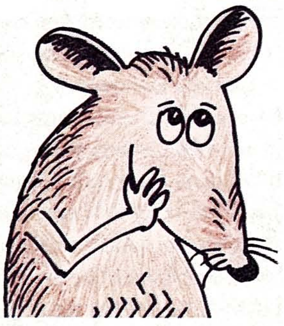
How the mouse got its zig-zag hair



Observing the miracle of living, moving creatures, we are struck by their marvellously intricate form and co-ordinated activity.

The beautiful markings on a butterfly's wing, the distinctive stripes on a zebra, the eye of an eagle . . . How does such handiwork, so incomparably more detailed than the works of man, come about? How do all the bits fit in the right place?

Geneticists don't have the answer. The way the genes transmit their messages is now largely known, but the mechanism that controls the unfolding of the embryo is a mystery.

One answer — still rather controversial — is a theory first put forward in the 1950s by Alan Turing, one of the pioneers of computing. He postulated entities called 'morphogens' — chemicals dispersed into a region of growing, undifferentiated cells.

The pattern formed by the diffusion and mutual reaction of these morphogens provides a template that is sensed by the cells, he contended. They differentiate — a pigmented cell here, a plain one there — according to the dictates of that guiding pattern.

Some 30 years later, morphogens remain only a theoretical deduction, just as genes once were. The theory of genetics was developed long before the physical reality of genes could be demonstrated.

Morphogens are still in limbo. With the exception of the occasional 'growth factor' and some other candidates, possible morphogens have yet to be identified.

However, the possibility that the reaction and diffusion of morphogens play a major role in the development of living things is gaining increasing acceptance as it explains more and more facts — such as why the underfur of mice and rats grows in a zig-zag.

This explanation belongs to Dr Barry Nagorcka and Dr John Mooney, of the CSIRO Division of Computing Research.

It calls for the presence of three morphogens interacting in the follicle bulb, directing the cells' development. The interaction of the morphogens can be modelled mathematically, and the equations predict that specific patterns in their distribution will develop.

In this way, the morphogen pattern determines both the shape of the hair fibre cross-section and the geometrical arrangement of different cell types.

The theory predicts that during the formation of a zig-zag hair the inner part of the follicle bulb (the dermal papilla) moves off-centre, causing a lop-sided distribution of morphogens. This causes cells on one side of the bulb to develop differently from cells on the other. As a result, the fibre bends when it reaches the upper part of the follicle.

That explains the zig. A zag forms when the bending fibre, before it emerges from the skin surface, pushes the dermal papilla off-centre to the opposite side of the bulb. The morphogens then form a pattern that is a mirror image of the previous one, and gives rise to a fibre that bends the other way. We are soon back to where we were before, and the zigs and zags keep coming as long as the hair grows.

The zig-zag mechanism is closely related to a mechanism explaining crimp in wool fibres proposed by Dr Nagorcka. The morphogen theory can also account for a range of fibre shapes — such as kidney-shaped, three-lobed, and four-lobed — as well as different patterns of cell types found in wool.

Dr Nagorcka and Dr Mooney are presently looking at whether the theory can explain how hair and feather follicles appear and develop in particular patterns.

Andrew Bell

The key to zig-zag growth is the bend in the hair — which forces the dermal papilla off-centre — which leads, via a change in morphogen pattern, to a bend in the opposite direction.

Evidence for a reaction–diffusion system as a mechanism controlling mammalian hair growth. B.N. Nagorcka. *Biosystems*, 1984, 17 (in press).

How a zig-zag hair grows