KATHOLIEKE UNIVERSITEIT LEUVEN

Wat is nanotechnologie en welke zijn de mogelijke gezondheidseffecten voor de werknemers

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Overview

- Introduction:
  - Definition: Nanomaterials – ultrafine particles?
  - Use of nanomaterials
  - Safe Nanomaterials
- Issues in NanoToxicology?
  - Role of size (nano versus larger)
    - Surface
    - Systemic delivery
  - Role of shap
    - One material different shapes
    - CNT ….
- Conclusions

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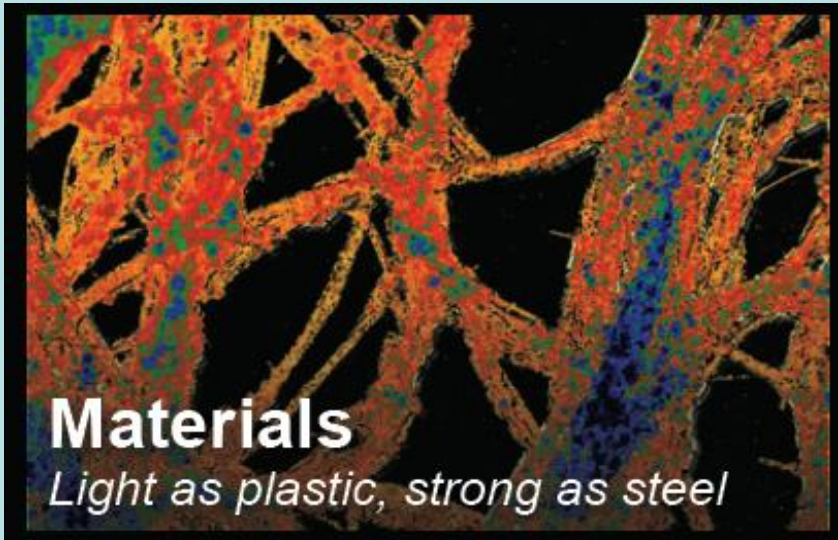
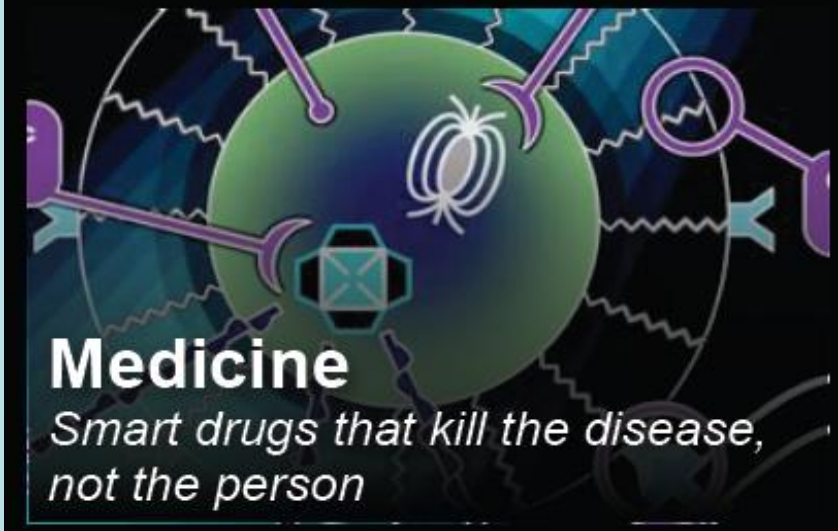
Definition?

- European Academy at Bad Neuenahr: “Nanotechnology (therefore man-made) is dealing with functional systems based on the use of subunits with specific size dependent properties of the individual sub-units or of a system of those.”
  - very general; no exact size ≠ 100 nm
  - excludes non purpose made materials such as soot and dust.
- Nanoparticle: one dimension <100 nm (and larger than 1 nm)
  - Spherical
  - Rods & Tubes
  - Surfaces

Do we “need” nanotechnology

Do we “need” nanomaterials





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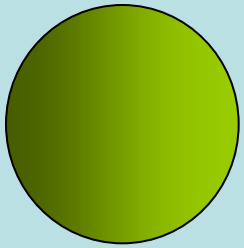
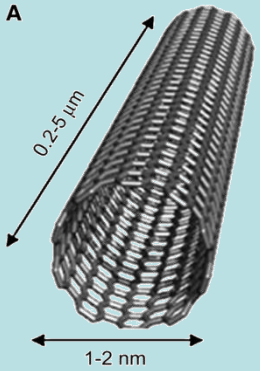




≠ Nano materialS
≠ Nano particleS

Origin
- natural
- unintentionally released
- manufactured („old“, „new“)

Dispersion in
- gases (aerosols)
- liquids (e.g. gels, ferrofluids)
- solids (e.g. matrix materials)

Nanoparticulate Materials

Nano-capsules

Ultrafine Aerosols

Quantum dots

Nano-particles

Nano-tubes

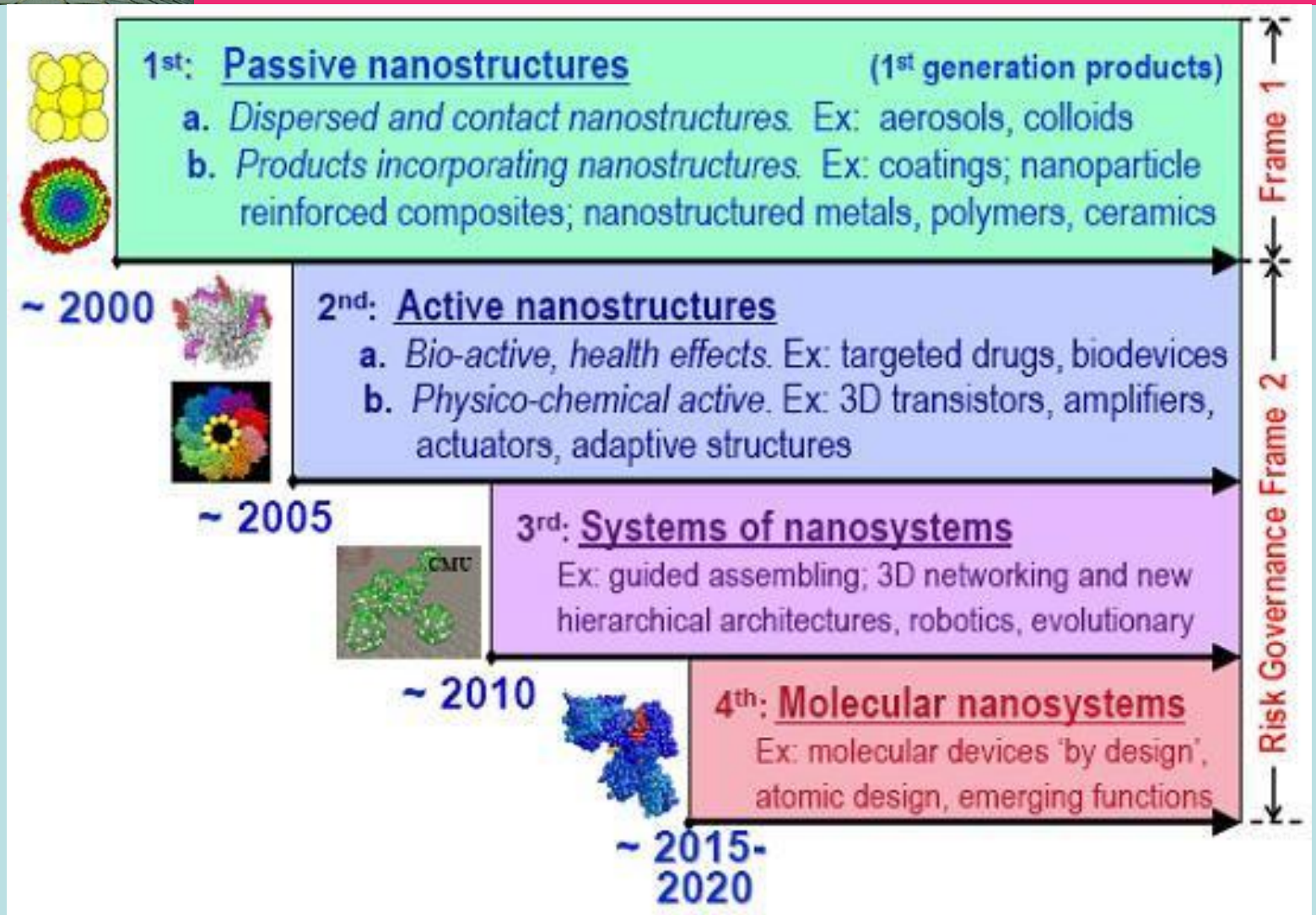
Chem. composition
- metals/ metal oxides
- polymers, carbon
- semiconductors
- biomolecules
- compounds ...

Shape/Structure
- spheres
- needles
- platelets
- tubes

Aggregation state
- single particles
- aggregates
- agglomerates

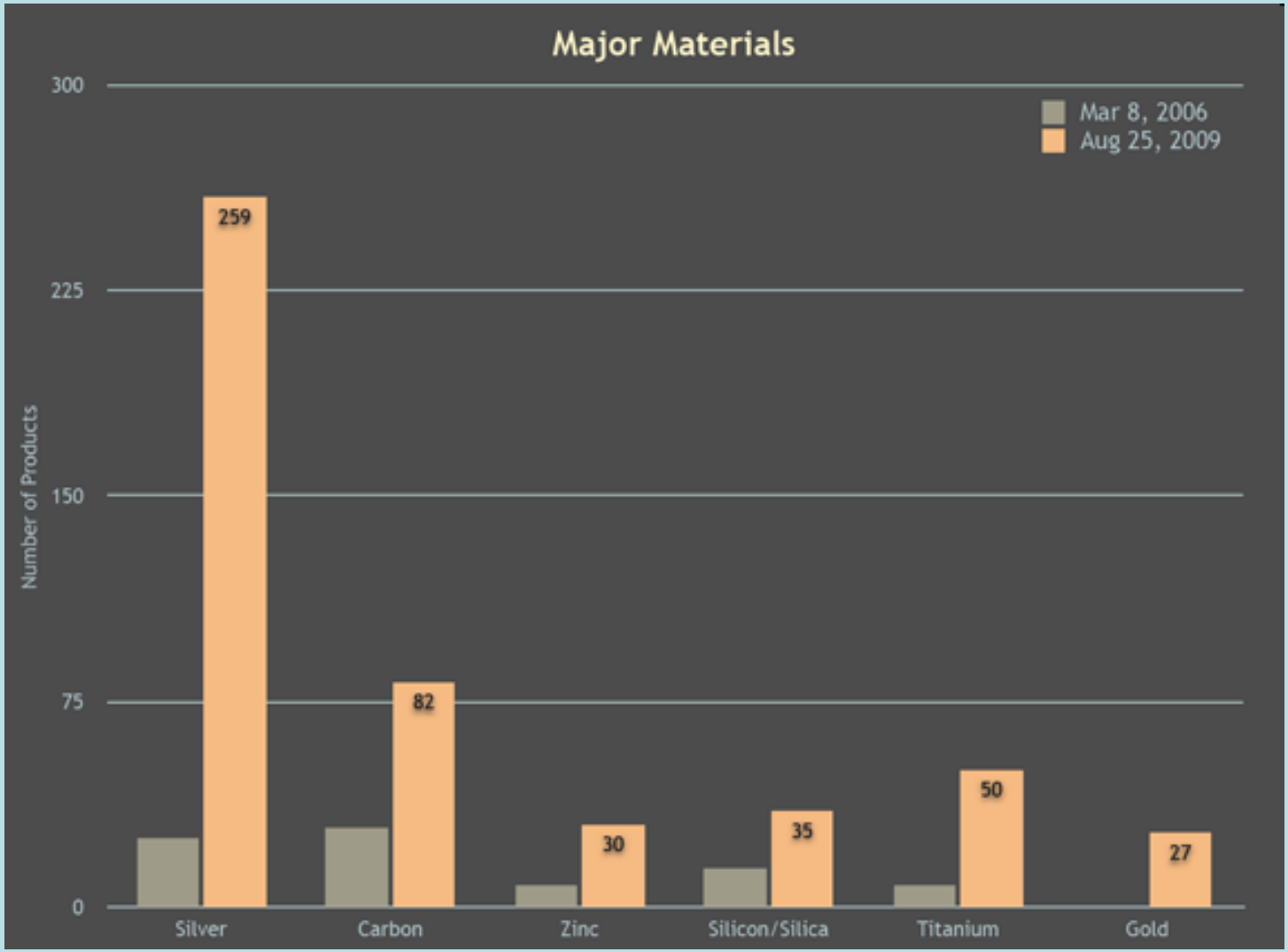
Surface modification
- untreated (as obtained in production process)
- coated (e.g. conjugates, polymeric films)
- core/shell particles (e.g. spheres, capsules)

Nanotechnology = fast evolving



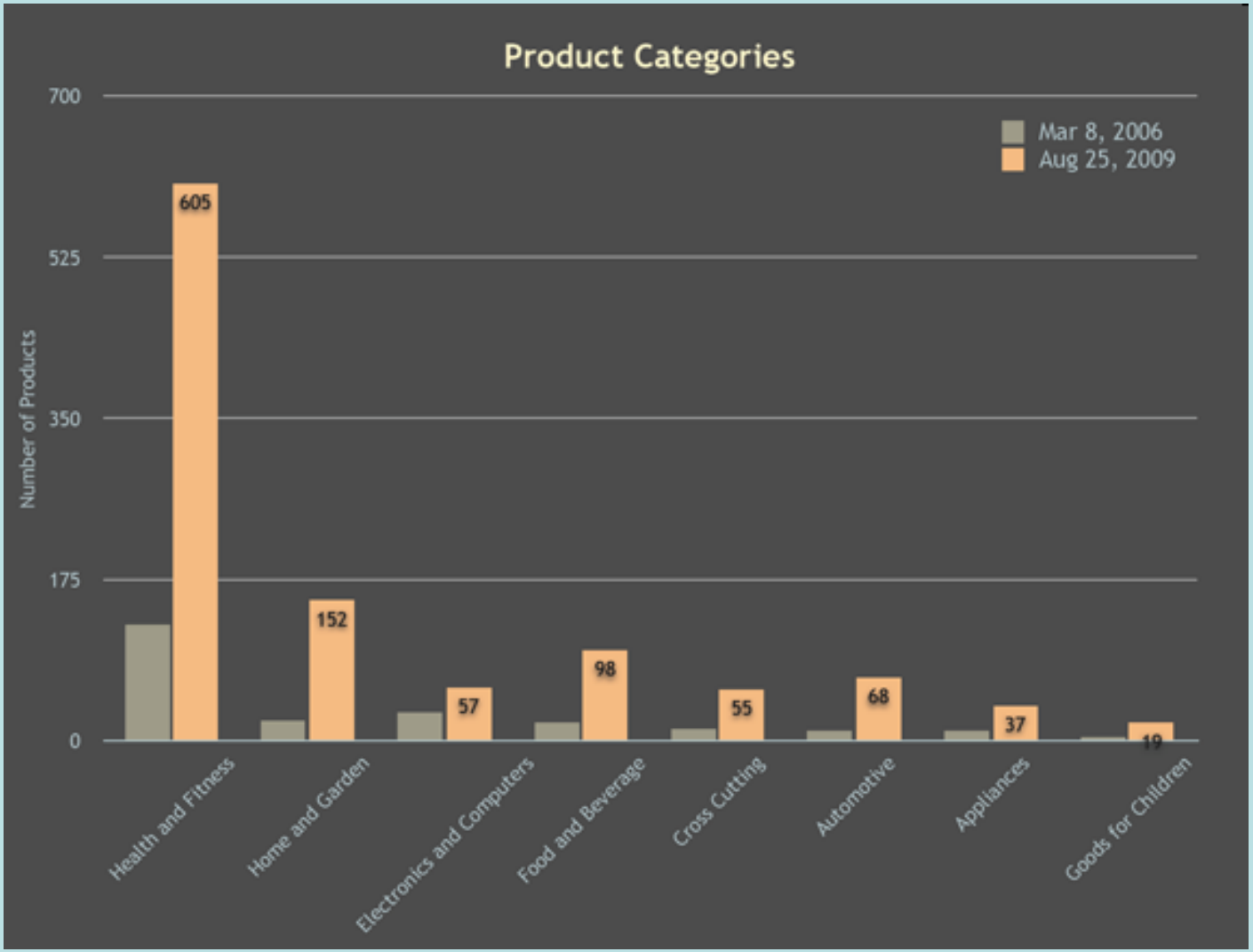
USE: What is produced?

www.nanotechproject.org/inventories/consumer/analysis_draft/

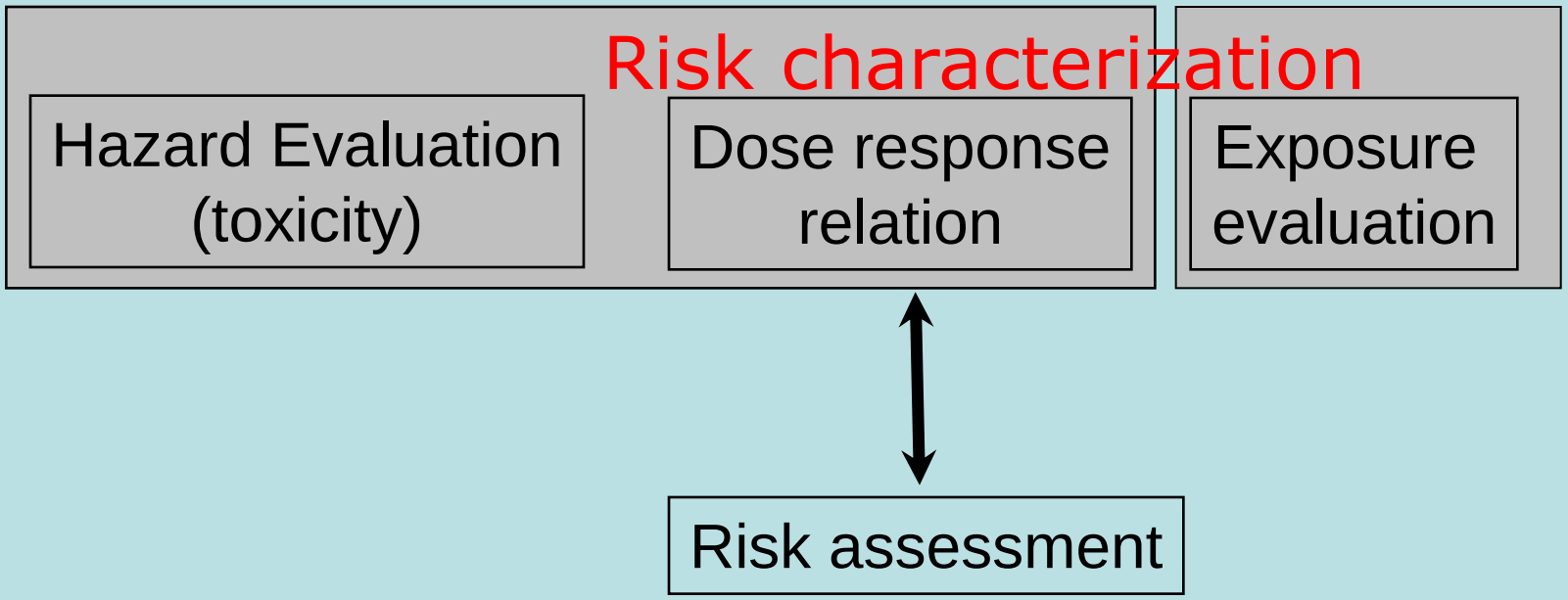


USE: Main applications?

www.nanotechproject.org/inventories/consumer/analysis_draft/



Safe nanomaterials?



Risk assessment

Systematic scientific characterisation of potential adverse health effects resulting from human exposure to hazardous agents (or situations).

Safe nanomaterials?

Risk characterization

Hazard Evaluation (toxicity)

Dose response relation

Exposure evaluation

Risk assessment

Does nano play a role in Hazard?
Exposure?

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Issues in NanoToxicology: SIZE

0.01 µM = 10 nm diameter

0.1 µM = 100 nm diameter

1 µM
= 0.000 001 m
= 0.001 mm
= 1 000 nm

diameter

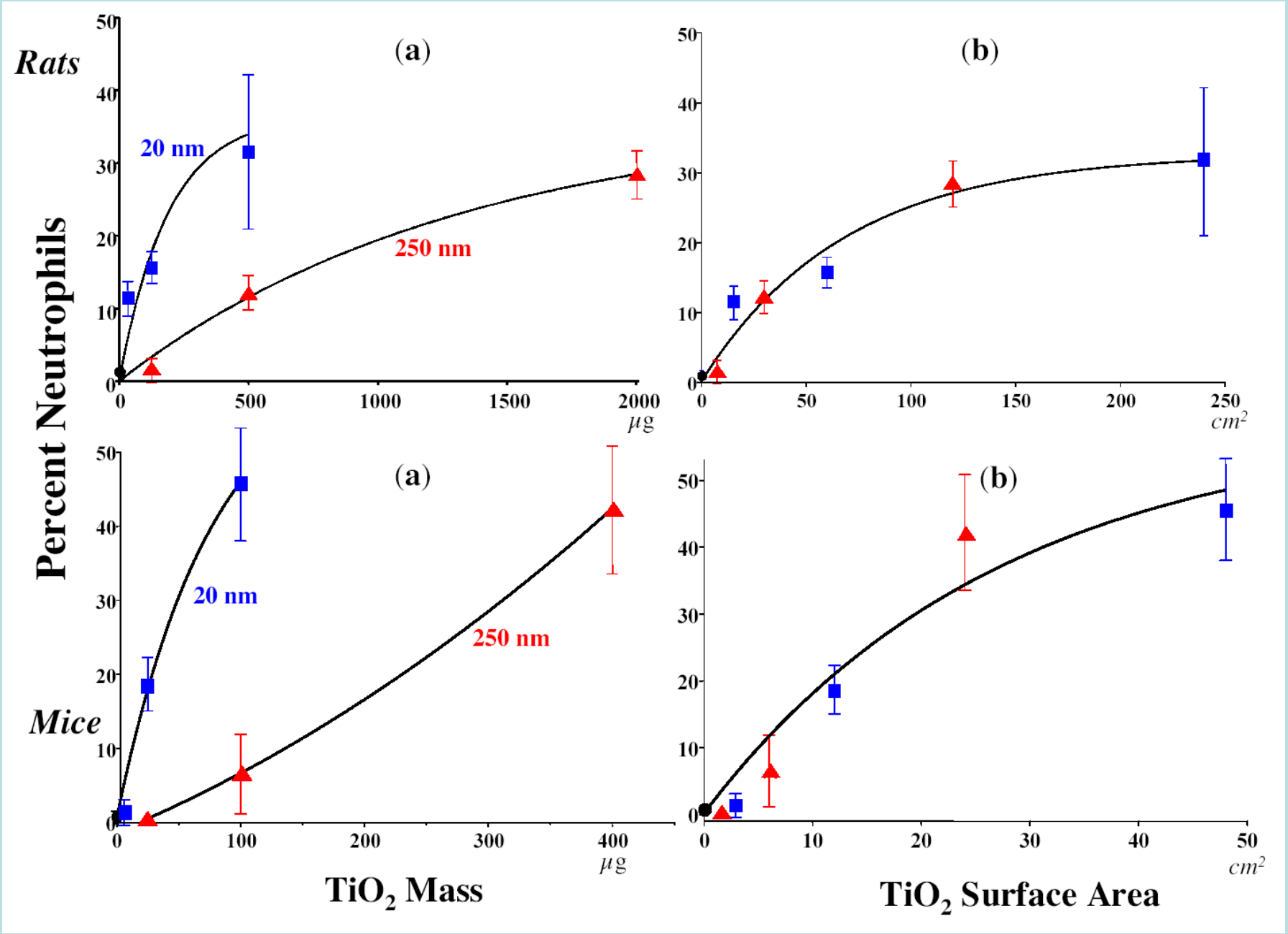
Issues in NanoToxicology: SIZE

- Existing molecule e.g. TiO2
  - Known in microsize (low toxicity)
  - Now in nanosize ….?

New risk assessment?

Yes – No?

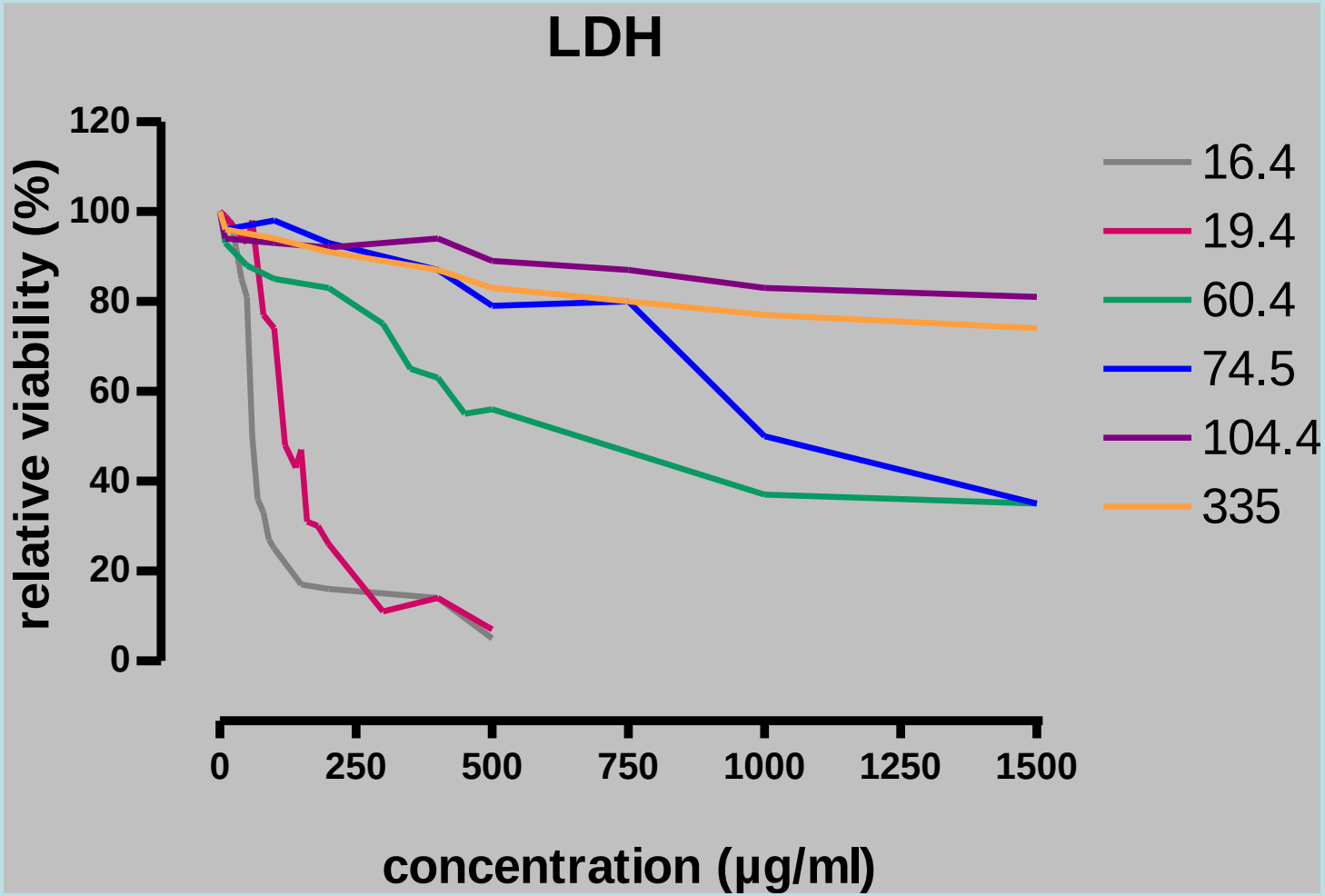
Why yes – Why no?



Oberdörster et al Environmental Health Perspectives , 113, 2005

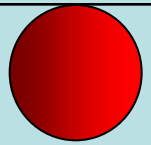
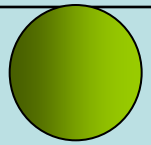
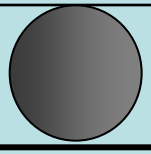
Size plays a role!

Amorphous monodisperse silica: In press: Napierska et al Small 2008



Size, number and surface area

Mass = 10 µg Density = 1 kg/dm³

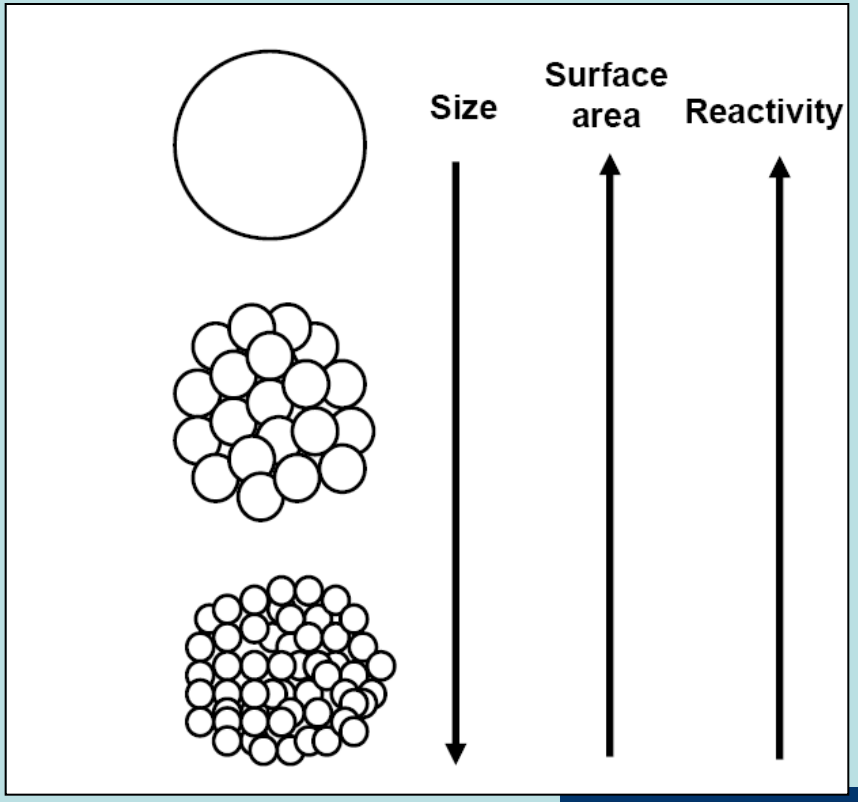
Diameter (µm)	N° particles	Surface area (µm²)
 0.01	19 000 000 x10⁶	6 000 x10⁶
0.05	153 000 x10⁶	1 200 x10⁶
 0.1	19 000 x10⁶	600 x10⁶
0.5	153 x10⁶	120 x10⁶
 1.0	19 x10⁶	60 x10⁶

Issues in NanoToxicology: SIZE

- Existing molecule e.g. TiO2
  - Known in microsize
  - Now in nanosize

New risk assessment?
Probably Yes

Why?
- Different (more) toxicity
  - Surface & reactivity!
- ?



Bioavailibility: deposition in lung

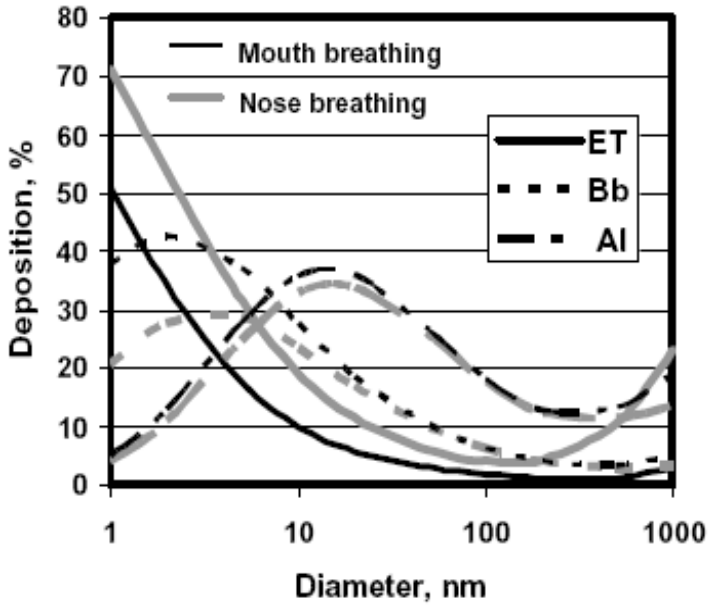
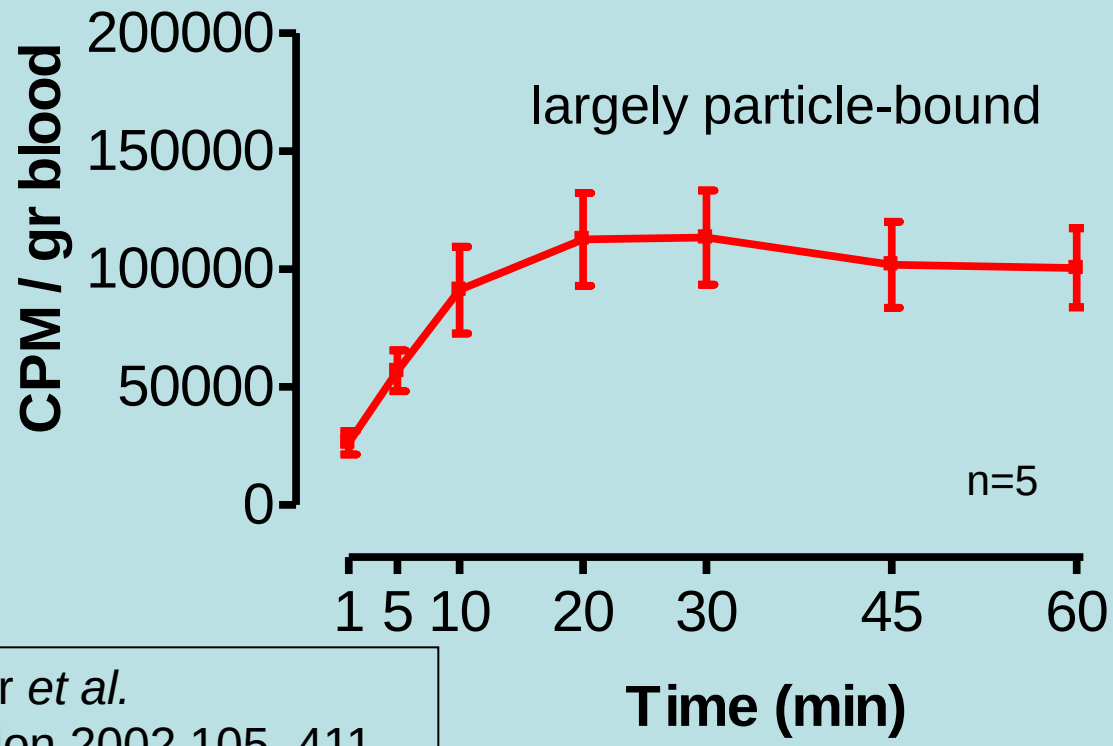


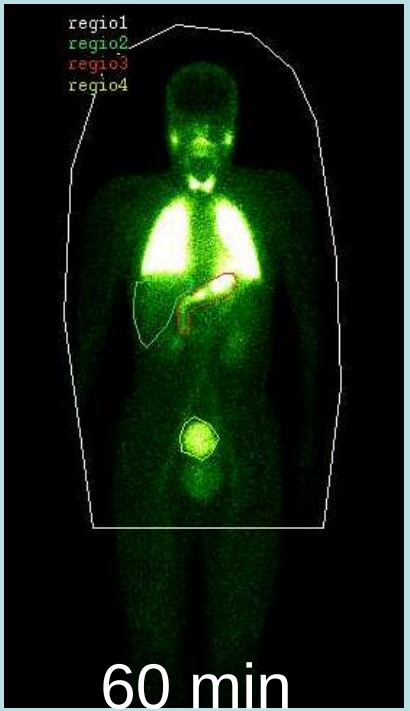
Figure 6
Regional deposition of inhaled NP with diameters between 1 nm and 1000 nm for nose and for mouth breathing in the extrathoracic airways (ET), the bronchial airways (Bb) and the alveolar region (AI) during breathing at rest, as predicted by ICRP 66 model (ICRP, 1994).

Inhalation of particles
≠
deposition

Systemic uptake of nanomaterials after inhalation in humans

Inhalation of ^{99m}Tc-carbon particles (“Technegas”)





Nemmar *et al.*
Circulation 2002,105, 411

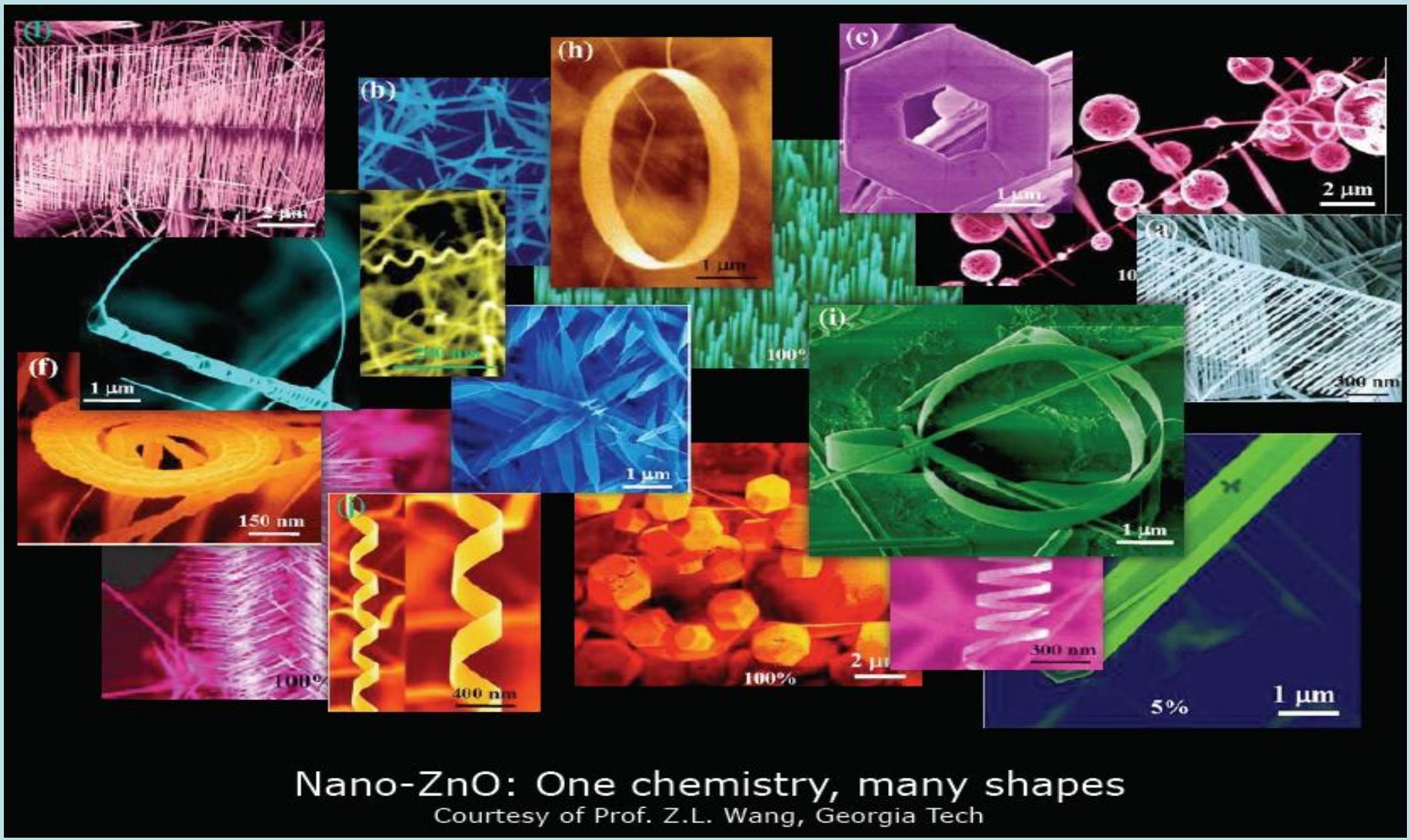
Issues in NanoToxicology: SIZE

- Existing molecule e.g. TiO2
  - Known in microsize
  - Now in nanosize

New risk assessment?
Probably Yes
Why?
-Different (more) toxicity
-Surface?

- Systemic delivery
-Higher/different internal exposure/dose

Issues in NanoToxicology: SHAPE



Nano-ZnO: One chemistry, many shapes

Courtesy of Prof. Z.L. Wang, Georgia Tech

SHAPE plays a role

- Delivery
  - Inhalation
  - Skin penetration
- Mechanical damage
  - Needle vs spheres
- Time of exposure
  - Excretion & Biopersistent

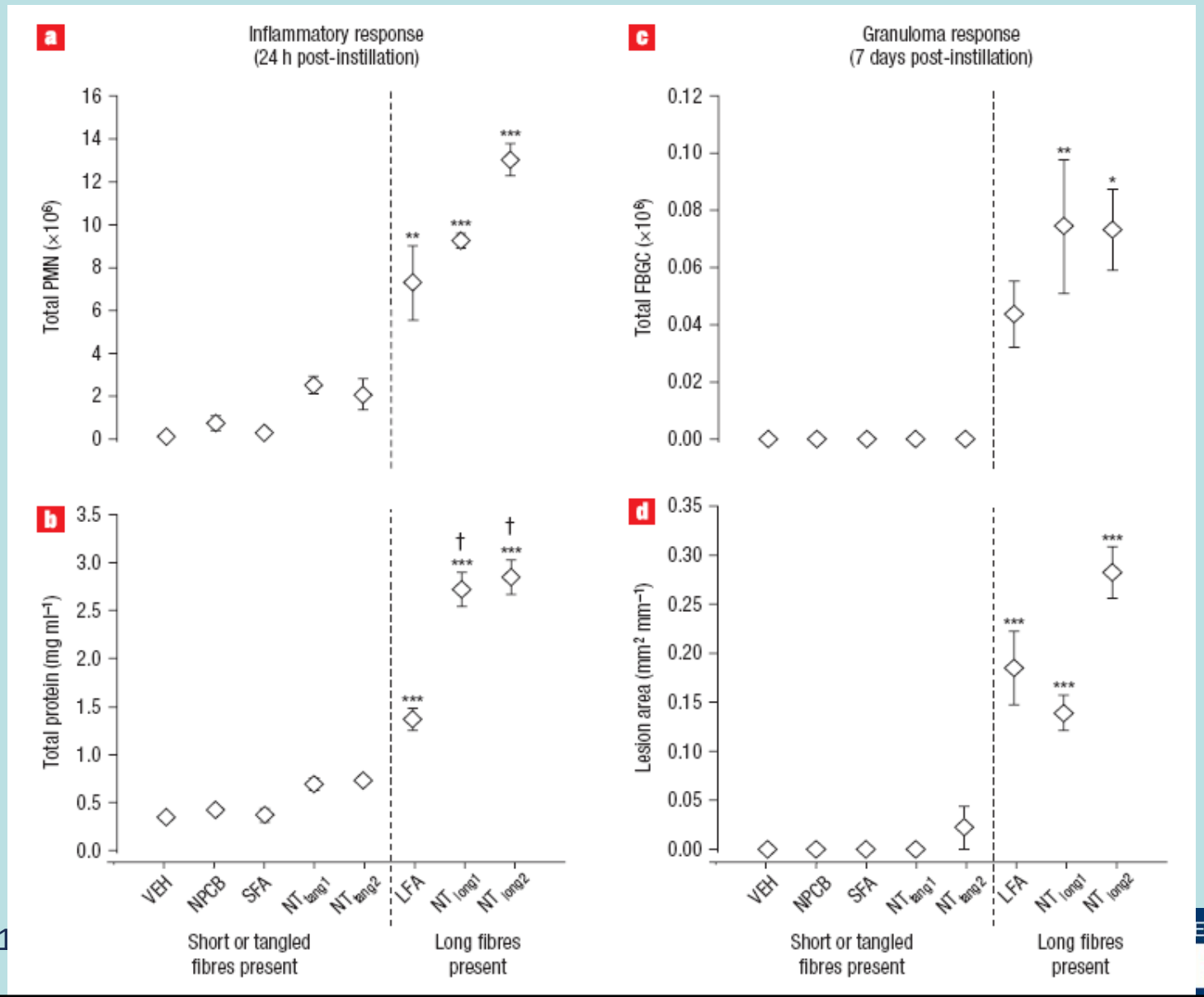
One study …

Carbon nanotubes introduced into the abdominal cavity of mice show asbestos-like pathogenicity in a pilot study

CRAIG A. POLAND[1], RODGER DUFFIN[1], IAN KINLOCH[2], ANDREW MAYNARD[3], WILLIAM A. H. WALLACE[1], ANTHONY SEATON[4], VICKI STONE[5], SIMON BROWN[1], WILLIAM MACNEE[1] AND KEN DONALDSON[1]*

Nature Nanotechnology May 20 2008

Nature Nanotechnology May 20 2008



Other study

TOXICOLOGICAL SCIENCES 110(2), 442–448 (2009)
doi:10.1093/toxsci/kfp100
Advance Access publication May 8, 2009

Absence of Carcinogenic Response to Multiwall Carbon Nanotubes in a 2-Year Bioassay in the Peritoneal Cavity of the Rat

Julie Muller,* Monique Delos,† Nadtha Panin,* Virginie Rabolli,* François Huaux,* and Dominique Lison*,[1]

*Industrial Toxicology and Occupational Medicine Unit, Catholic University of Louvain, 1200 Brussels, Belgium; and †Laboratory of Pathology, University Hospital of Mont-Godinne, Catholic University of Louvain, 5530 Yvoir, Belgium

Received April 8, 2009; accepted April 30, 2009

- Crocidolite (positive controls) → expected carcinogenic response
- No clear evidence of a similar activity for MWCNT

- The negative response to MWCNT in the study → critically interpretation
  + and calls for further studies
    - Different nanotube preparations
    - Different dosing regimens
    - Other bioassays

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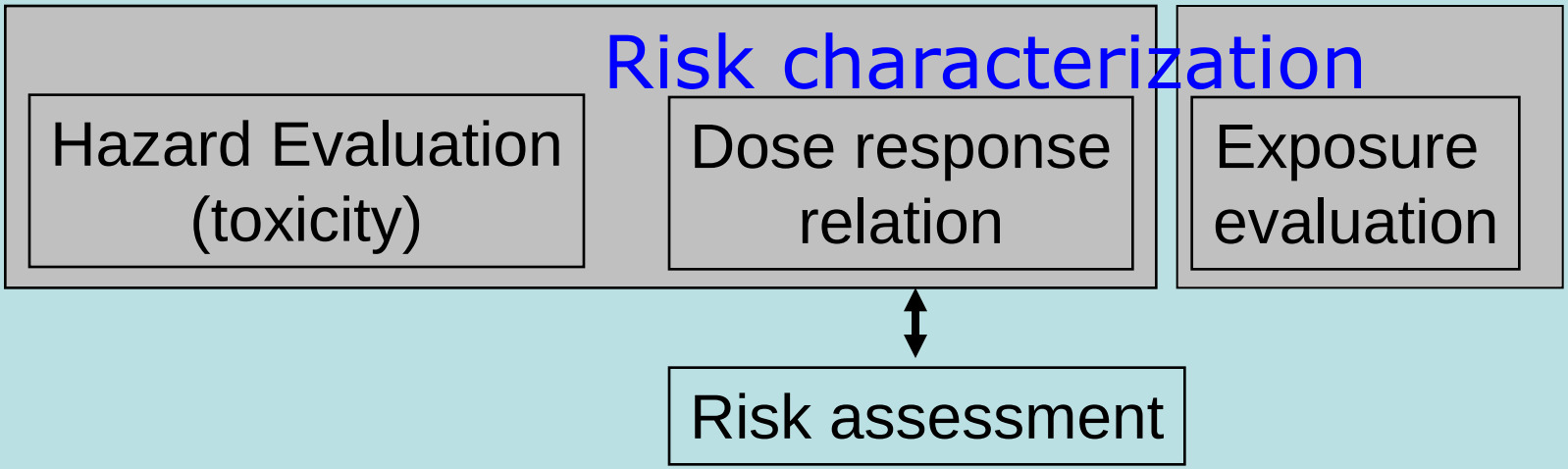
Conclusion: Safe nanomaterials



Each chemical entity ➔ more than one evaluation!

There is no universal “nanoparticle” to fit all the cases

Physico-chemical characteristics

Crystal structure, Size, aggregation, dissolution, …

Exposure & delivery micro vs nano

+ (Correct) test conditions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Eric Verbeken
Thank You For Your Attention
KATHOLIEKE UNIVERSITEIT
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