Early Detection of Life-Threatening Diseases

Rapid, Multiplexed Detection of Disease Markers

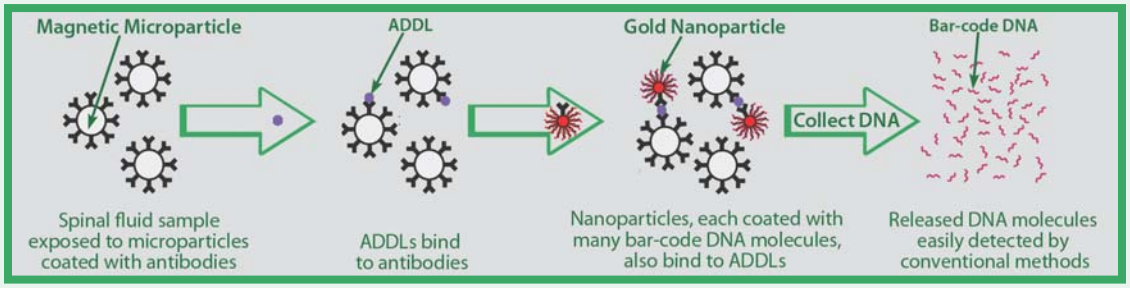
Interested Agencies: CSREES, DOD, FDA, NIH, NIST, NSF

Early detection of a life threatening disease, such as a cancer, or rapid and accurate detection of a life-threatening exposure, such as to a chemical or biological agent, can make a difference between death and survival. Similar technological approaches can be used to detect the molecular signatures of disease, an environmental exposure, or the presence of toxins or microorganisms in food. However, current detection methods often require multiple steps, do not provide data in real time, are not quantitative, and have limited sensitivity and specificity. Nanotechnology has the potential to overcome the limitations of current approaches and thereby advance the diagnosis and treatment of life-threatening diseases, enhance our national security, and improve food safety.

To make rapid, accurate, real-time detection possible, a number of advances will be required. The molecular signatures of disease, also called biomarkers, and biological threats are often present at concentrations that are too low to be measured by current technology, so new devices will need improved sensitivity. Additionally, many sensors are not able to measure multiple parameters simultaneously. This multiplexing capability is needed to distinguish one disease or exposure from another and will improve the specificity and accuracy of the disease or exposure identification. Ideally, these devices should be capable of measuring large numbers of markers simultaneously on a single, easily obtainable sample, such as breath, sweat, or saliva, be portable, and be easy to use in a doctor's office or by a first responder.

One example of a promising new medical approach that uses bionanotechnology is the bio-barcode assay for the detection of disease-related proteins or DNA in tissue samples. In its first application, the bio-barcode assay uses gold nanoparticles to amplify and detect amyloid beta-derived diffusible ligands (ADDLs), a molecular signature for early-stage Alzheimer's disease. This method is a million times more sensitive than the current point-of-care diagnostic tests, specific for molecular signatures of disease, and quantitative.

Other promising medical diagnostics using nanotechnology include methods to detect infectious agents and improved diagnostic imaging systems to examine tissues and organs for disease diagnosis, such as computed tomography and magnetic resonance imaging. Looking further down the road, many of these imaging agents could be coupled with targeted drug delivery.



Schematic presentation of the bio-barcode amplification and magnetic collection process for detecting the presence of ADDL, a molecular signature of early-stage Alzheimer's disease, using gold nanoparticles coated with DNA. Adapted from *Proc. Natl. Acad. Sci. USA*; original image © 2005 National Academy of Sciences, all rights reserved.