



Short Review of the Last Two Years of Magnetic Carriers (2024-2026)

Urs Häfeli



urs.hafeli@ubc.ca

This is Already the 30th Year of Our Meetings !



*Rostock 1996, Cleveland 1998, Rostock 2000, Tallahassee 2002, Lyon 2004,
Krems 2006, Vancouver 2008, Rostock 2010, Minneapolis 2012, Dresden 2014, Vancouver 2016,
Copenhagen 2018, London 2022, Barcelona 2024, Paris 2026*

First Names – Please

Sie **Vd** **Vous**
Du **You**

First Names – Please

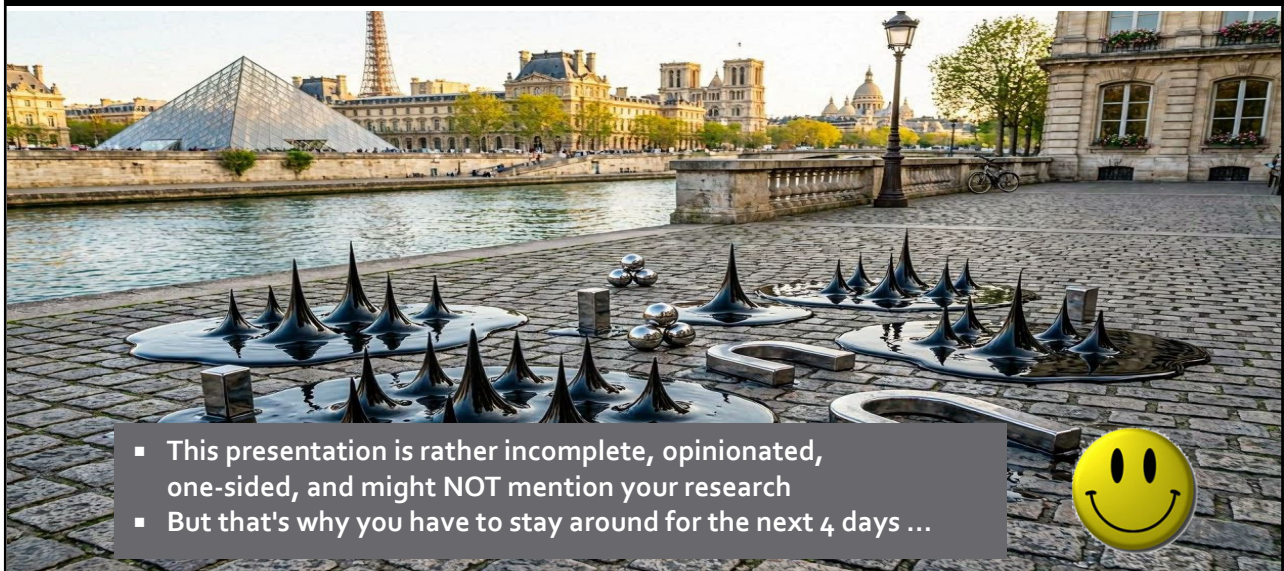


Just: You!

Thank You



DISCLAIMER



- This presentation is rather incomplete, opinionated, one-sided, and might NOT mention your research
- But that's why you have to stay around for the next 4 days ...

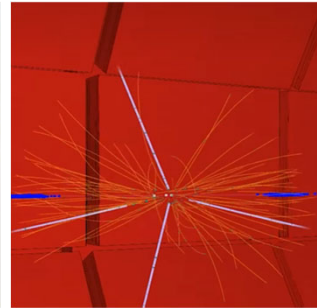
Magnets

Magnets in Quebec City



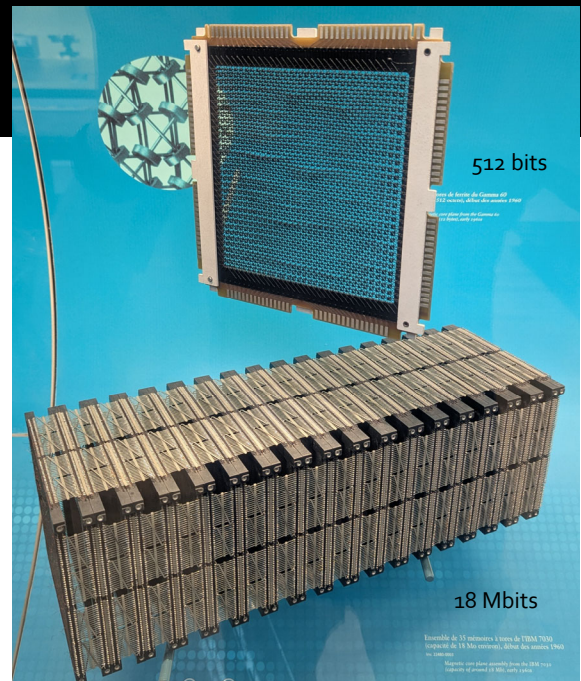
Large Hadron Collider at CERN (in Geneva) to go High Luminosity

- Switch off on June 29, 2026
- 4 Years later, the Hilumi HL-LHC will restart
- **Difference:** Stronger Magnets operating at 1.9 K, giving 10x brighter signal and 10x more data



First Magnetic Memory

- Go and see it for yourself at the **Musée des Arts et Métiers, Paris**
- Magnetic core plain from the gamma 60 (early 1960's)



Also from the Museum ...

- Large natural magnet, late 18th century

And by the way, on Fridays from 18:00 – 21:00, there is free access to the museum
- Very interesting for science geeks!



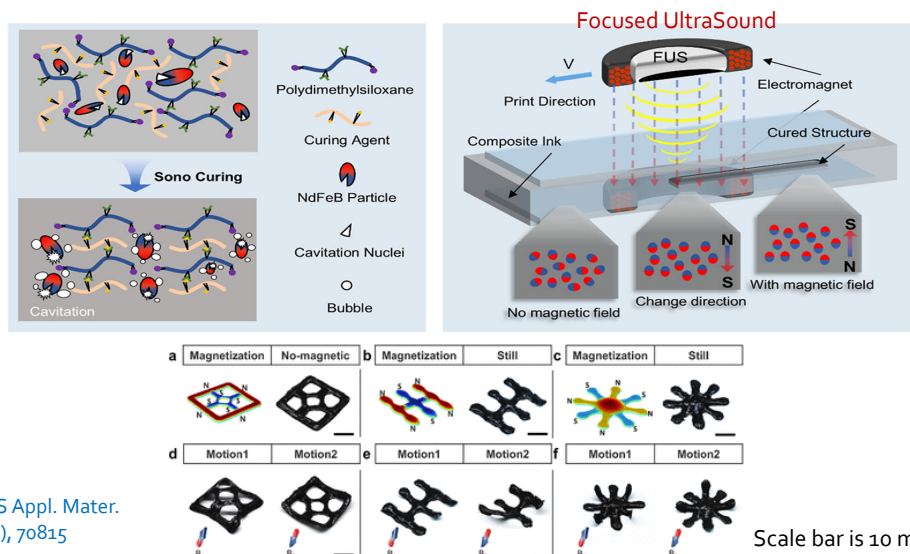
Magnets in Electric Cars

- One of the big applications is the use of NdFeB magnets for car motors
- Also: Electromagnetic damping
 - However, new EVs use purely electric linear actuators



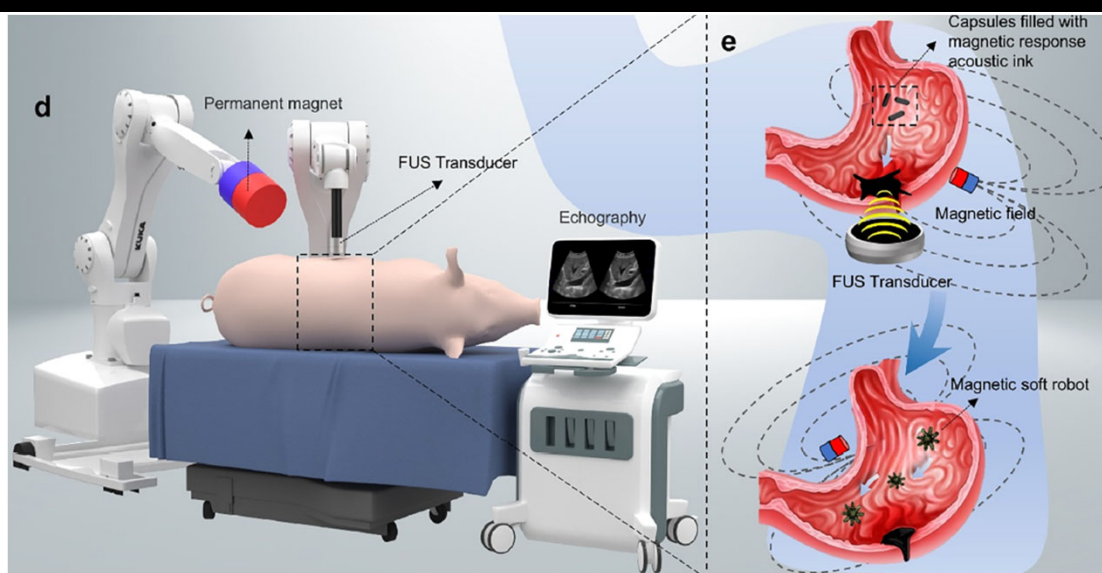
Watch it here: https://youtu.be/HFbvsrSoJ2w?si=cMv7P_4LdvO_GJEp

Magnetic Programming-Assisted Ultrasonic Printing To Prepare Magnetic Soft Robots



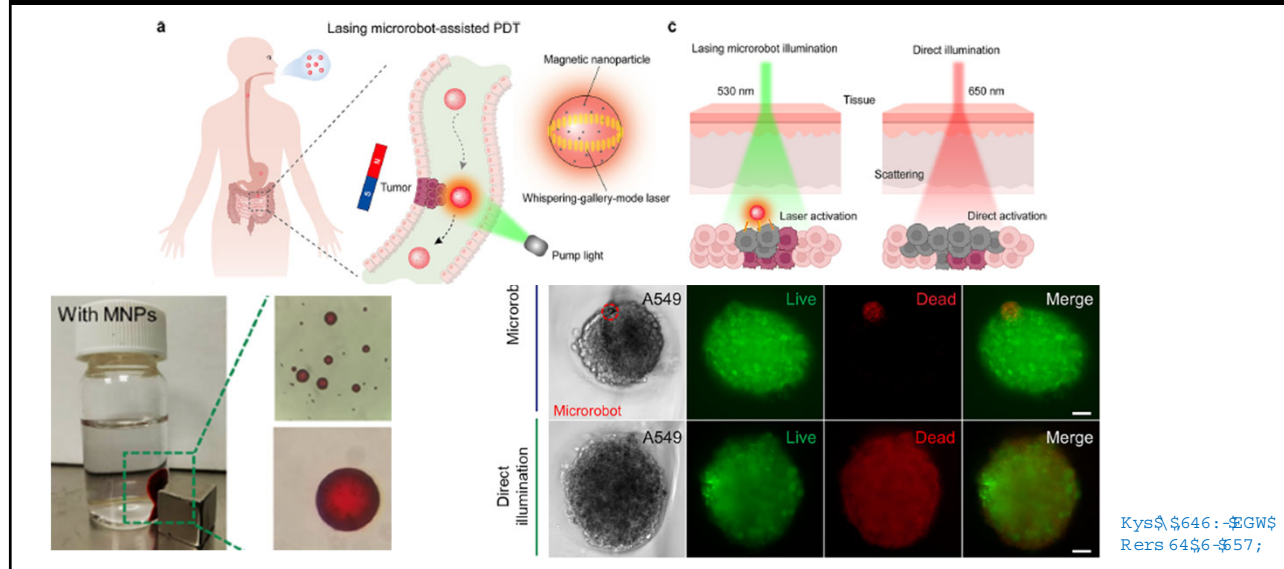
Sun C (2025) ACS Appl. Mater. Interfaces 17 (52), 70815

Magnetic Programming-Assisted Ultrasonic Printing To Prepare Magnetic Soft Robots

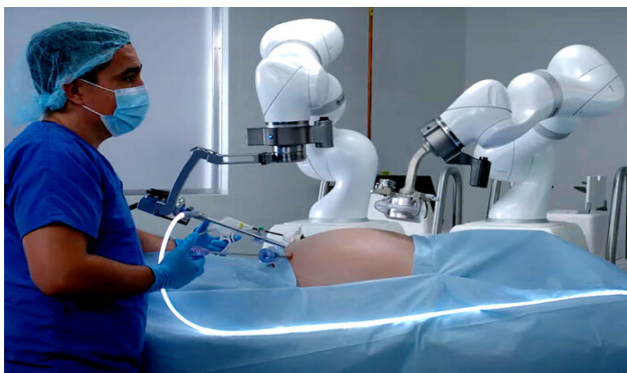


Sun C (2025) ACS Appl. Mater. Interfaces 17 (52), 70815

Magnetic Microrobots for Precise Photodynamic Therapy



New FDA-Approved Levita MARS System Allows for AI-Supported Gallbladder Surgery



- The **Levita Magnetics MARS** (magnetic-assisted robotic surgery) system uses magnetic forces to control a grasper instrument inside a patient
- Developed by surgeon Dr. Alberto Rodriguez-Navarro, head quartered in Silicon Valley, first tested in Chile
- FDA cleared on June 18, 2025
- <https://www.massdevice.com/levita-magnetics-mss-pediatric-clearance-cleveland-clinic-childrens/>



New FDA-Approved Levita MARS System Allows for AI-Supported Gallbladder Surgery



Magnetic Particle Imaging (MPI)

"Hiobs Botschaft" About MPI Hardware

- **Magnetic Insight** went bankrupt in November 2025
 - Shutdown or **Assignment for the Benefit of Creditors (ABC)** — a common California alternative to formal bankruptcy
 - Sold all their headquarters assets
- **Bruker** stopped doing MPI in March 2026
 - Service of equipment will end in Dec 2026
 - Sales of systems have ended

The commercial market for MPI is currently in a "deep freeze."

MPI Meeting in Beijing, China



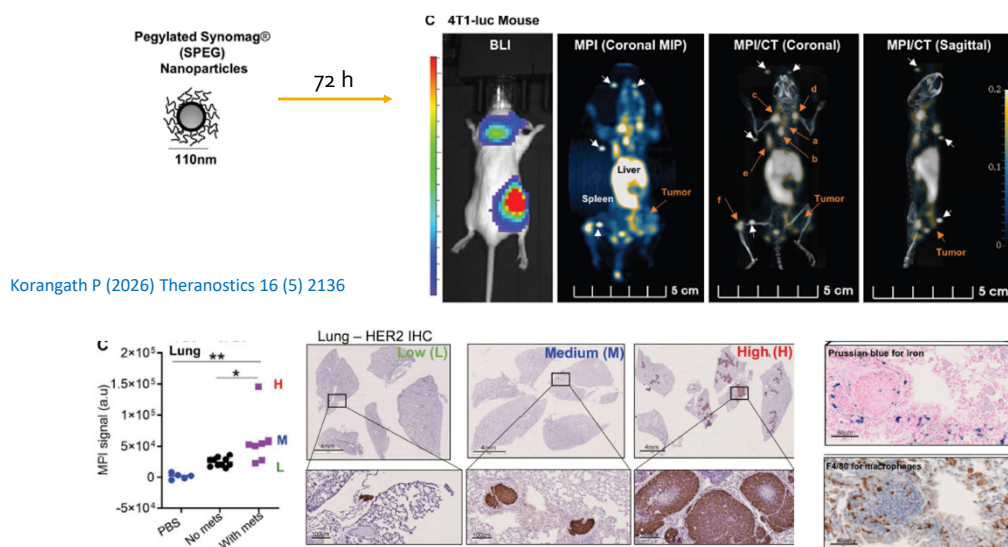
IWMPI 2026

MPI Equipment: What is Next?

- Collaboration of Bruker with Fraunhofer IMTE is currently being discussed - development will go on
- Bruker announced before the “bad message” a new MPI/CT instrument with a hyperthermia option – it will be developed!
- Smaller companies will still allow for ongoing MPI developments with their benchtop systems



MPI Makes Non-Invasive Detection of Metastases Possible



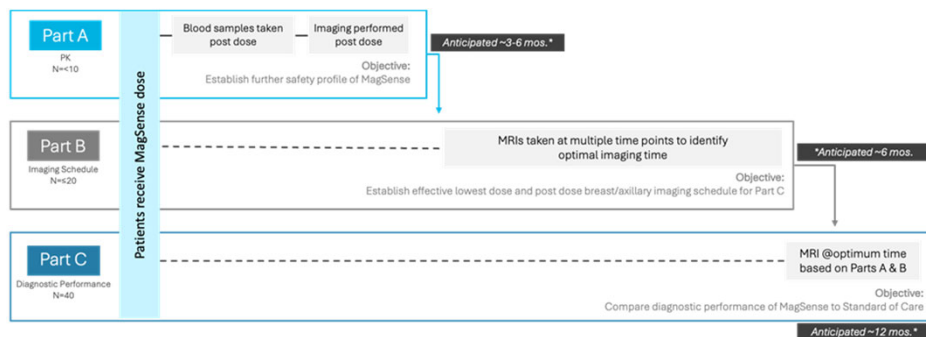
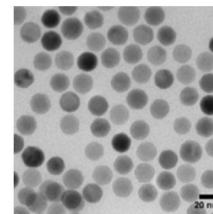
Magnetic Resonance Imaging (MRI)

MRI Imaging of Molecular HER-2 MNPs - Planned Phase II Trial

- Imagion Biosystems has submitted its Investigational New Drug (IND) application for the MagSense® HER2 Imaging Agent (MSH2IA) to the U.S. Food and Drug Administration (FDA)
- MagSense® HER2 Imaging Agent Phase II Clinical Study – IBI010105

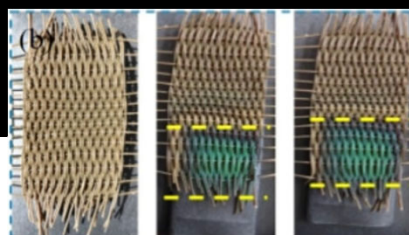
IMAGION
BIOSYSTEMS

PrecisionMRX
NANOPARTICLES

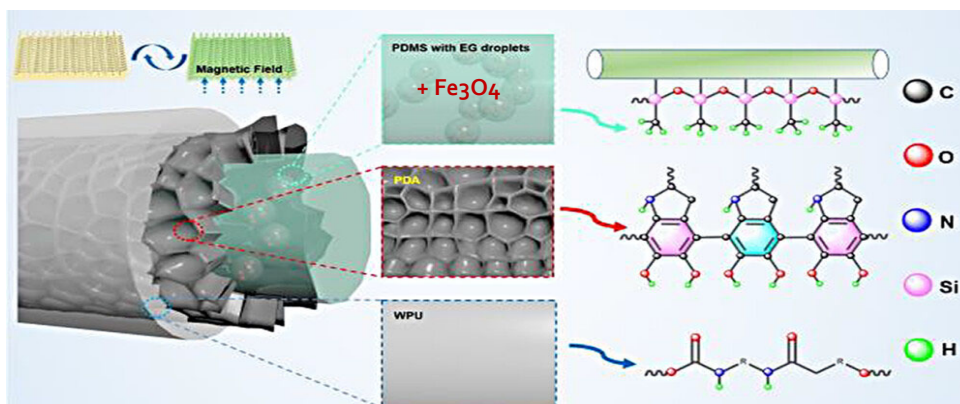


Technical Applications

Textiles That Change Colour

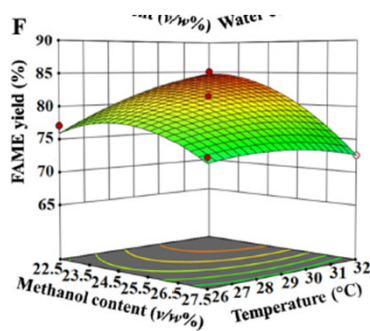
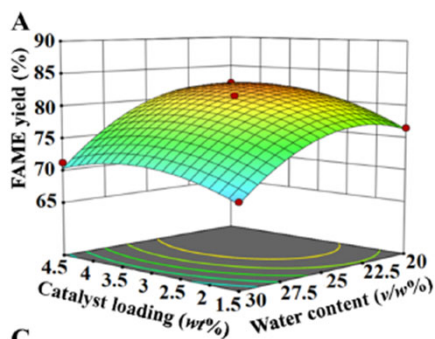


^link\$6468-\$
EGW\$Ett\$Q exiv\$
MxdivjegiW\$:\$
95;8<



Biodiesel Production from Waste Cooking Oil Using Magnetic E. Coli Microspheres

- Magnetic chitosan microspheres encapsulated recombinant E. Coli that produce MAS1 Lipase
- Waste cooking oil is turned into fatty acid methyl esters (FAME)
- Encapsulated cells stayed active for a long time, unlike the straight E. Coli suspension



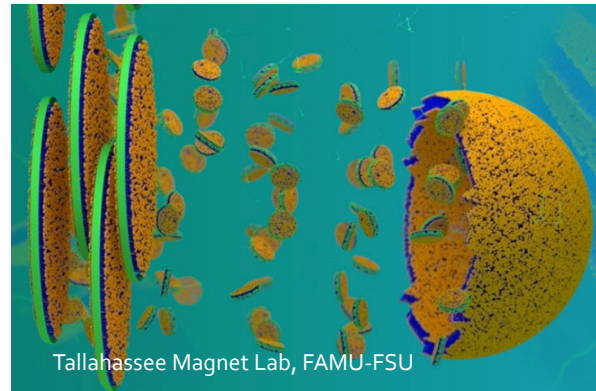
Zhao Z (2024) Molecules 29, 3469

Synthesis

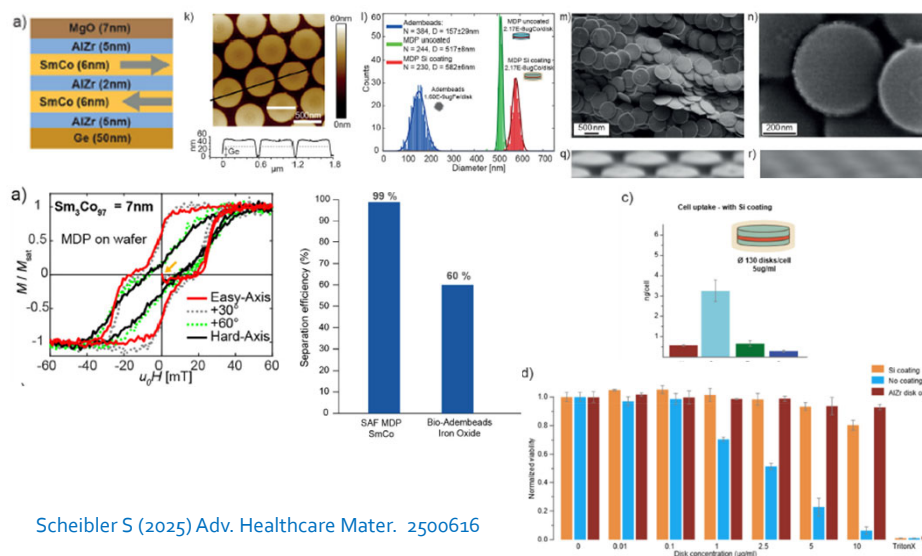
A Promising Biomedical Tool – Lipid Nanodiscs

- Research into membrane-bound proteins is difficult
- Lipid nanodiscs might provide a platform for this research by adding a stable environment
- Not magnetic yet, but might add functionality!

<https://nationalmaglab.org/news-events/news/maglab-hosts-lipid-nanodiscs-symposium/>

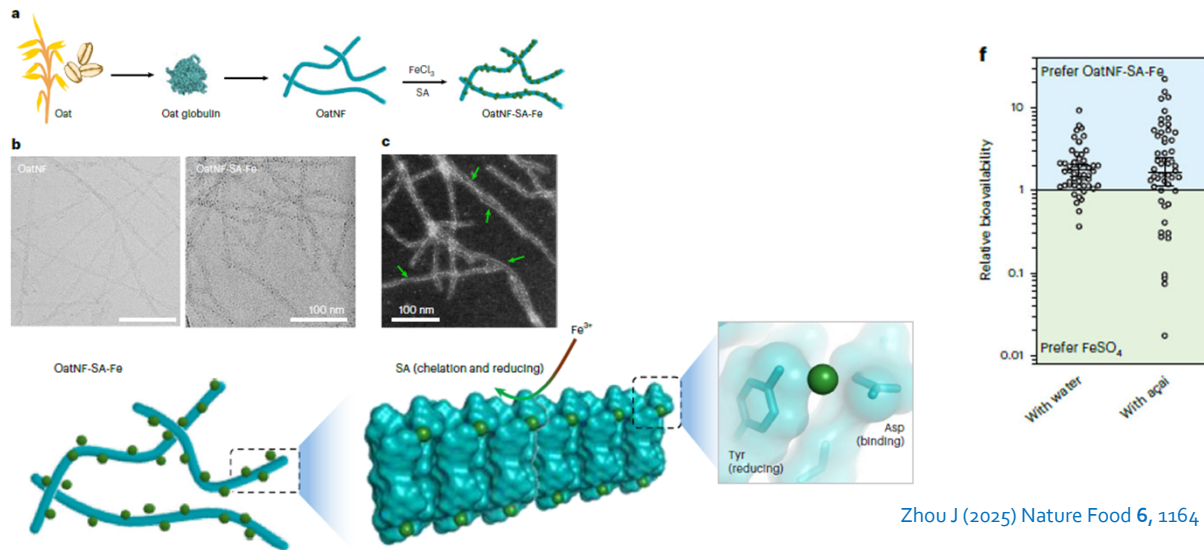


Antiferromagnetic Designer Nanodisks for High-Performance Magnetic Separation

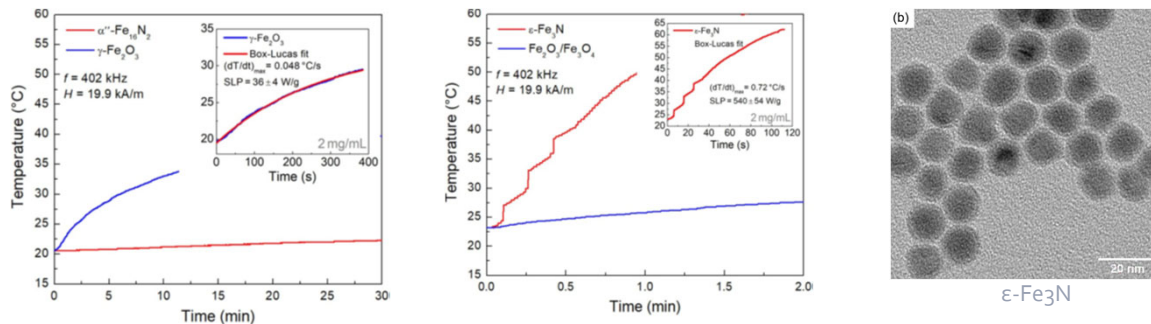


Scheibler S (2025) Adv. Healthcare Mater. 2500616

Oat Protein Nanofibril–Iron Hybrids for Vegans



Iron Nitride Nanoparticles for Magnetic Hyperthermia

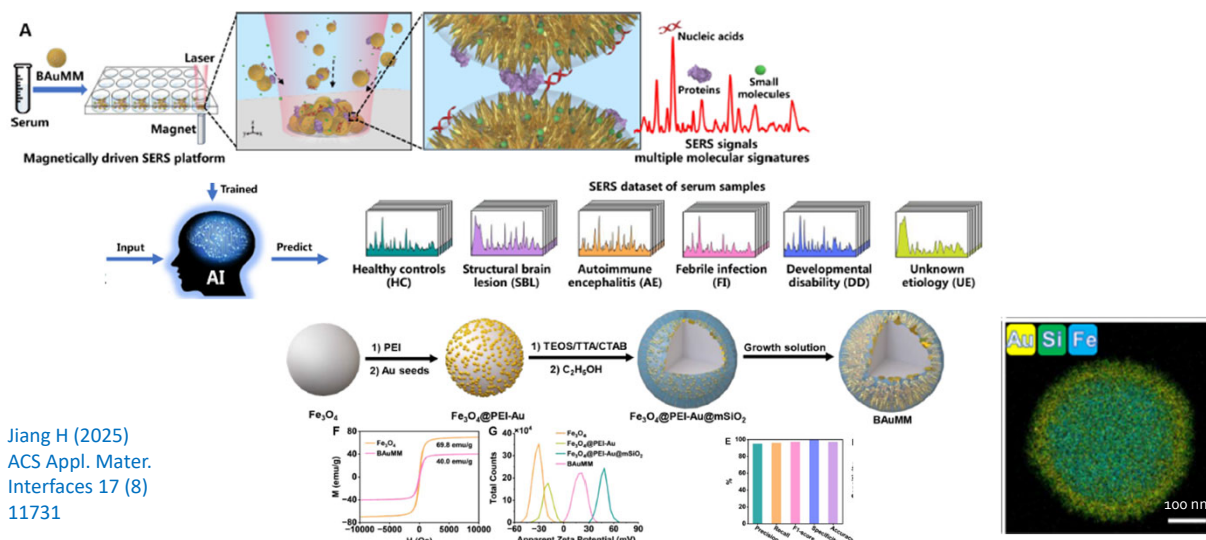


- Starting from theoretical basis hyperthermia effects calculations are useful
- Effects of lower anisotropy are discussed
- $\alpha''\text{-Fe}_{16}\text{N}_2$ are not useful for hyperthermia, but $\epsilon\text{-Fe}_3\text{N}$ MNPs are promising and biocompatible

Dirba I (2023) J Phys D: Appl Phys 56, 025001

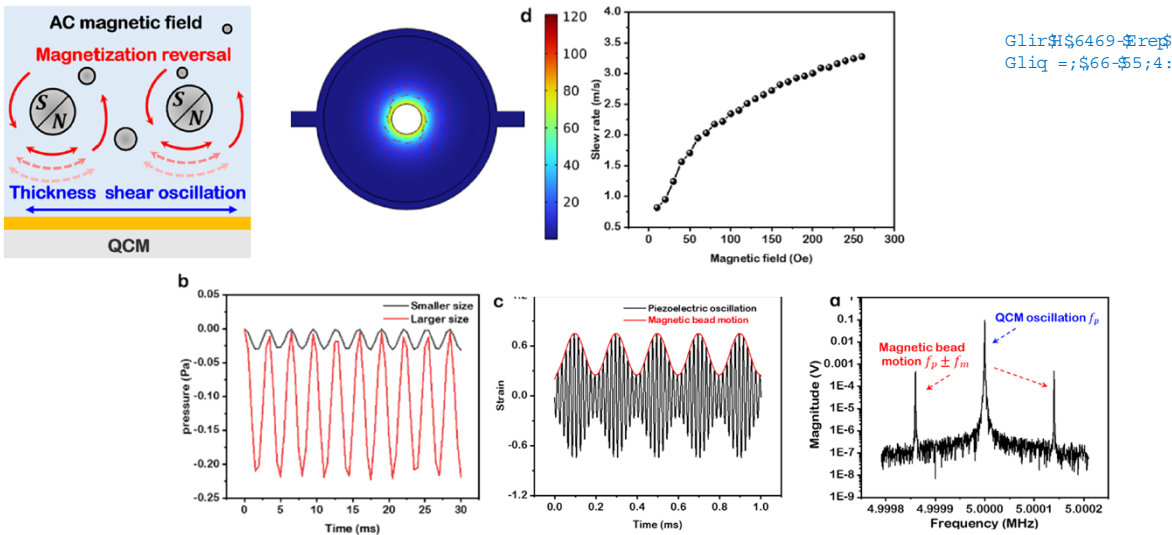
Assays and Diagnostics

Diagnosis and Etiological Differentiation of Childhood Epilepsy Using SERS



Jiang H (2025)
ACS Appl. Mater.
Interfaces 17 (8)
11731

QCM (Quartz Crystal Microbalance) Sensing of Magnetic Particles Motion



QCM (Quartz Crystal Microbalance) Sensing of Magnetic Particles Motion

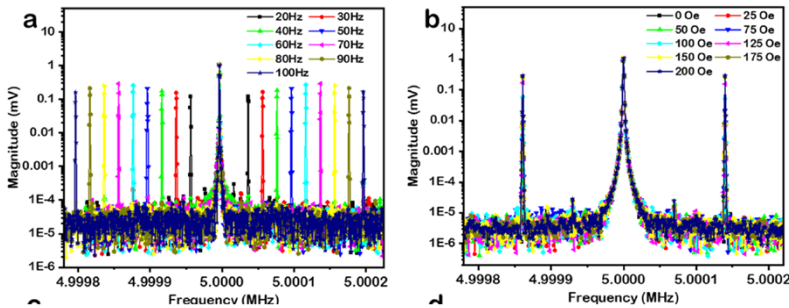


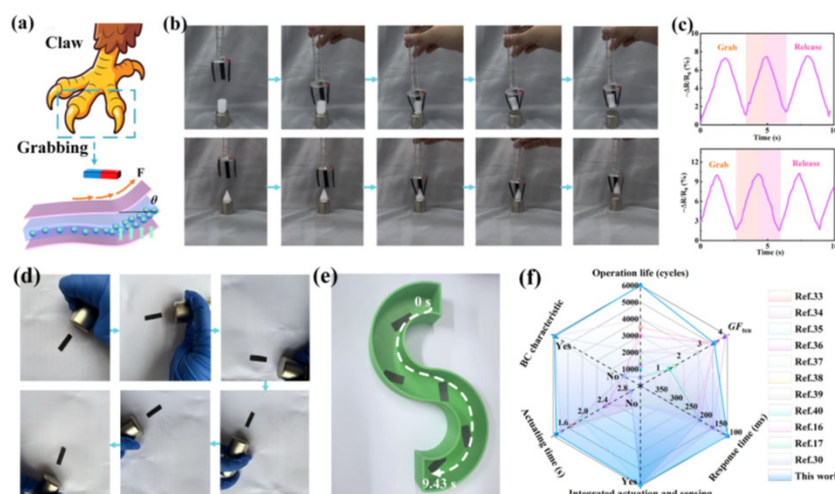
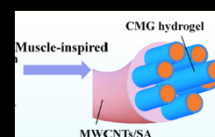
Table 1. Comparative Analysis of Optical, Electromagnetic, and QCM-Based Dynamic Sensing Methods

sensing method	working principle	sensitivity (typical)	spatial resolution	suitability in complex biological environments	refs
optical detection	light-based particle tracking	single particle	$\sim 0.2\text{--}1\text{ }\mu\text{m}$ (confocal/microscopy)	poor	29
electrochemical detection	redox reaction/impedance sensing	nano- to micromolar	electrode-localized	moderate (affected by fouling)	30
electromagnetic detection	inductive or impedance signal detection	pico- to nanoscale	$\sim 10\text{--}100\text{ }\mu\text{m}$ (depends on coil size)	moderate	31
QCM-based detection	shear stress modulation sensing	$\sim \text{ng}/\text{cm}^2$	area-averaged ($\sim 100\text{ }\mu\text{m}$ level across QCM surface)	excellent	this work

Glir#6469-#rep\$
Gliq = ;\$66-#5;4:

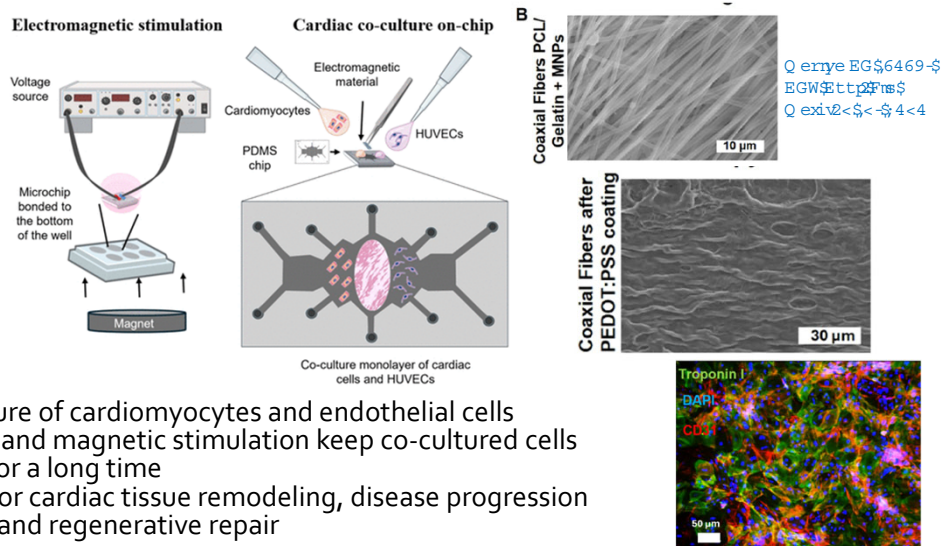
Biological Applications

Muscle-Inspired Hydrogels

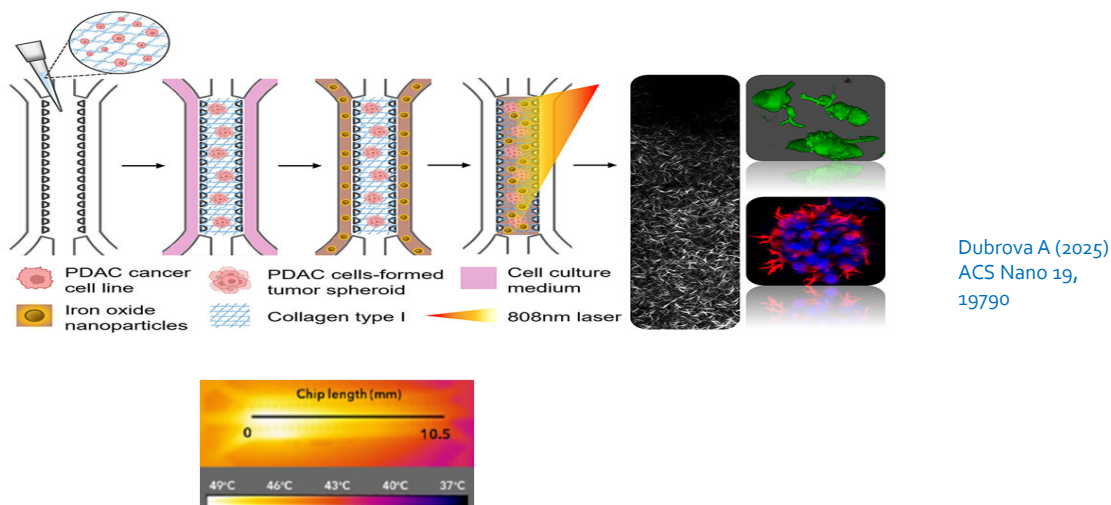


Fu Y (2026) Colloids and Surfaces B: Biointerfaces 265 (2026) 115781

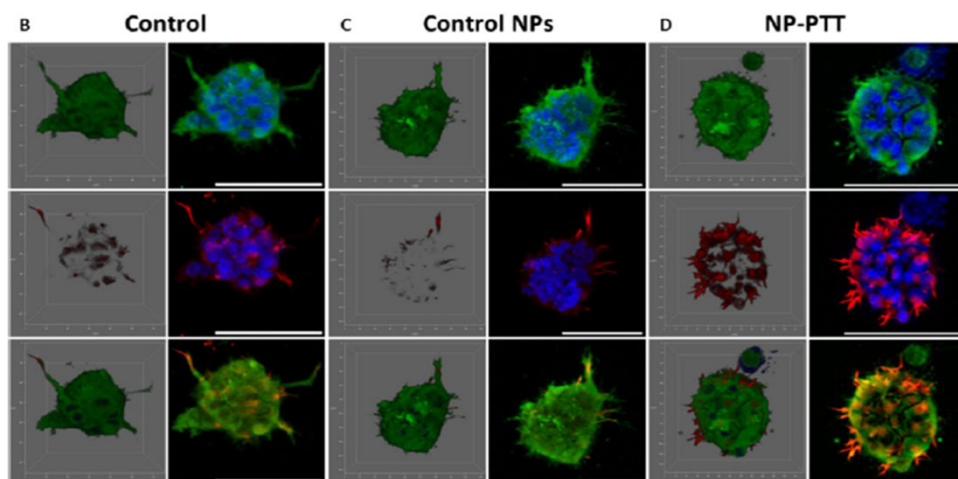
Heart on a Chip



Photothermal Therapy with MNPs on Pancreatic Tumour-on-Chip

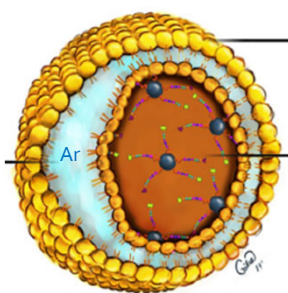


Photothermal Therapy with MNPs on Pancreatic Tumour-on-Chip



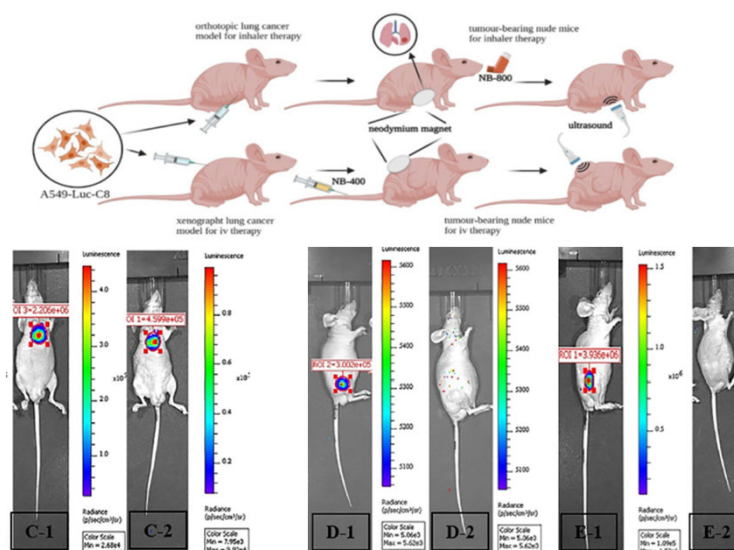
Dubrova A (2025)
ACS Nano 19,
19790

Magnetic Lipid Nanobubbles



Drug combination:
pemetrexed and pazopanib

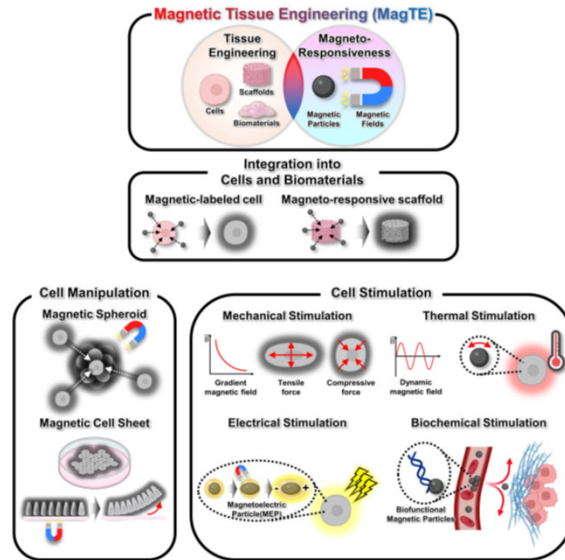
Al G (2025) J Liposome
Res 35 (4) 522



Nice Review About Magnetic-Based Tissue Engineering and Biofabrication

- Advantages:
 - Controlled release of drugs and even extracellular vesicles
 - Simplified biofabrication of many tissues
- Challenges:
 - Long-term biocompatibility
 - Attenuation of mag force and torque with distance

Choi H (2025) Biomater. Sci. 13, 6215

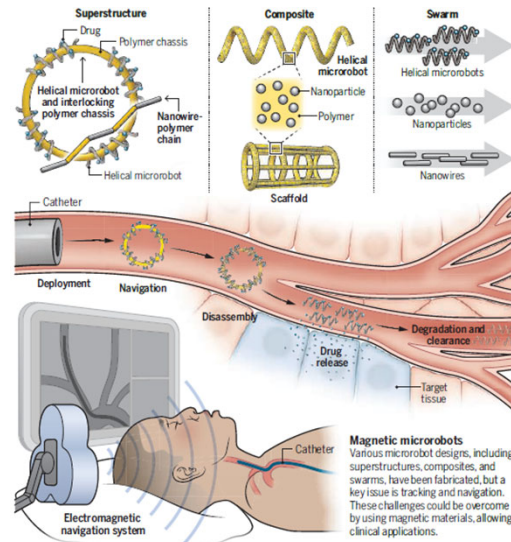


Medical Applications

Use of Microrobots for Therapy

- Delivery of a magnetic carrier through a catheter
- Guidance with magnetic fields
- Drug release and therapy
- Degradation of carriers and clearance

Nelson B & Pané S (2023)
Science 392. 1121



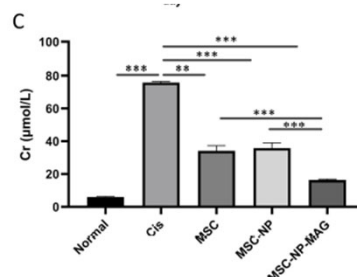
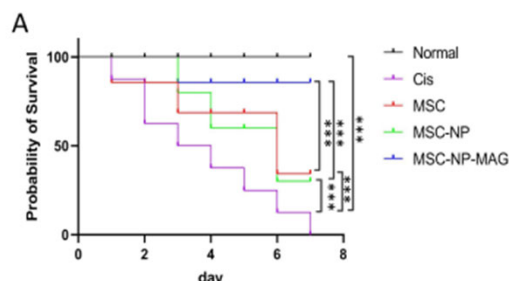
Theranostic Platform to Dissolve Thrombus



Landers F (2025) Science 390 (6774) 710

Treatment of Cisplatin-Induced Acute Kidney Injury

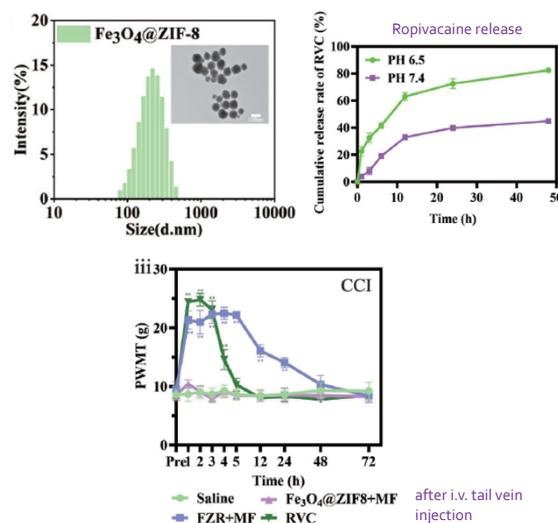
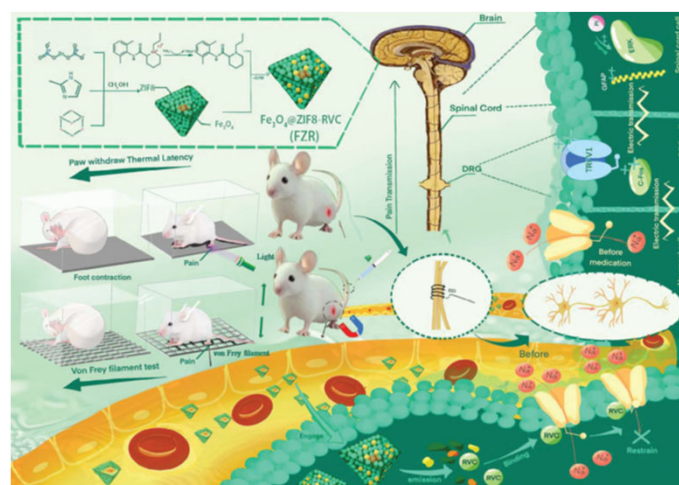
- Placental-derived mesenchymal **stem cells (MSC)** were labeled with **MNPs** and coated with polydopamine
- Mice with cisplatin-induced acute kidney injury received these magnetic particles or non-magnetic ones – magnetic targeting or non-targeting to the kidneys was also tested



- Magnetic targeting improved results for all indicators

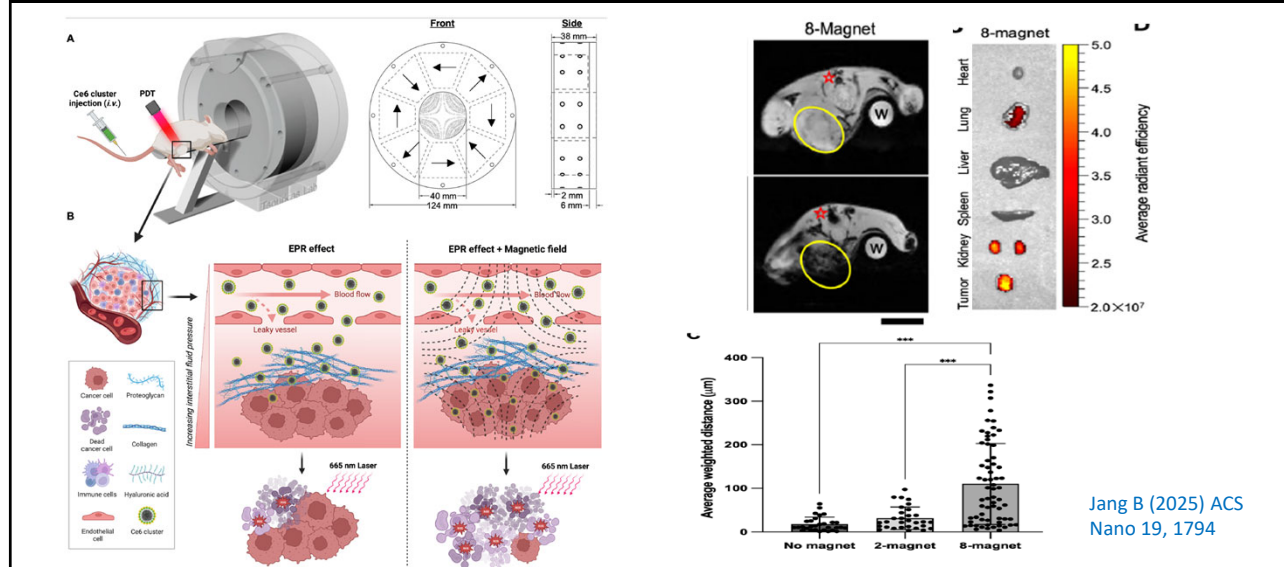
Wang (2025) Int J Nanomed 20, 11435

Precision-Guided Sustained Back Pain Relief



Li H (2025) Small 2025, 2410874

Drive MNPs With Halbach Magnet Into Tumors for Improved Cancer Therapy

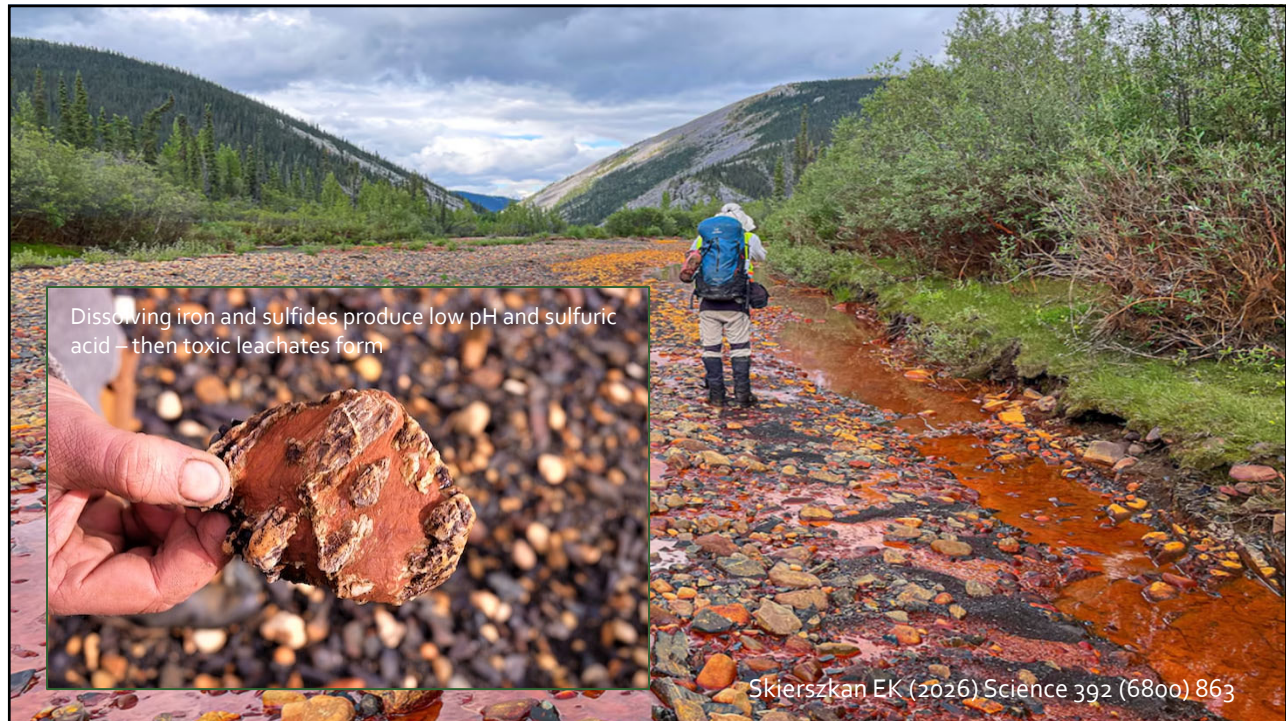


Other Maybe Related Things



Yukon's Rusty River







Mildred Thompson



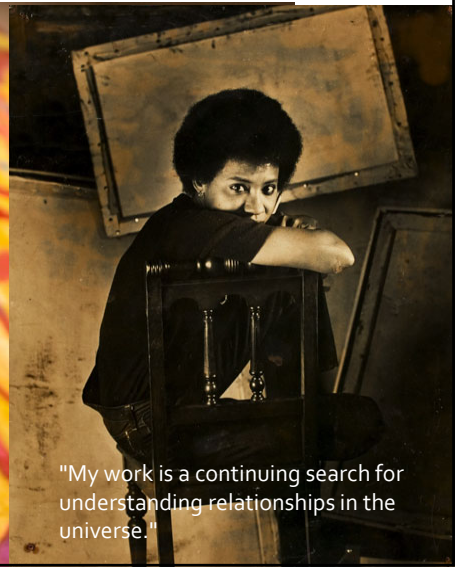
Wood Pictures (1961)

Mildred Thompson (1936-2003)



Magnetic fields, 1991
Cummer Museum of Art and Gardens, Jacksonville, FL

Mildred Thompson (1936-2003)



"My work is a continuing search for understanding relationships in the universe."

Mildred Thompson (1936-2003)



Music of the Spheres: Mars, 1996

Mildred Thompson (1936-2003)



There is Much More



... from your colleagues during the next few days here at the meeting !

<http://www.magneticmicrosphere.com>

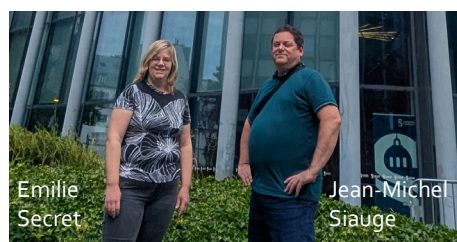
Thank You

- Participants / Reviewers
- Your local organizers & students
- Exhibitors / Sponsors



Thank You

- Especially the local organizers
- And the good "old" support team



Emilie
Secret

Jean-Michel
Siauge



Maciej

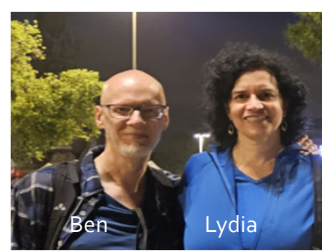


Wolfgang

Cordula



Thompson



Ben

Lydia