*In vitro* portraits of embryogenesis are obtained by tissue culture of pluripotent stem cells. Yet, the faithfulness of these models is limited: *e.g.*, while *in vitro* cells exhibit self-renewal, *in vivo* cells continue on a developmental trajectory. To reveal the regulatory circuits contributing to the distinct identity of each system, we merge quantitative immunofluorescence with genomic tools. Particularly, we employ single cell RNA-seq and high-sensitivity automated ChIP-seq to allow study of the *in vivo* small cell numbers, and use genetic tools to perturb candidate genes identified in our genomic data.