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Nanotube transistor interacts with cell membrane

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Scientists from Nanomix, US, and the University of California, Los Angeles, US, say they have demonstrated the first interaction of a nanoelectronic device with an intact biological system. They believe this advance could ultimately lead to the creation of an artificial eye.

“The integration of biological processes and molecules with nanoscale-fabricated structures offers the potential for electronic control and sensing of biological systems,” George Grüner of UCLA told *nanotechweb.org*. “Several technologies, ranging from artificial sensory systems to early detection of cancer using direct electronic detection, will be critically dependent on the nature of such interfaces.”

Grüner and colleagues combined the cell membrane of the bacterium *Halobacterium salinarum* with a nanotube network field-effect transistor. The cell membrane contained the light-sensitive membrane protein bacteriorhodopsin. At the heart of the transistor was a dense network of carbon nanotubes contacted by metal electrodes.

The researchers connected the components by depositing the cell membrane on a nanotube network field-effect transistor grown onto a substrate by chemical vapour deposition. They placed a silicon chip on top of the cell membrane layer, which was around 5 nm thick.

By applying an electrical potential to the upper chip, the scientists changed the orientation of the rhodopsin dipoles in the membrane layer. They tested the electrical properties of transistors with the neighbouring dipoles oriented upwards, downwards and with a random orientation. As well as interacting with each other, both the cell membrane and transistor carried on functioning.

“The electric dipole of the bacteriorhodopsin remained intact, and the transistor operation was retained,” said Grüner. “Furthermore, one could use the response of the electronic device to learn about some important aspects of the biological system, such as the charge distribution within the proteins.”

The scientists used the transfer characteristics of the transistor to determine that the electric dipole of bacteriorhodopsin lies about two-thirds of the way from the exterior of the cell to the inside of the membrane.

“Eventually, one can envision an artificial eye – where the conversion of photons to electrons is achieved through a light-absorbing molecule or layer that is coupled to an electronic device that, in turn, is attached to neurons,” said Grüner. “It should also be possible to connect living cells directly to nanoelectronic devices. Such work opens up the avenue for what could be called ‘cellectronics’, the detection and also modification of bio-processes at the cellular level.”

According to Keith Bradley of Nanomix, the team overcame a central problem in nanobioelectronics - the complex hierarchy of length scales in biosystems. “Organisms comprise multiple cells, and cell membranes contain objects as small as individual proteins distributed at various distances,” he said. “Individual nanotubes interacted with individual proteins, while the network of nanotubes contacted multiple cell membranes.”

The researchers reported their work in *Nano Letters*.