Quantifying the Landscape and Flux as the Nonequilibrium Driving Forces for Cell Fate Decision Making

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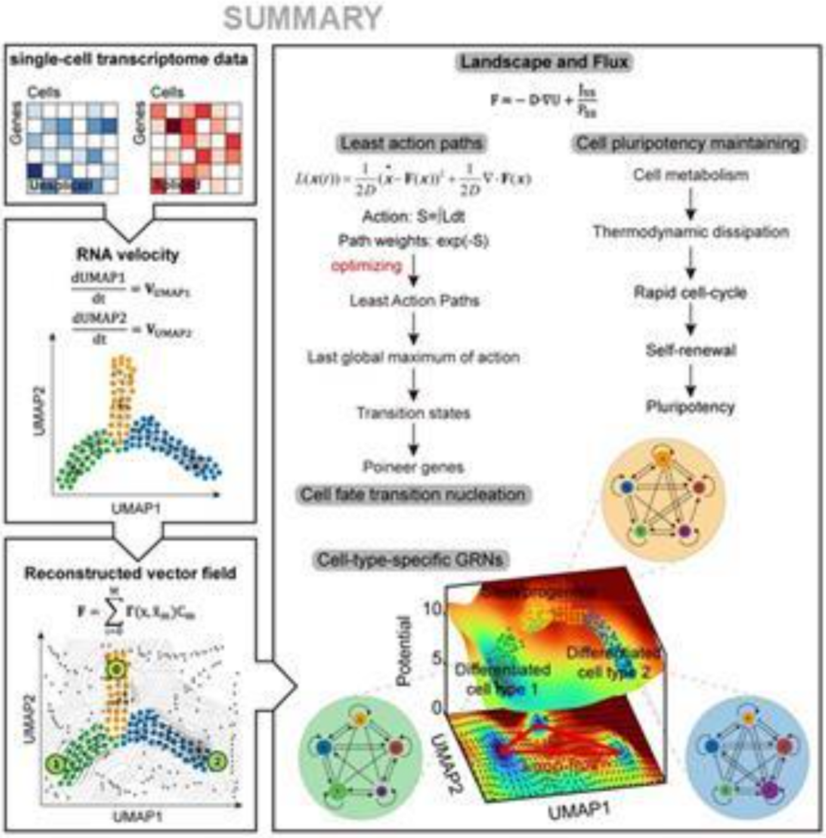

Life is characterized by a myriad of complex dynamic processes allowing organisms to grow, reproduce, and evolve. Physical approaches for describing systems out of thermodynamic equilibrium have been increasingly applied to living systems, which often exhibit phenomena not found in those traditionally studied in physics. Spectacular advances in experimentation during the last decade or two, for example, in microscopy, single-cell dynamics, in the reconstruction of subcellular and multicellular systems outside of living organisms, and in high throughput data acquisition, have yielded an unprecedented wealth of data on cell dynamics, genetic regulation, and organismal development. These data have motivated the development and refinement of concepts and tools to dissect the physical mechanisms underlying biological processes. Notably, landscape and flux theory has been proven useful in this endeavor. Together with concepts and tools developed in other areas of nonequilibrium physics, significant progress has been made in unraveling the principles underlying cellular regulatory networks, differentiation and development, cancer, neural network dynamics, population dynamics, ecology, and evolution. Here, recent advances are reviewed focusing on the cell fate decision making with low and high throughput data [1,2,3,4]. Many of these results are expected to be important as the field continues to build our understanding of life.

References:

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