Nano Cardiology Research to Fight US's Deadliest Disease

April 29 2005

Despite the fact that cardiovascular disease is the leading cause of death in the United States, there is a lack of understanding of the fundamental molecular biology behind the disease and how certain genetic factors contribute to plaque build-up in blood vessels.
But biomedical nanotechnology might help shed light on the molecular mechanisms responsible for one of the U.S.'s deadliest diseases.

The National Heart, Lung, and Blood Institute (NHLBI), National Institutes of Health (NIH), has awarded researchers from Georgia Institute of Technology and Emory University $11.5 million to establish a new research program focused on creating advanced nanotechnologies to analyze plaque formation on the molecular level and detect plaque at its early stages. Plaques containing cholesterol and lipids may build up during the life of blood vessels. When these plaques become unstable and rupture they can block the vessels, leading to heart attack and stroke.

The multi-disciplinary program, part of NHLBI’s Program of Excellence in Nanotechnology (PEN), is headed by Dr. Gang Bao, a professor in the Wallace H. Coulter Department of Biomedical Engineering at Georgia Tech and Emory University. The program includes 12 faculty investigators from both institutions and will be based at Emory. It is one of four national PEN awards. The initiative is in accord with the NIH Roadmap’s strategy to accelerate progress in medical research through innovative technology and interdisciplinary research.

The program’s work will focus primarily on detecting plaque and pinpointing its genetic causes with three types of nanostructured probes – molecular beacons, semiconductor quantum dots and magnetic nanoparticles.

Healthy, undamaged cells lining the vessel wall do not attract platelets or cause a build-up of plaque. But in a diseased blood vessel, cells lining the vessel wall may have certain cellular and molecular characteristics that make them stickier, causing platelets to stick to the vessel wall, create plaque blockage and obstruct blood flow.

A molecular beacon is a biosensor about four to five nanometers in size that can seek out and detect specific target genes. It is a short piece of single-stranded DNA (ssDNA) in the shape of a hairpin loop with a fluorescent dye molecule at one end and a "quencher" molecule at the other end. The ssDNA is synthesized to match a region on a specific messenger RNA (mRNA) that is unique to the gene. The fluorescence of the beacon is quenched, or suppressed, until it seeks out and binds to a complementary target mRNA, which causes the hairpin to open up and the beacon to emit light.

The level of gene expression within a cell can reflect susceptibility to disease. The fluorescence from the beacons will vary with the level of the target genes' expression in each cell, creating a glowing marker if the cell has a detectable level of gene expression that is known to contribute to cardiovascular disease.

"With molecular beacons, we hope to follow the dynamics of gene expression in normal and diseased cells," Bao said. "We can find out how quickly these genes are being turned on and how the expression levels are correlated with factors contributing to early plaque formation."

To complement gene expression studies using molecular beacons, the team will develop quantum-dot nanocrystal probes and use them to study protein molecular signatures of cardiovascular disease. Quantum dots are nanometer-sized semiconductor particles that have unique electronic and optical properties due to their size and their highly compact structure. Quantum dot based probes can act as markers for specific proteins and cells and can be used to study protein-protein interactions in live cells or to detect diseased cells. These ultra-sensitive probes may help cardiologists understand the formation of early stage plaques and dramatically improve detection sensitivity.

Other research will include using magnetic nanoparticles to detect early-stage plaques in patients. The magnetic nanoparticles will target specific proteins on the surface of cells in a plaque, and serve as a contrast agent in magnetic resonance imaging (MRI). This could provide an image of the plaque formation and could become a powerful tool for better disease diagnosis. The investigators will also develop ultra-sensitive probes for the free radicals inside cells and biomolecular constructs for molecular imaging and therapeutics.

The program will integrate the biomedical engineering strengths of Georgia Tech and the cardiology expertise of Emory University School of Medicine. The new program is part of the joint Wallace H. Coulter Department of Biomedical Engineering at Georgia Tech and Emory, established in 1997, and currently ranked third in the nation by U.S. News & World Report.

In addition to this cardiovascular nanotechnology award and an ongoing cancer nanotechnology program, the Georgia Tech/Emory group also plans to expand biomolecular engineering and nanotechnology to the detection and treatment of other diseases, such as neurodegenerative and infectious diseases.

“This program is only part of a larger scale biomedical nanotechnology effort at Georgia Tech and Emory,” said Dr. Larry McIntire, The

Wallace H. Coulter Chair in the Department of Biomedical Engineering at Georgia Tech and Emory. “We are pleased to add cardiology to our growing breadth of nanomedicine research.”

“The synergistic research relationship between Emory and Georgia Tech in engineering and medicine demonstrates the power of discovery that becomes possible when two institutions join their unique yet complementary strengths in an entirely new scientific approach to solving complex problems of medicine,” said Dr. James W. Wagner, president of Emory University.

“The Programs of Excellence in Nanotechnology is a vitally important research effort that will spur the development of novel technologies to diagnose and treat heart, lung, and blood diseases,” said Elizabeth G. Nabel, MD, director of the National Heart, Lung, and Blood Institute. “The program brings together bioengineers, materials scientists, biologists and physicians who will work in interdisciplinary teams. By taking advantage of the unique properties of materials at the nano-scale, these teams will devise creative
solutions to medical problems.”

Co-investigators on the project include Emory cardiologists Wayne Alexander, MD, PhD, Kathy Griendling, PhD, David Harrison, MD, Charles Searles and Robert Taylor, MD; and biomedical engineers from Georgia Tech and Emory Don Giddens, PhD, Xiaoping Hu, PhD, Hanjoong Jo, PhD, Niren Murthy, PhD, Shuming Nie, PhD and Dongmei Wang, PhD.

Source: Georgia Institute of Technology

Citation: Nano Cardiology Research to Fight US's Deadliest Disease (2005, April 29) retrieved

25 April 2024 from https://phys.org/news/2005-04-nano-cardiology-deadliest-disease.html