How the dragon got its 'snap'

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This is a bee on a snapdragon flower. Credit: John Innes Centre

Scientists at the John Innes Centre and the University of East Anglia are pioneering a powerful combination of computer modeling and experimental genetics to work out how the complex shapes of organs found in nature are produced by the interacting actions of genes. Their findings will influence our thinking about how these complex shapes have evolved.

"How do hearts, wings or flowers get their shape?" asks Professor Enrico Coen from the John Innes Centre. " Unlike man-made things like mobile phones or cars, there is no external hand or machine guiding the formation of these biological structures; they grow into particular shapes of their own accord."

"Looking at the complex, beautiful and finely tuned shapes produced by nature, people have often wondered how they came about. We are beginning to understand the basic genetic and chemical cues that nature uses to make them."

So, how does this happen? In a recent breakthrough, funded by the Biotechnology and Biological Sciences Research Council (BBSRC), scientists on Norwich Research Park have begun to answer this question, using the snapdragon flower as a convenient subject.

In the snapdragon flower, two upper petals and three lower petals form defined shapes, precisely coming together to form a tube with a hinge. When a bee lands on the lower petals the hinge opens up the flower, allowing access to nectar and pollen. The shape of petals is known to be affected by four genes, but precisely how these genes work in combination to produce the specialised flower shape, and how this shape evolved, was unknown. The same is true for many organ shapes, but the snapdragon flower provides a good system to study this problem, as it is genetically well characterised and growth can be followed at the cellular level.

By changing when and how the genes involved in growth are turned on and off, and tracking how these changes affect the development of shape over time, the researchers got pointers as to how genes control the overall shape. They then used computer modelling to show how the flower could generate itself automatically through the application of some basic growth rules.

A key finding was that genes control not only how quickly different regions of the petal grow, but also their orientations of growth. It is as if each cell has a chemical compass that allows it to get its bearings within the tissue, giving it the information needed to grow more in some directions than others. Genes also influence the cell's equivalent of magnetic poles; key regions of tissue that chemical compasses point to.

Publishing in the journal *PLoS Biology*, the researchers show how these principles allow very complex biological shapes to generate themselves.

"We are now trying to get a better understanding of exactly how the chemical compasses work and determining the molecular nature of the poles that coordinate their orientations," said Professor Enrico Coen of the John Innes Centre.

The study also throws light on how different shapes may evolve. In the computational model, small changes to the genes that influence the growth rules produce a variety of different forms. The shape of the snapdragon flower, with the closely matched upper and lower petal shapes, could have arisen through similar 'genetic tinkering' during evolution. Evolutionary tinkering could also underlie the co-ordinated changes required for the development of many other biological structures, such as the matched upper and lower jaws of vertebrates.

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