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Cellular and Ecotoxicological Analysis of Nanofunctionalized Textiles (Project TECHNOTOX)

Prof. Dr. Dirk Höfer

BfR, Berlin, February 9th 2012

COMPETENCE IN TEXTILES

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Hohenstein Institute
Department Hygiene, Environment and Medicine

Hohenstein is a public and independent textile research institute.

→ Research & Development using public funding

Department Hygiene, Environment & Medicine

→ Life science studies on functionalized textiles

→ Efficacy and safety of products along the textile chain

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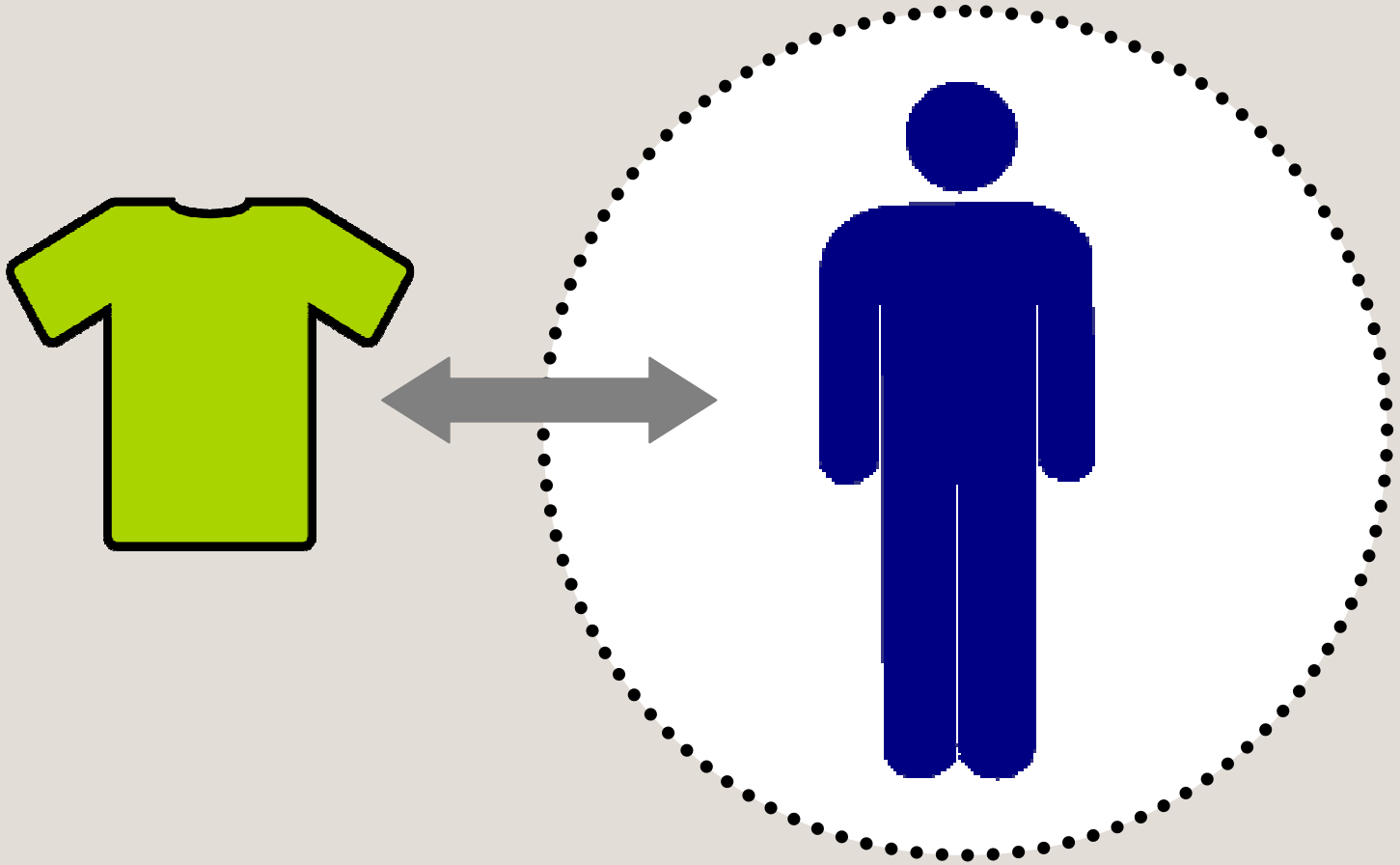
Interaction Textile | Human



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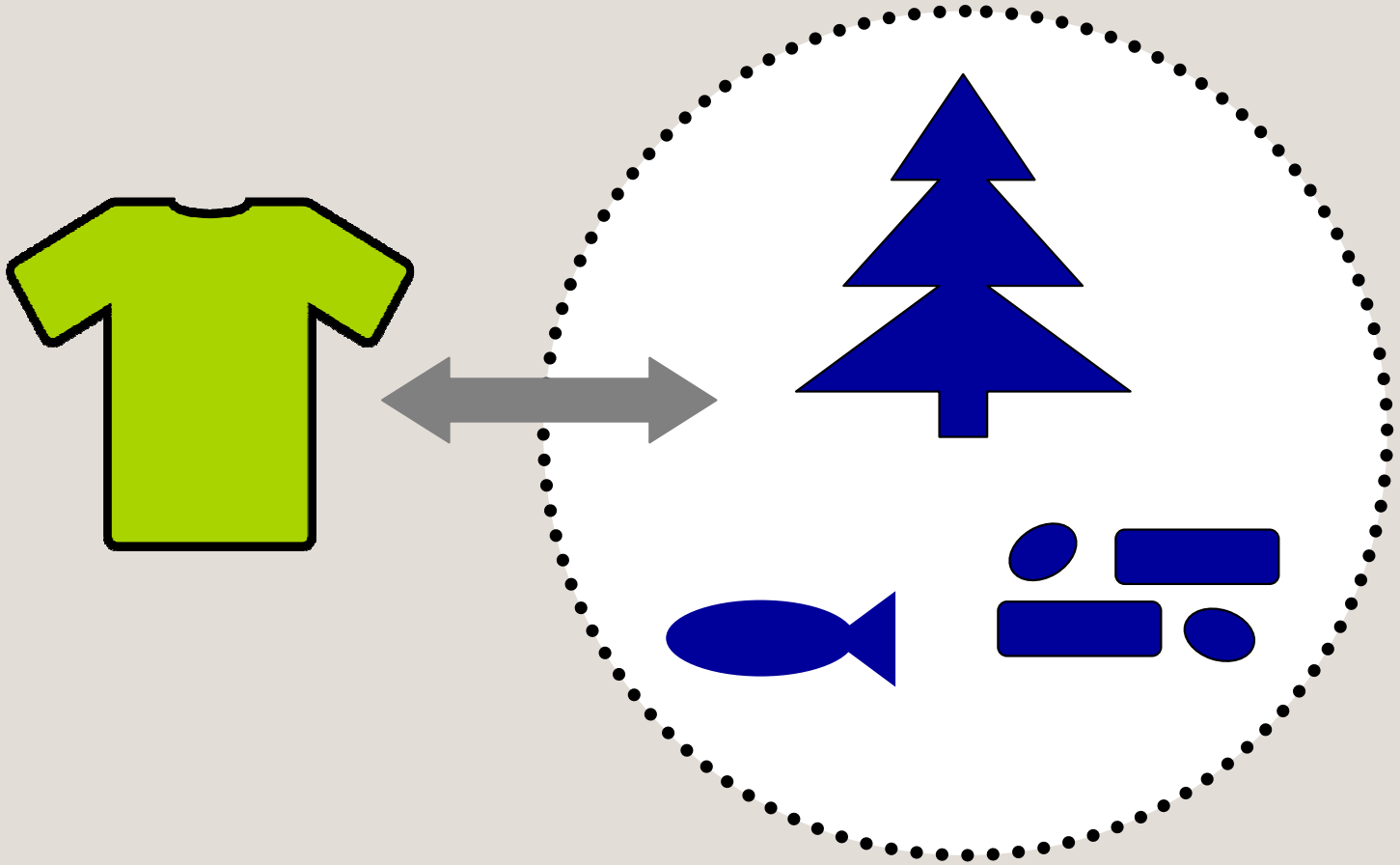
Interaction Textile | Environment



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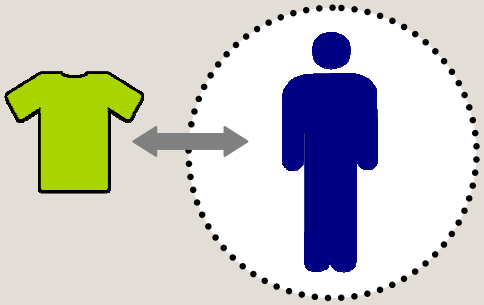
Silver and the human skin microflora



- Field study with 60 subjects (21 – 65 years)
- microbiological and dermatological supervision
- Halved shirts (verum/placebo) were worn for 8 h/d over a period of 5 weeks

International Scholarly Research Network
ISRN Dermatology
Volume 2011, Article ID 369603, 8 pages
doi:10.5402/2011/369603

Research Article

Antimicrobial Active Clothes Display No Adverse Effects on the Ecological Balance of the Healthy Human Skin Microflora

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Human skin microflora was not affected

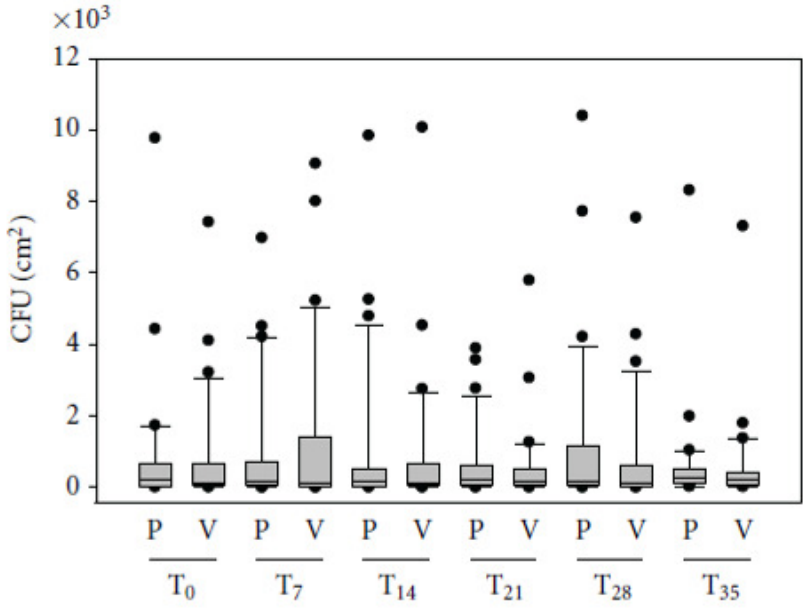

FIGURE 2: Boxplot diagram showing total germ count after application of fabric 1. PES-silver Verum side (V) and placebo side (P). T_0 = baseline, T_7 = after 1 week wear trial, T_{14} = after 2 weeks, T_{21} = after 3 weeks, T_{28} = after 4 weeks, T_{35} = 1 week after the wearing time (n = 30).

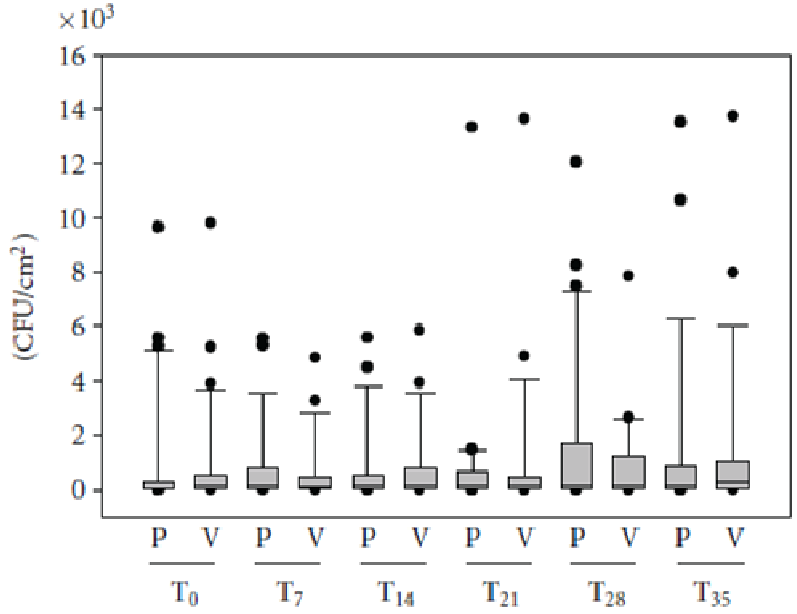

FIGURE 3: Boxplot diagram showing total germ count after application of fabric 2. Silver-finish Verum side (V), placebo side (P). T_0 = baseline, T_7 = after 1 week wear trial, T_{14} = after 2 weeks, T_{21} =after 3 weeks, T_{28} = after 4 weeks, T_{35} = 1 week after the wear period (n = 30).

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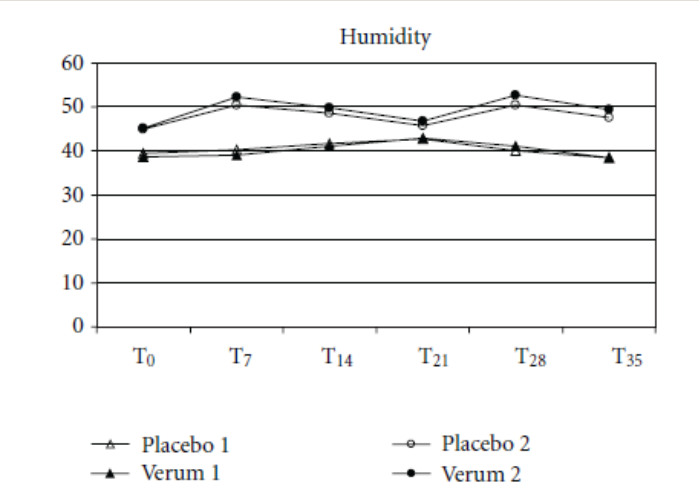
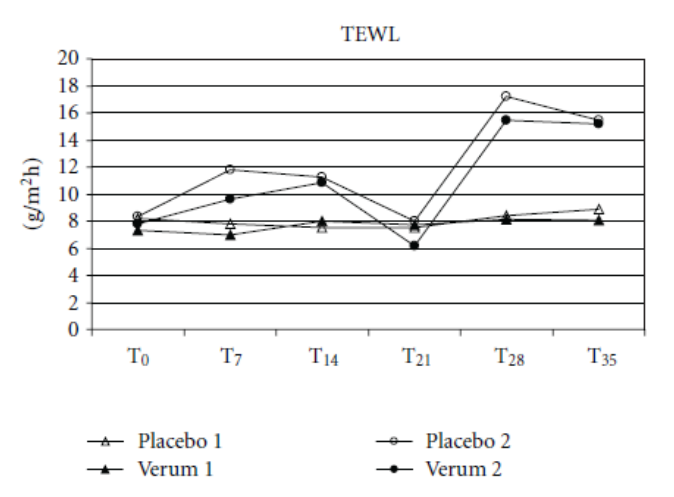
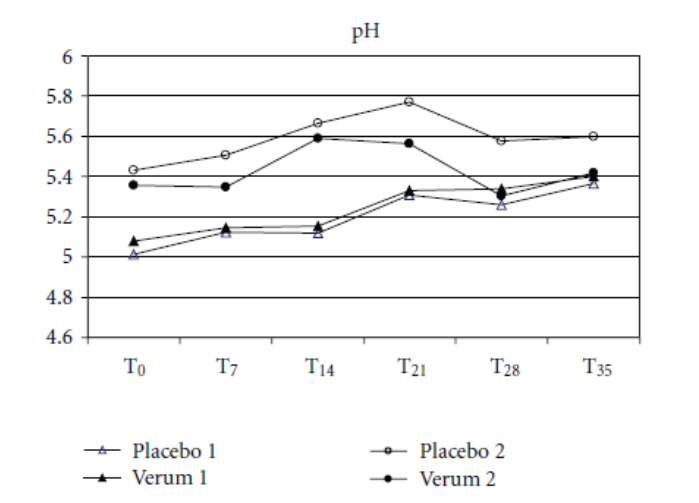
Skin physiology experiments







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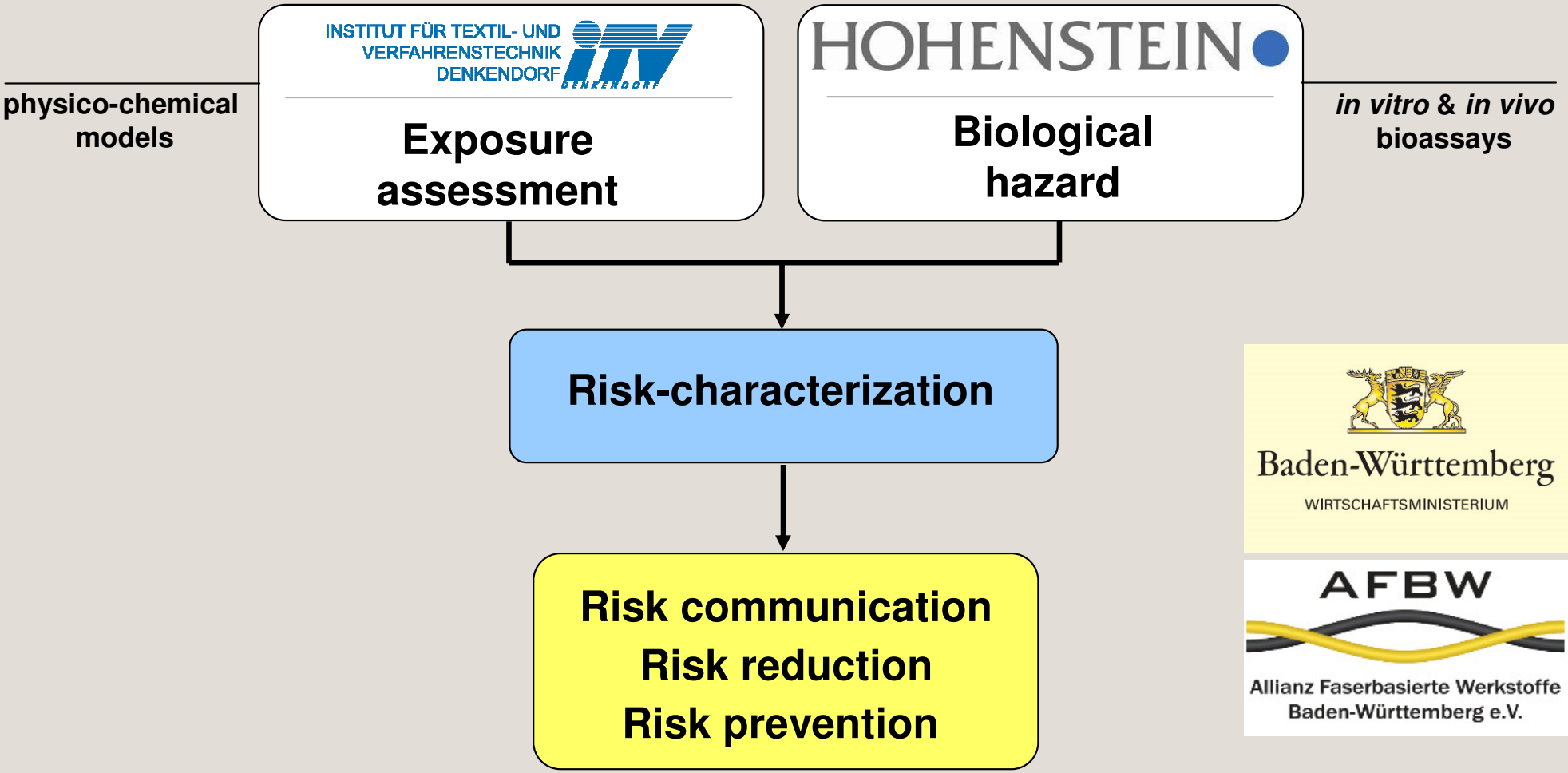
Research project TECHNOTOX (2011 – 2013)



Baden-Württemberg
WIRTSCHAFTSMINISTERIUM

AFBW
Allianz Faserbasierte Werkstoffe Baden-Württemberg e.V.

acc. to Krug & Wick (2011), Angew. Chem. 123(6): 1294-1314

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Nanomaterials in textiles

Nanomaterials	Properties/Applications
Carbon nanofibres	Increased tensile strength High chemical resistance Electrical conductivity
Carbon black nanoparticles	**Improved abrasion resistance and roughness** **High chemical resistance** **Electrical conductivity**
Clay nanoparticles	Electrical heat and chemical resistance Block UV light Flame retardant, Anticorrosive
Metal nanoparticles (Ag, Au, Cu)	**Antimicrobial** **Self sterilization** **Antiodour**
Metal oxide nanoparticles (TiO_2, Al_2O_3, ZnO, MgO)	Photocatalytic ability Electrical conductivity UV absorption Photooxidizing activity against chemical and biological species Antimicrobial/self-sterilization
Carbon nanotube	**100X tensile strength of steel at one sixth of the weight** **Electrical conductivity similar to copper** **Good thermal conductivity**
Chitin nanofibrils	Increased tensile strength High temperature resistance Drug delivery capacity

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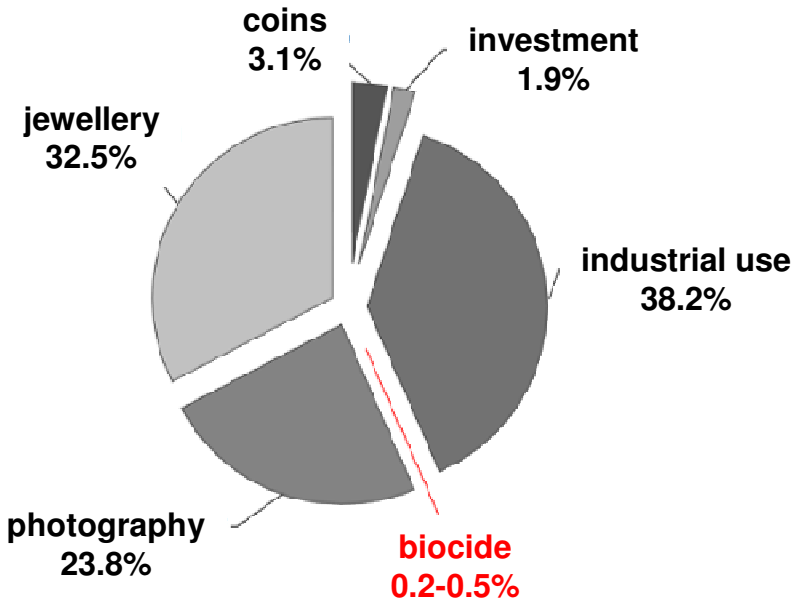
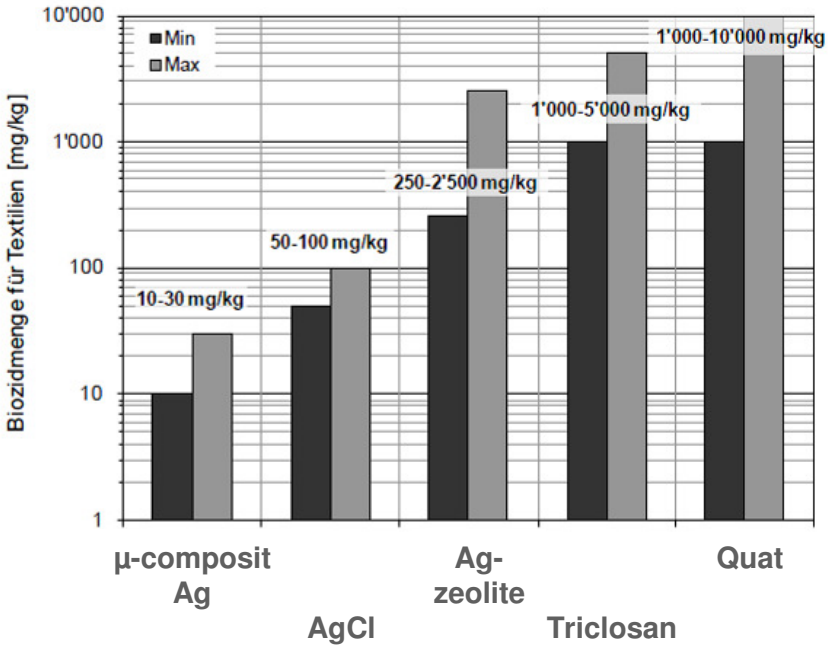
Use of organic biocides and silver in textiles

- 100 t/a organic biocides
- 28 t/a silver
- <0.2 t/a metallic nanosilver (mainly 50-500 nm AgCl particles)

Silver use worldwide



Biocide concentrations in textiles



Source: Burkhardt *et al.* (2011), Forschungsbericht HSR, UMTEC, Rapperswil (CH)

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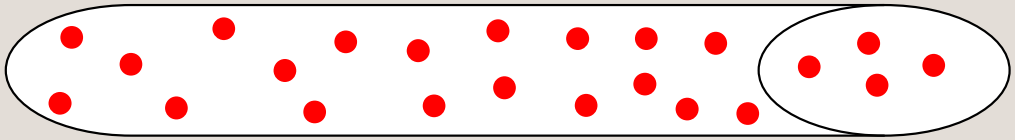
Fibre functionalization with nanosilver

Surface modification

Material modification



→ Different abrasion behaviour → Exposition

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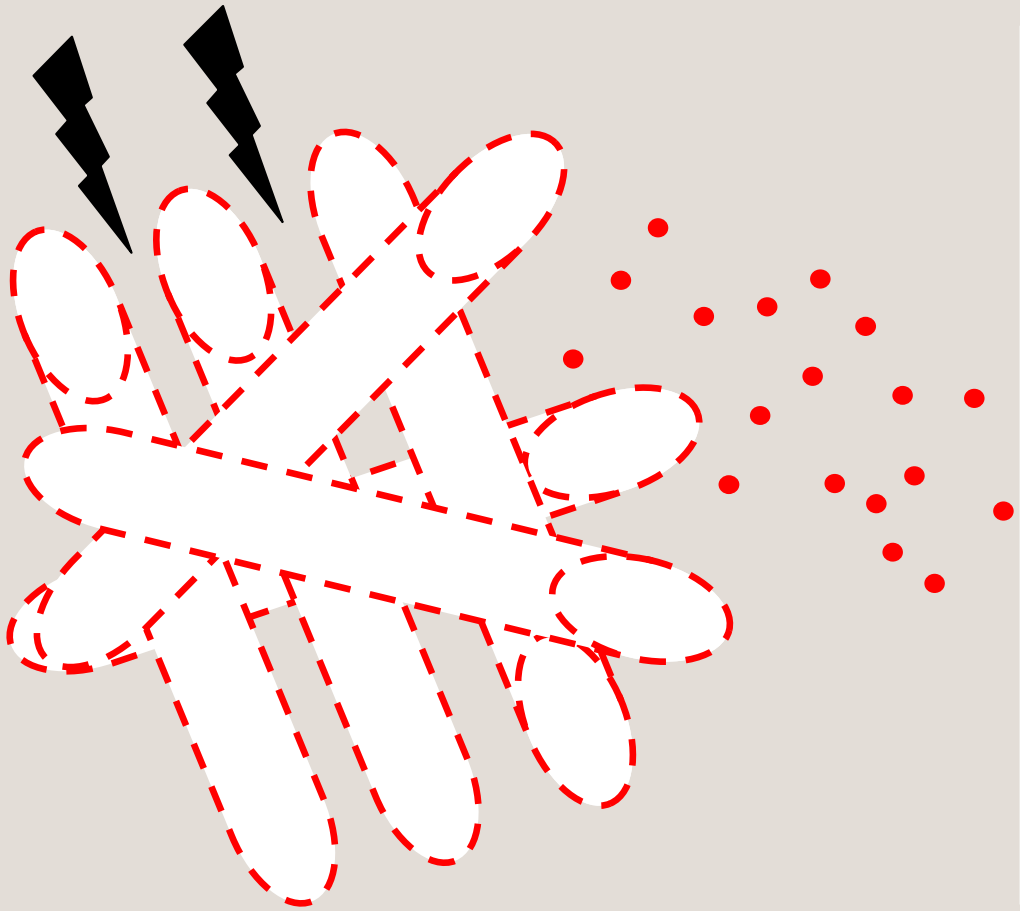
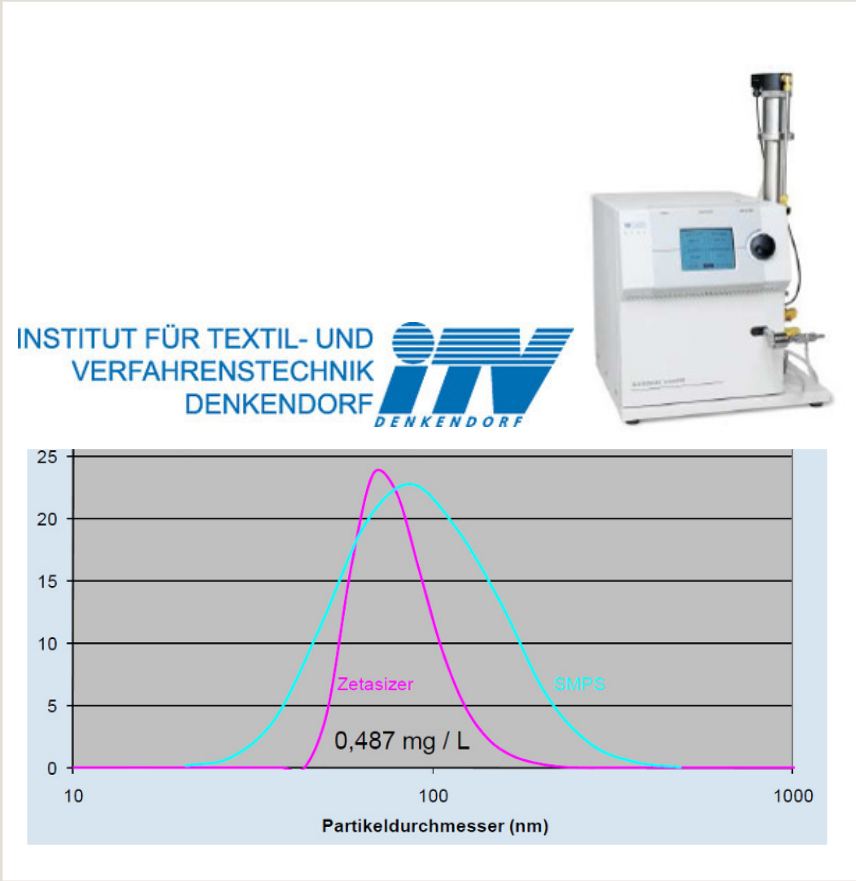
Textile abrasion



Mechanical stress (worst case scenario)



Detection and collection

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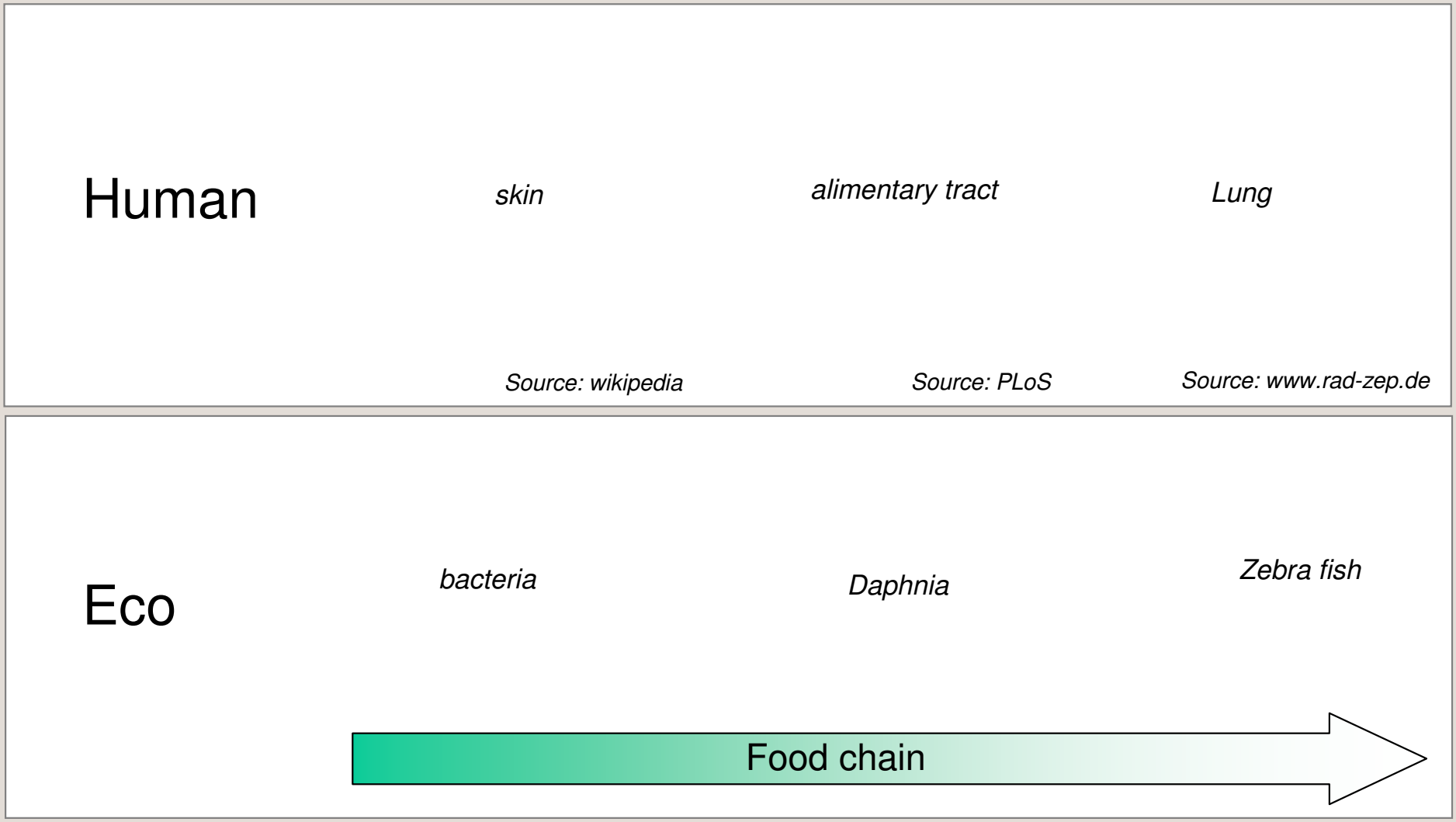
Distribution sites



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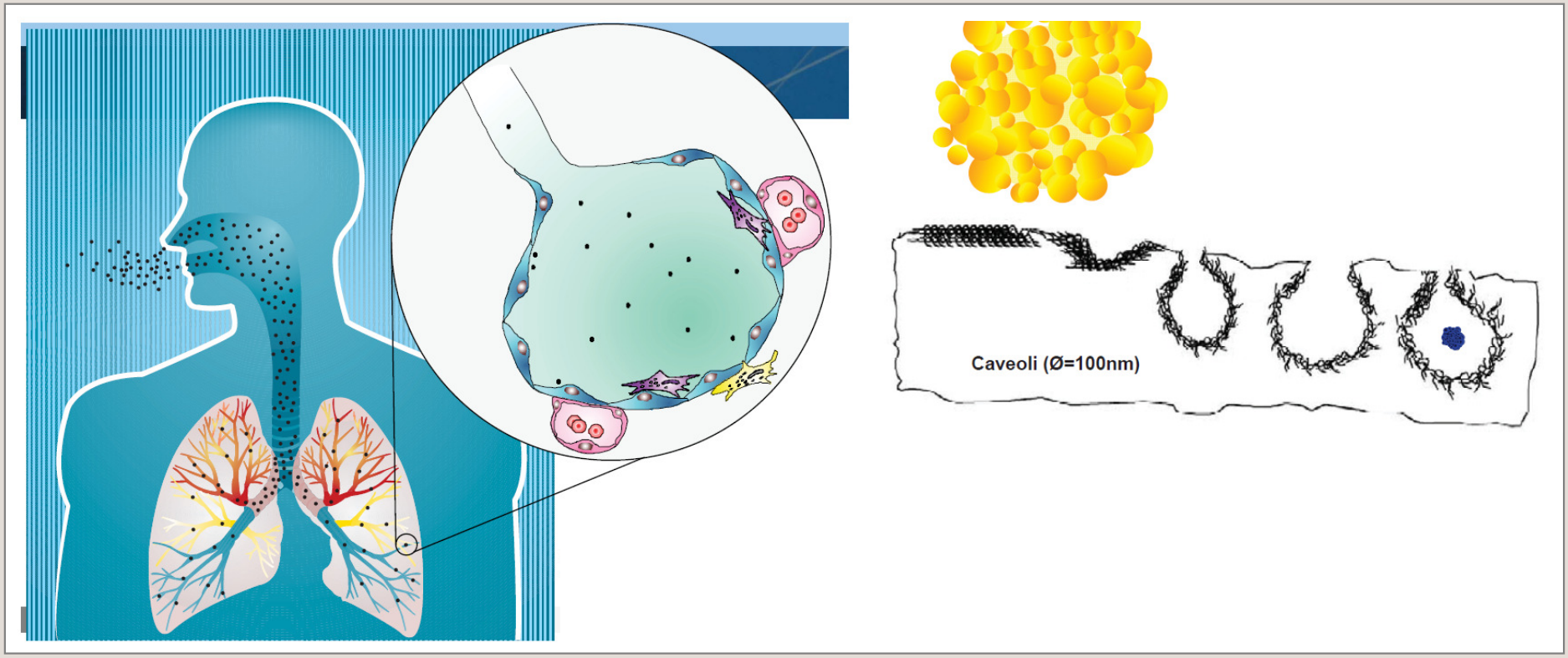
The lung as ‚main entrance' for nanoparticles

Size matters



from Krug & Wick (2011), Angew. Chem. 123(6): 1294-1314

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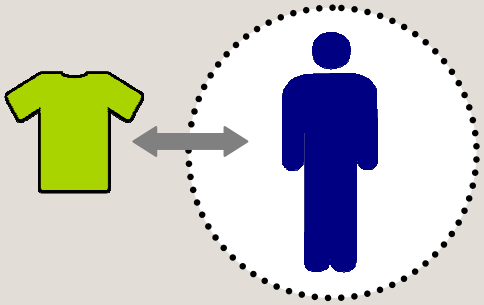
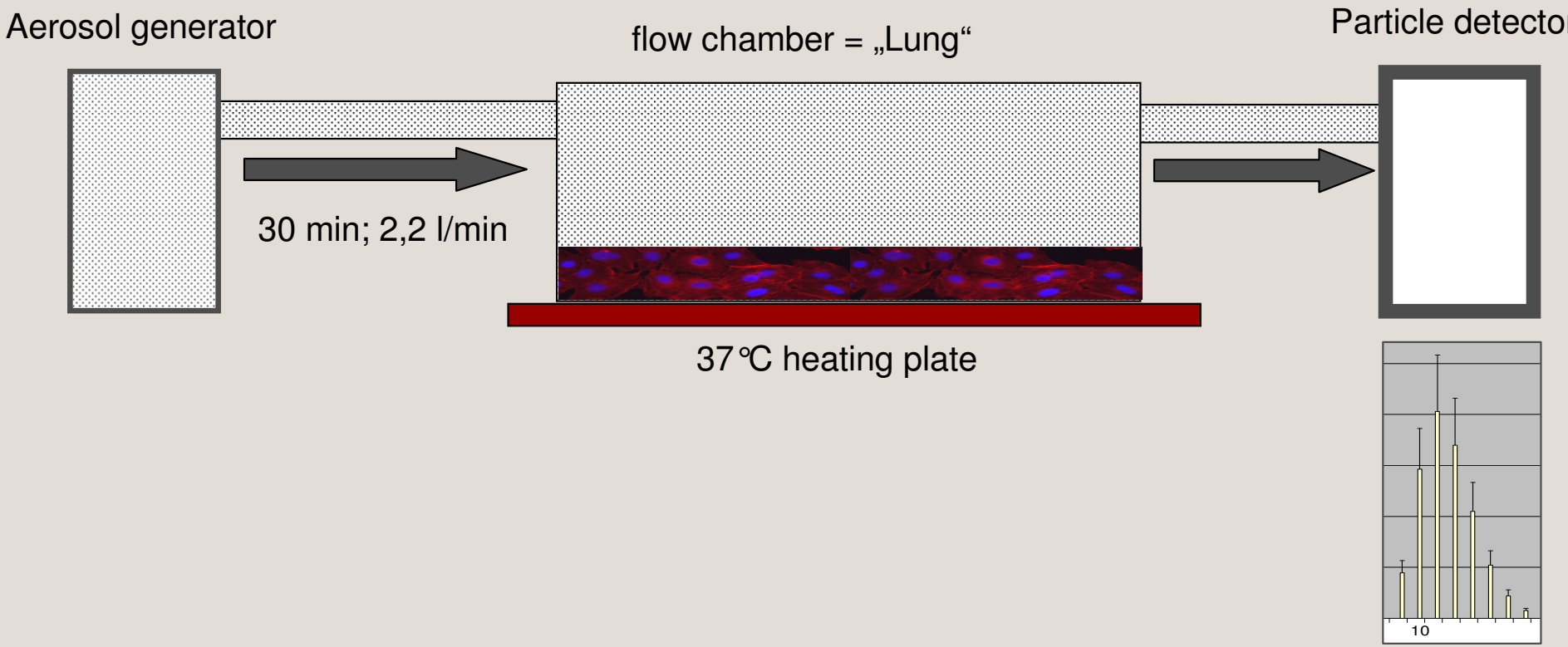
TECHNOTOX lung model





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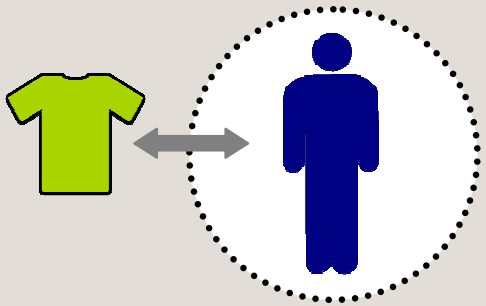
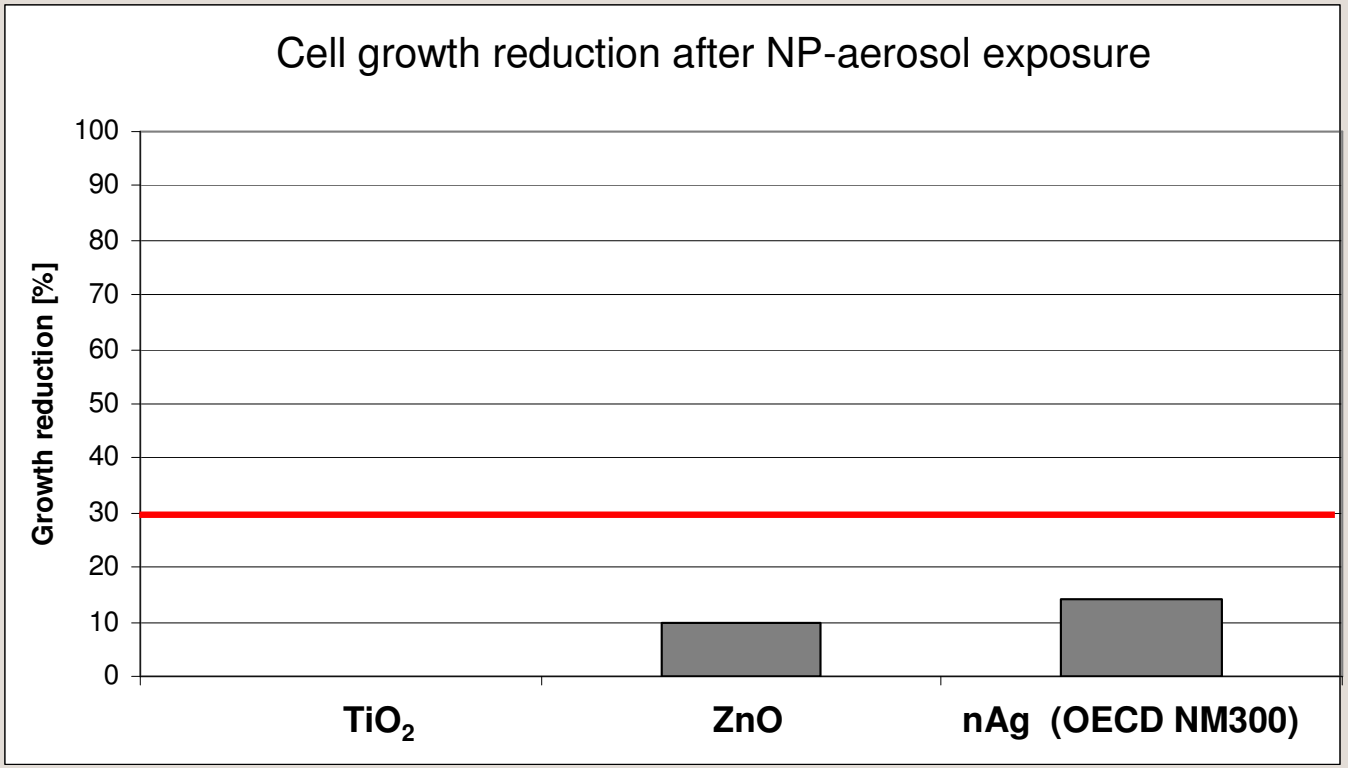
Lung model



Lung cell vitality after 30 min exposure to NP-aerosol



30% = Threshold
acc. to DIN EN ISO 10993-5

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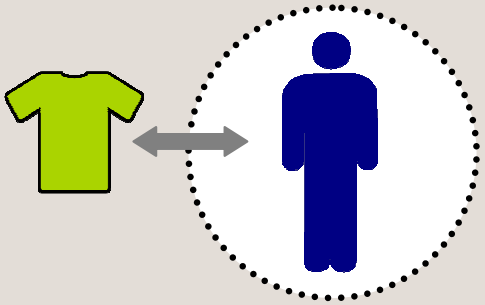
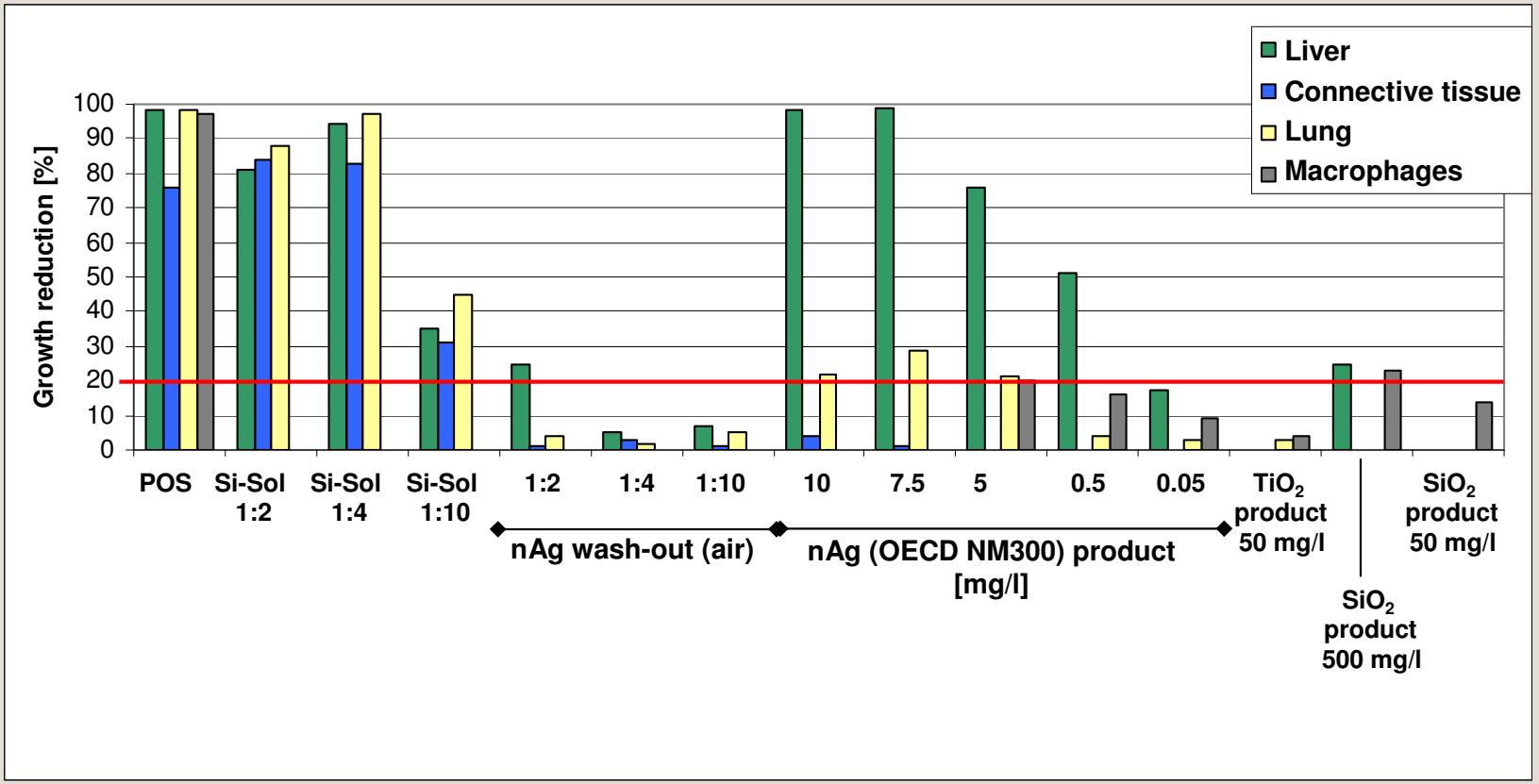
Cell toxicity studies
– according to DIN EN ISO 10993-5



Different cell types vary in their susceptibility!



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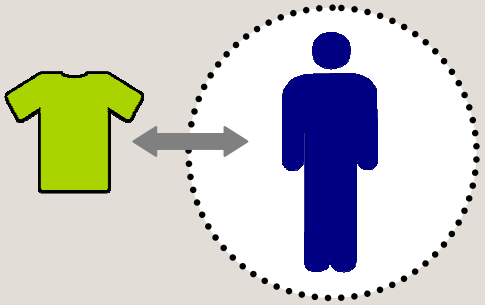
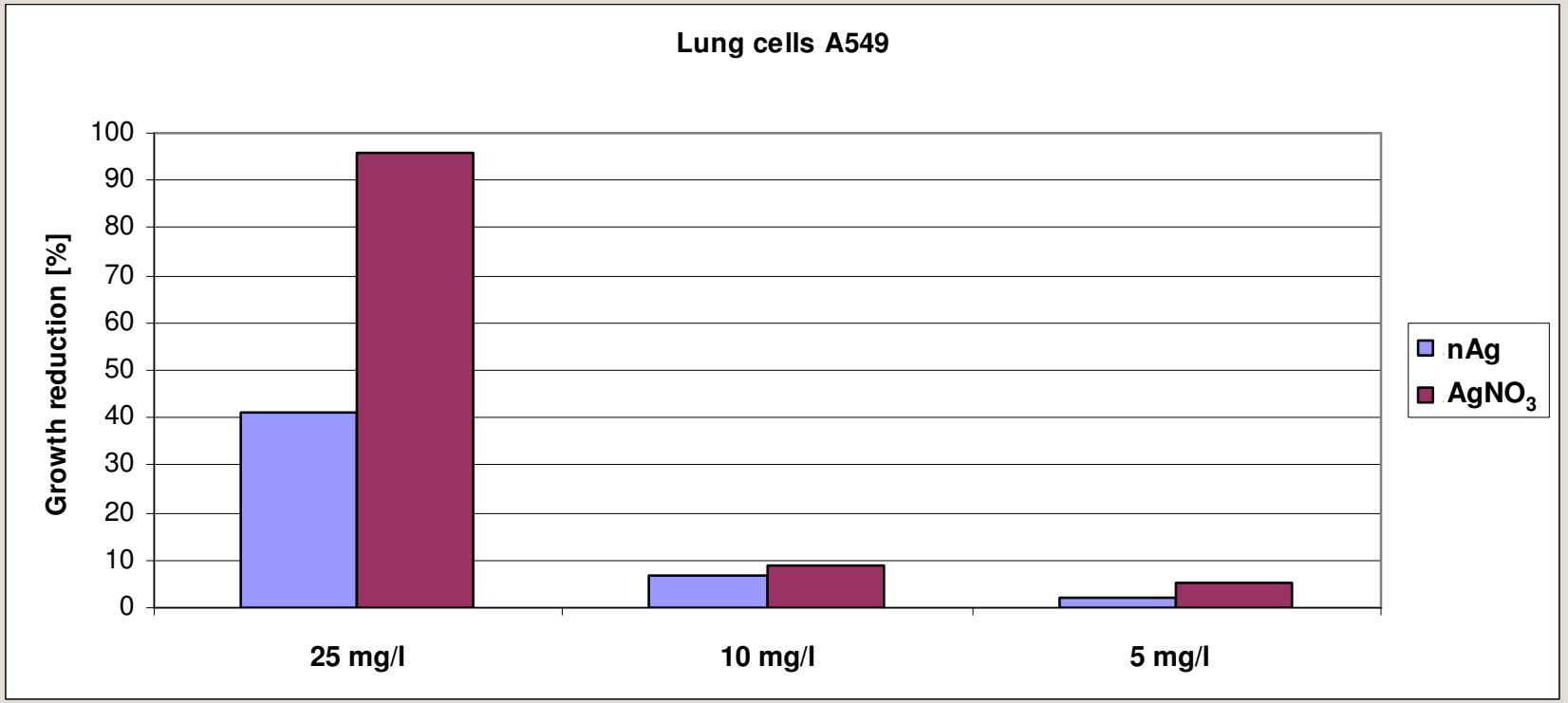
nAg versus $AgNO_3$ – lung cells



Silver ions are toxic for cells



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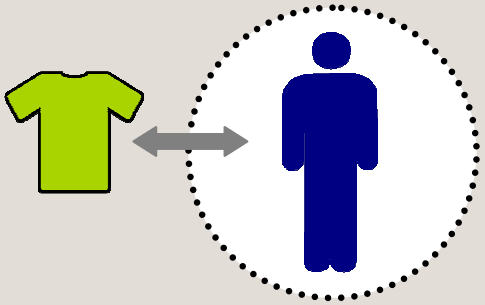
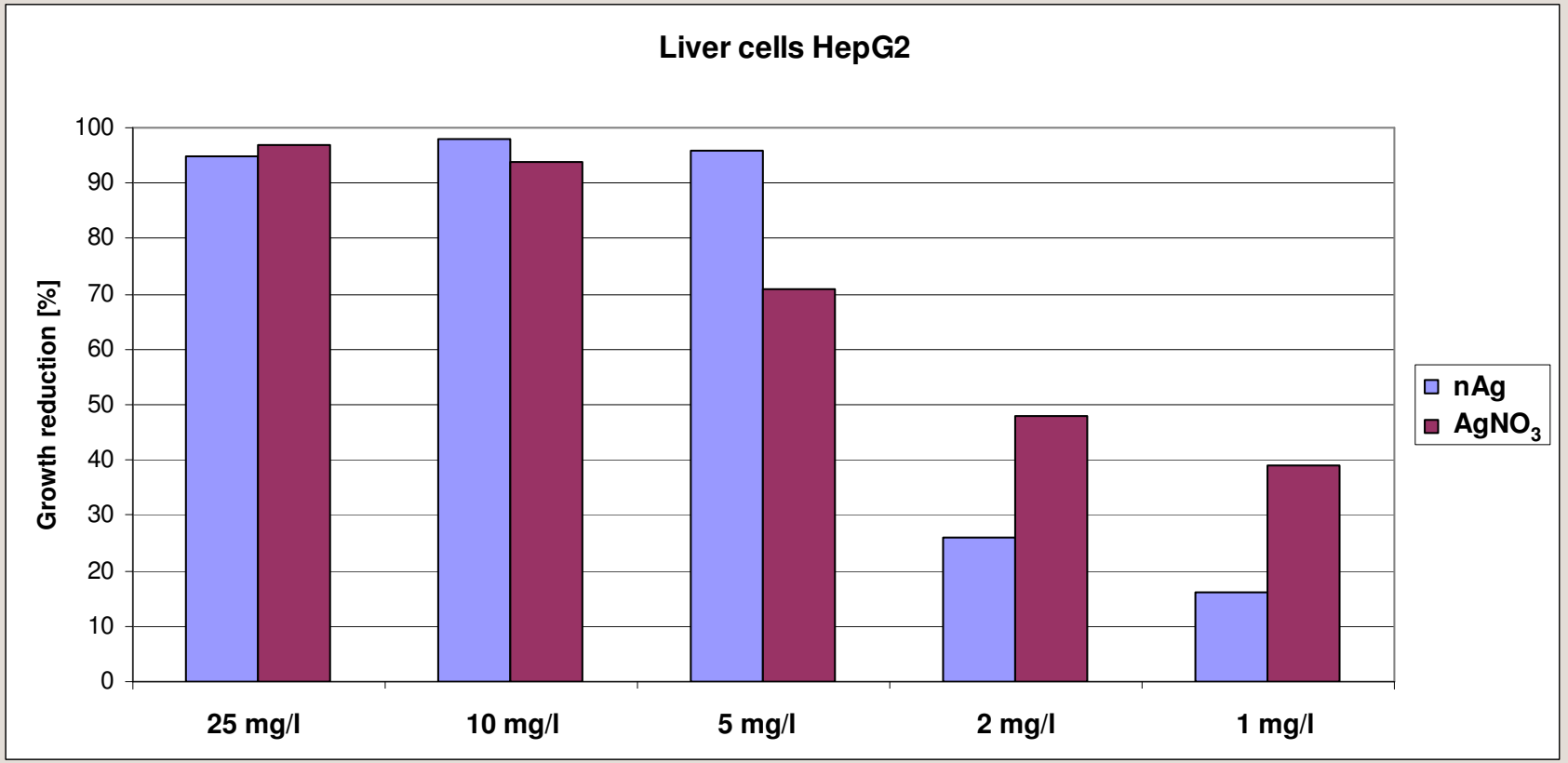
nAg versus $AgNO_3$ – liver cells



Dose-response relation



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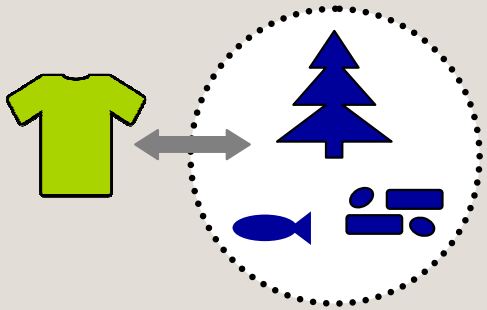
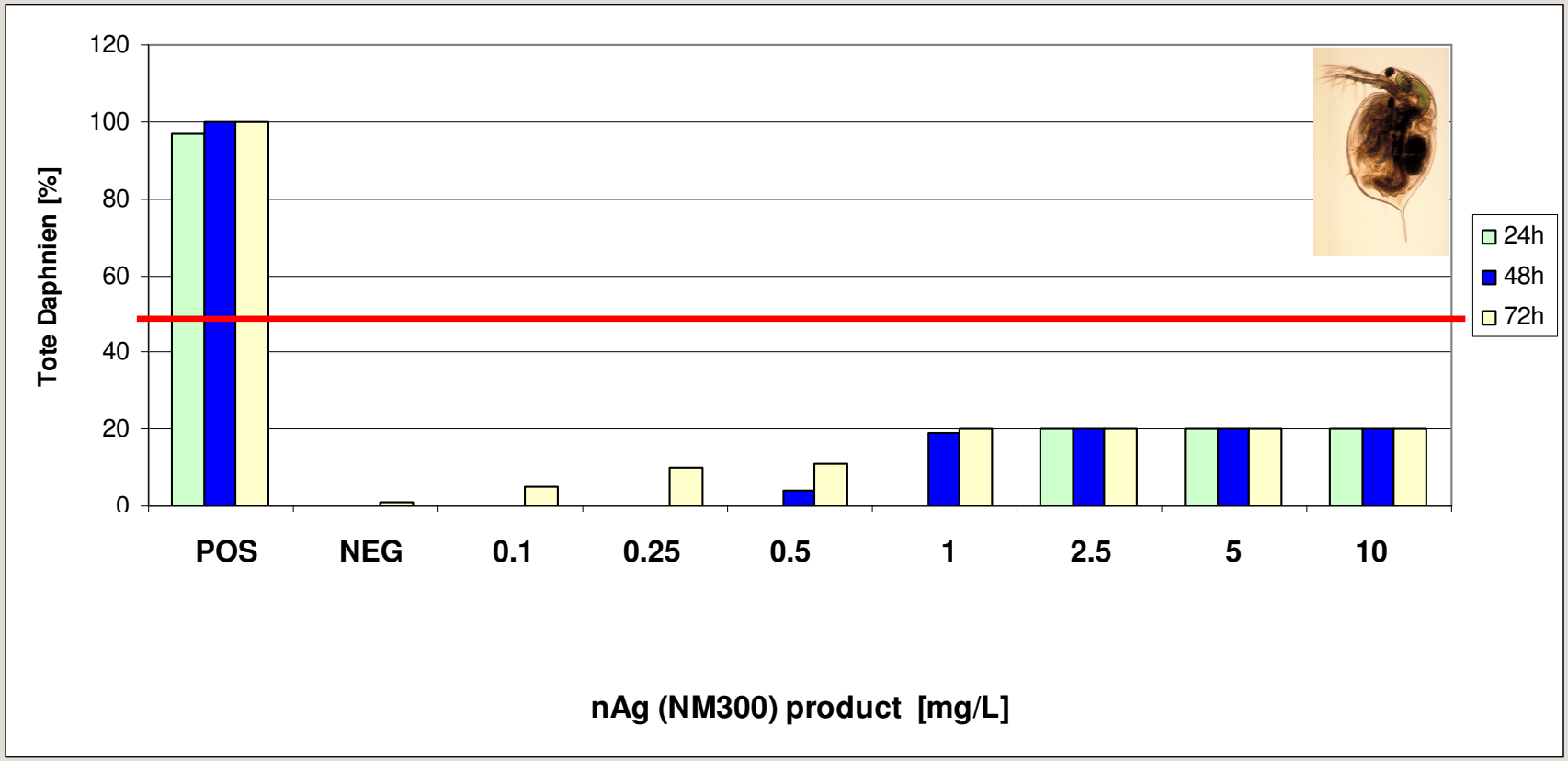
Effects of nAg on *Daphnia magna*



- acc. to DIN EN ISO 6341:2010



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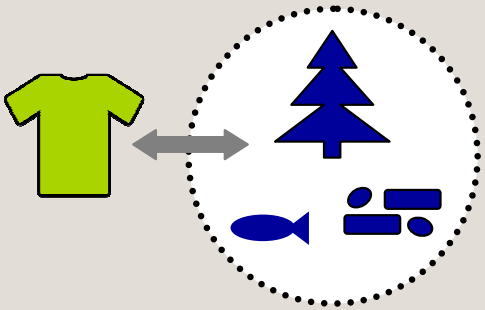
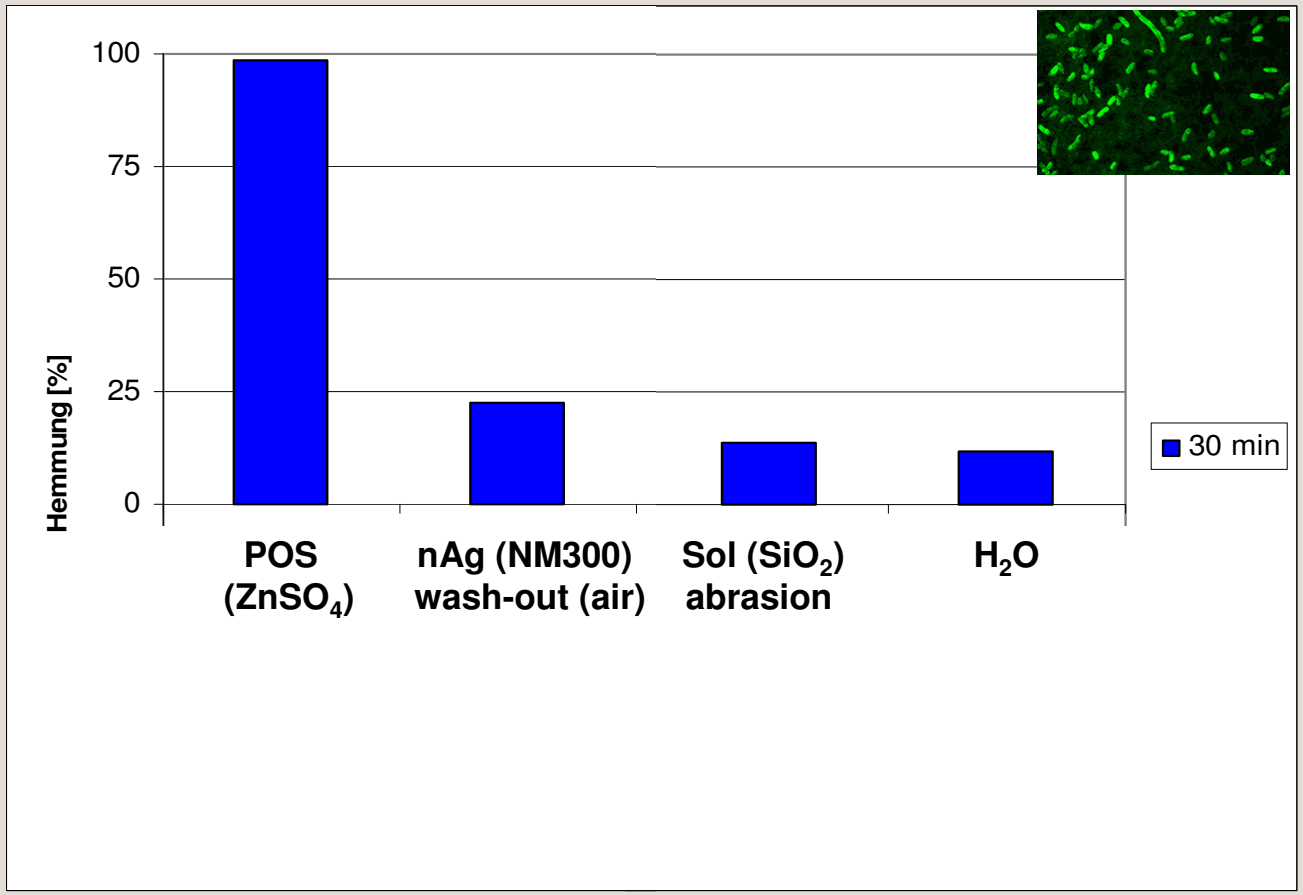
Effects of aerosols and textile abrasion samples



- Luminescent bacteria test acc. to DIN EN ISO 11483-1



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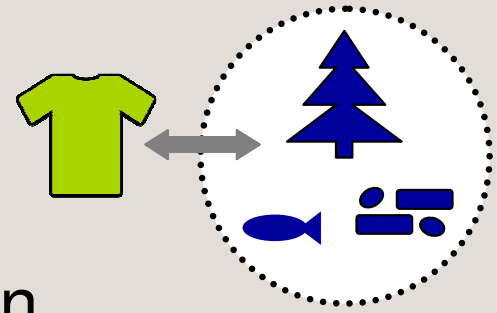
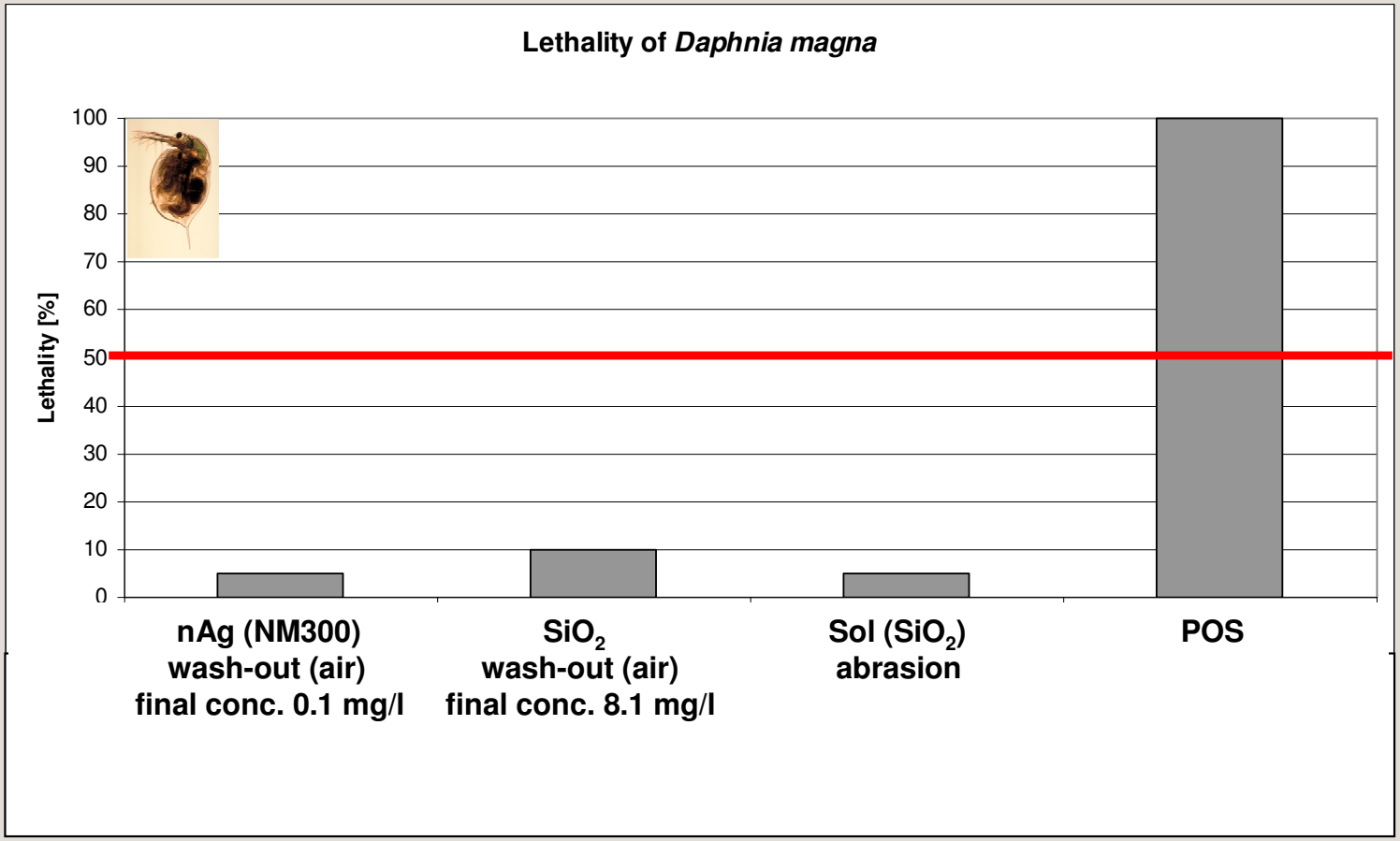
Effects of textile abrasion samples



Daphnia magna lethality after 48 h exposition



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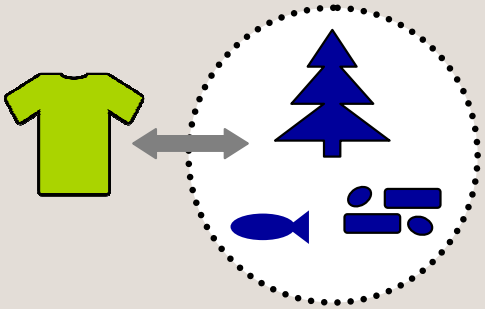
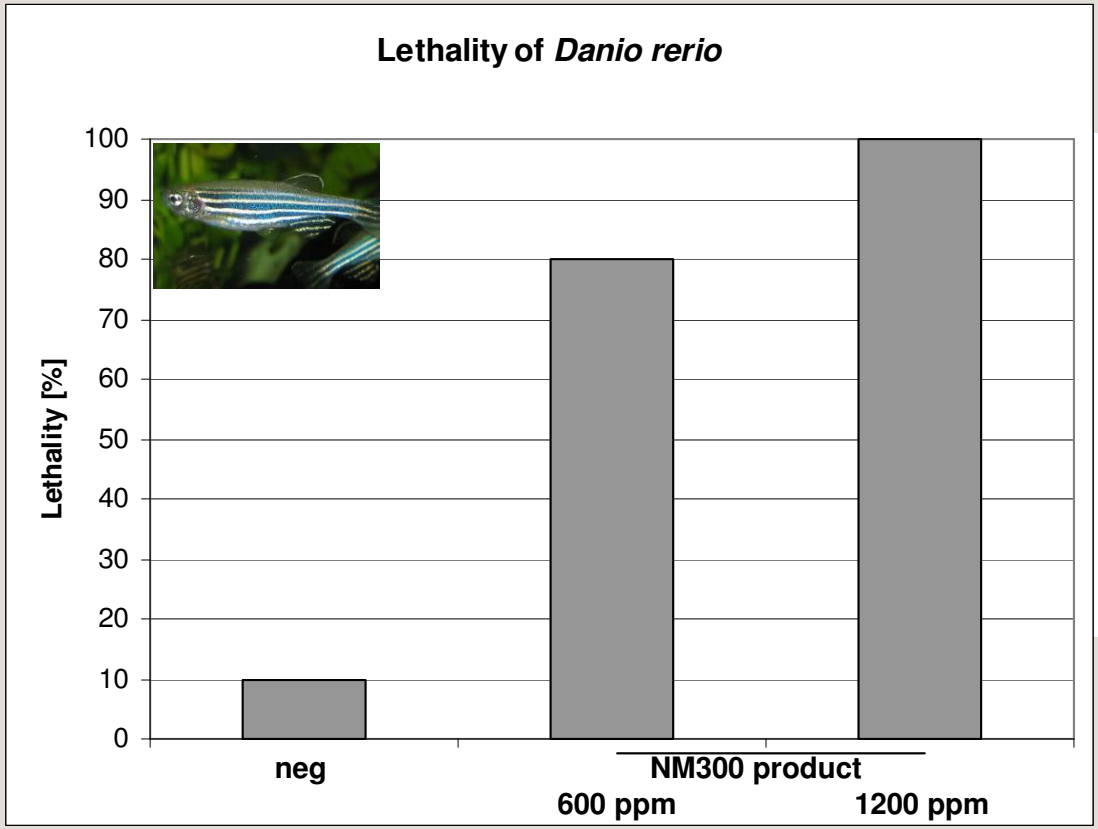
Zebrafish early larval stage test

acc. to DIN EN ISO 15988





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Effects of cigarette smoke residues from textiles on fibroblasts, neurocytes and zebrafish embryos and nicotine permeation through human skin

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ABSTRACT

Toxic substances from cigarette smoke can attach to carpets, curtains, clothes or other surfaces and thus may pose risks to affected persons. The phenomenon itself and the potential hazards are discussed controversially, but scientific data are rare. The objective of this study was to examine the potential of textile-bound nicotine for permeation through human skin and to assess the effects of cigarette smoke extracts from clothes on fibroblasts, neurocytes and zebrafish embryos. Tritiated nicotine from contami-

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Outlook TECHNOTOX project

- More realistic exposition scenarios
- Testing further textile abrasion samples

  → genotoxic potential

  → zebrafish early larval stage test
- Human 3D skin model
- Mucosa penetration (mouth, gut)
- Resorption into the blood

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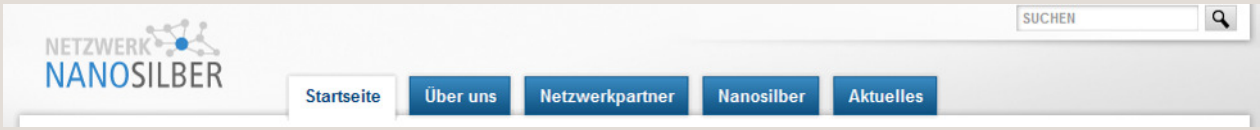
Outlook TECHNOTOX dialog

- Scientific publications
- Public presentation in web



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Conclusion

- Safety of products and processes is assessed with standardized biological test systems. These should be reliable, robust, sensitive and predictive.
- Realistic working concentrations must be used. No overload experiments.
- Textile products should be evaluated seperately depending on the exposition scenario.

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Thanks for your attention !

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