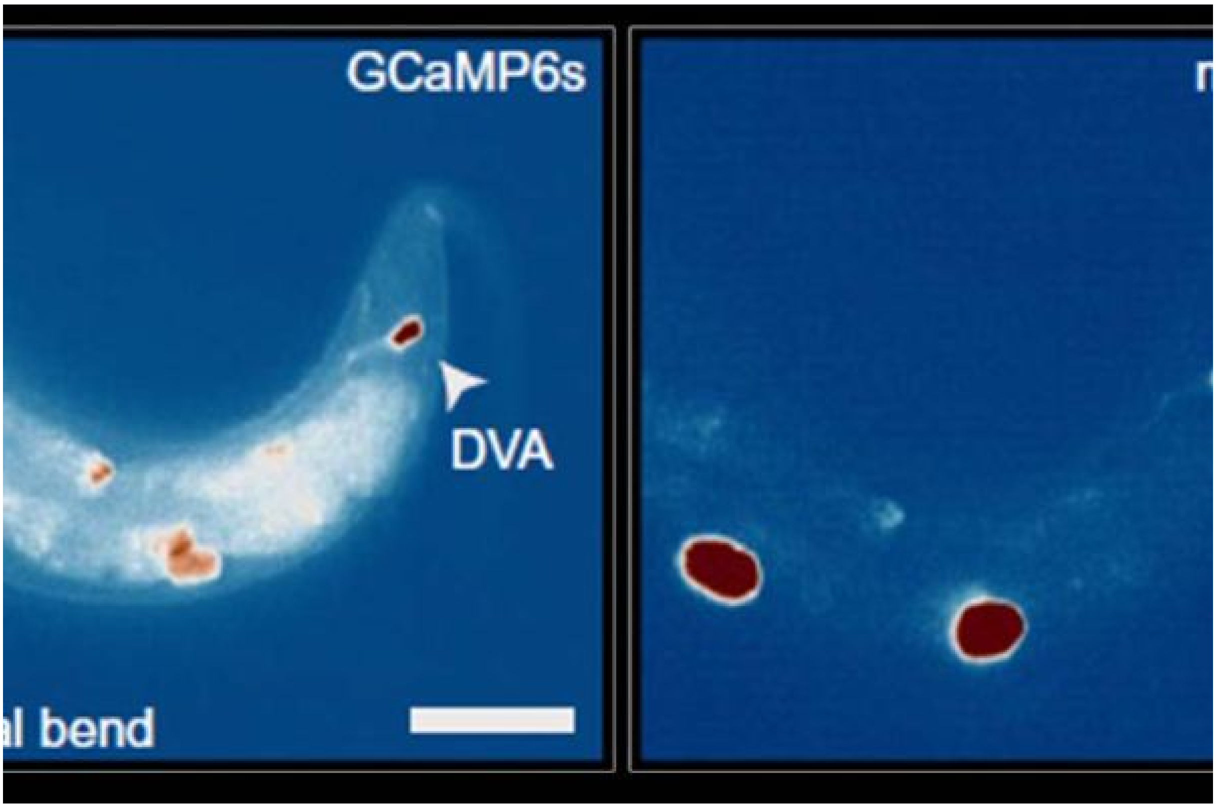


Self-movement and body position of the roundworm Caenorhabditis elegans

In a new study published in the journal Science Advances, ICFO researchers at the Neurophotonics and Mechanical Systems Biology group investigate the mechanics, molecules, and neurons that govern the locomotion of the roundworm Caenorhabditis elegans.

October 04, 2021

Typically, animals move in cyclic paces generated by the alternation of the contraction and relaxation of the muscle cells, controlled by excitatory and inhibitory motor neurons. The control of locomotion requires motor, neural and mechanical feedback. Most motile animals have a sense of self-movement and body position, called proprioception that helps them stabilize and coordinate their movements. This unconscious sense is crucial for survival, as it contributes to maintaining a correct organ function and the body's equilibrium.

Proprioception is governed by the mechanosensory neurons known as proprioceptors, responsible for detecting kinematic signals and transmitting them through the central nervous system, helping to create a global representation of the body position. That transmission takes place at the neuron's extensions, the dendrites, which contain specialized proteins that receive, process, and transfer signals from other neurons into the cell body.

How is proprioception ciphered?

Model organisms are widely used in biology to study several phenomena. One of the most studied is Caenorhabditis elegans, a roundworm whose full genome is known and the only animal with a mapped nervous system, is commonly used to dissect the integration of sensory and motor systems. Although many of the C. elegans proprioceptor neurons have already been identified, it remains unclear which stimulus drives them. To study how this sense of self-movement helps to regulate the gait cycles, the ICFO Neurophotonics and Mechanical Systems Biology group used genome editing, force spectroscopy, and computational modeling to unravel the molecular basis of C. elegans locomotion.

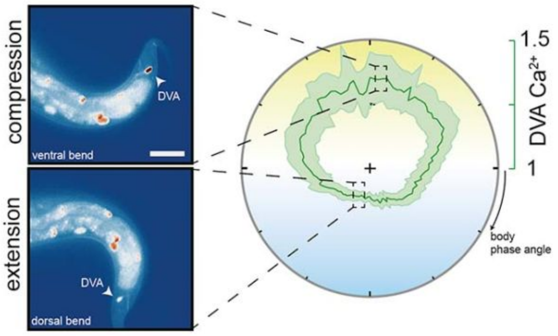
In the study published in Science Advances, the ICFO researchers Ravi Das, Li-Chun Lin, Frederic Catala-Castro, Nawaphat Malaiwong, Neus Sanfeliu-Cerdan, Montserrat Porta-de-la-Riva, and Aleksandra Pidde, led by the ICFO researcher Michael Krieg, first pointed out that the ? spectrin, a large protein of the cell's cytoskeleton, might have a role in the proprioception during locomotion. To further describe its role, they recorded videos of wild-type C. elegans individuals and compared them to the mutant ones - with altered ? spectrin protein. They saw that, in the mutants, the body bends were much exaggerated. When searching for other defects in the muscles contraction or any loss of neuronal control in the mutant roundworms, they couldn't find any. That led them to think that the role of ? spectrin is specific to only certain behaviours, as regulating the extension of body bending.

The team also observed one of the C. elegans proprioceptor neurons, known as DVA, and its activation under compression, both in living animals and in vitro cultures. They observed the changes in the neuron's calcium and potassium ion channels and how they induced or suppressed the neuron's activity.

Sensory neurons are activated locally under mechanical compressions

The team of researchers found a mechanosensory sensitivity to compression. They saw that what regulates the body posture is an alternation between tension and compression in the spectrin proteins of the sensory neurons, meaning that the protein spectrin interferes with the self-sensing of the body posture.

They also think that the signals that the proprioceptor neurons detect are transmitted following a general mechanism of dendrites. In this mechanism, compression and extension stresses modulate two opposing ion channels in the neurons, one excitatory and the other inhibitory, which are responsible for transmitting the signals. This modulation generates functional compartmentalization, with active and inactive zones, that allows the neurons to be activated locally, improving the control of the overall movements.



The ventral and dorsal bends of the roundworm C.elegans during locomotion, respond to the activation of the proprioceptor neuron DVA