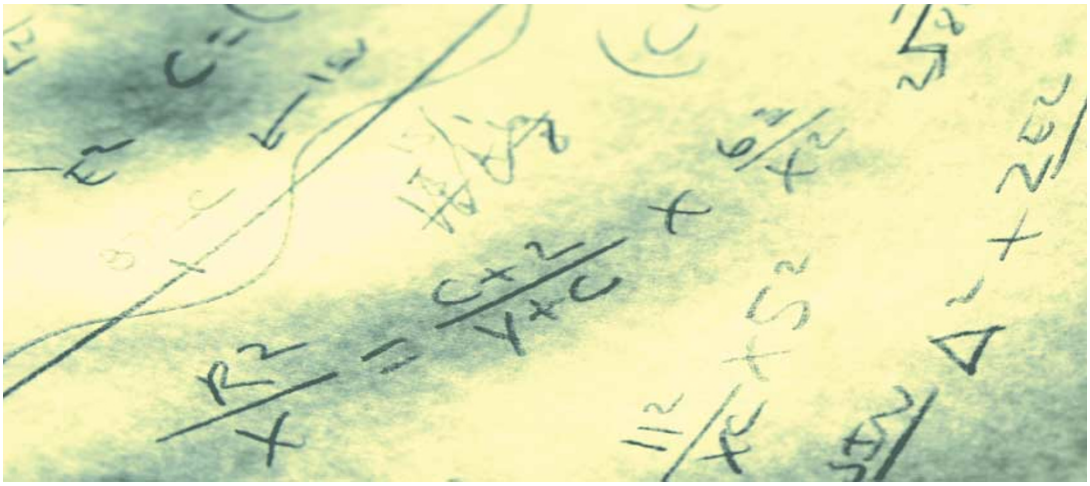

EVOLUTIONARY THEORY

Robust arguments about canalization

In genetics, as in many other fields, theoretical models rarely provide good substitutes for empirical evidence; after all, who would continue to uphold a model that has been contradicted by experiments? However, in a reversal of this situation, the authors of two studies published in *Genetics* now successfully defend the primacy of theoretical models, and force us to review our current views — that are largely derived from experiments — on developmental evolution.

In the late 1950s, Waddington laid the conceptual foundations for a growing body of research into the ability of a wild-type genetic system to withstand the effects of mutations — a property that he named 'canalization'. According to this idea, a wild-type character is so well adapted to its environment that any deviation from this condition — caused by a mutation, for example — would inevitably be deleterious. As a result, the wild-type trait would evolve to be buffered from any insult that threatened to deviate it from this fitness optimum. The fact that organisms show increased phenotypic variability after a genetic or environmental 'stress' provides good evidence that wild-type organisms suppress a certain degree of hidden genetic variation (also called cryptic genetic variation (CGV)), which is released only under altered circumstances.

Hermisson and Wagner have now probed this concept further. Is the release of CGV intrinsically linked to a robust (that is, canalized) wild-type character? Their theoretical model indicates otherwise. The authors devised a mathematical expression that would follow the impact of change (in the form of a genetic mutation or altered environmental conditions) on several statistical properties of a quantitative character. They found that CGV is always unleashed when a trait is subjected to change — this occurs when any genetic background is perturbed, not only a canalized, wild-type one. In fact, the observed increase in genetic variance seems to be a generic property of any system that has epistasis and genotype × environment interactions. The message that goes out to the growing number of biologists that are interested in CGV is that canalization is not a prerequisite for accumulating CGV and, conversely, that CGV does not constitute sufficient evidence for canalization.

In the second paper, Bagheri and Wagner focus on the evolution of phenotypic robustness itself, and tackle the thorny issue of how dominant phenotypes — which themselves represent a form of robustness to mutations — have evolved. Biologists have dismissed the need for an evolutionary explanation for dominant phenotypes on the grounds that selection for dominance can only arise under special circumstances. Alternatively, in some situations (such as metabolic pathways), it has been maintained that dominance is simply a default property of the system. The theoretical model that is presented in this paper, which is based on the interaction between two metabolic enzymes, now punches a few holes into this long-standing theoretical argument. Not only does the model predict that dominance can evolve as both a direct or indirect result of selection, but that the predictions of the model can be applied more generally to explain the evolution of any form of phenotypic robustness to mutations.

The results of these two studies, and the revisionist approach to the literature that they suggest, are intriguing. But what is equally admirable is the authors' effort to reconcile three areas of research — population genetics, quantitative genetics and phenotypic robustness — that have largely enjoyed independent research histories.

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References and links

ORIGINAL RESEARCH PAPERS Bagheri, H. C. & Wagner, G. P. Evolution of dominance in metabolic pathways. *Genetics* **168**, 1713–1735 (2004) | Hermisson, J. & Wagner, G. P. The population genetic theory of hidden variation and genetic robustness. *Genetics* **168**, 2271–2284 (2004)

WEB SITES

Günter Wagner's laboratory:
http://pantheon.yale.edu/~gpwagner/

Joachim Hermisson's laboratory:
http://www.biologie.uni-muenchen.de/ou/theopopgen/joachim.htm

IN THE NEWS

Purrfect copycat

A bereaved cat owner has paid a Californian biotechnology company the handsome sum of 50,000 US$ for the genetic clone of her dead moggie, Nicky. The buyer in question, a woman from Texas who is identified only as Julie, is delighted with the purchase of the kitten, Little Nicky, who was born in October 2004: "I see absolutely no differences" she said. "Little Nicky loves water, like Nicky did, and he's already jumped into the bathtub like Nicky used to do" (*The Times*, UK, 24 December 2004).

But scientists, ethics experts and animal rights groups are less than enthusiastic about the world's first commercial pet clone, which was produced by using a variation of the nuclear transfer technique (*ABC News Online*, 24 December 2004). Little Nicky was created by the whimsically named Genetic Savings & Clone Inc., which has been behind the creation of 5 cats since 2001, and hopes to deliver 50 more by the end of 2005 (*Intl Herald Tribune*, 24 December 2004).

This sale is "morally problematic and a little reprehensible" said the Stanford ethicist David Magnus. "For 50,000 US$ she could have provided homes for a lot of strays" (*San Francisco Chronicle*, 22 December 2004). But the company dismisses accusations of animal cruelty for a frivolous end. "We're not curing cancer, but we believe we are adding to the sum of joy in the world" (*Concord Monitor*, 23 December 2004).

Despite careful counselling by the company, some buyers are bound to be disappointed. As the US animal behaviourist Bonnie Beaver put it: "It may look exactly like Fluffy…but it's not Fluffy" (*The Mirror*, 24 December 2004).

The company hopes to produce a cloned-to-order dog by May 2005 (*New Scientist*, 23 December 2004), thereby tapping into a far more lucrative market.

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