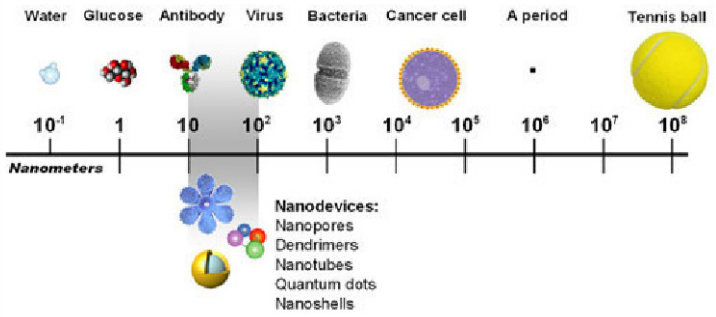
NATIONAL CANCER INSTITUTE

A Snapshot of Nanotechnology

What Is Nanotechnology?

Nanotechnology is the creation of useful materials, devices, and systems through the manipulation of matter on a miniscule scale. A nanometer is a billionth of a meter. Nanotechnology is being applied to almost every field imaginable, including electronics, magnetics, optics, information technology, materials development, and biomedicine. Because of their small size, nanoscale devices can readily interact with biomolecules on both the surface and inside cells. By gaining access to so many areas of the body, they have the potential to detect disease and deliver treatment in ways unimagined before now.



Nanoscale devices are 100–10,000 times smaller than human cells. For reference, the head of a pin is about 1 million nanometers across. A human hair is about 80,000 nanometers in diameter, while a DNA molecule is between 2–12 nanometers wide.

Nanotechnology and Cancer

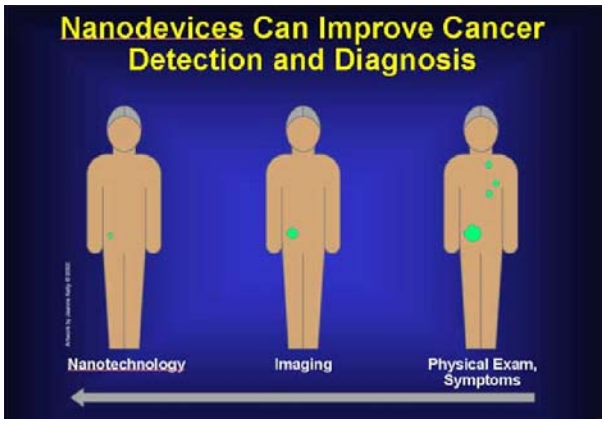
Nanotechnology has the potential to enable cancer research and improve molecular imaging, early detection, cancer prevention, and treatment.

Research enabler: Nanotechnology offers a range of tools capable of monitoring individual cells and tracking the movements of cells—even individual molecules—as they move about in their environment. Using such tools will enable researchers to study, monitor, and alter the multiple systems that go awry in the cancer process and identify key biochemical and genetic "choke points" at which the coming wave of molecular therapies may best be directed.

Molecular imaging and early detection: Nanotechnology can have a paradigm-changing impact on how clinicians will spot cancer in its earliest stages. Nanotechnology is being used to detect biomarkers, which may help researchers with molecular imaging of malignant lesions and allow doctors to see cells and molecules undetectable through conventional imaging. Additionally, photoluminescent nanoparticles may allow oncologists to discriminate cancerous and healthy cells.

Prevention and control: Advances driven by the NCI's initiatives in proteomics and bioinformatics will enable researchers to identify markers of cancer susceptibility and precancerous lesions. Nanotechnology will then be used to develop devices capable of signaling when those markers appear in the body and deliver agents that would reverse premalignant changes or kill those cells that have the potential to become malignant.

Therapeutics: Because of their multifunctional capabilities, nanoscale devices can contain both targeting agents and therapeutic payloads to produce high local levels of a given anticancer drug, particularly in areas of the body that are difficult to access. Nanoscale devices also offer the opportunity to utilize new approaches to therapy and to combine a diagnostic or imaging agent with a therapeutic and even a reporter of therapeutic efficacy in the same package. "Smart" nanotherapeutics may provide clinicians with the ability to time the release of an anticancer drug or deliver multiple drugs sequentially in a timed manner or at several locations in the body. http://nano.cancer.gov/resource_center/tech_backgrounder.asp



The Understanding Nanodevices slide presentation is a graphic-rich nanotechnology tutorial for educational use by life science teachers, medical professionals, and the interested public. http://www.cancer.gov/cancertopics/understandingcancer/nanodevices

Developed by NCI's Office of Science Planning and Assessment (OSPA) with assistance from SAIC. Snapshots can be found online at: http://planning.cancer.gov/disease/snapshots.shtml.

NCI Nanotechnology Programs

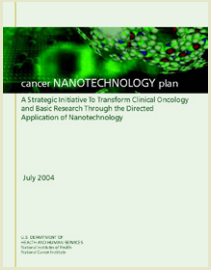
In 2005, the NCI created the Alliance for Nanotechnology in Cancer, which spearheads the integration of nanotechnology into biomedical research through the coordinated effort of alliance participants. The alliance homepage is located at http://nano.cancer.gov/.

- The primary goal of the **Centers for Cancer Nanotechnology Excellence (CCNEs)** is to integrate nanotechnology development into basic and applied cancer research. Each center is affiliated with an NCI Comprehensive Cancer Center and engages engineering and physical science departments of the university. By leveraging existing NCI resources, the centers bridge gaps in the development pipeline from materials discovery to preclinical testing. http://nano.cancer.gov/programs/ccne.asp
- The **Cancer Nanotechnology Platform Partnerships** are engaged in directed, product-focused research that aims to translate cutting-edge science and technology into the next generation of diagnostic and therapeutic tools. These platforms serve as the core technologies for a wide array of applications that will ultimately benefit cancer patients. http://nano.cancer.gov/programs/nanotech_platforms.asp
- NCI established the **Nanotechnology Characterization Laboratory (NCL)** to provide critical infrastructure support to this rapidly developing field. Working in concert with the National Institute of Standards and Technology and the U.S. Food and Drug Administration, the intent of the NCL is to accelerate the transition of basic nanobiotechnology research into clinical applications. http://ncl.cancer.gov/

Nanotechnology Resources

The NCI Alliance for Nanotechnology in Cancer Bulletin connects nanotechnology participants, partners, affiliates, and colleagues. http://nano.cancer.gov/news_center/alliance_bulletin.asp

Nanotech News reviews the most relevant nanotechnology articles published in the literature on a monthly basis. http://nano.cancer.gov/news_center/nanotech_news.asp



The Cancer Nanotechnology Plan (CNPlan) is a planning document that details the process for accelerating the application of nanotechnology to cancer research. http://nano.cancer.gov/alliance_cancer_nanotechnology_plan.pdf

- The **NCI Alliance for Nanotechnology in Cancer** has implemented numerous training and career development mechanisms (including postdoctoral fellowships, institutional training awards, and coordinated tutorial events) toward building an interdisciplinary, biologically inspired nanotechnology workforce and to support the research teams working on NCI-funded nanotechnology projects. http://nano.cancer.gov/programs/multidisciplinary_research_teams.asp

Selected Advances in Nanotechnology Research

- Targeted nanoparticles carrying significantly reduced doses of chemotherapy can preferentially block the spread of cancer in mice while sparing surrounding tissues. http://www.cancer.gov/ncicancerbulletin/NCI_Cancer_Bulletin_072208/page3
- A pilot toxicology study of specially designed carbon nanotubes (accurate vehicles for delivering antitumor agents into malignant cells) revealed no apparent toxicities in mice after 4 months. http://www.ncbi.nlm.nih.gov/pubmed/18654506
- A nanoprobe that can specifically target brain tumor cells has been constructed by chemically linking (conjugating) a small protein called chlorotoxin to superparamagnetic iron oxide nanoparticles. http://www.ncbi.nlm.nih.gov/pubmed/18232053
- A team of scientists at the NanoSystems Biology Cancer Center CCNE developed technologies that enable a comprehensive analysis of a biopsied brain tumor to allow physicians to ascribe appropriate therapy during the first round of treatment. http://nano.cancer.gov/programs/caltech/projects.asp?projectId=5