CURSO NANOTECNOLOGÍAS: SOCIEDAD, SALUD Y MEDIO AMBIENTE

- “Riesgos y beneficios para la salud humana de las nanotecnologías”
- DR. PAULO R. MARTINS
- Coord da RENANOSOMA

- **CICLO DE CIENCIA Y TECNOLOGIA**
- **UNIVERSIDAD COMPLUTENSE DE MADRID**
- MADRID, 4 DE MARÇO DE 2008

RENANOSOMA: www.nanotecnologia.iv.fapesp.br

URICH BECK

- “Apenas uma parte das competências nas quais são baseadas as tomadas de decisões se juntam ao nosso sistema político e estão sujeitos ao princípio da democracia parlamentar. Uma outra parte é removida das regras de fiscalização e aprovação pública e *delegada as empresas em nome da liberdade de investimento e da liberdade de pesquisa na ciência*.”

- Beck, U. Risk Society: Towards a new modernity 1992, Londres, Sage, p.184

LA NANOBIOTECNOLOGÍA EN LA MEDICINA Y LA BIOLOGÍA

Nanociencia para el estudio de los seres vivos:

¿Nuevas técnicas?

¿Cuáles son las preguntas que podríamos contestar ahora?

¿Cuál es la demanda de nuevas capacidades a estas escalas? Por ejemplo: instrumentos nuevos, cálculos y simulaciones para explicar experimentos, etc.

¿Cuáles son las nuevas terapias posibles: actualmente, en cinco años y en 10 años?

SISTEMAS NANOESTRUTURADOS

modular a função barreira do estrato córneo e controlar a penetração cutânea

aumentar a estabilidade química do ativo (degradação química e enzimática)

aumentar a interação do ativo com a pele

aumentar a atividade termodinâmica

diminuir efeitos irritantes

formulações com maior segurança, eficácia, estabilidade e melhores características sensoriais

De Rosa *et al*., 2003; Karande *et al*., 2004; Barry, 2004; Cevc, 2004; Lopes *et al*., 2005; Sadhale e Shah, 1999; Sandri *et al*., 2004

NANOBIOTECHNOLOGY

1. Research and technology development, or products that are at the atomic, molecular or macromolecular levels, and where at least one dimension, that affects the functional behavior of the product, is in the length scale ranging between 1-100 nanometers.

2. Creating and using structures, devices and systems that have novel properties and functions because of their small and/or intermediate size.

3. Ability to control or manipulate at the atomic scale.

FDA

Nanotechnology has several meanings

Depends on the area: different techniques

Better refer to
'NANOTECHNOLOGIES than
'NANOTECHNOLOGY'

- PHARMACEUTICAL FIELD

Some of Nanotechnology more prominent benefits would be:

Plastic eletronics
Sensors
Health screening
Lighter stronger materials
Clean-up of contaminates ground
Water purification
Implants
Targed delivery systems

Manufacturing

- Precision Manufacturing
- Material Reuse
- Miniaturization

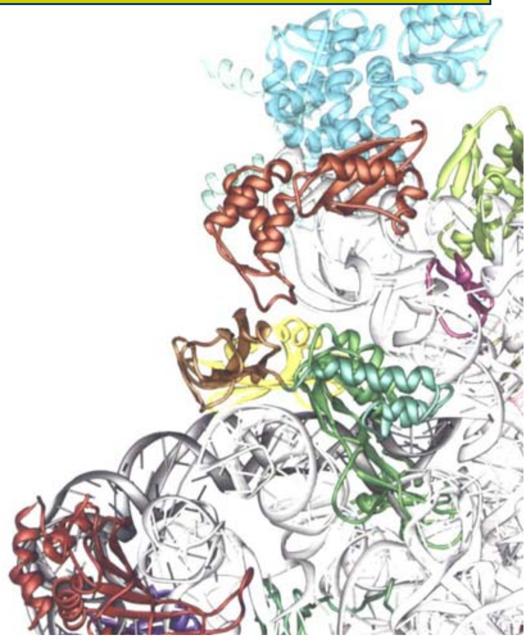
Environment

- Toxin Cleanup
- Recycling
- Resource Consumption Reduction

Medicine

- Pharmaceutical Creation
- Disease Treatment
- Nanomachine-assisted Surgery

Andrew Chen



BENEFICIAL USES OF NANOBIOTECHNOLOGY

- Tiny devices that roam the body, finding and destroying viruses or cancer cells
- Superfast drug discovery at a fraction of today's cost
- Ultraspecific drug targeting
- New biosensor for pollutants
- New medical devices

A mini nano sub cruises an artery

BBC News 2003

Biopharmaceutics

Drug Delivery

- Drug Encapsulation
- Functional Drug Carriers

Drug Discovery

Implantable Materials

Tissue Repair and Replacement

- Implant Coatings
- Tissue Regeneration Scaffolds

Structural Implant Materials

- Bone Repair
- Bioresorbable Materials
- Smart Materials

Implantable Devices

Assessment and Treatment Devices

- Implantable Sensors
- Implantable Medical Devices

Sensory Aids

- Retina Implants
- Cochlear Implants

Surgical Aids

Operating Tools

- Smart Instruments
- Surgical Robots

Diagnostic Tools

Genetic Testing

- Ultra-sensitive Labeling and Detection Technologies
- High Throughput Arrays and Multiple Analyses

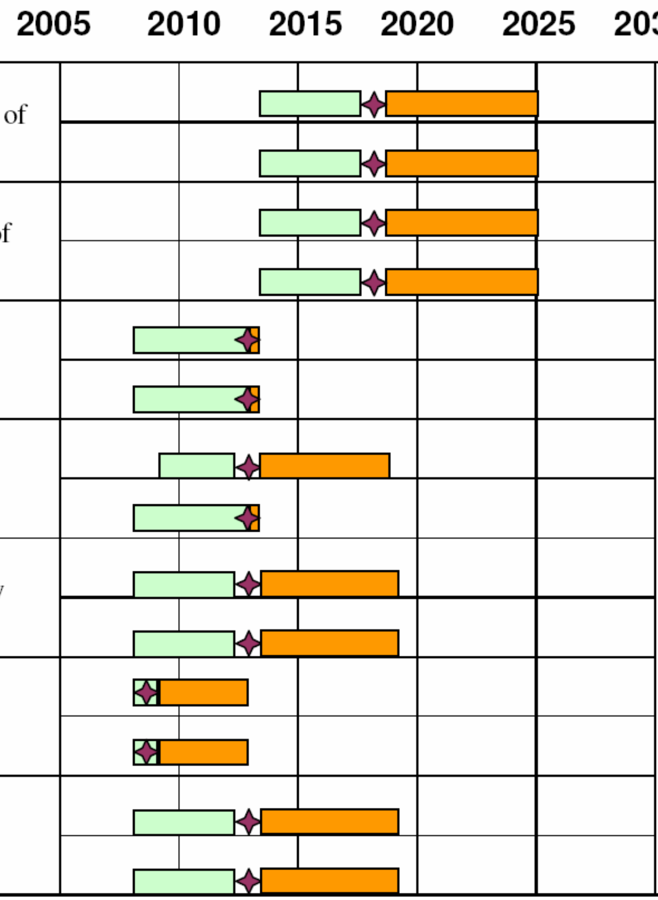
Imaging

- Nanoparticle Labels
- Imaging Devices

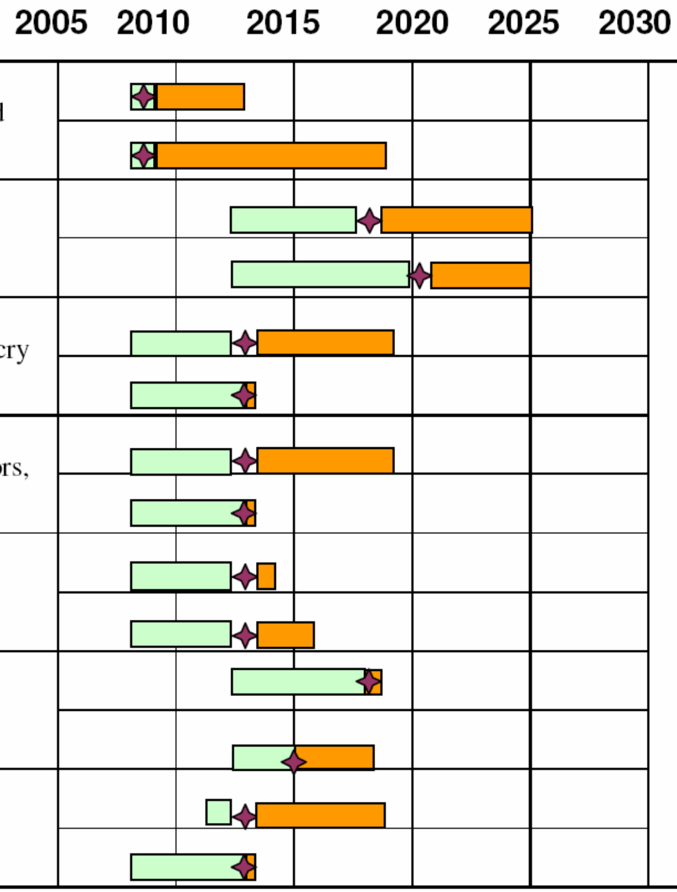
Understanding Basic Life Processes

1st line in each statement: all respondents
2nd line: experts/ & knowledgeable

Graph 3: Time of realization – all statements



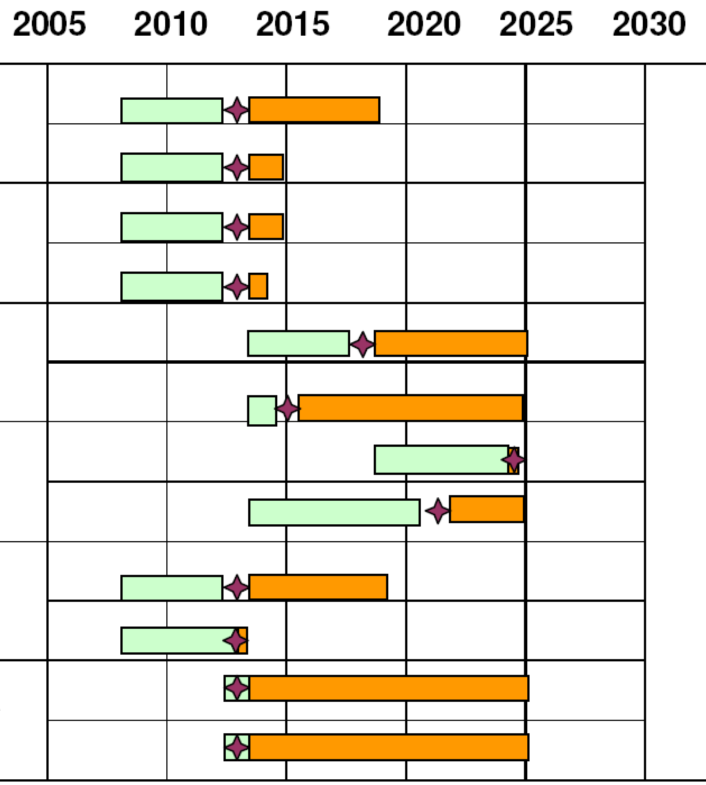
Statement	N	"Never"
1. Cellular cycle Thanks to advances in nanobiotechnology, the fundamental processes of the cellular cycle are mostly understood	79	7.6 %
	46	6.5%
2. In vitro construction of human organs Advancements in nanobiotechnology enable the construction in vitro of artificial human organs.	51	7.8%
	25	8.0%
3. Nanostructured biomaterials Novel nanostructured biomaterials replace existing materials (e.g. polymers).	64	10.9%
	46	13%
4. Targeted drug delivery Targeted drug delivery based on nanoparticles becomes a standard tool (for therapeutic purposes, performance enhancement etc).	73	1.4%
	49	2.0%
5. Smart probes used in in-vivo Smart probes (that illuminate when reaching their target) are practically used in diagnosis in-vivo.	40	5.0%
	22	0%
6. Biodetection with smart nano-surfaces Smart and adaptable surfaces at the nanoscale are the basic building block for Biodetection.	52	0%
	38	0%
7. Nanotools for manipulation inside cells Nanotools (e.g. optical tweezers) are used for manipulation inside cells while keeping the cells' integrity and activity.	39	12.8%
	19	5.3%



Item	N	"Never"
8. Nano-agents for analysis inside cells Nanosized imaging agents (e.g. quantum dots) are used for analysis and diagnosis inside cells without affecting their normal functionality.	51	5.9%
	30	0%
9. Bio energy conversion in micro/nano systems Biological energy conversion systems (e.g. biomolecular motors) are practically used in artificial micro and nano systems.	33	12.1%
	18	11.1%
10. Bio-inspired materials Advanced bio-engineered materials based on bio-inspiration/ bio-mimicry are widely used.	36	0%
	20	0%
11. Labs on chip Labs on chip are widely used for various applications, in different sectors, including households.	46	0%
	31	0%
12. Protein & DNA chips integrated Protein chips are integrated with DNA chips for specific diagnosis purposes in current hospital practices.	31	0%
	24	0%
13. Protein chips for personal use Protein chips are widely used by the public for personal use.	31	25.8%
	22	18.2%
14. Cells on chips replace animal testing In vitro tests based on cells on chips replace animal testing for various applications (e.g. pharma, cosmetics…).	32	18.8%
	20	20%

N N2L expert survey report December 2005

	N	"Never"
15. Biosensors for single molecules Biosensors for detection of single molecules based on nano arrays (for example, arrays of nanotubes) are commercially available.	42 31	4.8% 6.5%
16. Self-assembly widely implemented Self-assembly is widely implemented as a technique for development of materials and devices.	47 38	4.3% 0%
17. Self-repairing in artificial systems Living self-repairing abilities are implemented in artificial systems.	22 10	22.7% 20.0%
18. Nanomachines inside the body Nano-machines for theranostics (therapy and diagnosis) are practically used inside the body.	35 19	11.4% 15.8
19. Chips employing biomolecules Chips employing biomolecules as active elements are commercially manufactured.	39 20	5.1% 5.0%
20. Chips made by using DNA / peptides Nanoelectronics chips are commercially manufactured by using DNA or peptides (as templates or for nanopatterning).	34 19	5.9% 0%



Box 2. Nanotechnology in drug delivery: cost benefits

- Enhance delivery leads to superior performance characteristics of the product.
- The lifespan of the blockbuster drugs can be resurrected by reformulating the drugs through novel delivery system.
- The effective patent protection can be enhanced.
- Drug delivery formulation involves low-cost research compared to that for the discovery of a new molecule.
- Minimizing use of expensive drugs would reduce the cost of the product.

Sanjeeb *et al.* DDT 2003

Impactos à saúde e ao meio ambiente

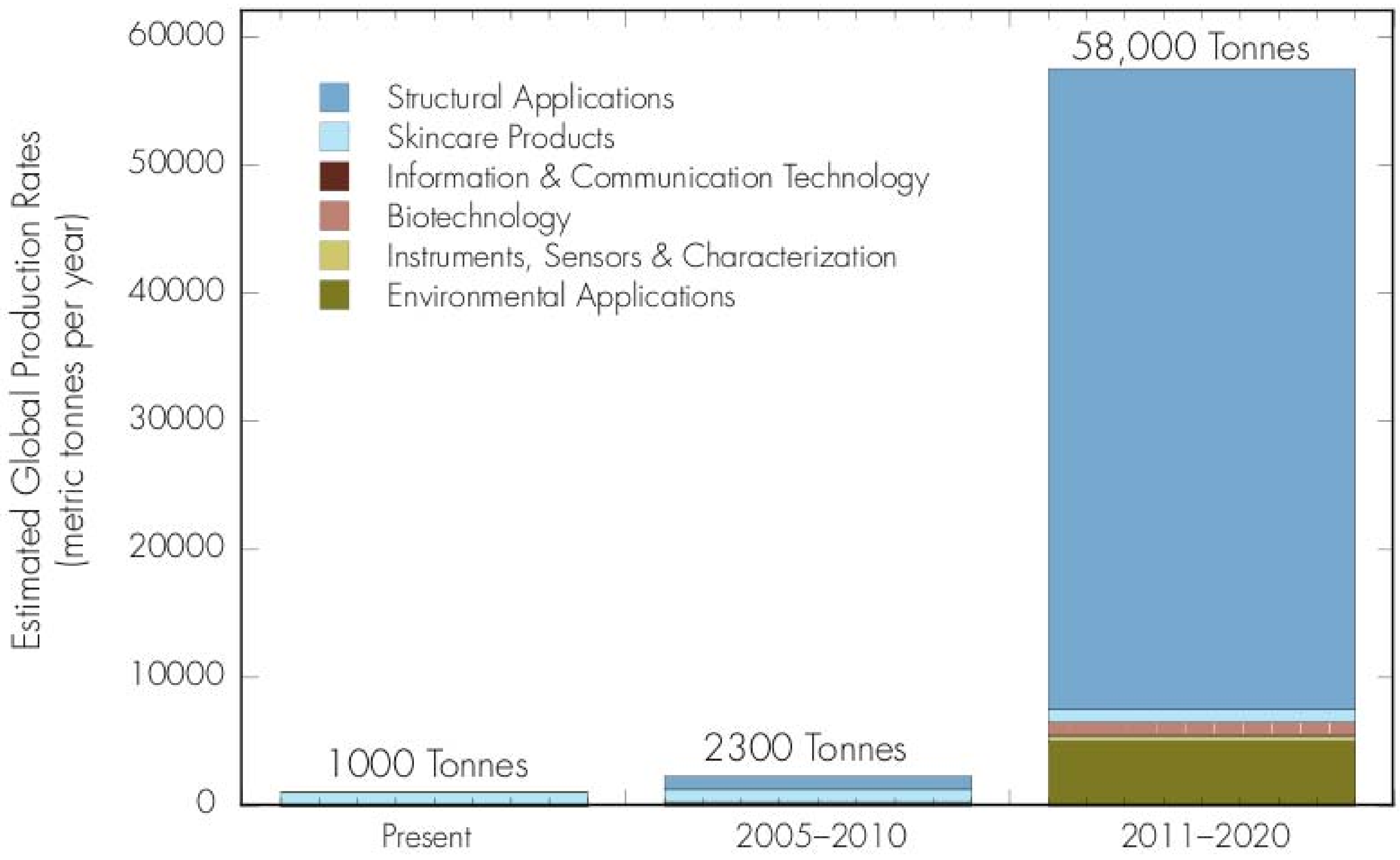
- **Os investimentos em pesquisa de novos materiais em nanotecnologia são cerca de 100 a 1000 vezes maiores (dependendo do país) do que os estudos sobre os impactos à saúde e meio ambiente**
- **DÚVIDAS!!!!!!!!!**

TABLE 1. U.S. FEDERAL GOVERNMENT ANNUAL SPENDING ON NANOTECH-RISK R&D ($MILLIONS)

Agency	NNI-estimated risk-related annual R&D	PEN-estimated risk-related annual R&D (all relevant research)	PEN-estimated risk-related annual R&D (highly relevant research)
NSF	24.0	19.0	2.5
DOD	1.0	1.1	1.1
DOE	0.5	0.3	0
HHS (NIH)	3.0	3.0†	3.0†
DOC (NIST)	0.9	1.0	0
USDA	0.5	0.5	0
EPA	4.0	2.6	2.3
HHS (NIOSH)	3.1	3.1††	1.9†††
DOJ	1.5	0	0
Totals	**38.5**	**30.6**	**10.8**

Annual spending estimated from the National Nanotechnology Initiative and the Project on Emerging Nanotechnologies (PEN).[25] Highly relevant research (right hand column) is specifically focused on health and environmental risks associated with engineered nanomaterials, and is included in the broader analysis of all relevant research (middle column). NNI figures are estimated budgets for October 2005–September 2006, while PEN figures are estimated expenditure for January–December 2005. †Estimate, based on research within the National Toxicology Program. ††Based on aggregated funding. Reported by NNI †††Estimated from the percentage of projects highly relevant to engineered nanomaterials.

FIGURE 1. ESTIMATED ANNUAL GLOBAL PRODUCTION RATES FOR ENGINEERED NANOMATERIALS



Values are based on estimates in the 2004 *Royal Society and Royal Academy of Engineering* report on nanotechnology.[9] They are intended for guidance only, as validated figures are commercially confidential.

VALE LEMBRAR QUE

- NANO PARTÍCULAS SÃO AFETADAS POR EFEITOS QUANTICOS
- ESTES EFEITOS MUDAM O COMPORTAMENTO ÓTICO, ELETRICO, MAGNÉTICO, RESISTÊNCIA
- NANO PARTÍCULAS PODEM SER QUIMICAMENTE MAIS REATIVAS
- ALGUMAS VEZES MATERIAIS DEIXAM DE SER INERTES EM NANOESCALA

UN. TASK FORCE. SCIENCE, TECHNOLOGY AND INNOVATION INNOVATION: APPLAYING KNOWLEDGE IN DEVELOPMENT, P.70

TOXICOLOGIA DOS NANOMATERIAS

[redacted]

Questões:

- ***Qual é a toxicidade destes materiais?***
- ***Podem ser agrupados materiais semelhantes relacionado a sua bioatividade?***
- ***Quais é a dose-resposta destes materiais?***
- ***Quais são os métodos apropriados para ensaios?***
- ***Que modelos de extrapolação prediz a toxicidade?***
- ***Qual é o mecanismo?***
- ***Que efeito poderia ocorrer se exposta uma população humana?***

DURAN, NELSON. NANOTECNOLOGIA E MEIO AMBIENTE. I SEMINARIO INTERNACIONAL NANOTECNOLOGIA, SOCIEDADE E MEIO AMBIENTE, SÃO PAULO, 18-19 OUTUBRO 2005

NANOMATERIAIS

- ***DESTINO AMBIENTAL E BIOLÓGICO,***
- ***TRANSPORTE E TRANSFORMAÇÃO***
- ***DE NANOMATERIAIS: A informação***
- ***relacionada com destino, transporte***
- ***é necessária para estimar a***
- ***exposição. Questões:***
- ***Através de qual meio estes materiais***
- ***penetram ao ambiente?***
- ***Quais são os modos de dispersão***
- ***destes materiais no ambiente?***
- ***Estes materiais são transformados***
- ***no ambiente?***

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RISCO A SAÚDE HUMANA

- ***EXPOSIÇÃO E BIODISPONIBILIDADE***
- ***DE NANOMATERIAIS:Possivelmente***
- ***há grande risco da saúde humana***
- ***associado a fabricação de***
- ***nanomateriais.Questões:***
- ***Quanto e em que grau estão os***
- ***humanos a exposição no ambiente?***
- ***Há sub-populações mais sensíveis?***

DURAN, NELSON. NANOTECNOLOGIA E MEIO AMBIENTE. I SEMINARIO INTERNACIONAL NANOTECNOLOGIA, SOCIEDADE E MEIO AMBIENTE, SÃO PAULO, 18-19 OUTUBRO 2005

OS POSSÍVEIS PROBLEMAS ESTAO:

- NATUREZA DAS NANOPARTICULAS;
- CARACTERÍSTICAS DO PRODUTOS FEITOS;
- PROCESSOS DE FABRICAÇÃO ENVOLVIDOS;
- QUAIS MATERIAIS SAO USADOS;
- QUE REJEITO E PRODUZIDO;
- SÃO USADOS PRODUTOS TÓXICOS NA FABRICAÇÃO DE PRODUTOS NANOS?;
- O QUE ACONTECE QUANDO PARTICULAS E/OU
- PRODUTOS NANOS CHEGAM AO AR, SOLO, ÁGUA
- OU BIOTA.

FIGURE 3. NANOTECHNOLOGY ES&H RESEARCH FUNDING FOR SIX CLASSES OF ENGINEERED NANOMATERIALS, COMPARED TO CONSUMER PRODUCTS USING THOSE MATERIALS[29]

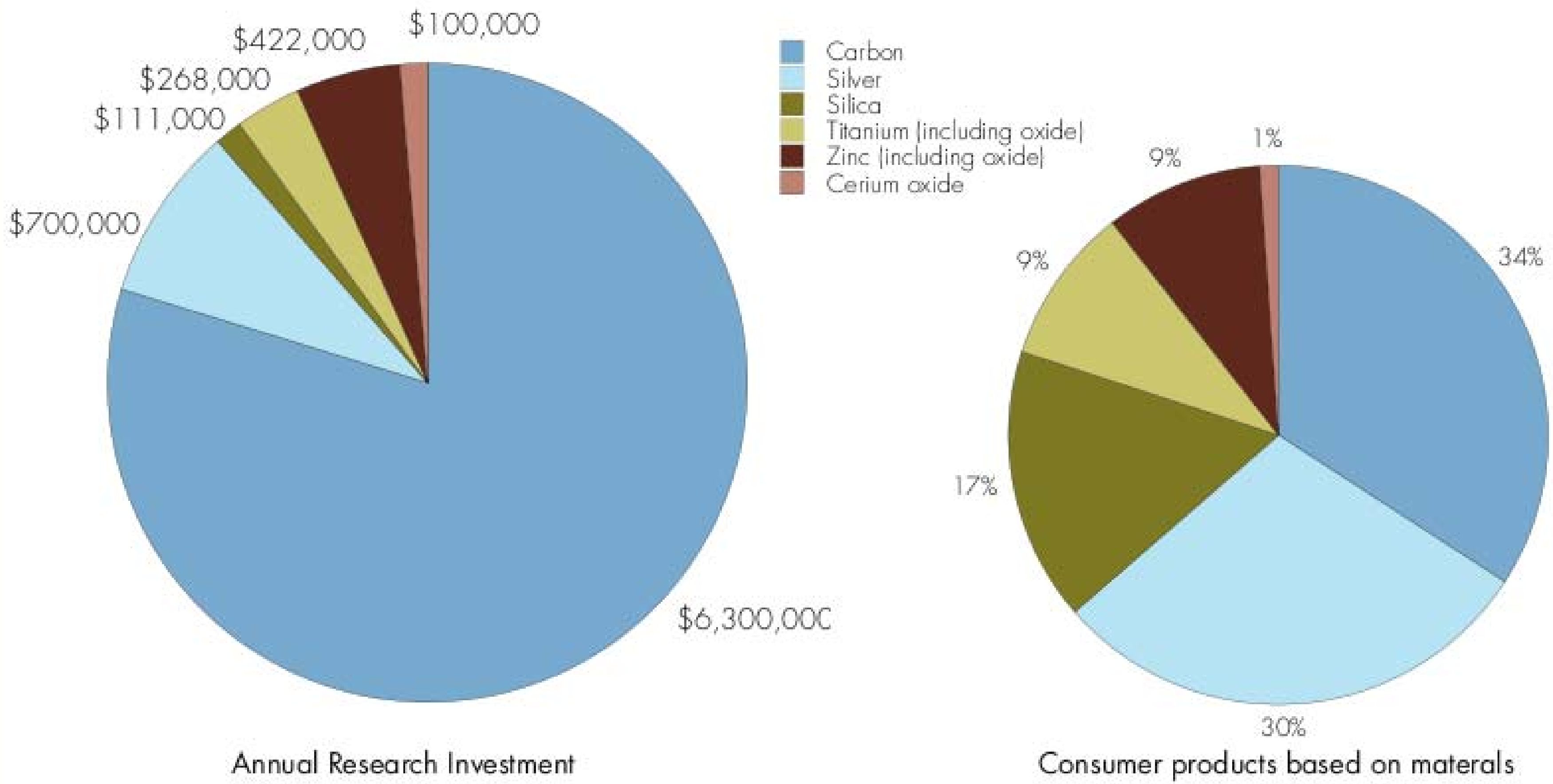
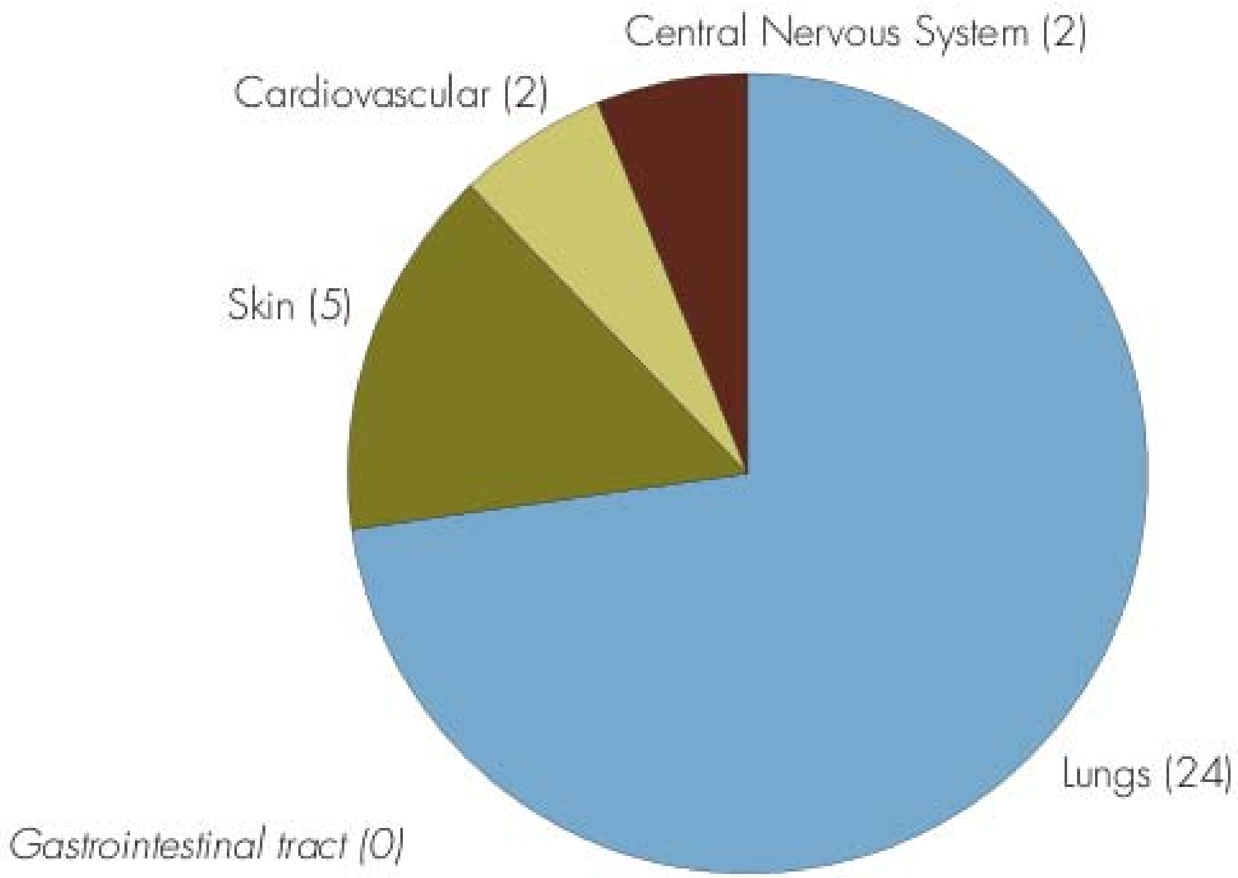
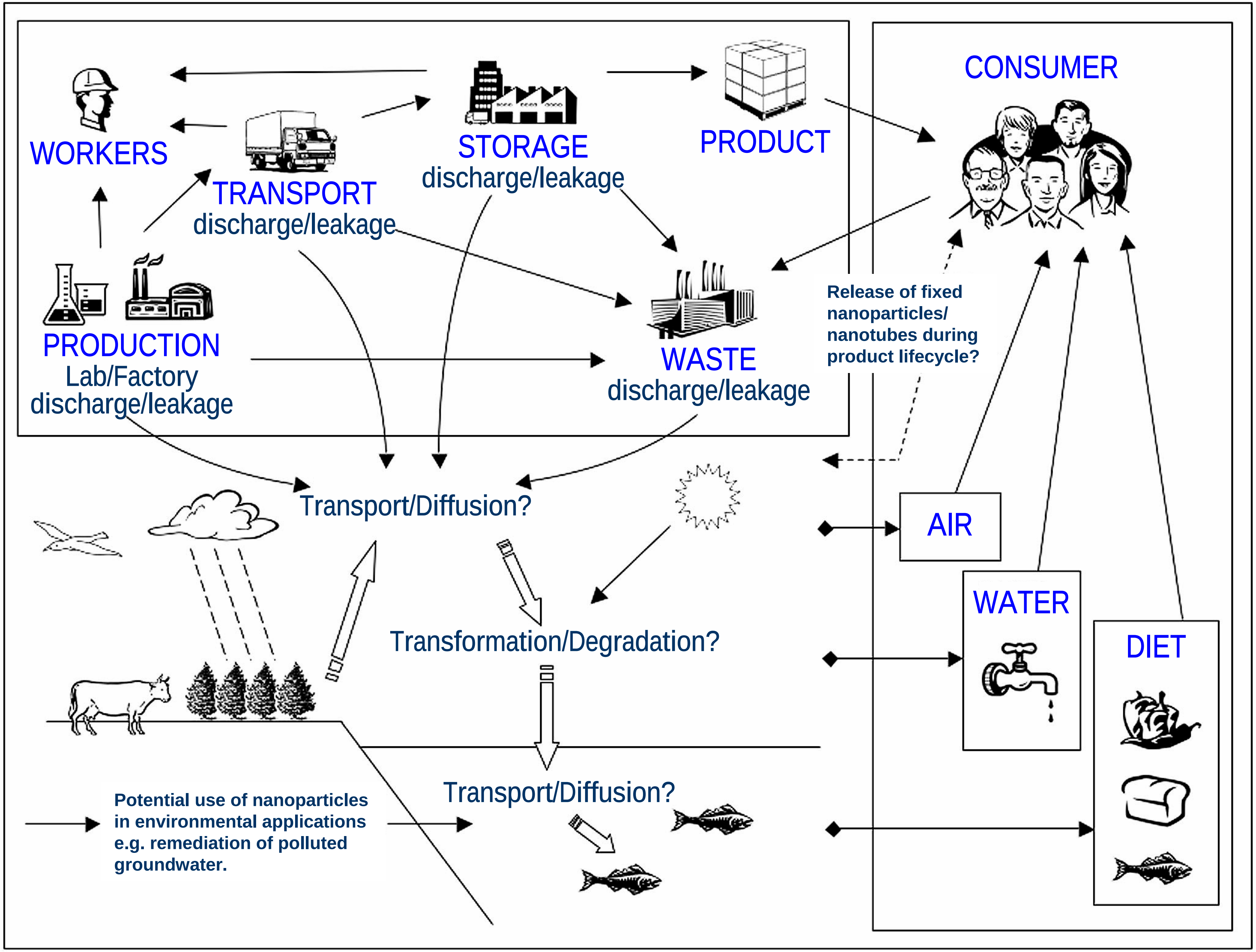
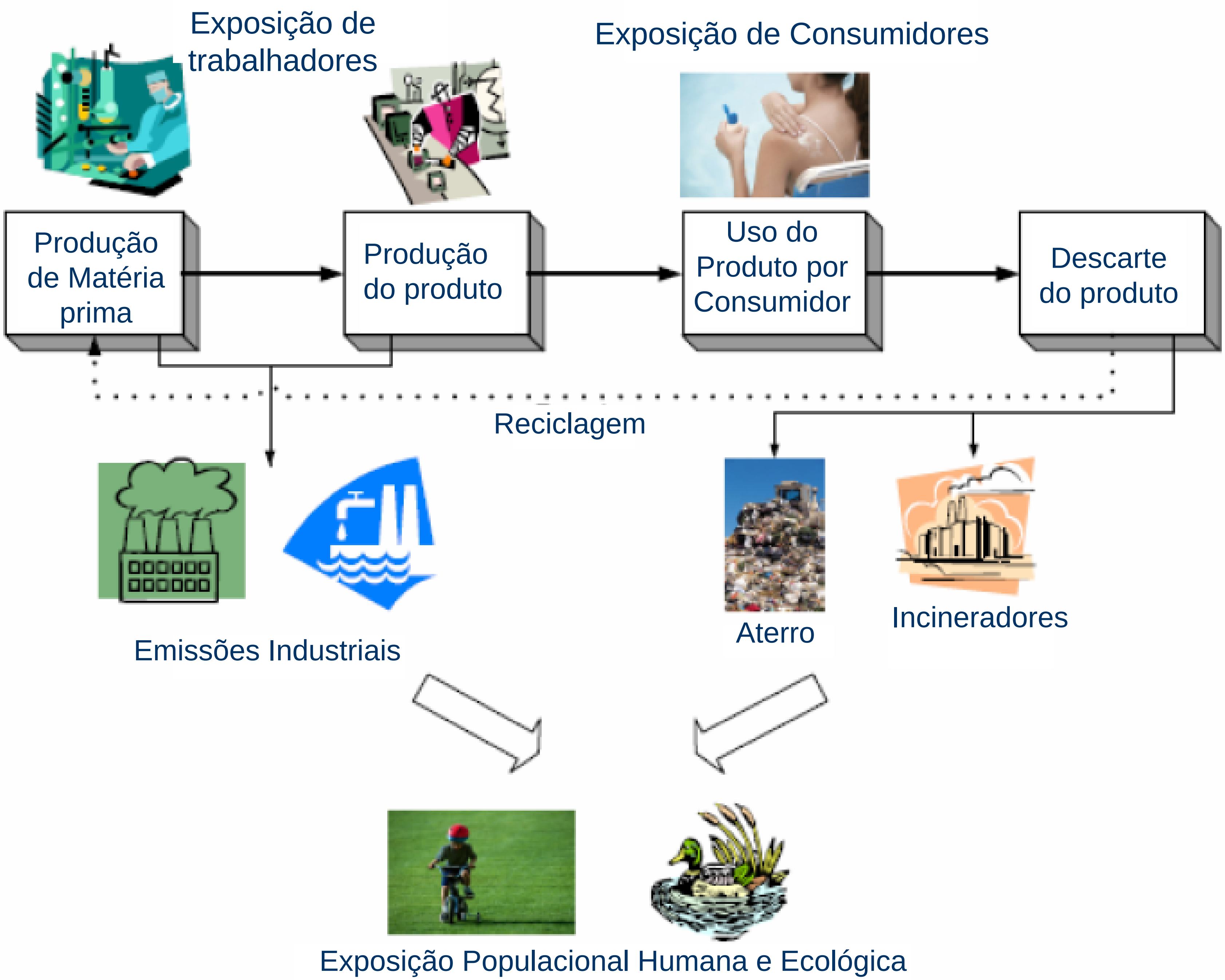


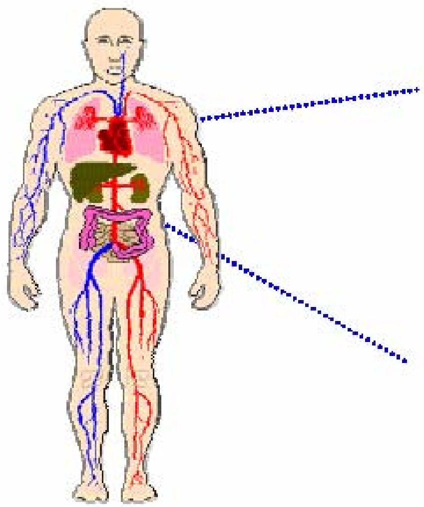
FIGURE 4. NANOTECH-RISK RESEARCH PROJECTS ON SPECIFIC AREAS OF THE BODY




CONSUMER
WORKERS
TRANSPORT
discharge/leakage
STORAGE
discharge/leakage
PRODUCT
PRODUCTION
Lab/Factory
discharge/leakage
WASTE
discharge/leakage
Release of fixed nanoparticles/ nanotubes during product lifecycle?
Transport/Diffusion?
Transformation/Degradation?
Transport/Diffusion?
AIR
WATER
DIET
Potential use of nanoparticles in environmental applications e.g. remediation of polluted groundwater.


Exposição de trabalhadores
Exposição de Consumidores
Produção de Matéria prima
Produção do produto
Uso do Produto por Consumidor
Descarte do produto
Reciclagem
Emissões Industriais
Aterro
Incineradores
Exposição Populacional Humana e Ecológica

FORMAS DE CONTAMINACAO NO SER HUMANO



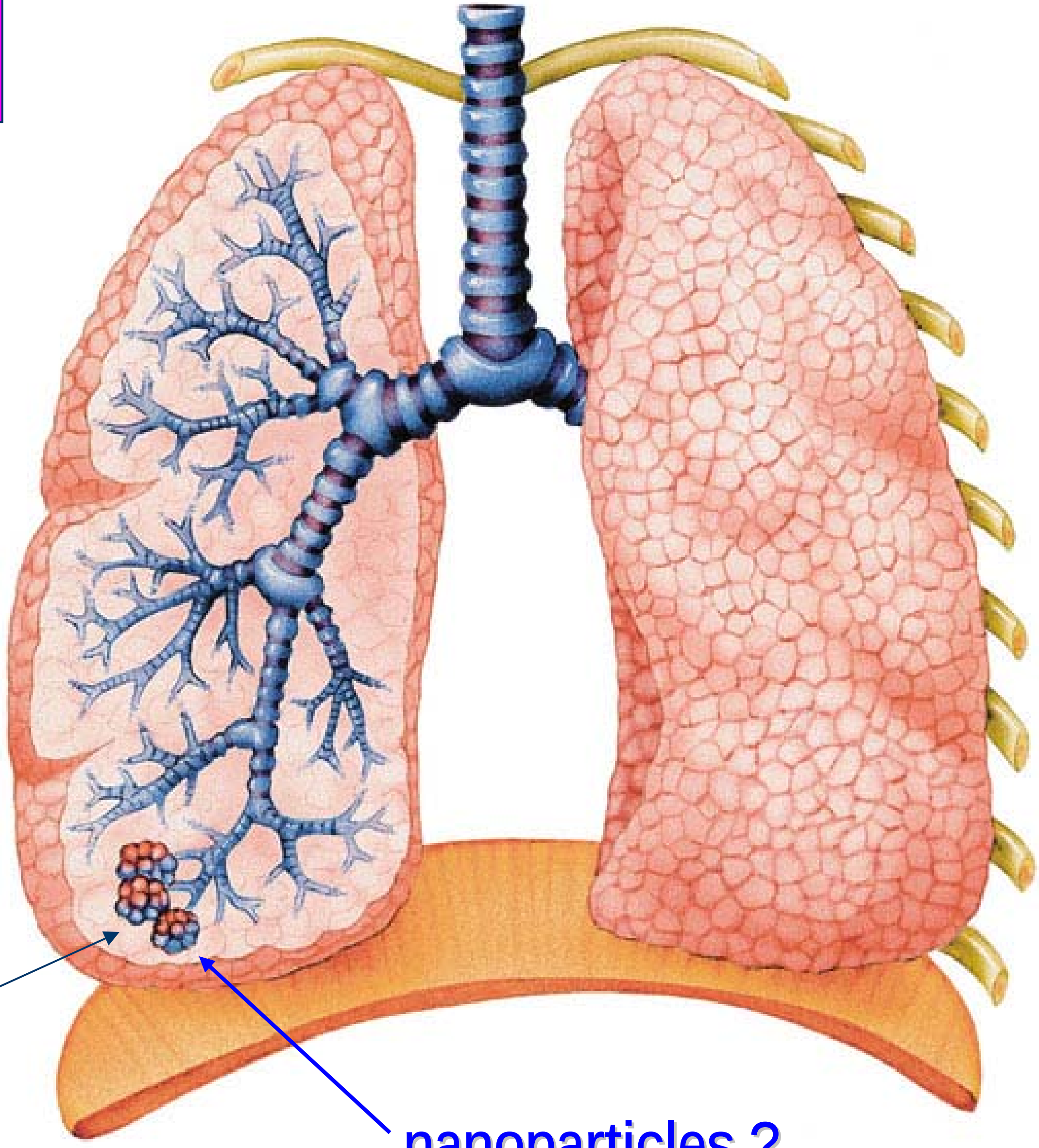
Inhaled particles could induce inflammation in the respiratory tract, causing tissue damage. Example : Inhalation of silica particles by industrial workers could cause "silicosis".

Ingested nanoparticles may cause liver damage: ingested nanoparticles (i.e. for oral drug delivery) have been found to accumulate in the liver, which could eventually provoke excessive immune/inflammatory responses causing permanent liver damage.

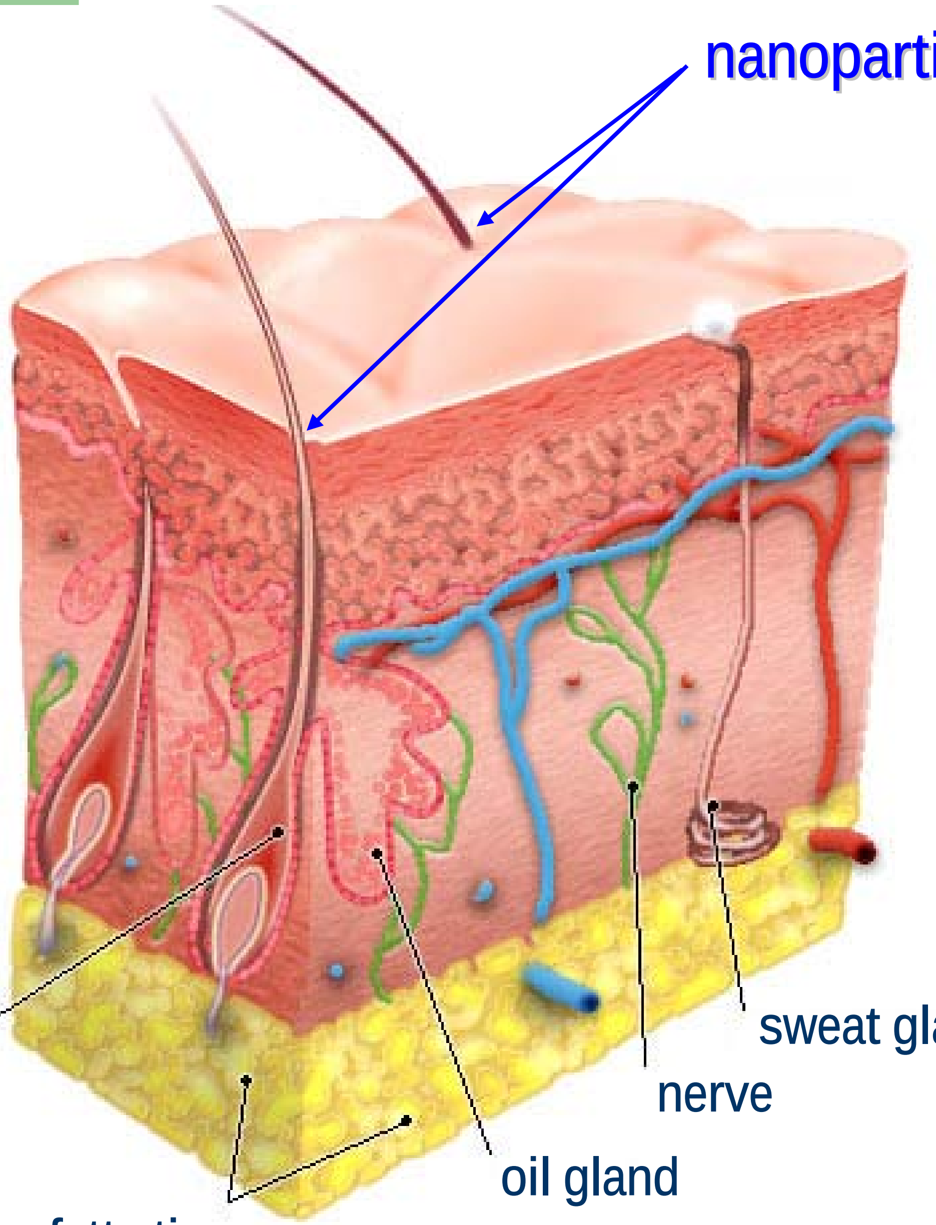
Figure 3.1. Source: http://www.environmentalfutures.org (Vicki Colvin study)

European Nanotechnology Gateway. Benefits, Risks, Ethical, Legal and Social Aspects of Nanotecnology, p.46

Lungs



Skin



nanoparticles ?
epidermis
dermis
follicle
fatty tissue
oil gland
nerve
sweat gland

Alguns estudos já realizados

- **Estudo publicado em julho de 2004 descobriu que moléculas de carbono em nanoescala, fulerenos, podem rapidamente desencadear danos cerebrais em peixes**

- **Em 2005, pesquisadores da Universidade de Rochester, EUA, demonstraram que coelhos ingerindo fulerenos mostraram um aumento na suscetibilidade à coagulação do sangue**

Alguns estudos já realizados

- **Também há algumas evidências que nano partículas de carbono pode diretamente entrar no cérebro via mucosa nasal respiratória e do bulbo olfativo**

- **Estudos preliminares, ressalta o toxicologista e pesquisador do Hospital de Bordeaux Patrick Brochard, indicam que, em contato com a pele, as partículas podem originar reações inflamatórias dos tecidos.**

E os Riscos em Nanotecnologia? Entre outros trabalhos ver:

- Science Vol 311Feb 2006. Toxic Potential of Materials at the Nanolevel. Net, Andre et All
- Swiss Re.2004, Nanotechnology: Small Matter, Many Unknowns. Zurich, Switzerland
- The Royal Society and Royal Academy of Engeneering, 2004. Nanocience and Nanotechnologies: Opportunities and Incertanties
- ETCGroup, 2004. Down on the farm: The Impact of Nano-scale Technologies on Food and Agriculture. Ottowa Canada
- European Commission 2004. A Preliminary Risk Analiysis on The Bases of a Workshop 1-2 March 2004.

Conclusão

- **Ainda há muito pouco estudo sobre os impactos dos materiais nanoestruturados na saúde e no meio ambiente, e em conseqüência na SST**

- **Há muito o que ser feito na elucidação dos possíveis efeitos e principalmente nos desenvolvimento de mecanismos que evitem o aparecimento de possíveis danos**

TABLE 3. NANOTECH RISK-RESEARCH AREAS THAT NEED ADDRESSING

Research areas	Sources								
	A	B	C	D	E	F	G	H	I
Human health hazard	■	■	■	■	■	■		■	■
Toxicity evaluation	■	■	■	■	■			■	■
Screening tests	■			■					■
Endpoints	■	■							
Testing methods	■	■	■					■	
Predictive toxicology	■	■				■		■	
Structure activity relationships	■	■							
Role of material physicochemistry	■	■							■
Computational toxicology	■	■							
Mechanisms of toxicity	■		■						
Behavior in the body	■	■	■	■		■		■	■
Routes of entry	■			■					
Dose		■				■			■
Transport, transformation and fate	■	■	■					■	
Health outcomes		■	■	■	■	■	■	■	■
Health impact		■	■			■			
Epidemiology				■	■	■	■		
Sensitive populations		■							
Environment		■	■	■			■	■	■
Life cycle analysis		■		■			■	■	
Dispersion (including sources)		■	■						■
Transformation		■	■					■	
Fate		■	■	■					
Persistence and bioaccumulation		■	■	■					
Toxic mechanisms		■	■						
Environmental control		■							
Exposure	■	■	■	■	■	■	■	■	■
Sources	■	■	■		■	■		■	
Exposure routes	■		■			■			
Exposure metrics			■	■	■				
Measurement methods	■	■	■	■	■	■	■	■	■
Nanomaterials in the environment		■	■						
Nanostructured material behavior	■	■	■		■				
Characterization	■	■						■	

	1	2	3	4	5	6	7	8	9
Health impact		■	■			■			
Epidemiology				■	■	■	■		
Sensitive populations		■							
Environment		■	■	■			■	■	■
Life cycle analysis		■		■			■	■	
Dispersion (including sources)		■	■						■
Transformation		■	■					■	
Fate		■	■	■					
Persistence and bioaccumulation		■	■	■					
Toxic mechanisms		■	■						
Environmental control		■							
Exposure	■	■	■	■	■	■	■	■	■
Sources	■	■	■		■	■		■	
Exposure routes	■		■			■			
Exposure metrics			■	■	■				
Measurement methods	■	■	■	■	■	■	■	■	■
Nanomaterials in the environment		■	■						
Nanostructured material behavior	■	■	■		■				
Characterization	■	■						■	
Control		■	■	■	■	■	■		
Potential release routes					■				
Engineering control		■	■	■	■	■	■		
Substitute materials						■			
Personal protective equipment		■				■			
Respirators and filters		■			■	■			
Process/material based control									
Spills		■							
Risk reduction	■			■	■	■	■	■	■
Risk assessment				■	■	■	■	■	■
Best practices	■			■	■	■		■	
Standards	■	■	■	■	■	■	■		■
Terminology			■		■		■		■
Measurement	■			■					
Materials	■	■	■		■	■			
Safety			■	■					
Informatics	■			■		■			
Research approaches		■	■	■	■	■	■	■	■

Research areas as identified in nine sources (Table 2)

TABLE 5. SHORT-TERM RESEARCH NEEDS (NOMINALLY 2007–2009)

Category	Research Needs
Immediate research needs	• Appropriate measurement methods • Best practices for working with engineered nanomaterials • Engineering controls • Exposure routes • Instrument-based exposure metrics • Personal protective equipment and respirator development and evaluation • Potential release routes • Process-based controls • Responsive and effective methods of doing risk research • Sources of exposre • Toxicity screening tests
Early investment in medium-term research	• Control and management of spills • Dose-metrics relevant to target organs • Ecotoxicity - toxicity testing • Health outcomes associated with exposure • Life cycle analysis • Measurement standards • Nanomaterial characterization • Predictive toxicology - role of physicochemistry and mechanisms of toxicity • Risk assessment • Routes of entry into the body • Safety (risk of physical harm) • Toxicity evaluation, including identification of appropriate endpoints and testing methods

	• Toxicity screening tests
Early investment in medium-term research	• Control and management of spills • Dose-metrics relevant to target organs • Ecotoxicity - toxicity testing • Health outcomes associated with exposure • Life cycle analysis • Measurement standards • Nanomaterial characterization • Predictive toxicology - role of physicochemistry and mechanisms of toxicity • Risk assessment • Routes of entry into the body • Safety (risk of physical harm) • Toxicity evaluation, including identification of appropriate endpoints and testing methods
Early investment in long-term research	• Computational toxicology • Control - substitute materials • Dispersion, transformation, fate, persistence and bioaccumulation in the environment • Ecotoxicity - toxic mechanisms • Informatics • Nanomaterials release into the environment • Standards - terminology, reference materials • Structure activity relationships • Transport, transformation and fate in the body

Research is categorized as addressing immediate needs, or laying the groundwork for medium-term and long-term priorities, based on Table 4. Research needs are listed in alphabetical order, and are not further prioritized.

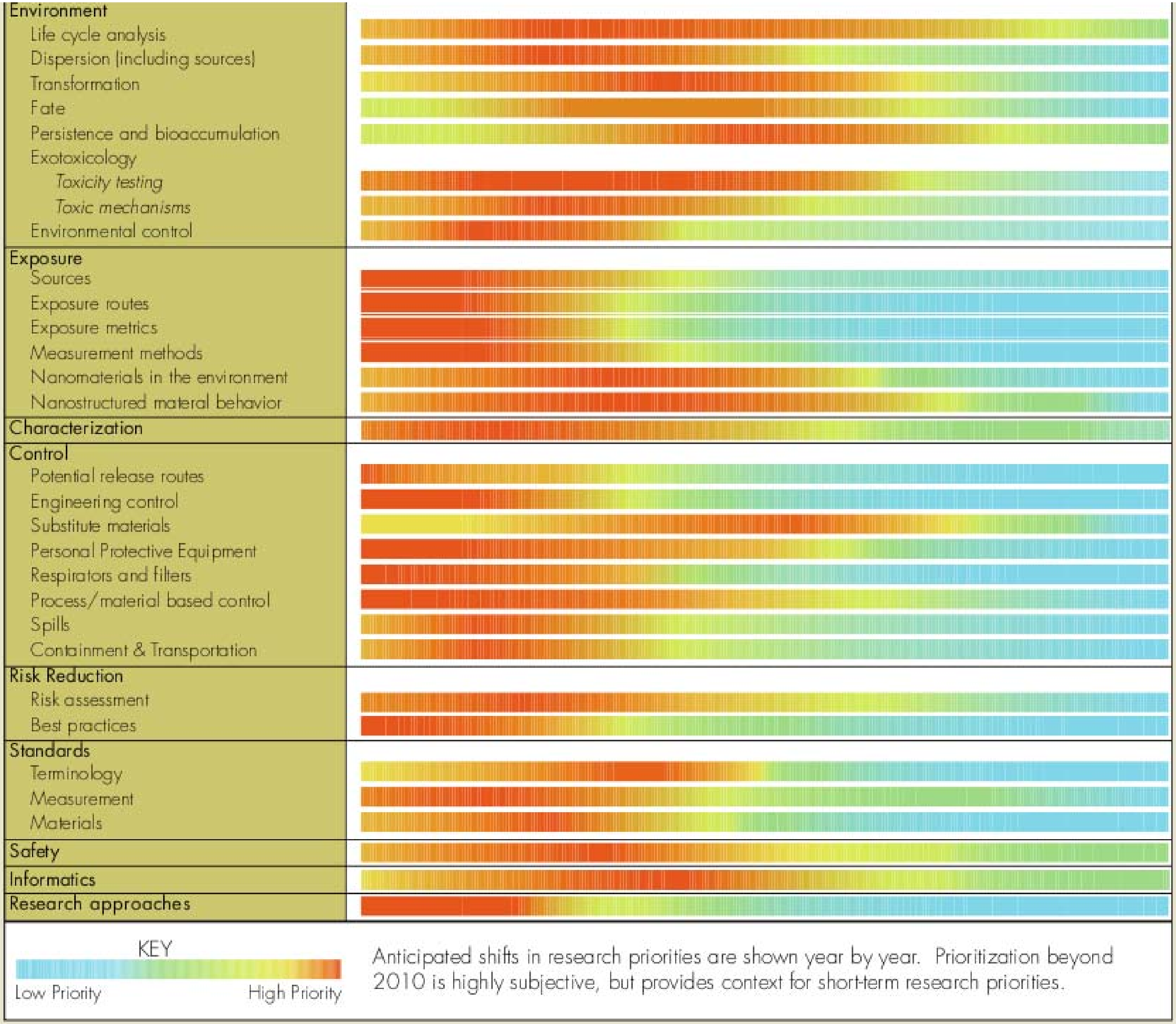
TABLE 6. SHORT-TERM RESEARCH GOALS

Lead Agency	Short Term Research Goals	Estimated Fundi
Cross Agency	• Develop research methodologies to proactively address risk • Begin developing appropriate risk assessment tools • Preliminary development of informatics systems for nanomaterials	7
EPA	• Identify sources and routes of exposure and release - environment • Develop and evaluate environmental measurement methods • Preliminary development of appropriate methods for evaluating ecotoxicity • Preliminary development of life cycle analysis tools for engineered nanomaterials • Preliminary investigation of ecotoxicity mechanisms • Preliminary investigation of nanomaterial release into the environment • Begin to study dispersion, transformation, fate, persistence and bioaccumulation in the environment	20
NIH	• Begin to evaluate the toxicity of representative nanomaterials • Preliminary development of appropriate toxicity testing endpoints • Preliminary development of appropriate toxicity testing methods • Begin developing predictive toxicology capabilities • Begin developing computational toxicology for engineered nanomaterials • Preliminary investigation of nanomaterial structure activity relationships	24
NIOSH	• Develop and evaluate human exposure measurement methods • Develop guidance on best possible working practices • Develop and evaluate personal protective equipment • Develop and evaluate respiratory protective equipment • Develop and evaluate process-based controls • Identify sources and routes of exposure and release - workplaces • Develop instrument-based exposure metrics	46

	Begin to study dispersion, transformation, fate, persistence and bioaccumulation in the environment	
NIH	• Begin to evaluate the toxicity of representative nanomaterials • Preliminary development of appropriate toxicity testing endpoints • Preliminary development of appropriate toxicity testing methods • Begin developing predictive toxicology capabilities • Begin developing computational toxicology for engineered nanomaterials • Preliminary investigation of nanomaterial structure activity relationships	24
NIOSH	• Develop and evaluate human exposure measurement methods • Develop guidance on best possible working practices • Develop and evaluate personal protective equipment • Develop and evaluate respiratory protective equipment • Develop and evaluate process-based controls • Identify sources and routes of exposure and release - workplaces • Develop instrument-based exposure metrics • Develop and evaluate appropriate toxcity screening tests • Develop a preliminary understanding of organ-specific dose • Preliminary research exploring associations between nanomaterials exposure and human health outcomes • Begin to develop methods to control and manage spills • Study the role and significance of routes of entry into the body • Preliminary investigations of nano-specific safety issues • Begin studying transport, transformation, and fate in the body • Preliminary evaluation of risk reduction through material substitution	46
NIST	• Preliminary development of appropriate nanomaterials characterization methods • Begin developing measurement and characterization standards • Begin developing standards for terminology and reference materials	9
Total		106

TABLE 4. A 10-YEAR NANO-RISK RESEARCH PRIORITIZATION

Research areas	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Human health hazard										
Toxicity evaluation										
Screening tests										
Endpoints										
Testing Methods										
Predictive Toxicology										
Structure Activity Relationships										
Role of material physicochemistry										
Computational toxicology										
Mechanisms of toxicity										
Behavior in body										
Routes of entry										
Dose										
Transport, transformation and fate										
Health outcomes										
Health impact										
Epidemiology										
Sensitive populations										
Environment										
Life cycle analysis										
Dispersion (including sources)										
Transformation										
Fate										
Persistence and bioaccumulation										
Exotoxicology										
Toxicity testing										
Toxic mechanisms										
Environmental control										
Exposure										
Sources										
Exposure routes										
Exposure metrics										
Measurement methods										
Nanomaterials in the environment										
Nanostructured materal behavior										
Characterization										
Control										
Potential release routes										
Engineering control										
Substitute materials										
Personal Protective Equipment										



A personal evaluation of research priorities. Hot/dark colors (red, orange) indicate high priority, while cooler/lighter colors (green, blue) represent lower priorities.

QUESTÕES QUE DEVEM PONTUAR O DEBATE POLÍTICO

- PARA QUE SERVE ESTA NANOTECNOLOGIA?
- QUAIS OS RISCOS DESTA TECNOLOGIA
- QUEM SERÁ SEU PROPRIETÁRIO OU IRÁ SE APROPRIAR DELA?
- QUEM IRÁ SE RESONSABILIZAR SE AS COISAS NÃO DEREM CERTO?
- EM QUEM NÓS PODEMOS CONFIAR?
- QUEM SERÃO OS INCLUÍDOS E OS EXCLUÍDOS??

SOCIEDADE CIVIL REINTERPRETA A NANOTECNOLOGIA

GRATO PELA ATENÇÃO

- CONTATO
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NANOTECNOLOGIA E MEIO AMBIENTE: OPORTUNIDADES E RISCOS

Nano & the Environment
Overview on opportunities and risks

Opportunities

- Potential for increased resource efficiency
- Substitution of harmful chemicals
- New or improved environmental technologies
- Pollutant remediation
- Clean(er) energy
- Increased fuel efficiency
- Env. Monitoring

Risks

- Increased Env. Rucksack
- Rebound-Effects
- Human- and Eco-toxicology potential
- Recyling- and Decomposition issue
- Diffusion of material with unknown characteristics (novel properties)

NANOTECNOLOGIA E MEIO AMBIENTE

Nano & the Environment

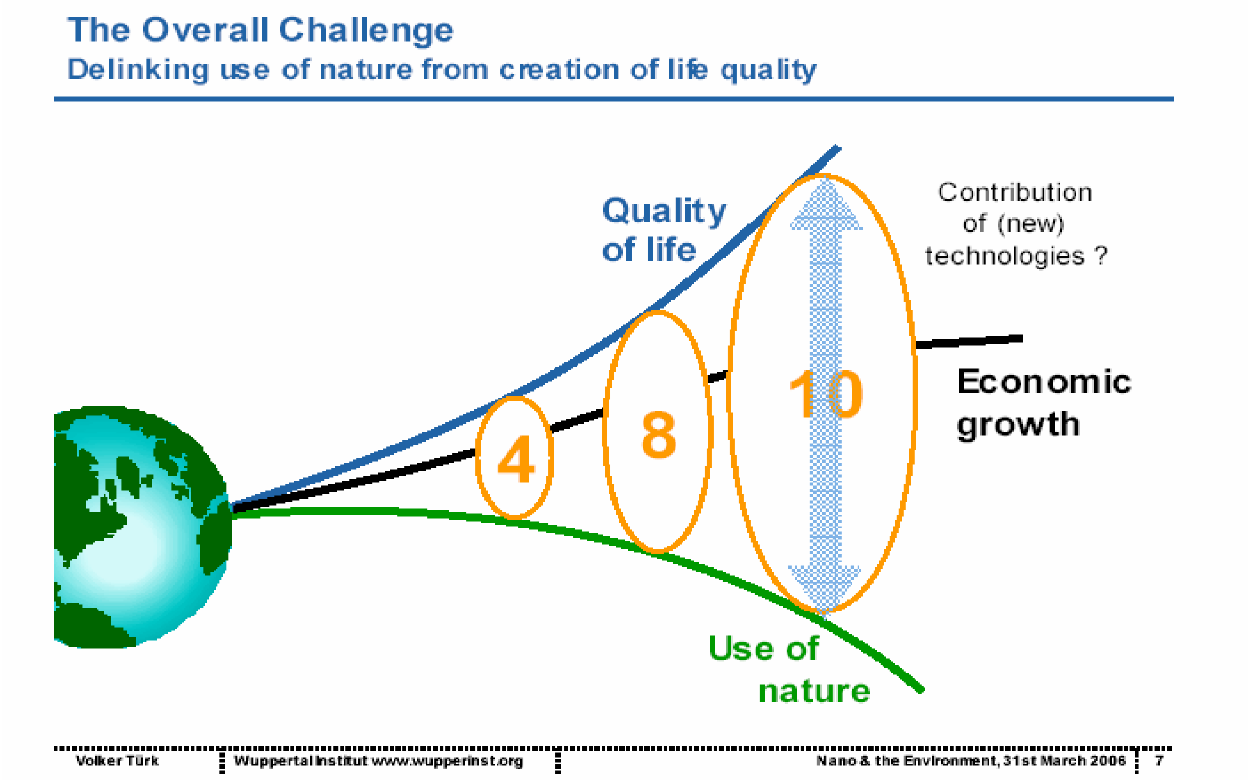
Nanotechnologies - Technologies to Improve Resource Efficiency?

Presentation by:

Volker Türk,

Wuppertal Institute for Climate, Environment, Energy
Sustainable Production & Consumption Department

O NOVO DESAFIO E A NANOTECNOLOGIA



“NANOTECNOLOGIZAR” E O MELHOR PARA O MEIO AMBIENTE?

Review
Miniaturisation - the smaller, the better?

Digital Europe

Are small products environmentally preferable?

	Weight, excl. packaging (kg)	Abiotic raw materials (kg)	Material intensity factor (kg/kg)
PC	23.1	1500	65
Notebook	2.8	434	155
Handheld	0.8	81	101

The Ecological Backpack of a Chip

Weight of chip die: 0.09g
abiotic raw materials for production: 20 kg

Source: Digital Europe, Wuppertal Institute 2003

COMO EU PODERIA IMAGINAR TER QUE VOAR COM ESTE “MOCHILA” ECOLOGICA

Review

Miniaturisation - the smaller, the better?

“ ... how am I supposed to fly with this ecological backpack ?“

Source: www.seppo.net

BICICLETA NANOTECNOLOGICA

Nanotechnologies & Resource Use
How do they relate?

How light is "light"?

Nanotube bike enters Tour de France

1 July 2005

This year's Tour de France will see cyclists from the Phonak Team use a bike with a frame containing carbon nanotubes. Swiss manufacturer BMC claims that the frame of its "Pro Machine" weighs less than 1 kg and has excellent stiffness and strength.

To create the frame, BMC used a composite technology developed by US sports equipment specialist Easton. The company's "enhanced resin system" embeds carbon fibre in a resin matrix that's reinforced with carbon nanotubes. Easton says that this improves strength and toughness in the spaces between the carbon fibres.

Nanotube bike

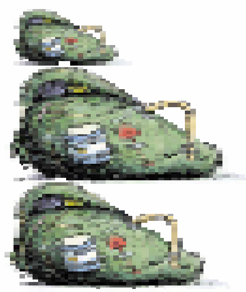
Source: http://nanotechweb.org/articles/news/4/7/1 11. Nov 2005

NANOTECNOLOGIA X USOS DE RECURSOS

Nanotechnologies & Resource Use
How do they relate?

How light is "light"?

Frame Material	Weight (kg)	TMR (kg)	KEA (MJ)	GWP (kg CO^2-Equiv.)
Steel	1.63	25	60	6
Aluminium	1.09	57	275	15
Carbon-fibre reinforced plastics	0.92	50	395	26



TMR: Total Material Requirement
KEA: Cumulative Energy Demand
GWP: Global Warming Potential

Source: Wuppertal Institute. Published in: Studiengesellschaft Stahlanwendungen (2003): Der Werkstoff Stahl im Vergleich zu Konkurrenzwerkstoffen

NANOTECNOLOGIA E O VIDRO AUTO-LIMPANTE

Nanotechnologies & Resource Use
How do they relate?

Self-cleaning glass

Zur Anzeige wird der QuickTime™ Dekompressor „TIFF (Unkomprimiert)" benötigt.

- Nano-coating of TiO_2 on ordinary float glass
- Photocatalytic effect: Breaks down and looses (organic) dirt
- Hydrophilic surface causes rain to sheet on glass

Questions

- Production more resource intense - does it level off along life-cycle?
- How long does the coating last?
- Will small scratches lead to replacement of entire window?
- Breaks down only organic matter - special cleaning detergent needed?
- Recycability as ordinary glass - what about Ti?

Picture source: http://www.japantimes.co.jp/images/photos2004/nb20040611a4a.jpg 25. Mar 2006

NANOTECNOLOGIA E O USO EFICENTE DAS FONTES

Conclusions
Nanotechnologies and Resource Efficiency

Positive improvements	NT provide potential for sometimes significant RE improvements
LC-wide assessment	A life-cycle wide and "all-resource-inclusive" perspective is needed to decide if NT-applications are favourable
Rebound effects	As a cross-cutting, pervasive technology, rebound effects are likely to happen. Consumer behaviour will be important
Closing material loops	Closing material loops of Nano-materials will be a challenge
No free lunch	RE potentials will not automatically be realised on a macro level

DESENV. NANOTECNOLOGIA BRASIL
10 Redes de Pesquisas

COORDENADOR	PROJETO	INSTITUIÇÃO	UF
Adalberto Fazzio	Simulação e Modelagem de Nanoestruturas	USP	SP
Anderson Stevens Leonidas Gomes	Rede de Nanofotônica	UFPE	PE
Eudenilson Lins de Albuquerque	Rede Nacional de Nanobiotecnologia e Sistemas Nanoestruturados (Nanobioestruturas)	UFRN	RN
Fernando Lázaro Freire Júnior	Rede Cooperativa de Pesquisa em Revestimentos Nanoestruturados	PUC	RJ
Gilberto Medeiros-Ribeiro	Microscopias de Varredura de Sondas - Software e Hardware Abertos	LNLS	SP
Marcos Assunção Pimenta	Nanotubos de Carbono: Ciência e Aplicações	UFMG	MG
Maria Rita Sierakowski	Nanoglicobiotecnologia	UFPR	PR
Oscar Manoel Loureiro Malta	Rede de Nanotecnologia Molecular e de Interfaces – Estágio I,II	UFPE	PE
Paulo César De Morais	Rede de Nanobiomagnetismo	UNB	DF
Sílvia Stanisçuaski Guterres	Nanocosméticos: do Conceito às Aplicações Tecnológicas	UFRGS	RS

DESENV. NANOTECNOLOGIA BRASIL
2005   9 Projetos Institucionais

Tabela 17- Projetos apoiados pela ação Fomento a Projetos Institucionais de Pesquisa e Desenvolvimento em Nanociência e Nanotecnologia, em 2005.

Título do Projeto	**Instituição Executora**	Instituição Co-executora	**Instituição Interveniente**
Desenvolvimento Tecnológico de Nano cosméticos	UFRGS	-	BIOLAB Ltda
Desenvolvimento de Biocerâmicas Nanoestruturadas, para uso clínico, como material para regeneração óssea	CBPF	Instituto Nacional de Traumato-Ortopedia / UFRJ	Óssea Technology Ind. e Com.
Nanocompósitos de borracha Natural para adesivos e outros produtos	UNICAMP	Centro Tecnológico do Couro, Calçados e afins	EF Engenharia LTDA
Desenvolvimento de Nanocosméticos de ação antioxidante e anti-Inflamatória	IPT	-	Natura LTDA.
Desenvolvimento de Nanocompósitos de Poliestireno contendo argilas modificadas	UFSC	-	CENPES
Síntese de Nanocompósitos de polipropileno por polimerização INSITU	IMPEM	Centro de Tecnologia Mineral	PETROBRAS S.A.
Desenvolvimento de sistemas nanoestruturados contendo antineoplásticos para tratamento de tumores sólidos e queratoses actínicas	UFMG	Fundação Centro Tecnológico de Minas Gerais	BIOCANCER S.A.
Dispositivos Ópticos ultrarápidos baseados em Quantum dots Semicondutores	UNICAMP	-	Padtec S.A.
Desenvolvimento de PP com alta força do fundido e extensibilidade por meio da síntese de nanogéis de polipropileno	IPEN	-	Embrarad - Empresa Brasileira de Radiações Ltda