Cyborg cardiac patch may treat the diseased heart

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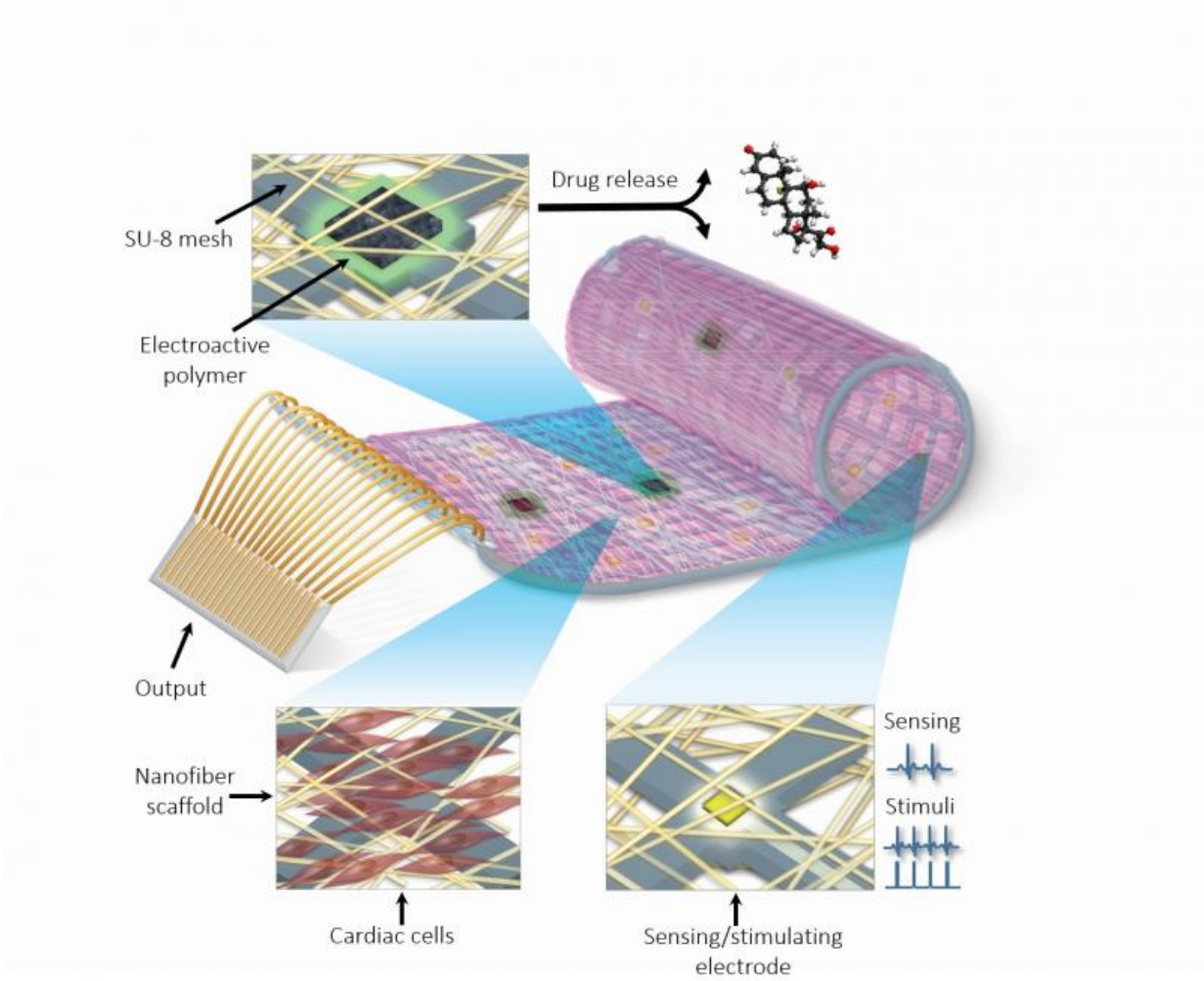

A remotely regulated living bionic heart is pictured. The engineered tissue is comprised of living cardiac cells, polymers, and a complex nanoelectronic system. This integrated electronic system provides enhanced capabilities, such as online sensing of heart contraction, and pacing when needed. In addition, the

electronics can control the release of growth factors and drugs, for stem cell recruitment and to decrease inflammation after transplantation. Credit: Tel Aviv University

More than 25% of the people on the national US waiting list for a heart will die before receiving one. Despite this discouraging figure, heart transplants are still on the rise. There just hasn't been an alternative. Until now.

The "cyborg heart patch," a new engineering innovation from Tel Aviv University, may single-handedly change the field of cardiac research. The bionic heart patch combines organic and engineered parts. In fact, its capabilities surpass those of human tissue alone. The patch contracts and expands like human heart tissue but regulates itself like a machine.

The invention is the brainchild of Prof. Tal Dvir and PhD student Ron Feiner of TAU's Department of Biotechnology, Department of Materials Science and Engineering, and Center for Nanoscience and Nanotechnology. Their study was published today in the journal *Nature Materials*.

Science fiction becomes science fact

"With this heart patch, we have integrated electronics and living tissue," Dr. Dvir said. "It's very science fiction, but it's already here, and we expect it to move cardiac research forward in a big way.

"Until now, we could only engineer organic cardiac tissue, with mixed results. Now we have produced viable bionic tissue, which ensures that the heart tissue will function properly."

Prof. Dvir's Tissue Engineering and Regenerative Medicine Lab at TAU has been at the forefront of cardiac research for the last five years, harnessing sophisticated nanotechnological tools to develop functional substitutes for tissue permanently damaged by heart attacks and cardiac disease. The new cyborg cardiac patch not only replaces organic tissue but also ensures its sound functioning through remote monitoring.

"We first ensured that the cells would contract in the patch, which explains the need for organic material," said Dr. Dvir. "But, just as importantly, we needed to verify what was happening in the patch and regulate its function. We also wanted to be able to release drugs from the patch directly onto the heart to improve its integration with the host body."

For the new bionic patch, Dr. Dvir and his team engineered thick bionic tissue suitable for transplantation. The engineered tissue features electronics that sense tissue function and accordingly provide electrical stimulation. In addition, electroactive polymers are integrated with the electronics. Upon activation, these polymers are able to release medication, such as growth factors or small molecules on demand.

Cardiac therapy in real time

"Imagine that a patient is just sitting at home, not feeling well," Dr. Dvir said. "His physician will be able to log onto his computer and this patient's file—in real time. He can view data sent remotely from sensors embedded in the engineered tissue and assess exactly how his patient is doing. He can intervene to properly pace the heart and activate drugs to regenerate tissue from afar.

"The longer-term goal is for the cardiac patch to be able to regulate its own welfare. In other words, if it senses inflammation, it will release an anti-inflammatory drug. If it senses a lack of oxygen, it will release

molecules that recruit blood-vessel-forming cells to the heart."

Dr. Dvir is currently examining how his proof of concept could apply to the brain and spinal cord to treat neurological conditions.

"This is a breakthrough, to be sure," Dr. Dvir said. "But I would not suggest binging on cheeseburgers or quitting sports just yet. The practical realization of the technology may take some time. Meanwhile, a healthy lifestyle is still the best way to keep your heart healthy."

More information: Engineered hybrid cardiac patches with multifunctional electronics for the online monitoring and regulation of tissue function, *Nature Materials*, DOI: 10.1038/nmat4590

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