



Engineering in
medicine



Empa

Materials Science and Technology

Health @ Empa

<https://www.empa.ch/health>

ETH Domain Human Health Day 2026
<https://human-health-day26.epfl.ch/>

20 August 2026

Translational technologies and devices at the molecular level towards clinical impact

Prof. Dr. Michel Calame

Transport at Nanoscale Interaces Lab, Empa, Switzerland
www.empa.ch/tnilab

Empa Research Focus Areas



**Nanoscale Materials
& Manufacturing
Technologies**



Built Environment



Health

Protect & support,
improve the quality of
life and physical capacity



**Energy, Resources &
Emissions**

Health @ Empa

Maintaining health and accelerating recovery



Materials at heart

- Understand the interactions between materials and biological systems
in different environments, from the molecular to the macro-scale (organs, tissues)
- Develop, design & engineer novel
 - **diagnostics tools** (devices & techniques),
 - innovative **implants** (e.g. active surfaces and interfaces),
 - materials-based **therapeutic concepts** (e.g.: drug carriers, wearables)
- Translation to clinics

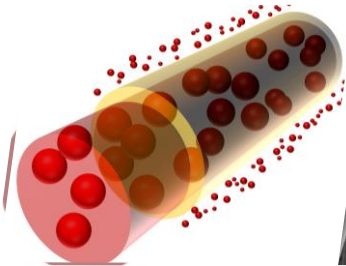


Health



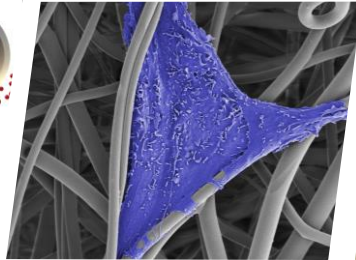
We maintain health and accelerate recovery

Materials streams



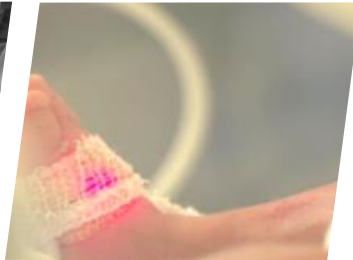
DELIVERING

Nanoscale delivery systems and precision targeting



INTERFACING

Implantable materials and biointerfaces



SENSING

Wearable sensors
Multiparametric monitoring



IMAGING

Biomedical imaging technologies
Multiscale morphology and composition



MODELLING

Organ and body modelling
E.g.: Digital twins, human manikins



MATERIAL STREAM

DELIVERING INTERFACING SENSING IMAGING MODELLING



HEALTH CLUSTER	Oncology	Tumor Micro Environment	Radioenhancers	3D-Virtual Histopathology
	Infections	Antimicrobial Resistance		Biofilm
	Wounds	Integrated Wound Management		
	Cardiovascular	Vascular Grafts	Septal Defects	Blood Clots
	Musculoskeletal	Implants	Structural Biodynamics	
	Women's Health	Prenatal Therapies	Endometriosis	Microplastics
	Dementia	Early Diagnostics		Amyloid Analytics
	Ophthalmology	Injectable Nanotherapeutics	Glaucoma Pressure Sensor	
	One Health	Safety and Sustainability	Pollutants	Heat

Infections – Anti-microbial resistance (AMR)

Connecting materials engineering and microbiology to tackle AMR



5

million
deaths associated
with AMR infections
per year.

60

US\$ billion
annual health costs
due to AMR, projected
to rise to US\$ 160 billion
by 2050.

130

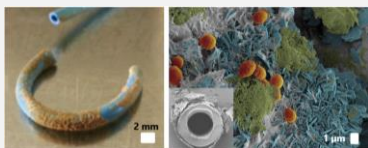
million
AMR infections each year,
with an estimated annual
increase of 20–30%.

Infections – Anti-microbial resistance (AMR)

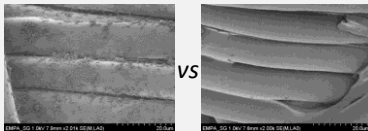
Connecting materials engineering and microbiology to tackle AMR



Prevention



*Preventing
implant-
associated
infections*

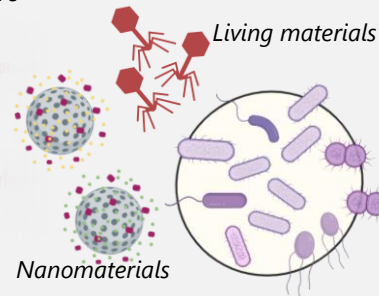


*Bio-responsive
materials*

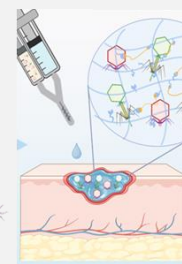
Sensing/Diagnosis



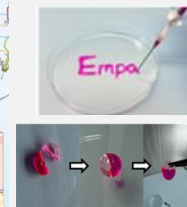
*Point-of-care
diagnostics*



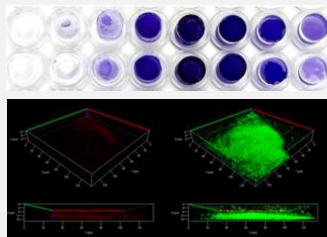
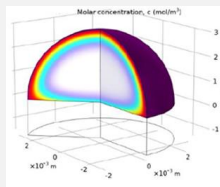
Treatment



Delivery materials



In vitro models & controls



Understanding bacteria - living/non-living materials interactions

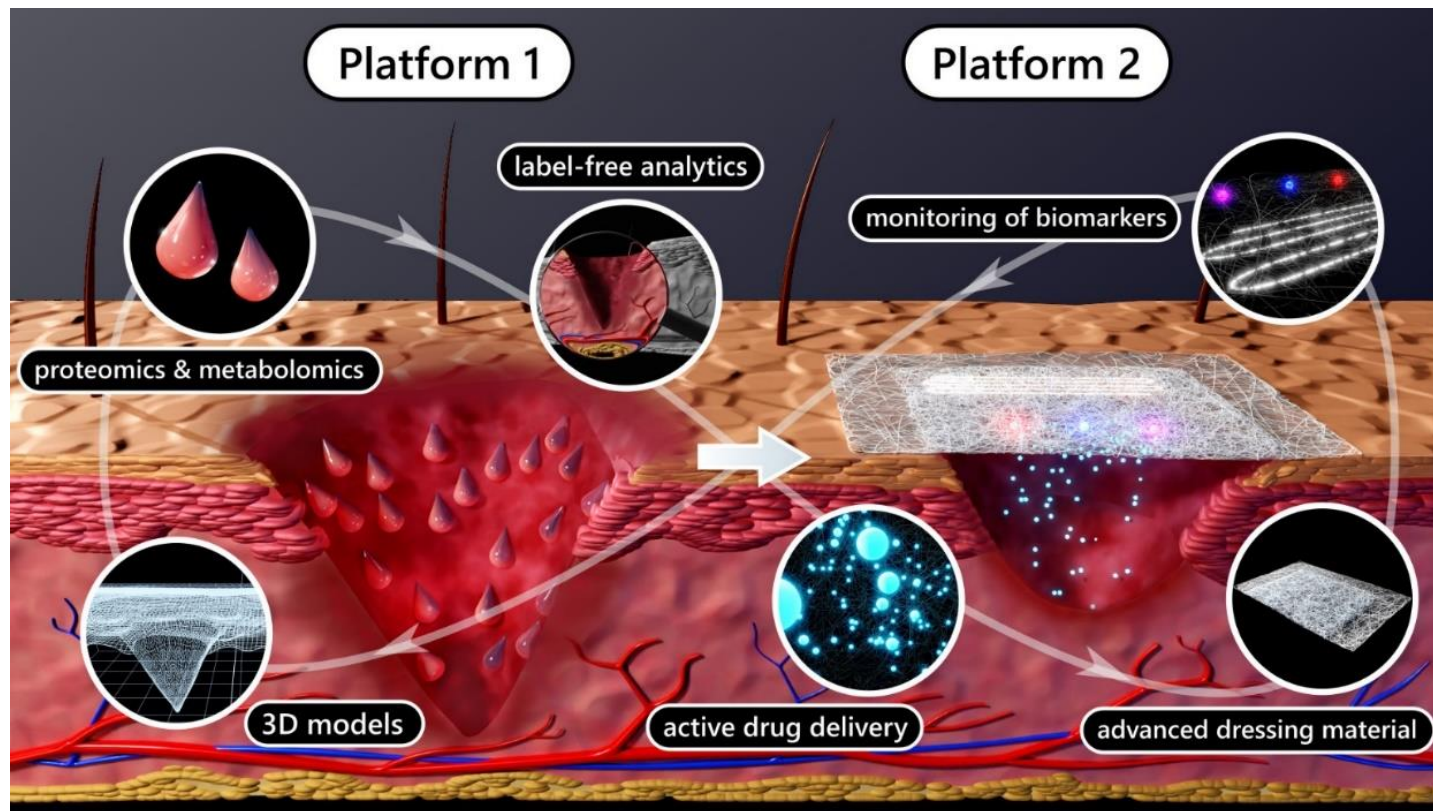
Probiotics-host cell interactions

Biofilm-materials interactions



Chronic Wounds (CW)

Integrated Wound Management Initiative



Chronic wounds affect 1-2% population

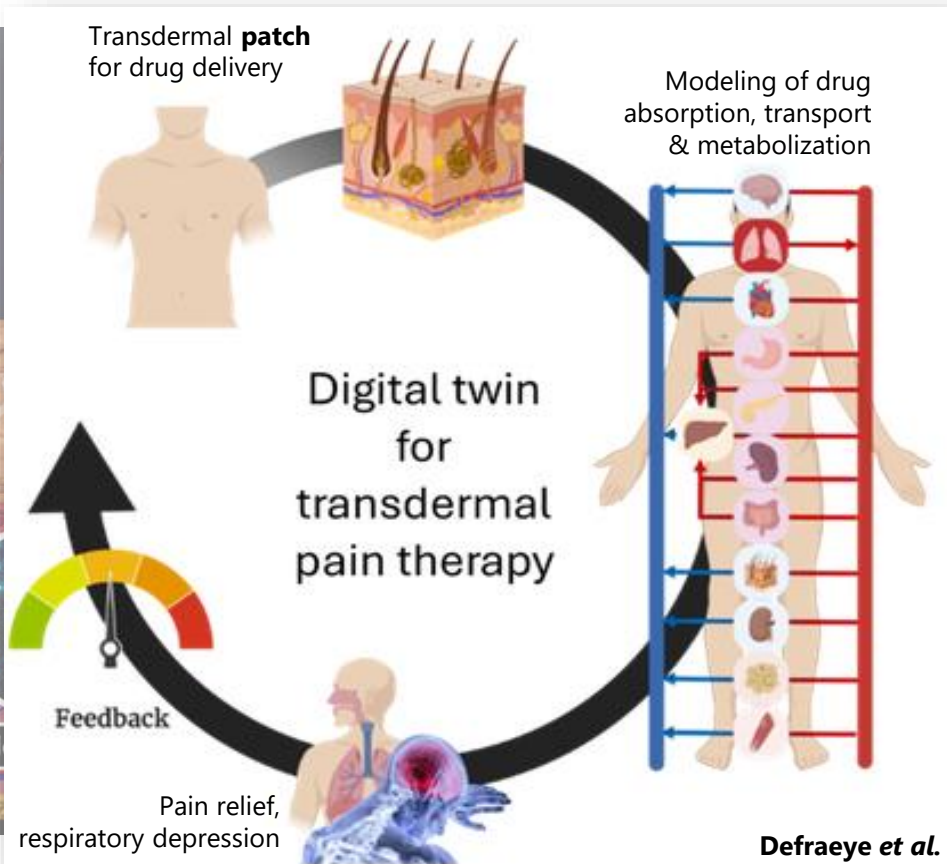
- Pain, discomfort
- Increased mortality risks
- Up to 4% of healthcare expenses

Need for

- individualized treatments
- Understanding, monitoring and modeling beyond simple parameters (pH, temperature)

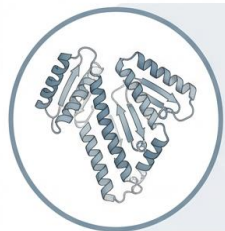
Chronic Wounds (CW)

Integrated Wound Management Initiative

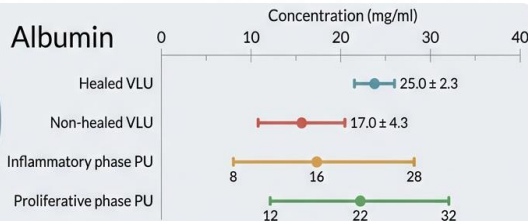


Chronic Wounds (CW)

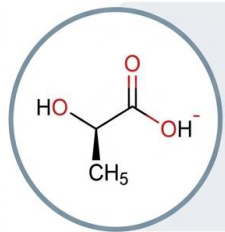
Integrated Wound Management Initiative



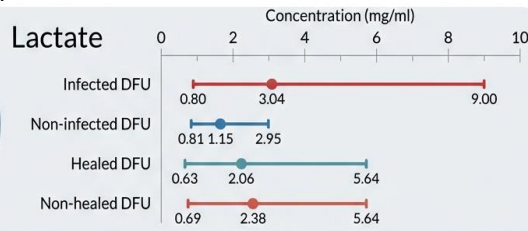
Albumin



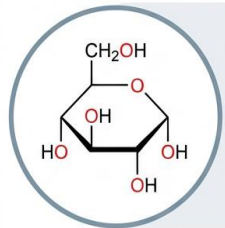
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DOI:10.1111/j.1524-475x.2009.00564.x



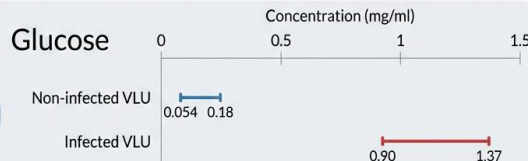
Lactate



DOI: 10.1111/j.1464-5491.2010.03123.



Glucose



Dimitrievska, Guo *et al.*

DOI: org/10.1111/j.1524-475x.2009.00564.x

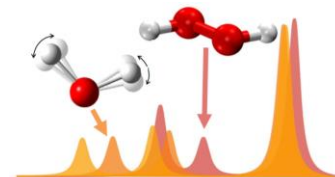
Platform 2

Self-Care Wearables

- **Real-time tracking of multiple biomarkers** with spatiotemporal detection system
- **Dynamic response to CW evolution** via adaptive, multifunctional composites
- **On-demand active delivery system** for precise, spatiotemporal, feedback-controlled therapeutic release

Dr. Luciano Boesel, Prof. Dr. René Rossi *et al.*

Time and spatially-resolved Raman fingerprinting

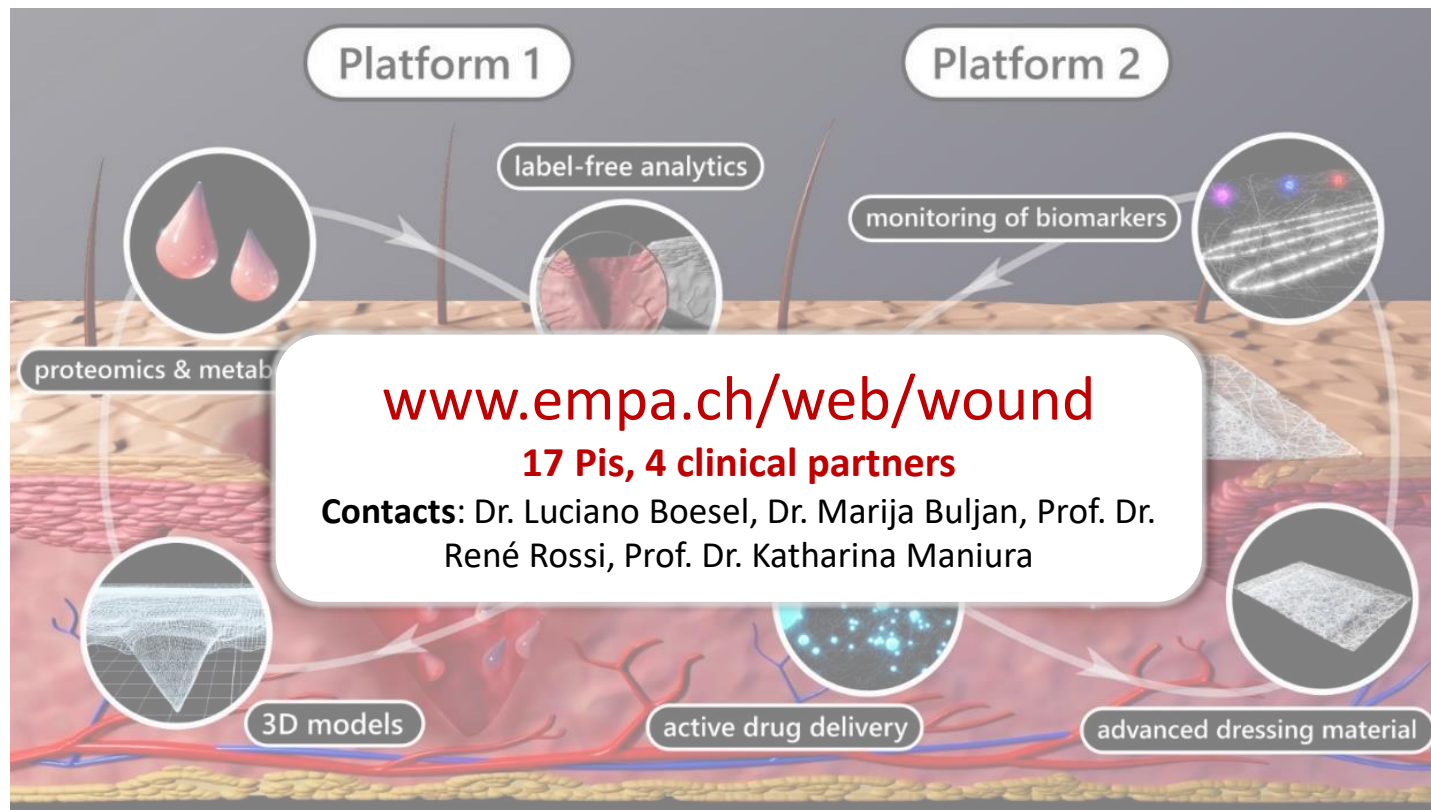


drug delivery

advanced dressing material

Chronic Wounds (CW)

Integrated Wound Management Initiative



Clinical Validation

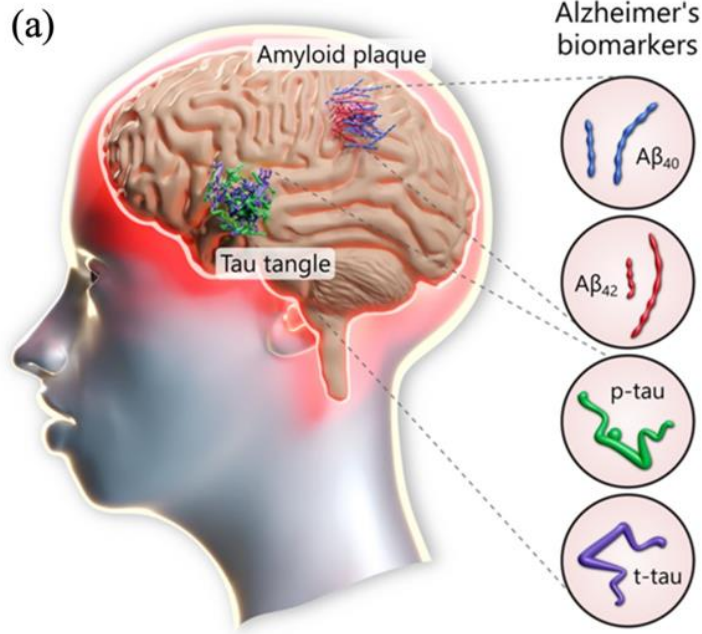
- Collection of **wound exudates** for P1 and P2
- **Pilot study** to validate both platforms

Prof. Dr. Jürg Hafner *et al.* (USZ),
Prof. Dr. Antonio Cozzio *et al.* (KSSG)



Dementia

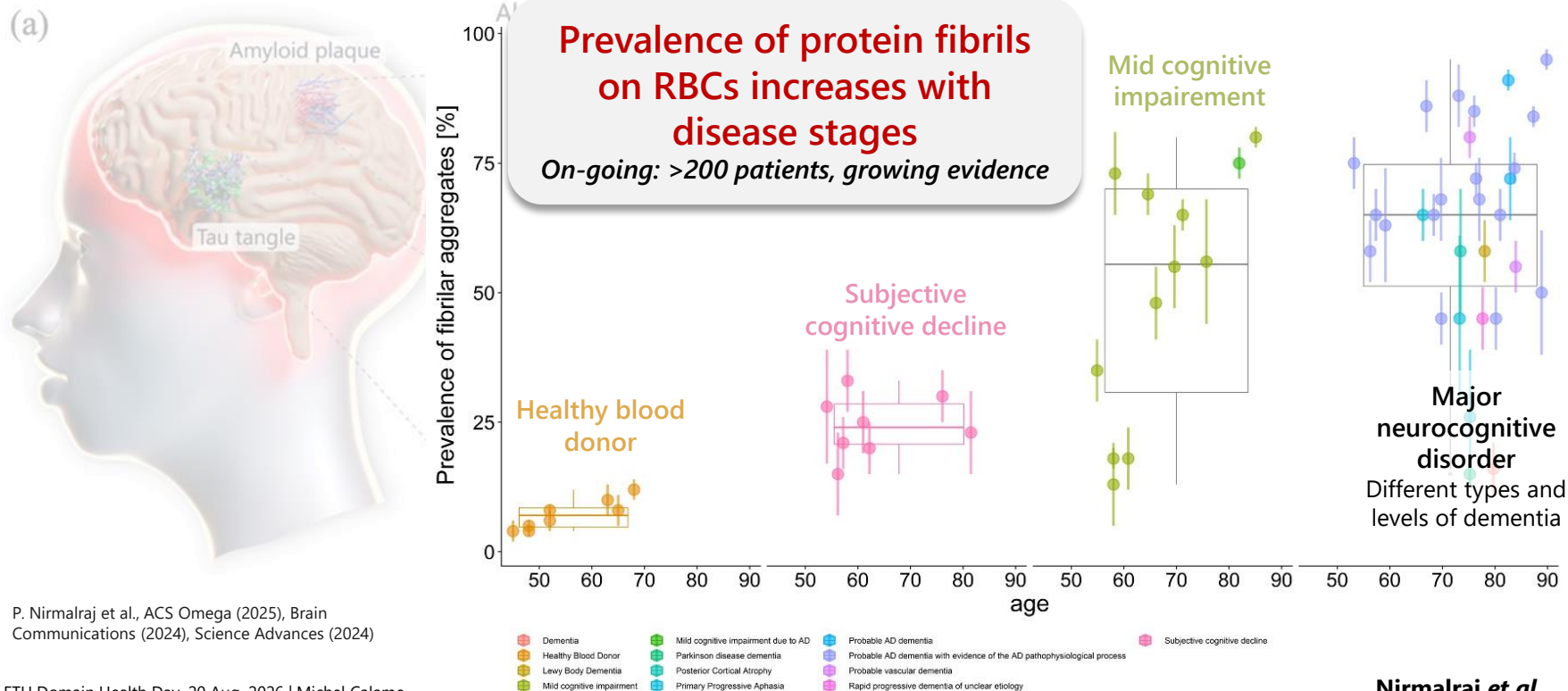
Multimodal Analytics in Dementia Diagnosis



AFM imaging: size, shape & **prevalence of pathological proteins on surface of RBCs** and in spinal fluid

Dementia

Multimodal Analytics in Dementia Diagnosis



P. Nirmalraj et al., ACS Omega (2025), Brain Communications (2024), Science Advances (2024)

Dementia

Multimodal Analytics in Dementia Diagnosis



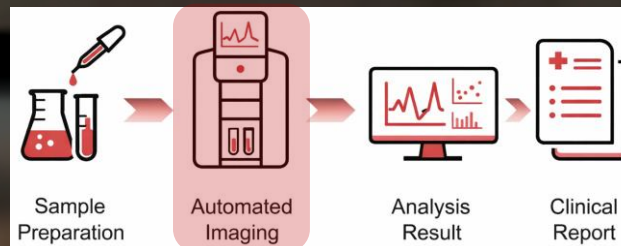
1. NANOSCALE IMAGING



AFM / Nanoscale microscopy
Visualizes protein aggregates
(amyloid, tau) at nanoscale



AFM Automation to meet clinical needs



Clinical Readiness Level scale ?

Dementia

Multimodal Analytics in Dementia Diagnosis

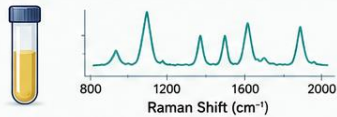


1. NANOSCALE IMAGING



AFM / Nanoscale microscopy
Visualizes protein aggregates (amyloid, tau) at nanoscale

2. CHEMICAL SPECTROSCOPY



Raman / IR / Mass Spectroscopy
Identifies molecular signatures in biofluids (blood, CSF, saliva)

3. WEARABLES & DIGITAL BIOMARKERS



- Activity & Mobility
- Sleep Patterns
- Cognitive Performance

Continuous, real-world data on behavior, sleep, activity & cognition

Molecular scale analytics + behavioral & cognitive performance



Annaheim *et al.*

Tailored wearables, software

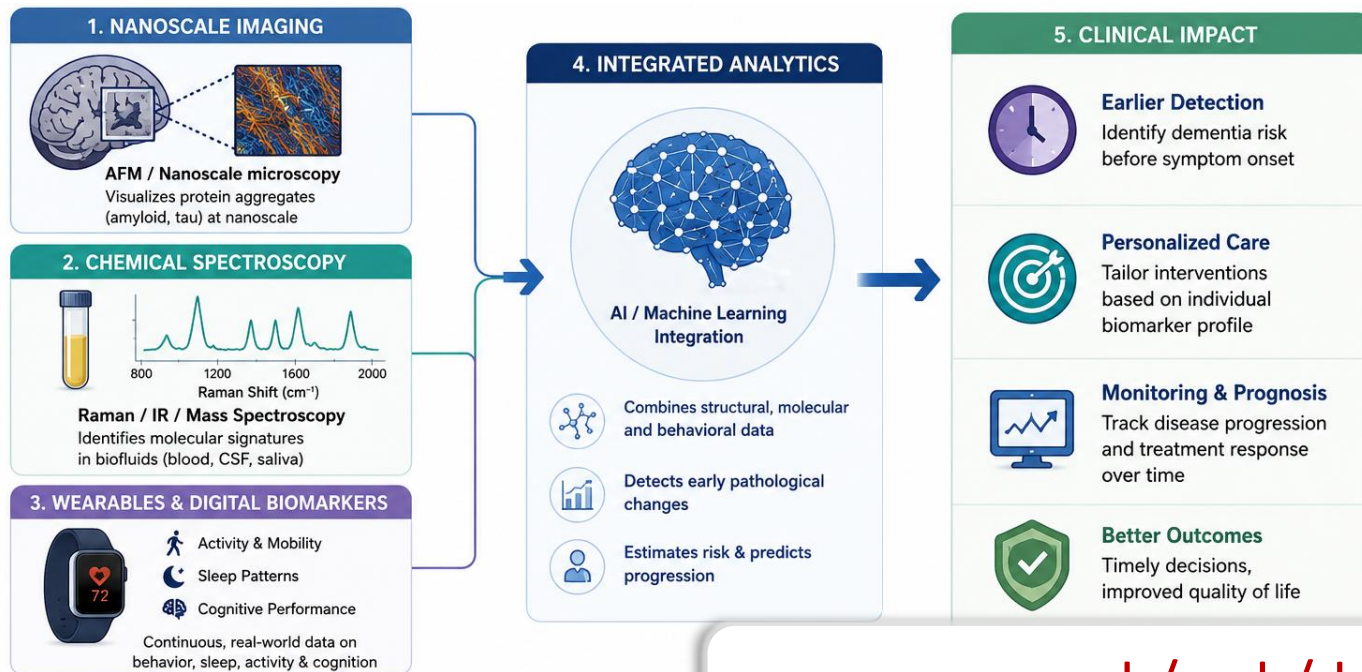
NB: broader applicability (e.g.: extreme conditions)



Gartmann, Kupferschmid, Scheidegger *et al.*

Dementia

Multimodal Analytics in Dementia Diagnosis



University Hospital
Zurich

hoch Health
Ostschweiz

INSELSPITAL
UNIVERSITÄTSSPITAL BERN
HÔPITAL UNIVERSITAIRE DE BERNE

www.empa.ch/web/dementia

Contacts: Dr. Peter Nirmalraj, Dr. Simon Annaheim

Human Health @ Empa



Schweizer
Paraplegiker
Zentrum

Balgrist

Universitätsklinik



hoch Health
Ostschweiz

HUG Hôpitaux
Universitaires
Genève

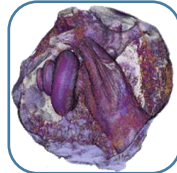
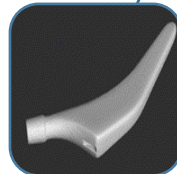
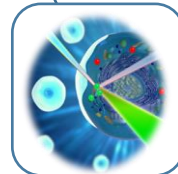
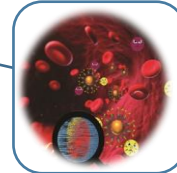
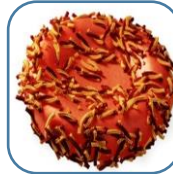


University Hospital
Zurich



Universität
Zürich

Hospital
network



UNIVERSITÄTS-
KINDERSPITAL
ZÜRICH

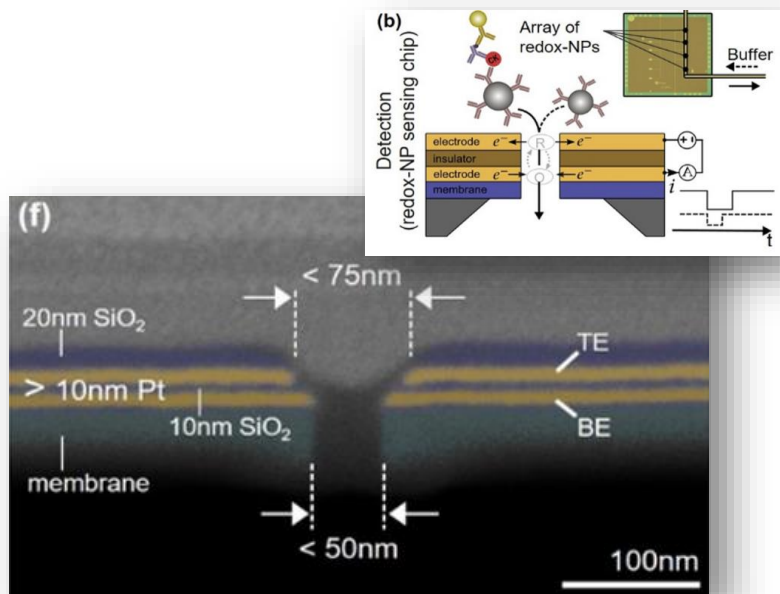
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UNIVERSITÄT
BERN

KSW
KANTONSPITAL WINTERTHUR

HIRSLANDEN

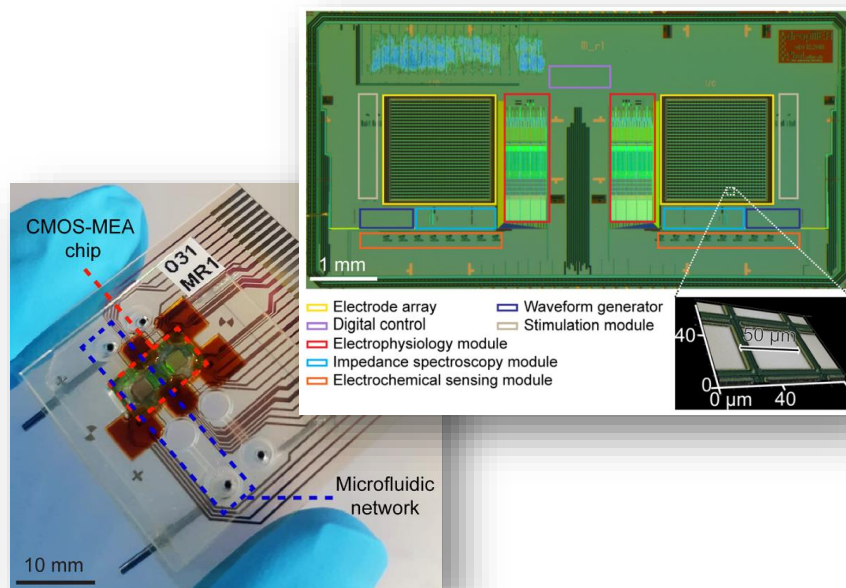
Engineering solutions to improve healthcare



Nanopore devices for single-molecule analytics

For e.g.: DNA translocation, protein analytics

Mermoud, M.C. *et al.*, Empa & OST



Integration of CMOS microelectrode array in a microfluidic system

For e.g.: electrophysiology, impedance spectroscopy, electrochemical sensing.

Hierlemann *et al.*, Lab. Chip (2025)

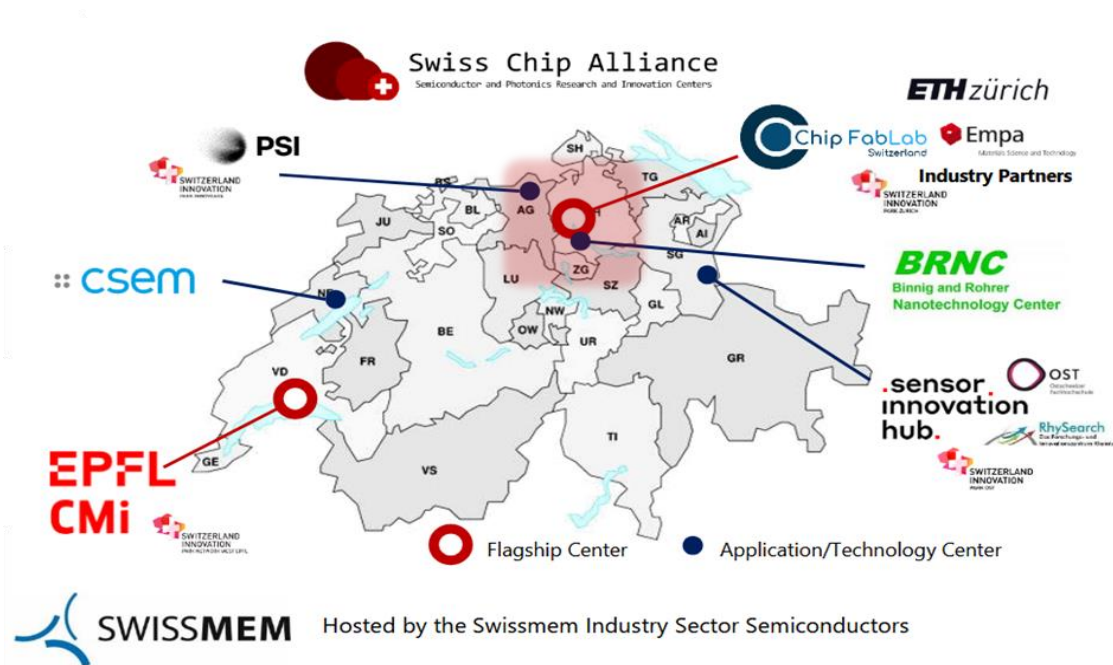
Engineering solutions to improve healthcare



... require

state-of-the-art
nanofabrication
facilities

with research & industrial
capabilities



Empa – The Place where Innovation Starts

www.empa.ch/health

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Thank you

