Using nanomedicine to improve human health

By Robin Arnette

Moore's Law states that the number of transistors on a computer chip will double approximately every two years. Since Intel co-founder Gordon Moore offered that assessment in 1965, the development of smaller and smaller transistors has allowed computing power to double every 18 months. By borrowing the manufacturing techniques of the microelectronics industry, today's biomedical and chemical engineers are designing better medicines and vaccines using nanotechnology.

DeSimone is the Chancellor's Eminent Professor of Chemistry at UNC, William R. Kenan Jr. Distinguished Professor of Chemical Engineering at NCSU, and founder of several local biotech companies. (Photo courtesy of Steve McCaw)

One of the researchers at the forefront of nanomedicine is Joseph DeSimone, Ph.D., founder of Liquidia Technologies, *(http://www.liquidia.com/)* a nanotechnology company based in Research Triangle Park (RTP), N.C. As part of the 2014 NIEHS Distinguished Lecture Series, DeSimone visited the Institute Jan. 24 to talk about making organic particles for therapeutics. Gary Bird, Ph.D., staff scientist in the NIEHS Calcium Regulation Group, hosted the seminar.

Linked Video

Watch DeSimone discuss the process of making therapeutic nanoparticles at his 2011 TEDMED talk. (19:44)

Perspective rooted in materials science

DeSimone is a materials scientist by training and holds professorships at the University of North Carolina at Chapel Hill and North Carolina State University. He has spun off several other biotech firms, but the basis for all of his entrepreneurial pursuits is the work his team performed in his university lab. *(http://desimone-group.chem.unc.edu/)*

NIEHS and NTP Director Linda Birnbaum, Ph.D., shared DeSimone's excitement about bringing down the cost of vaccines, during the question-and-answer session. (Photo courtesy of Steve McCaw)

At the beginning of his talk, he provided context for how scientists have accelerated the growth of nanotechnology. "In the early 70s, you could only fit about 2,300 transistors into the couple of square centimeters of a computer chip, because each transistor was a little bigger than a red blood cell - about 10 microns," DeSimone said.

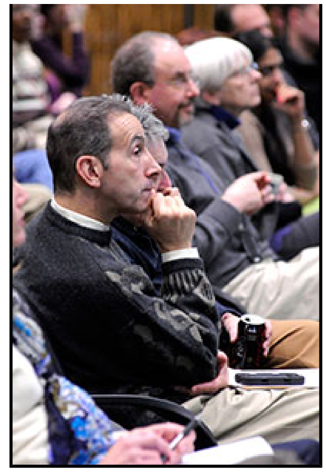
"Today's chip has billions of transistors in that same area, so, biologically, Moore's Law has gone from the size of a single cell to a virus particle."

Using nature as a template

DeSimone said that the inspiration for the size, shape, chemical properties, and mechanics of his nanoparticles comes from nature. For instance, after studying how a helicopter maple seed creates aerodynamic lift, he shaped one group of particles like it. By mimicking a maple seed's natural autorotation when falling through air, these particles float effortlessly through the lung's airway when inhaled, delivering their pharmaceutical content.

In another example, DeSimone and his team examined the physical properties of red blood cells. He explained that these cells are soft when young, permitting them to squeeze through extremely small sinusoids in the spleen. As these cells near 120 days, the average life expectancy of a red blood cell, they stiffen, becoming unable to travel through the spleen.

"That's how the body removes old red blood cells, so using some of characteristics of mechanobiology allows us to understand how to evade biological barriers," DeSimone said. Mechanobiology is an emerging field of science at the interface of biology and engineering.



NIEHS Scientific Director Darryl Zeldin, M.D., a lung disease specialist, was especially interested in DeSimone's inhalation data. (Photo courtesy of Steve McCaw)

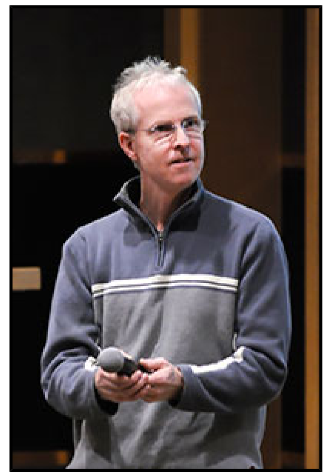
PRINTing better medicines and vaccines

After the particle design phase is done, the next step is to produce large quantities of particles using a technique DeSimone's team developed. The process, known as particle replication in non-wetting templates, or PRINT, physically etches a form into silica, pours liquid fluoropolymers into it, and zaps the liquid with light so that it hardens.

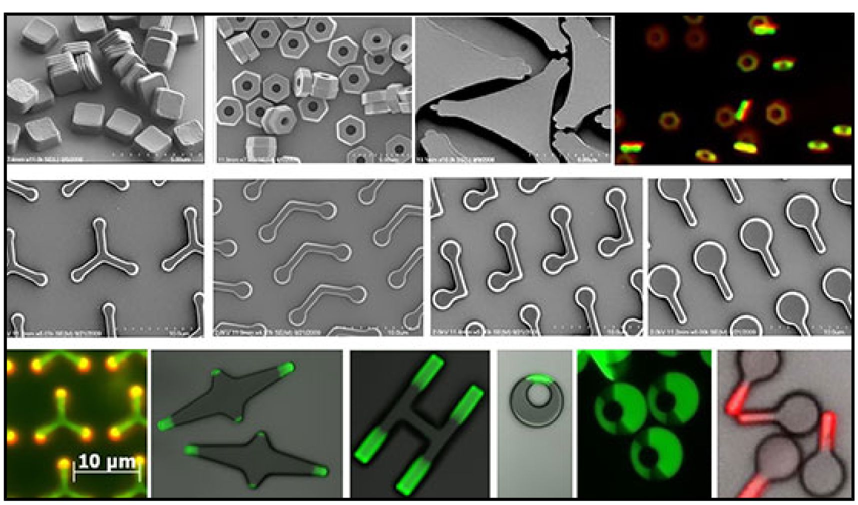
At this point, DeSimone said it essentially looks like an ice cube tray, but on the nano scale. Then, technicians fill the tray with a liquid form of a cancer drug, antibiotic, or whatever therapeutic agent they want to study. Other processing steps ultimately lead to the creation of particles having the precision and uniformity of microcircuits.

"We converted this to a GMP [good manufacturing practice]-compliant process," DeSimone said, referring to the manufacturing process at the Liquidia facility housed in RTP. "It allows us to deliver a drug strategy of chemotherapeutics, vaccines, and immunostimulatory approaches for cancer."

The PRINT method has been so successful that Liquidia received the first ever equity investment in a for-profit biotech firm from the Bill and Melinda Gates Foundation. When DeSimone and Bill Gates met 3 1/2 years ago, both men came away from the meeting believing they could use this technology to drive down the cost of vaccines and improve global access.



Bird said DeSimone's research has had an enormous impact on bridging engineering and nanomedicine. (Photo courtesy of Steve McCaw)



DeSimone's team can produce nanoparticles with a variety of sizes and shapes using PRINT technology. (Photo courtesy of Joseph DeSimone)

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