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Universality, criticality and scaling in biochemical networks with feedback TOMMY BYRD, Physics Department, Purdue University, West Lafayette IN, USA, AMIR EREZ[1], Center for Cancer Research, National Cancer Institute, Bethesda MD, USA, ANDREW MUGLER, Physics Department, Purdue University, West Lafayette IN, USA — Feedback is ubiquitous in biological networks, stretching from gene regulation to cell-to-cell interactions and beyond. In the context of living cells, feedback and feed-forward are important mechanisms for dynamically scaling response, allowing for both sensitivity and specificity. Here we focus on feedback at the single-cell level, and its role in producing protein distributions typically observed experimentally. We introduce a generic model that, depending on a tuning parameter, can yield unimodal or bimodal steady-state protein distributions, and we examine the model's static and dynamic universality classes. We show that statically, the stochastic cell near its bifurcation point is analogous to an Ising model near its critical point, despite the inherent non-equilibrium nature of the system. We demonstrate how this abstract description of a cell as a stochastic birth/death feedback process can be equally applied to several commonly used feedback functions in biophysics. Our approach can therefore be used as a powerful tool to analyze experimental observations without restricting the analysis to a specific (and usually unknown) form of the feedback function.

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