



Empa

Materials Science and Technology



Nanoparticles-biobarriers interactions: impact of particle properties on barrier penetration and functionality

Dr. Tina Buerki-Thurnherr
Group leader particles@barriers

9th VERT Focus event
16.2.2018

Outer epithelial barriers:

Skin



Intestine



Lung



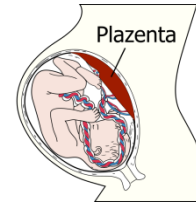
- The intact skin provides an effective barrier against NP penetration (Watkinson, Pharm Res, 2013)
- NPs can cross the intestinal and lung barrier (Kreyling et al, Nanotoxicology, 2017)

Blood-tissue barriers:

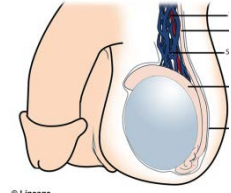
Blood-Brain Barrier



Placenta



Testis

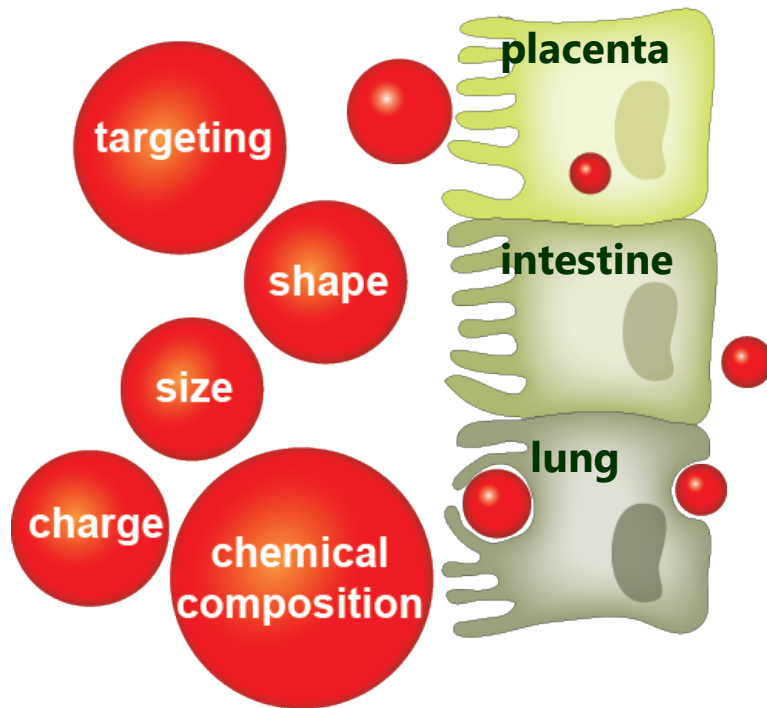


- NPs can penetrate the BBB (Moura et al, pneurobio, 2017), the placental barrier (Muoth et al, Nanomedicine, 2016) and the blood-testis barrier (Ema, Reprod Toxicol, 2017; Liu, Curr Drug Metabol, 2016)

Knowledge gaps:

- Understand the **impact of NP properties and surface modifications** on uptake and toxicity
- Studies using **realistic exposure routes and concentrations**
- Elucidate **underlying mechanisms** of NP translocation and toxicity

We study particles-barrier interactions in human organotypic models to enable the design of safe particles for industrial, commercial and medical use



NANOSAFETY



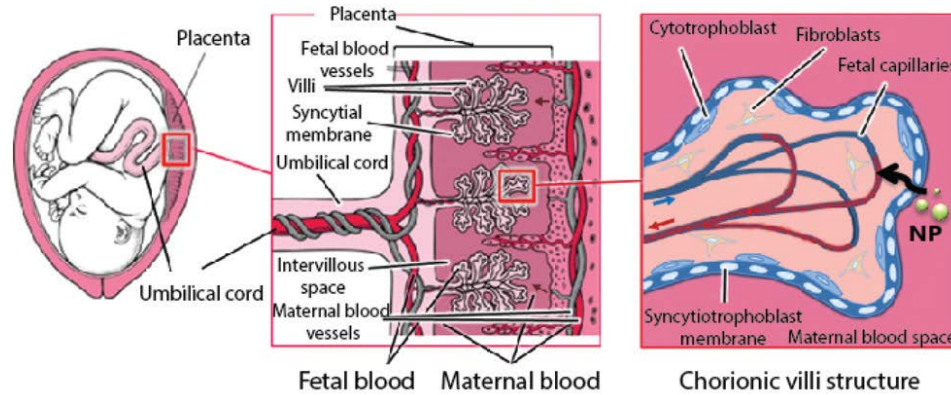
Contribution to ...



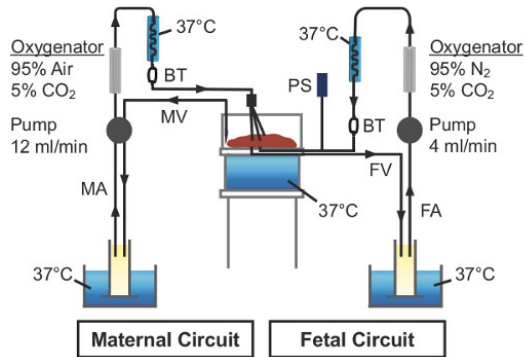
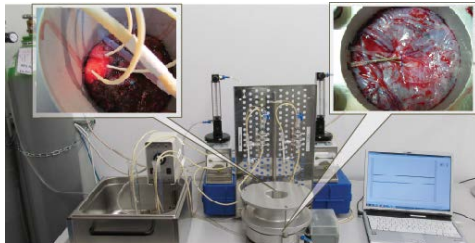
NANOMEDICINE

Human placental barrier and models

modified from Keelan et al. *Nanomedicine*, 2015



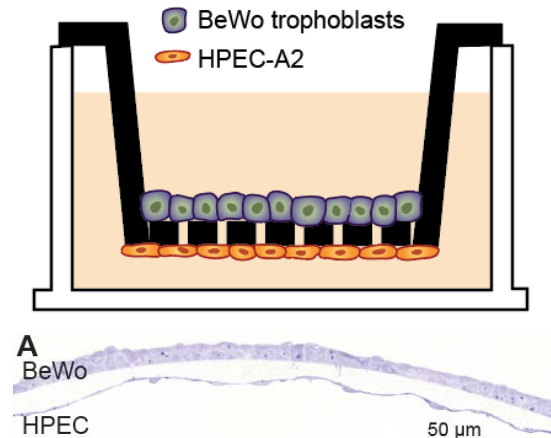
Ex vivo perfusion



NP translocation

Grafmueller et al, *JOVE*, 2013

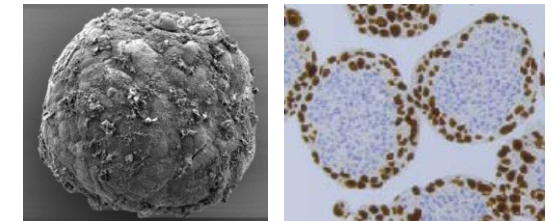
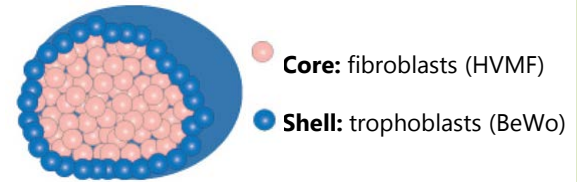
Co-culture transfer model



NP translocation
NP toxicity

Aengenheister et al, *Sci Rep*, in revision

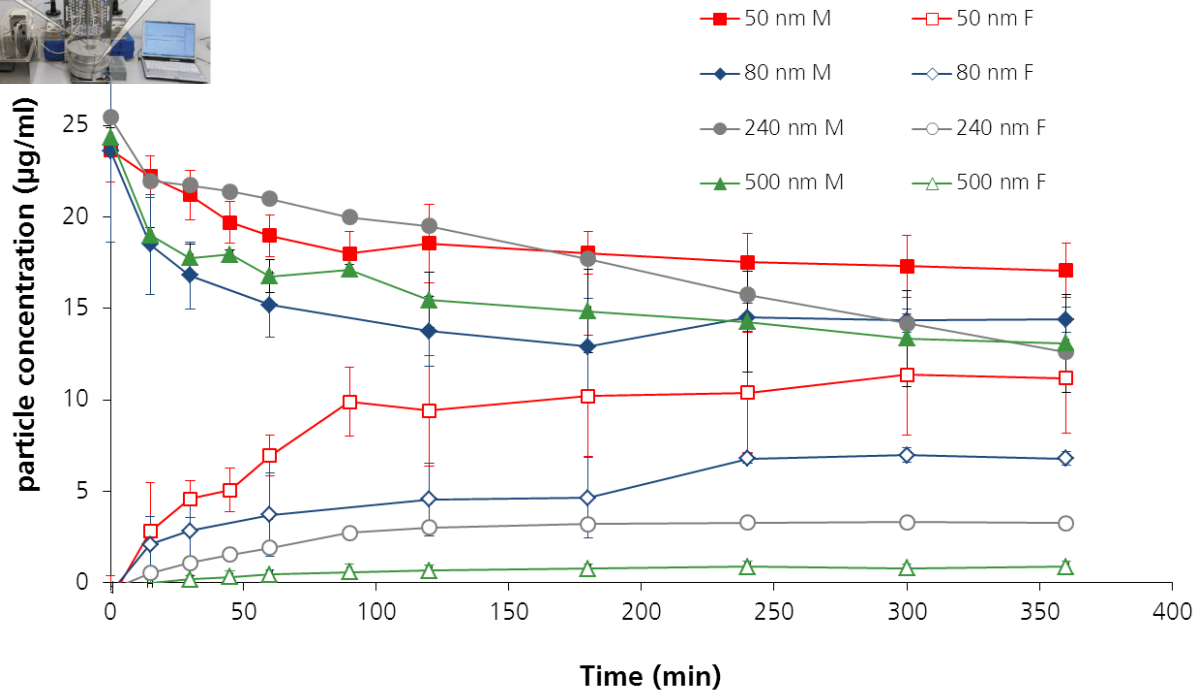
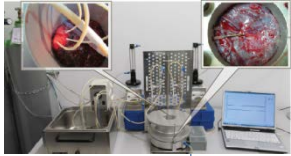
3D microtissues



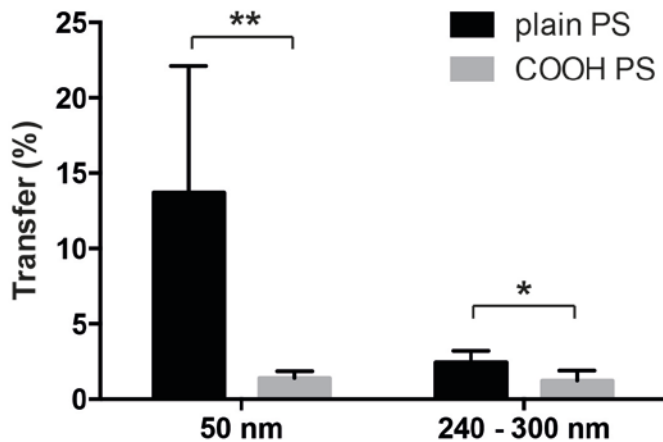
NP uptake/penetration
NP toxicity

Muoth et al, *Nanoscale*, 2016

Placental transfer of polystyrene (PS) NPs

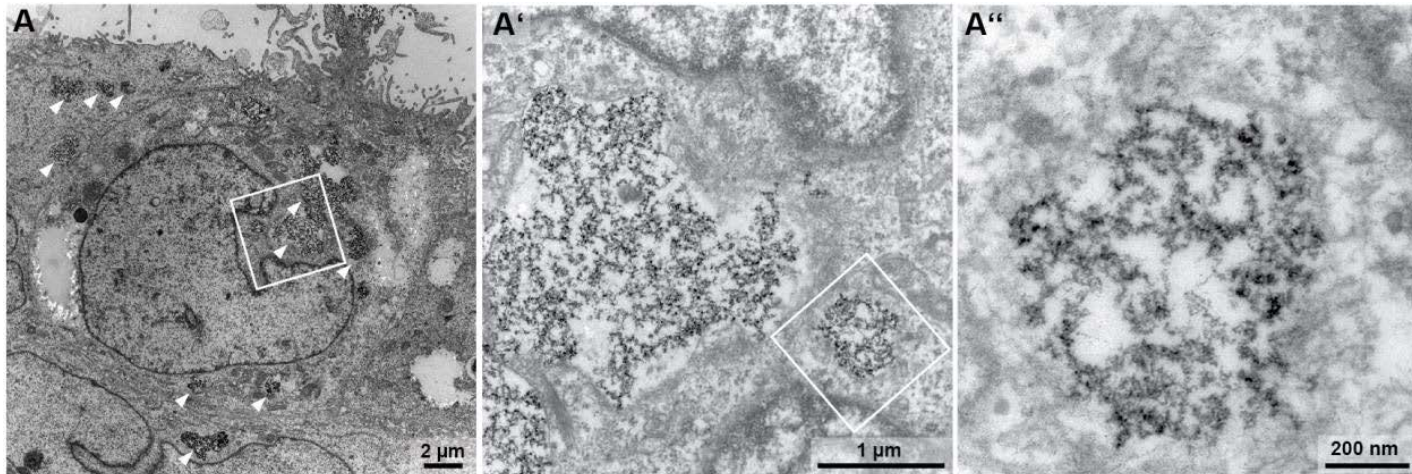
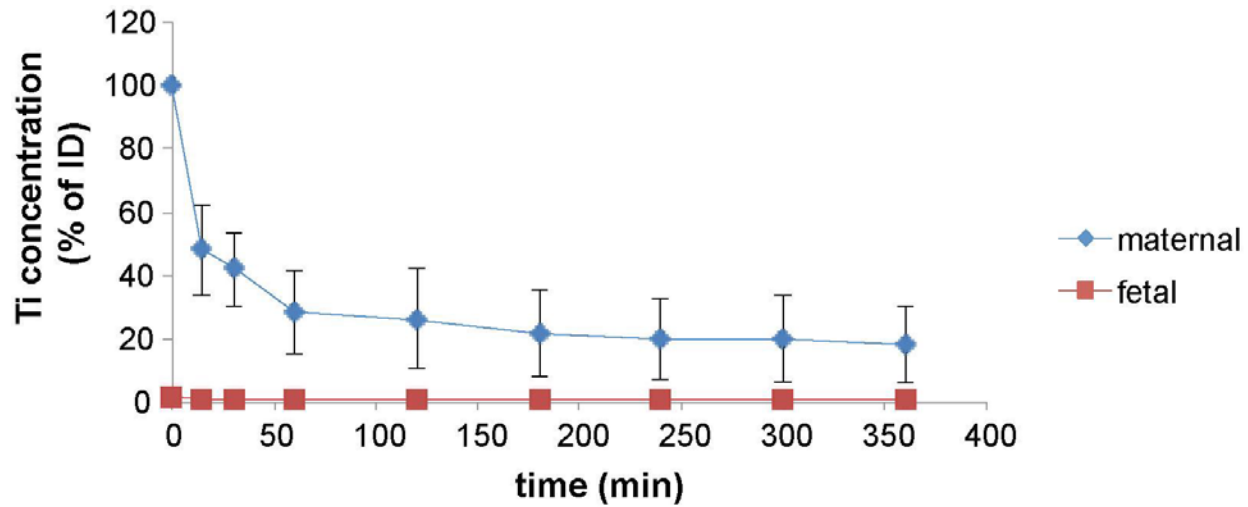
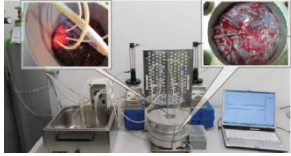


- Size-dependent transfer of PS NPs



- Modification-dependent transfer of PS NPs

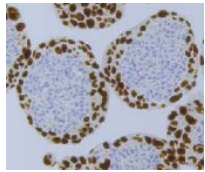
Placental transfer of 4nm TiO₂ NPs



- **Material-dependent transfer**

Muoth et al. Nanoscale, 2016

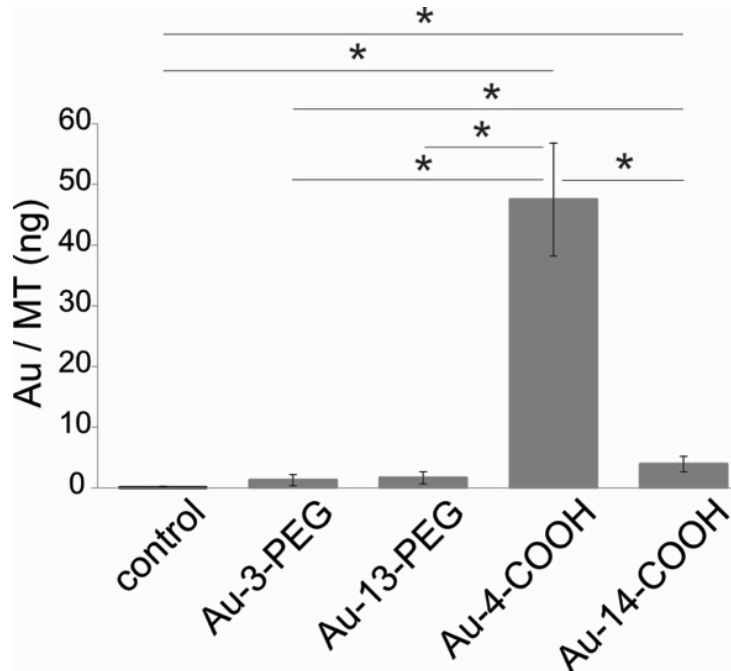
Placental penetration of gold (Au) NPs



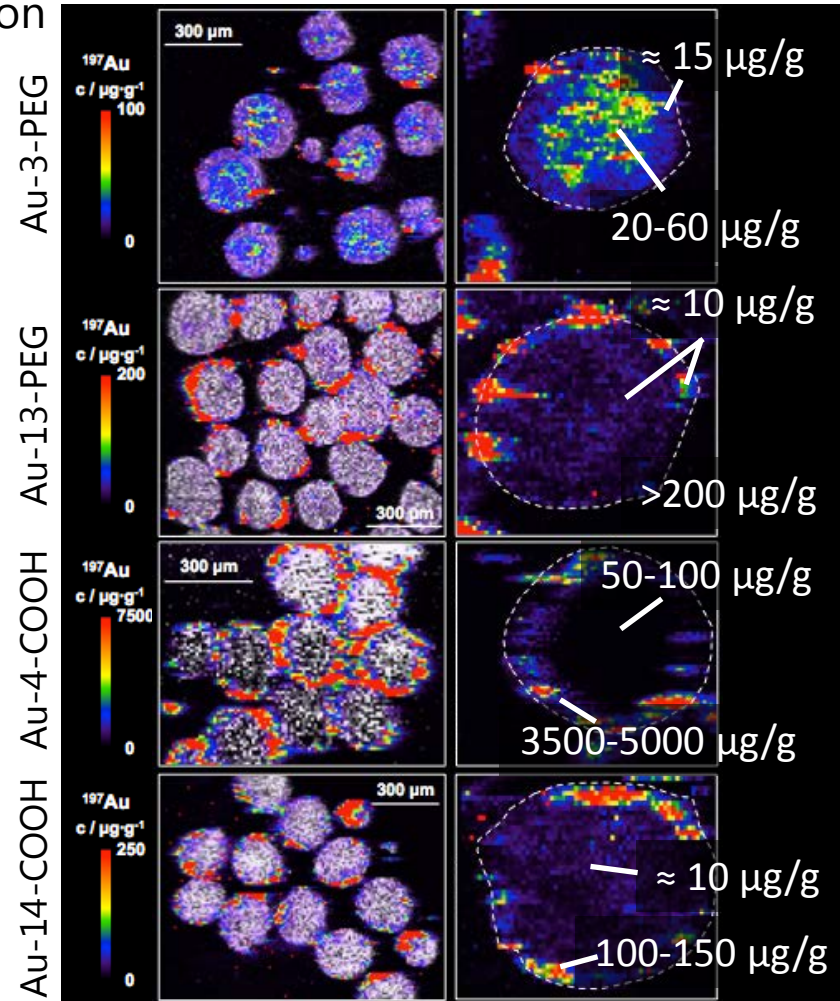
- Au NPs:
- 3-4 vs 13-14 nm
 - PEG vs COOH

Laser-ablation
ICP-MS:

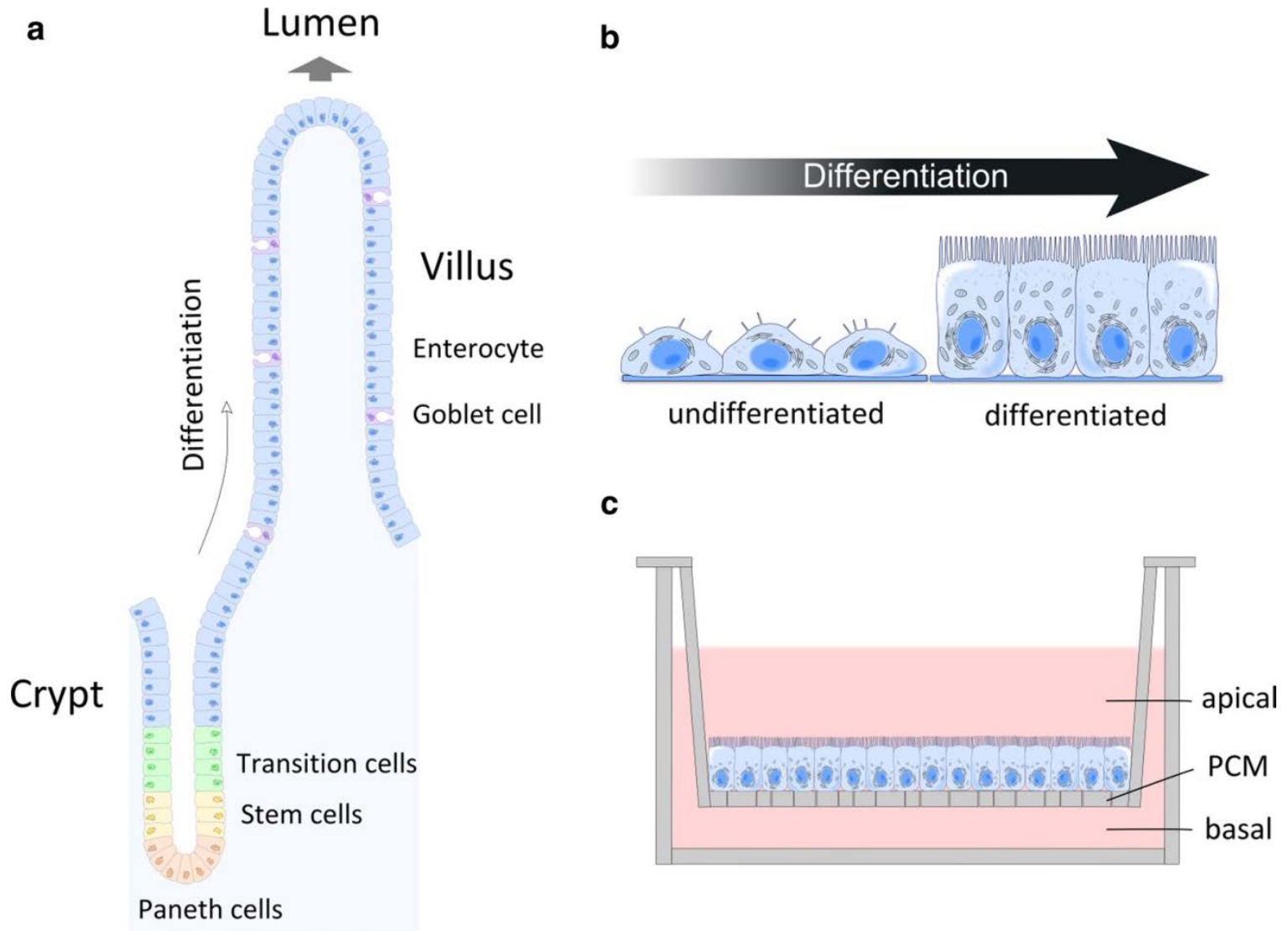
ICP-MS:



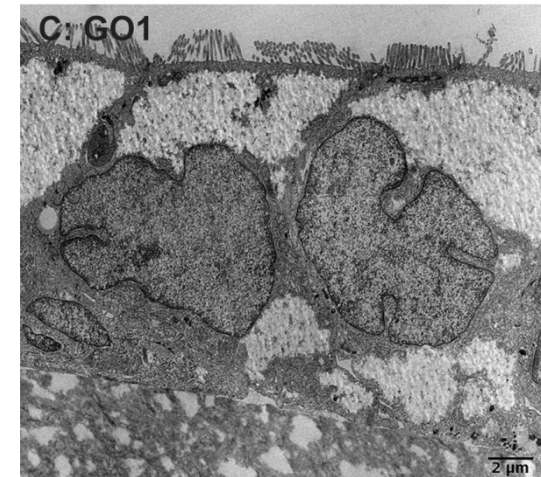
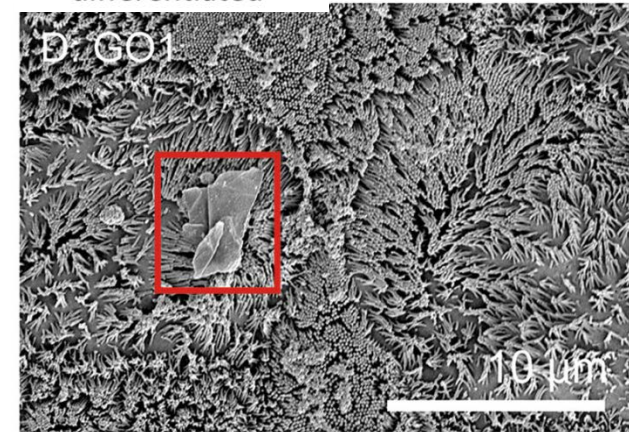
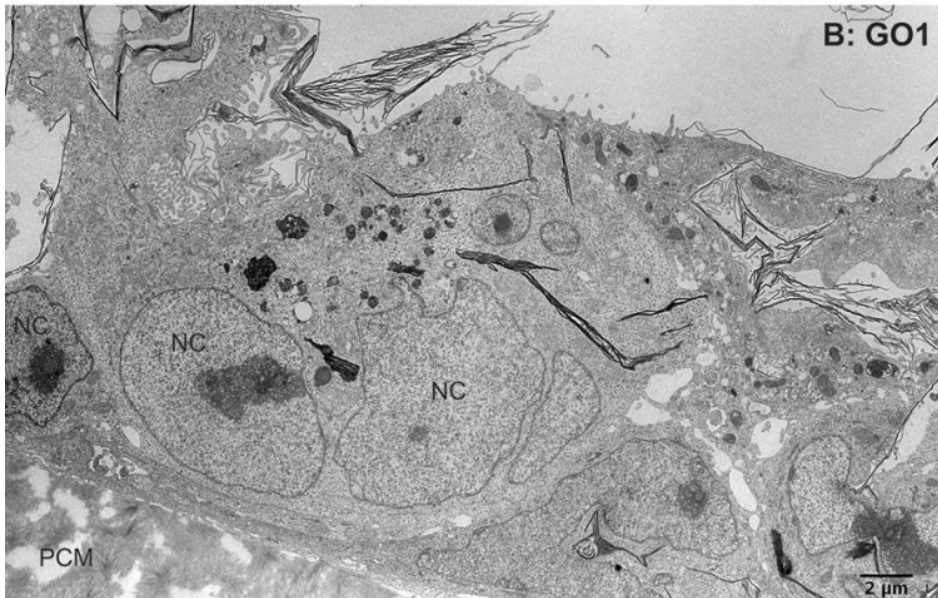
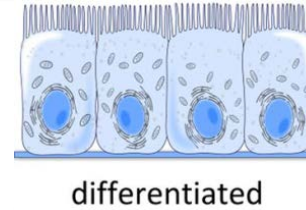
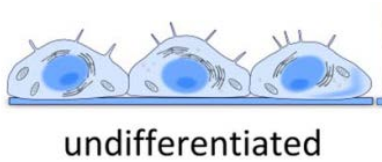
➔ **Size- and/or surface modification-dependent uptake**



Muoth et al. Nanomedicine, 2017



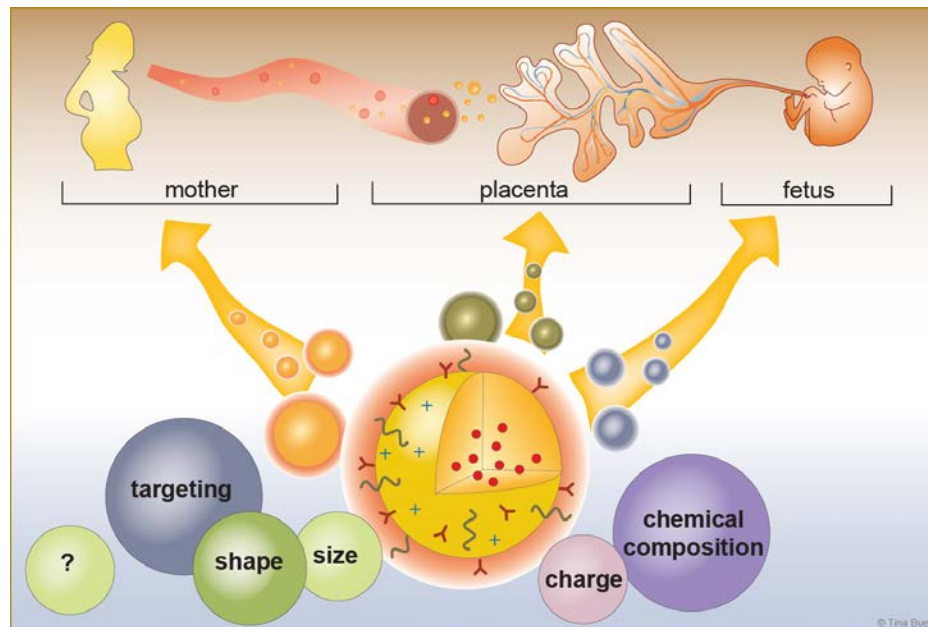
Uptake of GO by intestinal epithelial cells (Caco-2)



- GO sheets are only taken up by undifferentiated Caco-2 cells

Kucki et al. , 2016, J Nanobiotech.

- NP translocation across tissue barriers is dependent on **particle type, size and surface modification**
- NP uptake/effects are **cell-type specific** and dependent on the **differentiation status** of the cells
- These findings indicate that it is possible to **steer NP uptake and translocation across tissue barriers** to a certain extent by tailoring their properties and surface modification

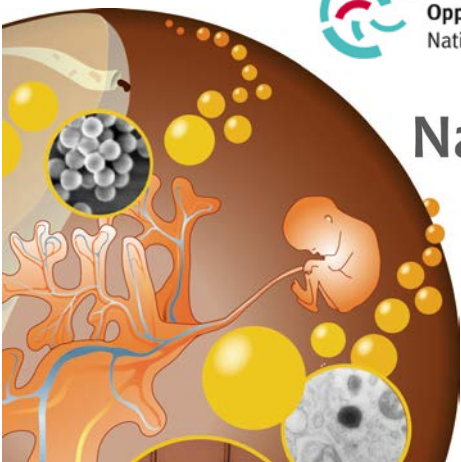
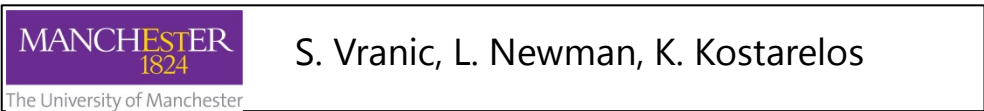
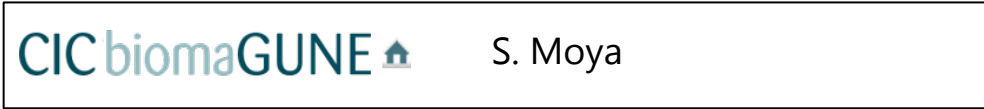


Buerki-Thurnherr et al. , 2015, SMW

Acknowledgement



L. Aengenheister,
C. Muoth,
P. Manser,
L. Diener,
A. Wichser,
A. Rippl
M. Kucki,
P. Wick



Thank you for your attention!