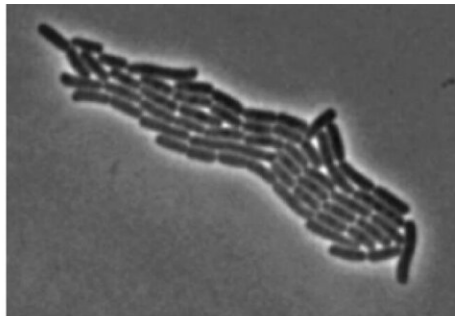


Describing growing tissues in the language of thermodynamics

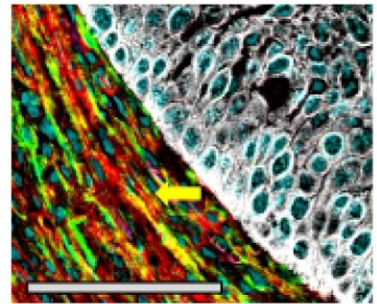
April 18 2024, by Samuel Jarman



(a) Growing cyst of polar cells



(b) Growing nematic bacterial colony



(c) Nematic fibroblasts around a tumour nest

a Growing cyst of polar cells. Polarity induces an anisotropy in growth, which in turn creates stresses that have a feedback effect on the growth. b Growing bacterial colony. The nematic nature of the bacteria leads to a specific structure in the colony, and in the polar field. c Cancer cells may not have an intrinsic polar or nematic order. However, in desmoplastic tumors, the environment is highly ordered, as displayed here with fibroblasts surrounding a lung tumor nest.

Credit: *The European Physical Journal Plus* (2023). DOI:

10.1140/epjp/s13360-023-04669-9

A key feature of biological tissues is their inhomogeneity and their ability to grow via cell reproduction. To study this behavior, it is important to describe it using equations, which account for factors including growth rates, chemical signaling, and tissue structure.

Researchers from Paris aim to develop consistent continuous descriptions of these deeply [complex systems](#): accurately predicting properties such as [cell reproduction](#) rates, disorder, and how their growth varies in different space directions, depending on their interactions.

Through their new analysis [published](#) in *The European Physical Journal Plus*, Joseph Ackermann and Martine Ben Amar at Sorbonne University Paris, show that [tissue development](#) can be reliably captured within "Onsager's variational principle," a mathematical framework used widely in thermodynamics.

Their approach could lead to a deeper understanding of tissue properties across a wide array of scenarios, from essential processes such as embryo development, to harmful ones such as tumor growth.

In thermodynamics, Onsager's variational principle describes how systems tend towards a state of minimum dissipation as they are continually altered by their own transformations and their environment. Mathematically, the principle expresses these systems as groups of interconnected equations, each describing the rates of change of certain quantities describing them.

Starting from Onsager's variational principle, new "momentum" and growth equations are derived, which could better describe the flow of mass and the proliferation, as well as the orientations of cells in biological tissues. Their equations considered the growth and death rates of cells, as well as the [chemical reactions](#) driving their activity. This approach could also illustrate the genesis of patterns in growing organs.

Altogether, the duo's work definitively shows how Onsager's variational principle can be a valuable tool for exploring different theoretical scenarios in growing tissues, and how their growth depends on interactions between different cellular-scale properties.

More information: Joseph Ackermann et al, Onsager's variational principle in proliferating biological tissues, in the presence of activity and anisotropy, *The European Physical Journal Plus* (2023). [DOI: 10.1140/epjp/s13360-023-04669-9](https://doi.org/10.1140/epjp/s13360-023-04669-9)

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