Embryonic patterning makes the feathers fly

December 10 2006

How the chicken got its feathers in the right place is not a Rudyard Kipling “Just So” story, but an illustration of how simple causes can stack up into complicated results. For a chicken, it’s the difference between having feathers arranged in spots or stripes. For biologists at the University of Southern California and mathematicians at Oxford University in the UK, it’s all a question of patterning.

To understand patterning on the molecular and the systems level, the researchers looked at how feather patterns are laid down in embryonic chickens. Feathers, or more properly feather buds, will appear on the skin of the developing embryo wherever fibroblast growth factor (FGF) is activated. The mystery has been how a pattern of activation was laid down by FGF. Speculation pointed to a downstream cellular signaling pathway but which one (and if it was just one pathway) was unknown.

To discern which pathway mediates FGF activity during skin patterning, the researchers set up a cultured embryonic chicken skin model and targeted a variety of potential downstream signaling pathways with specific inhibitors. They got their biggest hits with the so-called mitogen-activated protein kinase, or MAPK, pathway. Manipulating the MAPK pathway produced a wide repertoire of feather patterning, from spots, to stripes, to homogenous patches, all reflecting varying degrees of inhibited feather bud segregation. Stripes, for example, increased with higher inhibitor dosage and earlier times of administration.

But which skin layer was the major target of FGF/MAPK activity, the epithelium or the mesenchyme" The researchers grew skin explants in an

environmental chamber that enabled them to continually observe cell movements and track individual cells using fluorescent markers. The results were recorded in real time by time-lapse video microscopy. The resulting chicken feather movie resolved the question: the FGF/MAPK pathway acted through the mesenchyme.

Analyses of fluorescent-labeled cells confirmed an increase in mesenchymal cell motility following MAPK pathway inhibition. In the controls, rudimentary feather bud epithelia emerge by cell rearrangements and coordinated cell shape elongation. In inhibitor-treated explant epithelia, cells remain cobblestone shaped and randomly arranged.

While the chicken feather movie poses no threat to Hollywood, the researchers say that watching the formative process of stripes versus dots play out was fascinating. From those feathery patterns, a team of theoretical biologists was able to develop a mathematical model that simulated the process of periodic pattern formation. This kind of basic work can throw light on health problems like developmental disorders, on questions in evolutionary biology, and on new biotech possibilities including tissue engineering.

Source: American Society for Cell Biology