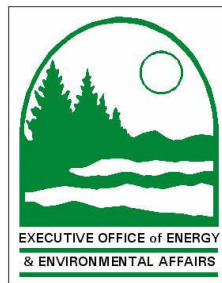


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Risk Concern as a Hurdle to Nanotech Commercialization

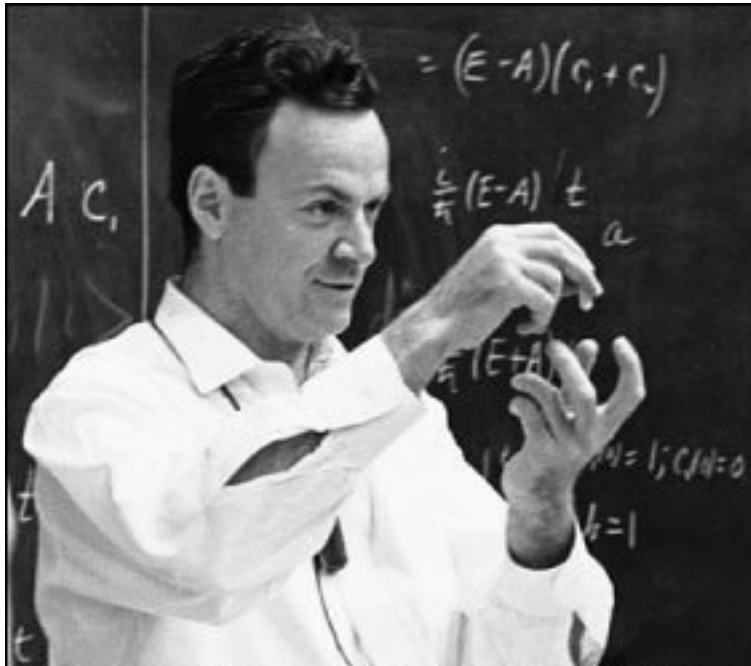


Michael Holman, Senior Analyst

The Big Picture: Safe Development of Nanotechnology

Marlborough, MA

Thursday, November 15, 2007



“There’s plenty of room at the bottom.”

-Richard Feynman, December 29, 1959



“Plenty of room at **this** bottom”

-Topless Humans Organized for Natural Genetics (THONG), October 6, 2004

Agenda

- Overview of nanotech commercialization
- Current state of nanotech EHS issues
- How companies can manage EHS issues

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What's nanotechnology?

Not “nano by accident”:

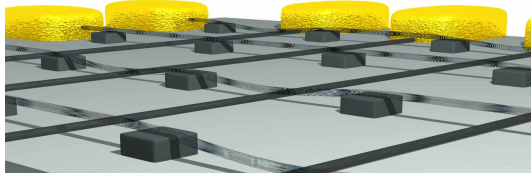
- Ancient Egyptian pottery
- Stained glass
- Cat litter

“The *purposeful engineering* of matter at *scales of less than 100 nanometers (nm)* to achieve *size-dependent* properties and functions.”

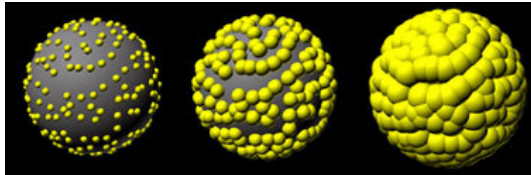
Really small

Not just “small;” “small and different”

Products built with nanotechnology exploit *size-dependent properties*



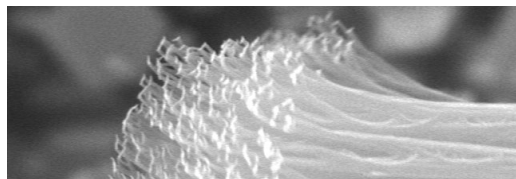
Carbon nanotube crossbar memory
(LSI Logic, BAE Systems licensing from Nantero)
Van der Waals forces hold nanotube crossbars together



Gold nanoshell cancer treatment
(Nanospectra Biosciences)
Size and curvature of shell determines light absorption



Ultradur High Speed engineering plastic
(BASF)
Nanoscale particles make plastics more moldable



Artificial setae
(U.S. Army contracting with Nanosys to develop)
Weak atomic interactions allow soldiers to climb walls

Conventional wisdom about nanotechnology is wrong

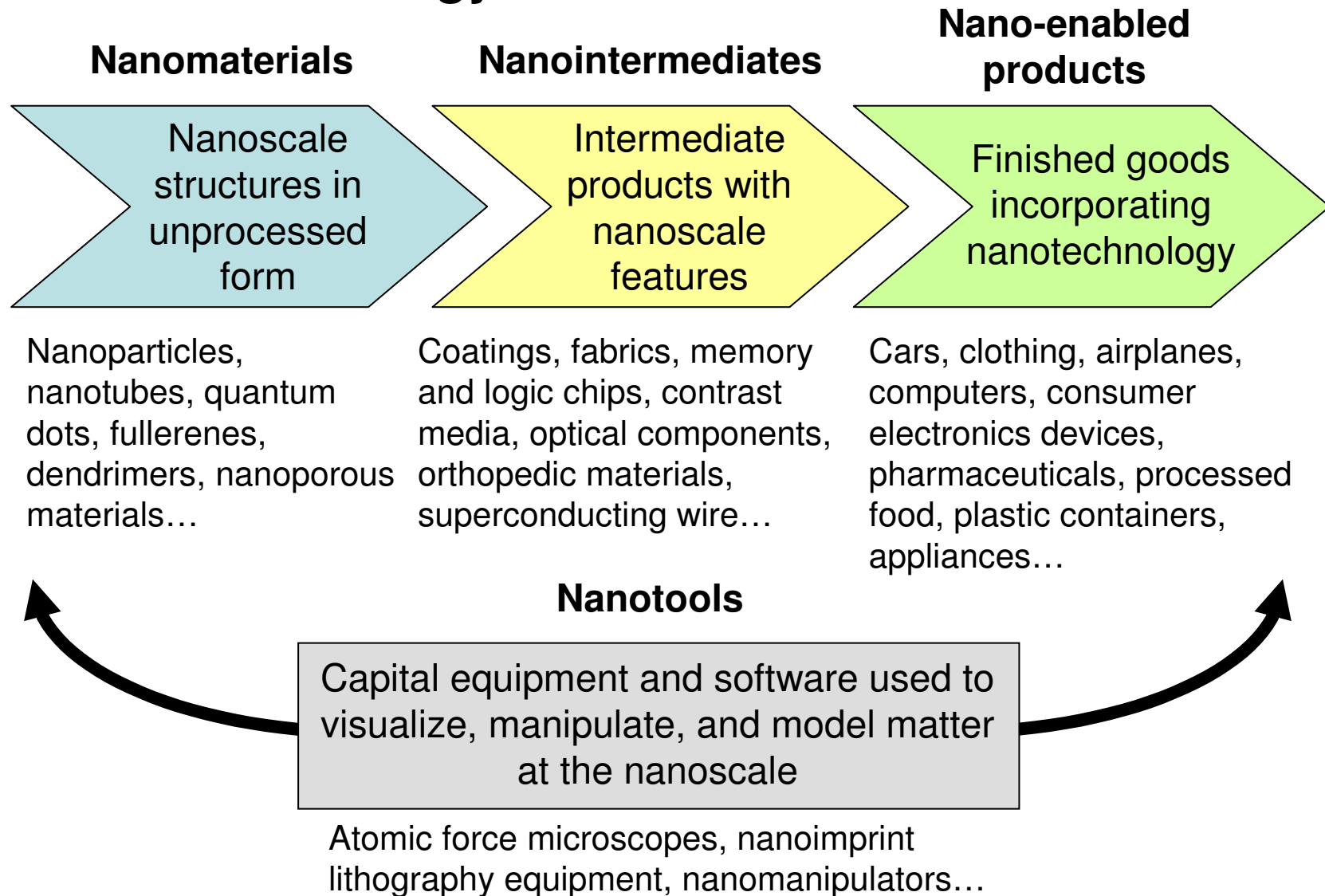
Conventional wisdom

A “nanotechnology market” is emerging, comprised of “nanotechnology companies” selling “nanotechnology products”

Commercial reality

There is no “nanotechnology market;” there *is* a nanotechnology value chain

The nanotechnology value chain



Conventional wisdom about nanotechnology is wrong

Conventional wisdom

A “nanotechnology market” is emerging, comprised of “nanotechnology companies” selling “nanotechnology products”

All “nanotechnology products” are new

Commercial reality

There is no “nanotechnology market;” there *is* a nanotechnology value chain

Not all nanotechnology is new.
Emerging nanotechnology is developing against a backdrop of *established* nanotechnology

Conventional wisdom about nanotechnology is wrong

Conventional wisdom

A “nanotechnology market” is emerging, comprised of “nanotechnology companies” selling “nanotechnology products”

All “nanotechnology products” are new

Anything “nano” has the potential for huge profit margins

Commercial reality

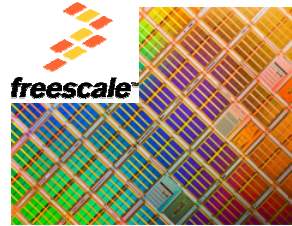
There is no “nanotechnology market;” there *is* a nanotechnology value chain

Not all nanotechnology is new. *Emerging* nanotechnology is developing against a backdrop of *established* nanotechnology

Many products incorporating nanotechnology will be only marginally profitable

Early nano-enabled products are on the market now

Freescale
magnetoresistive
memory (MRAM)



Wilson Double
Core tennis balls



Eddie Bauer

Eddie Bauer
Ruston Fit Nano-
Care khakis



3M

3M Adper Single
Bond Plus
dental adhesive



Wyeth Rapamune
immuno-suppressant

Wyeth



smith&nephew

Smith & Nephew Acticoat 7
antimicrobial wound dressing



Petrol Ofisi
with diesel
fuel catalysts

Henkel Nanit-
Activ toothpaste
for sensitive teeth



LAUFEN
bathrooms

Laufen Gallery washbasin
with Wondergliss



Hummer H2

Behr NanoGuard
Mildew-resistant paint



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Firms need to handle three aspects of nanotech EHS...

Real risks

Nanomaterials might have negative effects on people or the environment



Rat exposed to cobalt nanoparticles on the left side, bulk cobalt on the right side

Best case: Nanomaterials prove to be more dangerous than ordinary substances in only a handful of cases

Worst case: Studies show that many nanomaterials have elevated hazard and are more difficult to control

Perceptual Risks

Nanotechnology might come to be seen as unsafe – irrespective of actual harm



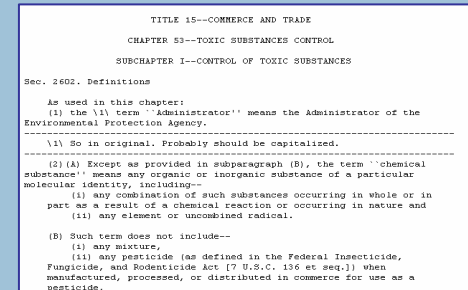
Protest of the use of Nano-Tex fabric treatment outside an Eddie Bauer store

Best case: Consumers appreciate the benefits nanomaterials can offer and embrace the technology

Worst case: Nanotech comes to be seen as synonymous with danger and consumers are reluctant to accept it

Regulations

Regulations might – rightly or wrongly – slow or block commercialization

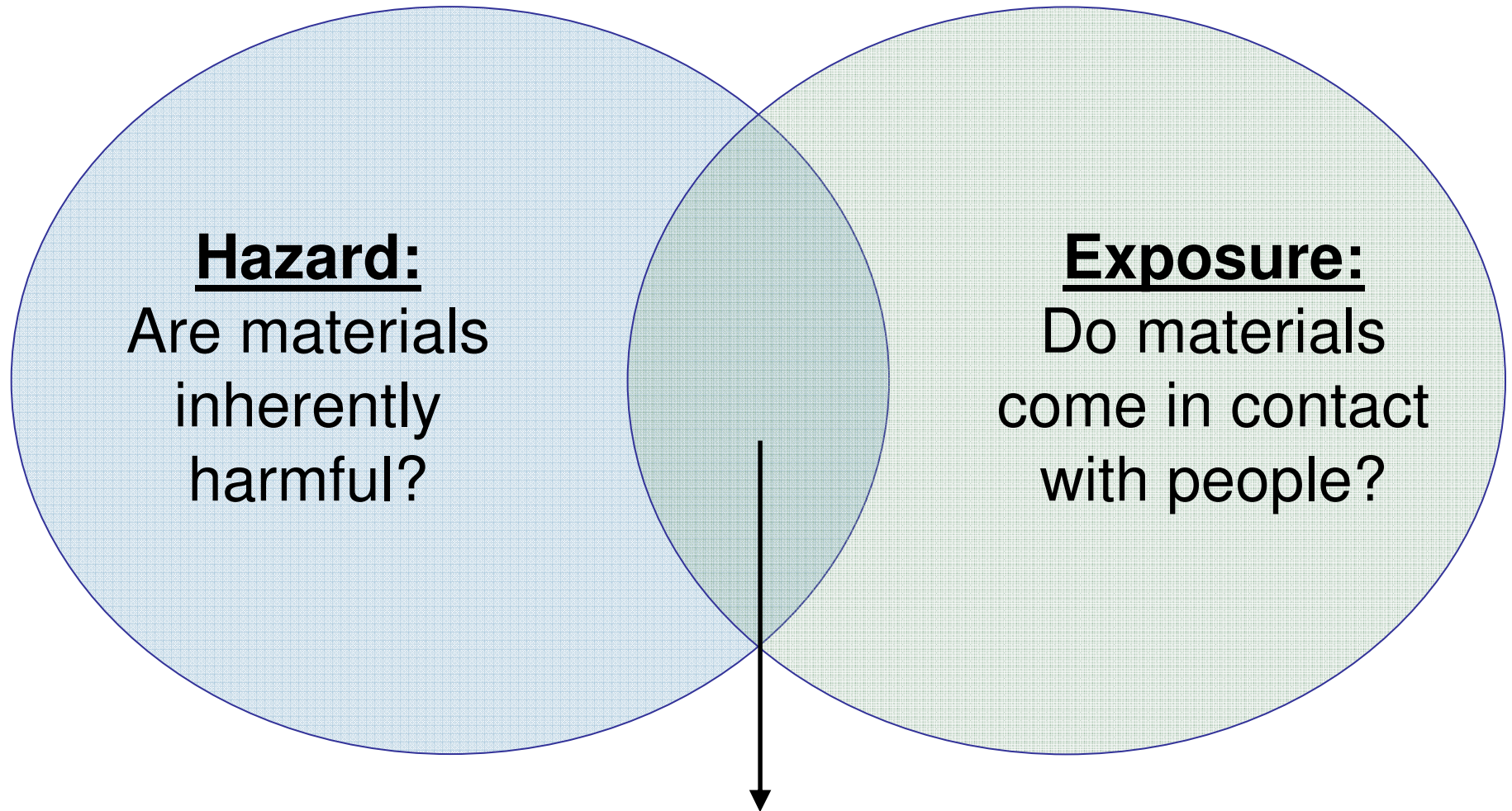


Text of the Environmental Protection Agency's Toxic Substances Control Act

Best case: Existing regulatory frameworks can be painlessly adapted to manage nanomaterials

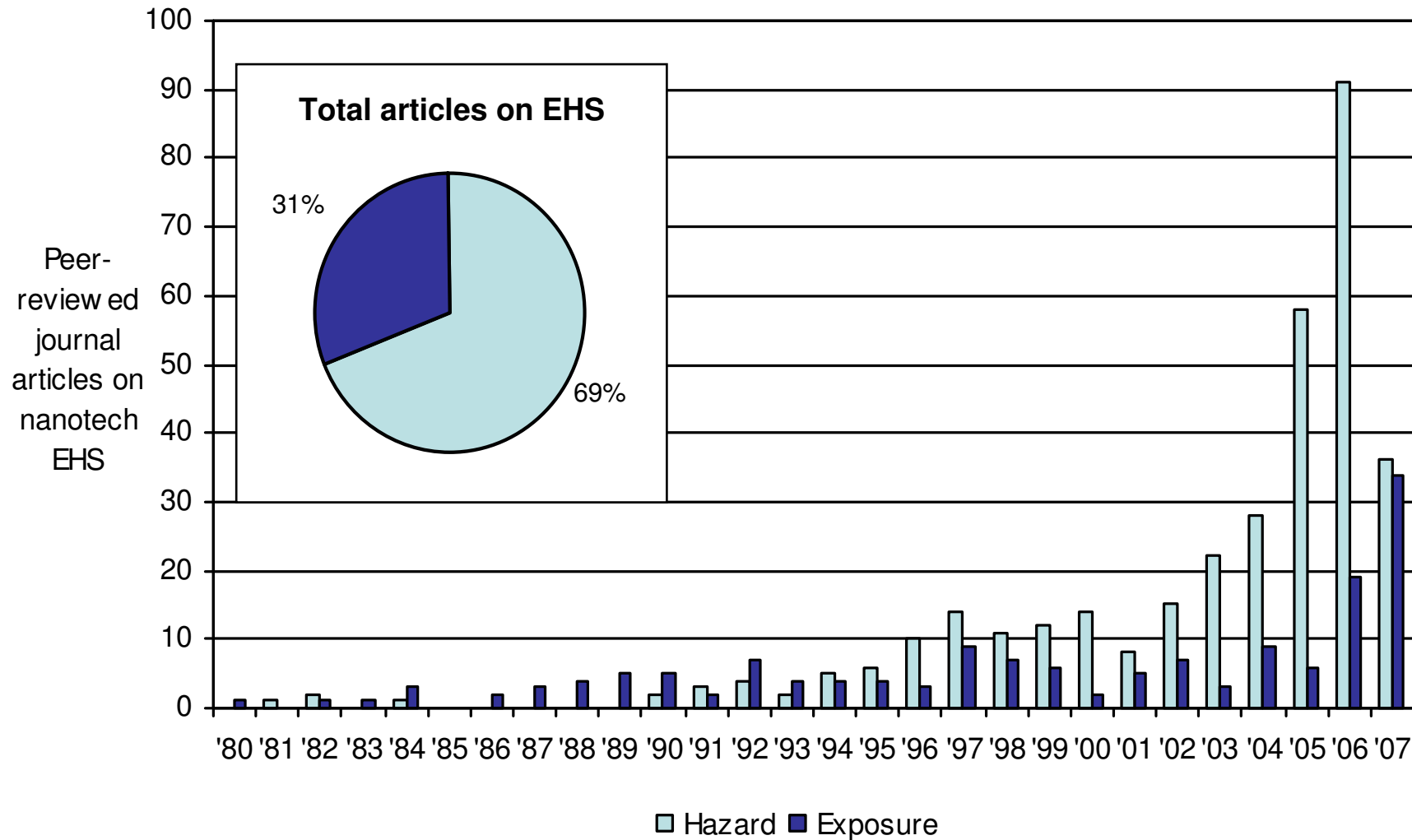
Worst case: Risks drive regulators to impose stringent testing requirements on all nanomaterials

Source: May 2006 Lux Research Report "Taking Action on Nanotech Environmental, Health, and Safety Risks"









High-risk scenarios:
High hazard and exposure

In 2007 nanomaterial exposure studies gain ground



Sources: ICON database (icon.rice.edu), review articles, literature searches

Consumers are uninformed but optimistic

Researcher(s)	Year	Description	People	Region	Awareness	Attitude	Key finding
Currall, King, Lane, Madera, and Turner ^a	2005 2004 2005	Telephone survey; online survey; telephone survey	503; 4,452; 501	U.S.	Low		Perception of benefits influence the perception of risks – if benefits are perceived to be low, concern about risk will be greater
Peter D. Hart Research Associates, Inc. ^b	2006	Telephone survey	1,014	U.S.	Low		30% have heard something about nanotech, but 42% still unaware – most with opinions believe benefits and risks will be about equal
Kahan, Slovic, Braman, Gastil, and Cohen ^c	2006	Online survey	1,800	U.S.	Low		People with “individualistic” values focus on the benefits of nanotech, while “communitarian/egalitarian” types focus on the risks
Siegrist, Cousin, Kastenholz, and Wiek ^d	2006	Telephone survey	153	Switzerland	N/A		Participants hesitant to buy nanotechnology in foods and food packaging, depending upon perceived benefits
Market Attitude Research Services, Pty Ltd ^e	2005 2007	Telephone survey; telephone survey	1,000; 1,000	Australia	Low		54% of Australians believe potential benefits outweigh risks in 2007, as opposed to 39% in 2005
Peter D. Hart Research Associates, Inc. ^f	2007	Telephone survey	1,014	U.S.	Low		Repeat of 2006 poll finds similar results despite doubled number of nanotech consumer products

Regulatory update: EPA

- Proposed “Nanoscale Materials Stewardship Program” (NMSP) for information collection of nanomaterial risks; long delayed, set to launch now in early 2008 – but don’t hold your breath
- Released in July long-awaited details on how it will handle nanomaterials under the Toxic Substances Control Act (TSCA).
 - Won’t consider nanoscale version of materials already on the TSCA inventory as new materials – as forecast to Eastman in October 2006
 - Likely will still Significant New Use Rulings (SNURs) to restrict uses of particular nanomaterials, based on NMSP data
 - Will continue to regulate nanomaterials with new chemical structures (nanotubes, fullerenes, POSS, etc.) as new materials under TSCA
- Clarified FIFRA rules on nanosilver antimicrobials in November 2006
 - Nanosilver antimicrobials treated like any other – do require registration to make claims!
 - Some uses ducking requirement by modifying claims (e.g., Sharper Image); key material makers pursuing testing (e.g., NovaCentrix)

Companies struggle with all three aspects today

“We’ve stopped development where costs were too high to ensure no exposure or risk across the lifecycle, or we couldn’t clearly judge hazard potential due to the lack of accepted methods. It’s quite complicated; we can’t set decision points today.”

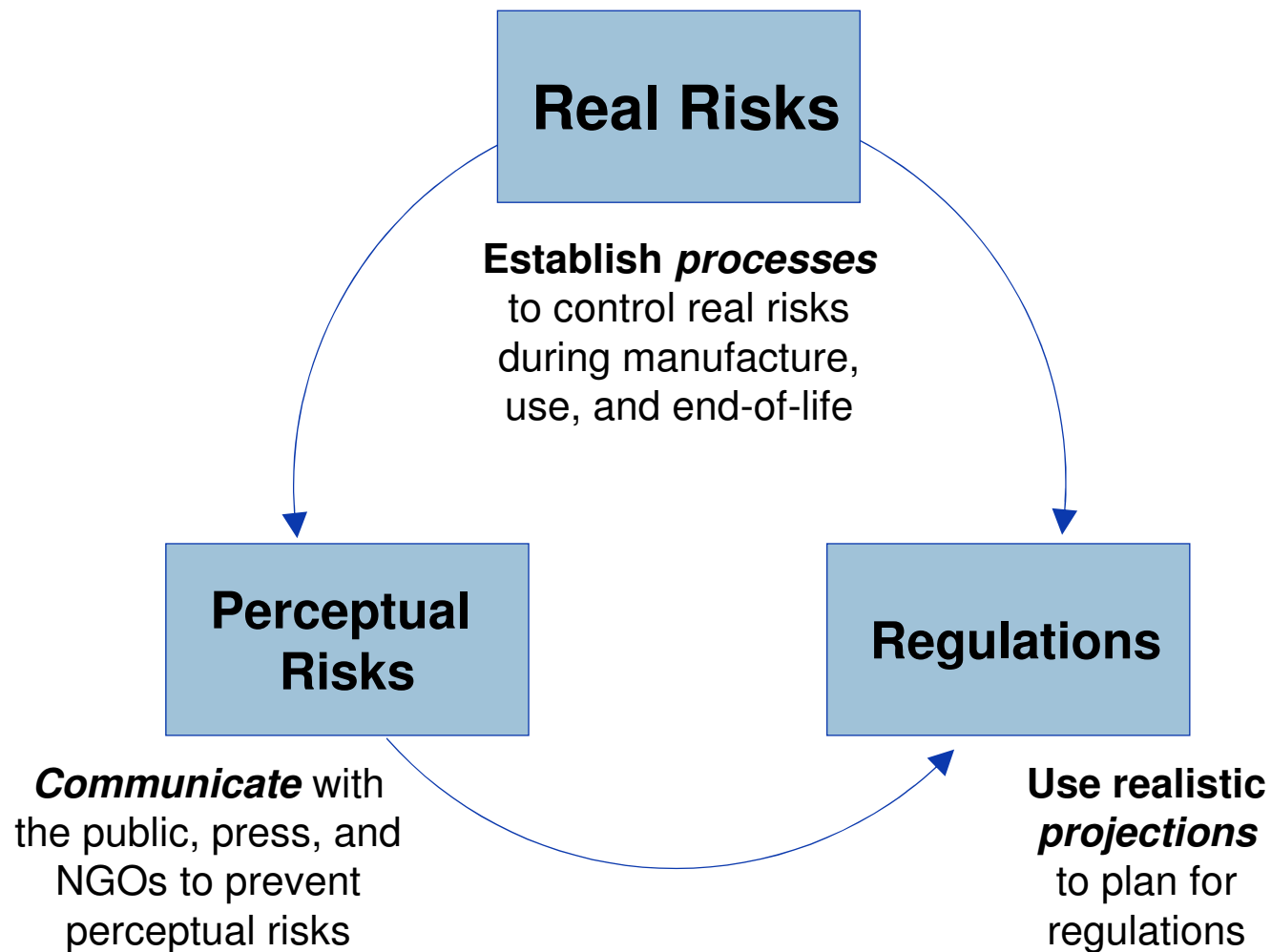
“We promote the benefits better products bring, without talking about technology. With nanotech, it’s no different: You won’t hear us talking about nanotech or advertising it in any way. That’s our strategy for dealing with potential negative publicity.”

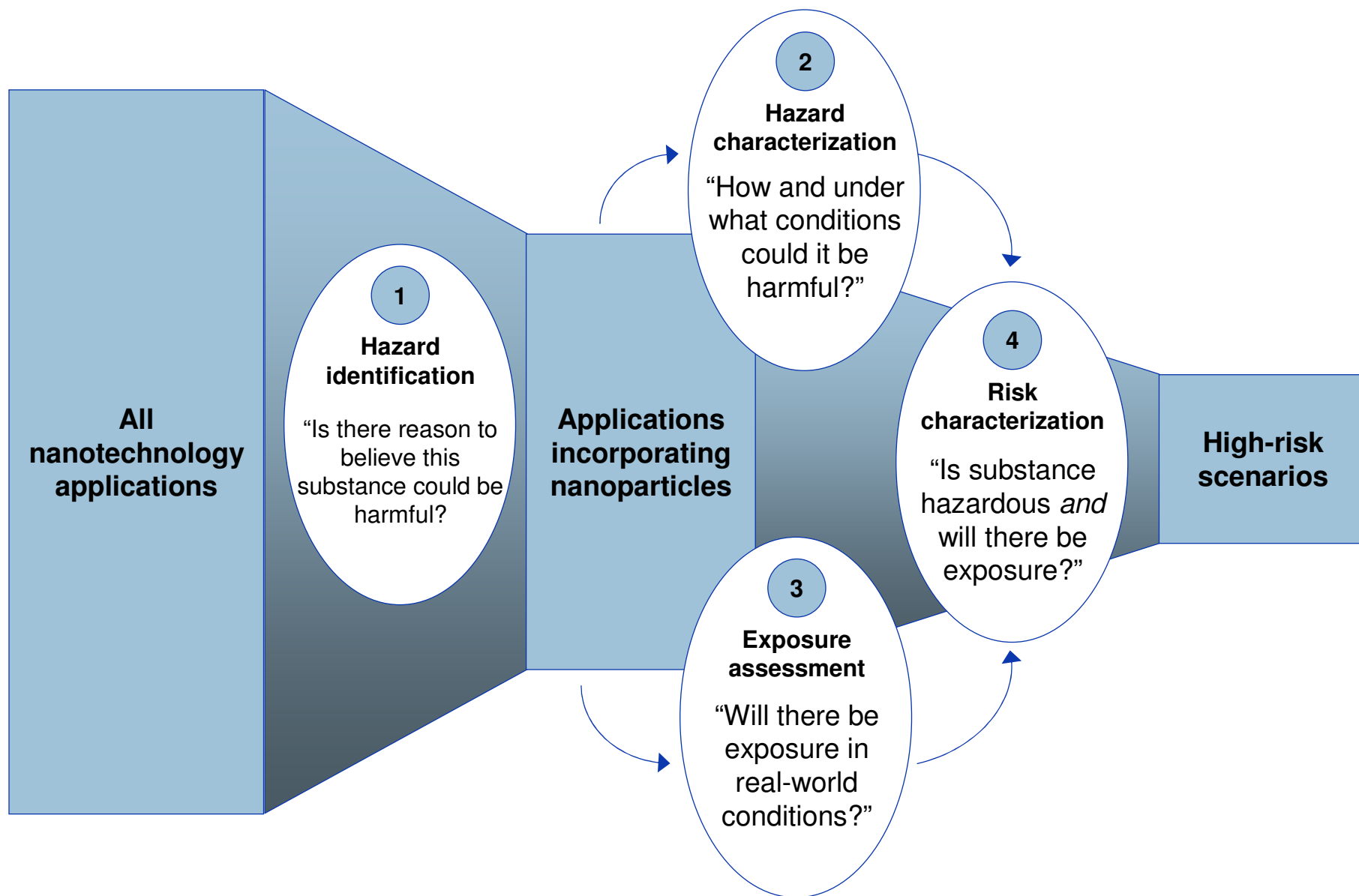
“Our CEO decided it was too early to make any more investments in nanotech until the FDA makes some decisions on how it will be handled. We’re all very disappointed about this since we have already dedicated significant resources.”

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Firms need a comprehensive plan for nanotech EHS





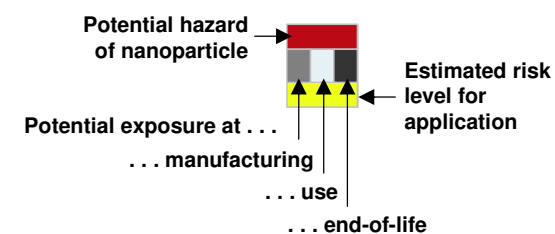
Source: Lux Research Report “A Prudent Approach to Nanotechnology Environmental, Health, and Safety Risks”


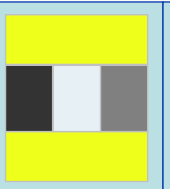

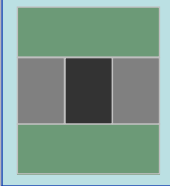
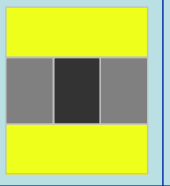
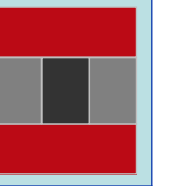
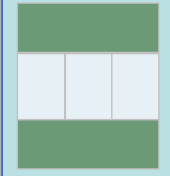
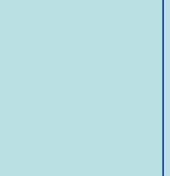
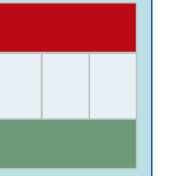


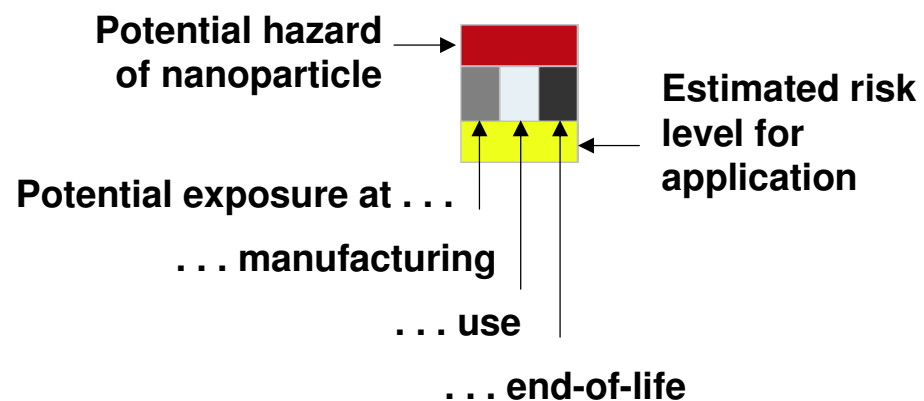
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	Single-walled carbon nanotubes	Multi-walled carbon nanotubes	Nanoclay particles	Cadmium-selenide quantum dots	Zinc oxide nanoparticles	Titanium dioxide nanoparticles	Dendrimers	Fullerenes	Nanocrystalline drug formulations	Silicon nanowires
In vivo imaging										
Structural composite for automotive body										
Sunscreen additive										
Food additive										
Display backplane										
Polishing agent										
Memory chip										
Printer toner										
Drug										
Flexible solar cell										



	Nanoporous silicon	Dendrimers	Single-wall carbon nanotubes
Structural composite for auto body			
Drug			
Memory chip			



Hazard/risk level:



Exposure:



Integrate EHS into product development to ensure a smooth path forward in the future

Real Risks

**Perceptual
Risks**

Regulations

Stage 2: **Identify**

Stage 3: **Plan**

Stage 4: **Implement**

Stage 5: **Launch**

Launch

Ongoing
monitoring of
hazard/exposure

Publish and
promote data on
product safety

Share studies
as regulations
evolve

Conclusions

- Nanotech is affecting many industries across the value chain
- EHS risks need attention, but aren't always well-understood
- Companies can manage nanotech EHS responsibly

Thank you

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