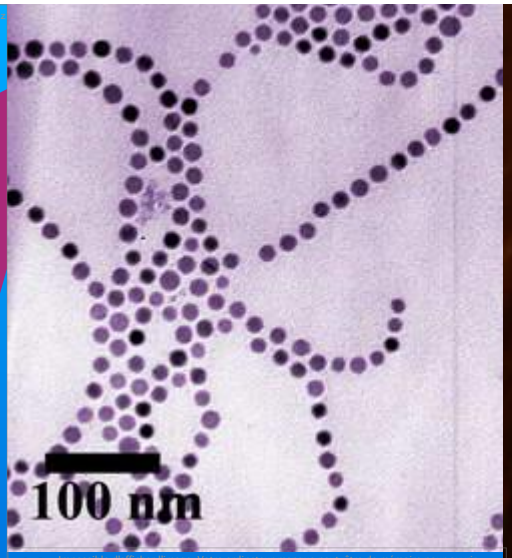
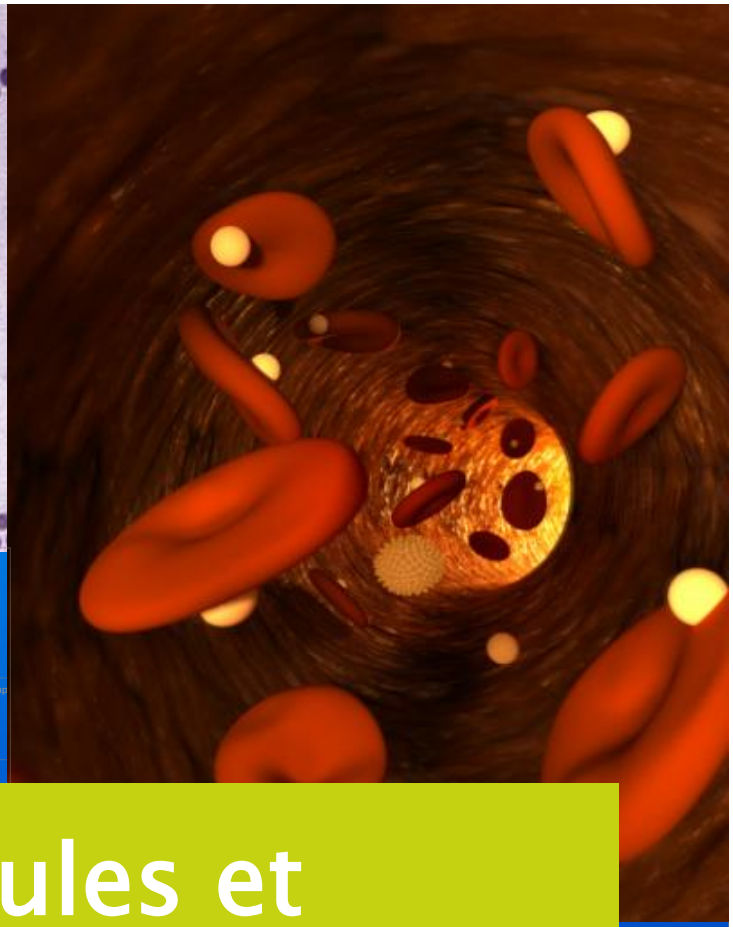
Séminaire Annuel de l'Observatoire des Micro et Nanotechnologies

7 février 2008
Paris, Maison de la Chimie

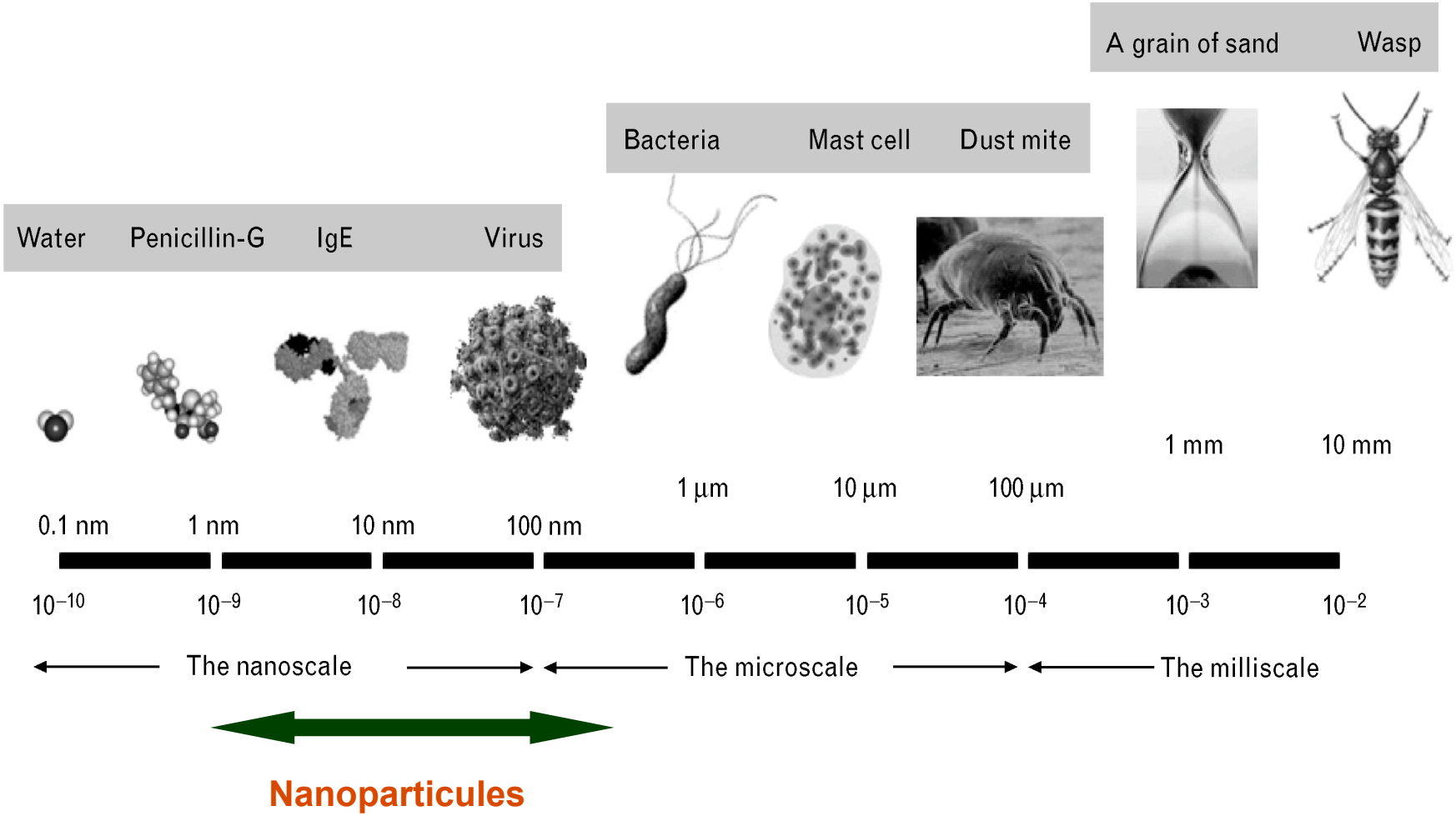




Nanoparticules et alimentation

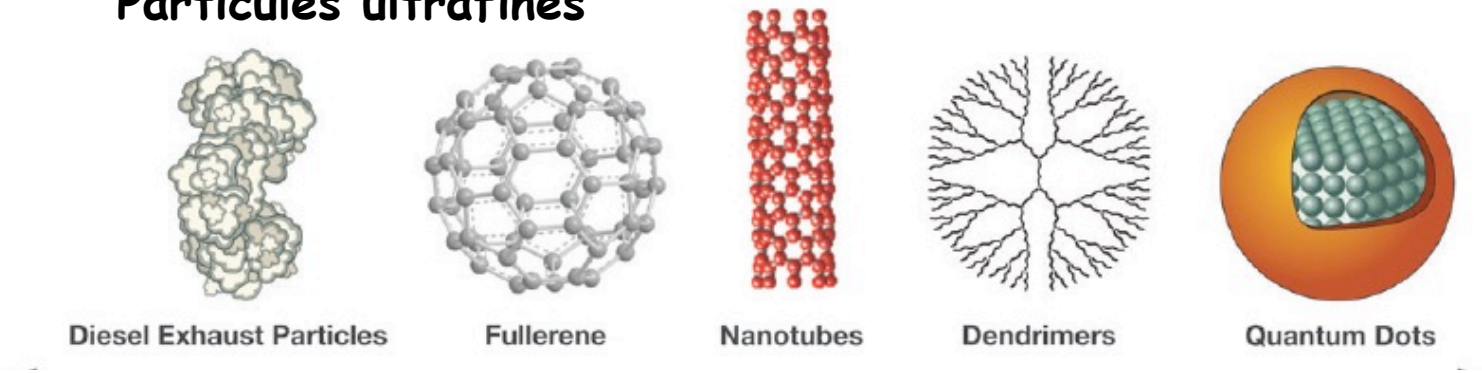
Francelyne Marano
Université Paris Diderot Paris 7

LE NANOMONDE



Nanoparticles non intentionnelles — Nanoparticles manufacturées

Particules ultrafines



NP naturelles et non intentionelles

NP intentionelles

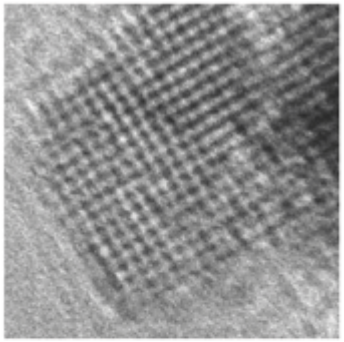
- Feux de forêt
- Volcans
- Particules atmosphériques secondaires

- Particules Diesel
- Incinerateurs
- Avions
- Chauffages urbains

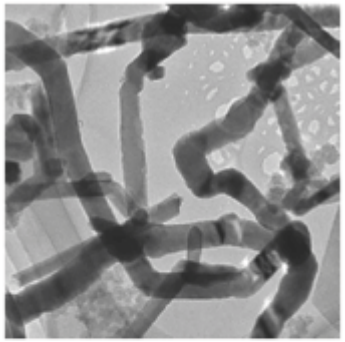
After Stern and McNeil, Tox Sci, 2008

Diversité des Nanoparticules

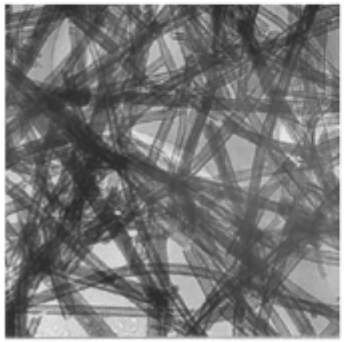
Diversité de forme, de composition



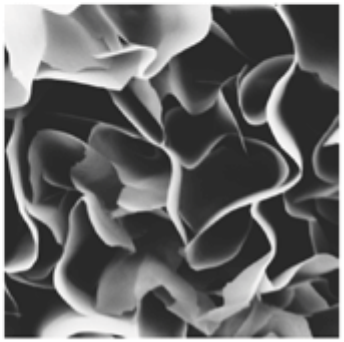
0D- Nanocrystal



1D- Nanowires



1D- Nanotubes



2D- Nanowalls .....

Usages nombreux

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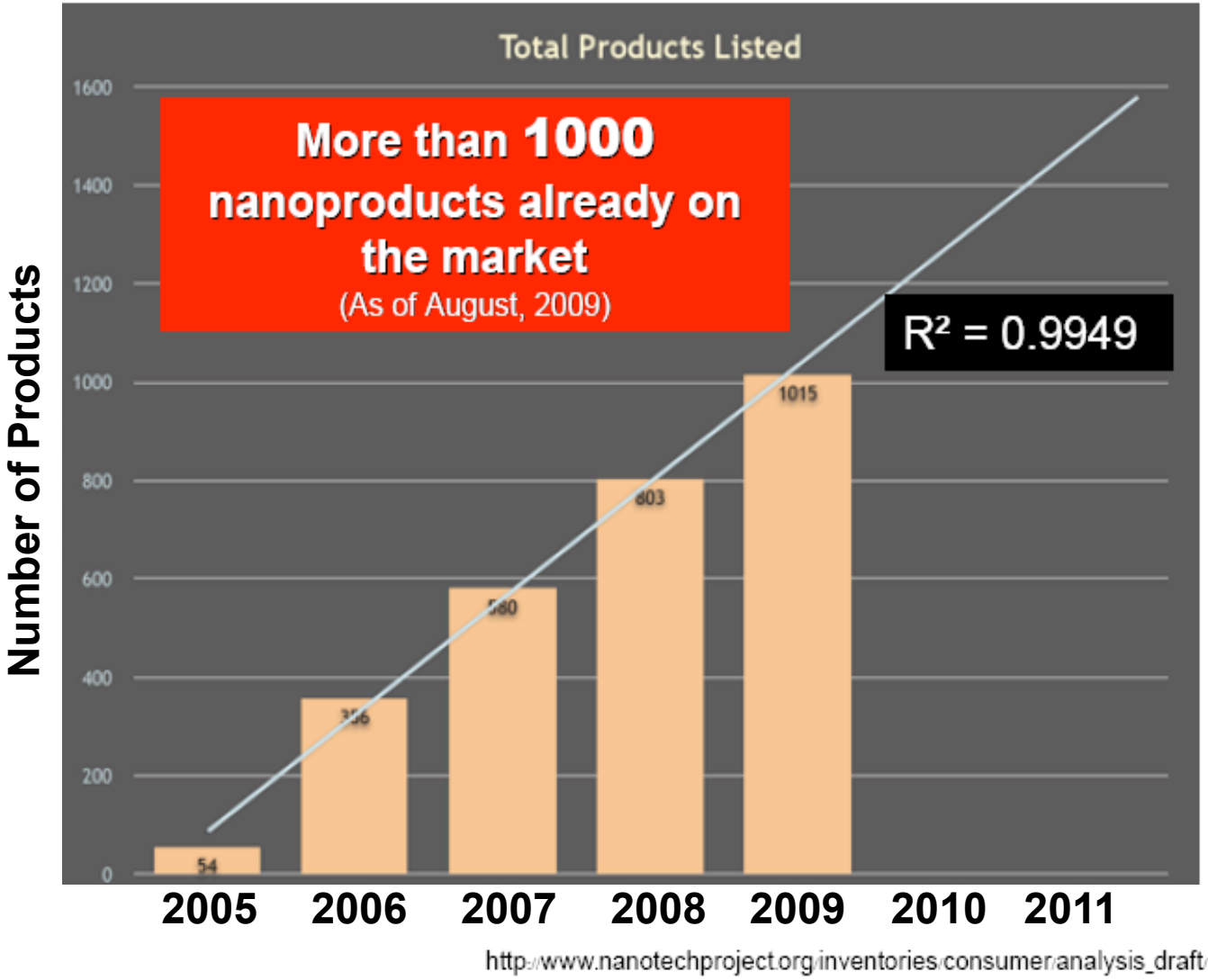
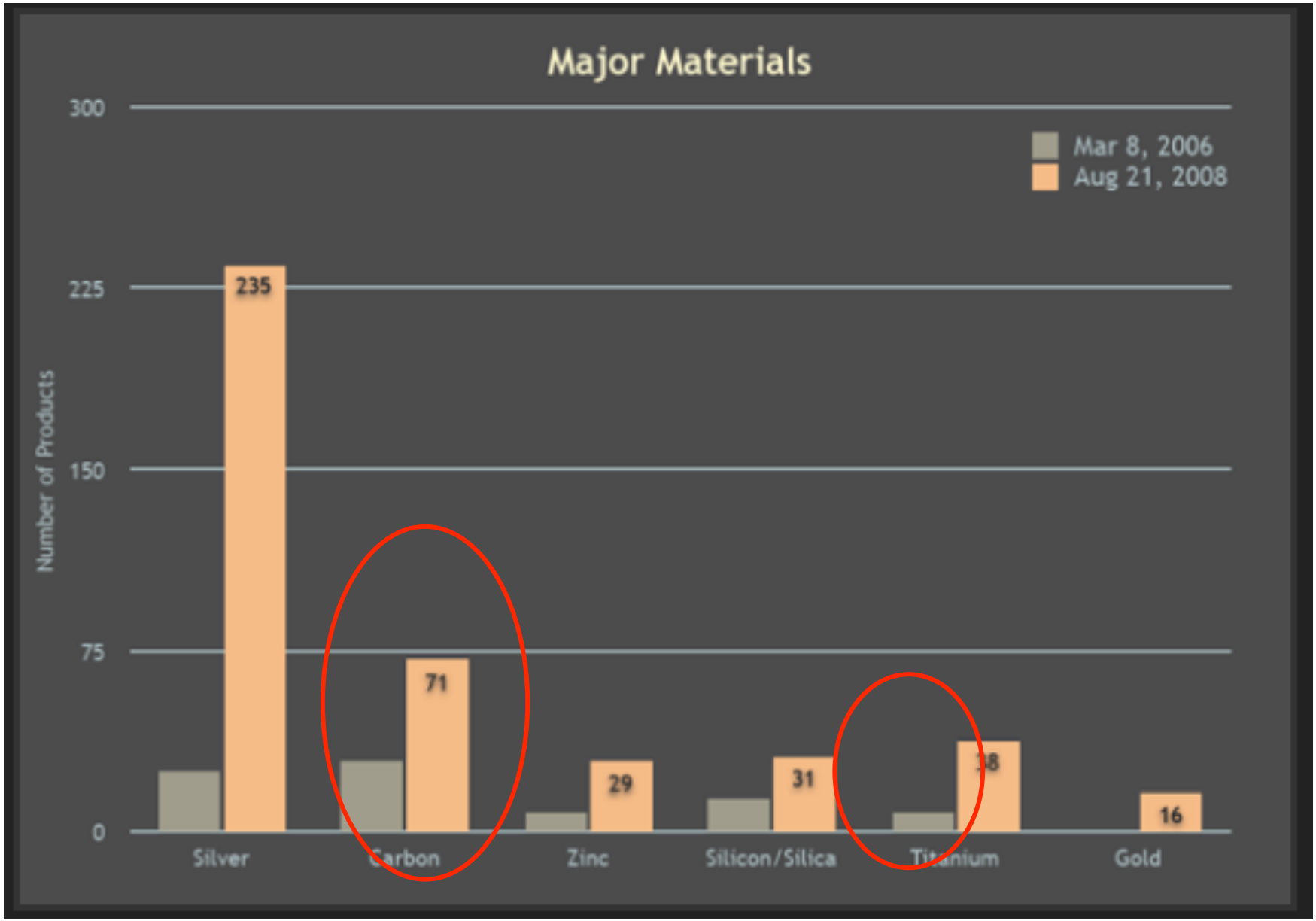
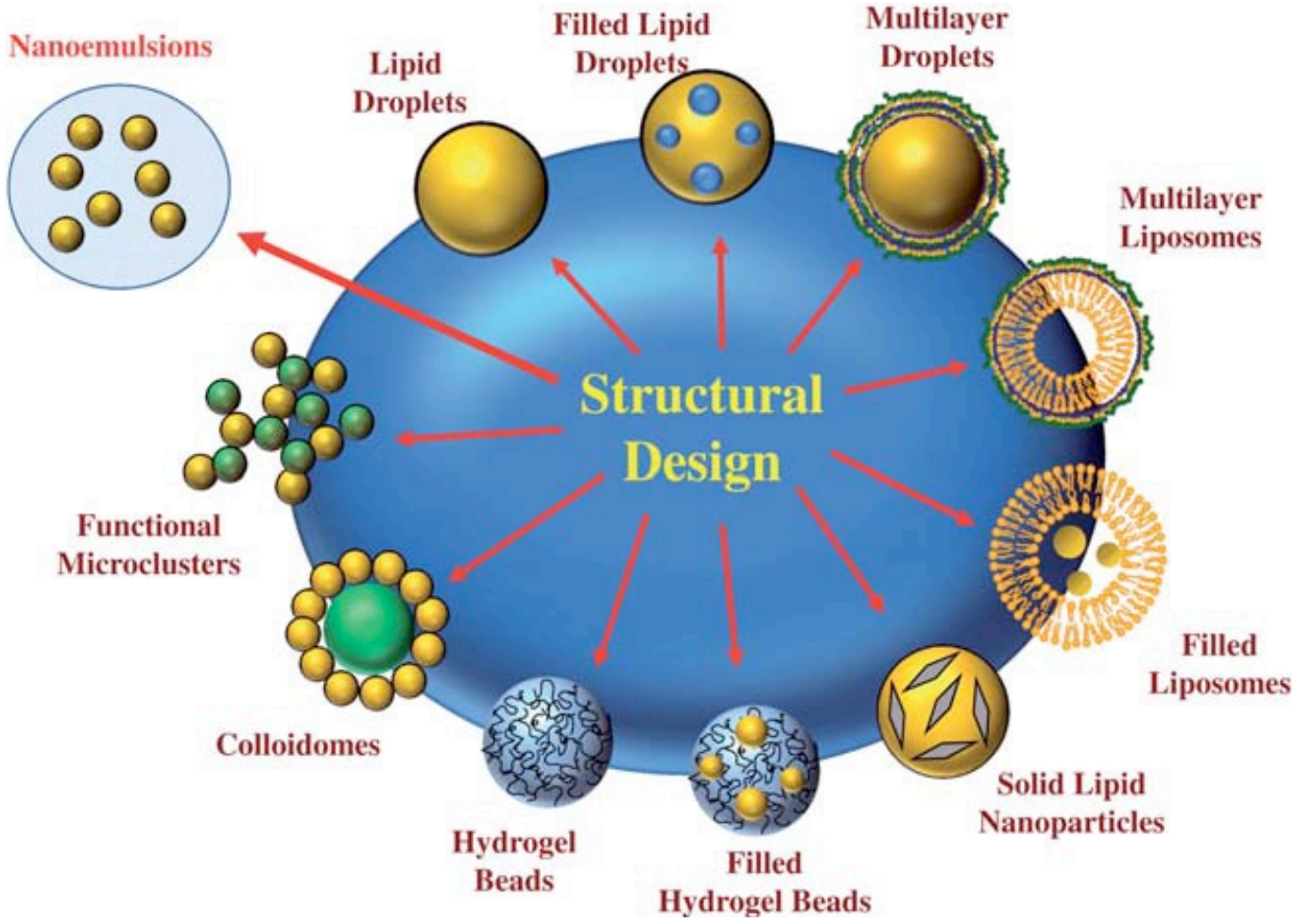
LE MARCHE DES NANOPRODUITS

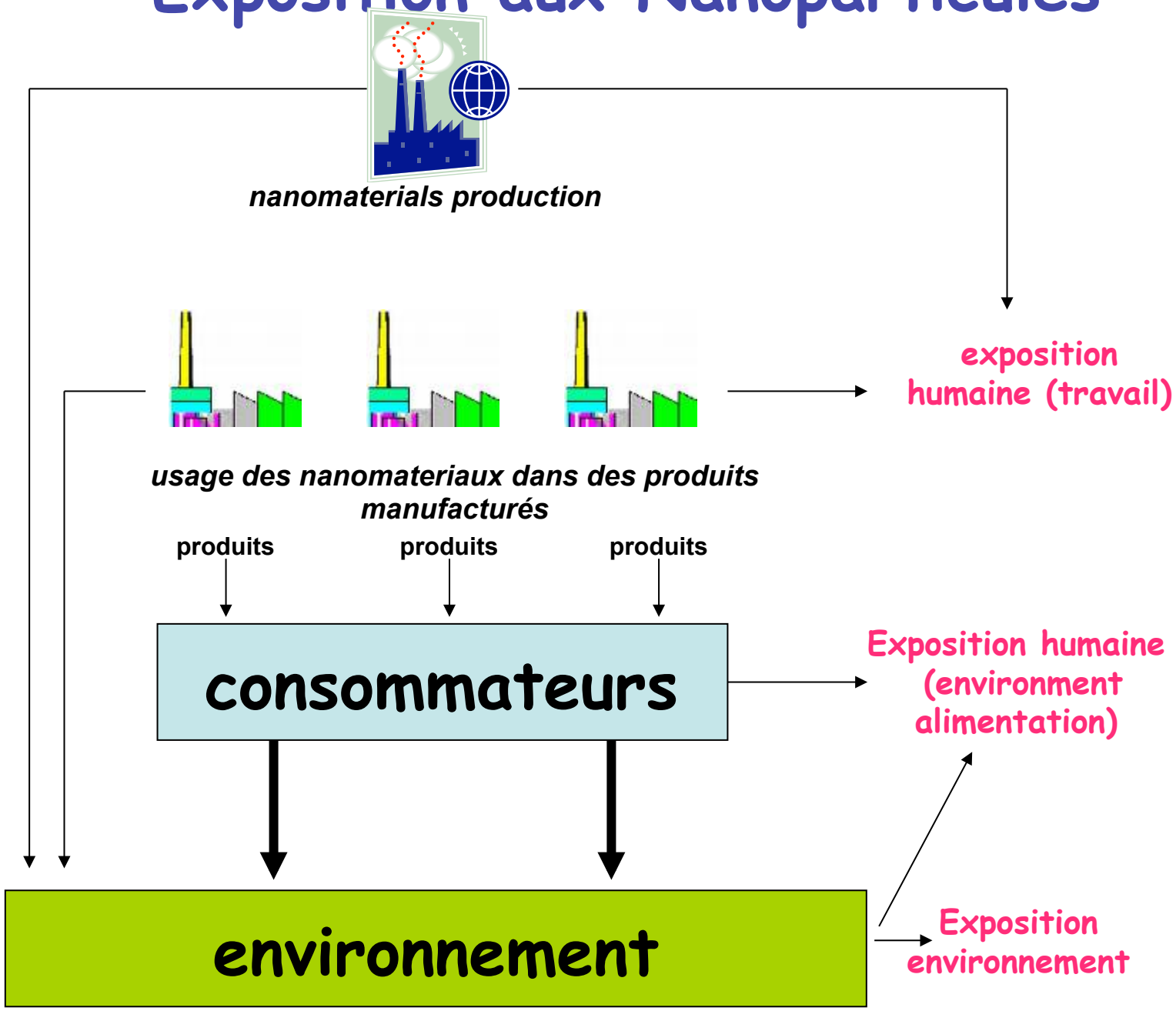


Nanoparticules principales




Nanoemulsions
Lipid Droplets
Filled Lipid Droplets
Multilayer Droplets
Multilayer Liposomes
Structural Design
Functional Microclusters
Filled Liposomes
Colloidomes
Solid Lipid Nanoparticles
Hydrogel Beads
Filled Hydrogel Beads

Exposition aux Nanoparticules



(Witschger and Fabriès, 2005)

Nanotechnology Applications

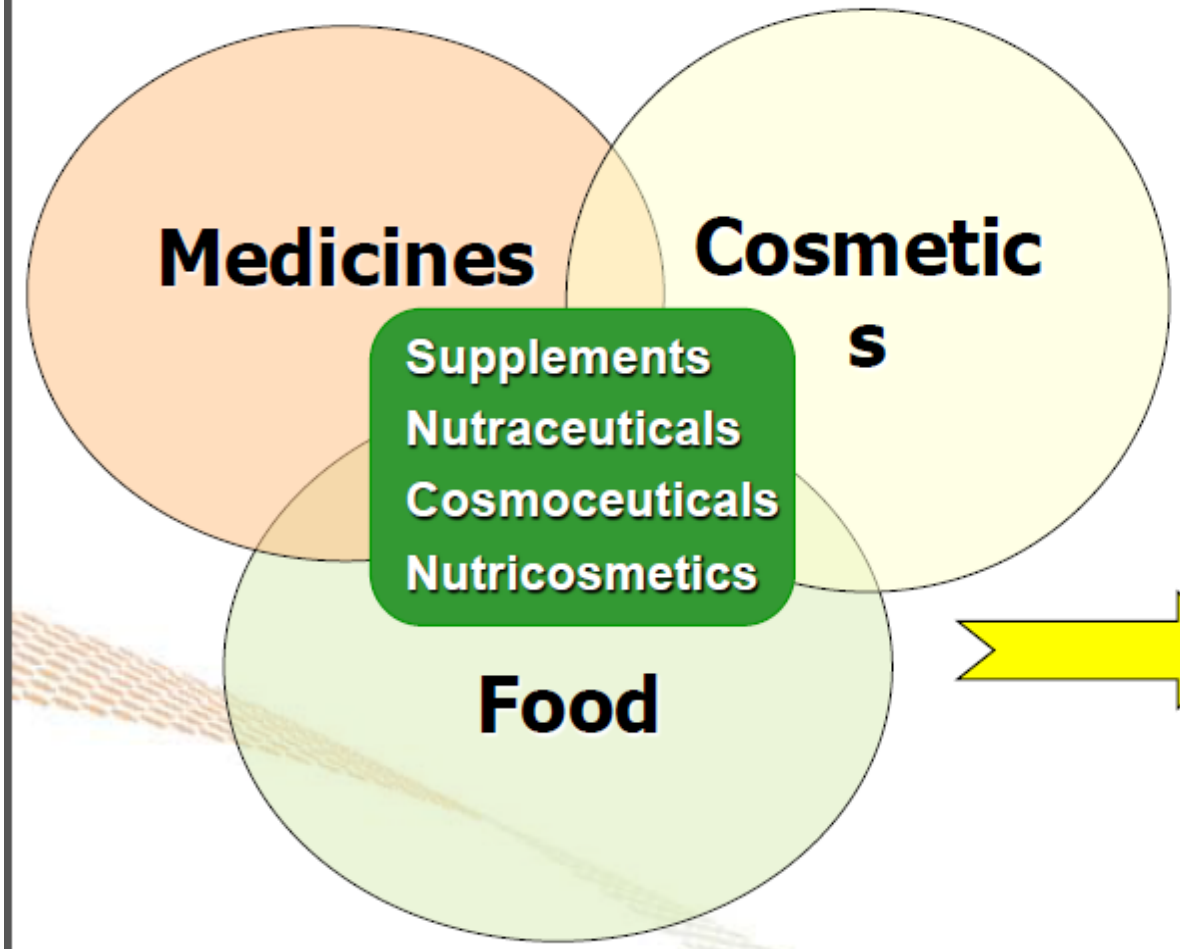
fera
The Food and Environment Research Agency

- Cosmetics and personal care products ~60%
- Paints & coatings ~10%
- Catalysts & lubricants
- Security printing
- Textiles & sports
- Medical & healthcare
- Food and nutritional supplements ~10%
- Food packaging
- Agrochemicals
- Veterinary medicines
- Water decontamination
- Construction materials
- Electrical & electronics ~10%
- Fuel cells & batteries
- Paper manufacturing
- Weapons & explosives

*Source: www.nanotechproject.org/inventories/consumer/

Nanotchnology Applications for Food/ Feed Sectors

The Food and Environment Research Agency



- ✓ New tastes, flavours, and textures of food
- ✓ Less amount of fat, salt, sugar and preservatives
- ✓ Enhanced uptake and bioavailability of nutrients and supplements
- ✓ Increased nutritional value
- ✓ Maintenance of food quality and freshness,
- ✓ 'Improved', 'Active', 'Intelligent', and 'Smart' packaging
- ✓ Better traceability and safety of food

Quelques produits sur le marché!

A Nanotechnology Consumer Products Inventory

Search

Home

Browse Products | Advanced Search

Displaying records 1-10 of 13
Results Page: 1 2 Next

Aquanova® Novasol® by Aquanova® GmbH
Food and Beverage > Supplements

Canola Active Oil by Shemen Industries
Food and Beverage > Food

Daewoo® Refrigerator by Daewoo® (Germany)
Appliances, Food and Beverage > Large Kitchen Appliances, Storage

FresherLonger™ Miracle Food Storage by Sharper Image®
Food and Beverage > Storage

Nanoceuticals™ Artichoke Nanoclusters by RBC Life Sciences®, Inc.
Food and Beverage > Supplements

Nanoceuticals™ Citrus Mint Shampoo by RBC Life Sciences®, Inc.
Health and Fitness > Supplements, Personal Care

Nanoceuticals™ Hydracel by RBC Life Sciences®, Inc.
Food and Beverage > Supplements

Nanoceuticals™ Microbright Tooth Powder by RBC Life Sciences®, Inc.
Food and Beverage > Supplements

Nanoceuticals™ Microhydrin® Products by RBC Life Sciences®

A Nanotechnology Consumer Products Inventory

Search

Home

Browse Products | Advanced Search

Displaying records 11-13 of 13
Results Page: Previous 1 2

Nanoceuticals™ Slim Shake Chocolate by RBC Life Sciences®, Inc.
Food and Beverage > Food

Nanoceuticals™ Spirulina Nanoclusters by RBC Life Sciences®, Inc.
Food and Beverage > Supplements

OilFresh™ 1000 by OilFresh® Corporation
Food and Beverage > Cooking

Results Page: Previous 1 2

Disclaimer

Using the Inventory

Nano-sized Ingredients/ Additives

Technology

- Processed nano-structures in food
- Use of nano-sized ingredients & additives

Benefits

- Improved texture, flavour, taste
- Reduction in the amount of salt, fat, sugar, and other additives
- Enhanced bioavailability/ health benefits

Examples

- Nano additives (colours, flavouring agents, preservatives, antioxidants)
- Lycopene, Nano-salt, WOW Mayonnaise

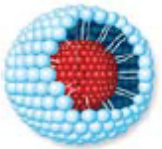
Concerns

- Need to ensure nanostructures are solubilised/ digested in the gut – i.e. they do not carry insoluble biopersistent materials to the circulatory system

Delivery Systems for Supplements/ Nutraceuticals

Technology

- Nanoencapsulation of ingredients, additives and supplements
- Based on micelles & liposomes



Benefits

- Taste masking, protection from degradation during processing
- Enhanced bioavailability of nutrients/ supplements
- Antimicrobial and other health benefits

Examples

- Food additives (benzoic acid, citric acid, ascorbic acid), Supplements (vitamins A and E, isoflavones, ß-carotene, lutein, omega-3 fatty acids, coenzyme-Q10)

Concerns

- Need to ensure that greater bioavailability does not lead to increased health risks
- Tissue distribution is not different from that of conventional forms

* Tip Top UP Bread contains microencapsulated tuna fish oil

Engineered Nanoparticulate (ENP) Additives

Technology

- Manufactured nanoparticle forms of additives and supplements

Benefits

- Enhanced bioavailability of nutrients/ supplements
- Antimicrobial and other health benefits

Examples

- Mineral supplements (calcium, magnesium, iron, zinc, silica, diatomaceous earth, silver, gold)
- Nano-tea; "slim-shake chocolate"

Concerns

- Possible exposure to insoluble free ENPs, inside and outside the gut
- Toxicological properties of most ENPs are not yet known

Food Packaging Applications

- **Improved nano-composites**
  - Polymers incorporating nanomaterials to improve flexibility, durability, temperature/ moisture stability, barrier properties
- **'Active' nano-composites**
  - Plastic polymers incorporating nanomaterials with antimicrobial properties
- **'Intelligent' & 'Smart' packaging**
  - Packaging incorporating nanosensors to monitor condition of the food

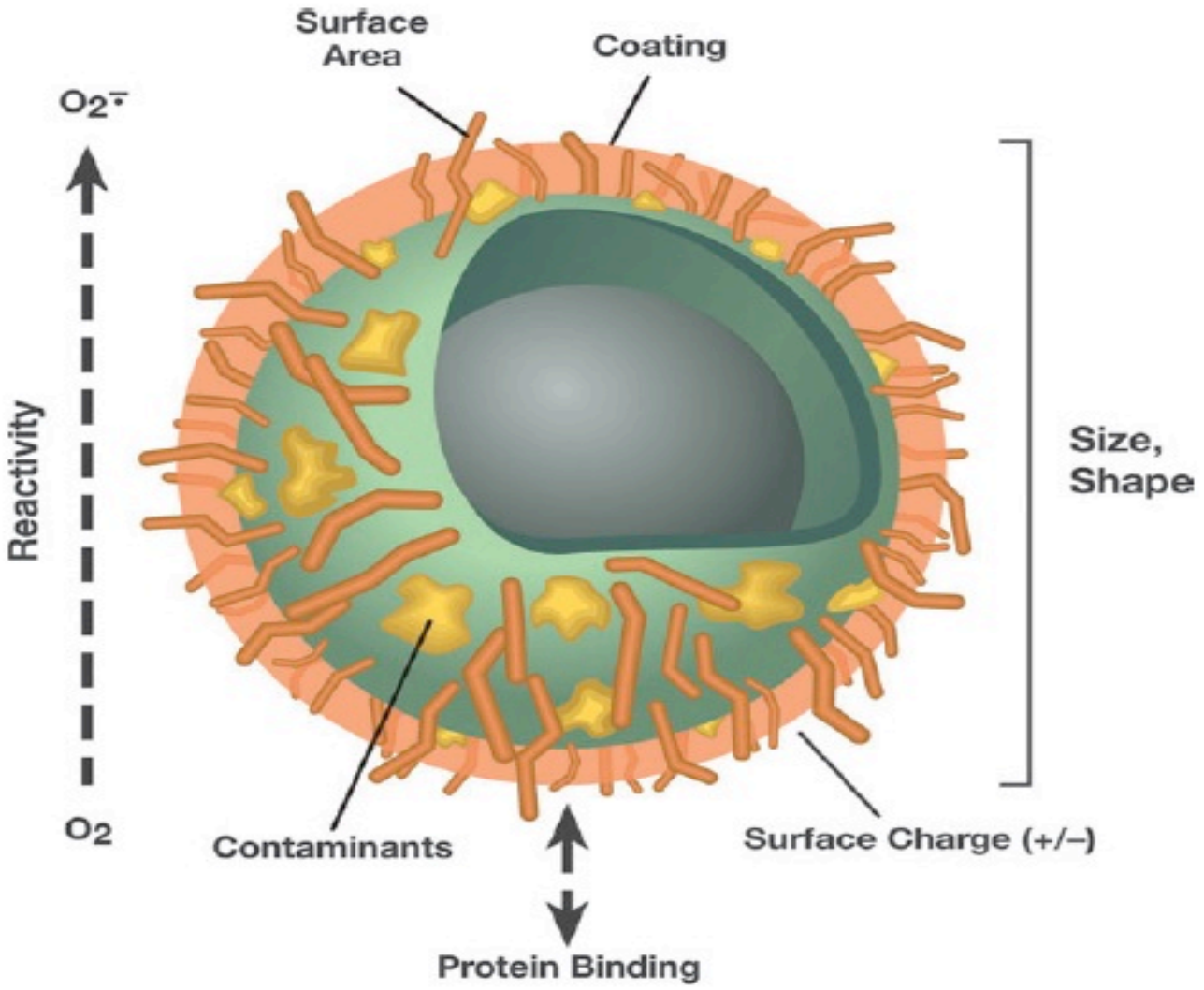
Examples

Concerns

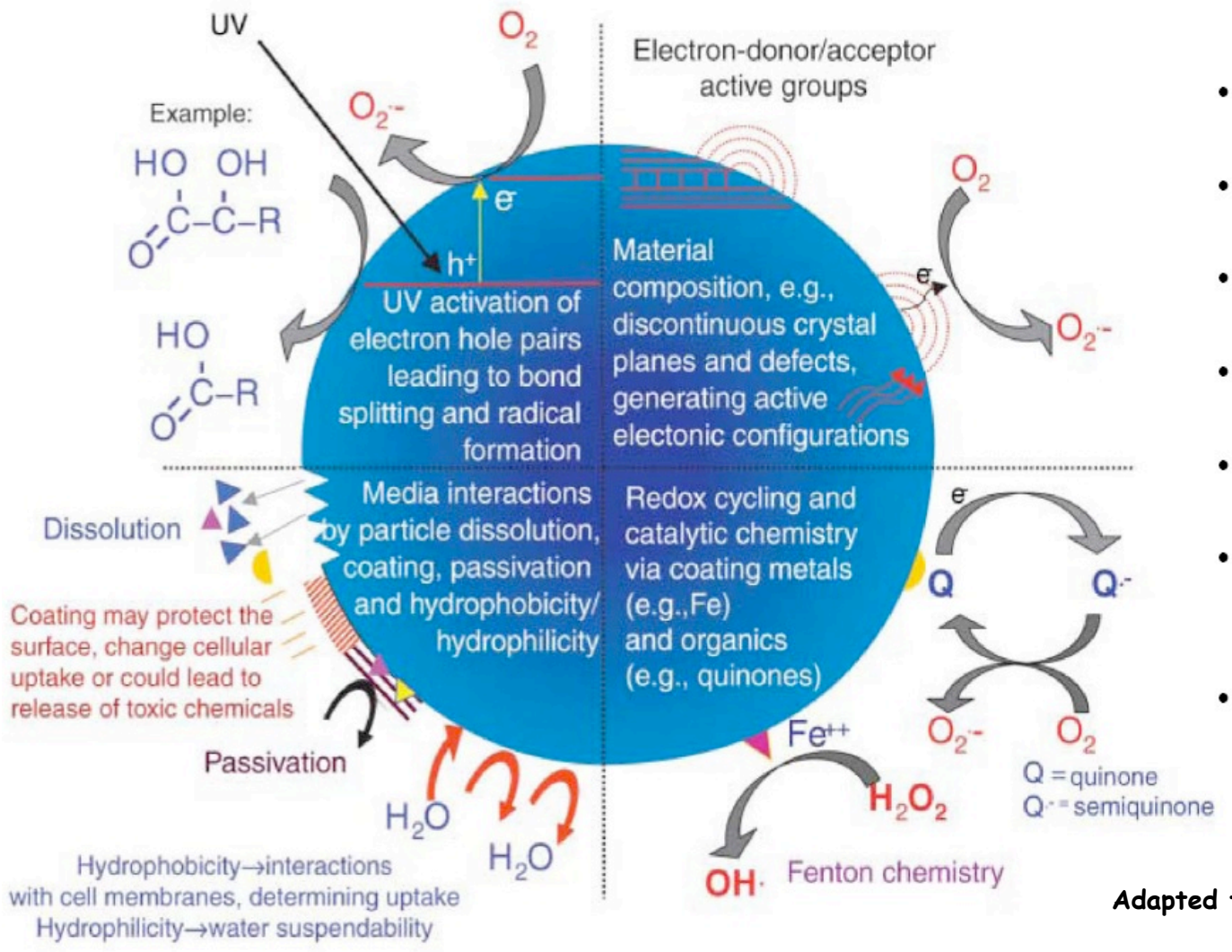
- Potential risks due to migration of ENPs into food and drinks

Une question de propriétés de surface:

Possibilité de l'internalisation? Franchissement de barrières? Réponses cellulaires, d'organes, d'organismes ?



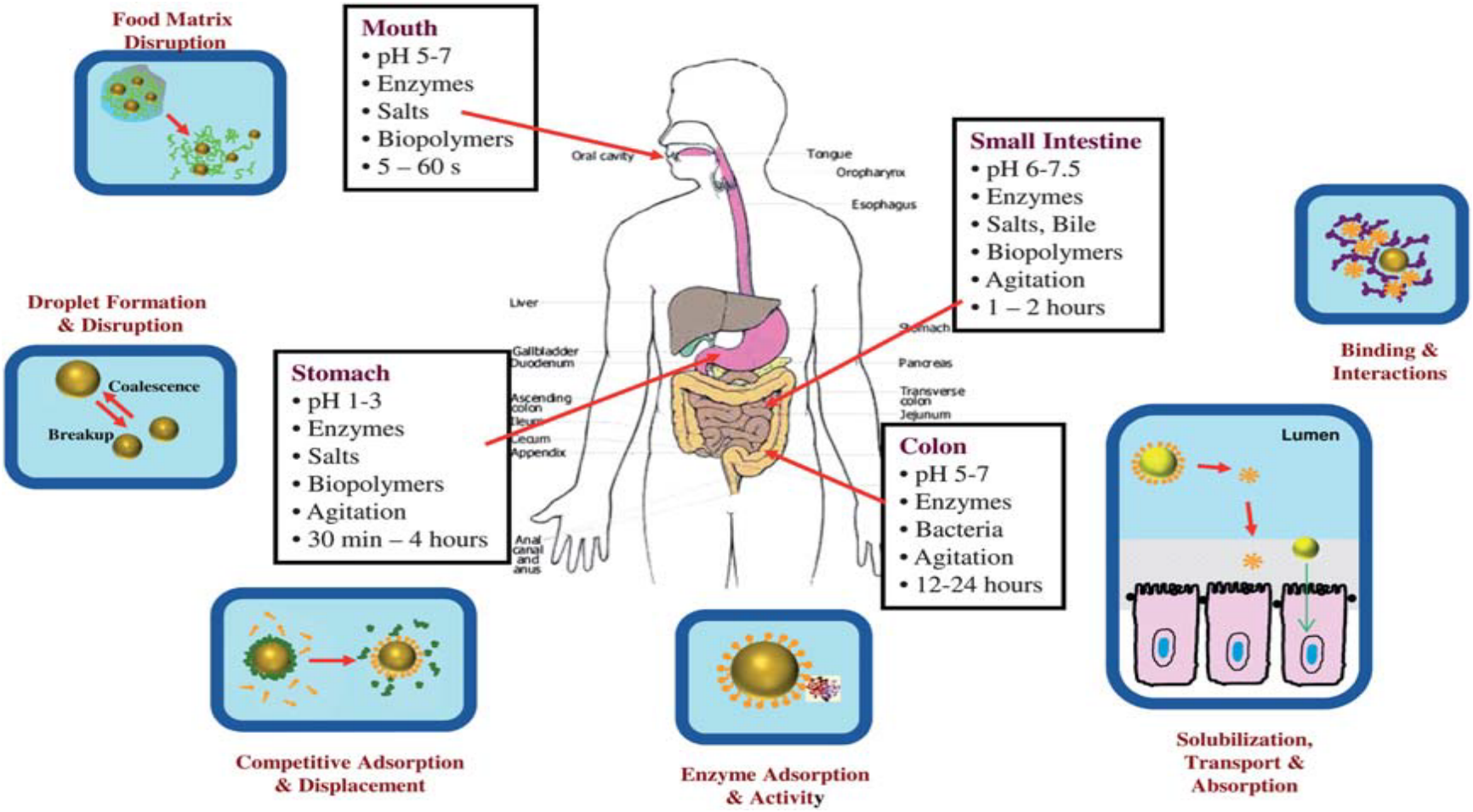
Propriétés physicochimiques des NPS et Toxicité



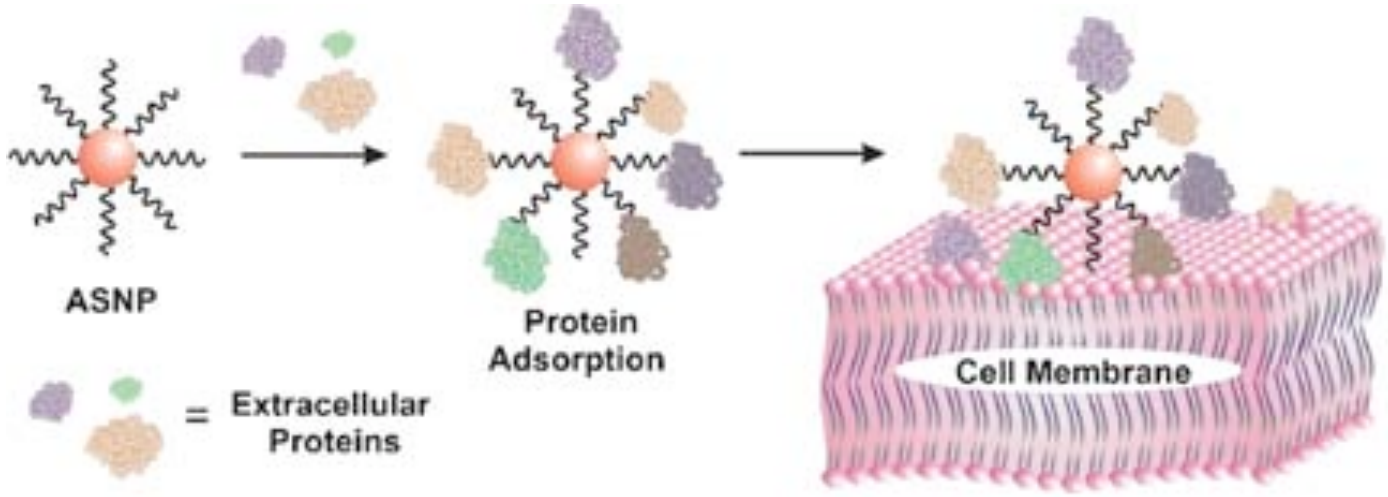
- Material composition
- Electronic structure
- Bonded surface species
- Surface coating
- Solubility
- Contribution of surface species
- Environmental factors

Adapted from Nel et al, Science 2006

Comportement d'une Nanoparticule dans l'appareil digestif (d'après McClements and H Xiao Food and Fonction 2011)

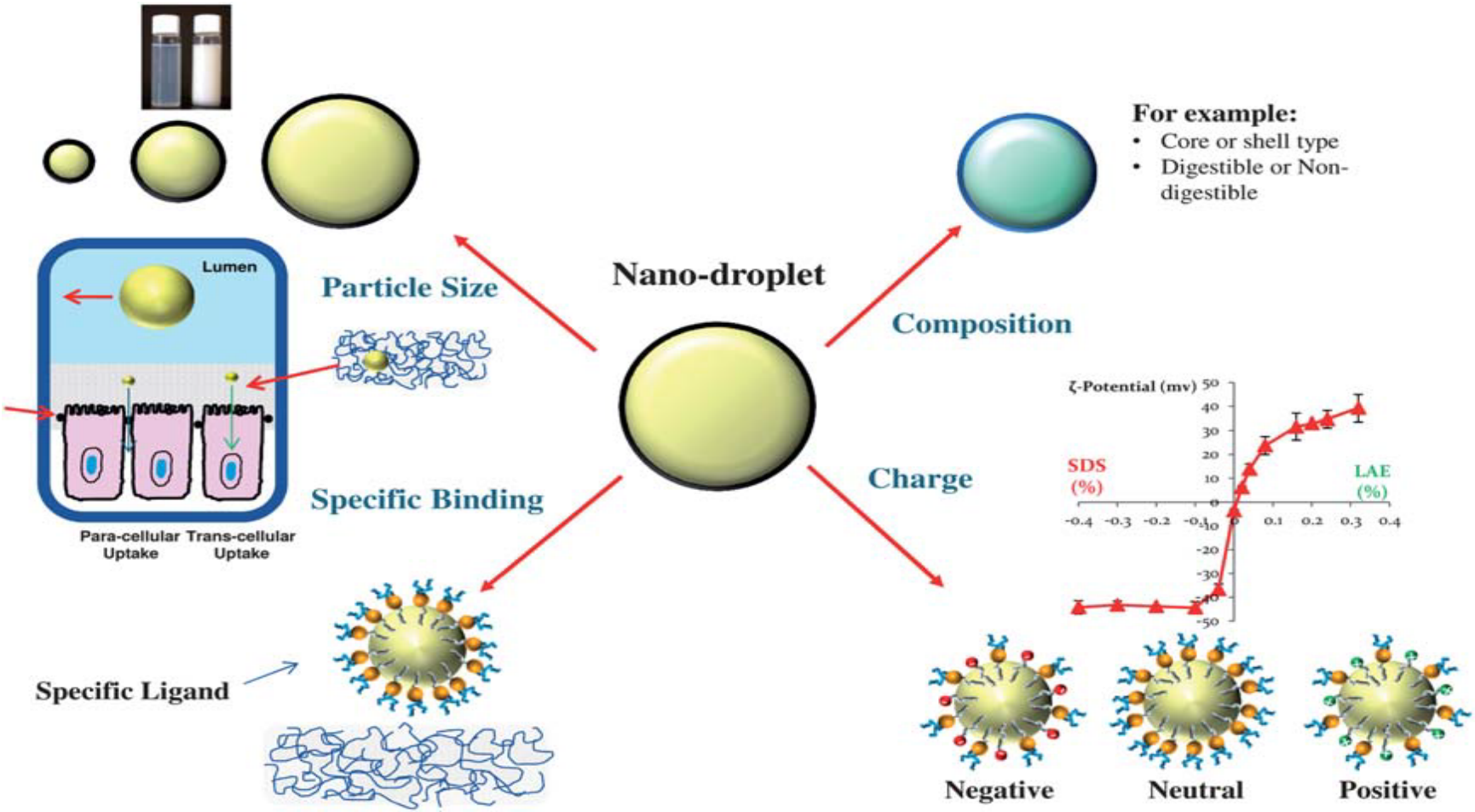


La « Corona »



Liu et al Int.J.Cancer 2007

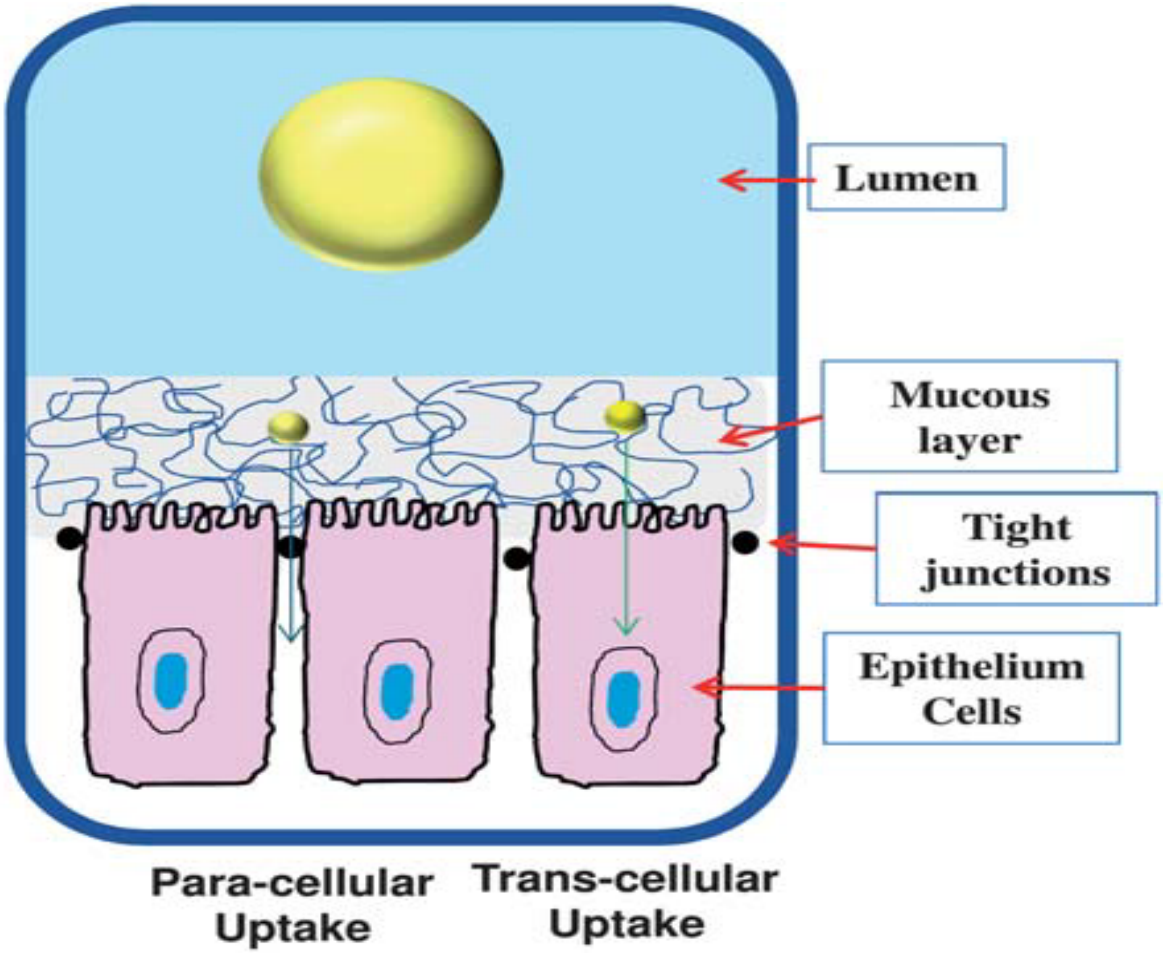
Rôle de la composition, de la charge et de la corona (d'après McClements and H Xiao Food and Fonction 2011)



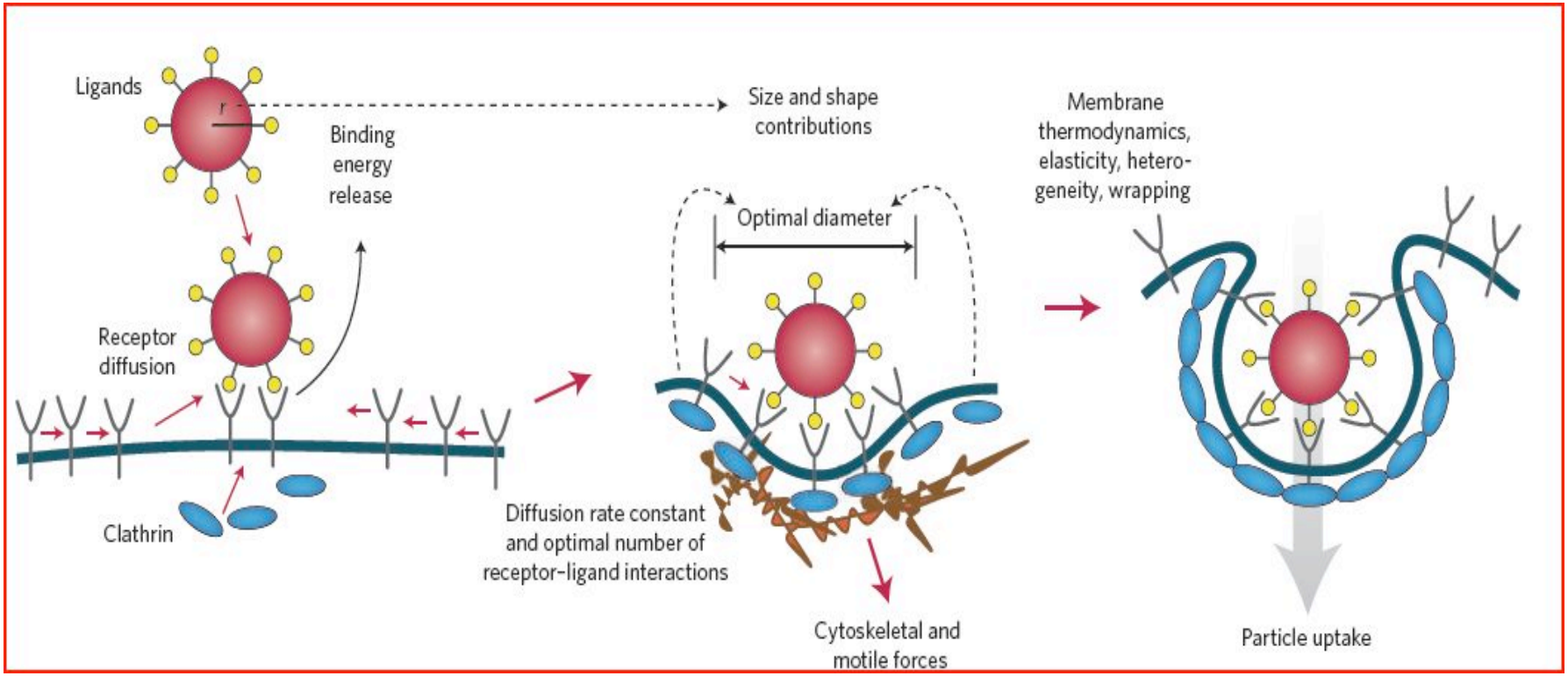
Importance de la taille des NPs dans les interactions avec l'épithélium

Large particles may be unable to enter the mucous layer.

Nanoparticles may be trapped in the mucous layer, which increases their retention time.



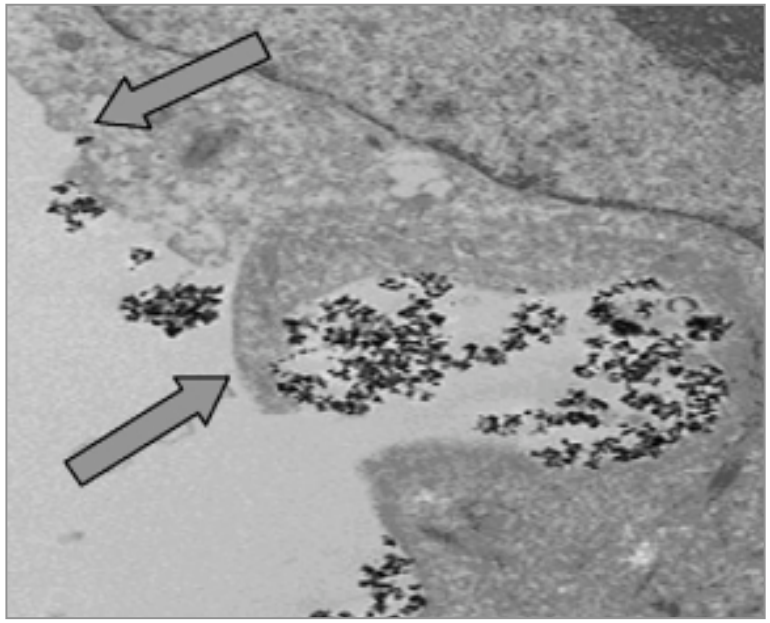
Internalisation de NPs



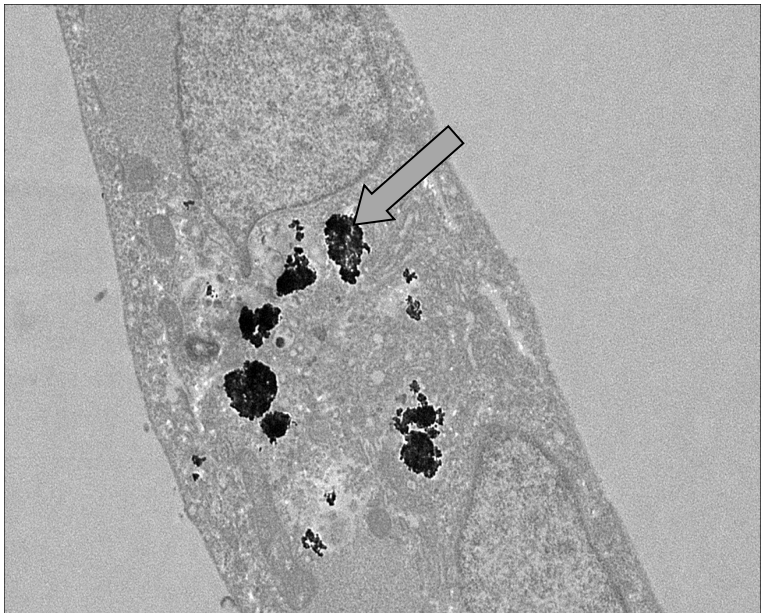
Nel et al Nature Nanomat 2009

Phagocytose de NP de Carbone et de TiO2 dans des cellules bronchiques humaines en culture

MET



CB 13 nm



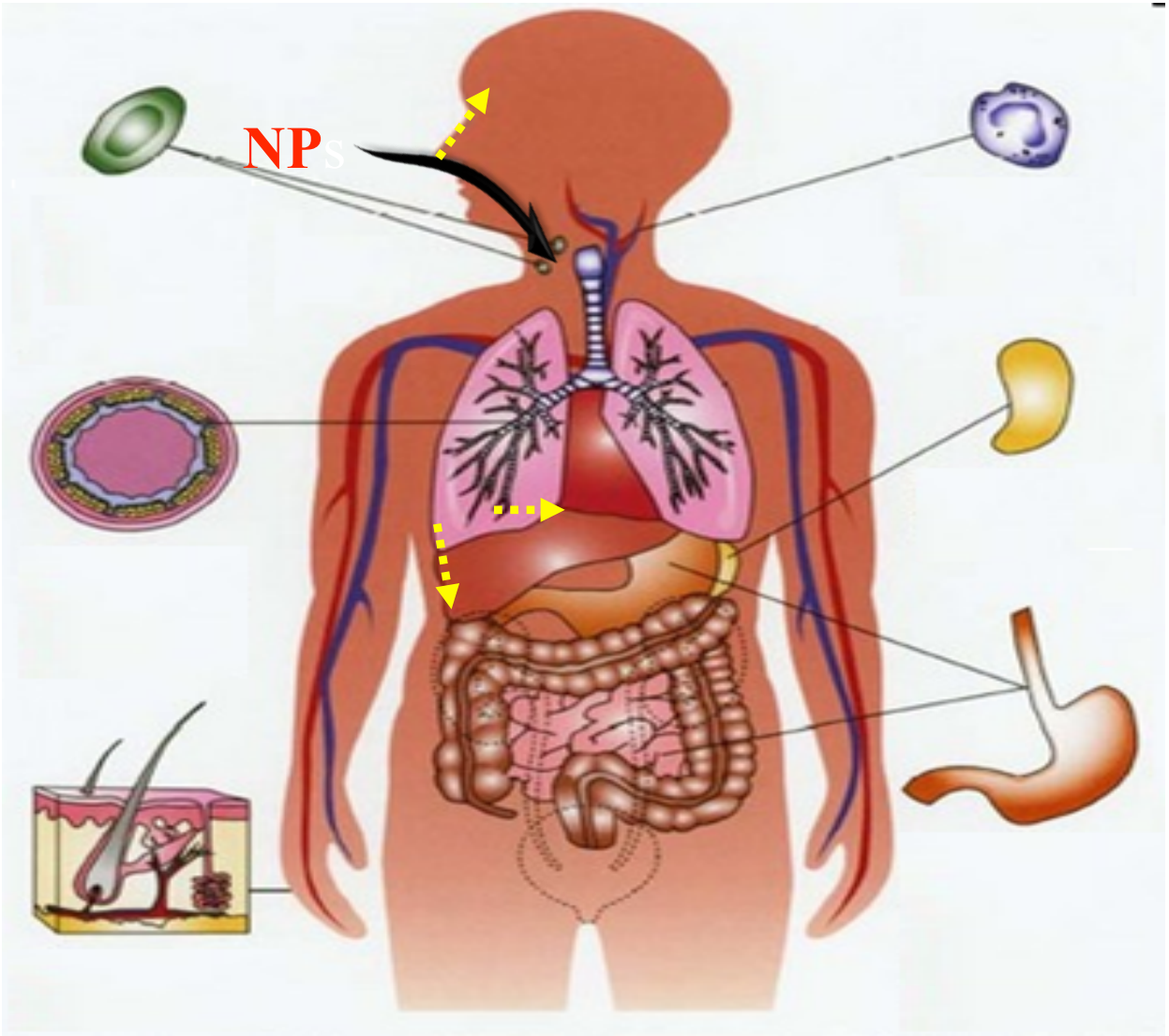
TiO_2 15 nm

➢ Internalisation dose-dépendante confirmée par cytométrie de flux

Hussain et al, Toxicology, 2009

Voies d'entrée des nanoparticules

Poumons



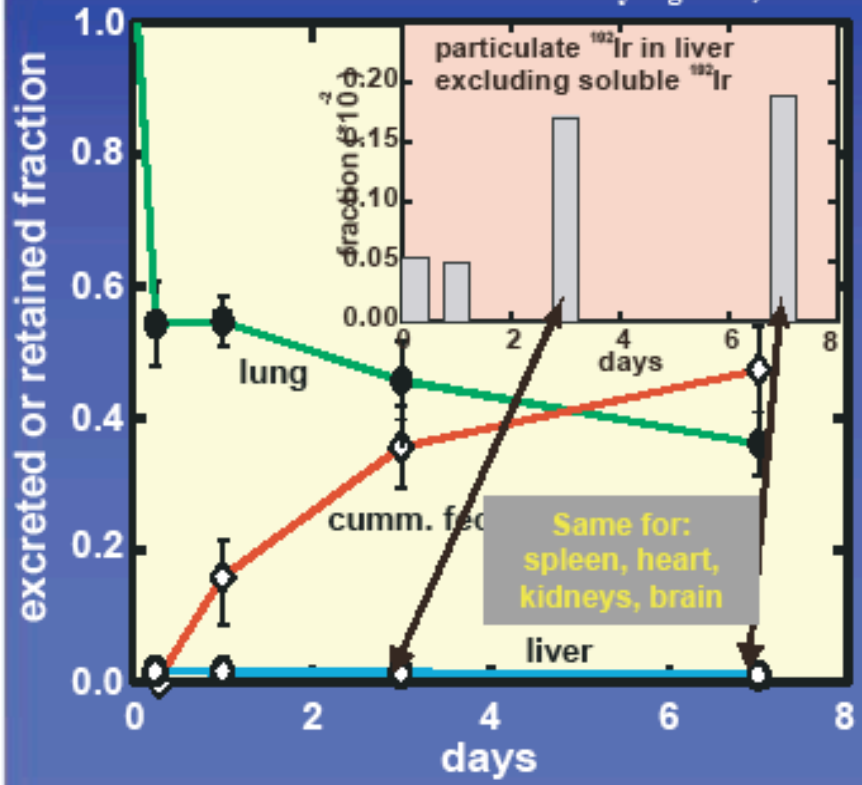
Intestin

Peau

Translocation systémique des NP vers des organes secondaires

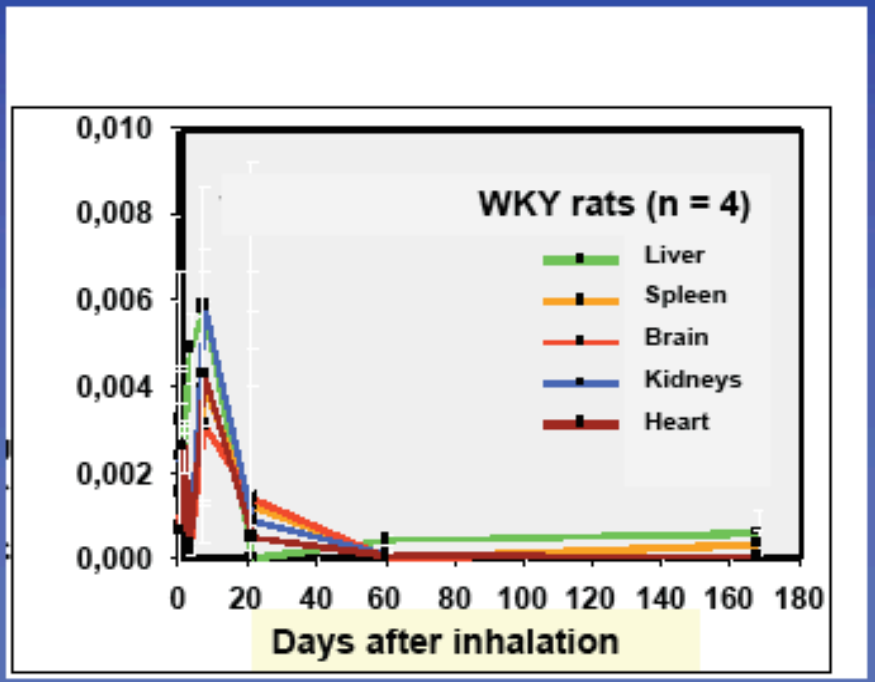
WKY rat, ^{192}Ir NP, 1 hr exposure
15 nm CMD, 10^7 cm^{-3}, 0.2 mg/m^3

Kreyling et al., 2002



Long-term translocation kinetics
same exposure

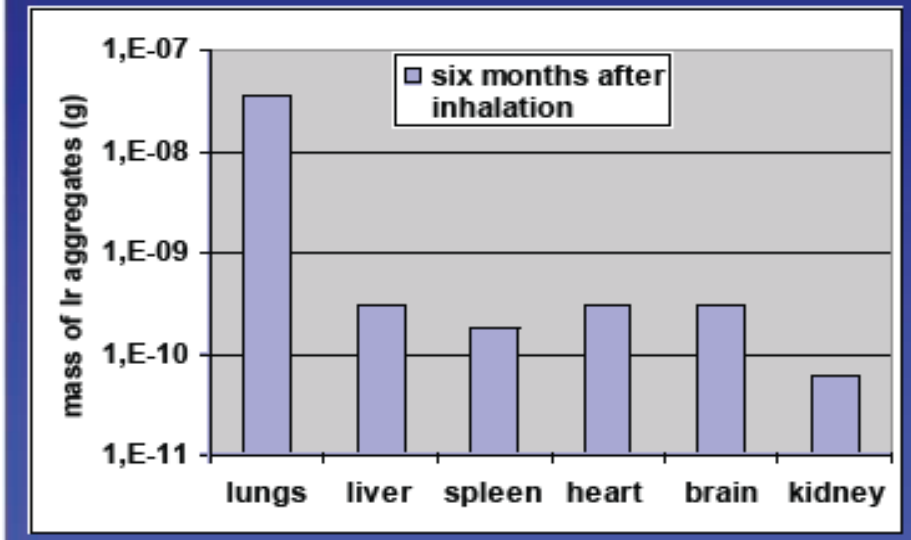
Semmler et al., 2004

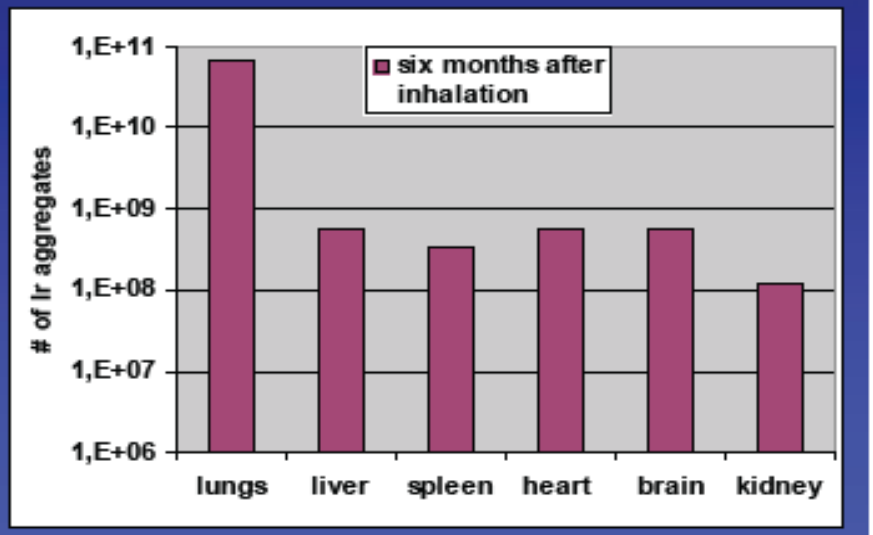


There is little but persistent translocation of Ir-NP towards secondary target organs

Translocation systémique des NP vers des organes secondaires (Kreiling et al 2007)

WKY rat, ^{192}Ir NP, 1 hr exposure
15 nm CMD, 10^7 cm-3, 0.2 mg/m^3



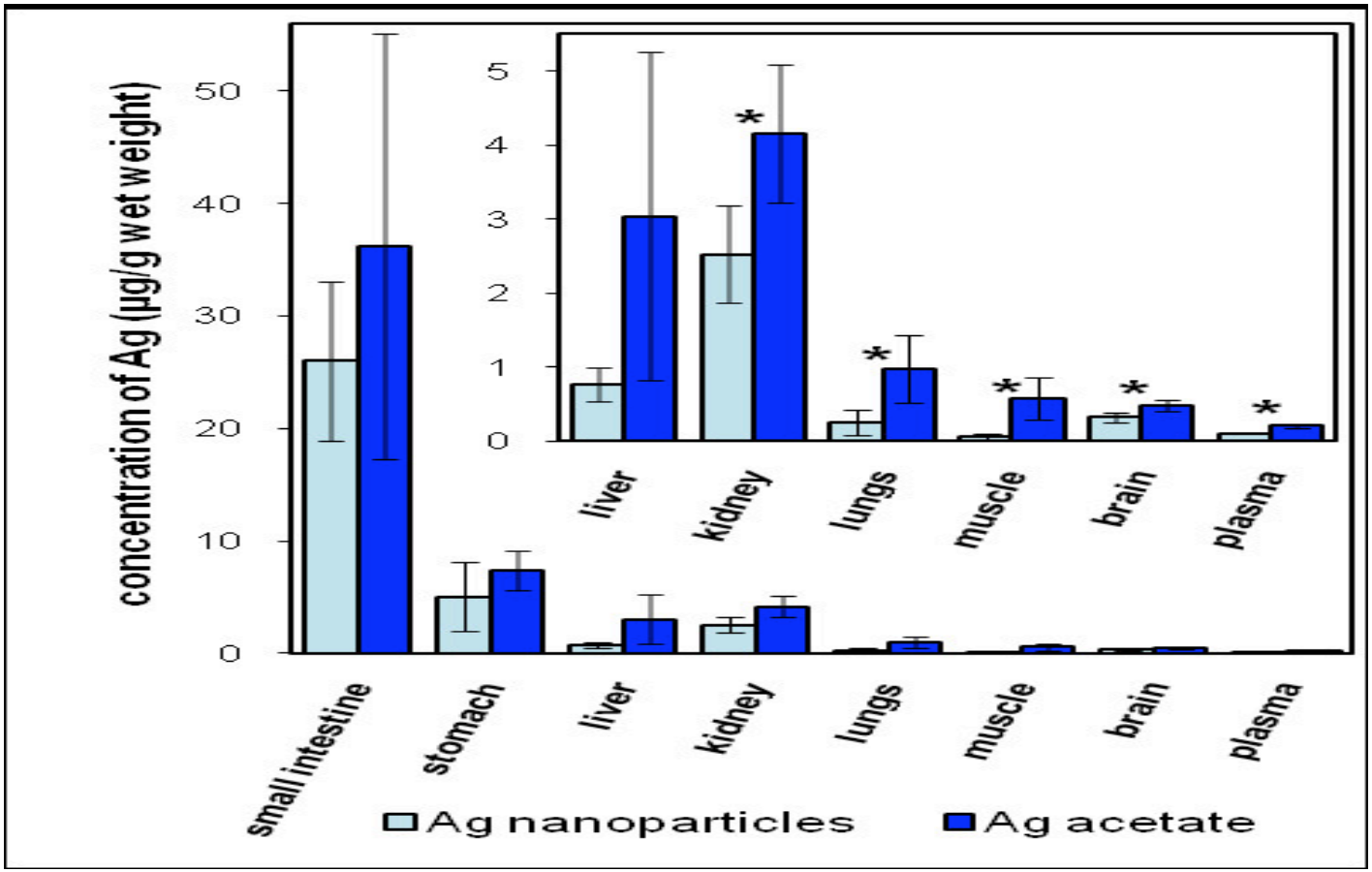


Primary particles	~ 2 nm
Specific surface area	1200 m^2 / cm^3
Zeta potential	- 20 mV
SIMS-TOF surface analysis	IrO_2

Unexpected high NP numbers in secondary target organs including heart and brain after six months. These organs are not considered to be exposed to particulate foreign bodies.

Do these many NP cause harm?

Translocation systémique de NPs de l'intestin vers des organes secondaires



Distribution d'argent chez le rat exposé à des NPs d'Ag (14nm) et à de l'acétate d'Ag et gavés 2 fois par jour pendant 28jours (d'après Loeschner et al PFT 2011)

Excrétion des NPs d'Ag et de l'acétate d'Ag dans les fèces et l'urine

Table 1

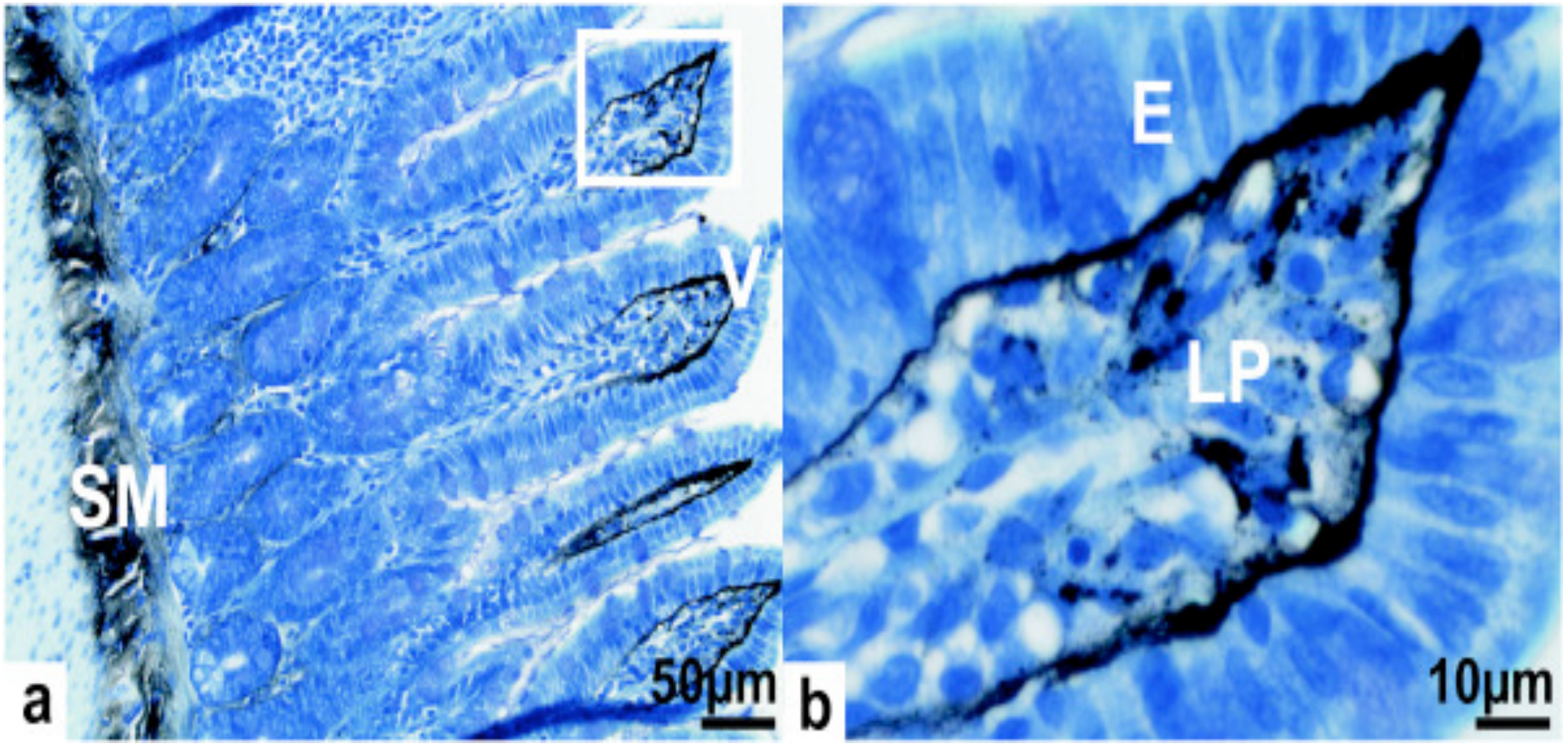
24 h excretion of silver in urine and feces

	urine (µg)	feces (µg)	urine (% of 24 h intake)	feces (% of 24 h intake)
Ag-PVP nanoparticles	0.10 ± 0.05	1190 ± 430	0.005 ± 0.003	63 ± 23
Ag acetate	0.73 ± 0.23	610 ± 250	0.057 ± 0.017	49 ± 21

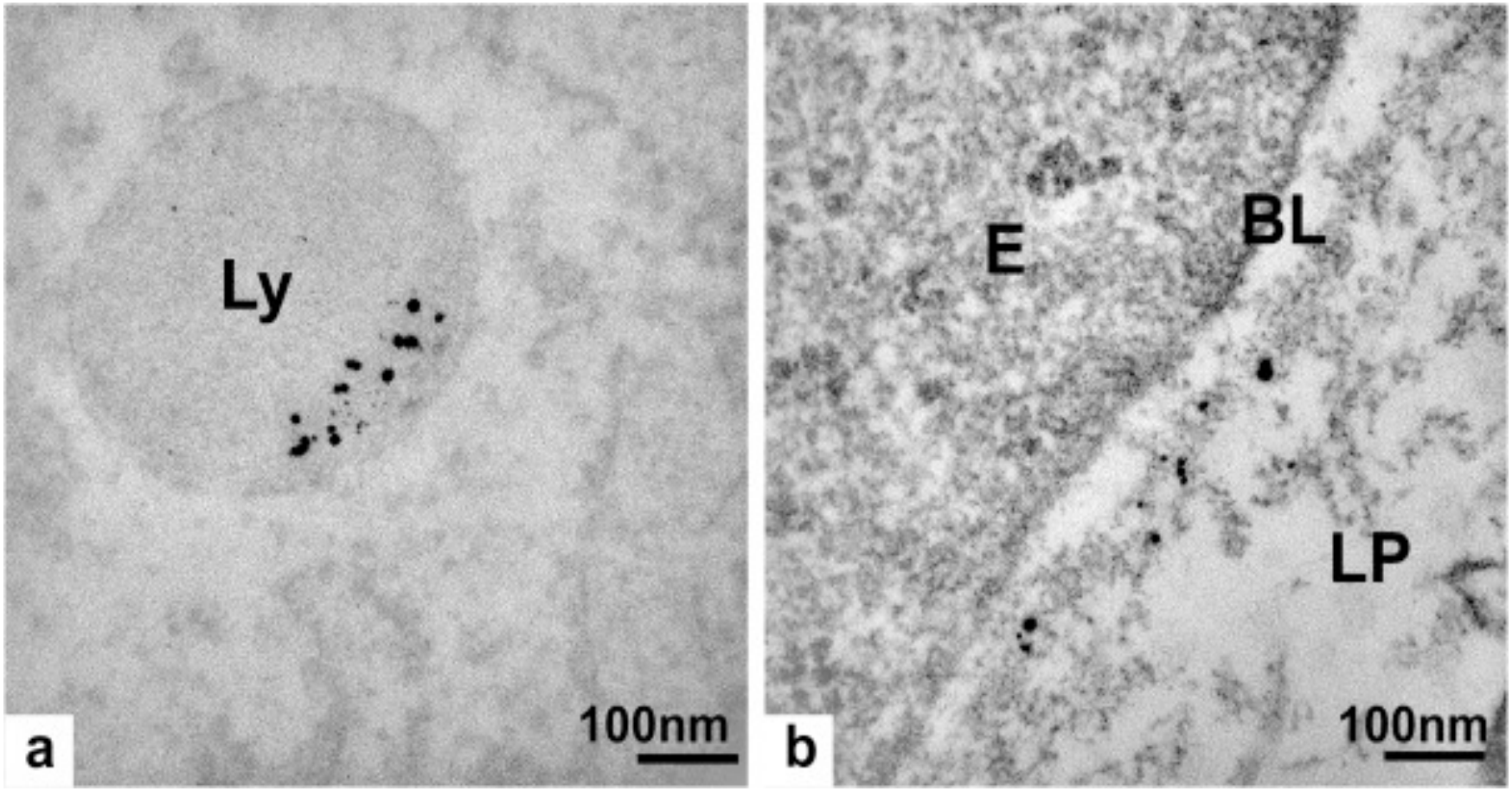
Absolute and relative amount of silver (mean ± 1s.d., N = 5) excreted in urine and feces within a 24 hour time period in week 3 of the study.

d'après Loeschner et al PFT 2011

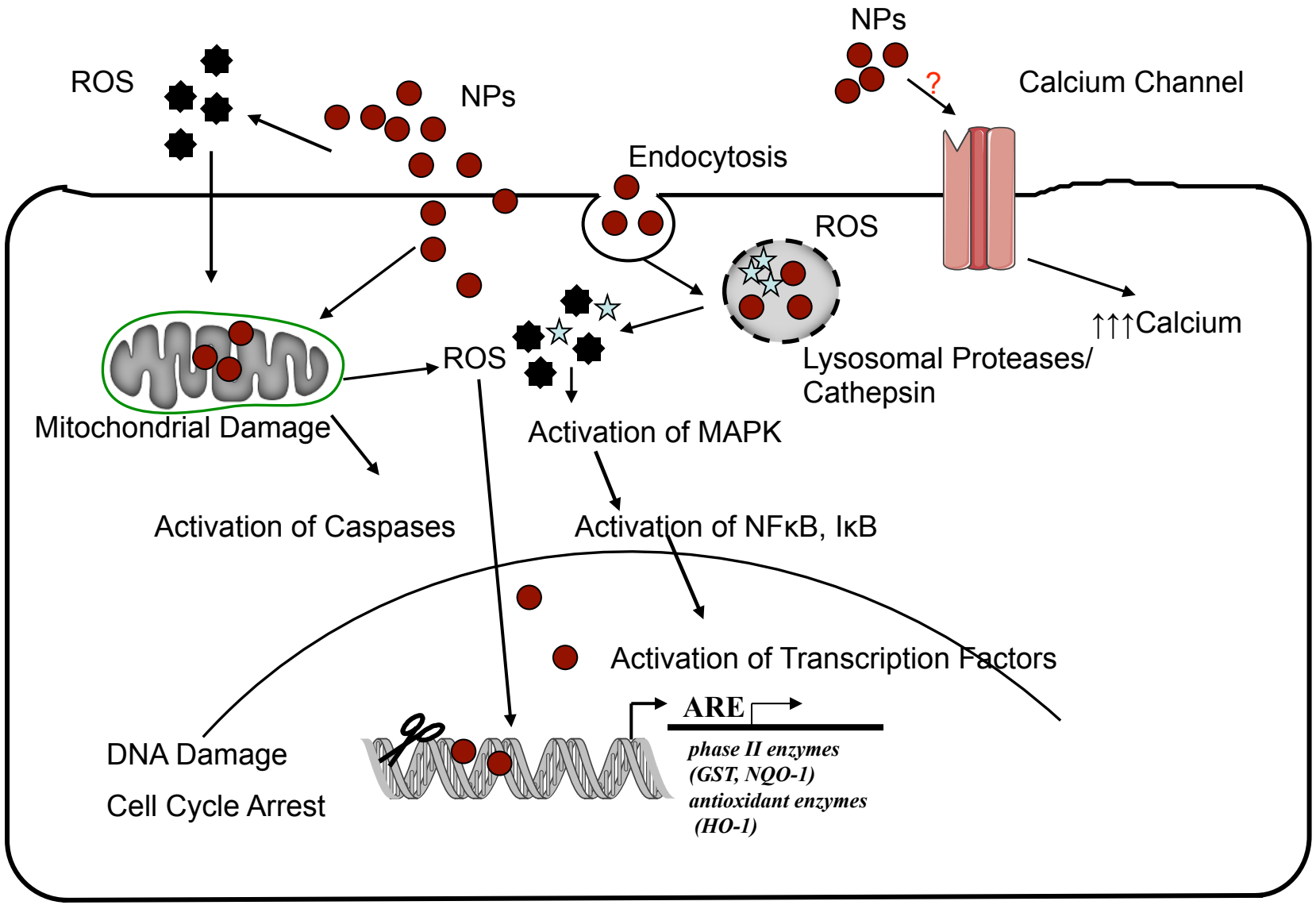
Détection d' Argent dans l' épithélium intestinal aprés exposition des rats pendant 28jours par voie orale aux NPs d' Ag



Détection de NPs d'Ag dans les lysosomes des entérocytes.



Mécanismes de cytotoxicité pouvant être induits par les NP

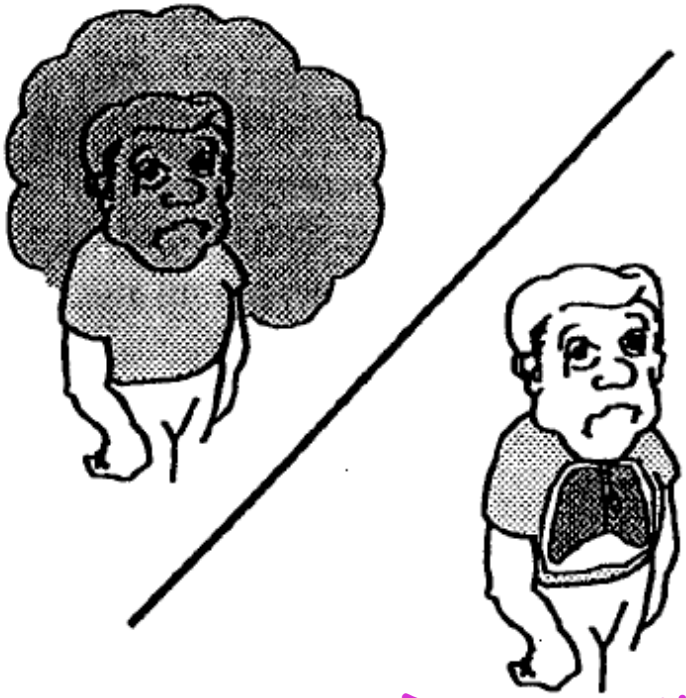


Marano et al AOT 2010

L'evaluation de risque est-elle possible?

Evaluation de l'exposition? Insuffisante!

Exposition: quantité de substance disponible pour l' absorption



Dose: quantité de substance réellement absorbée

Caractérisation du danger? Insuffisante!

- ✓Organes cibles
- ✓Réponse toxique
- ✓Dose-réponse

Etudes expérimentales

In vivo et in vitro

Enjeux de la nanotoxicologie

Développer des connaissances encore parcellaires:

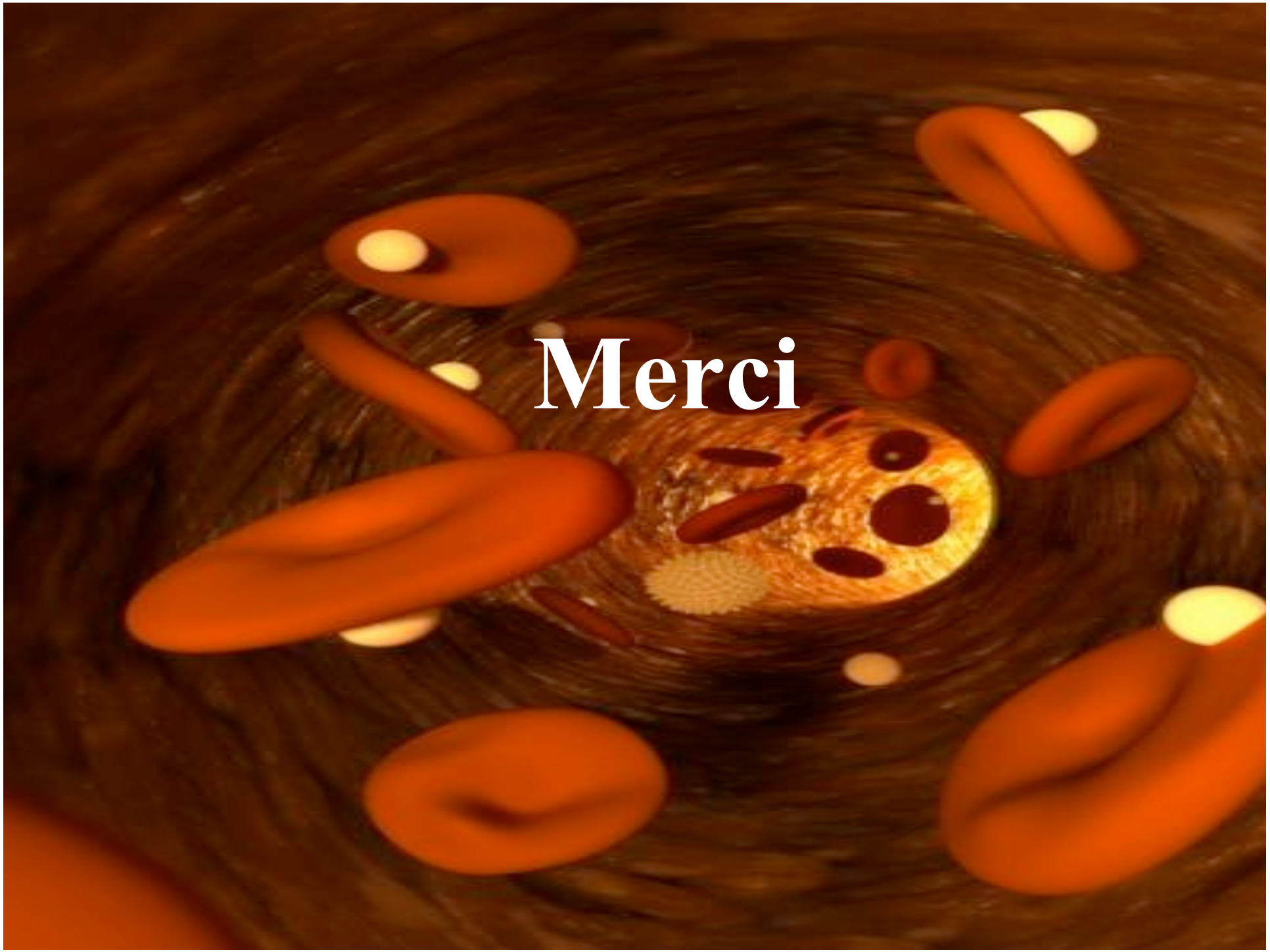
Transposition de l'animal à l'homme?

Passage des barrières cutanée, intestinale, hématoencéphalique, placentaire?

Cinétique d'élimination rénale?

Possibilité d'accumulation dans des organes cibles?

Effets à long terme?


Merci