inhibitory control of DVB. This refinement improves the male's mating efficiency[7]. Hart and Hobert now show that this male-specific outgrowth of DVB occurs between days 1 and 5 of adult life. The outgrowth produces a branching neuronal architecture that, unlike many neuronal circuits in *C. elegans*, varies between individuals.

Hart and Hobert used fluorescent 'reporter' proteins to visualize DVB outgrowth and synapse formation. Their analysis reveals that outgrowth does not occur if the male does not experience copulatory activity. The authors then mimicked natural behaviours by using sophisticated genetic techniques to activate or inhibit the signalling or movement of DVB's target neuron and muscles, respectively. This shows that activity in DVB's targets stimulates the neuron's outgrowth.

What molecular pathways might mediate DVB outgrowth? Neural cell-adhesion proteins are expressed on cell surfaces in the nervous system. They have extracellular protein–protein interaction domains that can mediate communication between cells, and are thought to have a role in encoding and building the nervous system's synaptic structure[8]. Two of the best-studied proteins in this class are neurexin and neuroligin, which can interact with one another and are involved in synapse formation and regulation[9]. As such, they were natural candidates for Hart and Hobert to test.

The authors examined the roles of these proteins by combining genetic deletion or overexpression of the proteins with stimulation or suppression of activity in the circuit. These analyses led to several findings. First, neurexin is expressed in DVB and is required for DVB outgrowth. Second, the activity of neurexin is inhibited by neuroligin, which is expressed in male sex circuits and muscles. Third, neuroligin expression is suppressed by activity in the circuit, which explains why DVB outgrowth is activity dependent. Precisely how neuroligin inhibits DVB outgrowth, and whether the two proteins physically interact in this setting, remain to be determined.

Hart and Hobert's work brings together three areas of study in neuroscience: outgrowth, branching and target selection in plastic neurons; control of these processes through neuronal activity; and the function of neural cell-adhesion proteins. The value of the study therefore lies not only in the discovery of a new phenomenon, but also in the framework it provides for making more discoveries.

Analysis of *C. elegans* mutants will make it possible to identify additional molecules that affect DVB outgrowth, such as the binding partner of neurexin that stimulates outgrowth. The intracellular mechanisms that drive DVB outgrowth, and how they are controlled by interactions between neurexin and its binding partner, can then be analysed. Other questions for study include how DVB knows where to send processes, how its axonal extensions recognize appropriate synaptic targets, and precisely how circuit activity controls neuroligin expression.

Finally, Hart and Hobert found that these events occur only in males. The authors attempted to stimulate DVB outgrowth in hermaphrodites, but their results suggest that neither circuit activity nor the neurexin–neuroligin pathway are by themselves sufficient to do this. Other work[10] in *C. elegans* suggests that it is the complement of sex chromosomes (two X chromosomes in the hermaphrodite and only one in the male) in the cells of the circuit that ultimately makes them respond to sex-neutral pathways in sex-appropriate ways.

Genetic studies[9] have implicated mutations in neural cell-adhesion genes, including neurexin and neuroligin, as the bases of psychiatric disorders, partly because of the roles of these genes in neural plasticity. Progress in unravelling details of the molecular pathways underlying their activity could therefore have profound implications for understanding not only learning and memory, but also mental disorders and their sex-specific expression. ■

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ORGANOMETALLIC CHEMISTRY

Dogma-breaking catalysis

The catalysts conventionally used for industrially important hydrogenation reactions are expensive and generate toxic residues. Catalysts have now been reported that might lead to cheaper, less toxic alternatives.

DOUGLAS W. STEPHAN

Reactions of hydrogen gas with organic compounds are performed on a large scale worldwide by the chemicals industry[1]. Such hydrogenation reactions are essential to the production of numerous commercial goods, including many polymers, foodstuffs and pharmaceuticals. However, a catalyst is needed to provide a thermodynamically accessible reaction pathway that allows hydrogenations to occur. Until the past decade or so, it was thought that these catalysts must derive from transition metals, but there is now a growing list of alternatives. Writing in *Nature Catalysis*, Bauer *et al.*[2] add to that list by reporting effective hydrogenation catalysts derived from alkaline-earth elements — the group of metals that includes calcium.

About 100 years ago, the chemist Paul Sabatier was the first to recognize that amorphous metals could act as catalysts to mediate the hydrogenation of organic substrates[3]. By the middle of the twentieth century, the emergence of the subdiscipline of organometallic chemistry led to the development of a wide variety of transition-metal complexes that are highly effective catalysts for these reactions[4]. Soluble transition-metal catalysts have undergone continual development to offer higher and higher reactivities. In addition, judicious changes to the ligand molecules bound to the metal atom were found to control the reactivity and selectivity of the catalytic complexes — not only the substrate selectivity, but also the stereoselectivity (the 3D geometric arrangement of atoms generated in the product). Despite these advances, most catalysts used in industrial processes are derived from the metals platinum, palladium, rhodium and ruthenium, which are expensive, toxic and rare.

The cost of the precious metals in such catalysts is not the only expense associated with their use — the removal of toxic catalyst residues from the products is also costly. This, together with increasing environmental concerns, has prompted efforts to find alternatives to conventional hydrogenation catalysts. One strategy that uses the principles of

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