

Debye Lecture 11

Nanomaterials Challenges & Opportunities Health & Environmental Safety Discussion of New Trends C. B. Murray

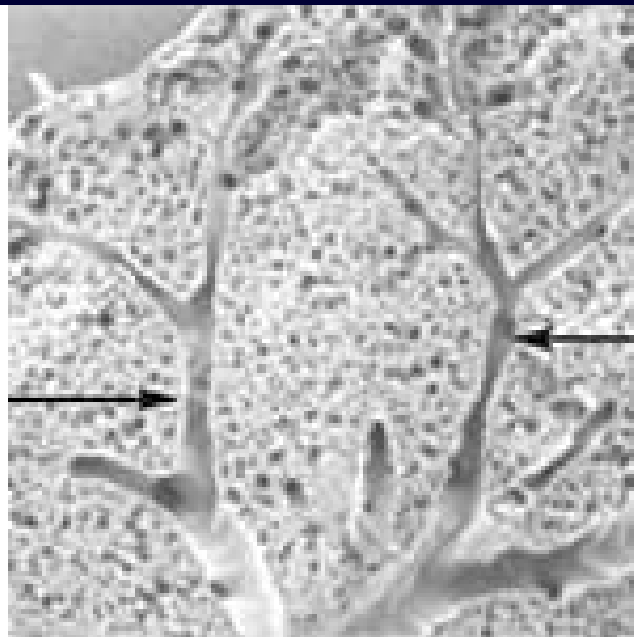


Photo courtesy of David
B. Warheit

A scanning electron micrograph of a rat's lung, pointing to inhaled nanoparticles. Researcher David Warheit's study is one of only a few nanoparticle toxicity studies available.

PRINCE CHARLES SPEAKS ON NANO REGULATION

July 12, 2004 - Two prominent voices for caution and regulation within nanotechnology have published new calls for action.

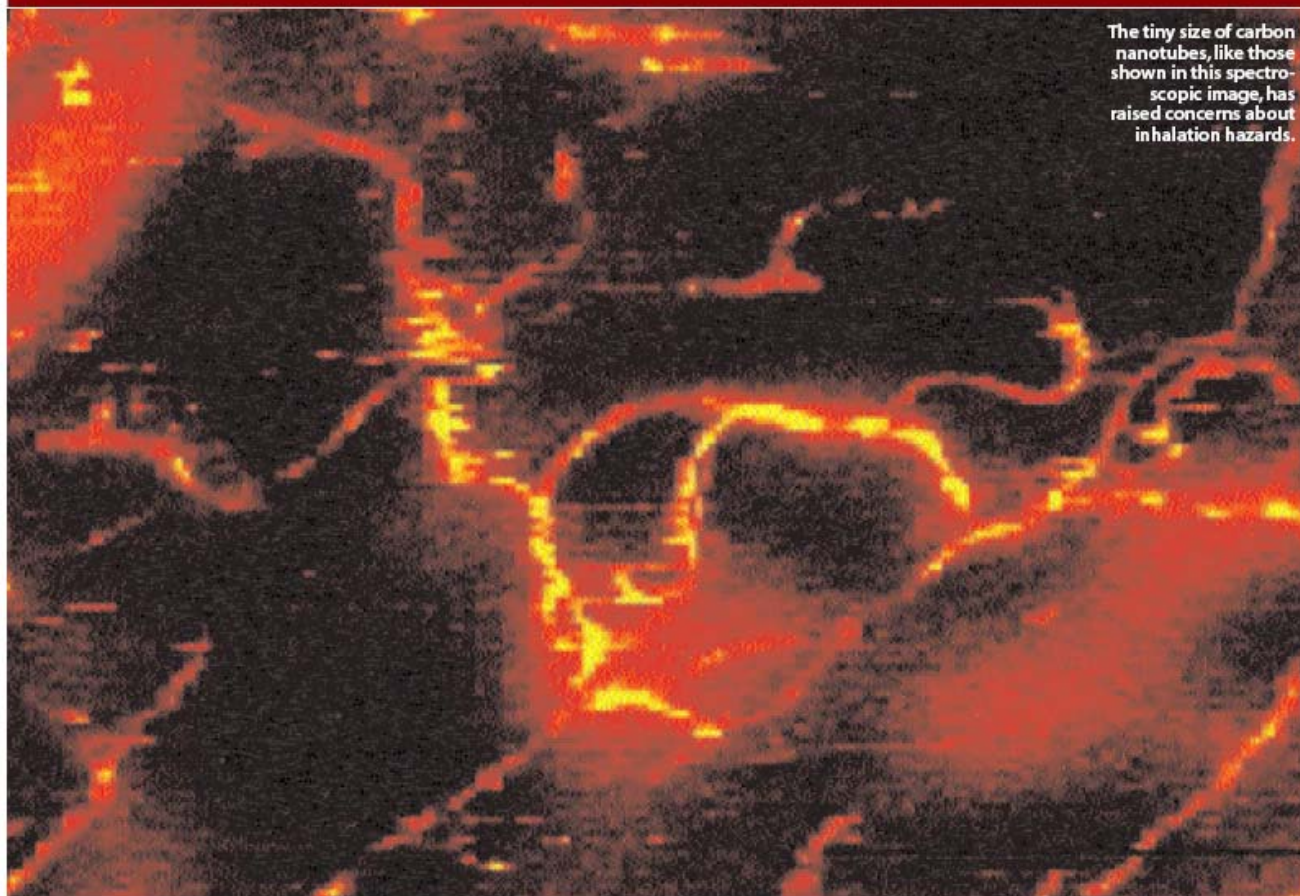
The U.K.-based Independent newspaper on Sunday published an essay by Prince Charles, who seeks greater examination of the impact of nanotech on ethics, society and the environment.

Charles, who last year called on the Royal Society and Royal Academy of Engineering to help him weigh the risks of the field, said broader public acceptance will only come "if public attitudes and regulatory processes are encouraged to develop at the same rate as the technology itself."

The article expressed concerns about the control and ownership of nanotechnologies, and whether there is a danger of "awarding patents on nature." It also raised questions about nanotech displacing existing technologies, and if that will widen the existing disparities between the rich and poor.

The ETC Group came to similar conclusions in its latest communiqué. The Canadian social advocacy group's report pushes for the creation of a new international body to track, evaluate and accept or reject new technologies and their products.

Since 2002, ETC has called for a moratorium on nanoparticle research and commercialization until governments adopt "best practices" for research.



The tiny size of carbon nanotubes, like those shown in this spectroscopic image, has raised concerns about inhalation hazards.

Nano's Safety Checkup

Concerns over particle dangers could slow nanotech's growth. **BY IVAN AMATO**

Howard: Nanotechnology Represents an "Exciting Challenge" for EHS - 05/07/2004

NIOSH Director John Howard offered attendees at the American Occupational Health Conference in Kansas City, Mo., a glimpse into nanotechnology and the challenges it offers occupational safety and health professionals. He provided *OH.com* with a more detailed look at this emerging technology.

Nanotechnology involves the engineering and manipulation of materials, structures and devices on a nanometer scale &— less than 100,000th the width of a human hair, said Howard. "At this ten to the minus seven to minus nine meter scale, many materials have unique and unusual properties," he noted.

Nanotechnology is one of the fastest growing technological areas in human history. "Carbon nanotubes were discovered in 1991 as excellent sources of field-emitted electronics, and by 2000 were being used commercially in a high-brightness light source to illuminate sports stadiums — a jumbotron lamp. In contrast, it took 23 years between the modeling of the semiconductor property of germanium in 1931 and the commercialization of the first product, the transistor radio in 1954," said Howard.

Nanomaterials - A Risk to Health at Work

The application of nanotechnology permits the alteration of the fundamental physical and chemical properties of conventional materials as their size is reduced to the nanoscale, these materials offering unique and commercially useful electrical, optical and mechanical properties because of their size, shape, and composition. Already numerous applications exist in aerospace, automotive, biomedical, microelectronics, semiconductors, pharmaceuticals, energy storage and anti-friction coatings.

A Health and Safety Laboratory hosted event, **Nanomaterials - A Risk to Health at Work**, First International Symposium on Occupational Health Implications of Nanomaterials, co-sponsored by the HSE and the US National Institute of Occupational Safety and Health, will take place on the 10-12th October 2004, at the Palace Hotel, Buxton, Derbyshire.

The event will consider current and future developments in the nanotechnology industry, health effects of nanoparticles and new materials, exposure assessment and control of nanoparticles, potential knowledge gaps, and the regulatory implications of nanotechnology.

No Small Thing

Getting Nanodevelopment Right the First Time

Richard A. Denison, PhD

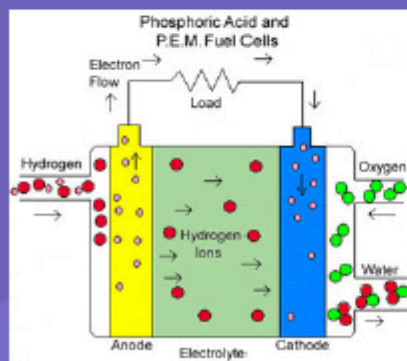
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ENVIRONMENTAL DEFENSE

finding the ways that work

ENVIRONMENTAL DEFENSE

Our Hopes for Nanotech: Environmental Benefits

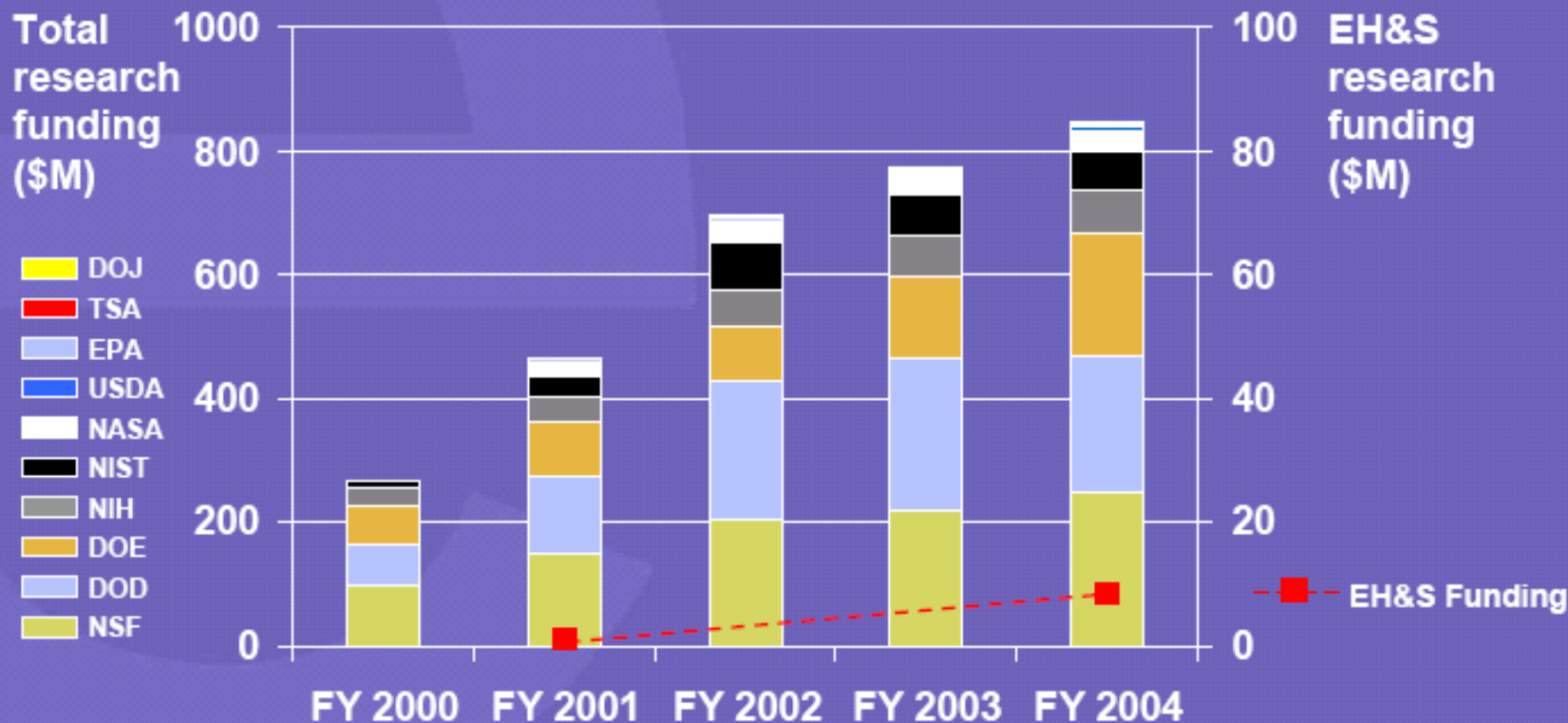


What We Want to Avoid: The “Wow- to-Yuck” Trajectory

<u>Technology</u>	<u>Promise</u>	<u>Problem</u>
Asbestos	Insulator, fire retardant	Lung disease; carcinogen
DDT	Mosquito and malaria control	Persistent, bioaccumulative, toxic;
Leaded gas	Engine improvements	Persistent, bioaccumulative, toxic; Carcinogen; developmental toxin
PCBs	Insulator, fire retardant	Persistent, bioaccumulative, toxic; Probable human carcinogen; Multiple other probable toxic effects
CFCs	Refrigerant, aerosol	Ozone depletion
GMOs	Improved crop yields	Public backlash; inadequate controls

Can we get it right the first time with nanotech?

Why It's Uncertain: Not Enough Implications Research



Source: National Science Foundation, National Science and Technology Council

Preliminary Studies Raise Concerns

Mobility

- Through groundwater?
- Bioaccumulation?
- Across cell membranes?
- Across blood-brain barrier?
- Across placenta?

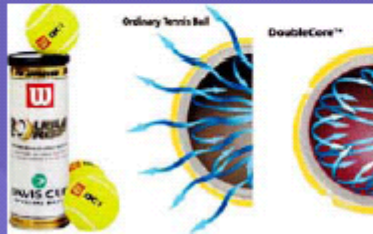
Toxicity

- Lung granulomas?
- Brain lipid peroxidation?
- Aquatic toxicity?
- Cytotoxicity?

**Testing needed to properly identify hazards, assess risks,
and develop proper safety standards and control protocols**

ENVIRONMENTAL DEFENSE

Marketplace Presence Creates Urgency



Will OSHA Protect Workers?

- Particulates Not Otherwise Regulated (“Nuisance Dusts”)
 - Inhalation standard based on 30-year old science, mass-based
 - New standards unlikely
- Essentially no dermal exposure standards
- Limits to personal protective equipment (PPE) approaches
 - Reduced efficiency of respirators in 100-300 nm range
 - NIOSH working on interim guidance
- How about HAZCOM?
 - MSDS for carbon nanotubes = MSDS for graphite

EPA: TSCA Complexities / Limitations

- When are nanomaterials “new” chemicals?
- Existing exemptions (e.g., weight threshold)
- No up-front data requirements for new chemicals
- Significant burden on EPA to require testing
- Poor basis for evaluating risk in absence of data on specific types of nanomaterials
- Nomenclature confusion

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Nanomaerials Opportunities and Challenges

Intergration

Scale-up

Doping

Geometric control

Multi-component materials

Controlled Complexity

Emergent Phenomena

Nanomaterials - Market Size, Market Share, Demand Forecast, Sales, Company Profiles, Market Research, Industry Trends

The US nanomaterials market will surpass \$1 billion in 2007, driven by the development of basic nanoscale materials such as metal oxides, nanotubes and buckyballs. Early growth will come from niche applications in the consumer products, defense, auto and printing industries, while longer run opportunities are focused on nanoelectronics and nanomedical devices.