# MIT student develops new innovations to selectively kill cancer cells

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Harvard-MIT graduate student Geoffrey von Maltzahn is pictured before an abstract representation of his scientific advancements in the area of nanotechnology; specifically, he invented a new class of cancer therapeutics and a new paradigm for enhancing drug delivery to tumors. For these inventions and the overall breadth of his work, von Maltzahn has won the 2009 $30,000 Lemelson-MIT Student Prize, an award recognizing students at MIT who have demonstrated remarkable inventiveness. Credit: Lemelson-MIT Program

When it comes to solving complex problems, Geoffrey von Maltzahn, MIT graduate student and biomedical engineer, looks to nature for

solutions. Finding inspiration in systems that evolution has produced, von Maltzahn is currently helping to tackle one of society's biggest challenges: improving tumor detection and therapeutic delivery in order to boost the survival rate of cancer patients.

Today, the 28-year-old Ph.D. candidate in the Harvard-MIT Division of Health Sciences and Technology (HST) received the prestigious $30,000 Lemelson-MIT Student Prize for his promising innovations in the area of cancer therapy, specifically two inventions in nanomedicine: a new class of cancer therapeutics and a new paradigm for enhancing drug delivery to tumors.

Cancer currently kills more people worldwide than HIV/AIDS, tuberculosis and malaria combined. Despite billions of dollars invested into drug development and decades of research, selectively eradicating cancer cells has remained an elusive goal. Chemotherapies, a common class of cancer treatments, are intended to kill the fast-growing cells that form tumors. However, these drugs travel throughout the entire body, and often affect normal, healthy tissue along with cancer cells, causing side effects such as hair loss, nausea, anemia, and even nerve and muscle problems. Furthermore, resistance to these drugs can arise and can cause even initially successful treatment regimens to fail.

Working at the confluence of nanotechnology, engineering and medicine, von Maltzahn's innovations have the potential to reduce side effects and overpower drug resistance mechanisms by more powerfully concentrating external energy and targeted therapeutics in tumors.

## Using Gold Nano-Antennas to Target and Destroy Tumors

Since 2004, von Maltzahn has worked closely with his advisor, Dr.

Sangeeta N. Bhatia, an electrical engineering and computer science professor in the Harvard-MIT Division of HST, to invent novel treatments that could precisely target and destroy tumor cells without affecting healthy tissue. Seeking to improve the specificity of cancer ablation—the destruction of tumors through the application of heat—von Maltzahn developed polymer-coated gold 'nano-antennas' that can target tumors and convert benign-infrared light into heat.

The nanoparticles are designed to be injected intravenously, where they circulate through the bloodstream and progressively concentrate at the tumor site by infiltrating pores in rapidly growing tumor blood vessels. Once in the tumor, the antennas can be precisely heated with a non-invasive, near-infrared light to specifically kill the cancerous cells. "The polymer coated gold nano-antennas are the longest-circulating and most efficiently heated to date," states Dr. Bhatia. "Pre-clinical trials reveal that a single intravenous nanoparticle injection eradicated 100 percent of tumors in mice using a near-infrared light. The results of these trials are very promising, meaning that the impact of this technology is wide-reaching with many potential applications."

## Scout and Assassin: Communicating Nanoparticles

Von Maltzahn's second invention aims to fundamentally improve the intravenous delivery of therapeutics to tumors by taking a 'systems' approach to their design. This work draws on insights from biological systems, like ants foraging and bees swarming, where relatively simple methods of communication can lead to very sophisticated system behaviors.

Inspired by the potential for inter-nanoparticle communication to improve therapeutics' ability to find tumors, von Maltzahn invented a series of ways for nanoparticles to 'talk' to one another in the body. One method involves benign 'scout' particles initially locating the tumor and,

once inside, sending powerful signals to recruit secondary, 'assassin' particles that contain the therapeutics. In pre-clinical trials, this system has been able to deliver over 40-times higher doses of therapeutics to tumors in mice, in comparison to non-communicating control nanoparticles.

"If such highly-targeted delivery can be achieved clinically, this method would enable doctors to increase the drug dose that is delivered to tumors, increasing its overall efficacy and reducing side-effects," von Maltzahn explains. "This concept of engineering systems of nanoparticles that collectively outsmart disease barriers has many potential applications in medicine, from improving regenerative medicines to ultra-sensitive diagnostics."

## Looking Forward

Von Maltzahn's work has already made a significant impact scientifically and commercially, resulting in eight patent applications, 19 submitted or published papers, and his founding roles in two companies: Nanopartz Inc. and Resonance Therapeutics.

Nanopartz was founded more than one year ago to address the nanotechnology industry's need for dependable and standardized nanoparticle sources. Von Maltzahn's goal with Nanopartz is to aid in research endeavors worldwide by supplying a repertoire of gold nanoparticles for a broad spectrum of commercial applications, ranging from biomedicine to energy.

Resonance Therapeutics was founded to bring nano-rods towards clinical applications and to develop technologies that amplify the efficacy of existing cancer therapeutics.

"In addition to the long hours spent in the lab, finishing up his Ph.D., and

founding two companies, Geoff mentored 14 undergraduate students, taking them out of the classroom setting and inspiring them to make the link from science to the real world," states Joshua Schuler, the executive director of the Lemelson-MIT Program. "Geoff is not only a mentor for aspiring scientists, but also a shining example of bridging the gap between technological invention and entrepreneurship."

## Additional Inventions

During von Maltzahn's time at MIT he has also developed inventions outside of the polymer nano-rods and 'systems nanotechnology' paradigm for improving drug delivery, including: a low-cost method for hemorrhage detection; a new class of 'self-assembling' lipid-like peptides with promising applications in gene therapy; sensors for detecting tumor protease hot-spots in MRI; a method for remotely-controlling drug release from nanoparticles; and a variety of new nanostructures for improved drug delivery and imaging.

## Collegiate Student Prize Expansion

On March 4th, the winners of the third annual $30,000 Lemelson-Illinois Student Prize and $30,000 Lemelson-Rensselaer Student Prize will be announced at the University of Illinois at Urbana-Champaign and Rensselaer Polytechnic Institute, respectively. Following, on March 5th the first $30,000 Lemelson-Caltech Student Prize will be announced at the California Institute of Technology.

Source: Lemelson-MIT Program