

## Nanotechnology: The Big Picture

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Several major developments relating to nanotechnology have occurred recently at both the federal and state level. These include a major budget initiative from the United States Congress and the White House, new directions in which federal agencies are moving, a timely and much needed report assessing the competitive position of the Commonwealth of Massachusetts, and a new funding initiative at the state level. This article will provide a brief summary of these exciting developments, and of the important recommendations being formulated for the future.

### Big Money

On December 3, 2003, after lengthy debate in Congress, President Bush signed into law the 21st Century Nanotechnology Research and Development Act (the "Act" (1)). The Act appropriates \$3.7 billion over the next four years to be administered by the National Nanotechnology Initiative ("NNI" (2)) and its named successor to fund nanotechnology initiatives. On February 2, 2004, President Bush released his proposed budget for fiscal year 2005 (October 1, 2004-September 30, 2005), which recommends spending \$1 billion of these funds during the 2005 fiscal year, a doubling over 2001 levels.

The Office of Science and Technology Policy identifies ten federal agencies that currently fund nanotech activities, though more participate in coordination. The budget requests that the National Science Foundation ("NSF") manage nearly one third of the funds authorized by the Act, that the Departments of Defense ("DOE") and Energy ("DOE") each manage over one quarter of the funds, and that the National Institutes of Health ("NIH") oversee \$89 million, or nearly ten percent. These are increases over the 2001 budget of 103, 121, 140, and 122 percent respectively (3).

While many constituencies have expressed real concerns over budget priorities generally, including what is arguably flat funding of basic research overall, the worst that might be said of nanofunding is that the Bush administration is proposing that certain agencies receive fewer nanodollars in the 2005 proposed budget than they received in 2004. For example, DOD is estimated to have spent \$315 million in 2004 on nanotechnology initiatives, and the administration has requested that the agency receive \$276 million in 2005 for nanotechnology initiatives, a 12% decrease (4). At the end of the day, however, it seems difficult for nanophiles to be upset with the federal funding of nanotechnology initiatives over the next four years.

### Big Government

In addition to funding, the Act provides that the President "implement a National Nanotechnology Program" (the "NNP"). The NNP will effectively replace the NNI, which since 2001 has embodied a federal effort to coordinate nanotechnology policy that has formally existed since at least 1996. The mandate of the NNP is to establish goals, priorities and metrics for evaluating Federal nanotechnology research, development and other activities; to invest in Federal research and development programs in nanotechnology and related sciences; and to provide for interagency coordination of Federal nanotechnology research, development, and related activities.

Concrete examples of activities authorized by the Act include: creating additional Nanoscale Science and Engineering Centers, affirming the success of the six Centers initiated in 2001 with \$65 million from the NSF; creating additional collaborative facilities, like the Institute for Soldier Technologies created at M.I.T.; accelerating the deployment and application of nanotechnology research and development in the private sector, including startup companies; and,

through the National Science and Technology Council, developing a plan to utilize Federal programs, such as the Small Business Innovation Research Program and the Small Business Technology Transfer Research Program to support nanotechnology research and development in the private sector.

### Big Push

At the state level, the Massachusetts Technology Collaborative (the "MTC"), a state-affiliated economic development agency, recently announced the Massachusetts Nanotechnology Initiative (the "MNI"). There is no formal relationship between the MTC and the NNP; rather, the MTC created the MNI as a vehicle for Massachusetts to compete more effectively with the many organizations created in other states over the last few years in response to the economic, scientific, social, and other benefits that form the promise of nanotechnology. MTC hardly amounts to big government, with a staff of six people and a total budget for technology-related initiatives of approximately \$1 million; but it certainly qualifies as government with big ambitions.

In collaboration with the Nano Science & Technology Institute, the MTC spent nearly one year conversing with academic, industry and government leaders as homework for the production of the recently-released report entitled Nanotechnology in Massachusetts (the "MTC Report" (5)). Operating from the threshold proposition that nanotechnology is an enabling technology that will impact many applications and industries that are critical to Massachusetts, the MTC Report principally serves to identify those key industries and the effect nanotechnology is likely to have on employment in Massachusetts. During a recent telephone interview with this writer, MTC Vice President Tom Hubbard stressed the importance of regional competitiveness in the next several years and beyond. The New York state government, for example, has committed \$500 million for the construction of semiconductor prototype fabrication facilities at the State University of New York at Albany, as part of a larger initiative dubbed Albany Nanotech aimed at making metropolitan Albany the leading regional center of nanotechnology research and development. The MTC Report identifies SEMATECH as one source of industry investment resulting from this initiative; in our interview, Mr. Hubbard noted similar investments in Albany Nanotech from IBM, Sony, and Tokyo Electronics, all focused on the semiconductor industry where wire lines etched on chips are now below 100 nanometers in width and, therefore, are within the scope of what is commonly considered nanotechnology.

Massachusetts has not committed public funds on the scale of New York, but significant developments are underway. The Massachusetts legislature recently approved the expenditure of \$100 million over the next five years for economic development programs that will finance facility expansions for emerging technology firms, support collaborative scientific research to attract continued federal funding, and accelerate technology transfer from universities to industry. While not devoted exclusively to nanotechnology, nanotech firms will undoubtedly benefit from this initiative.

Academic and research institutions in Massachusetts are also making strides. U Mass Amherst recently announced an ambitious five-year plan called MassNanoTech (6) to enhance its nanotechnology program, while Northeastern University, the University of Massachusetts Lowell and the University of New Hampshire have teamed up to propose creation of the New England Nanotechnology Center for Enabling Tools, a program to support 'nanomanufacturing' research that is now awaiting funding from the National Science Foundation.

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### Big Capital

Venture capital is a necessary resource for most companies developing products made possible by advances in nanotechnology because such companies typically require significant funding over a sustained period.

One study found that in 2003, Massachusetts companies received \$114.2 million in venture capital, or 13% of the total venture capital investment in nanotechnology in the U.S., which represents a 2% decline in investment as compared with 2002 (7). In comparison, the Nano Science and Technology Institute and the MTC found that in 2002 venture capital accounted for nearly \$20 million in "Massachusetts nano-startups, narrowly defined (nanoscale technologies), and as much as \$140 million in Massachusetts startups more broadly defined (nanoscale technologies and related fields, such as biotechnology and semiconductors (8))."

Notwithstanding some imprecision as to how to calculate venture capital investments in nanotechnology in the Commonwealth, Massachusetts is well ahead of its regional competitors, including New York, which received \$16.2 million in 2003. Nationally, Massachusetts ranks second only to California, although the gap between the two is not nano in scale, with California the beneficiary of more than \$480 million in 2003, up from approximately \$400 million in 2002.

Venture capital arguably assumes greater significance in Massachusetts, given that the Commonwealth has lost its share of major corporate operations. "In the absence of such 'mothership' companies, Massachusetts' prosperity becomes even more dependent on new venture creation and the growth of early-stage firms (9)."

### Big Future

Many recommendations are being encouraged and developed by the federal and state government in the effort to efficiently leverage the potential benefits of nanotechnology as we move forward.

At the federal level, the Act mandates the development of recommendations, the review of the implementation of those recommendations, and the public dissemination of those recommendations: The Act creates an Advisory Panel which "shall report, not less frequently than once every 2 fiscal years, to the President on its assessments ... and its recommendations for ways to improve the Program"; it creates the National Science and Technology Council, which shall provide at the time of the President's budget an annual report providing "an analysis of the extent to which the Program has incorporated the recommendations of the Advisory Panel"; and it creates the National Nanotechnology Coordination Office, which shall "conduct public outreach, including dissemination of findings and recommendations of the Advisory Panel."

In addition, some federal agencies are actively formulating recommendations targeted to their mission. For example, prompted by what it views as "the recent slowdown, instead of the expected acceleration, in innovative medical therapies reaching patients," the Food and Drug Administration's recently released report, *Innovation or Stagnation: Challenge and Opportunity on the Critical Path to New Medical Products*, argues that "the applied sciences needed for medical product development have not kept pace with the tremendous advances in the basic sciences." This report examines the critical path of new drug development from research to market, and concludes that "a new product development toolkit ... is urgently needed to improve predictability and efficiency along the critical path from laboratory concept to commercial product (10)." The FDA identifies "an urgent need for additional public-private collabora-

tive work on applying technologies ... to the science of medical product development," asserting that new medical technologies, including "nanotechnology applications, ... will all need new product development tools and standards ... to be able to move from the laboratory to the market quickly (11)." Other federal agencies, however, are just now formulating strategic initiatives to study how best to leverage nanotechnology to accomplish their institutional mission. For example, the NIH is organizing the NIH Nanomedicine Roadmap Initiative (12), scheduled to launch officially on May 4, 2004, and is organizing a series of workshops this year to plan the launch of Nanomedicine Centers next year. Some federal agencies seem to have little in the way of a clear strategy.

At the state level, the MTC Report provides the following summary of recommendations: extending nano-enabled productivity gains from established industries into the growth of new industries; creating nano institutes; retraining professionals; establishing various fora to discuss and exchange ideas; educating academics about entrepreneurship; and educating the business community about nanotechnology (13). Other local observers have pointed to the need to apply innovative problem-solving techniques to local barriers such as the high cost of housing and healthcare, and the need to increase investment in public education (14).

### Big Finish

While the advances that nanotechnology promise are just beginning to take shape, one thing is clear: For nanotechnology to realize its full potential as an enabling technology that will affect numerous applications and industries, the sometimes diverse worlds of federal and state government must coalesce as an enabling force in support of nanotechnology research and development.

1. See <http://thomas.loc.gov/cgi-bin/bdquery/z?d108:s.00189>.
2. See <http://www.nano.gov>.
3. See <http://www.ostp.gov/html/budget/2005/FY05NNI1-pager.pdf>.
4. See <http://www.nano.gov/html/about/nhibudget.html>.
5. See [http://www.masstech.org/nano/nano2004\\_3\\_1.pdf](http://www.masstech.org/nano/nano2004_3_1.pdf).
6. See <http://www.umass.edu/massnanotech/>.
7. PricewaterhouseCoopers/Thomas Venture Economics/National Venture Capital Association Money Tree Survey prepared in cooperation with Small Times Media, cited in the MTC report.
8. The MTC Report at p. 2.
9. Mitchell Adams and Patricia Flynn, *THE INNOVATION IMPERATIVE*, MassHighTech December 8, 2003, available at 10. [http://www.masshightech.com/displayarticledetail.asp?art\\_id=64244](http://www.masshightech.com/displayarticledetail.asp?art_id=64244) (hereinafter, *THE INNOVATION IMPERATIVE*).
10. See <http://www.fda.gov/oc/initiatives/criticalpath/whitepaper.html> at p. ii.
11. *Id.* at p. 15.
12. See <http://nihroadmap.nih.gov/nanomedicine/>.
13. The MTC Report, and therefore this article, gratefully acknowledges use of the work of Richard Freeman, from the SEWP project, in formulating the recommendations offered in the report.
14. *THE INNOVATION IMPERATIVE*.