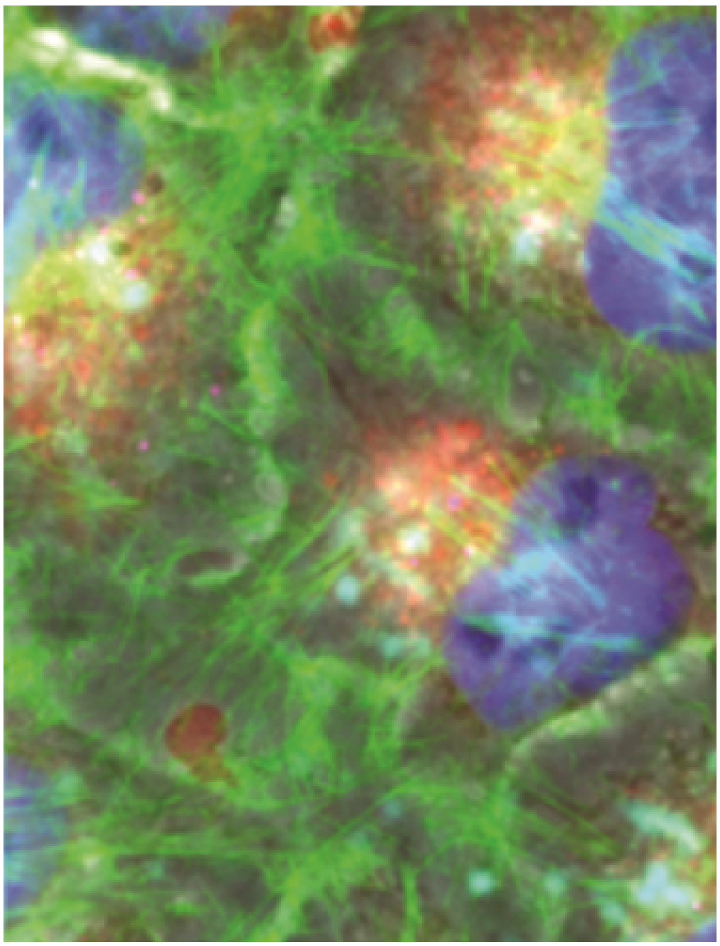
Using carbon nanotubes for drug delivery

May 17 2016, by Emily Durham



Cells with millions of nanotubes coated in protein. The actin cytoskeleton is in green, the nucleus is in blue, the intracellular lipid vesicles are in red, and the nanotubes are in cyan. Credit: Carnegie Mellon University Materials Science and Engineering

Carbon nanotubes, or tiny hollow cylinders of one-atom-thick carbon sheets, have incredible potential for a wide variety of applications due to their strength, flexibility, and other uniquely powerful properties. They are particularly promising in nanotechnology and electronics applications, but Carnegie Mellon University's Kris Dahl and Mohammad Islam are on an interdisciplinary mission to put these carbon nanotubes to a new use—in medicine.

By combining their respective fields of expertise, Dahl, an associate professor of Chemical Engineering and Biomedical Engineering, and Islam, an associate research professor of Materials Science and Engineering, have been working together for years to answer many questions related to using carbon nanotube-based structures for drug delivery.

Through the years, Dahl and Islam have made significant advancements in biomedical carbon nanotube research—just in 2016, they have already published two articles detailing their research related to engineering proteins which wrap around specific types of drugs in order for them to be delivered more effectively. The drugs, when being delivered to the body's cells, sit on the surface of the carbon nanotubes, then are covered by proteins.

Picture feeding a dog a pill. In order to do so, one would wrap it in cheese to mask the medicine and make it more appealing. In a similar vein, to enhance drug delivery, Dahl and Islam have engineered proteins that wrap around the drug-coated carbon nanotubes. The cells, which love these proteins, more readily take up the drug—much as a dog would more readily eat the cheese-coated pill.

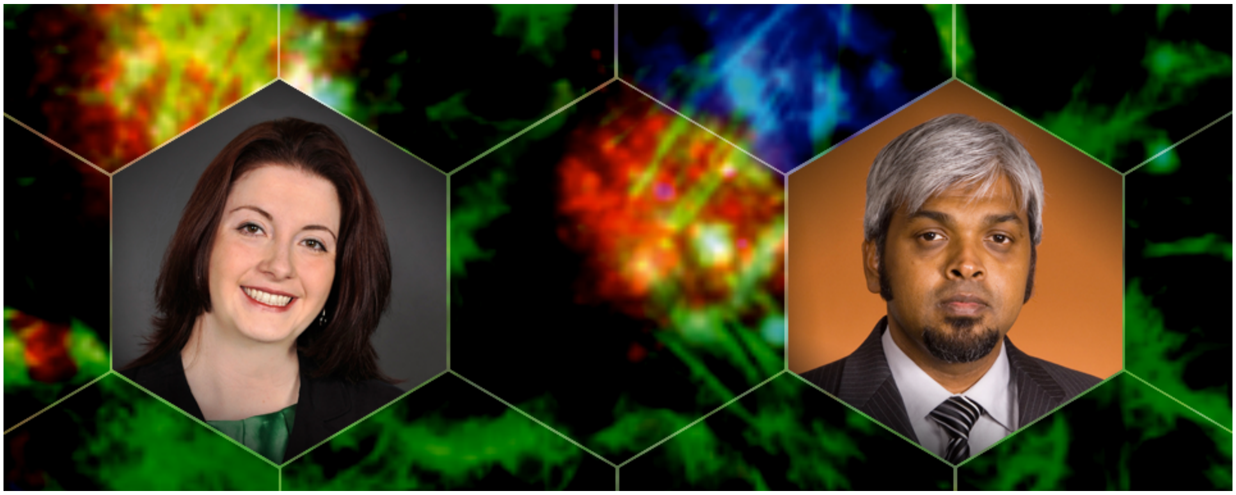
"The great thing about using carbon nanotubes to deliver drugs is that, scientifically, they're just carbon," explains Dahl. "They're similar to graphite in pencils, diamond, or char—they're just organized in a different way. But because they're latticed in this certain way, cells don't break them down. Another advantage of this drug delivery method is the fact that these nanotubes are nearly completely inert to the cell. You can get tens of millions of them inside the cell before there's any real impact on the cell, and that means you can deliver a huge amount of a drug and it doesn't really disrupt the cells."

The two articles published this year, entitled "Enhanced intracellular delivery of small molecules and drugs via non-covalent ternary dispersions of single-wall carbon nanotubes" and "Delivering single-walled carbon nanotubes to the nucleus using engineered nuclear protein domains," are a huge step in the advancement of this field. If cells are more likely to absorb large amounts of the drug being delivered, then the efficacy of the drug increases significantly.

The next question to tackle? How to target specific cells.

"Now that we understand how to disperse carbon nanotubes, how to control the toxicity, how to deliver them to the cells, how to detect them or identify where they are in the cell—now we are in a place where we can begin to target specific cells," says Islam. "Because carbon nanotubes have such a high surface area and they go into the cell by the millions, you can have a very high efficiency of delivery to a specific cell."

In June, Dahl and Islam will each be presenting aspects of this work at the Carbon Nanostructures in Medicine and Biology Symposium of the Electrochemical Society conference, a meeting ground where leaders in the field have long discussed advances in nanomaterial technology and science. Dahl and Islam are proud that their collaboration has allowed innovation in the area of bionanomedicine and drug delivery, embodying the Carnegie Mellon spirit of interdisciplinary research.



Kris Dahl (Associate Professor of Chemical Engineering and Biomedical Engineering at Carnegie Mellon University) and Mohammad Islam (Associate Research Professor of Materials Science and Engineering at Carnegie Mellon University)

Provided by Carnegie Mellon University Materials Science and Engineering