Phase transitions in biology

Liquid-liquid phase separation in the nucleus and tissue remodeling during development

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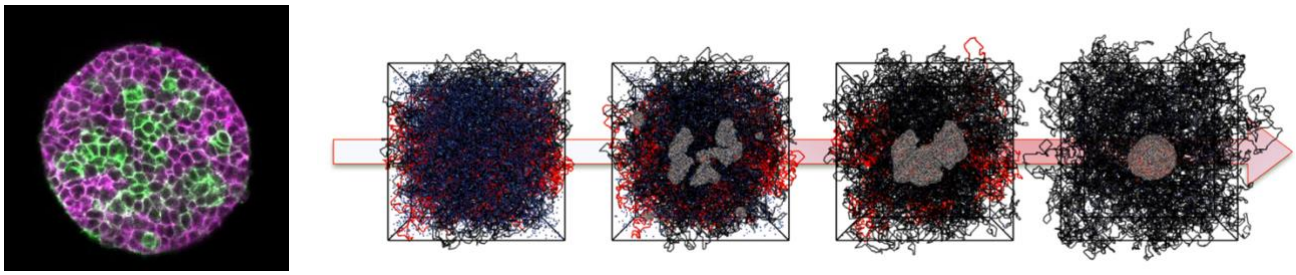
Support: This mini-symposium is supported by the "Physics and Life" (Physique et Vivant") Division of the French Physical Society and the le GDR "Quantitative applications of the Living"(Applications Quantitatives du Vivant).

Biological tissues are complex systems that can undergo drastic changes in their organization and mechanical properties, particularly during development. These changes can lead to transitions analogous to jamming or liquid-to-solid transitions, which are starting to be revealed through in vitro and in vivo experiments.
At the level of the nucleus, these remodeling processes are accompanied by liquid-liquid phase separation (LLPS) phenomena, which give rise to the formation of nanoscale droplets. These membrane-less organelles combine all the necessary elements for a biological function, reorganize the 3D conformation of chromosomes, and play a crucial role in regulating organism development.



Left: Aggregation of embryonic stem cells showing heterogeneities in the expression of adhesion molecules, leading to the separation of cell populations (image by S. Tlili, IBDM, Marseille).

Right: Segregation of the pericentromeric region (in red) of a mouse chromosome (in black), coupled with LLPS of the HP1 protein (gray droplet), enabling blastoderm development (numerical simulation: Tortora et al., PNAS 2023).

The objectives of this mini-symposium are to present and discuss:

(i) The characteristics of phase transitions in the living matter;
(ii) The underlying molecular, cellular, and multicellular mechanisms;
(iii) How these transitions can be detected and measured in situ.

Furthermore, the aim is to foster dialogue between physics communities positioned at different length scales, from the nucleus to the tissue.