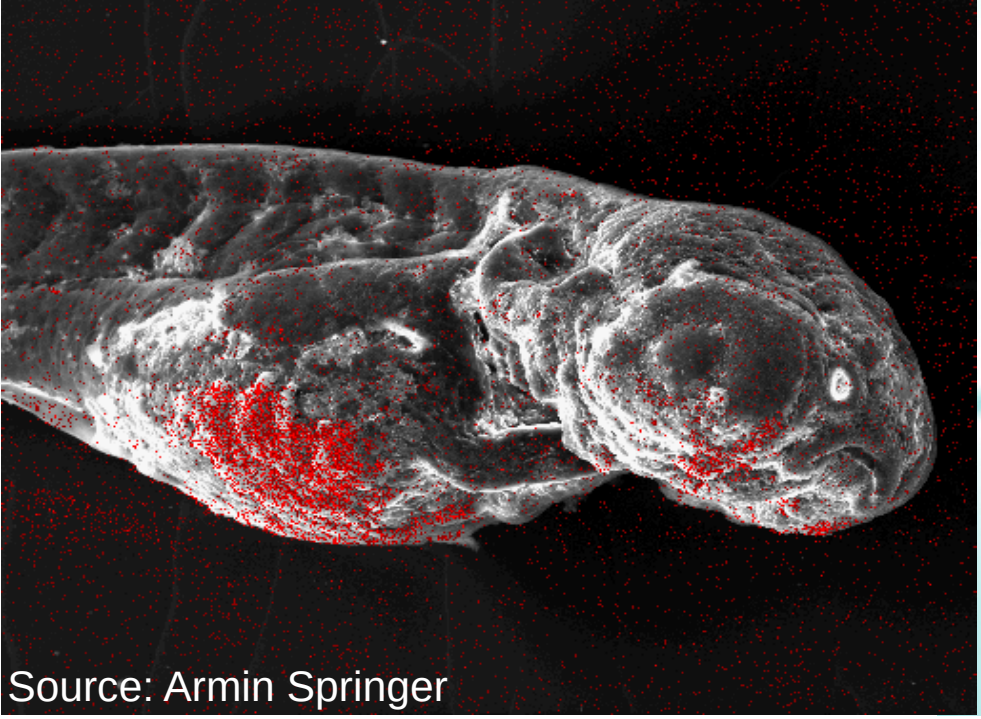
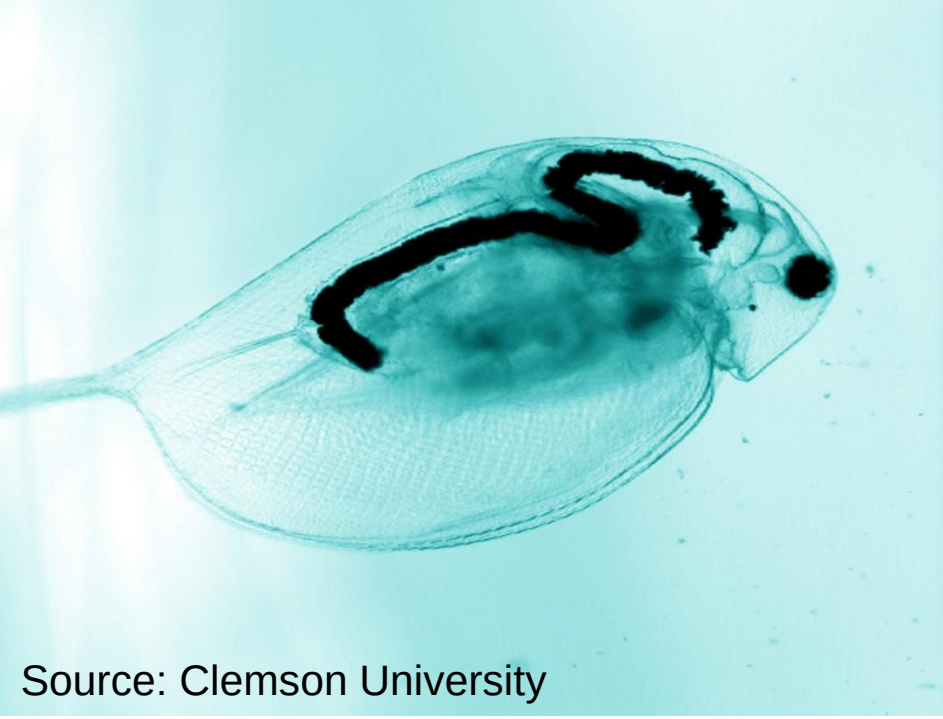


Source: Armin Springer



Source: Clemson University

Nano-Ecotoxicology – Assessment of Potential Effects of Engineered Nanomaterials in the Environment

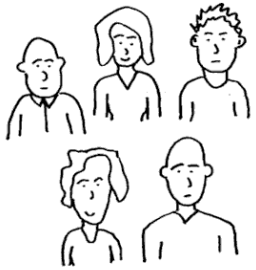
Dana Kühnel
Department Bioanalytical Ecotoxicology

HELMHOLTZ CENTRE FOR ENVIRONMENTAL RESEARCH – UFZ

Toxicology

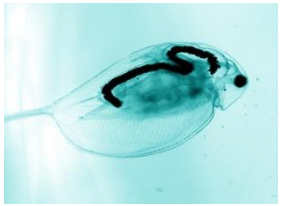
… is a branch of biology, chemistry, and medicine studying adverse effects of **chemicals** on living organisms.

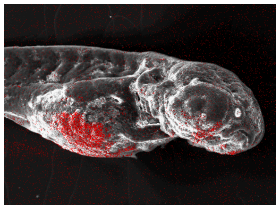
(Human)Toxicology



human beings

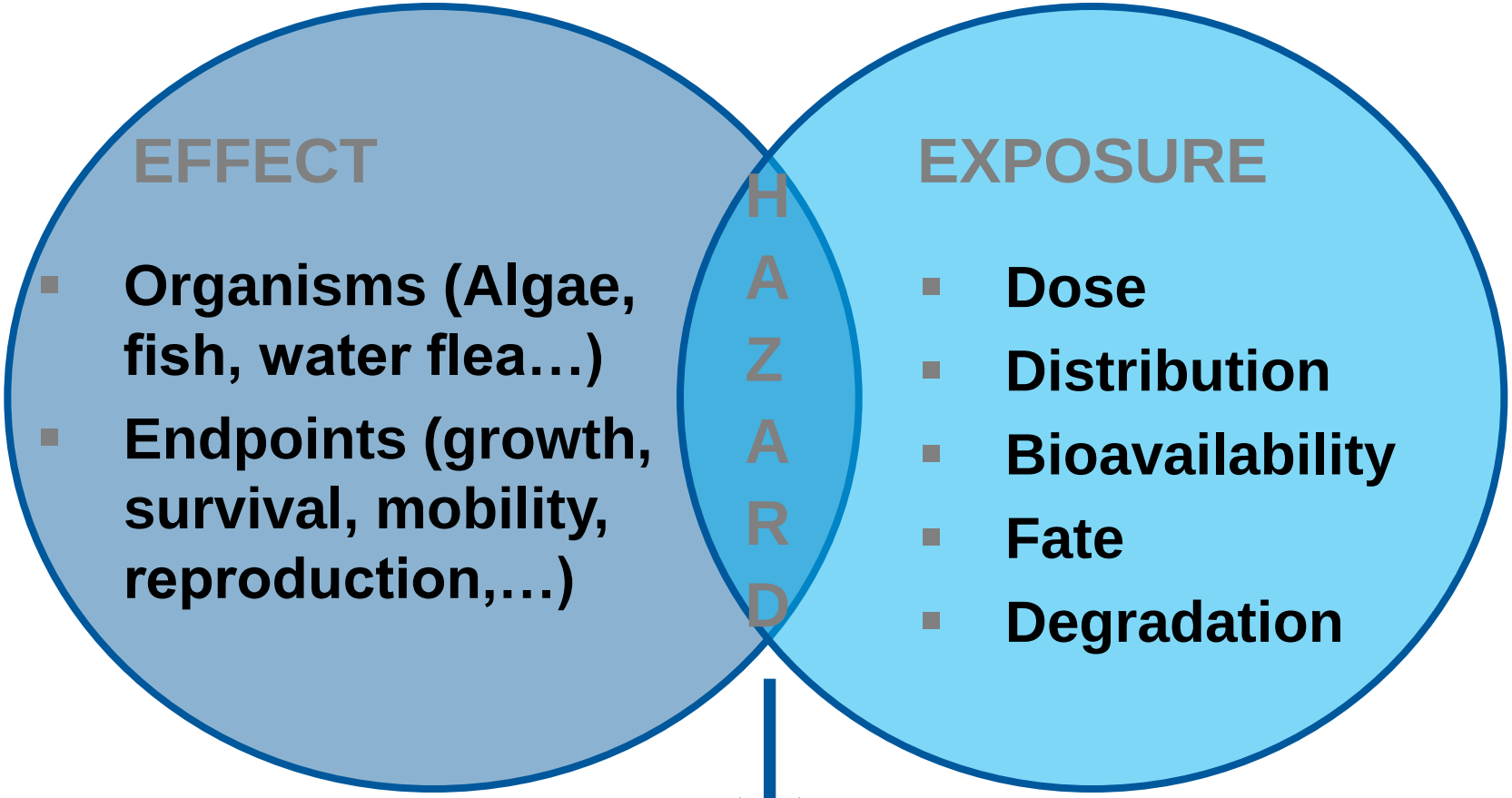
Ecotoxicology





all other organisms, populations and ecosystems

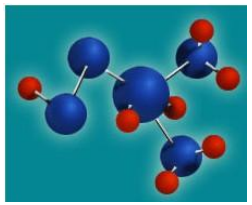
Fundamentals



Biological size scale

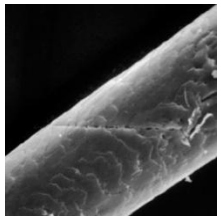
10^{-2}m ant

molecule



10^{-10}m

10^{-3}m

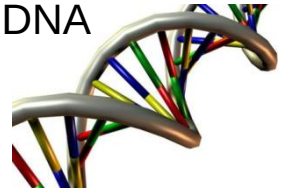


human hair

MICRO NANO

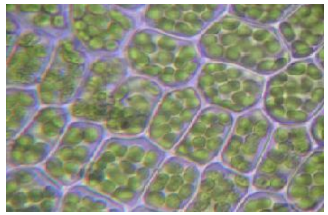
nanoparticles

DNA



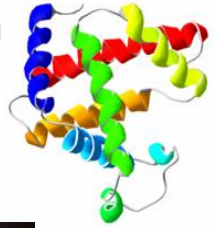
10^{-9}m (1 nm)

10^{-4}m (100 µm)



plant cells

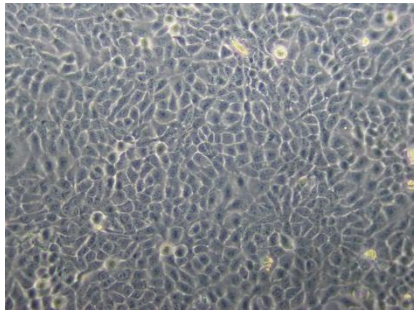
protein



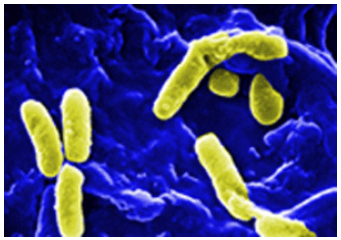
10^{-8}m (10 nm)

human and animal cells

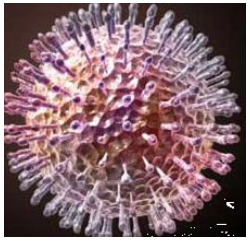
10^{-5}m (10 µm)



bacteria



virus



10^{-7}m (100 nm)

10^{-6}m (1 µm)

Relevant properties of nanomaterials for testing of nanomaterials

Properties

Reactivity

Sorption

Size / Shape

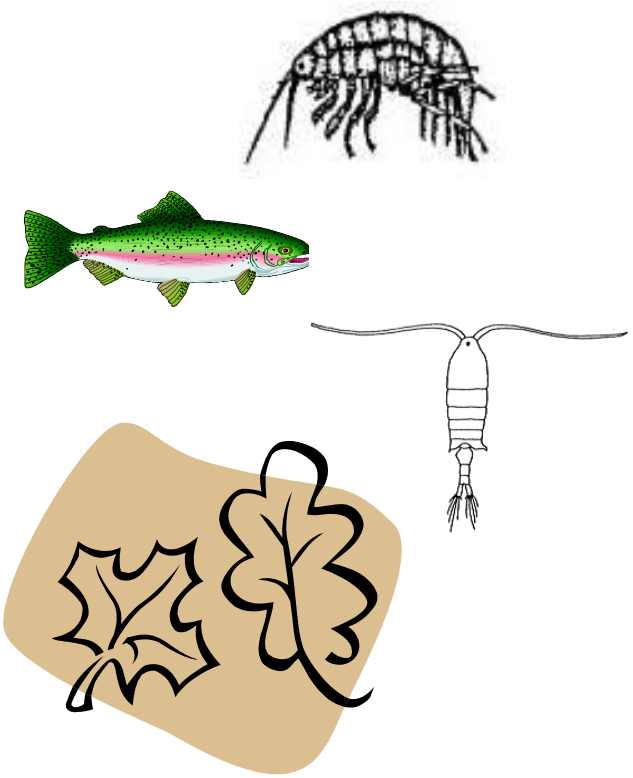
Solubility

Aggregation / Agglomeration

Coating

…
Others

Organisms in the Environment



Effects

Reactive oxygen species (ROS)

Carrier of toxic substances

Dissolved compounds (Me^{2+})

Bioaccumulation

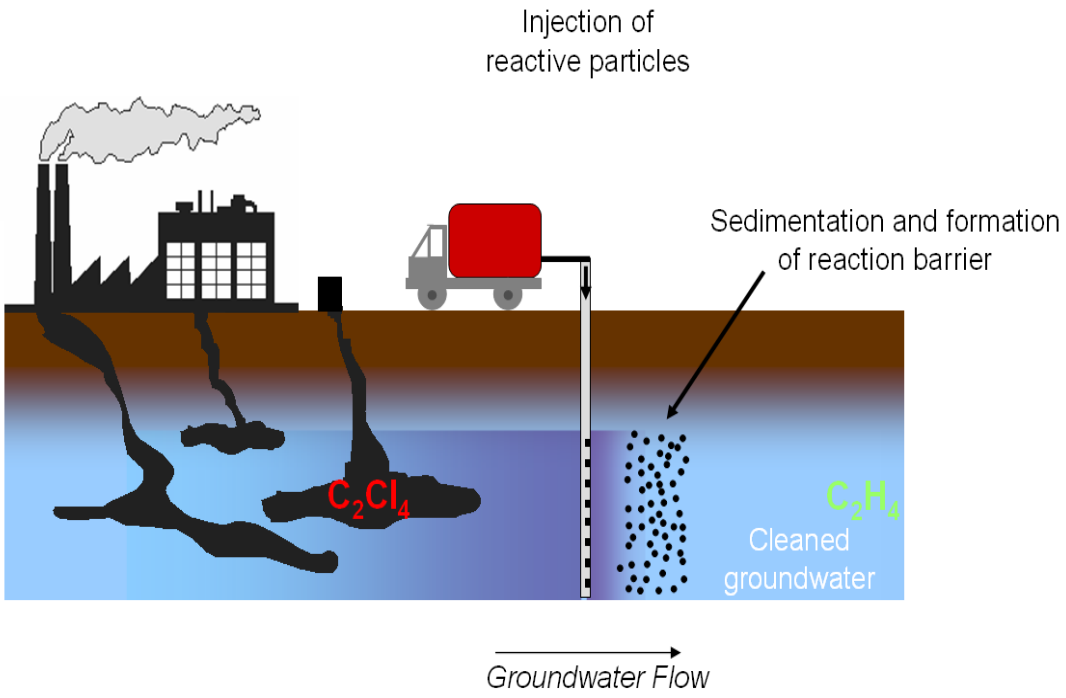
Molecular interaction

Indirect effects

…
Others

Nanomaterials for Groundwater Decontamination

In-situ Generation of an Reactive Barrier by Injection and Sedimentation of Small Particles



Carbo-Iron ®

Activated Carbon + Fe^0

$2e^- \rightarrow Fe^{2+}$

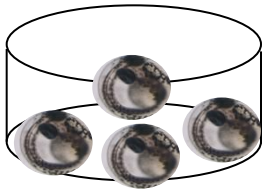
$RCl + 2e^- + H^+ \rightarrow R\text{-}H + Cl^-$

In the lab…

Chemical / Nanomaterials

Add to test media (e.g. water, soil)

Exposure of organisms

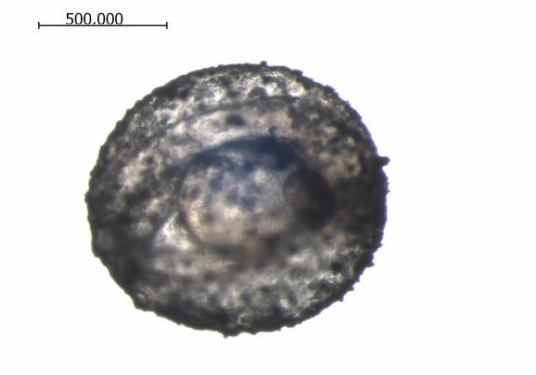


Acute / chronic

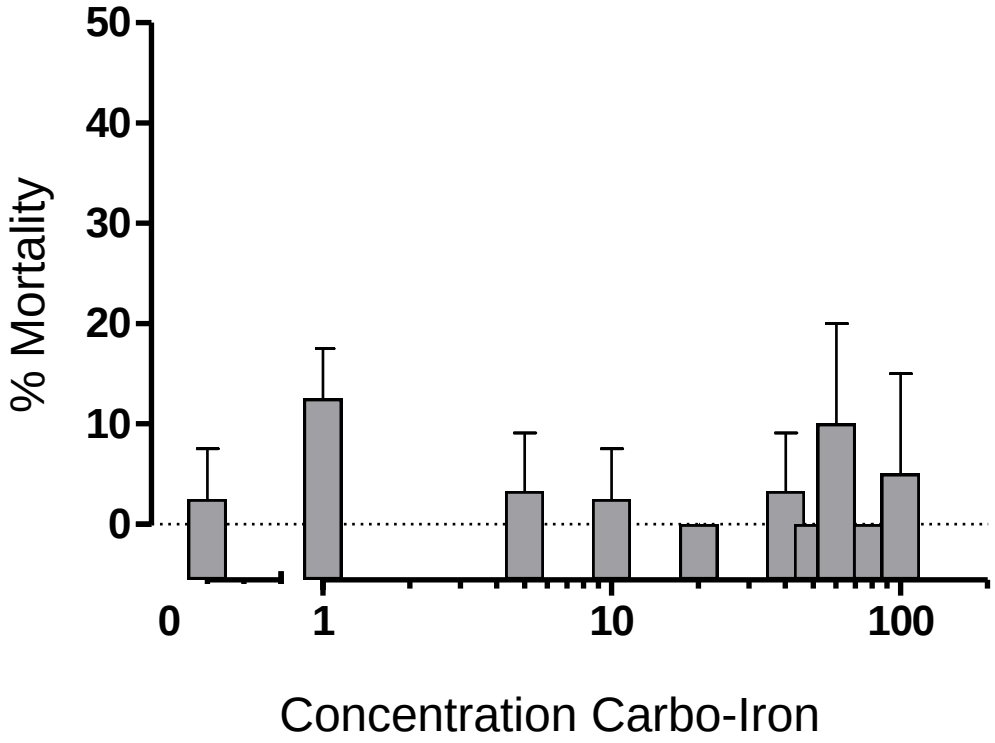
Effect / Observation / Measurement of endpoints

NMs for Groundwater Decontamination

control



10 mg/l Carbo-Iron



No particle uptake into tissue, no toxic effects on organisms

Nanoparticles can reach different organs

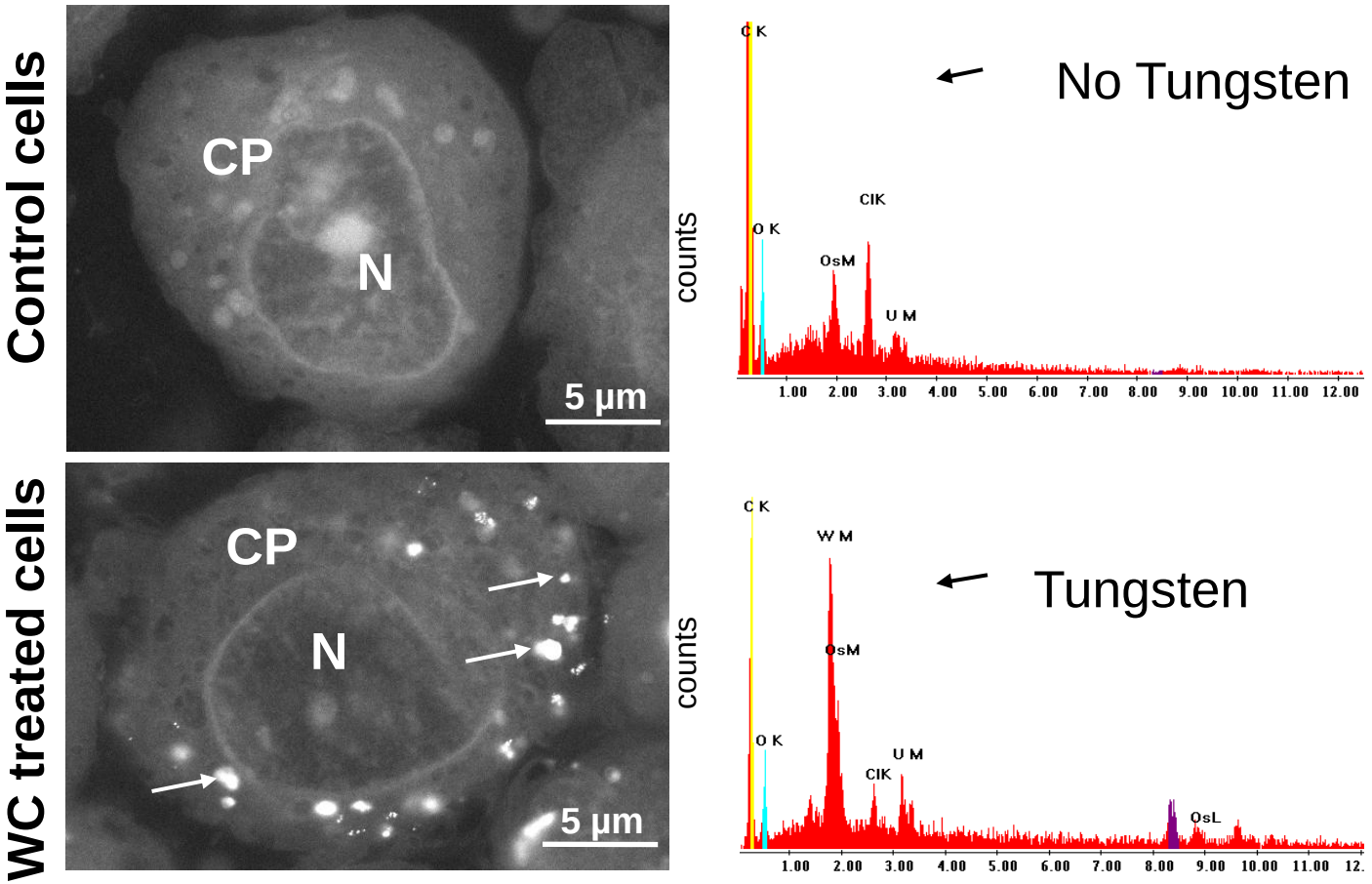
See-through medaka (*Oryzias latipes*)
Uptake of fluorescent polystyrene particles (40 nm)

Distribution of particles after 7 days:

Organs (no.)	Control[a] (mean ± SE)	Exposure[a] (mean ± SE)
Brain (16)	28.2 ± 5.6	57.1 ± 8.7
Gills (16)	28.3 ± 4.2	113 ± 10
Liver (16)	48.7 ± 6.2	93.9 ± 19
Kidney (16)	62.6 ± 14	103 ± 16
Gallbladder (16)	183 ± 30	246 ± 3.1
Intestine (16)	25.8 ± 3.7	147 ± 20
Spleen	NM	NM
Lungs	NA	NA
Testis (8)	47.1 ± 18	112 ± 15
Ovary (8)	118 ± 67	129 ± 36

Kashiwada (2006) EHP 114 (11): 1697-1702

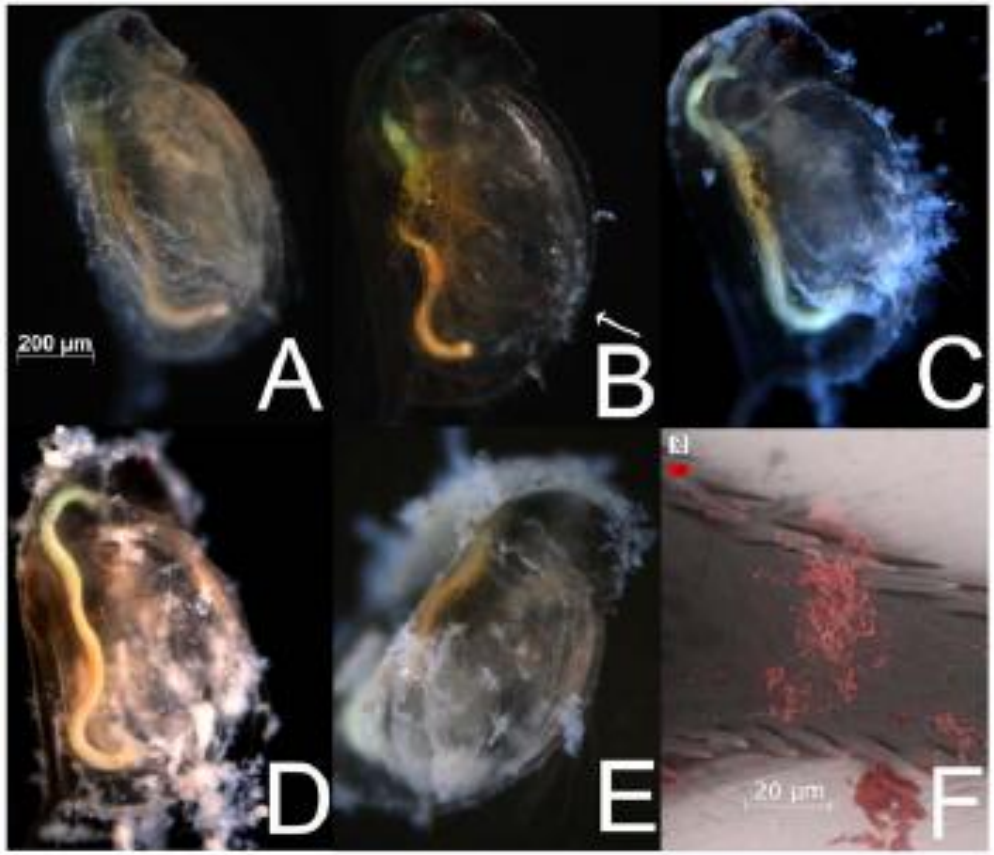
Nanoparticle uptake into cells



Exposure occurs, effect?

Kühnel et al. 2009 *Aquatic Toxicology* 93 (2009) 91–99.

Effect on molting and reproduction – daphnids exposed to TiO_2

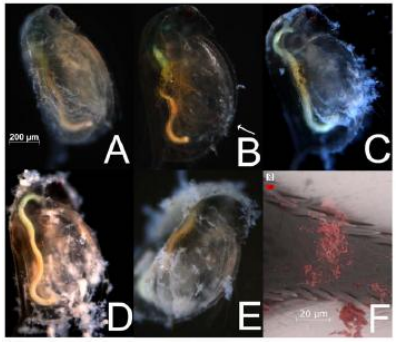


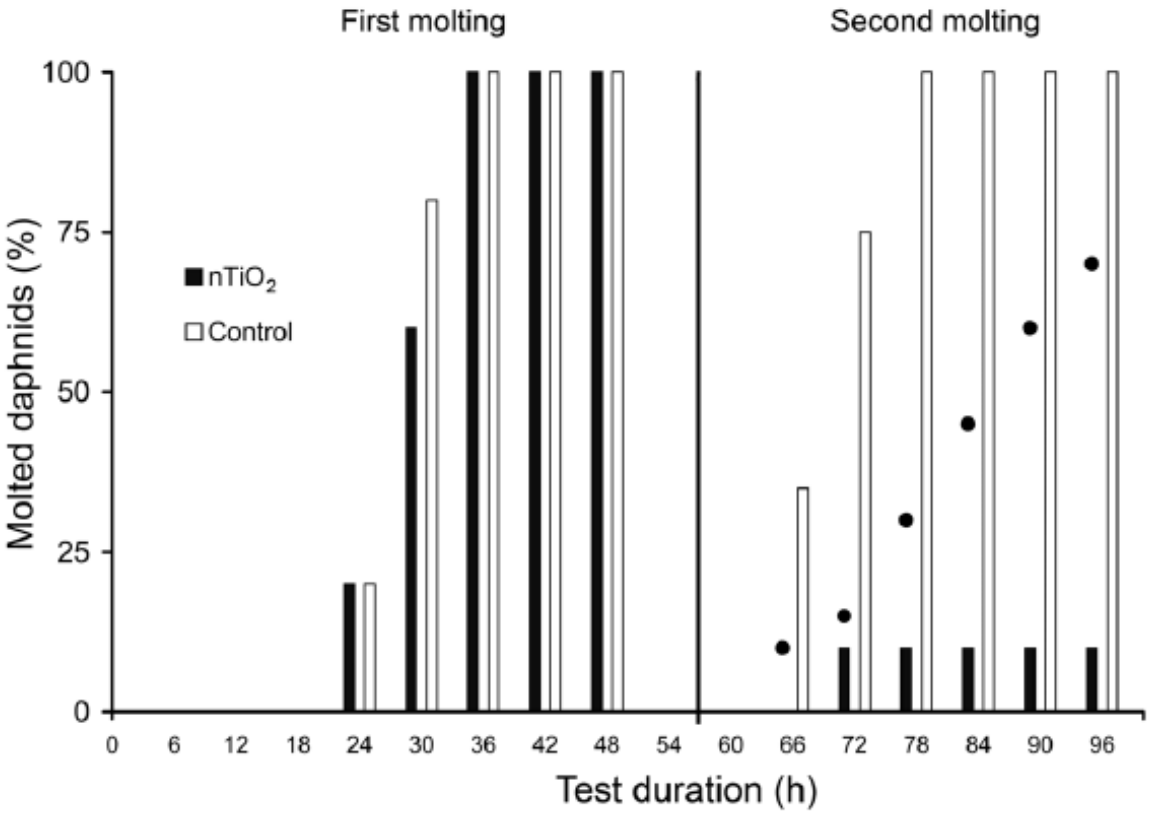
Particles adhere to exoskeleton
Particles present in the gut

No effect on mobility and molt after 48 h

Dabrunz et al. (2011) *PLoS ONE*, 6, e20112.

Effect on molting and reproduction – daphnids exposed to TiO_2



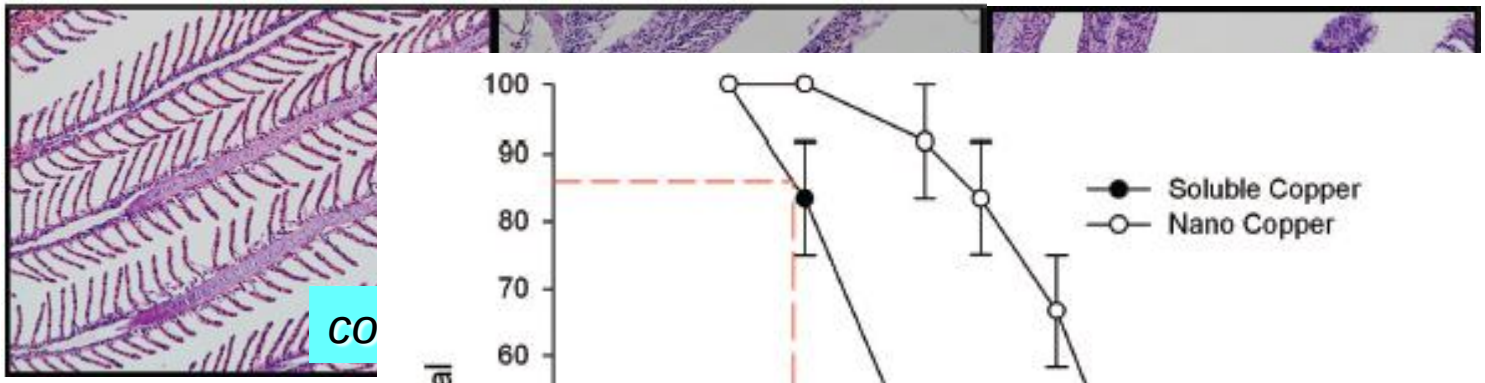


Indirect and mechanical effects

Dabrunz et al. (2011) *PLoS ONE*, 6, e20112.

Effects of dissolved ions?

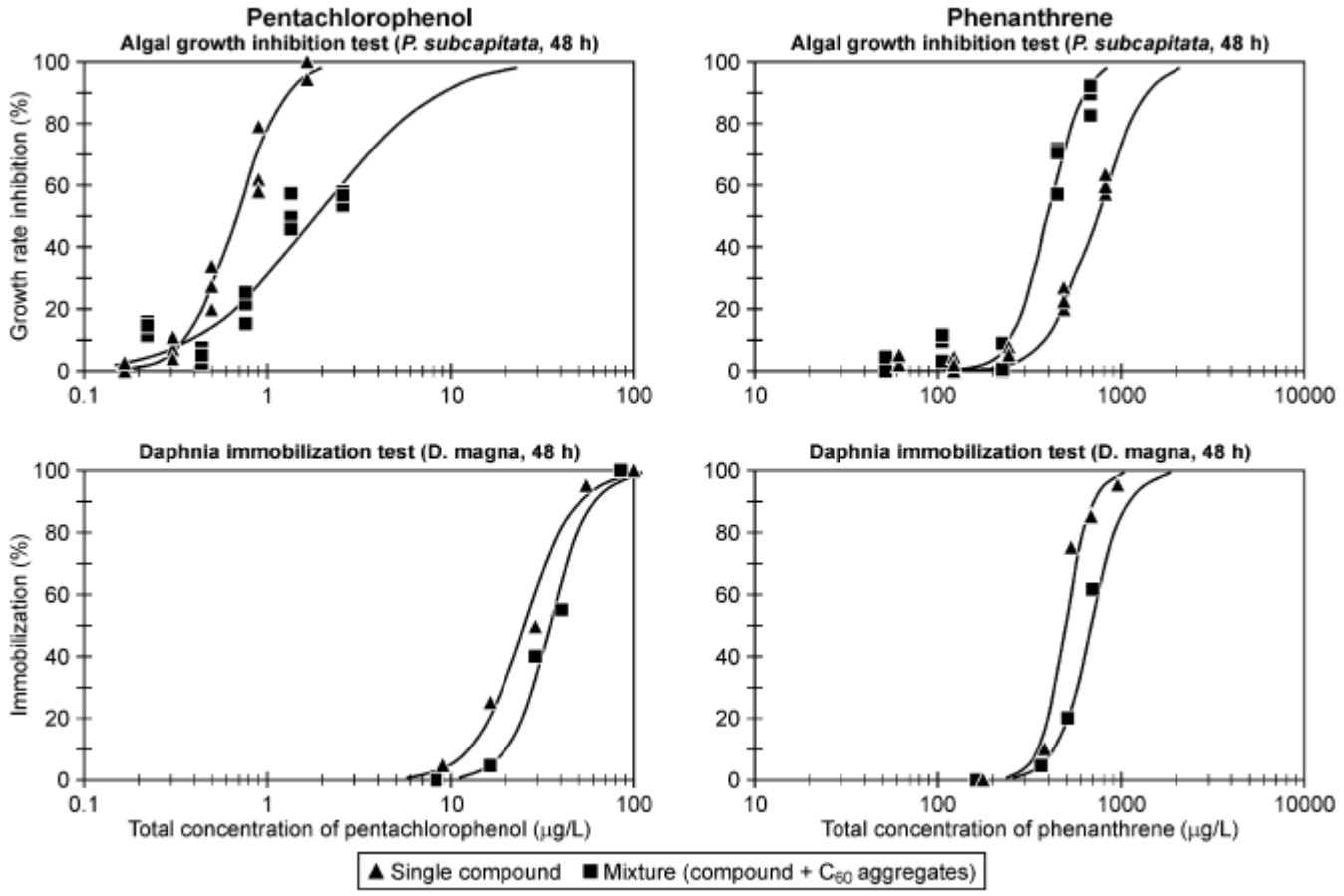
Impact on gill structure



Concentration of dissolved ions at 1.5 mg/l nanocopper

Griffitt et al. (2009) *Environ. Sci. & Technol.* 41: 8178–8186.

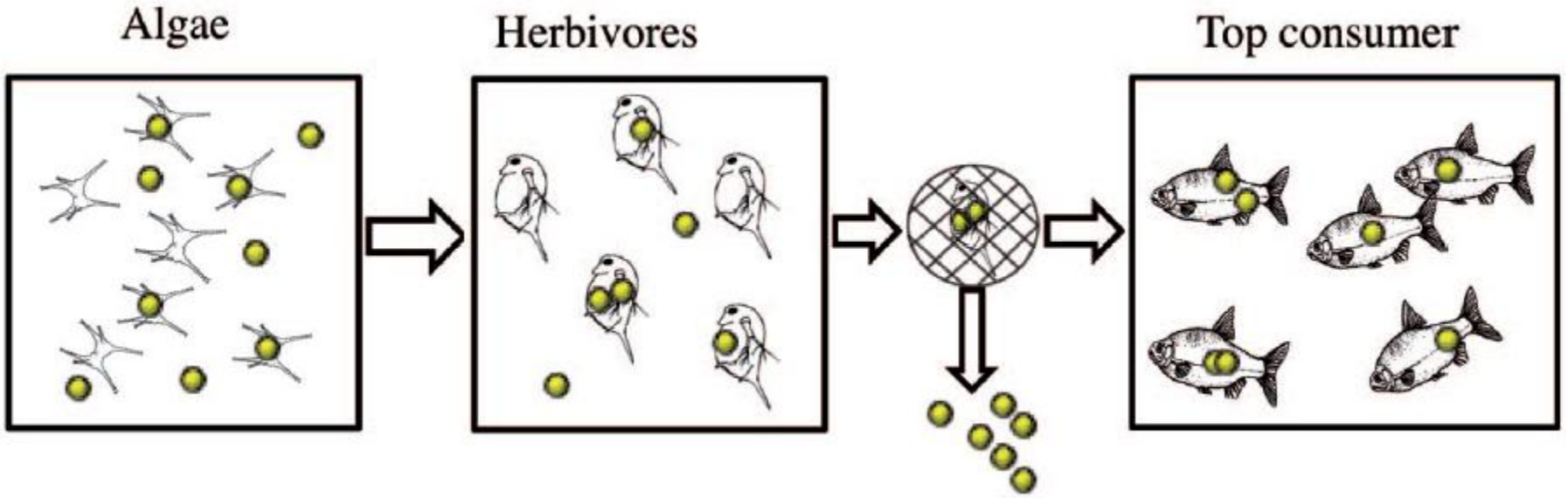
Particles as carrier



→ Particles can carry toxicants (Trojan horse effect)

Baun et al. (2008) *Auqatic Toxicology*, 86, 379-387.

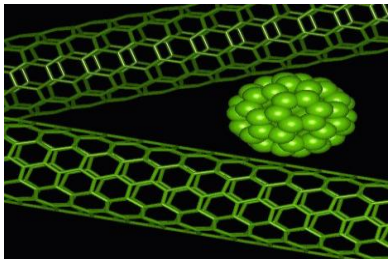
Food chain transport

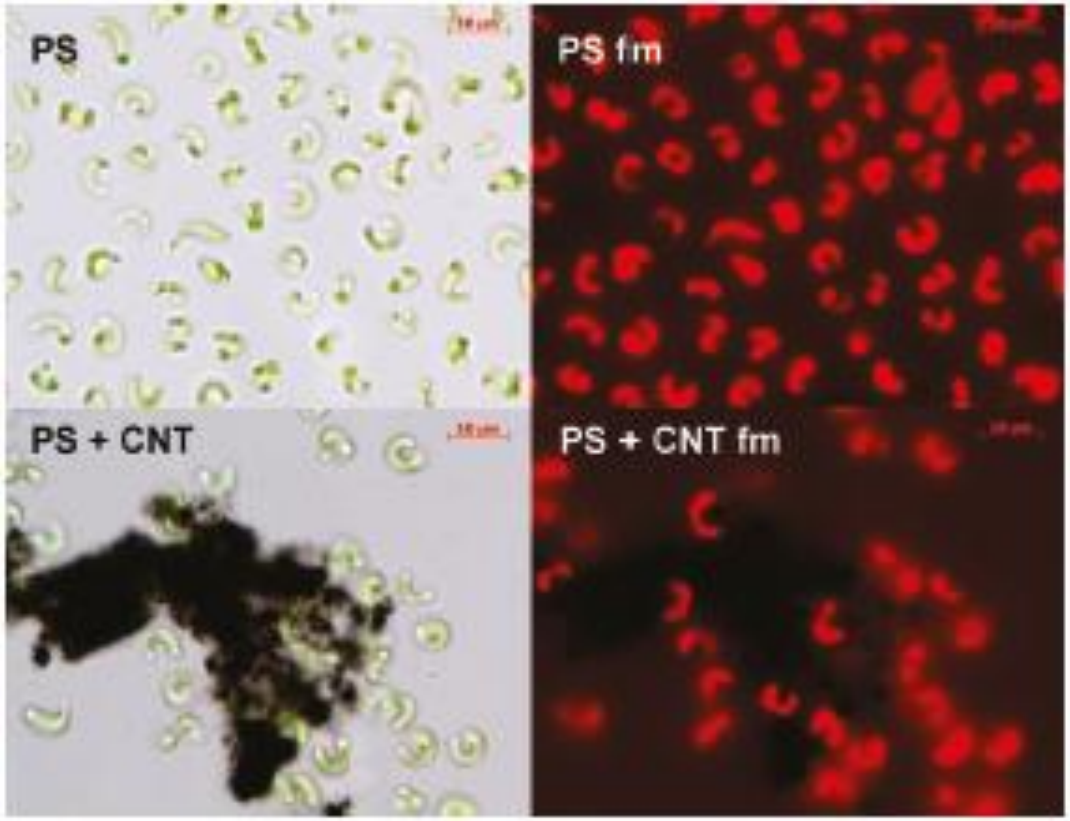


Polystyrene Nanoparticles Affect Behaviour and Fat Metabolism in Fish

Cedervall T et al. (2012) *PLoS ONE*, 7, e32254.

Green algae exposed to CNT





Growth inhibition as an effect of shading, interference of NM with test system

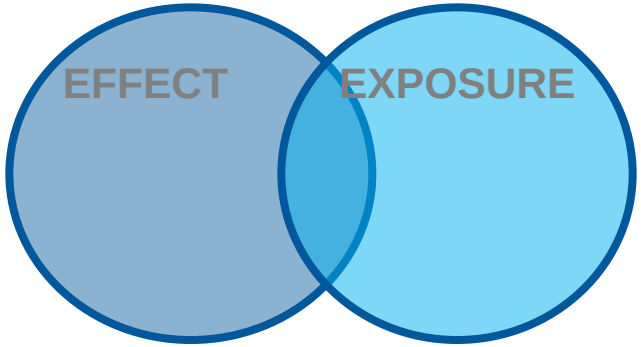
Schwab et al. (2011) *ES&T,* 45, 6136–6144.

Summary – Exposure

- Uptake into animals, tissues and cells
- Environmental exposure with some ENM shown

Summary – Effects

- Nanomaterials have effects
- Mechanical effects
- Indirect effects
- Dissolution of ions
- Carrier of substances
- Food chain effects



Conclusions – Implications for future testing

- Knowledge on physical-chemical properties
- Suitability of standard tests (duration, application, exposure conditions, shading), realistic exposure scenarios
- Long term tests, mixtures (NM+NM, NM+Chemical)
- Environmental concentrations needed, suitable methods
- More knowledge on behaviour and fate in the environment (e.g. degradation)

Thank you for you attention!

What are the concentrations in the environment?

Exposure Modelling

Predicted Environmental Concentrations

Predictions are based on:
- production volumes
- categories of products containing nanomaterials
- paths of particle release

	unit	nano-Ag		nano-TiO_2		CNT	
		Real.	High	Real.	High	Real.	High
Air	µg m^{-3}	0.0017	0.0044	0.0015	0.042	0.0015	0.0023
Water	µg L^{-1}	0.03	0.08	0.7	16	0.0005	0.0008
Soil	µg kg^{-1}	0.02	0.1	0.4	4.8	0.01	0.02

Mueller and Nowack (2008) *Environ. Sci. Technol.* 42: 4447-4453

Risk assessment

Risk Quotients (PEC/PNEC) for all ENM and Regions

nano TiO2

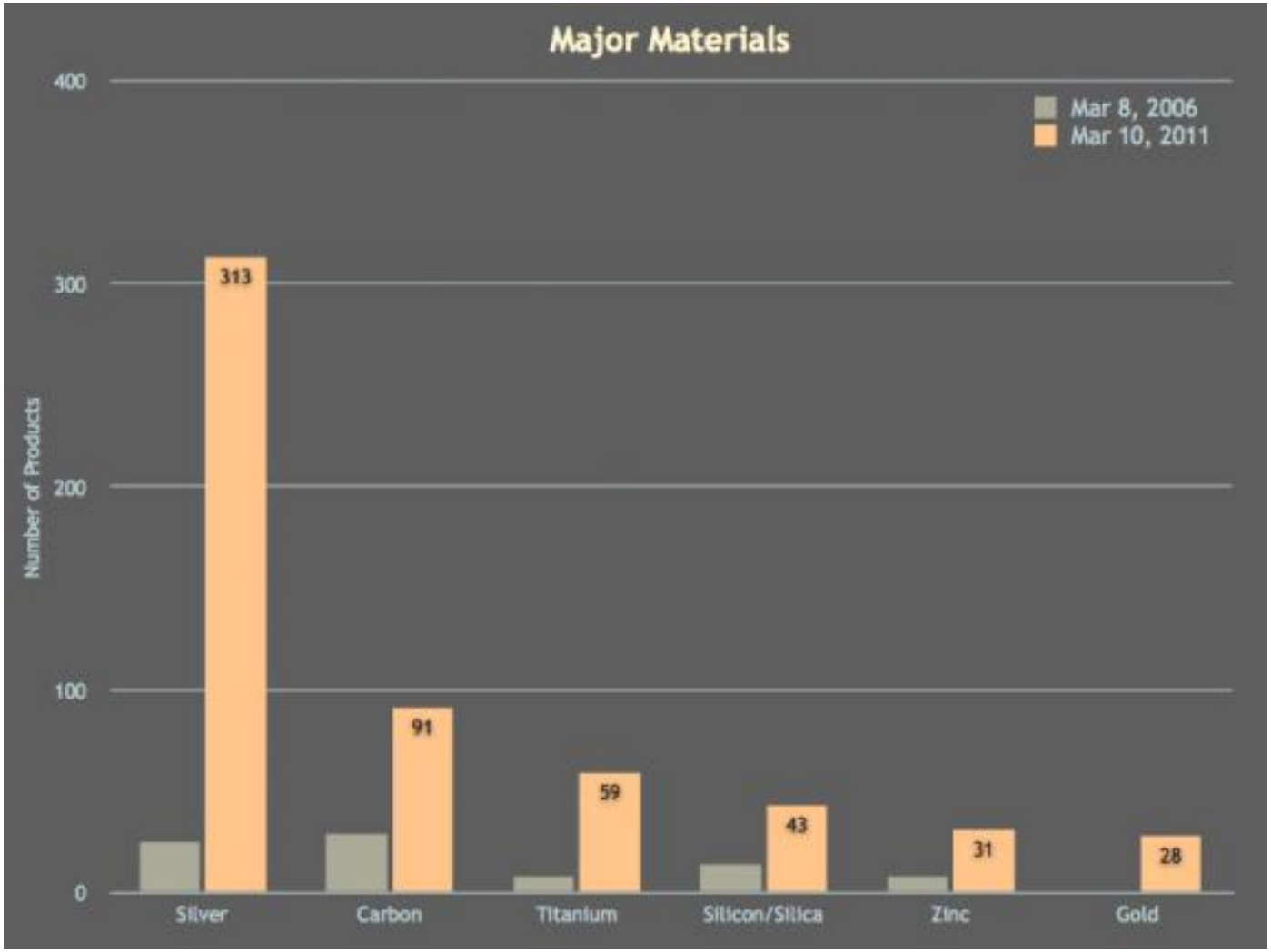
compartment	**Europe**	**U.S.**	**Switzerland**
surface water	0.015	0.002	0.02
STP effluent	3.5	1.8	4.3
air	<0.0005	<0.0005	<0.0005
soil	0.004	0.002	0.001
sludge treated soil	0.3	0.14	

predicted no effect concentration (PNEC)

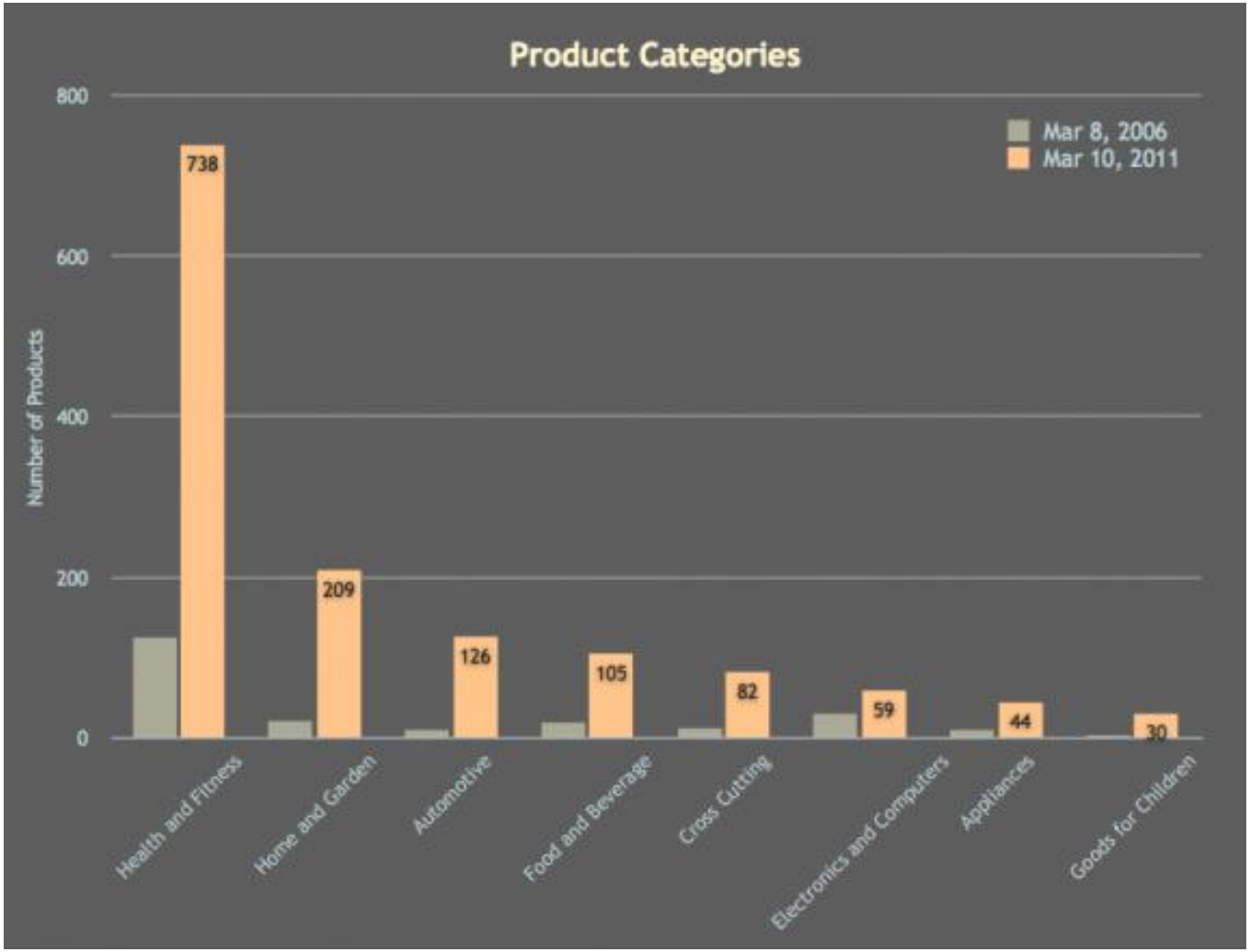
Predicted environmental concentrations (PEC)

sewage treatment plant (STP)

www.nanoproject.org

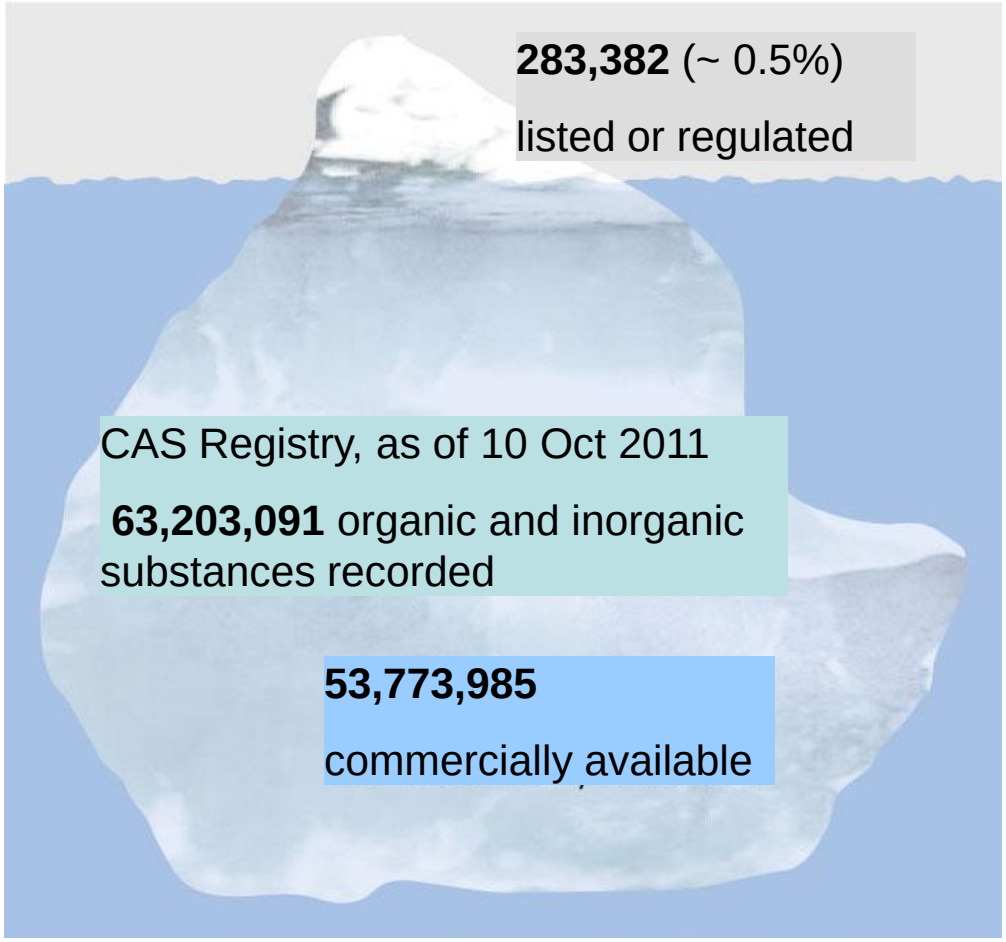


www.nanoproject.org



Example: Diclophenac

Chemicals and REACh



Registration,

Evaluation,

Authorisation

and Restriction of

Chemical substances.

Nanoparticles are not yet considered within REACh!

But might be implemented in the future.