Why some neurons 'outsource' their cell body

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Nerve cells have different shapes: while the cell body (red) is found in a central position in rats, it is located at the end of a cell prolongation in flies. Credit: © Janina Hesse, 2015

Nerve cells come in very different shapes. Researchers at the Bernstein Center Berlin now reveal why, in insects, the cell body is usually located at the end of a separate extension. Using mathematical models, they show that this increases the strength of electrical signal transmission at no additional energetic cost.

Nerve cells follow a functional design: They receive input signals over more or less ramified cell branches (dendrites), which they forward to other nerve cells along an elongated, thin cell process (axon). The cell body contains the nucleus with genetic material and other components of the machinery that keeps the neuron alive. Its location differs significantly between animal classes: in mammals, the cell body is usually found at a central position between the dendrites and the axon, while in insects, it is often "outsourced" to the end of a separate prolongation.

"Since the description of nerve cells by Santiago Ramón y Cajal, there have been many speculations about the reasons for these different morphologies," says first author Janina Hesse at the Bernstein Center Berlin and the Humboldt University of Berlin. "Our study now points to a crucial cause: the reduction of signal loss and energy required during the transmission of electrical signals within the nerve cell."

To support their hypothesis, the biologists applied mathematical models to determine the benefits of the remote location of the cell body. The computer models included the essential components of a nerve cell in a simplified form. In the models, the cell body was located either in a central or in an externalized position. This way, the researchers could simulate the electrical signal transmission in both conditions and estimate the required energy and conduction losses.

"In order to transmit a signal to another cell, a neuron requires a certain signal strength in the axon. When the signal has to pass a central soma before it reaches the axon, the membrane leak diminishes the signal. This signal loss can be countered by active boosting, which is energetically costly for large cell bodies. A better solution may be an externalization of the cell body," senior author Susanne Schreiber explains.

Hence, for organisms with large cell bodies, it is best not to make the signal pass across the cell body, but to transmit it straight from the dendrite to the axon. Insects take this direct route by relocating the neural cell bodies to the end of a thin prolongation. This advantageous shape allows the neurons to efficiently transmit even small input signals to neighboring cells. With their results, the Berlin researchers have shed light on a mystery neuroscientists have pondered since the first detailed morphological studies over 100 years ago. Their study has been published in the current issue of the journal *Current Biology*.

More information: J. Hesse & S. Schreiber (2015): Externalization of neuronal somata as an evolutionary strategy for energy economization. *Current Biology*, 25(8), R324 - R325. DOI: 10.1016/j.cub.2015.02.024

J. E. Niven (2015): Neural Evolution: Marginal gains through soma location. *Current Biology*, 25(8), pR330-R332. DOI: 10.1016/j.cub.2015.02.059

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