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Exploiting single-cell variability to infer the dynamics of immune responses

THOMAS HÖFER, German Cancer Research Center (DKFZ) Heidelberg

Cell division, differentiation, migration and death determine the dynamics of immune responses. These processes are regulated by a multitude of biochemical signals which, at present, cannot faithfully be reconstituted outside the living organism. However, quantitative measurements in living organisms have been limited. In recent years experimental techniques for the "fate mapping" of single immune cells have been developed that allow performing parallel single-cell experiments in an experimental animal. The resulting data are more informative about underlying biological processes than traditional measurements. I will show how the theory of stochastic dynamical systems can be used to infer the topology and dynamics of cell differentiation pathways from such data. The focus will be on joint theoretical and experimental work addressing: (i) the development of immune cells during hematopoiesis, and (ii) T cell responses to diverse pathogens. I will discuss questions on the nature of cellular variability that are posed by these new findings.