



University
of Basel

Department
Biozentrum



Swiss Institute of
Bioinformatics

BIOZENTRUM

The Center for
Molecular Life Sciences

Basel Computational Biology Seminar 22830 Current research in Bioinformatics I



Jonas Fleck

Generative Modeling for Fate Engineering and Developmental Dynamics

Advances in brain organoid technologies and single-cell multi-omics provide powerful tools to study human brain development. We have used these approaches to investigate gene regulation and epigenomic dynamics underlying brain development and to characterize alterations associated with neuro-developmental disorders. However, predicting developmental outcomes remains a major challenge.

New generative modeling techniques provide promising opportunities to learn how cell populations evolve over time and respond to perturbations. We developed CellFlow, a flow-matching framework for modeling single-cell phenotypes induced by complex perturbations. In neuronal differentiation and brain organoids, CellFlow predicted heterogeneous cell populations arising from perturbations and combinatorial morphogen treatments, enabling virtual screening of differentiation conditions and helping guide cell-fate engineering and organoid protocol design.

We are now building on these methods to learn the stochastic dynamics underlying differentiation from single-cell snapshot measurements. Finsler Flow Matching provides a framework for learning a continuous generative model from cell-cell Markov transition graphs by constructing a Finsler geometry that guides generative trajectories through cell-state space. Together, these approaches aim to move from descriptive maps of development toward predictive models for understanding and engineering developmental processes.

Speaker Information

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Host: David Brückner

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