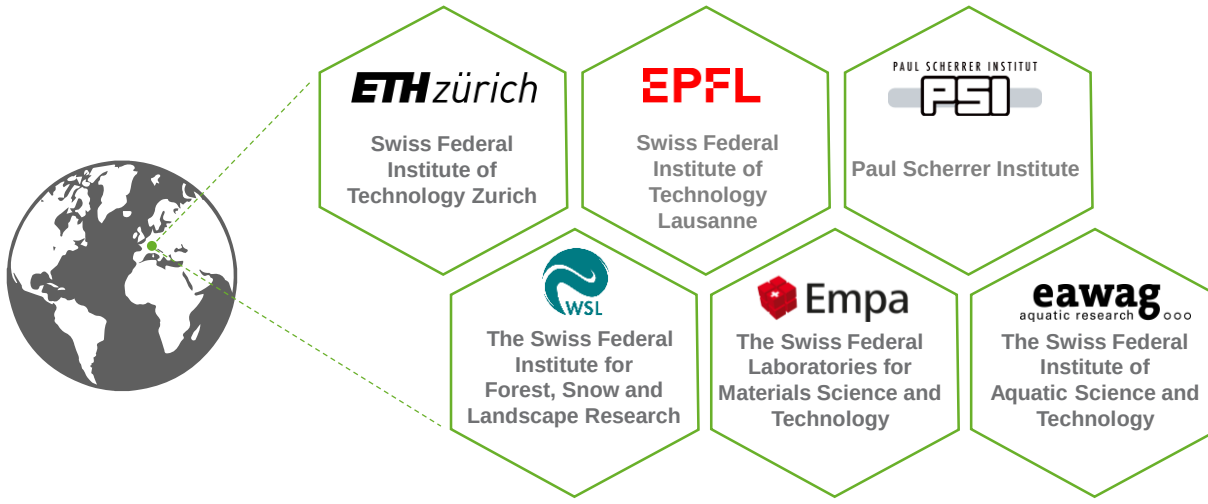

Empa – The Place where Innovation starts
Materialien in Wechselwirkung mit dem menschlichen Körper
28. 10. 2019, St. Gallen
Prof. Dr. Alex Dommann and Team

ETH Domain


ETH zürich
Swiss Federal Institute of Technology Zurich
EPFL
Swiss Federal Institute of Technology Lausanne
PAUL SCHERRER INSTITUT
PSI
Paul Scherrer Institute
WSL
The Swiss Federal Institute for Forest, Snow and Landscape Research
Empa
The Swiss Federal Laboratories for Materials Science and Technology
eawag
aquatic research
The Swiss Federal Institute of Aquatic Science and Technology

Empa - the place where innovation starts

Empa: Our Strategic Focus

The challenges of today's society


Sustainable Energy System

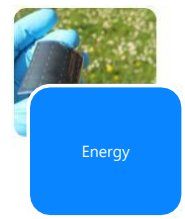

Demographic Change

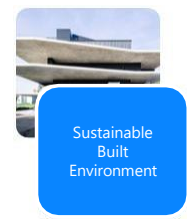

Climate and Environment


Scarcity of Ressources


Renewal of Infrastructure

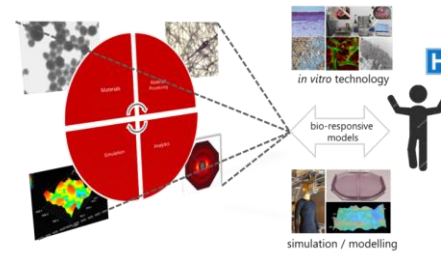
…. and our answers





Challenges of our society

Empa's Research Focus Area
"Health and Performance"



Ageing society

Integration of implants, prevention of chronic diseases, accurate dosage of drugs, predictive (disease) models, merging of big data and mechanistic world

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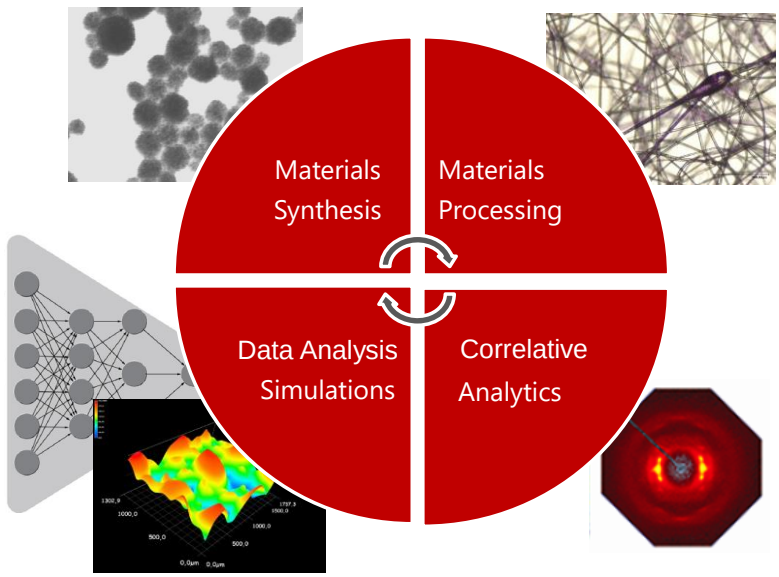
Acceleration of material development cycles and prediction



high content data high through put data
Comprehensive, multiscale & multilayer characterization datanfrom e.g. analytical imagingn'omics'-based data

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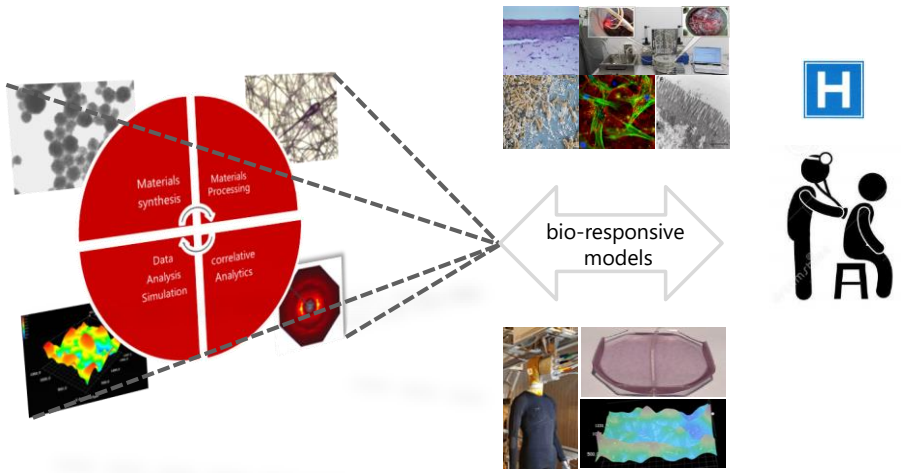
Health and Performance:
with innovative materials into a healthy future



Materials meet Life

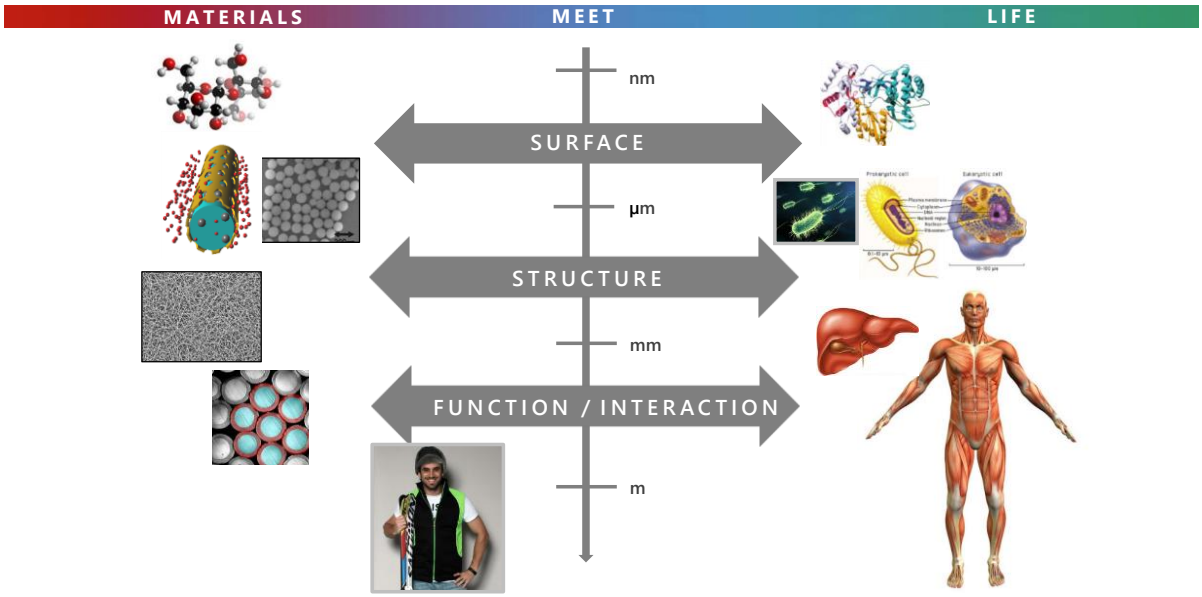
Materials

meet

Life

Materials meet life

Empa
Materials Science and Technology



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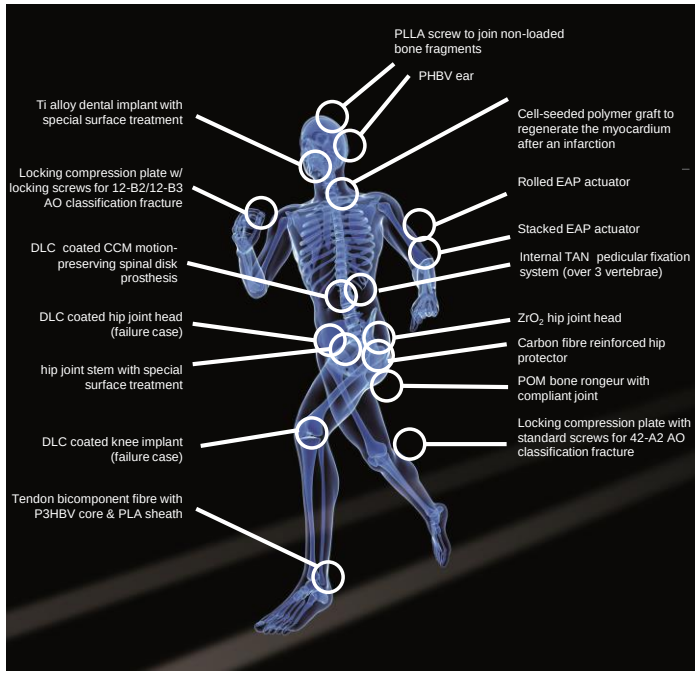

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MedTech

Combining the expertise of more than 10 Empa laboratories

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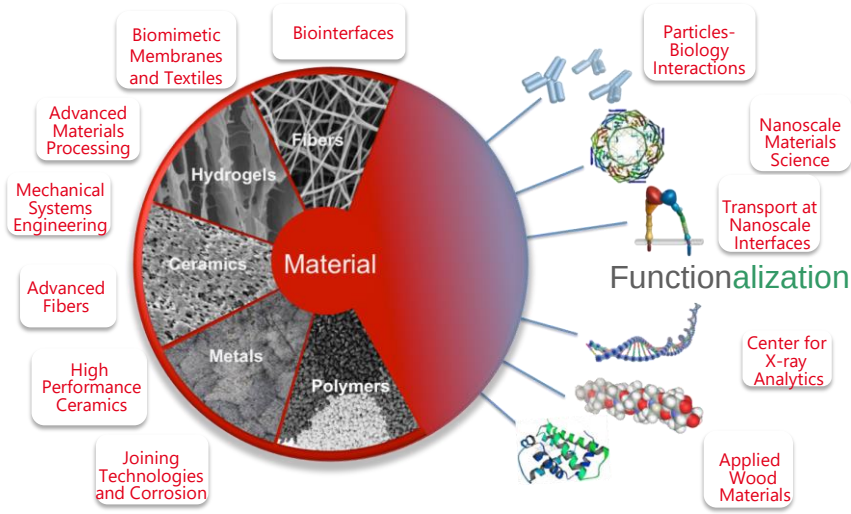
From Materials to Biointerfaces



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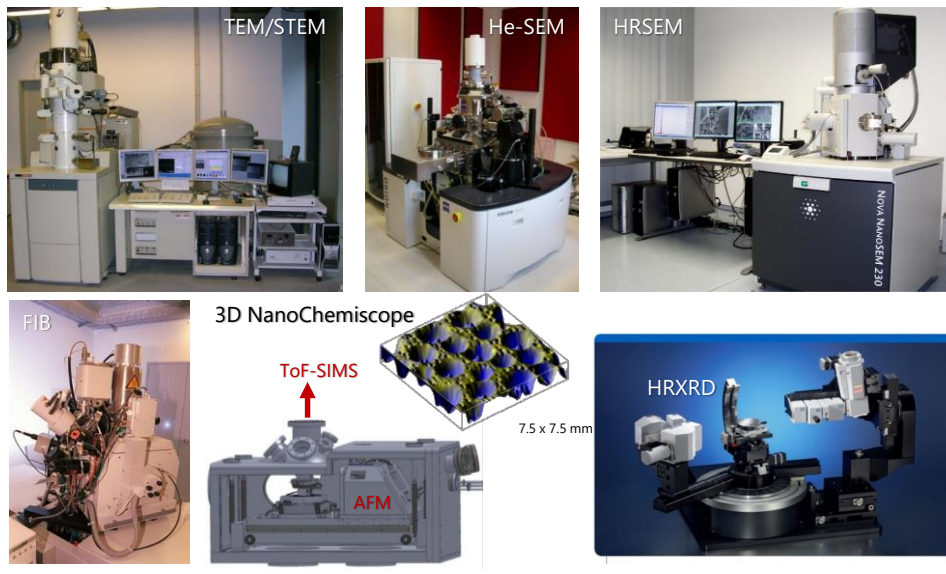
Surface Analytics @ Empa



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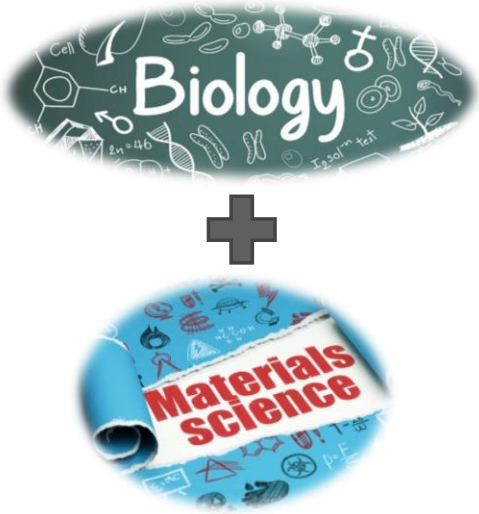
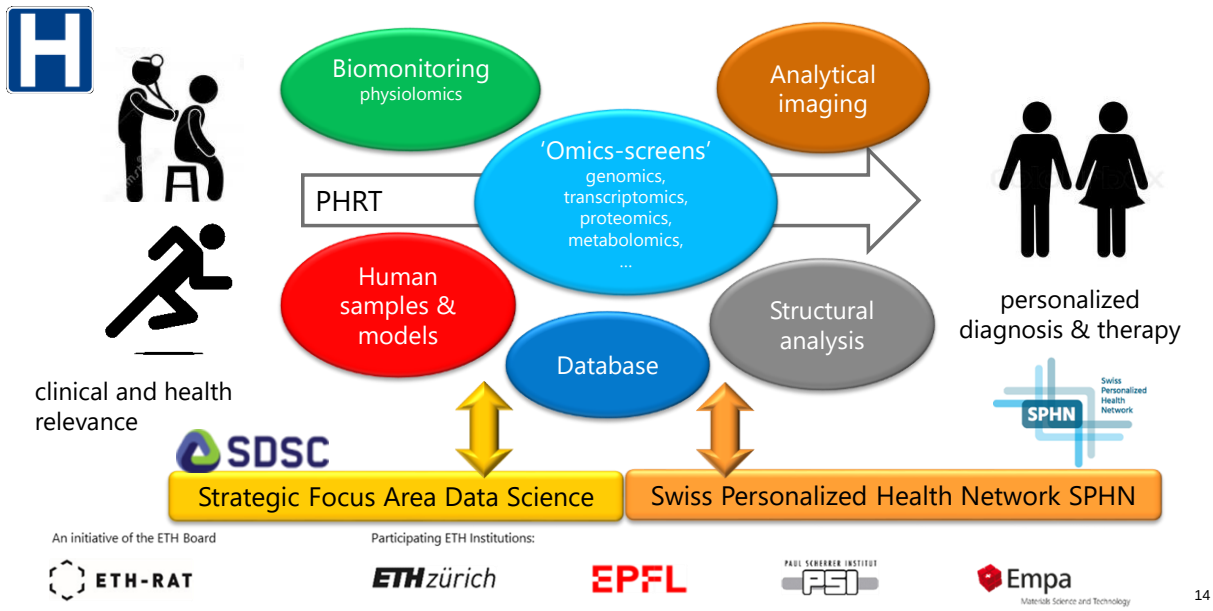
Our approaches:
Leverage in-house material and biological expertise



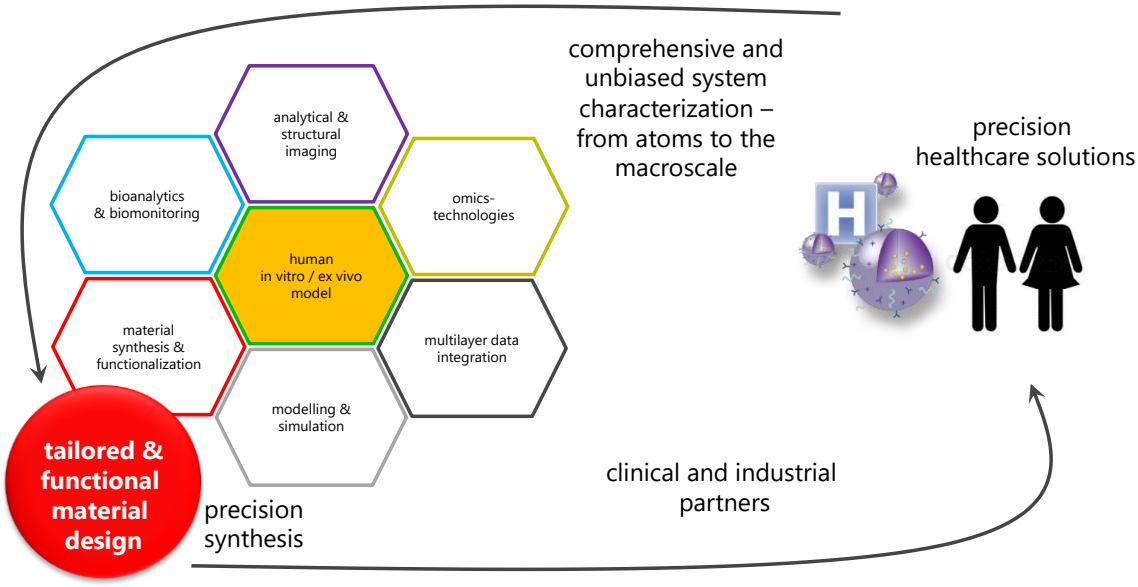
Membrane suitable for nanoparticle transfer studies

Image sources: https://groves.christian.college/2018/08/year-11-biology-stem-project-pig-autopsy/; https://www.polymersolutions.com/blog/the-polymer-solutions-glossary/; https://www.medline.com/product/30-m-PET-Membrane-Cell-Culture-Inserts-by-Corning/Z05-PF153814/

Personalized Health and Related Technologies



Health and Performence



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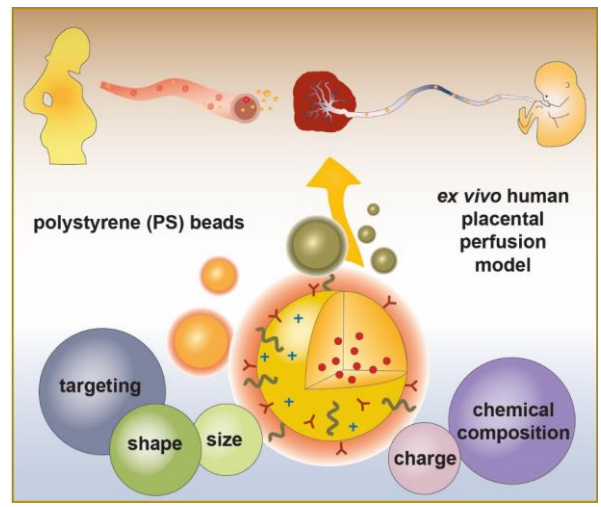
Aim of the Placenta Research

Determination of ENM physicochemical properties which influence placental translocation.



ENM: engineered nanomaterials

Advanced *in vitro* placenta models

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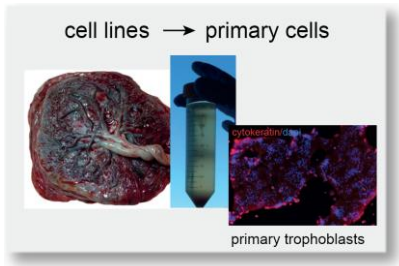
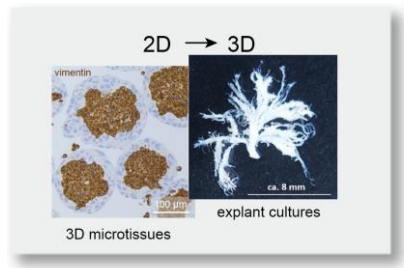
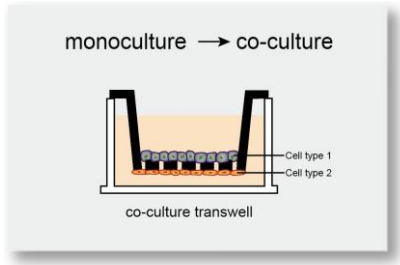
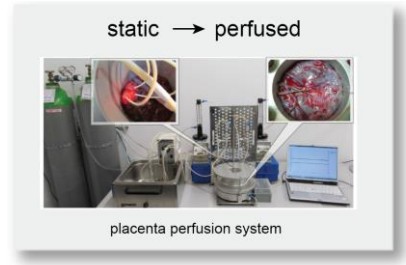
Strategies to increase predictiveness









System dynamics (4D) understanding through X-ray analytical methods

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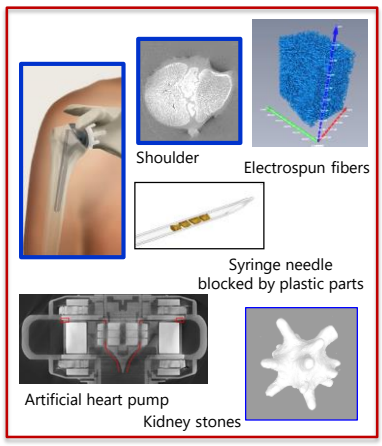
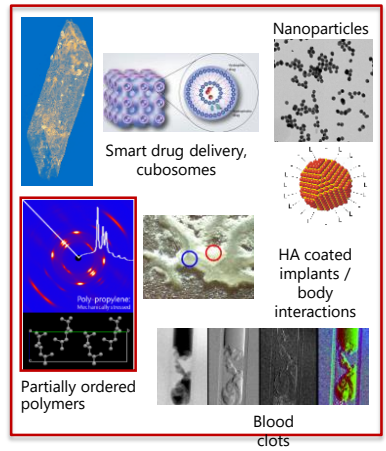
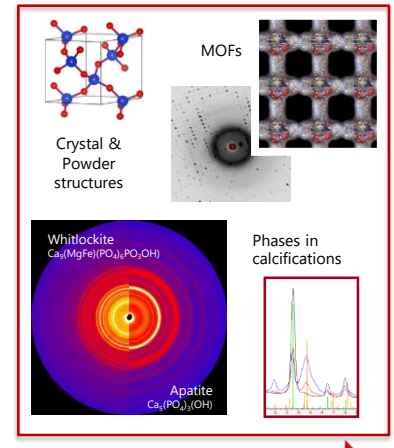
Imaging
→ Seeing the invisible !

Multi-modal concepts
Multiscale
Combined Direct & Fourier space approach

Molecular Structures
→ Where are the atoms ?







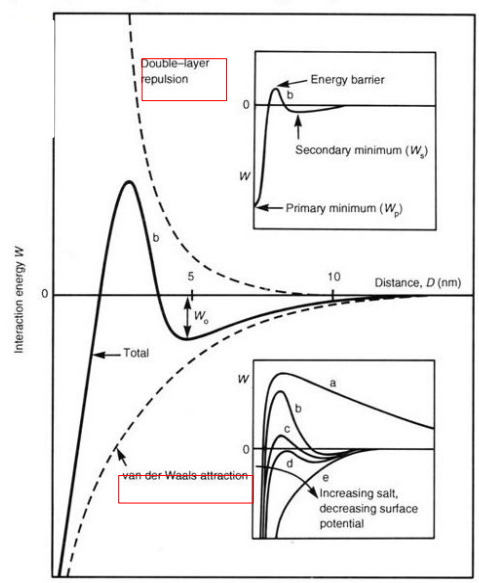
1D → 2D Dimensionality **3D** **+ dynamics**

Introduction

Theory of colloidal stability

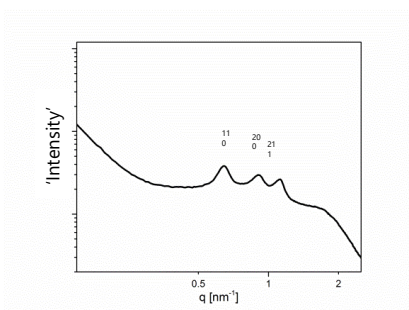
➢ Due to DLVO theory

- *Van der waals interactons*
  - ✓ Originated from dipolar interactions
  - ✓ Attractive
  - ✓ Short range
- *Electrostatic Interactions*
  - ✓ Only when charged interactionpartners exist
  - ✓ Long range
  - ✓ Surface charge and ionic strength of the media will determine the magnitude of these interactions
- *Steric interactions*
  - ✓ Depend on kind of surfactants these interactions can be attractive or repulsive

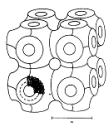


1) http://www.colloid.ch/index.php?name=dlvo 2) Derjaguin&Lndau (1937), Verwey&Overbeek (1944)

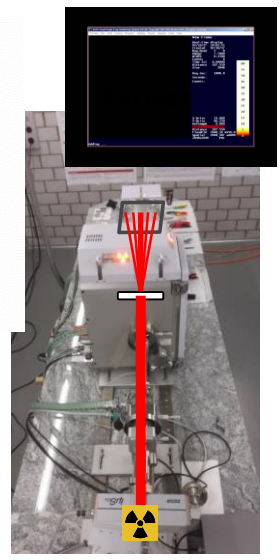
Nanostructure characterization



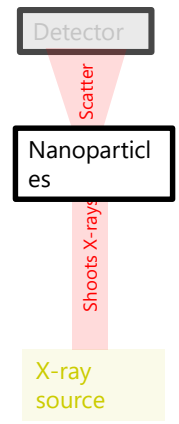
Angular intensity patterns help identify internal structures. The three characteristic peaks belong to Im3m Cubic Phase!



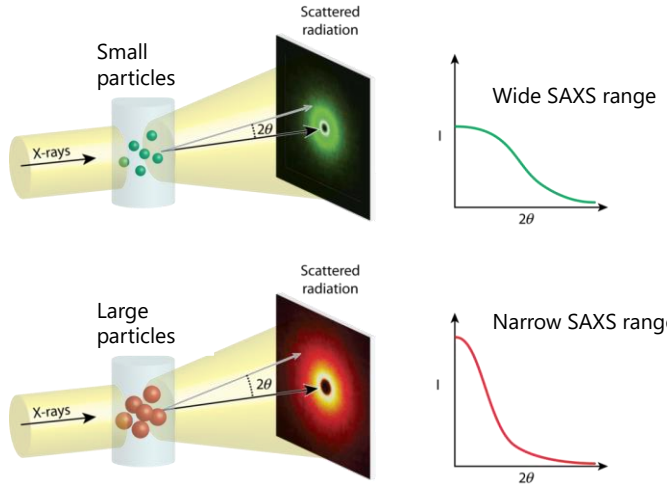
Nat. Chem. **2014**, 6, 534–541



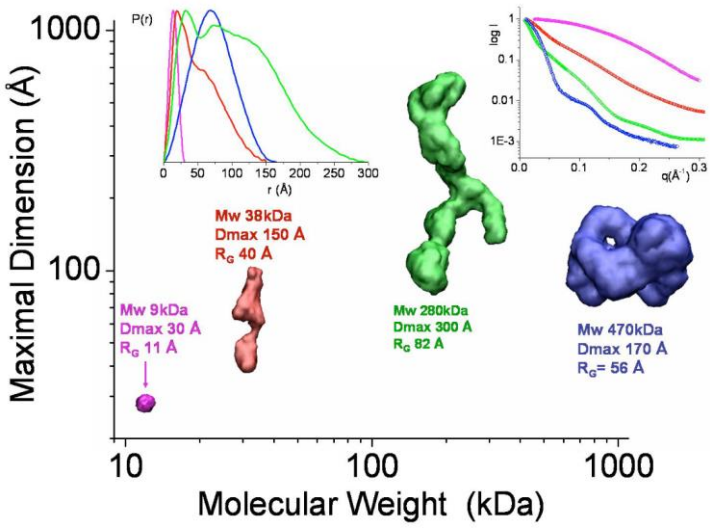
Repeating units of crystalline structure gives distinct circular reflections



The Reciprocity: Size – Scattering Angle



SAXS Size Range



Limit:

$q_{min}.D_{max} \leq \pi$

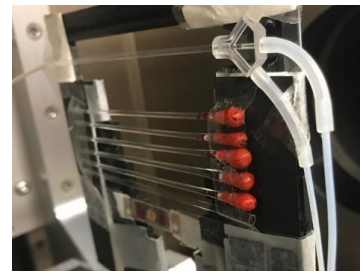
Putnam and Hammel et al. 2007
Q R Biophysics, 40:191-285

Experimental

Mixing System

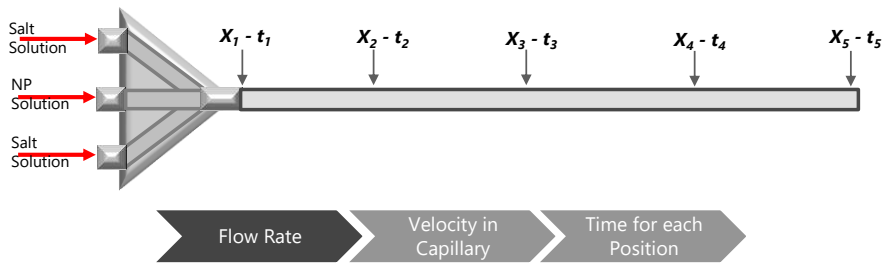
3D-Print

Poly Carbonate



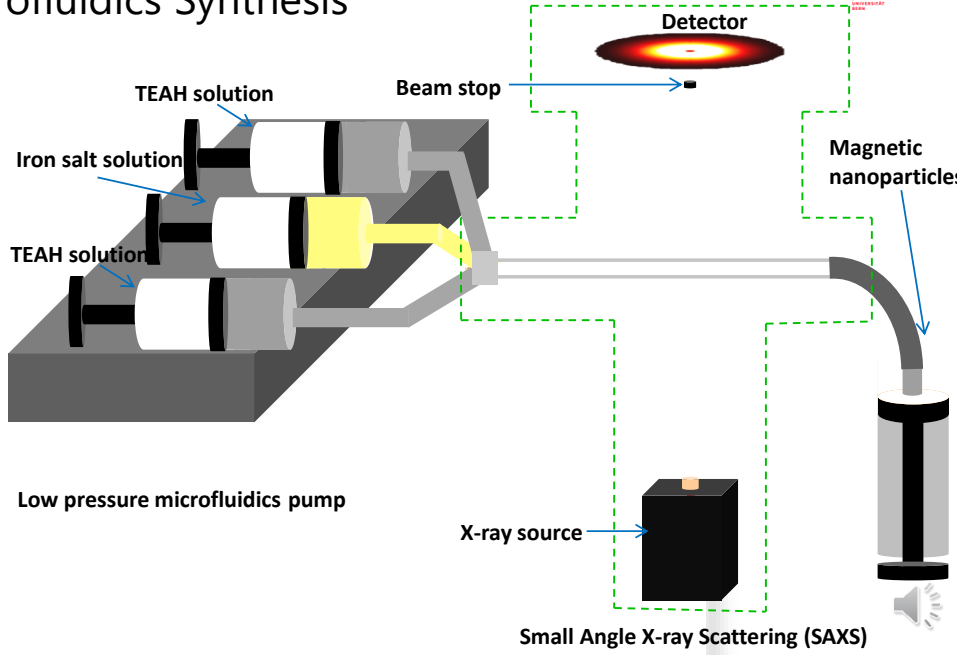
Mixing System

Convert Time to position in Microfluidic system

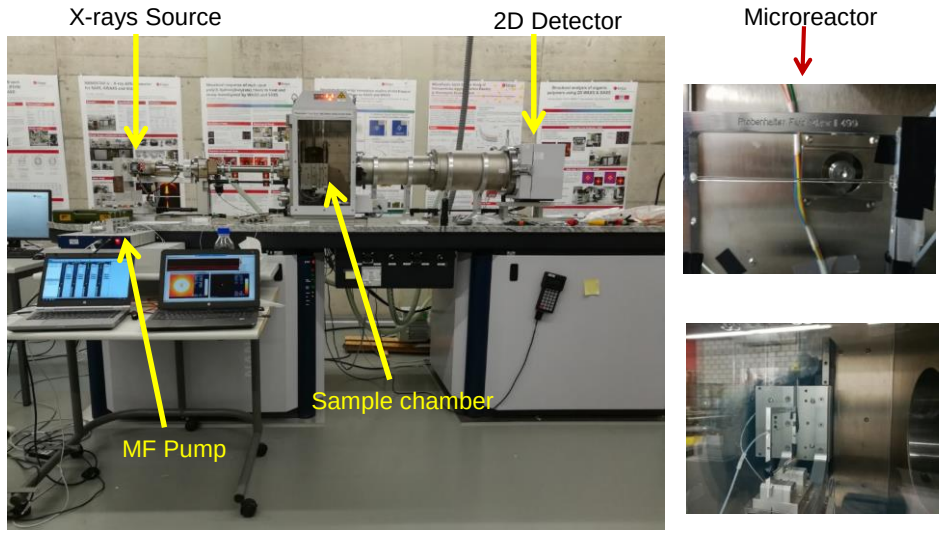


Flow rate (µl/min)	Flow rate (nl/min)	Fluid velocity in capillary (mm/min)	Time for passing the whole capillary (hr)	Total sample Volume (µl)	Time for each measurement (5 points) (min)	Time for each measurement (5 points) (s)
0.493	**493**	**0.157**	**6.92**	**5600**	**83.05**	**4983.2**
1	1000	0.318	3.412	5600	40.94	2456.7

Microfluidics Synthesis

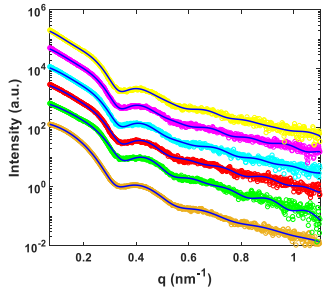


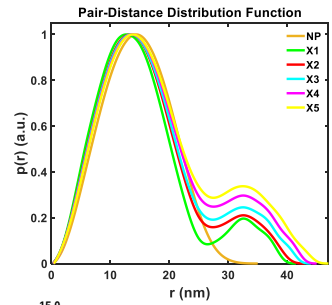
Experimental setup

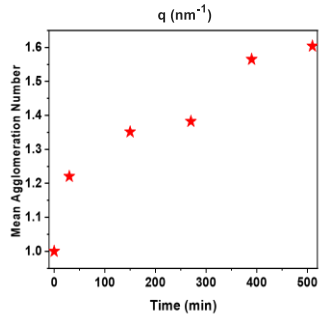


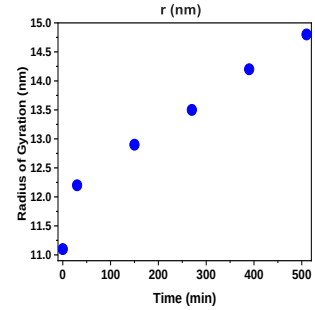
Results

Data for NP 1.5 mg/ml- Salt 1 M

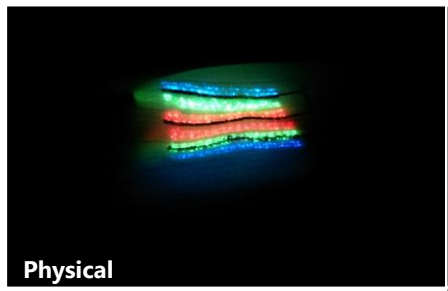


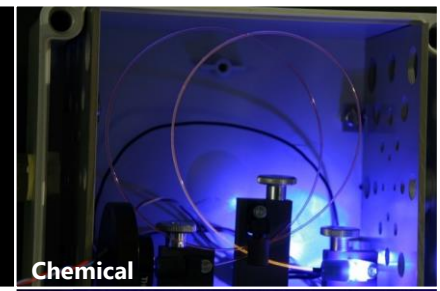


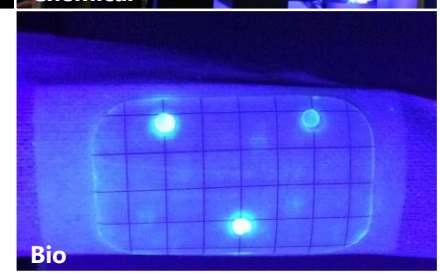




Optical detection



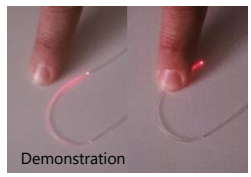




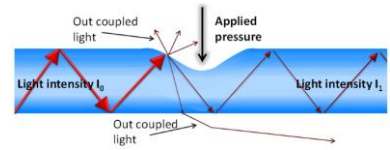
- Molecular design of fluorescent moieties (e.g., GCDs)
- Synergistic approach for inclusion of optical probes in matrix
- Precise insertion of the active matrix into textiles

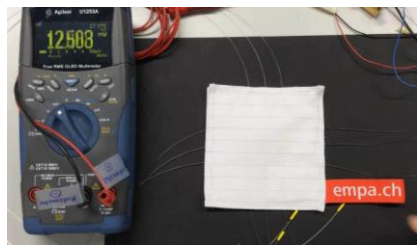
Light out-coupling by pressure

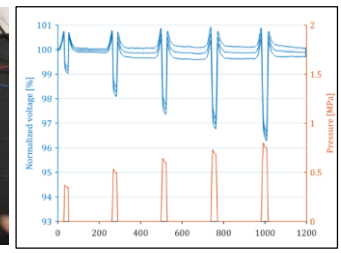
→ Out-coupling of light proportionally to the deformation



- ✓ Non-invasive
- ✓ Low-cost
- ✓ Small

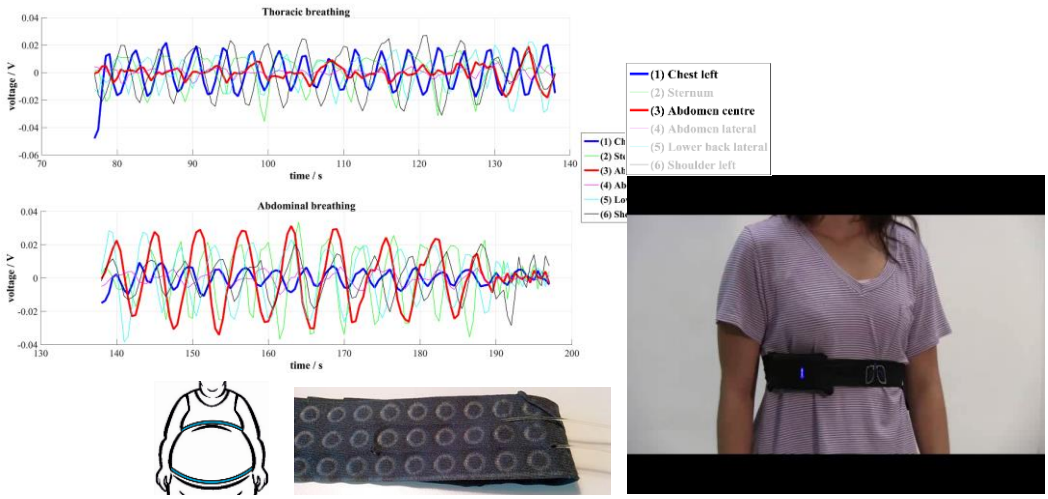






Krehel et al. *Sensors*, 2013, 13: 11956.
Quandt et al. *Eur Polym J*, 2017, 88: 44

Breath monitoring



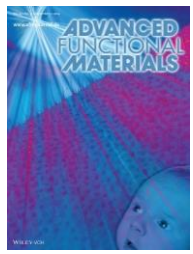
Krehel et al. *Sensors*, 2014, 14, 13088-13101.

Der Brustgurt warnt vor Demenz

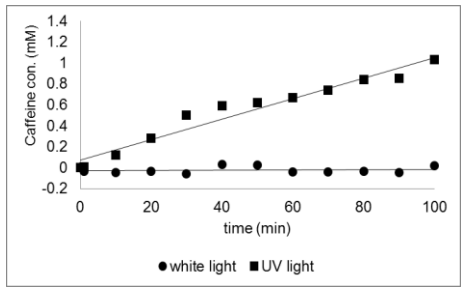
Messsystem zur Früherkennung von Alzheimer

Ostschweiz

From polymer-fibers to drug release



Light-responsive membrane



Pflaster statt Spritzen für Frühchen und Diabetiker

20 minuten

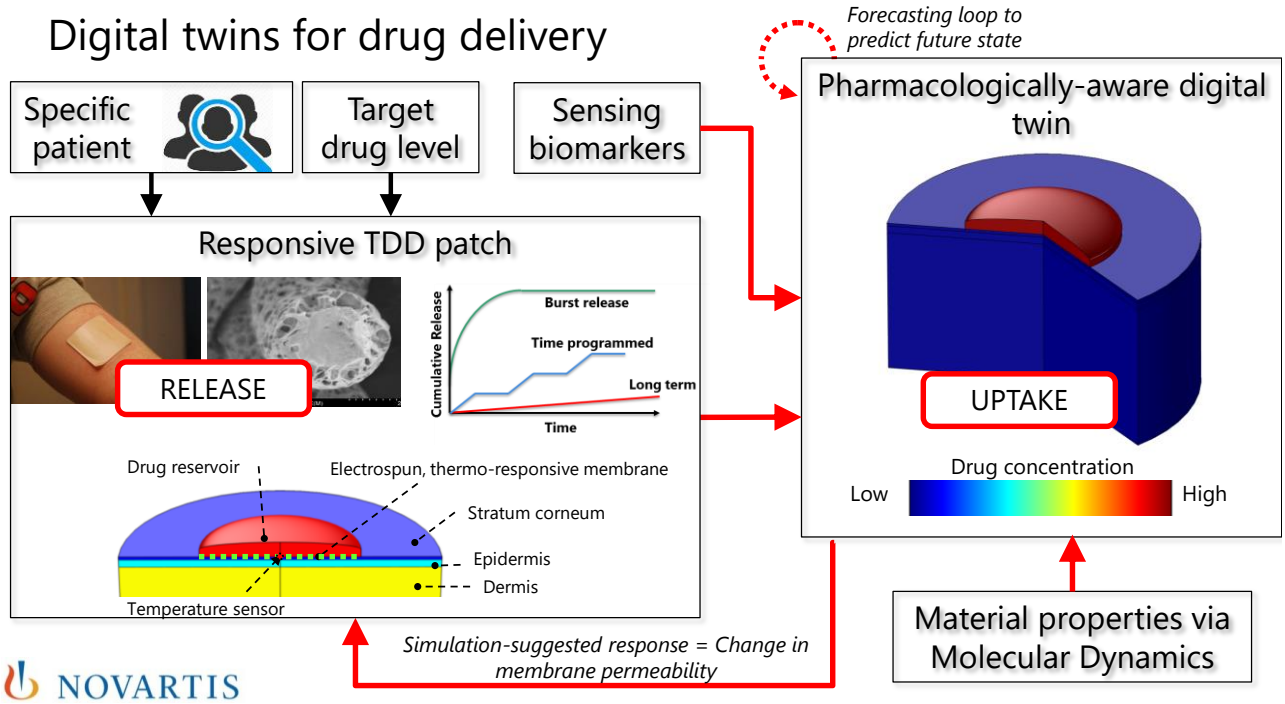
DÜBENDORF. Anstelle von schmerzhaften Spritzen könnten künftig Pflaster zum Einsatz kommen. In diese werden Medikamente integriert, die der Patient über die Haut aufnimmt. Dafür haben Forschende der Empa eine spezielle Membran entwickelt. Diese lässt Wirkstoffe durch, sobald sie mit UV-Licht bestrahlt wird. Danach ist die Membran für mehrere Stunden durchlässig. Während dieser Zeit erhält der Patient eine gleichmässige Dosierung des Medikaments. Die Membran lässt sich aber auch verschliessen, indem sie mit sogenanntem Weisslicht bestrahlt wird.

Nützen könnten solche Pflaster zum Beispiel zu früh geborenen Kindern. Ihnen wird in den ersten Tagen nach der Geburt Koffein gespritzt, um einen möglichen Atemstillstand zu verhindern. «Ersetzt man die Spritzen durch Pflaster, erspart das den Frühchen Schmerz und Stress», sagt Empa-Forscher Luciano Boesel. Eine weitere Anwendung sieht er beispielsweise bei Diabetes-Patienten. Diese müssen sich heute regelmässig Insulin spritzen. In Zukunft könnten sie sich das Medikament verabreichen, indem sie ein Insulin-Pflaster mit einer tragbaren Lampe aktivieren. KWW

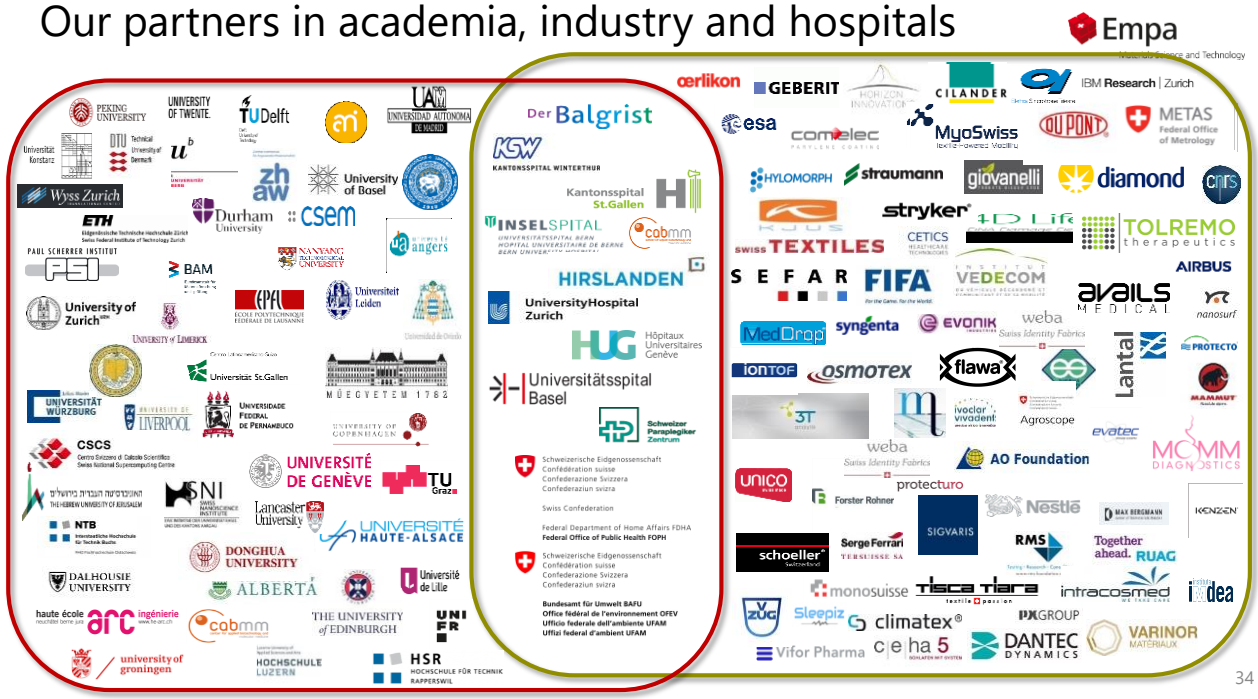
Frühchen wie dieses sollen bald weniger Schmerzen leiden. ISTOCK

UniversityHospital Zurich

Digital twins for drug delivery



Our partners in academia, industry and hospitals



Thank you for your attention

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