Research defines neurons that control sociability in worms

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Social surgery. By using a laser to kill the RMG neurons in social strains of C. elegans, researchers showed that worms lacking this "social brain" failed to congregate (right) compared to those with it (left).

(PhysOrg.com) -- Ants colonize. Fish shoal. Flamingos flock and caribou herd. Earth is populated by inherently social beings. Even lowly worms seek out the benefits of companionship. New research at The Rockefeller University has dissected the social proclivities of a model worm, identifying a single type of neuron — RMG — that "decides" whether these worms will mingle with their fellows or keep to themselves.

"We can think of RMG neurons as the world's simplest social brain, as the place where information relevant to the worm's decision to hang out with other worms converges, and the decision is made," says Cori Bargmann, head of the Laboratory of Neural Circuits and Behavior at Rockefeller, who led the research. The work was published this week in

Nature.

Even the world's simplest social brain, one pair of only 302 neurons in Caenorhabditis elegans's compact nervous system, is rather complicated, it turns out. A host of genetic and environmental variables contribute to the decision-making. RMG is the central integrating hub of a network of sensory neurons that feeds the worm readings of its environment such as whether food is available, how much oxygen is in the air and other factors known to influence gregarious behavior. Only when the right conditions are met will the animals congregate. Evan Macosko, an M.D.-Ph.D. student in the Bargmann lab, found that the crucial trigger for aggregation is a switch in the response to other worms' pheromones. RMG and a pheromone-detecting neuron named ASK are the essential players in the "hub-and-spoke" circuit that drives social behavior.

Pheromones are known to bring creatures together in many species, from insects such as ants and moths to mammals including prairie voles and possibly even people. In social strains of C. elegans, a transparent, one-millimeter-long roundworm, the same is true. Bargmann determined that ASK, known to be involved in the attraction of the relatively rare males to the more common hermaphrodites, senses pheromones. ASK is relatively inactive in solitary hermaphrodites, which ignore or avoid pheromones. However, in social worms, RMG amplifies the signal from pheromone-sensitive ASK neurons, driving the worms toward each other and increasing sociability.

The hub-and-spoke circuit, Bargmann says, is a relatively rare but recurring theme in the map of C. elegans's nervous system known as its wiring diagram. The neurons connected in such circuits primarily communicate electrically across gap junctions rather than through the more common connections of chemical synapses. Bargmann believes that hub-and-spoke circuits could be the integrative sites that coordinate different characteristic behaviors in worms and other species.

RMG is the hub of the worm's social brain, and also a hub of genetic differences in social behavior. The activity of one receptor gene in the worm's brain determines whether hermaphrodite worms will be relatively social, congregating at a moment's notice, or relatively solitary. The receptor gene, npr-1, sets the activity level of RMG neurons, so genes and environment act on the same target when modifying social behavior.

"The decision to congregate gets made in certain environments and not in others and in certain genotypes and not in others," says Bargmann, who is also a Howard Hughes Medical Institute investigator. "Aggregation is a true regulated behavior that's an option, not a requirement. Behavior is all about choosing between your options based on your genes, your experience and your current situation."

More information: Nature online: April 6, 2009. A hub-and-spoke circuit drives pheromone attraction and social behaviour in C. elegans, Evan Z. Macosko, Navin Pokala, Evan H. Feinberg, Sreekanth H. Chalasani, Rebecca A. Butcher, Jon Clardy and Cornelia I. Bargmann

Provided by Rockefeller University (news : web)