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INSIDE JEB

Wriggling sea squirt larvae teach us how nerves control behaviour

A *Ciona* larva. Photo credit: Matthew J. Kourakis.

Behind every piece of high-tech modern gadgetry, there is a complex wiring diagram, showing in minute detail how each individual component links to and communicates with the others. However, when it comes to lifeforms, there are only two complete 'connectomes': the much-celebrated neuron network of the humble *C. elegans* worm and, more recently, the 177 neuron network that comprises the entire central nervous system of the tiny *Ciona intestinalis* sea squirt larvae. 'The *Ciona* larval connectome study of Kerrianne Ryan, Zhiyuan Lu and Ian Meinertzhagen opened up huge opportunities for functional neurobiology', says William Smith from the University of California, Santa Barbara (UCSB), USA. And sea squirts are much closer relatives to vertebrates than the worms. But there was a catch: no one had categorically defined the larvae's behavioural repertoire. With the tempting prospect that they could tie down the specific nerves that control particular behaviours, Smith and two UCSB undergraduate students, Priscilla Salas and Vall Vinaithirthan, decided to catalogue the larvae's responses to light changes.

Why light? Many marine animals use light for guidance and sea squirt larvae are no exception. They are equipped with a simple eye, an ocellus, composed of two types of light-sensitive cells (photoreceptors): Group I photoreceptors, which are surrounded by a dark pigmented cup and detect light from only one direction; and Group II photoreceptors, which are unshaded and can detect light from all directions, including light passing through the larvae's transparent body. However, some larvae, known as albinos, have lost the pigment shielding, so Smith, Salas and Vinaithirthan decided to test how the albinos and regular larvae responded to light.

Collecting freshly fertilised eggs of a close relative, *Ciona robusta*, in a Petri dish and allowing them to hatch, the trio shone light on the tiny larvae and their albino cousins from one side of the dish for 3 days. During that time, the regular larvae swam enthusiastically to the other side of the dish. In contrast, the albino larvae seemed to have no sense of direction, although they were still sensitive to light, as they swam vigorously when the light was switched off indicating that the Group I photoreceptors detect the direction of light.

The team also monitored when the larvae were first able to swim away from light and discovered that the behaviour set in about 24 h after fertilisation. 'The larvae are very skittish', Smith says, adding, 'The smallest perturbation, such as adjusting the lighting or moving your hand over them, could set them off on a minute or more of frantic circular swimming'. They also noticed that the larvae sometimes flicked their tails without launching into a full-blown swim and realised that tail flicks and sustained swimming are different behaviours. In addition, 21 h post-fertilisation larvae that were stationary when the trio switched out the light suddenly burst into a flurry of spiral swimming, while those that had been swimming in a straight line switched direction. 'The erratic swims in response to dimming would appear to be ideal for avoiding predation', says Smith and he adds that the two behaviours are probably completely independent because they set in at different stages of the larvae's development.

So, the Group I photoreceptors guide the larvae away from light while the Group II photoreceptors trigger the larvae's helter-skelter escape response. And the team suggest how the photoreceptors may directly control both behaviours, knowing how each of the neurons in the larvae's pared-down nervous system interconnects with the others.

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