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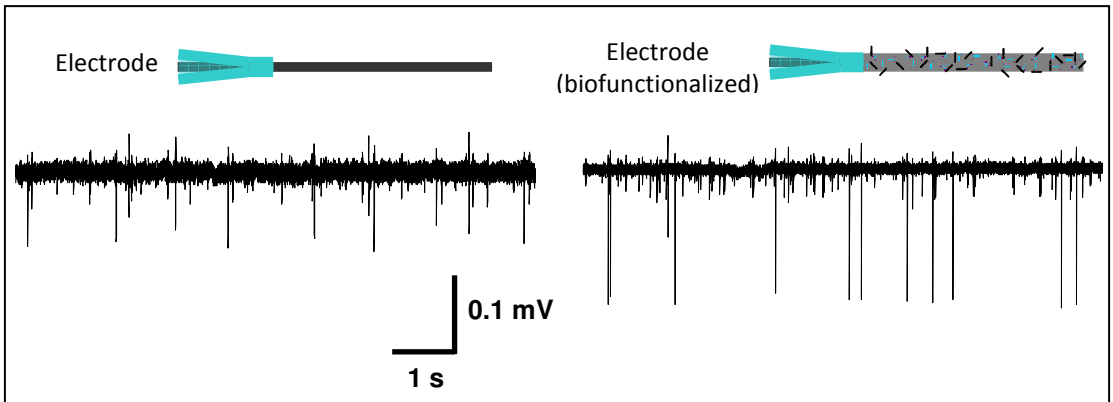
With a solid background in electrophysiological techniques, Dr. Vara has investigated the mechanisms of synaptic plasticity in the nervous system. The notion that synaptic plasticity is at the base of the processes of learning and memory is widely accepted by the scientific community nowadays. Dr. Vara has been part of research projects that have reported alterations in synaptic plasticity in the brain of rodent pharmacological or genetic models of human disorders like Niemann-Pick disease, Alzheimer's disease and congenital hypothyroidism, all of them involving different degrees of neurological impairment.

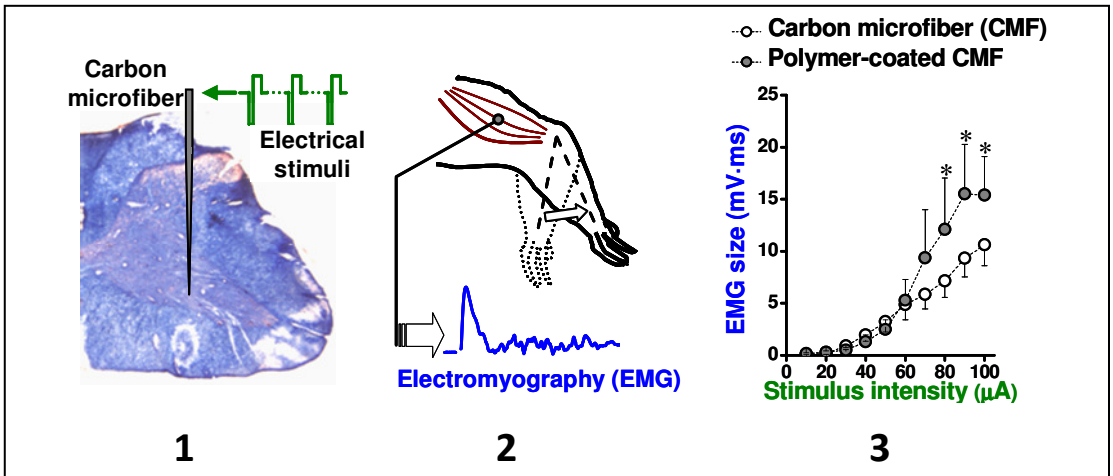
Since January 2013, Dr. Vara works in the Laboratory of Neural Repair and Biomaterials in the National Hospital for Paraplegics. Here, he participates in the development and characterization of an electrical stimulation and neural activity recording system that could be used, at the same time, to induce cell migration and growth of neuronal processes. Using carbon microfibers as base material, the goal of this research is to develop a prototype of biocompatible device that could be implanted in the injured neural tissue.



Spontaneous neural activity recorded from rat brain slices in vitro using a standard carbon fiber-based electrode (left) or a polymer-coated, biofunctionalized carbon-based electrode (right). Note that the neural activity recorded using the biofunctionalized electrode exhibits lower electrical background noise and higher signal amplitude.

He is currently assessing the effectiveness of carbon microfiber-based electrodes in intraspinal microstimulation (ISMS). ISMS has been proposed as a novel rehabilitative therapy to recover motor functions after spinal cord injury. In the laboratory, ISMS is used to activate the motoneurons of the spinal circuits that control the muscles of the rat, while using electomyography thechniques to evaluate muscle contraction and, simultaneously, analyzing the cinematic of the produced movements employing high-speed cameras.

The results of this study have shown that carbon microfibers are very effective to activate specific spinal cord motoneurons. Moreover, when these microfibers are coated with the conducting polymer PEDOT:PSS-co-MA, the generation of undesired voltages that could cause cell damage during electrical stimulation are avoided. ISMS experiments have also demonstrated that polymer-coated microfibers allow obtaining higher activity in the muscles that are innervated by the activated spinal motoneurons. Then, these polymer-coated carbon microfibers constitute a valid option for the development of effective, low-invasive electrodes that could be incorporated to neuroprosthetic instruments. However, further experiments should be performed to guarantee that the use of this type of electrodes is biologically safe on the long-term.



1. Scheme of a carbon microfiber ready to stimulate a group of motoneurons superimposed on a photograph of the left half of a histological section of the spinal cord. The selected motoneurons are located in the ventral horn of the spinal cord.
2. Electrical stimulation of the motoneurons provokes the extension of the rat foreleg, due to contraction of *triceps* muscle. This muscle receives innervation from the selected motoneurons. Muscle activity was recorded by electromyography.
3. Muscle activation was larger when the stimulation was performed using microfibers that had previously been coated with a thin layer of a particular conducting polymer (PEDOT:PSS-*co*-MA) that improves the electrical properties of the microfibers.

Selected readings:

Del-Cerro P, Barriga-Martín A, **Vara H**, Romero-Muñoz LM, Rodríguez-De-Lope A, Collazos-Castro, JE (2021). Neuropathological and motor impairments after incomplete cervical spinal cord injury in pigs. Journal of Neurotrauma. DOI: 10.1089/neu.2020.7587

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