

On a Theory of Cell Decision-Making in Multicellular Systems

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Precise regulation of cell fate decisions is crucial in the development of multicellular organisms, during which cells differentiate from a single cell into the multitude of cell types that compose the adult organism. Incorrect cell fate decisions can lead to various diseases, such as cancer. Experimentally, cell decision-making has been well-studied in the context of isolated single cells. However, how cells make decisions within a complex multicellular environment remains elusive. Starting from the example of migration/proliferation plasticity—a cell decision-making mechanism found in tumor cells—I will introduce the current challenges of this problem. To address these, I propose combining Bayesian learning with the Least Environmental Uncertainty Principle (LEUP) as a unified framework to understand cell decisions. Specifically, this approach employs statistical physics tools that allow for (i) a low-dimensional description of the relevant dynamics, and (ii) the coupling of single-cell decisions with corresponding collective behaviors at the multicellular level. Finally, I will outline the main mathematical premises of the proposed theory and its application to collective migration, tissue development, and tumor growth.