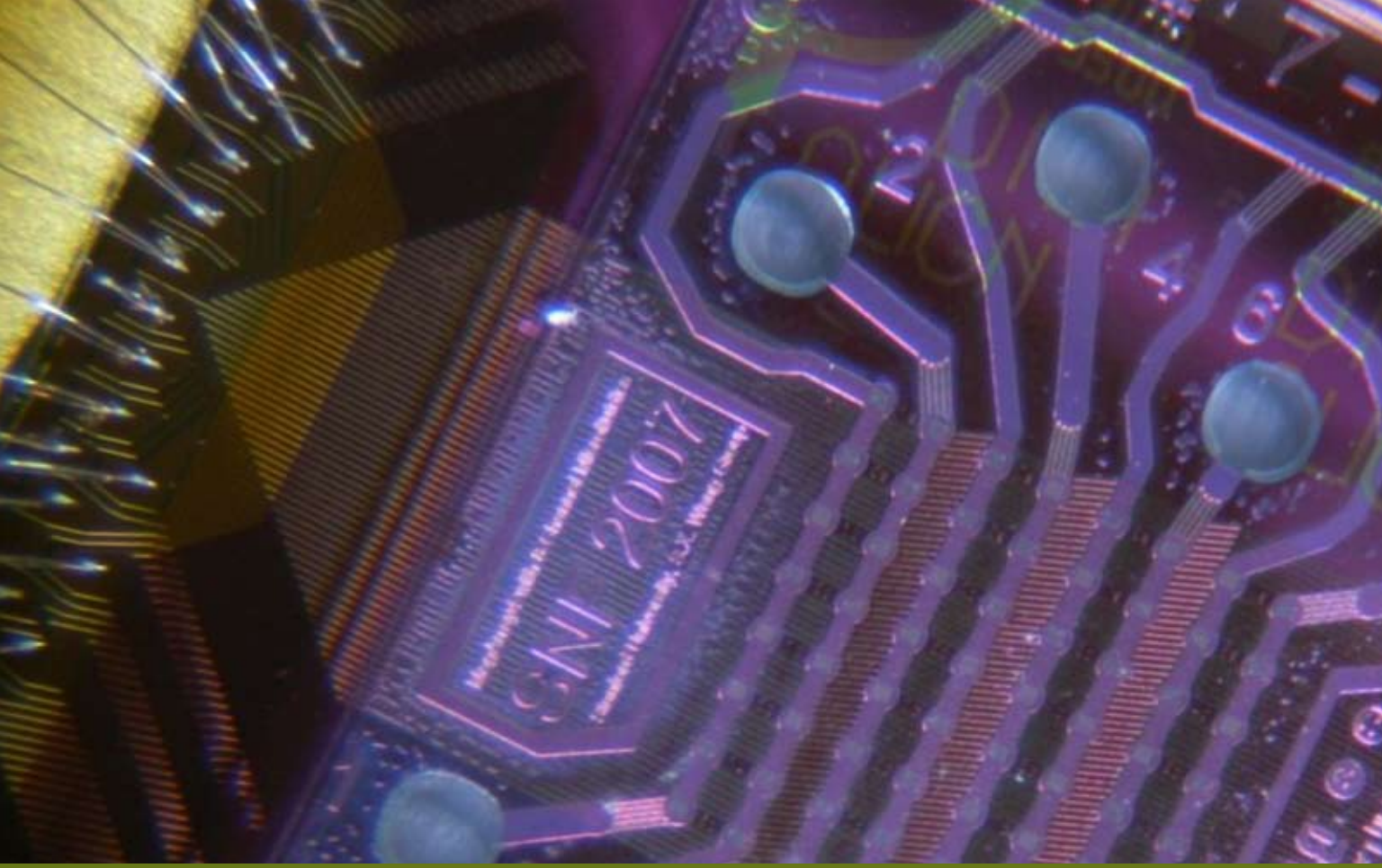
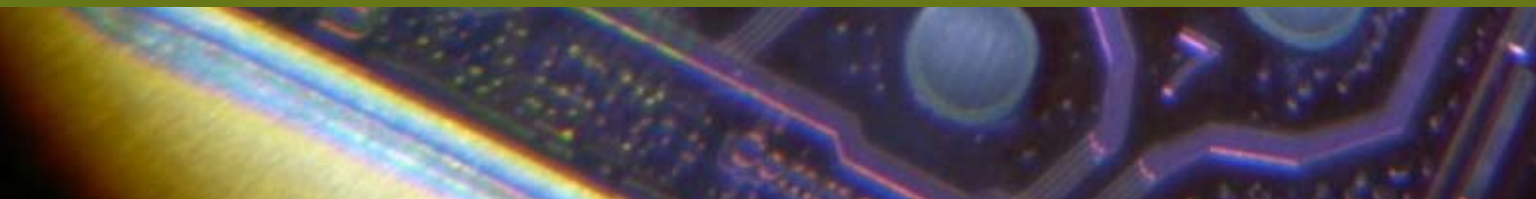
Nanotechnology

AT THE NATIONAL INSTITUTES OF HEALTH

NEW UNDERSTANDING, NEW CAPABILITIES, & NEW APPROACHES FOR IMPROVING HEALTH



Researchers at the Center for Cancer Nanotechnology Excellence focused on Therapeutic Response (CCNE TR) from Stanford University are working on developing rapid diagnostic assays based on detection of magnetic nanoparticle labels. Imaged here is a microfluidic magneto-nano chip with 8 by 8 sensors arrays and 8 microfluidic channels mounted on a chip carrier and an electronic test board. These chips are being developed to monitor protein profiles in blood samples from cancer patients to improve therapeutic effectiveness. The key to this technology is the use of magnetic nanoparticles to label protein molecules which are then accurately counted by the magneto-nano chip. Image courtesy of Professor Shan X. Wang, PhD, and Sebastian J. Osterfeld, PhD.



WHAT IS NANOTECHNOLOGY?

Nanotechnology is defined as the understanding and control of matter at dimensions of roughly 1 to 100 nanometers, where unique properties of materials emerge that enable novel applications. At the nanoscale, the physical, chemical, and biological properties of materials differ from the properties of individual atoms and molecules, or of bulk matter. Nanotechnology involves imaging, measuring, modeling, and manipulating matter at this scale.

Nanotechnology is advancing quickly. In 1996, the Nobel Prize in Chemistry was awarded for the discovery of fullerenes, a highly ordered, specific arrangement of carbon atoms at the nanoscale with unique properties attributable to their structure. More recently, in 2007, the Nobel Prize in Physics was awarded for the discovery of giant magnetoresistance, a quantum mechanical effect that appears only at the nanoscale.

This work already has had enormous practical benefit, leading to radical improvements in storage capacities in computer hard drives and other electronic devices. Novel nanomaterial properties similarly provide tremendous promise for biomedicine. The National Institutes of Health (NIH) funds a wide array of projects and programs focusing on two broad goals: manipulating and understanding biological structures and processes at the nanoscale and utilizing the unique properties of materials at the nanoscale to develop new diagnostics, therapeutics, biological interfaces, drug delivery systems, and other applications.

NIH NANOTECHNOLOGY ACTIVITIES

The NIH is the nation's medical research agency, comprising 27 institutes and centers that fund biomedical research across the United States and around the world to improve human health. For more than 7 years, the NIH has recognized the tremendous potential of nanotechnology as a scientific focus that could transform our current understanding of biology and our ability to prevent and treat disease. The NIH sponsored a national symposium to evaluate the state of the science in this area and to increase awareness of the NIH's interest in funding applications of nanotechnology to biomedical problems.

Most nanotechnology research at the NIH is funded by individual institutes with disease-specific, technology-driven, or basic research missions. The NIH invests over $200 million per year on nanotechnology research, and many of the institute-specific programs are noted below (See Nanotechnology Resources).

Nano Task Force

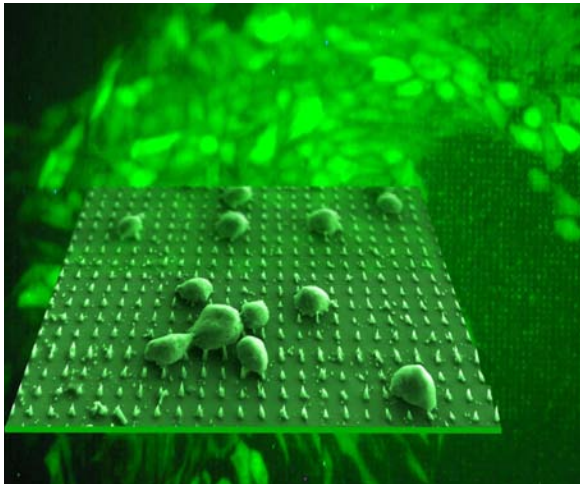
The NIH Nano Task Force, established in 2006, consists of several working groups charged with addressing a range of issues including developing an overarching scientific vision for nanotechnology at the NIH; communicating to the public and scientific communities; understanding the health and safety implications of nanomaterials; exploring ethical, legal, and societal issues; and analyzing the NIH nanoscience research portfolio. Members also represent the NIH on federal interagency matters and at international meetings and activities related to nanotechnology.

Nanotechnology in Biology and Medicine

Novel materials are being developed with unique utility for ultrasensitive detection of biomolecules, for targeted delivery of therapeutic agents directly to affected cells and tissues in the body, and as a tissue scaffold to promote healing. Novel diagnostic methods and treatments are emerging from our increasing ability to control the synthesis of materials such as quantum dots, dendrimers, and nanotubes, and to develop methods for optimizing the properties of these materials in living biological systems. In parallel, we are learning how to make nanomaterials that can be used safely and effectively for many other types of consumer products.

Major NIH Programs

Although the majority of NIH funding in nanotechnology is awarded using investigator-initiated grant mechanisms, three major NIH programs complement those efforts. All NIH institutes and centers participate in supporting a network of Nanomedicine Development Centers that represent a unique approach to translational biomedical research. The centers were challenged to develop a deep understanding of a fundamental biological system and gradually move the research to apply this basic knowledge to improve our understanding, diagnosis, and treatment of one or more diseases. This requires a multidisciplinary effort in which teams of scientists and clinicians are working together to improve health.



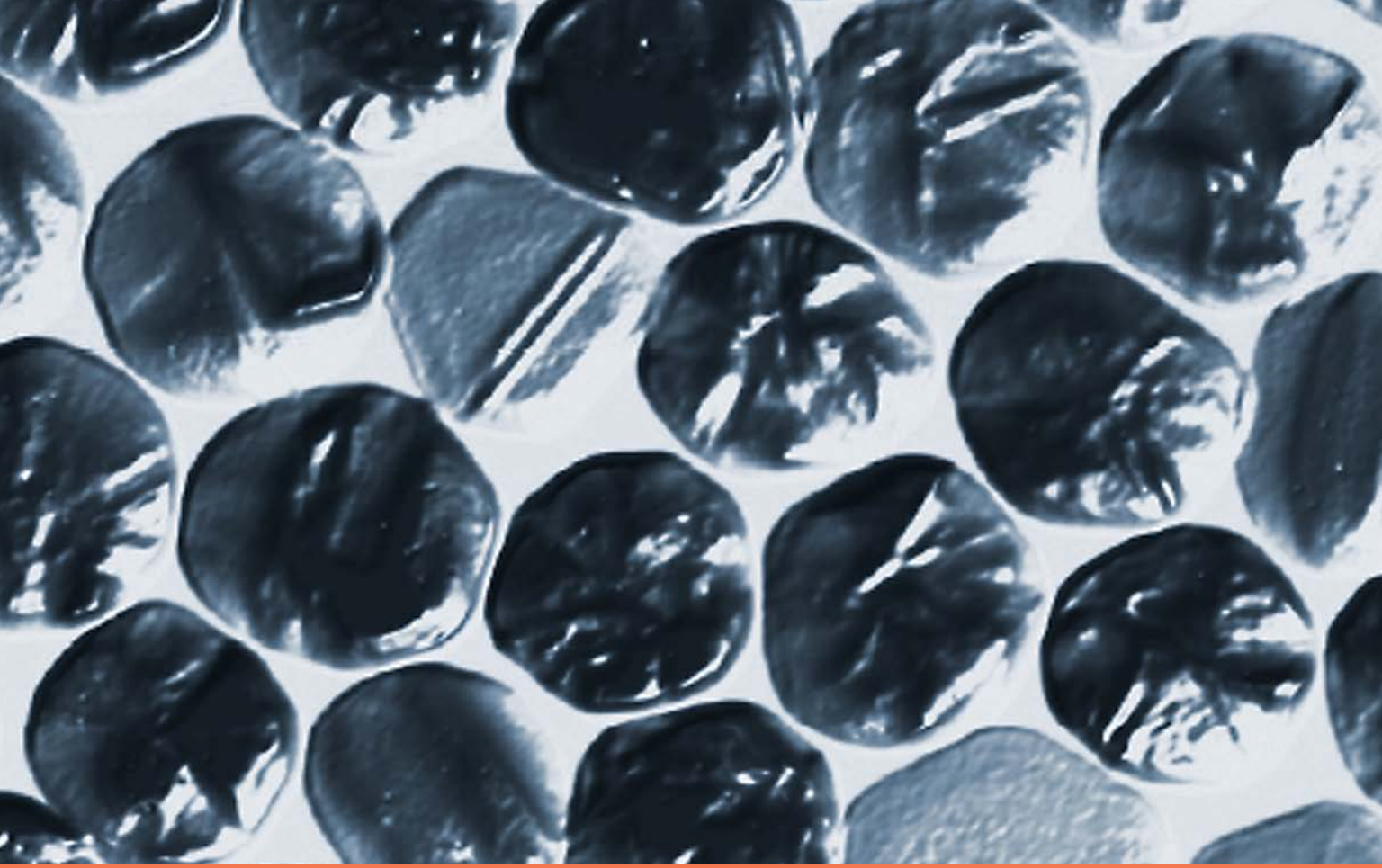
Tim McKnight, Oak Ridge National Laboratory, Nanoarrays for real time probing within living cells.

The National Heart, Lung, and Blood Institute supports a unique Program of Excellence in Nanotechnology (PEN). This program brings together bioengineers, materials scientists, biologists, and physicians who also work in interdisciplinary teams. This research is expected to spur the development of novel technologies to diagnose and treat heart, lung, blood, and sleep disorders.

The National Cancer Institute has created the NCI Alliance for Nanotechnology in Cancer. This comprehensive program consists of four major components: Nanotechnology Platform Partnerships focused on developing new technologies and novel products for cancer diagnosis and treatment; Cancer Centers of Nanotechnology Excellence that complement existing cancer research centers to integrate nanotechnology into basic and applied research; a Nanotechnology Characterization Lab to facilitate product safety and regulatory approval; and training opportunities in relevant multidisciplinary sciences.

National Nanotechnology Initiative (NNI)

The NIH participates in the National Nanotechnology Initiative (NNI), a federal R&D program established to coordinate multi-agency efforts in nanoscale science, engineering, and technology. Twenty-six federal agencies currently participate in the NNI by funding or conducting studies, applying results from federally funded R&D efforts, or through collaborations with other agencies. The NNI is managed within the framework of the National Science and Technology Council (NSTC), the Cabinet-level council by which the U.S. President coordinates science, space, and technology policies across the federal government. The Nanoscale Science Engineering and Technology (NSET) Subcommittee of the NSTC coordinates planning, budgeting, program implementation, and review to ensure a balanced and comprehensive initiative. The NSET Subcommittee is comprised of representatives from each of the agencies participating in the NNI.



Researchers at the Northwestern University Center of Cancer Nanotechnology Excellence (NU CCNE) are using nanotechnology to develop highly sensitive diagnostic systems for cancer. The image above, taken with a transmission electron microscope, shows DNA-functionalized gold nanoparticles that have been assembled into a two-dimensional superlattice. DNA-functionalized gold nanoparticles are being used in a variety of high sensitivity biodiagnostic systems. Image courtesy of Professor Chad A. Mirkin, PhD, and Savka Stoeva, PhD.

NANOTECHNOLOGY RESOURCES

Information on major programs and investigator-initiated nanotechnology efforts across the NIH, as well as other federal agencies, can be found at the following websites:

NIH Nano Task Force
A roster of the representatives from NIH institutes and centers with nanotechnology portfolios
http://www.becon.nih.gov/nano_taskforce_010808.pdf

NIH Nanotechnology and Nanoscience Information
Information on current funding opportunities and links to other NIH sites relevant to nanotechnology
http://www.becon2.nih.gov/nano.htm

NIH Roadmap Nanomedicine Initiative
Program descriptions, goals of the initiative, and center contact information
http://nihroadmap.nih.gov/nanomedicine/fundedresearch.asp

NIH Nano Health Enterprise
A public-private partnership initiative of government, industry, academia, and other interested sectors to facilitate research on the fundamental interactions of engineered nanomaterials with biological systems
http://www.niehs.nih.gov/research/supported/programs/nanohealth/index.cfm

NIH Nanotechnology Initiatives
Currently open funding opportunities in nanotechnology at the NIH:

Nanoscience and Nanotechnology in Biology and Medicine (R01)
http://grants.nih.gov/grants/guide/pa-files/PA-08-052.html

Nanoscience and Nanotechnology in Biology and Medicine (R21)
http://grants.nih.gov/grants/guide/pa-files/PA-08-053.html

Bioengineering Nanotechnology Initiative - SBIR (R43/R44)
http://grants.nih.gov/grants/guide/pa-files/PA-06-009.html

Bioengineering Nanotechnology Initiative -STTR (R41/R42)
http://grants.nih.gov/grants/guide/pa-files/PA-06-008.html

NANOTECHNOLOGY RESOURCES

NCI Alliance for Nanotechnology in Cancer
Information about Alliance programs, funding opportunities, research highlights, and institute contacts
http://nano.cancer.gov/

NCI Nanotechnology Brochure
A guide to NCI nanotechnology programs, areas of research emphasis, and research resources
http://nano.cancer.gov/resource_center/cancer_nanotechnology_brochure.pdf

NCI Nanotechnology Characterization Laboratory
Preclinical toxicity and efficacy testing is performed at this laboratory, located in Frederick, Maryland.
http://ncl.cancer.gov/

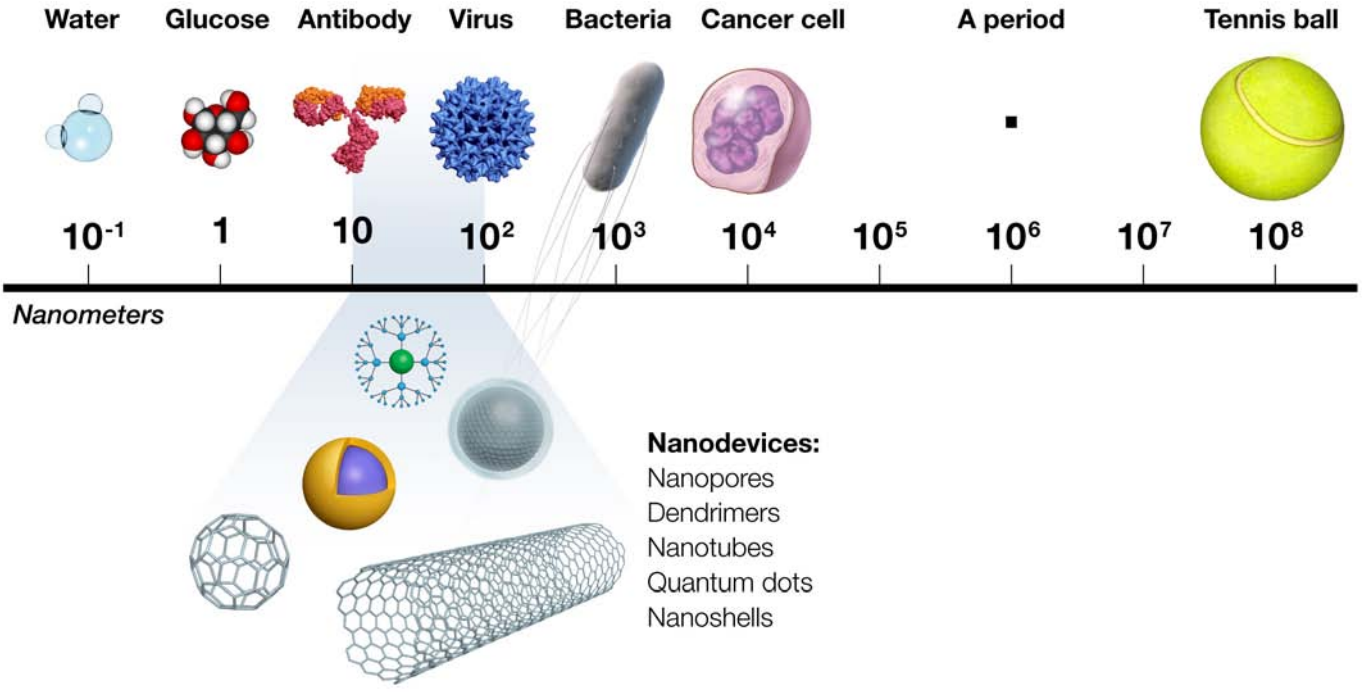
National Heart Lung and Blood Institute Programs of Excellence in Nanotechnology
Program information, currently funded centers, and contact information
http://www.nhlbi-pen.net/

National Institute of Biomedical Imaging and Bioengineering (NIBIB) Nanotechnology Program
Program information, contacts, and funding opportunities at NIBIB
http://www.nibib.nih.gov/Research/ProgramAreas/Nanotech

National Institute for General Medical Sciences (NIGMS) Nanotechnology Program
Program information, contacts, and funding opportunities at NIGMS
http://search.nigms.nih.gov/research/programs.htm#Single%20Molecule%20Biophysics%20and%20Nanoscience

NTP Nanotechnology Safety Initiative
The National Toxicology Program's Nanotechnology Safety Initiative to address potential health hazards created by the manufacture and use of nanomaterials
http://ntp.niehs.nih.gov/index.cfm?objectid=7E6B19D0-BDB5-82F8-FAE73011304F542A

National Nanotechnology Initiative
The homepage of the NNI, which coordinates multi-agency federal nanotechnology efforts
http://www.nano.gov



Nanoscale devices are one hundred to ten thousand times smaller than human cells. They are similar in size to large biological molecules ("biomolecules") such as enzymes and receptors. As an example, hemoglobin, the molecule that carries oxygen in red blood cells, is approximately 5 nanometers <http://nano.cancer.gov/resource center/nanotech glossary. asp#nanometer> in diameter. Nanoscale devices smaller than 50 nanometers can easily enter most cells, while those smaller than 20 nanometers can move out of blood vessels as they circulate through the body.

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