It is sometimes said that one cannot have intermediary forms of organs or tissues in evolution that are useful, despite a great deal of data to show that this is simply not true (the eye, the subject of a previous Biologic, was formed in about 400 000 years\textsuperscript{1}). Richard Dawkins has often written about the difficulties that creationists and others (he singles out lawyers as a group that believe in discontinuities rather than continuous variation) have with the absence of intermediate forms, perhaps because of a view of evolutionary action that is ‘progress driven’. But continuous variation is obvious, and runs from us through \textit{Homo erectus} and \textit{Homo habilis}, and so on. In evaluating this, we have looked at how the molecular clock runs in evolution in this series and discussed the point that while most mutations are neutral in genetic effect (and some are harmful), often phenotypic change over time does not depend on structural change in the genome—changes in gene expression may be more significant. So while it would be satisfying to be able to see continuous variation leading to phenotypic change, it is not often that one can study evolution as it happens. More observations of this kind are now being made as the new biology allows a better investigation of phylogeny, and we can now watch changes as they occur, or at least repeat them experimentally.

Rexnick \textit{et al.}\textsuperscript{2} have examined live births in a guppy-like fish of the genus \textit{Poeciliopsis}, and found that the placenta has evolved at least three times in this genus (it has evolved repeatedly in many forms in fish, amphibians, reptiles and mammals). Fifty or so loci regulate the development of the placenta, and other related genes are members of gene families that produce proteins only found in pregnancy (fetal haemoglobin, hormones, suppressors of the immune response and so on). Any mother taking on the metabolic care of her fetus or fetuses has an additional metabolic burden to deal with, which often results in gene expression. In the genus \textit{Poeciliopsis}, there is a variety of fetal support mechanisms; some zygotes are simple yolk feeders (no further support to the egg), others have a range of ‘follicular pseudoplacentae’ that vary greatly in complexity. But there is a step-like change in the range from what could be called moderate to extensive maternal support, assessed by the amount of lecithin in the egg and the rate at which it is consumed during development. Using what they describe as ‘a relaxed molecular clock approach’, the authors concluded that the two types of moderate and substantial support evolved over a period comparable to that considered to be valid for the eye, but their main point was that the availability of clusters of different types of maternal provisioning, and the possibility of hybridization, allows examination of the process of structural development. In the hybrids it will be possible to examine the development of the genetic and morphological mechanisms associated with increasing maternal provisioning and what the authors call the ‘escalating intergenomic conflict’ associated with egg retention and the increasing commitment of maternal resources to the nutrition of the offspring. This cannot be done in mammals, since our precursors took these steps 100 million years ago. Seeing how the genetic/phenotypic interactions occur in a controllable system will be of the utmost importance, and may tell us more about the basis on which selection may operate in this complex organ.

But a further series of surprising observations come from a completely different area that is also the focus of sometimes heated debate: learning behaviour. In some the idea that learning may be genetically determined is an unwelcome idea—again, I suspect, because of lack of understanding of how nature and nurture interact. Whitfield \textit{et al.}\textsuperscript{3} have found that in the honey bee, the age-related transition from hive work (first 2–3 weeks of life) to foraging behaviour (3 weeks to death at about 7–8 weeks) is associated with changes in gene expression, measured by messenger RNA abundance in the brain, of around 40% of the 5500 genes they examined. They studied individual bees (\textit{Apis mellifera}) because there is great specialization—bees may fly tens of metres or several
kilometres, may collect pollen or nectar, and may specialize in particular flowers. Some work harder than others (there are few that could reasonably be described as slackers).

The authors cleverly manipulated age structures in the colonies they studied by creating cohorts of bees who acted as nurses when they were too old or went out flying earlier than they should. In this way they were able to show a strong association between brain gene expression and behaviour, excluding age as the major factor. By examining brain gene expression profiles for individuals, they were able confidently to identify foragers and nurses, based on a two-fold expression difference. Nurses had higher expression of genes that act on axonogenesis and cell adhesion, which might facilitate the changes that are necessary to prepare the brain for flight and pattern recognition. There is a foraging gene (imaginatively called foraging) that when pharmacologically activated, induces precocious foraging and other gene expression.

Now any amount of argument might develop about whether the bees get fed up with nursing and go flying, or whether after a certain continuous pattern of development in their brain they suddenly discover they can fly. Other data suggest that the ‘needs’ of the hive may affect behaviour—this merely changes the position of the argument—how is the hive need signalled to the individual in a way that causes gene expression to be altered?

In the last five years the ‘evo-devo’ community has become more and more impressed by the rapidity of adaptive change, and it has become apparent that many of the changes we had supposed fixed and painfully arrived at have come and gone a number of times in the history of life on earth. There are chordates who decided they didn’t need a brain, given the choice. It makes me wonder whether it is really the mice that run the show, as Douglas Adams suggested.

References