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Morphogenesis at criticality? DMITRY KROTOV, Joseph Henry Laboratories of Physics, Lewis-Sigler Institute for Integrative Genomics, JULIEN DUBUIS, Joseph Henry Laboratories of Physics, Lewis-Sigler Institute for Integrative Genomics, Howard Hughes Medical Institute, ERIC WIESCHAUS, Lewis-Sigler Institute for Integrative Genomics, Department of Molecular Biology, and Howard Hughes Medical Institute, THOMAS GREGOR, WILLIAM BIALEK, Joseph Henry Laboratories of Physics, Lewis-Sigler Institute for Integrative Genomics — Embryonic development of many multicellular organisms begins with the generation of spatially varying patterns of morphogens that encode the body plan of the future organism. We study the spatial pattern formed by the gap gene proteins in the early fruit fly embryo, which is anchored by "crossing points" between expression levels of different genes; these are thought to result from mutual repression. We explore a broad class of models for such interacting genes and show that the parameters implied implied by recent quantitative measurements are non-generic, but rather tuned to certain values, so that the entire gap gene network operates close to the critical surface in its phase diagram. We develop a mean field description of this system as well as derive signatures of critical behavior in the structure of expression noise. One such signature is that fluctuations are dominated by a single "massless" mode, so that fluctuations of expression levels of different genes are highly correlated/anticorrelated. We find a surprisingly high degree of anticorrelation in the real experimental data. These results suggest an interesting possibility that the network of genes responsible for development is operating near criticality.

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