Very small organisms get the oxygen they need for life by diffusion across their body surface, but larger organisms need specialized respiratory organs to do the same job. In insects, the main respiratory organs are the tracheae, an internal tubular network that develops from clusters of ectodermal cells on either side of the thoracic and abdominal embryonic segments. Two papers in this issue of Development provide new information about the evolution and development of tracheae. On p. 785, Franch-Marro and colleagues raise the possibility that an evolutionary relationship exists between insect tracheae and the external respiratory gills of crustaceans. These gills are associated with appendages, and Franch-Marro et al. show that Drosophila tracheal placodes arise next to leg primordia in the thoracic segments and next to cryptic leg primordia in the abdominal segments; the different fates of the tracheal placode and leg primordia are controlled by Wingless signalling. The researchers also report that homologues of tracheal-inducing genes are expressed in the developing gills of crustaceans. Based on these results, they propose that the ancestors to arthropods had areas on the surface of their body that were specialized for gas exchange, which evolved into crustacean gills and insect tracheae. On p. 957, Matsuki and co-workers reveal new details about the development of the Drosophila tracheal system by reporting that the formin DAAM (Dishvelled-associated activator of morphogenesis) regulates the tracheal cuticle pattern. The tracheal cuticle resembles a corrugated vacuum-cleaner hose. This structure gives the tracheae rigidity but allows them to bend as the insect moves. The researchers report that in the absence of DAAM, an array of actin cables beneath the apical surface of the tracheal cells fails to form properly – formins are key regulators of the cytoskeleton – and consequently the pattern of ridges (taenidial folds) in the tracheal cuticle is disrupted and the tracheal tubes collapse. Other results indicate that DAAM activity is regulated by RhoA and that DAAM works with the non-receptor tyrosine kinases Src42A and Tec29 to organise the actin cytoskeleton and thus determine the cuticle pattern of Drosophila tracheae. 

Topographic maps – arrangements of synaptic connections that mirror the relationships between neighbouring neurons – ensure the spatially ordered flow of information through the nervous system. Many insights into how these maps are established have come from studying developing visual systems. Now, on p. 791, Uematsu and colleagues report that Hedgehog (Hh) and the transcription factor Single-minded (Sim) regulate the ordered connection of retinal axons with their synaptic partners in the optic lamina of the Drosophila visual system. As this system develops, retinal axons extend from the eye into the lamina ganglion layer, where they stimulate proliferation and differentiation of the lamina neurons by secreting Hh. The researchers show that Sim is induced by Hh in the lamina neurons and that this expression is required for the association of retinal axons with lamina neurons – the first step in forming a topographic map. Thus, postsynaptic cells may interact dynamically with presynaptic cells to establish topographic maps rather than waiting passively for axons to arrive, as previously thought.

The transplantation of insulin-producing pancreatic β-cells holds great hope for treating type 1 diabetes. Supplies of these cells are limited, but a report by Stafford and co-workers that retinoic acid (RA) signalling from the mesoderm directly induces insulin-expressing β-cells in zebrafish endoderm advances the prospect of converting stem cells into β-cells for transplantation (see p. 949). The pancreas develops from the endoderm in response to RA synthesized by adjacent mesoderm, but whether RA signals directly or indirectly to the endoderm has been unclear. The researchers used cell transplantation to show that RA synthesis and RA receptor expression in the anterior paraxial mesoderm and endoderm, respectively, but not in other tissues, are required for the development of insulin-expressing β-cells. Furthermore, the activation of RA signal transduction in the endoderm alone induces insulin expression. Together, these results indicate that mesodermally derived RA is an instructive signal that directly induces pancreatic precursors. Thus, RA could be used to induce stem cells to differentiate into β-cells for therapeutic purposes.

Jane Bradbury