

Intergovernmental Collaboration Key to Nano Success

> Historically, revolutionary and transformative technological breakthroughs, such as the Internet, have been borne from broad-based collaboration. With nanotechnology – whose potential spans everything from aerospace to national defense and from environmental improvement to treating disease – the potential for collaboration seems unmatched. The nation’s coordinated federal program charged with organizing nanotechnology efforts across all agencies – the National Nanotechnology Initiative (NNI) – and one of its largest biomedical components – the NCI Alliance for Nanotechnology in Cancer – have made collaboration a central tenet, reaching out to a broad spectrum of experts and stakeholders to define opportunities, map strategy and implement programs through a series of meetings, symposia and funded studies.

The NNI: How the Commitment Began

The National Nanotechnology Initiative originated in 1996 when staff members of several federal agencies began meeting to discuss emerging plans and programs related to nanoscale science and technology. In September 1998, the White House formalized the group as the Interagency Working Group on Nanotechnology (IWGN) under the direction of the National Science and Technology Council – the cabinet level advisory council to the President on science policy.

The IWGN convened experts from government, industry and academia to identify promising opportunities in nanotechnology, author related reports and draft the initial NNI Strategic Plan. The group concluded that the President should increase funding, under the existing “21st

Century Research Fund,” to provide specifically for the formal establishment of the NNI. The FY2001 budget submission to Congress raised nanoscale science and technology for the first time to the level of a federal initiative, designated as the NNI.

The 2004 NNI Strategic Plan envisions “a future in which the ability to understand and control matter on the nanoscale leads to a revolution in technology and industry.” In order to realize this vision, the NNI endeavors to “expedite the discovery, development and deployment of nanotechnology in order to achieve responsible and sustainable economic benefits, to enhance the quality of life and to promote national security” through a “multi-agency, multi-disciplinary program that supports research and development (R&D); develops infrastructure; and **promotes education, knowledge diffusion, and commercialization in nanotechnology.**”

From its inception, the NNI flourished and received steady annual increases in funding as a White House initiative. On December 3, 2003, the NNI matured into a long-term Congressionally funded program when President George W. Bush signed the 21st Century Nanotechnology Research and Development Act (Public Law 108-153) into law in an Oval Office ceremony.

Throughout its development, the NNI has enjoyed consistent bipartisan support through several administrations. The President’s 2007 Budget provides over \$1.2 billion for the NNI, bringing the total investment since the NNI was established in 2001 to over \$6.5 billion and nearly tripling the annual investment.

Nanotech and Cancer: Clinical Applications to Save Lives

The NCI Alliance for Nanotechnology in Cancer (<http://nano.cancer.gov>) is integrated into the NNI under the U.S. Department of Health and Human Services (HHS), National Institutes of Health (NIH). Dedicated to applying nanotech to transform the diagnosis, prevention, treatment and clinical outcomes for patients, the NCI Alliance was based on the NCI’s Cancer Nanotechnology Plan that emerged from a series of cross-disciplinary symposia exploring the intersections of nanotechnology and cancer research, as well as input from a broad cross-section of the cancer research and clinical oncology communities. The Cancer Nanotechnology Plan, published in 2004, heralded a “focused and coordinated translational research effort that will have near-term benefits for patients.”

The NCI Alliance’s role within NNI is to specifically focus on the use of nanotechnologies to improve the diagnosis and treatment of cancer by coordinating, facilitating and mobilizing multiple stakeholders and resources in the cancer research community toward a common goal.



President Bush, flanked by representatives of academe, government and industry, signs 21st Century Nanotechnology Research and Development Act into law on December 3, 2003 in the Oval Office.

To that end, the NCI Alliance advances two of the NNI's fundamental goals: (1) to maintain a world-class research and development program aimed at realizing the full potential of nanotechnology; and (2) to facilitate transfer of new technologies into products for economic growth, jobs, and other public benefit (in this case, the treatment of cancer).

“Since nanotech by its nature has wide potential applications throughout health-care, it’s vital to keep the representatives of all federal agencies fully connected,” said Gregory Downing, D.O., Ph.D., Director, Center for Strategic Science and Technology Initiatives, Office of the Director, NCI. “NCI is particularly interested in communications activities that engage all the stakeholders as nanotech-based products enter the clinic and begin to have a major impact on healthcare.”

Interagency Collaboration Accelerates Nanotech Advances

Once the NNI was formally established, the Nanoscale Science, Engineering and Technology (NSET) Subcommittee of the National Science and Technology Council’s Committee on Technology was formed. NSET is comprised of representatives from all NNI departments and agencies as well as officials from the Office of Science and Technology Policy. NSET is responsible for the interagency coordination of all of NNI’s federal nanoscale

research and development programs, and has representatives from over 20 federal agencies, including Dr. Downing from the National Cancer Institute.

The National Nanotechnology Coordination Office (NNCO) was established to provide day-to-day support to NSET, including the collection and dissemination of information on industry, state and international nanoscale science and technology research, development and commercialization activities. The NNCO (<http://www.nano.gov>) serves as the point of contact on federal nanotechnology activities for government organizations, academia, industry, professional societies, foreign organizations and other stakeholders.

“The NNI works to leverage resources across the government to help guide the federal program in the responsible development of nanotechnology – meaning that benefits of the technology are realized, while risks are identified and avoided in its development,” said Clayton Teague, Ph.D., Director of the NNCO. “NNI agencies also work together to coordinate research toward understanding potential health and environmental effects of nanotechnology. The NCI has a major role in this effort through the research of its many grantees and, in particular, through the Nanotechnology Characterization Laboratory, which will benefit all agencies – and non-governmental institutions – working in this area.

“The NCI actively supports outreach and public engagement activities both through NNI and its own activities,” added Teague. “These efforts are helping to assess and address societal and ethical concerns associated with nanotechnology.”

Since the NCI Alliance is dedicated to facilitating the development and commercialization of products that have an impact on patient lives, a major program component is the Nanotechnology Characterization Laboratory (NCL), where interagency coordination is a day-to-day part of the operations. The NCL (<http://ncl.cancer.gov>), located at NCI’s Frederick, Maryland facility, provides critical infrastructure and characterization services to nanomaterial providers to accelerate the transition of nanoscale particles and devices into clinical applications. The activities of the NCL represent a formal scientific interaction between the NCI (<http://www.cancer.gov>) and U.S. Food and Drug Administration (FDA) (<http://www.fda.gov>), both part of the U.S. Department of Health and Human Services, and the National Institute of Standards and Technology (NIST) (<http://www.nist.gov>), part of the U.S. Department of Commerce.

“At the NCL, we are evaluating nanoparticles and devices to inform the regulatory process and support environmental, health and safety research of nanotechnologies,” said Scott McNeil, Ph.D., Director of the NCL. “By working together through the Nanotechnology Characterization Laboratory, the NCI, FDA and NIST reinforce each agency’s commitment toward the smooth transition of nanotechnologies into therapeutics and diagnostics to fight cancer.”

“The NCL-FDA-NIST interaction continues to play a critical role in the development of a national position regarding the environment and health and safety of nanomaterials,” said Stanley Brown, D. Eng., Office of Science and Engineering Laboratories, CDRH, FDA. “The NCL brings the characterization of the biological responses while NIST brings the particle characterization to the table. Both are critical for FDA review of the safety and

National Nanotechnology Initiative (dollars in millions)

	2001 Actual	2006 Estimate	2007 Proposed	Dollar Change 2001 to 2007	% Change 2001 to 2007
National Science Foundation	150	344	373	223	149%
Defense	125	436	345	220	176%
Energy*	88	207	258	170	193%
Health & Human Services*	40	175	173	133	333%
Commerce (NIST)	33	76	86	53	161%
NASA	22	50	25	3	14%
EPA	5	5	9	4	80%
Agriculture*	0	5	5	5	N/A
Homeland Security	0	2	2	2	N/A
Justice	1	1	1	0	0.0%
TOTAL	464	1,301**	1,277	813	175%

* 2006 and 2007 funding levels for DOE includes Basic Energy Sciences and Fossil Energy; HHS includes NIH and NIOSH funding; and USDA includes CSREES and Forest Service.

**2006 estimate includes Congressional earmarks that are outside the NNI plan totaling over \$100 million at DOD and over \$10 million at NASA.

Table 1. Dispersion of NNI funding

efficacy of nanotechnology products. Furthermore, the collaboration is proving effective in the development of national and international standards for nomenclature, characterization and biological testing of nano products for medical applications.”

Already, the NCL has developed a cascade of assays to determine the characteristics of nanoparticles, and has accepted numerous nanoparticles for evaluation. In coming months, a stream of scientific reports and data reflecting the physical, *in vitro* and *in vivo* attributes of nanoparticles will emerge, thereby building a base of knowledge for all researchers to facilitate the development and commercialization of nanotech-based cancer diagnostics and therapeutics.

“Because the field of nanotechnology is evolving so quickly, one of the biggest hurdles academic entities and companies may face when publishing their findings and submitting applications to regulatory agencies will be lack of rigorous/validated assays (for example, characterization assays and toxicological tests) and data to support their claims,” said Wendy Sanhai, Ph.D., Senior Scientific Advisor, Office of the Commissioner, FDA. “Through our collaborations with the NCL and other entities such as NNI, NSET, ASTM, etc., we are sharing our best practices and expertise, as early as possible in the development process, to help ensure that scientifically robust protocols and assays are developed for potential commercially viable products.

“This approach will decrease duplication of efforts, leverage resources and expertise and help move the field forward,” added Sanhai. “Collaborations such as these will contribute to the quality of scientific data, which in turn facilitates regulatory review by building ‘critical path’ tools and other pro-competitive resources that will benefit stakeholders and the public health. In this regard, having the FDA at the table early in the process will help establish a transparent regulatory path forward. The recent execution of the tripartite FDA/NCI/NIST Memorandum of Understanding is a clear indication of the commitment of these parties to help move the field forward, together.”

“This type of alliance – a true multidisciplinary effort – is exactly what’s needed to move these technologies into clinical use,” said Janet Woodcock, M.D., Deputy Commissioner for Operations and former Director of the Center for Drug

Evaluation and Research at the FDA, speaking at the 2004 launch of the NCI Alliance. “As these teams develop their ideas into actual products, FDA is involved in assessing how they actually work in the clinic and we stand ready to have that hand-off when these products come forward.”

In addition, the NCI Alliance has established multidisciplinary training and team development programs to expose the next generation of scientists and cancer researchers to the knowledge and understanding in biology and physical sciences that is required to apply nanotechnology to cancer. Through established fellowship programs and collaboration with the National Science Foundation (NSF), the NCI is funding U.S. science and engineering doctoral students to focus on interdisciplinary nanoscience and technology research with applications to cancer – thereby building a workforce that is savvy about multidisciplinary work and the new generation of nano-based clinical approaches.

“These awards represent an exciting new model for collaboration between federal agencies, that not only makes wise use of budget resources, but also opens new channels for bringing promising new technologies to bear on an important health problem that touches nearly all of us,” said NSF Deputy Director Kathie L. Olsen, Ph.D.

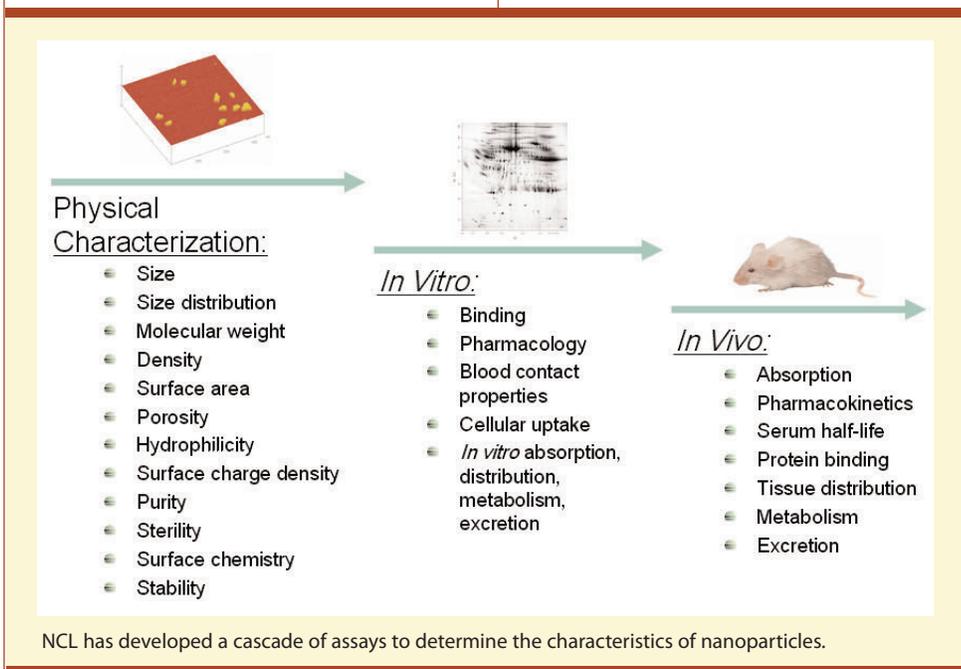
The NCI-NSF awards were granted through NSF’s Integrative Graduate Education and

Research Traineeship Program (IGERT). The IGERT program is intended to facilitate greater diversity in student participation and preparation and contribute to the development of a diverse, globally engaged science and engineering workforce.

“The collaboration between the NCI and the NSF is based upon the IGERT program, which is ideally suited to support the interdisciplinary nature of cancer nanobiotechnology training,” added Debasish Dutta, Ph.D., Acting Director, Division of Graduate Education at NSF. “This unique partnership between NCI and NSF is a model for leveraging the strengths and missions among federal agencies to collectively achieve mission-oriented goals that would be difficult if not impossible to achieve independently.”

Another point of contact between agencies to facilitate product development is the joint NCI-FDA Interagency Oncology Task Force (IOTF), established in 2003 to enhance and accelerate the overall process of developing new cancer diagnostics and therapeutics. IOTF formed a Nanotechnology Subcommittee, co-chaired by Dr. Downing and Dr. Sanhai.

“This subcommittee serves as a forum to foster a greater understanding of the pre-clinical and clinical potential of nanotechnology, particularly in the area of oncology, but also having much broader application,” described Sanhai. “Here, FDA and NCI leadership leverage the core expertise



and resources of each party to guide the science and technology that underpins the critical pathway in the development of research tools, know-how and other resources to facilitate biomedical product development.”

Linking All the Stakeholders in the Cancer Community

The largest program component within the NCI Alliance are the eight Centers of Cancer Nanotechnology Excellence (CCNEs), each of which functions as a consortium or network of laboratories and research facilities organized to address one or more specific cancer nanotechnology platform needs, and includes researchers from both the public and private sectors. In addition to multidisciplinary teams, the CCNEs have developed partnerships with the not-for-profit community and the private sector to accelerate their work.

“We have roped together a multidisciplinary team that not only includes distinguished physicians, scientists, mathematicians and engineers, but also seasoned entrepreneurs,” said Sadik Esener, Ph.D., Principal Investigator of the Center of Nanotechnology for Treatment, Understanding, and Monitoring of Cancer (NANO-TUMOR), “and [have] established some collaboration with the industry to incrementally move in a timely manner our discoveries to the marketplace to eliminate suffering and death due to cancer.”

NANO-TUMOR is a collaborative effort involving the University of California, San Diego (UCSD), Moores UCSD Cancer Center, UC-Santa Barbara, UC-Riverside, the Burnham Institute, market research organization NanoBioNexus and five corporate partners: General Electric Company, Honeywell, Nanogen, Irvine Sensors Corporation and Enterprise Partners Venture Capital. This team is developing smart multifunctional nanoplatfoms capable of targeting tumors and delivering large payloads of therapeutics and nanosensors to the tumor environment. In addition to general oncology applications, this CCNE will focus on breast cancer and leukemia.

At the Emory-Georgia Tech Nanotechnology Center for Personalized and Predictive Oncology, where Principal Investigators Shuming Nie, Ph.D., and Jonathan Simons, M.D., are developing nanoparticles for cancer molecular imaging, molecular profiling and personalized cancer therapy, the established partnerships span across the United States.

“Our Center is embedded in the Winship Cancer Institute here on the Emory campus,” described Nie. “It’s also supported by two other NCI Comprehensive Cancer Centers; one at the Johns Hopkins University, the other at the Fred Hutchinson Cancer Research Center.

“Our Center is also in partnerships with non-profit organizations such as The American Cancer Society and the Centers for Disease Control [and Prevention],” added Nie. “Both of these non-profit organizations are actually located on the Emory University campus, and we are also forming partnerships with outside companies, including Applied Biosystems, Beckman Coulter and Nanoplex Technologies in California. In biocomputing, we are supported by Hewlett-Packard Corporation and also Microsoft Research.”

Within the NCI Alliance research is tied directly to clinical applications; the foundation of preclinical knowledge, which is essential to successful clinical development, has the input of the regulatory experts; and the product pipeline is tied to the private sector innovators who will carry the product through development, regulatory review and into the marketplace – a coordinated system designed to “catalyze” the fastest route to improved patient outcomes. Throughout the process, NCI is linked to all the relevant government agencies that are also investing in nanotechnology.

Moreover, patient advocates are involved at each juncture. “In 2004, as funding for the CCNEs was announced to the public, NCI leadership decided that the collaboration of these widely diverse disciplines should be extended to include the presence of a cancer patient advocate,” noted Wayland Eppard, a cancer survivor and cancer research advocate associated with the Consumer Advocate for Research and Related Activities (CARRA) organization. As a voting member of the CCNE Coordinating and Governance Committee

of the NCI Alliance, Eppard takes an active role in the Initiative’s activities.

“The research underway at each of the eight CCNEs will lead to nanotech-based products to help cancer patients,” added Eppard. “In my position, I will be able to assist the CCNE leaders as they expand their collaborative effort to include the patient advocate community with the objective of helping educate the public and ensuring new treatments – from cancer clinical trials to new cancer standards of care – are properly communicated and understood.”

Where It Leads

The NCI Alliance for Nanotechnology in Cancer continues to support the NNI through its integrated, systematized approach to applying nanotechnology to the challenges of cancer. With cooperation among multiple scientific disciplines, across federal agencies and within the cancer research and advocacy communities, the NCI Alliance is working to transform the diagnosis, prevention, treatment and clinical outcomes for cancer patients.

“With over 1.4 million Americans diagnosed with cancer each year, the National Cancer Institute is focused on the tremendous potential of nanotechnology to accelerate progress against cancer,” said NCI Deputy Director Anna D. Barker, Ph.D. “We’re anticipating that one of the greatest impacts of the Alliance will be the development of targeted drugs that are safer, more effective, and better tolerated by cancer patients. Nanotechnology over the next 10 years is going to be a catalyst for the development of 21st century interventions for cancer, and intergovernmental collaboration is essential to enabling the translation of new discoveries from the lab to the clinic.” 

—Griffith Kundahl

Selected References

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