Neuron-integrated nanotubes to repair nerve fibers

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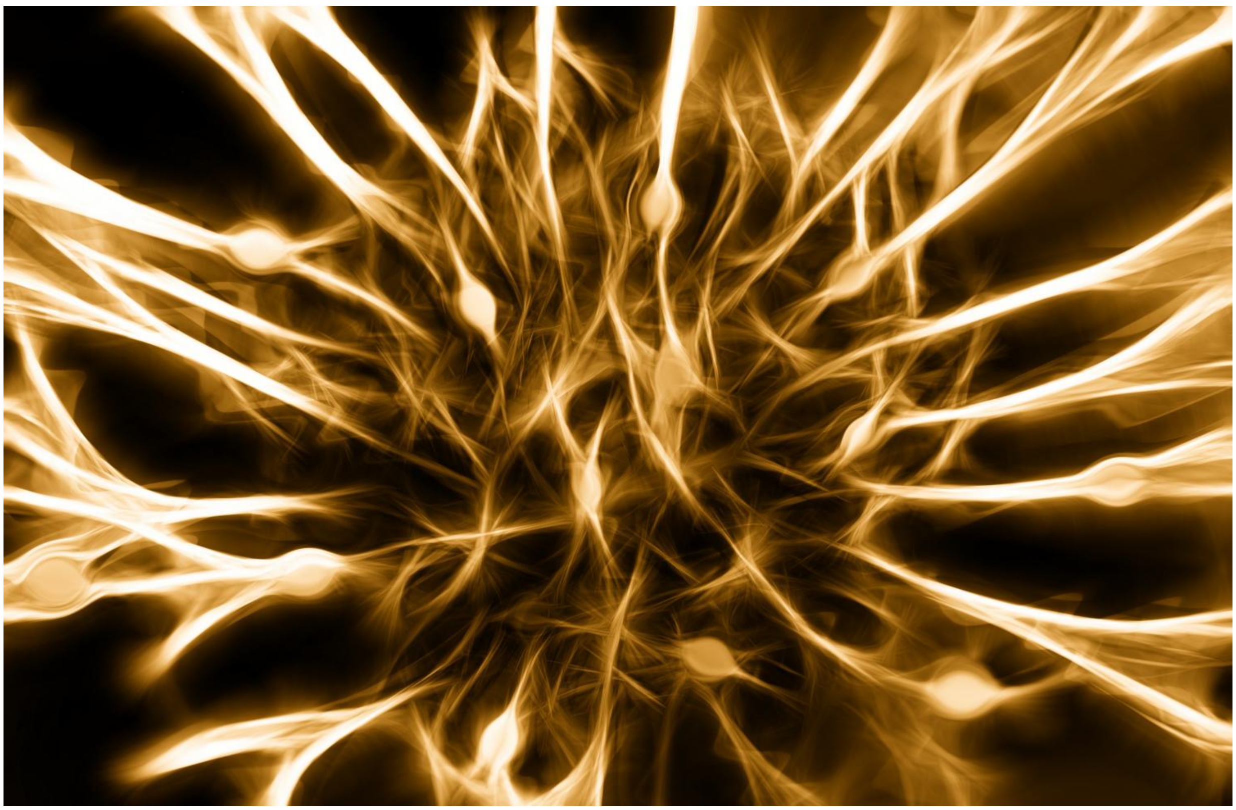

Scientists have proven that these nanomaterials may regulate the formation of synapses, specialized structures through which the nerve cells communicate, and modulate biological mechanisms, such as the growth of neurons, as part of a self-regulating process. Credit: Pixabay

Carbon nanotubes exhibit interesting characteristics rendering them particularly suited to the construction of special hybrid devices consisting of biological issue and synthetic material. These could re-establish connections between nerve cells at the spinal level that were lost due to lesions or trauma. This is the result of research published in the scientific journal *Nanomedicine: Nanotechnology, Biology, and Medicine* conducted by a multi-disciplinary team comprising SISSA (International School for Advanced Studies), the University of Trieste, ELETTRA Sincrotrone and two Spanish institutions, Basque Foundation for Science and CIC BiomaGUNE.

Researchers have investigated the possible effects on neurons of interactions with carbon nanotubes. Scientists have proven that these nanomaterials may regulate the formation of synapses, specialized structures through which the nerve cells communicate, and modulate biological mechanisms such as the growth of neurons as part of a self-regulating process. This result, which shows the extent to which the integration between nerve cells and these synthetic structures is stable and efficient, highlights possible uses of carbon nanotubes as facilitators of neuronal regeneration or to create a kind of artificial bridge between groups of neurons whose connection has been interrupted. In vivo testing has already begun.

"Interface systems, or, more generally, neuronal prostheses, that enable an effective re-establishment of these connections are under active investigation," says Laura Ballerini (SISSA). "The perfect material to build these neural interfaces does not exist, yet the carbon nanotubes we are working on have already proved to have great potentialities. After all, nanomaterials currently represent our best hope for developing innovative strategies in the treatment of spinal cord injuries." These nanomaterials are used both as scaffolds, as supportive frameworks for nerve cells, and as interfaces transmitting those signals by which nerve cells communicate with each other.

Many aspects, however, still need to be addressed. Among them, the impact on neuronal physiology of the integration of these nanometric structures with the cell membrane. "Studying the interaction between these two elements is crucial, as it might also lead to some undesired effects, which we ought to exclude," says Laura Ballerini. "If, for example, the mere contact provoked a vertiginous rise in the number of synapses, these materials would be essentially unusable."

"This," Maurizio Prato adds, "is precisely what we have investigated in this study where we used pure carbon nanotubes."

The results of the research are extremely encouraging: "First of all, we have proved that nanotubes do not interfere with the composition of lipids, of cholesterol in particular, which make up the cellular membrane in neurons. Membrane lipids play a very important role in the transmission of signals through the synapses. Nanotubes do not seem to influence this process, which is very important."

The research has also highlighted the fact that the nerve cells growing on the substratum of nanotubes via this interaction develop and reach maturity very quickly, eventually reaching a condition of biological homeostasis. "Nanotubes facilitate the full growth of neurons and the formation of new synapses. This growth, however, is not indiscriminate and unlimited. We proved that after a few weeks, a physiological balance is attained. Having established the fact that this interaction is stable and efficient is an aspect of fundamental importance."

Laura Ballerini says, "We are proving that carbon nanotubes perform excellently in terms of duration, adaptability and mechanical compatibility with the tissue. Now, we know that their interaction with the biological material, too, is efficient. Based on this evidence, we are already studying the in vivo application, and preliminary results appear to be quite promising also in terms of recovery of the lost neurological functions."

More information: Niccolò Paolo Pampaloni et al, Sculpting neurotransmission during synaptic development by 2D nanostructured interfaces, *Nanomedicine: Nanotechnology, Biology and Medicine* (2017). [DOI: 10.1016/j.nano.2017.01.020](https://doi.org/10.1016/j.nano.2017.01.020)

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