Researchers target cells for tissue engineering

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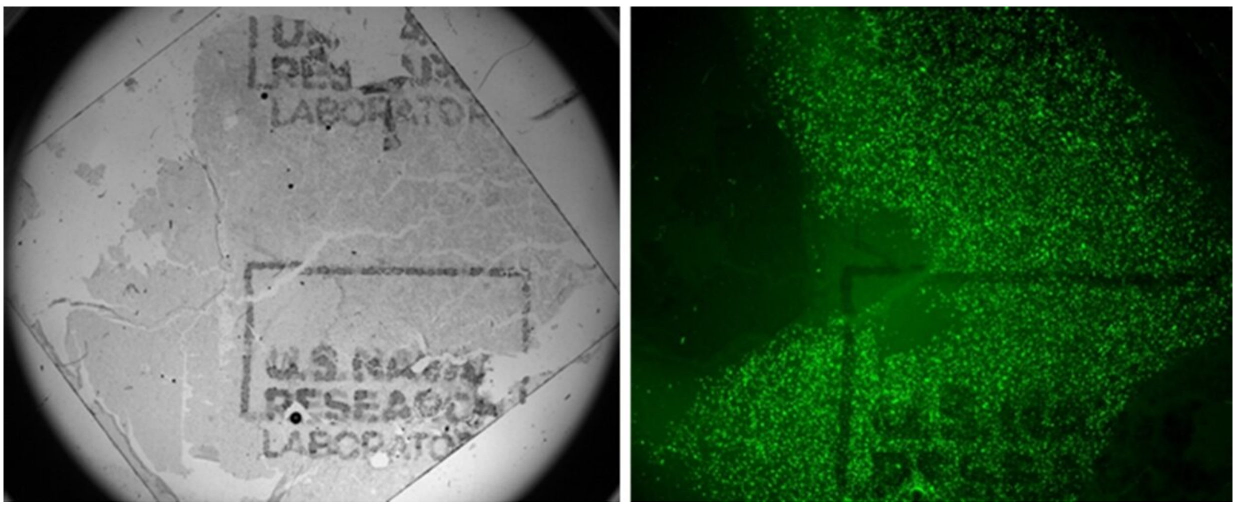

Cell culture with gelatin and reduced graphene oxide. The NRL-developed system enables on-demand printing of elaborate patterns for direct electronic and chemical manipulation of cells, such as the printed electrically-conductive silver NRL logo shown here. The technology is simple and inexpensive, and may eventually be used to design advanced wound dressings and monitoring devices. Left: brightfield image, Right: live cell fluorescent stain. (Photo provided by NRL Chemistry Division). Credit: U.S. Naval Research Laboratory

U.S. Naval Research Laboratory researchers in the Chemistry Division apply their knowledge of biology in conjunction with materials to improve understanding of how cells and tissues organize and apply new methods to affect cell communication.

Advanced understanding in this field may make it possible to develop wearable technology with real-time wound monitoring capability.

"Our work has applications to a number of important Department of Defense challenges, including enhanced wound healing, bioelectronics interfacing, and intercellular communication of stress response," said Keith Whitener, Ph.D., a research chemist from the NRL Chemistry Division. "We are currently working on capabilities to improve wound monitoring for Sailors and Marines in the field."

Advanced medical help is often unavailable to expeditionary and isolated warfighters, and even minor wounds can become infected and escalate rapidly to a life-threatening situation. Improved wound monitoring and treatment will help wounded warfighters receive the medical attention they need to ensure their survival and resilience.

The researchers build graphene-based devices called Transferrable Active Chemical Structures (TACS) to deliver information to individual cells and small groups of cells, either electronically or biochemically, to clarify and control how cells communicate with one another.

Stem cells of a single kind have the ability to develop into tissues and organs with many different kinds of cells, and the researchers are building tools to help determine how this phenomenon occurs.

Christopher So, Ph.D., a materials research scientist from the NRL Chemistry Division, develops bulk biomaterials such as gelatin or surface binding peptides to interface between the graphene oxide and stem cells as biocompatible adhesives. Since cells must remain in liquid culture to stay alive, the team needed to develop a material that could bond the TACS to the cells underwater.

"Developing biomaterials that adhere to the TACS membrane underwater was a challenge, as gelatin is quite hydrophilic," said So. "Our team developed methods to process the material so that less water was at the interface, which provides stronger interactions between the gel and the membrane. Underwater adhesion is a persistent issue for the Navy, and methods of adhering electronics underwater could lead to new biosensing applications."

Graphene materials are usually toxic and damage cells, and the addition of gelatin is a simple way to protect the cells from the graphene oxide while providing a bio-friendly environment. Additionally, So designs and produces genetic materials to be delivered to cells, which carry instructions for stem cell differentiation.

Spatial control over cell populations is important to manipulate and integrate living systems used in advanced biological engineering.

The team developed techniques to transfer graphene-based thin film materials in a biocompatible way to interface a number of materials directly with live cells without sacrificing viability.

"We use partially reduced graphene oxide to print and transfer materials, including metallic structures, fluorescent cell dyes, and phase-separated block copolymers to mesenchymal stem cells," Whitener said. "We found that our graphene oxide membranes are impermeable to most molecules, and we are exploiting this impermeability to use these membranes as cell masks for spatially patterned delivery of molecular stimuli in cells."

The team also pioneered transferrable photolithography on graphene to enable more precise patterning of molecule delivery as well as co-culture patterning.

"This technique allows us to apply the precision of micro- and nano-fabrication to the messy world of living cells," Whitener said.

Dhanya Haridas, Ph.D., a research biologist from the NRL Chemistry Division, provides the eukaryotic expertise needed for this project. Haridas manages the cell line requirements and analyzes cell behavior under the various conditions explored in the program.

"TACS is an excellent example of a program harnessing the findings in the field of chemistry to further probe and understand biological processes that best serve to address the various needs of the Navy," Haridas said. "We are in the process of developing techniques that will pave the way for decoding of cell-to-cell communication down to a single cell with applications in the field of wound healing and cell stress."

The Chemistry Division conducts basic and applied research and development to address critical Navy needs and advance the frontiers of physical, chemical, biological, and material science as well as nanoscience. Research ranges from laboratory to intermediate and real-scale experiments and demonstrations.

Provided by Naval Research Laboratory

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