GREEN NANO-VISIONS AND THEIR POLICY CONSEQUENCES

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Abstract

Environmental visions about nanotechnology from the mid-1980s to 2000s initially encouraged exclusive exploration on nanotechnology's applications during the first years of the U.S. National Nanotechnology Initiative (NNI). Scientists' and policy-makers' early attention on applications delayed investigation into nanotechnology's potential risks and environmental implications. My historical research materials include the personal papers and publications of leading scientists, and internal emails from the U.S. Environmental Protection Agency (EPA), along with other government documents. Between the mid-1980s and 2000s, key figures such as Eric Drexler, Nobel scientist Richard Smalley, and National Science Foundation administrator Mihail Roco all promoted visions of nanotechnology that would make anthropogenic activity more environmentally sustainable. Their green nano-visions helped inspire creation of the NNI, in which initial research focused on realizing nanotechnology's promises. Internal EPA emails during these crucial early years of the NNI reveal that even the government agency tasked with protecting environmental and human health mostly overlooked the Environmental, Health, and Safety (EHS) risks of new nanomaterials in excitement over nanotechnology's environmental applications. Today, despite numerous studies revealing the likely toxicity of some nanomaterials to humans, soils, plants, and other organisms, only three percent of the NNI budget is dedicated to EHS implications. Uncovering the early environmental visions of nanotechnology helps explain why American efforts to explore nanotechnology's EHS issues were delayed and remain underfunded.

Research Questions and Argument

- **What visions did scientists and policy-makers express for the environmental benefits of nanotechnology?**
- **What were the policy consequences of those green nano-visions?**

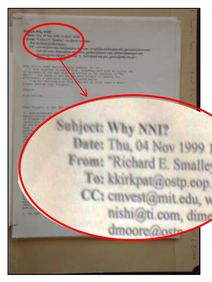
"Green Nano-Visions and Their Policy Consequences" argues that environmental nanotechnology visions by scientists and policy-makers between the 1980s and 2000s were one of the reasons for delays in EHS research and regulations during the early NNI years.

Historical Research Methods

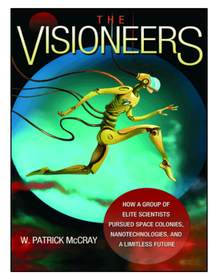
History is an evidence-based discipline. Historians use and analyze both primary and secondary sources to tell a story about events in the past, and they give meaning to those events.

A primary source is evidence **created during the time being examined**. Primary source examples include newspaper articles, legislation, scientific studies, emails and any form of original documentation.

A secondary source is evidence **created after the time being examined,** based on primary sources. Secondary source examples include encyclopedias, textbooks, and historical journal publications.



An original e-mail in Nov. 1999, from Dr. Richard Smalley to the U.S. Government about "Why NNI?" (Richard E. Smalley papers, Chemical Heritage Foundation)



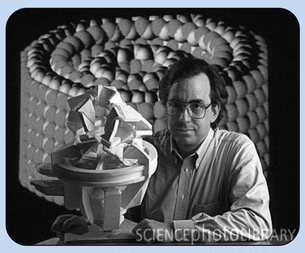
The Visioneers (2012) by Dr. Patrick McCray is a secondary source, based on both primary and secondary sources (press.princeton.edu)

Many environmental groups have questioned the safety of **Genetically Modified Organisms (GMOs)** in our food chains, which has sparkled significant controversy and backlash since the 1980s. (schoolfood.info)

*Let's **prevent** nanotechnology from following past **technological pitfalls**!*

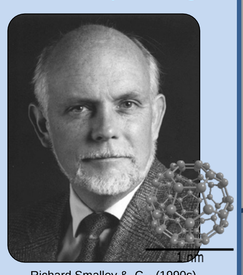
In the 1950s, **nuclear power's** promoters promised a free and endless energy supply. Today, nuclear power produces great amounts of toxic waste that can wash into our oceans and rivers. (smashinglists.com)

Green Nano-Visions (1986-99)



Eric Drexler and his nanobots models (1980s)

Dr. Eric Drexler, an MIT Ph.D., published *Engines of Creations* in 1986 and popularized nanotechnology as a technological fix to help humanity move beyond our environmental limits. For example, as a solution to global warming, he envisioned self-replicating nanobots able to sort gas molecules and extract carbon dioxide from air. Drexler's imaginative visions influenced scientists like Richard Smalley.



Richard Smalley & C_{60} (1990s) (ostl.gov/nanooze.org)

Dr. Richard Smalley won the 1996 Nobel Prize in Chemistry for co-discovering a nano-scale form of carbon called a "buckyball." In 1999, Smalley e-mailed the U.S. Government describing his visions about nanotechnology and the importance of a NNI. He had more realistic ideas about using nanotechnology to improve the environment with clean, renewable forms of nano-energy and "green" manufacturing. Smalley worked closely with major science administrators in the U.S. Federal Government such as Mihail Roco.

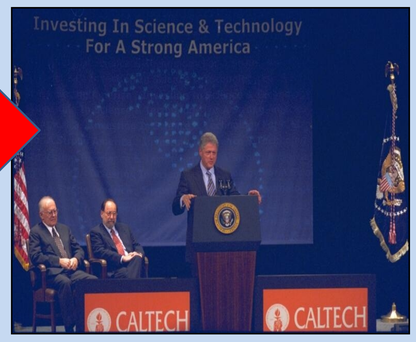
Mihail Roco (2000) (view.koreaherald.com)

Dr. Mihail Roco, the current Senior Advisor for Nanotechnology at the National Science Foundation (NSF), had even more realistic environmental visions of nanotechnology. He formally proposed the NNI in 1999, and in 2000, when the NNI began, Roco argued that nanotechnology would provide a plethora environmental benefits and technological solutions to environmental challenges.

"Nanotechnology will improve agricultural yields for an increased population, provide more economical water filtration and desalination, and enable renewable energy sources." (M. Roco, 2000)

2000

National Nanotechnology Initiative Focused on Applications (2000)

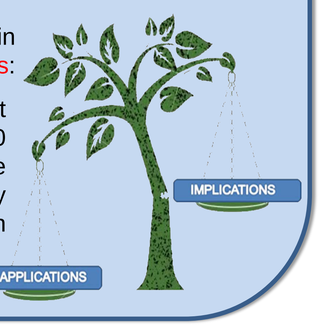


President Clinton announcing the National Nanotechnology Initiative at Cal Tech (January 2000)

In January of 2000, the United States initiated a multi-billion dollar venture in nanotechnology to fund the "Next Industrial Revolution." Many government departments, agencies, and laboratories benefited from this major investment.

Initially, the NNI focused on nanotechnology's environmental applications and overlooked the environmental risks and implications of new nano-scale materials and chemicals.

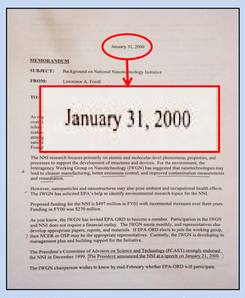
Many factors explain this focus on applications:



With such investment in nanotechnology, the U.S. Government desired rapid returns. The internet boom between 1995 and 2000 created expectations of steady commercial growth. And, as the sole super-power after the Cold War, America hoped nanotechnology would maintain its hegemony over capitalist globalization. This, in addition to the green nano-visions, led to a focus on applications and commercialization during the NNI's first years.

2000 - 03

Early Policy Consequences (2000-03)



EPA "Background on the NNI" focused on applications. (EPA papers, Chemical Heritage Foundation)

Mihail Roco belatedly invited the Environmental Protection Agency's Office of Research and Development to join the NNI just before Clinton announced it. Early in 2000, even the EPA—the agency obligated to protect environment and human health—focused almost entirely on nanotechnology's environmental applications in its first "Background on the NNI" (top left). In its excitement to fulfill scientists' and policy-makers' green nano-visions, the EPA failed to consider whether nano-materials themselves might actually damage the environment.

In 2002, the EPA still focused on nanotechnology's "green" applications over its potential environmental hazards. The EPA's second nanotechnology grant solicitation called for research projects on environmental applications of nanotechnology. As a final thought, the EPA introduced ideas about possible environmental implications (right). But even here the EPA sought either "the beneficial or harmful effects of nanotechnology on society" rather than on the environment itself, including "impacts from the development of nano-machines."

Finally, in 2003, three years after the NNI began, the EPA called explicitly for research on nanotechnology's toxicity, bioavailability, fate, transport, and transformation (left). It took the EPA three years to look explicitly at nanotechnology's Environmental Health and Safety (EHS) implications, and it took even longer for the rest of the NNI and the U.S. Government to follow.

"Little is known about the fate, transport, and transformation of nano-sized materials…."

"What is the toxicity or potential toxicity of these manufactured nano-materials?" (EPA April 2003 STAR Grant Solicitation) (EPA papers, Chemical Heritage Foundation)

"Environmental Implications of Nanotechnology: Environmental **benefits** and potential harmful effects of nanotechnology at a **societal level**" (EPA's June 2002 STAR Grant Solicitation) (EPA papers, Chemical Heritage Foundation)

2003-Today

Recent Policy Consequences (2003-Today)

The NNI and U.S. Government gradually acknowledged nanotechnology's EHS concerns. Between 2000 and 2003, the NNI focused mainly on nanotechnology's applications and some societal implications. In September 2006, the U.S. House Committee on Science echoed the EPA's internal concerns about environmental and health risks of nanotechnology. In 2007, the EPA released publically its first white paper on nano-science, which addressed environmental benefits and some risks. Finally, in 2008 the NNI funded two centers focused explicitly on environmental applications: the Center for the Environmental Implications of NanoTechnology (CEINT) at Duke University, and the Center for the Environmental Implications of Nanomaterials (CEIN) at UCLA and UCSB.

Yet, as recently as December 2011, an internal EPA evaluation criticized its own ineffectiveness in managing nanomaterial risks.

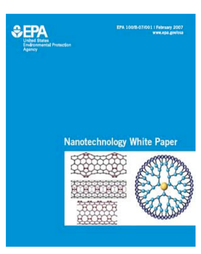
Today, only three percent of the NNI total budget goes to EHS research. Even though hundreds of nanotechnology products are sold today, the EPA has only managed, after several years of delay, to put in place a voluntary regulatory program. Lack of EHS oversight for nanotechnology not only presents an on-going problem for the United States. It remains a global challenge.

"**No nation—**including the United States—**has the oversight policies** and institutions needed to deal with these risks." (J. Clarence Davies, *Governing Uncertainty: Environmental Regulation in the Age of Nanotechnology,* 2010, pg. xii)

The NNI focused on applications during its early years (2000 – 2003) spacemart.com

NNI expressed concerns over nanotechnology's social implications. (2003) humorgenome.com

U.S. House Committee on Science expressed EHS concerns. (2006) sharetrails.org



EPA's Nanotechnology White Paper (2007)

Centers funded explicitly for research on environmental implications (2008) nanobiotech.org

Conclusions & Future Work

- The green nano-visions of scientists and policy makers from the 1980s and 2000s helped cause delays in research on nanotechnology's EHS issues in the first years of the NNI.
- Today, hundreds of nanotechnology products already exist on the market, yet we have only ineffective and voluntary regulatory programs to protect workers, consumers, and the environment.
- By looking both at nanotechnology's applications *and* implications from the very start, we can help prevent both environmental and economic losses.
- For future work I want to learn about the implications of current nano-products in the market.

Literature cited

Bosso, Christopher J., editor., *Governing Uncertainty.* Washington, DC: Earthscan, 2010, XII-XVII, 1-23
Drexler, Eric K. *Engines of Creation: The Coming Era of Nanotechnology.* New York: Anchor Books, 1986, 16-43
Environmental Protection Agency internal e-mails. Chemical Heritage Foundation. Philadelphia, PA
Office of Inspector General. "EPA Needs to Manager Nanomaterials More Effectively." Washington, DC, 2011.
Roco, Mihail C. "From vision to the implementation of the U.S. National Nanotechnology Initiative." *Journal of Nanoparticle Research* (2000): 5-11
Science Policy Council. EPA Nanotechnology White Paper. Washington, DC, 2007
Smalley, Richard E. papers. Chemical Heritage Foundation. Philadelphia, PA

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