
UNIVERSITY OF TWENTE. | TECHMED CENTRE
THE TECHMED EVENT | SHAPING A HEALTHY FUTURE
13:15-14:30 | ORGAN-ON-A-CHIP: BETTER DESIGNS, BETTER HEALTH| MARCEL KARPERIEN & LAURENS SPOELSTRA

JOINT ON CHIP TECHNOLOGY: A NEW ERA IN STUDYING RHEUMATIC DISORDERS

Prof. Dr. **Marcel Karperien - TNW-DBE**

DISCLOSURE SLIDE

Founder and stockholder Hy2Care B.V.

Founder and stockholder Orthros Medical B.V.

Founder and stockholder LipoCoat B.V.

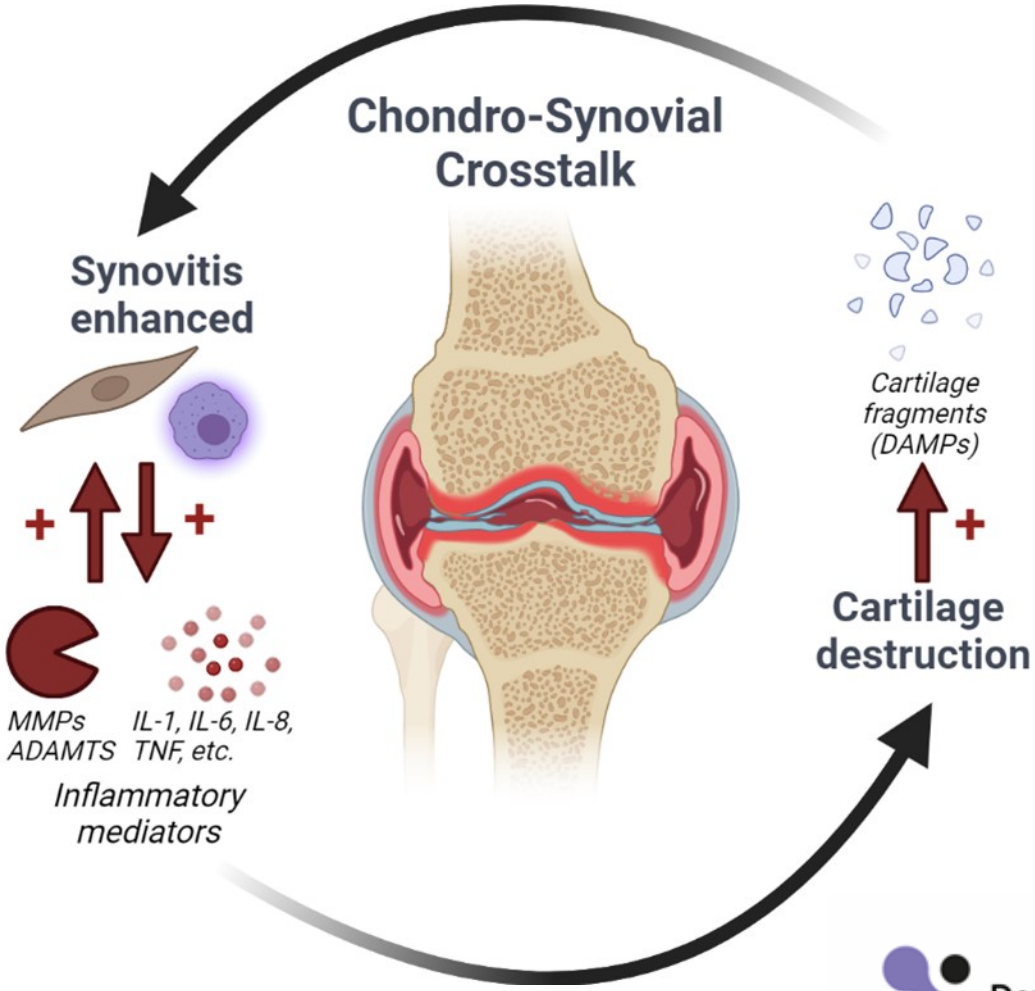
Hy2Care

Orthros Medical™

LipoCoat

Developmental BioEngineering

OSTEOARTHRITIS IS A SERIOUS DISEASE



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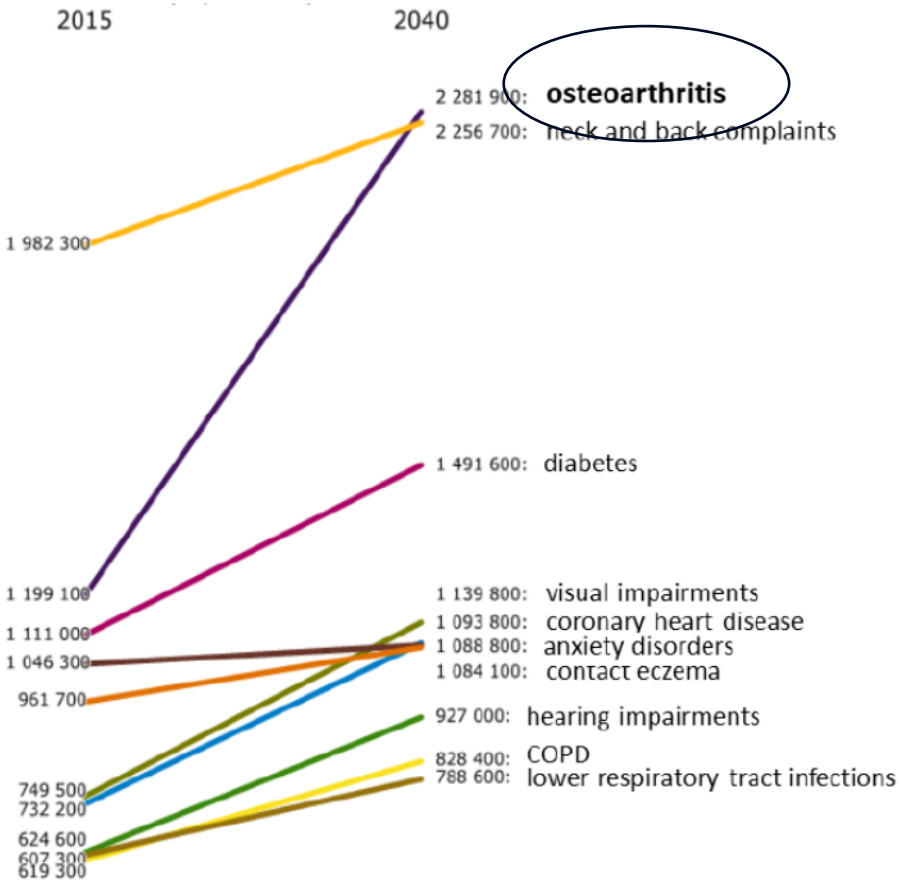
IN 2040 OSTEOARTHRITIS IS THE MOST COMMON CHRONIC DISORDER



No disease modifying treatment because:

- In vitro and in vivo models poorly reflect the complexity of human disease and lack translational power
- lack of biomarkers for detection of early disease
- disease heterogeneity with many different onsets converging in a similar phenotype
- lack of patient stratification

Need for a “diagnostic to treatment chain” enabling personalized medicine

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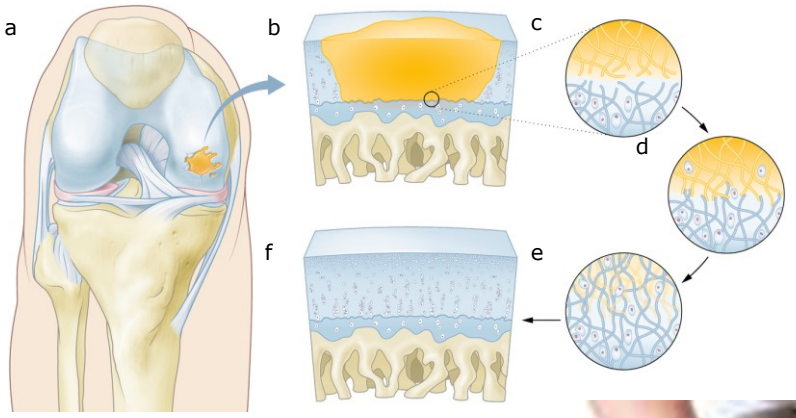
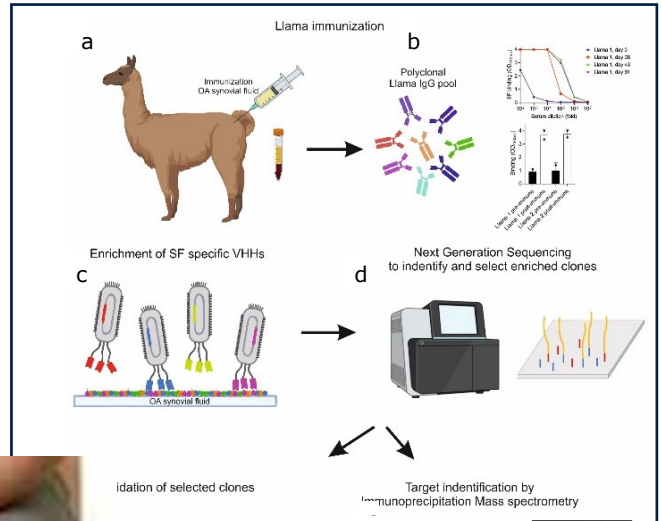
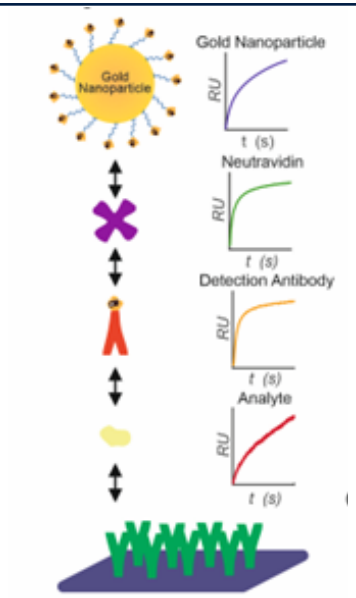


Injectable Hydrogels for Cartilage repair



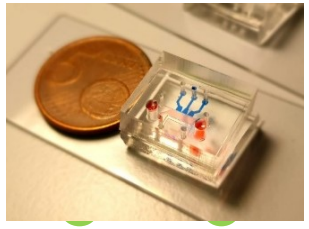
VHH antibody fragments for disease modification

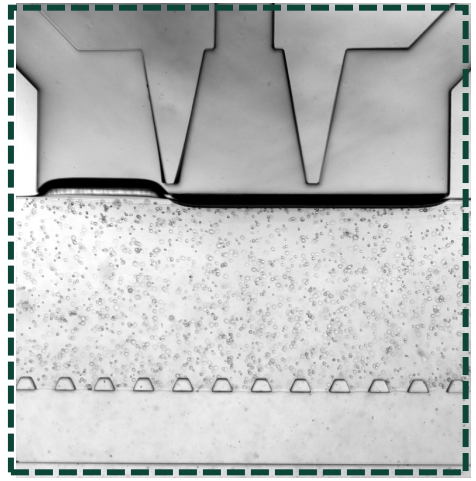
Technovolution in Joint Repair



Point of Care device for early detection and patient stratification

Mechanical actuation unit

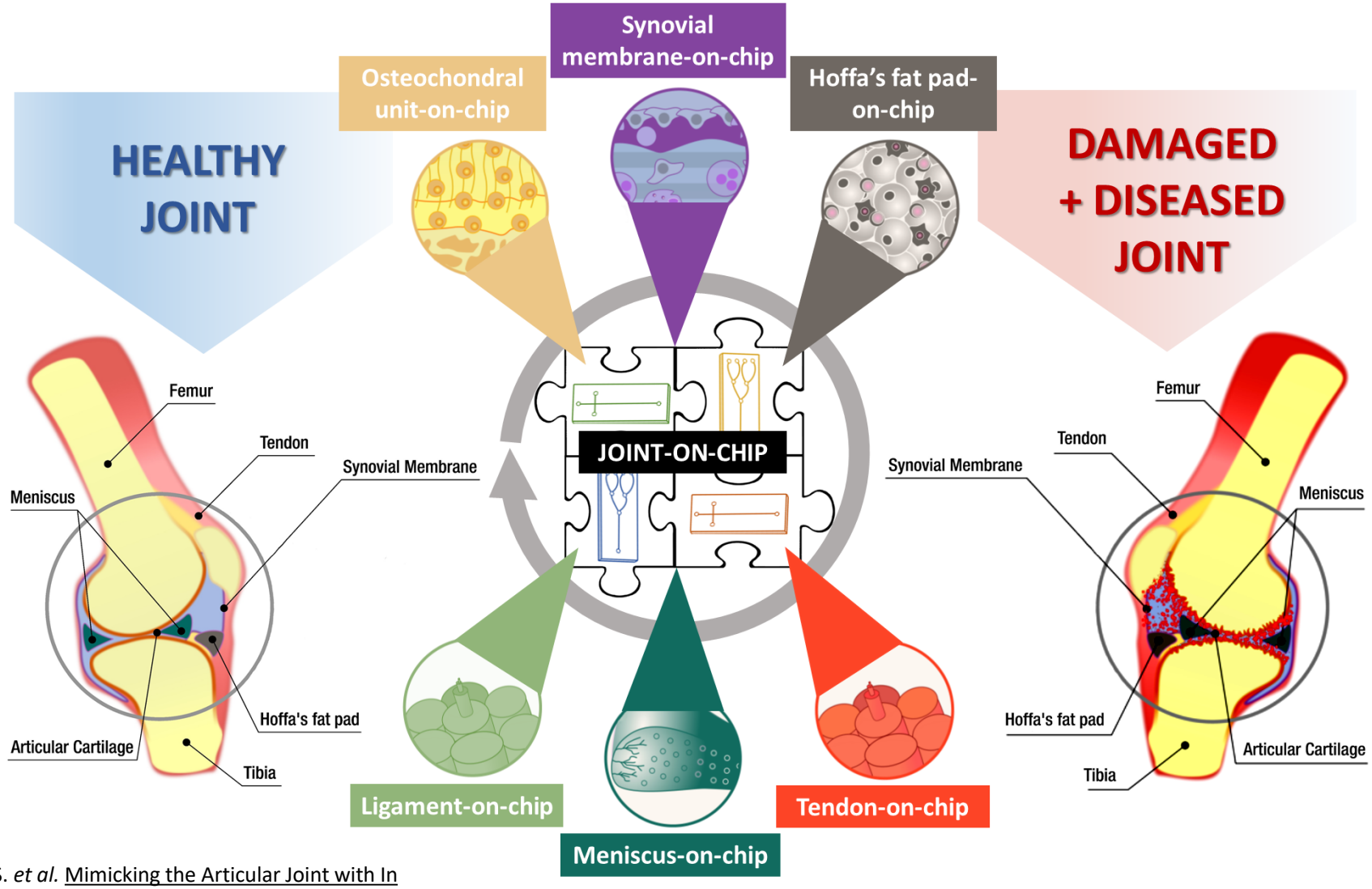




Joint-on-Chip

Developmental BioEngineering

Route Towards a Joint on Chip:
a modular approach



From: Piluso S. *et al.* Mimicking the Articular Joint with In Vitro Models. Trends in Biotechnology, 2019.

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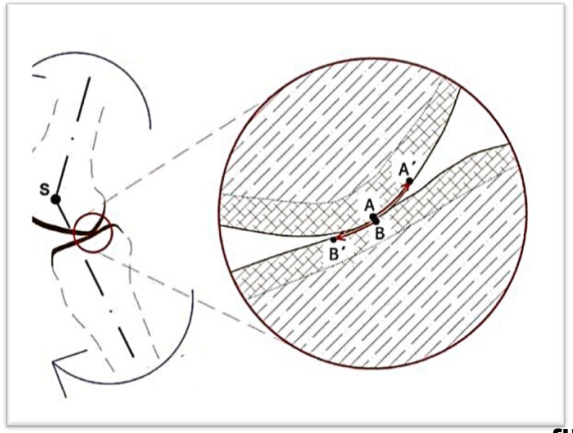
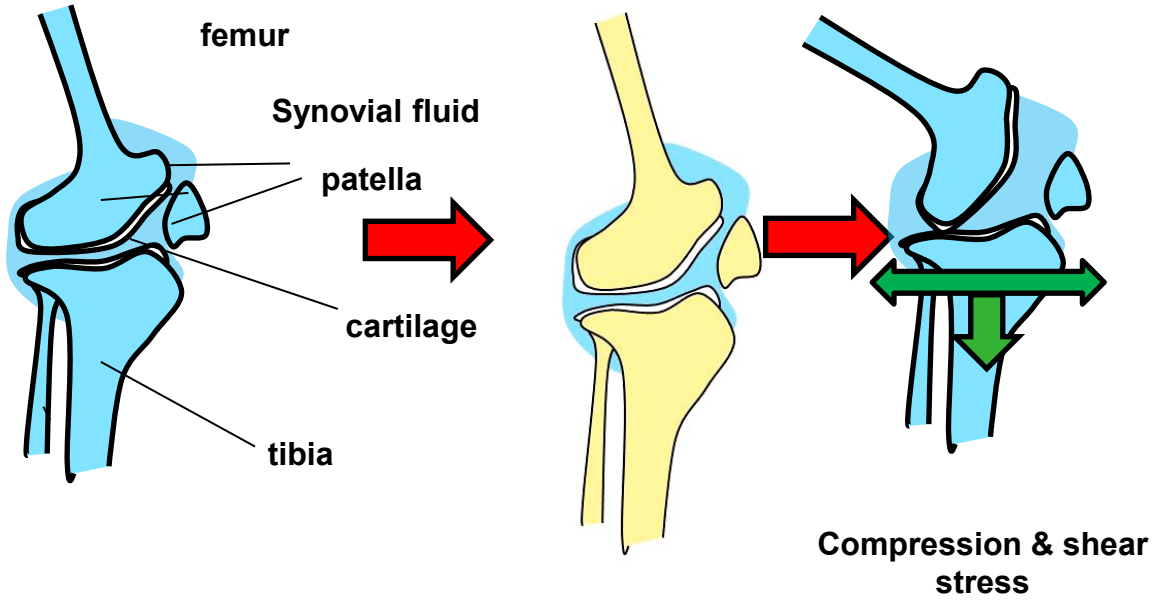
Mimicking joint articulation: Mixture of compression and shear stress

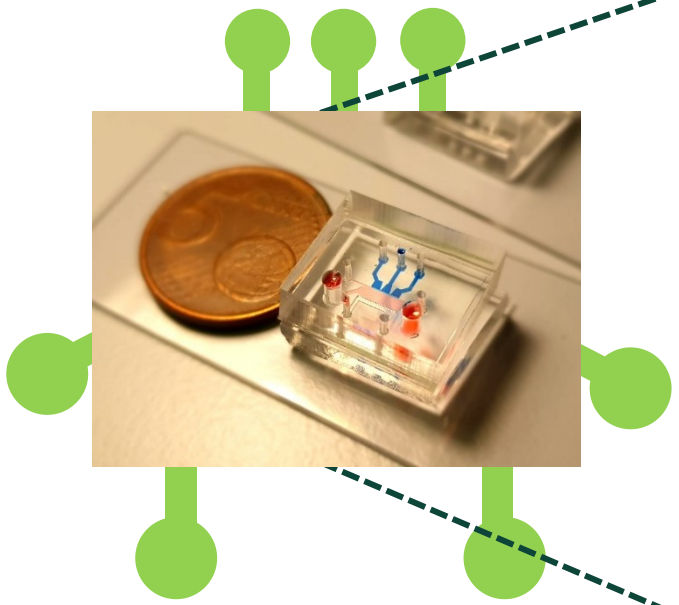


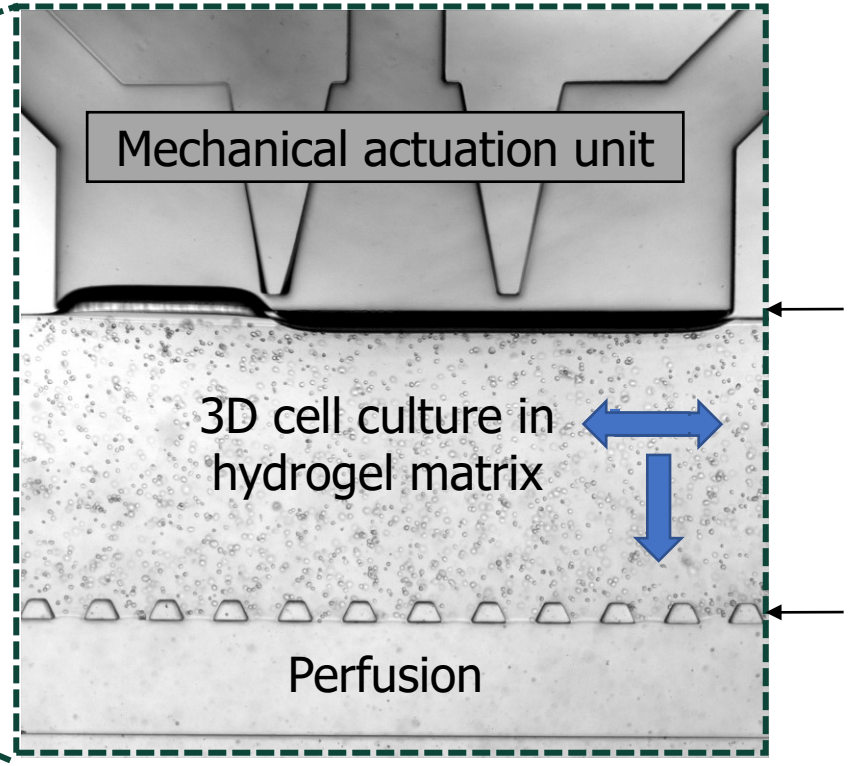
From: Petrtyl M. *et al.* Biomechanical Properties of Synovial Fluid in/Between Peripheral Zones of Articular Cartilage. Biomaterials – Physics and Chemistry, 2011.



Cartilage on chip

TRL 4-5





- Highly versatile: compressive, shear, (possibly) stretching forces, and combinations thereof
- Fully programmable: duration, frequency, amplitude, negative and/or positive, etc.

Paggi et al., Lab on a Chip. 2022

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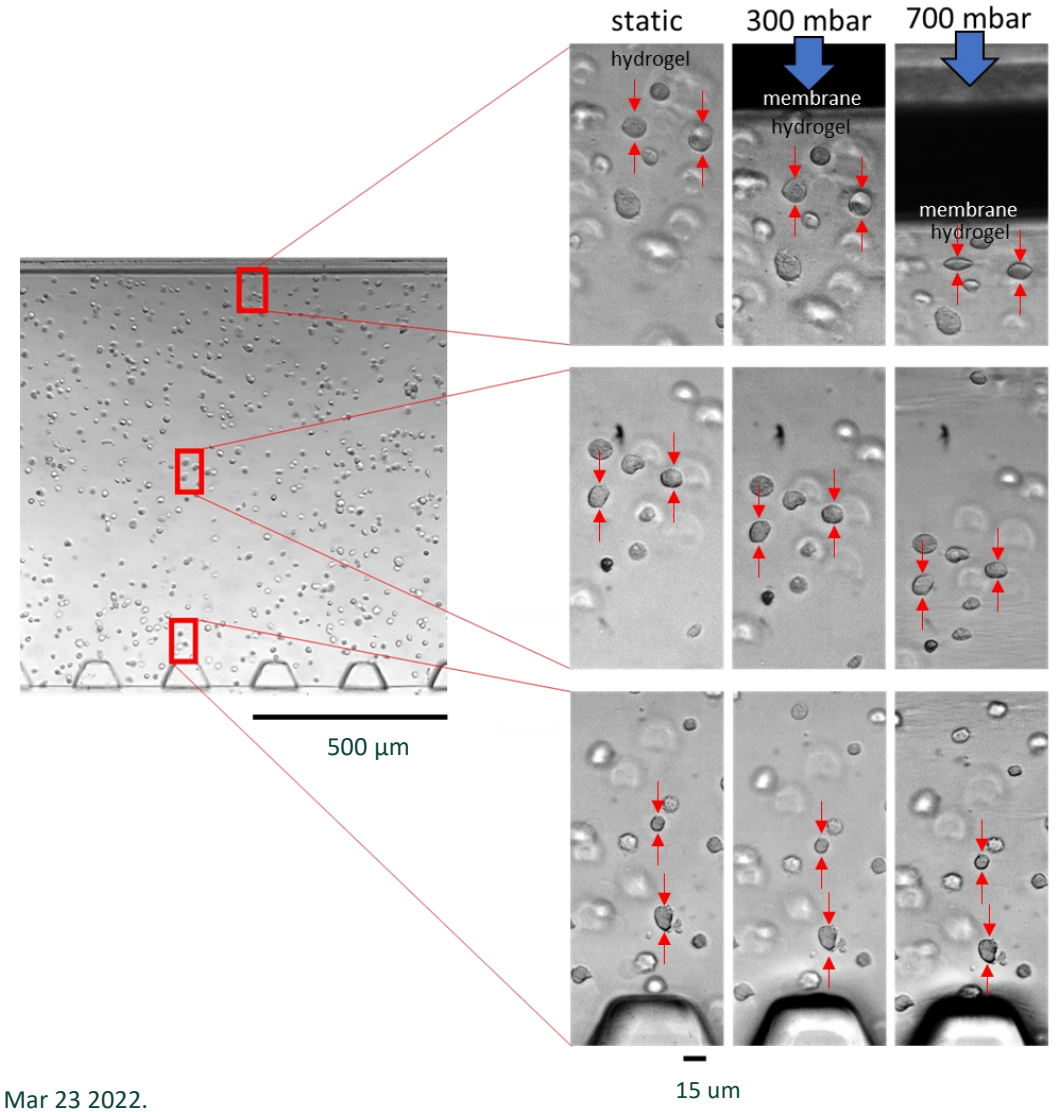
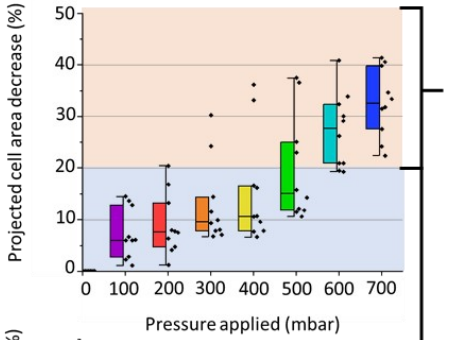
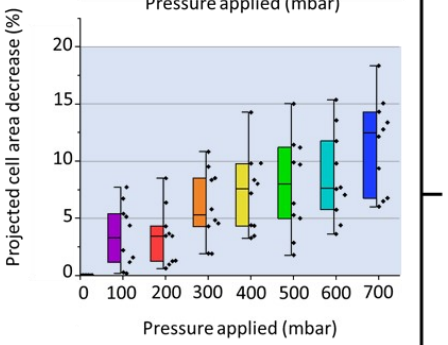
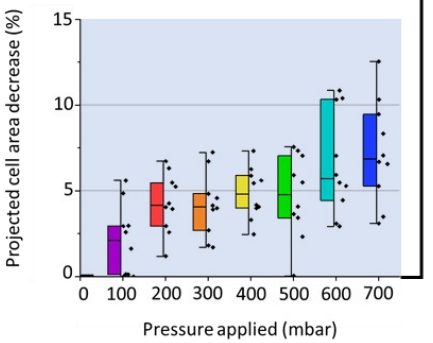
SINGLE CELL TRACKING UNDER PHYSIOLOGICAL AND HYPERPHYSIOLOGICAL LOADING CONDITIONS

Track single cells, under the microscope, within the hydrogel suspension









Hyperphysiological Stimulation

Physiological Stimulation

*Paggi, et al., *Lab on a Chip*, Mar 23 2022.

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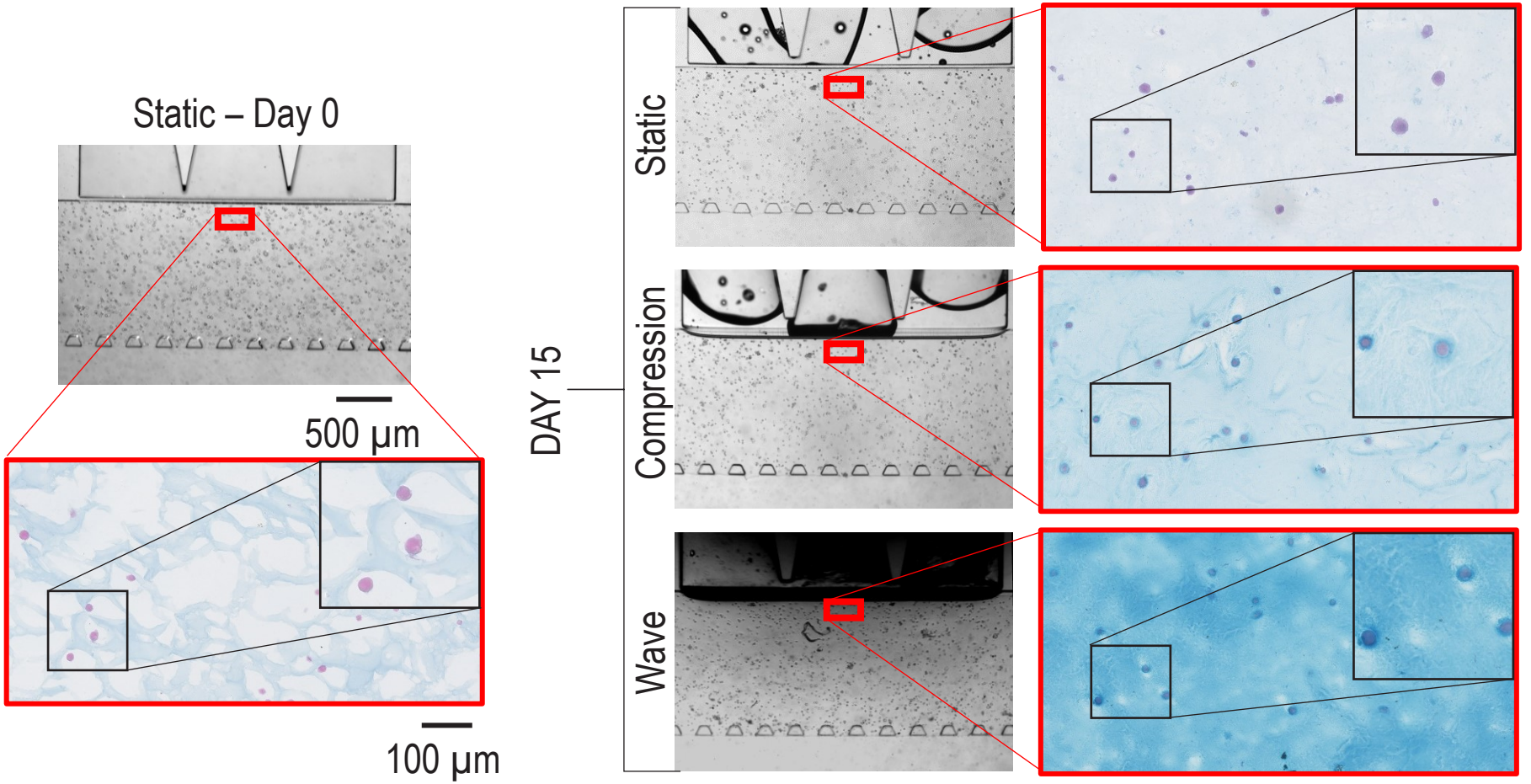
STRAIN AND STRESS ARE BOTH NEEDED FOR EFFICIENT CARTILAGE FORMATION



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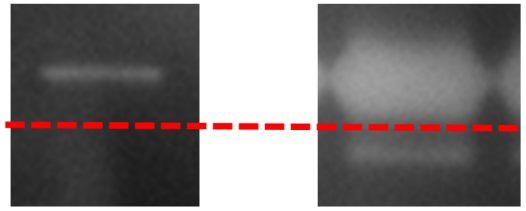
CARTILAGE ON CHIP IN DMOAD DEVELOPMENT

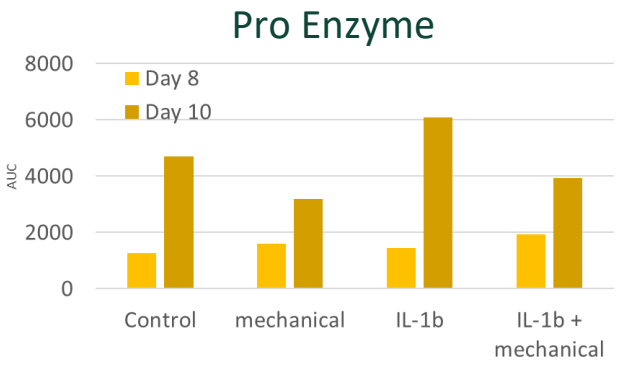
THE TECHMED EVENT

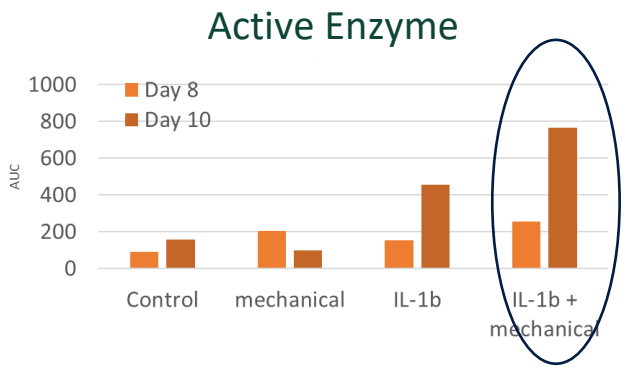
Petri dish On chip



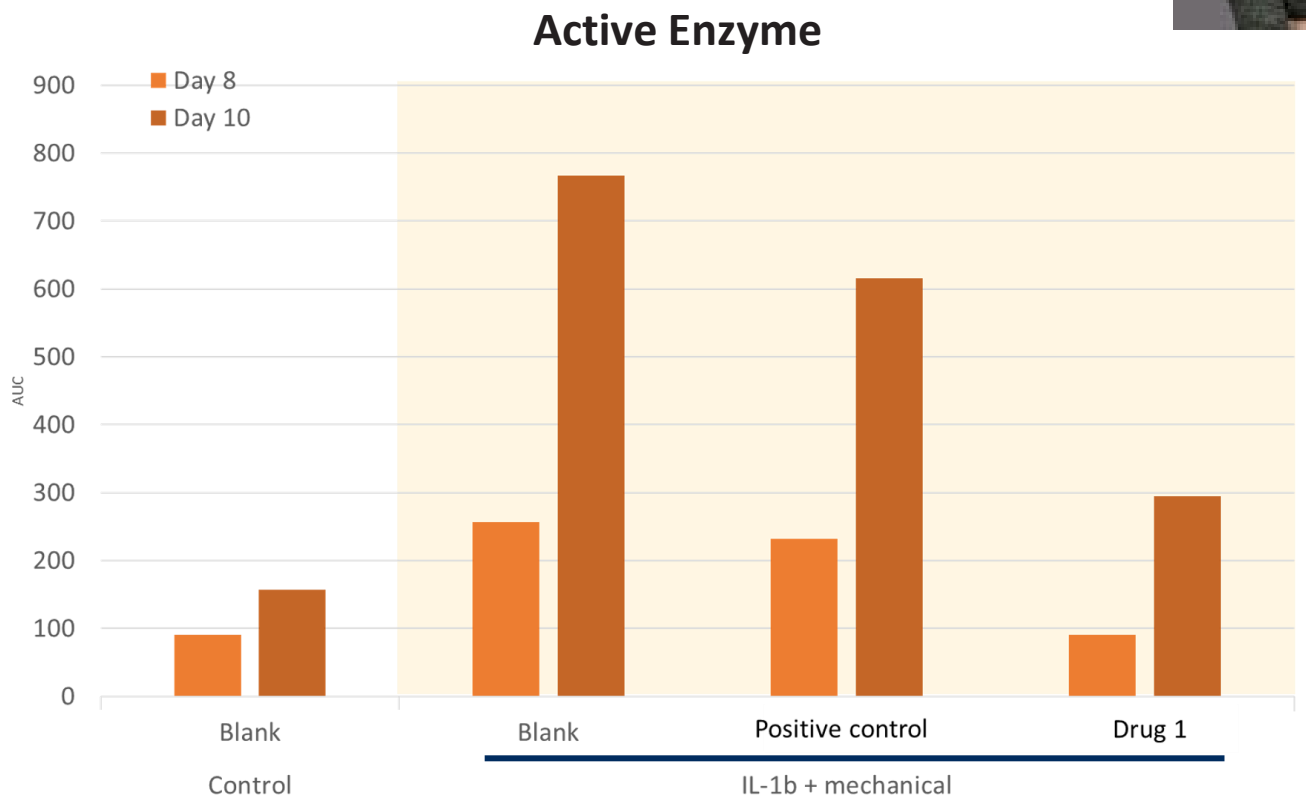
Pro Enzyme

Active Enzyme





Inflammation



Drug Response

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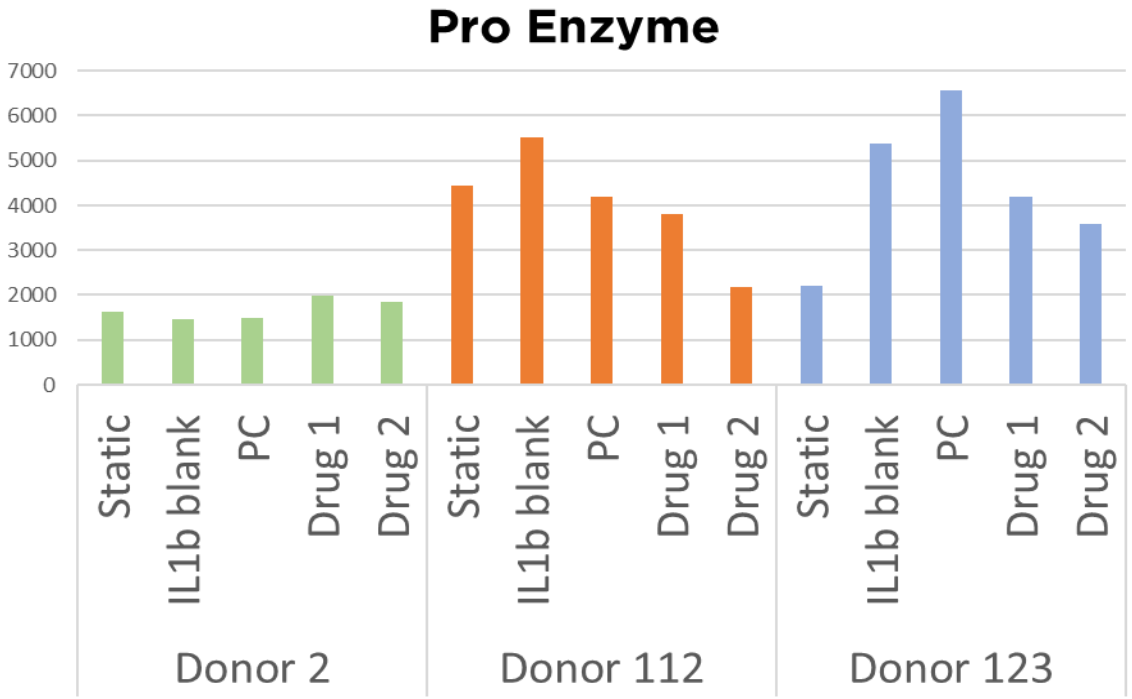
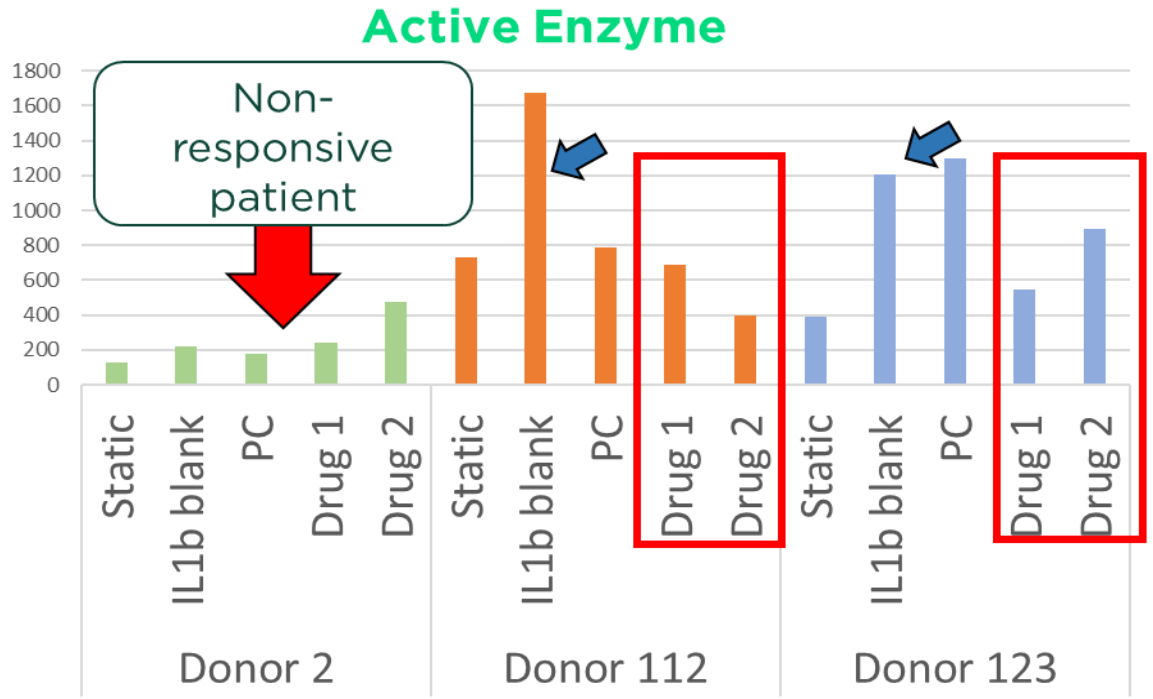
Towards precision medicine in OA drug development





***PC:** positive control (RA drug currently available in the market)

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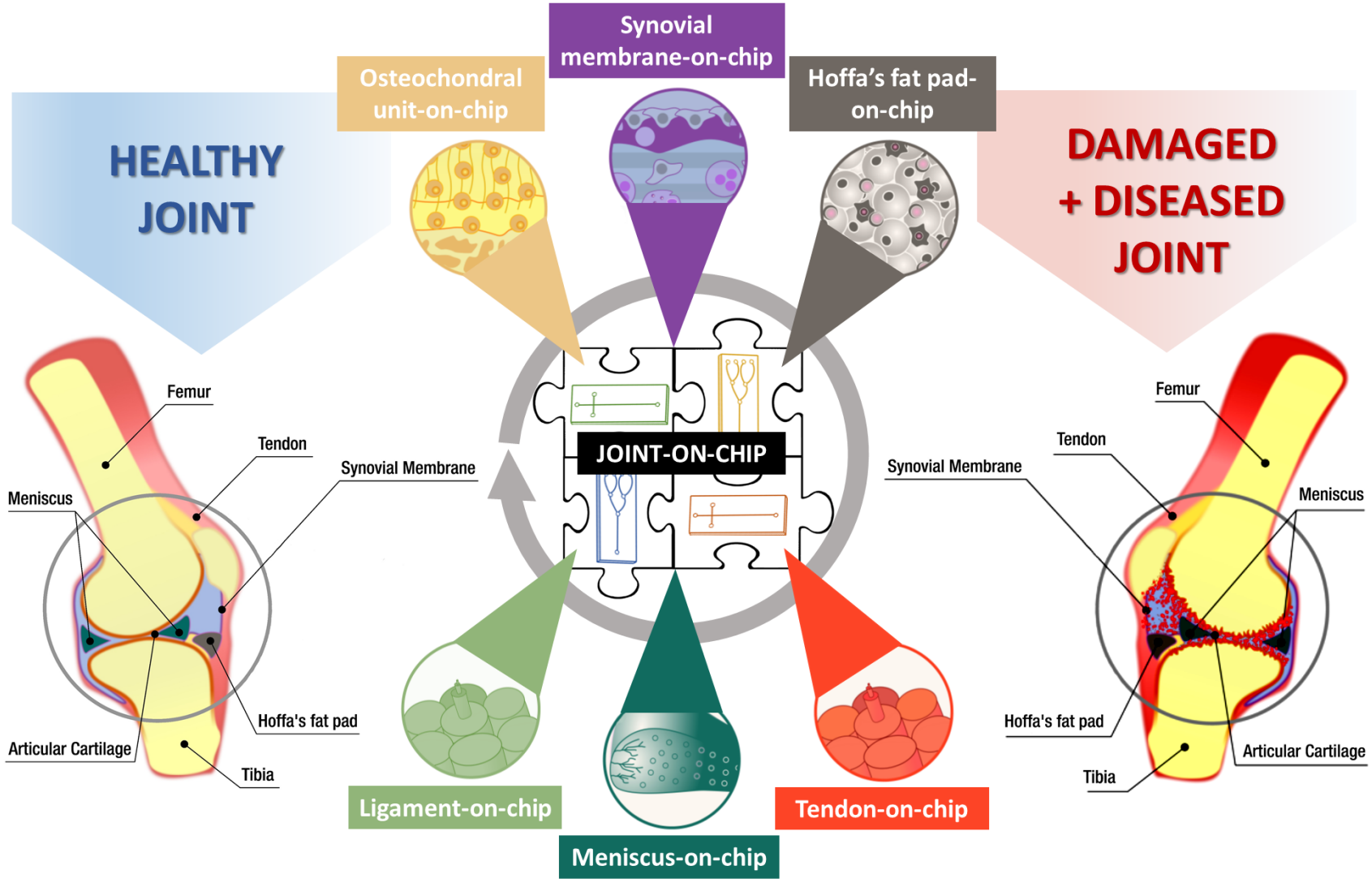
Route Towards a Joint on Chip:
a modular approach



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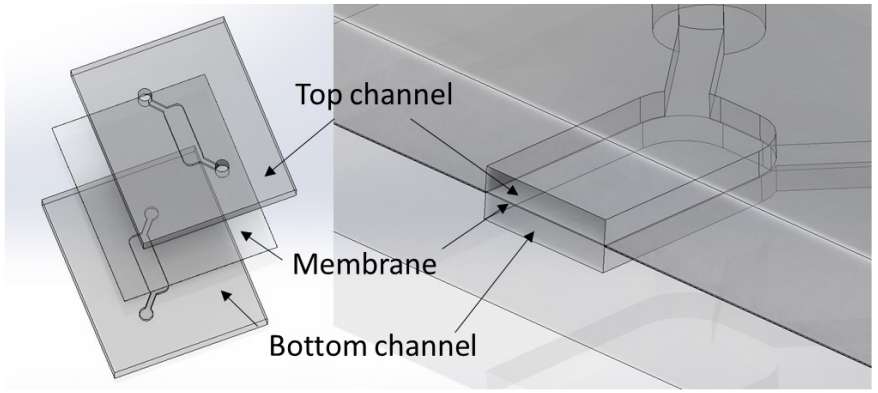
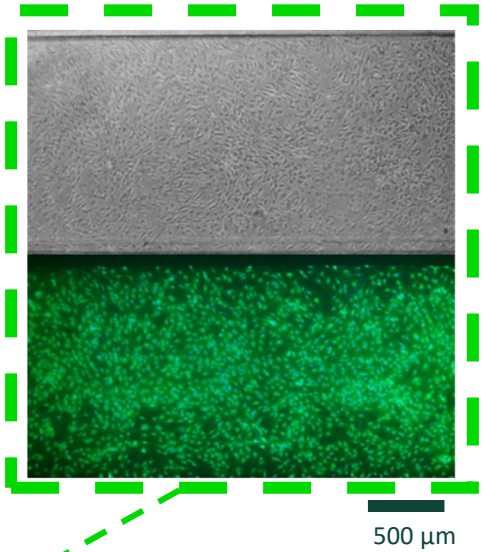
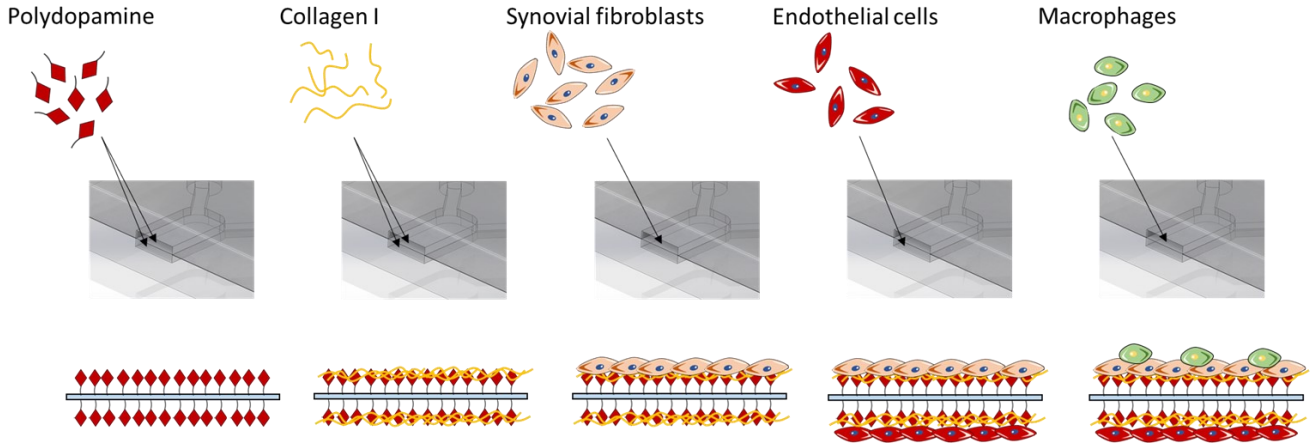
SYNOVIAL MEMBRANE ON CHIP

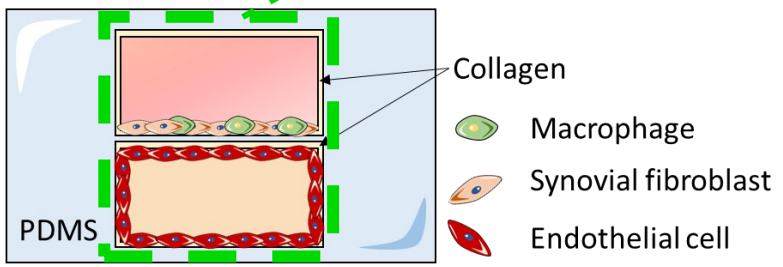
Organ-on-chip device with multi-layered triple-culture system

Mimic the immune response and inflammation seen in rheumatoid arthritis tissue









Real-time visualization under the microscope during experiments

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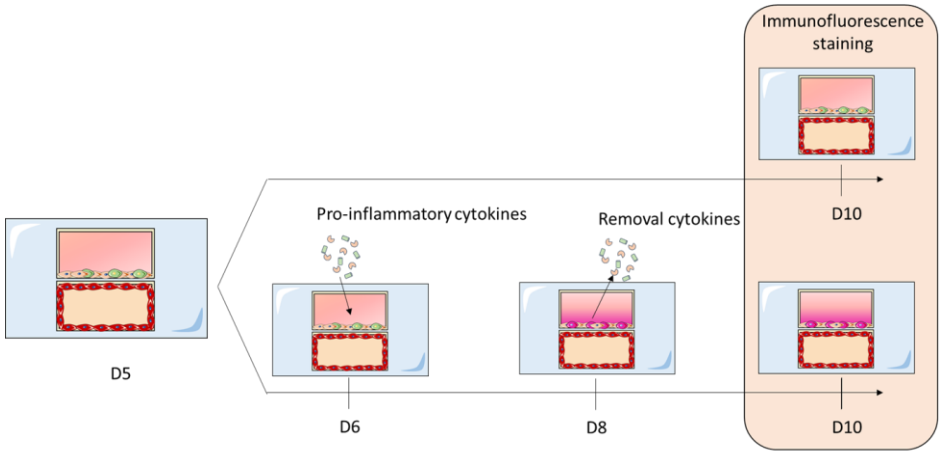
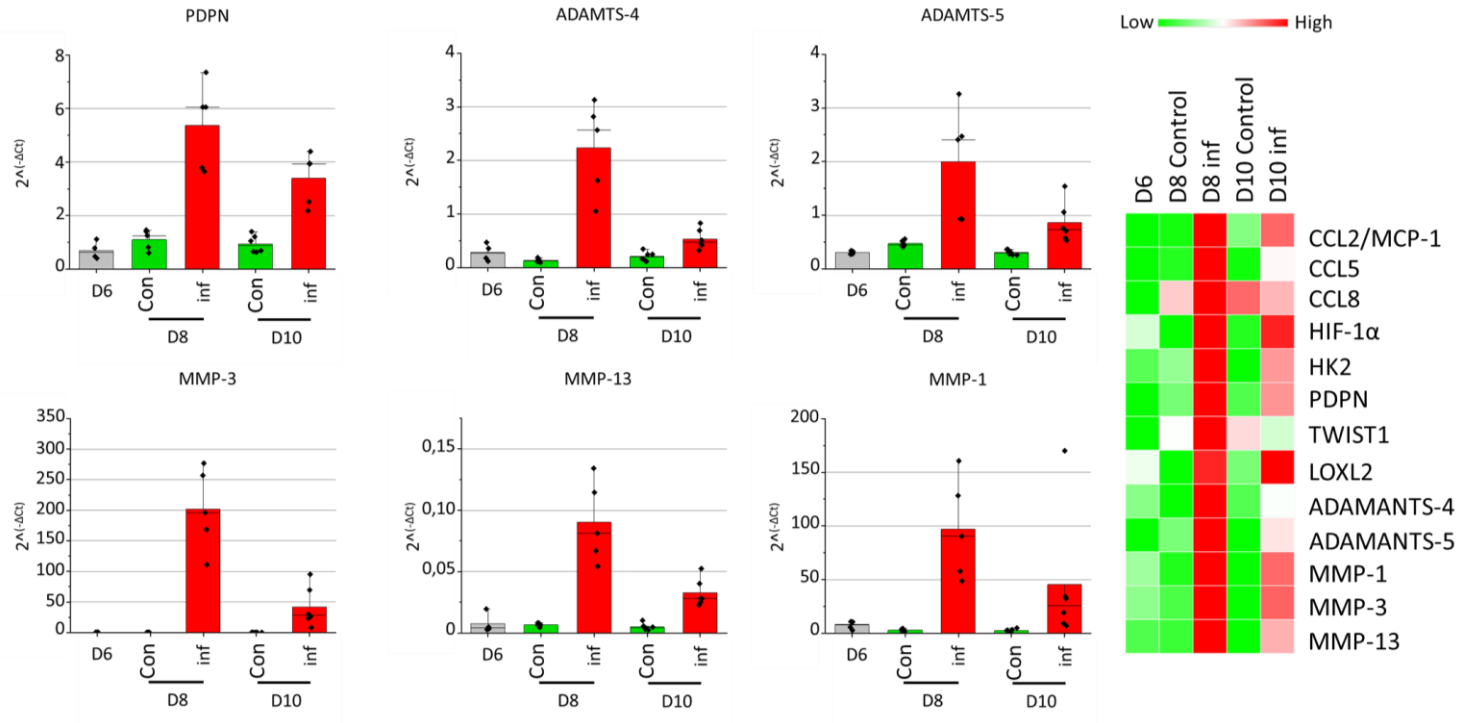
Inflammation on chip:
mimicking rheumatoid arthritis





Inflammation enhances MMP production and triggers expression of multiple degradation markers

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JOINT on CHIP: A NEW ERA IN STUDYING RHEUMATIC DISORDERS

BEFORE:

Symptom-based diagnostics

Non-translatable models

Non-specific treatments

Failed DMOAD development

NEW ERA:

IDENTIFY

Understand and mimic human (patho-) physiology

VALIDATE

Translatable and personalized models:
- Patient-specific
- Pathology-specific

TREAT

Precision medicine:
-Targeted drug development

Successful DMOADs?

Developmental BioEngineering

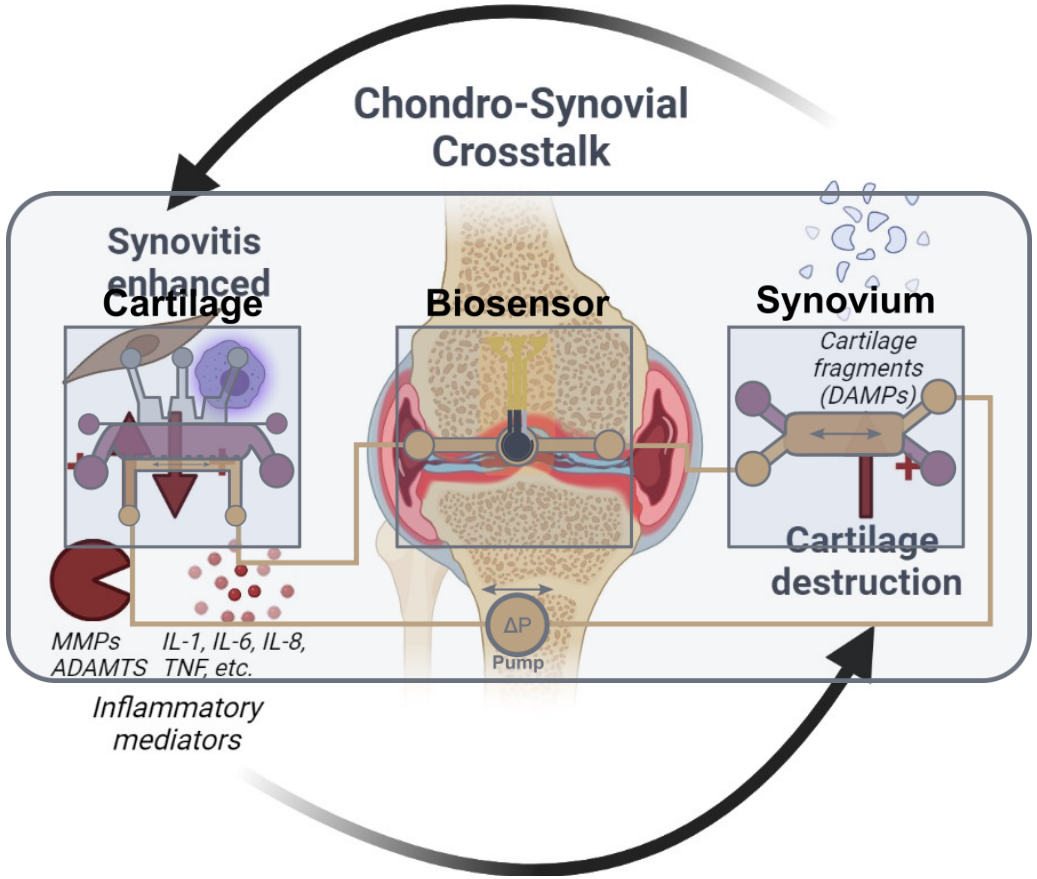
JOINT ON CHIP TECHNOLOGY: A NEW ERA IN STUDYING RHEUMATIC DISORDERS

Laurens Spoelstra, MSc **- TNW-DBE, EEMCS-BIOS, EEMCS-AMBER**

THE IMPORTANCE OF *COMMUNICATION* IN THE JOINT

Arthritis is a *whole joint* disease…

- Crosstalk between joint tissues
- Cartilage ←→ Synovium (amongst others)
- Physiologically relevant model → **Need for communication!**
  - → **The Joint-on-Chip**
  - Insight in communication: **biosensing**

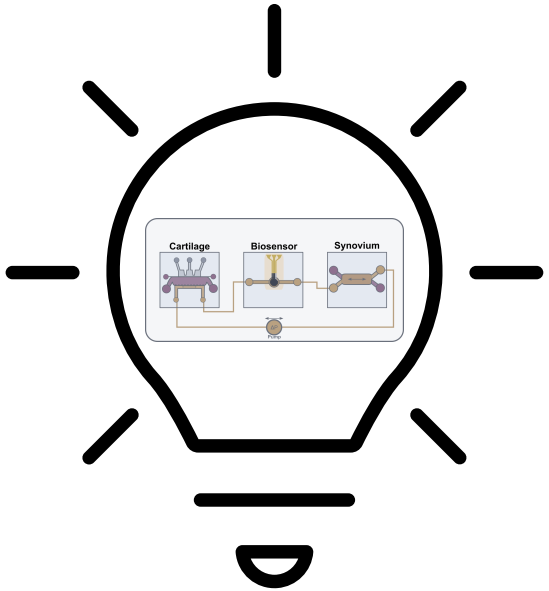


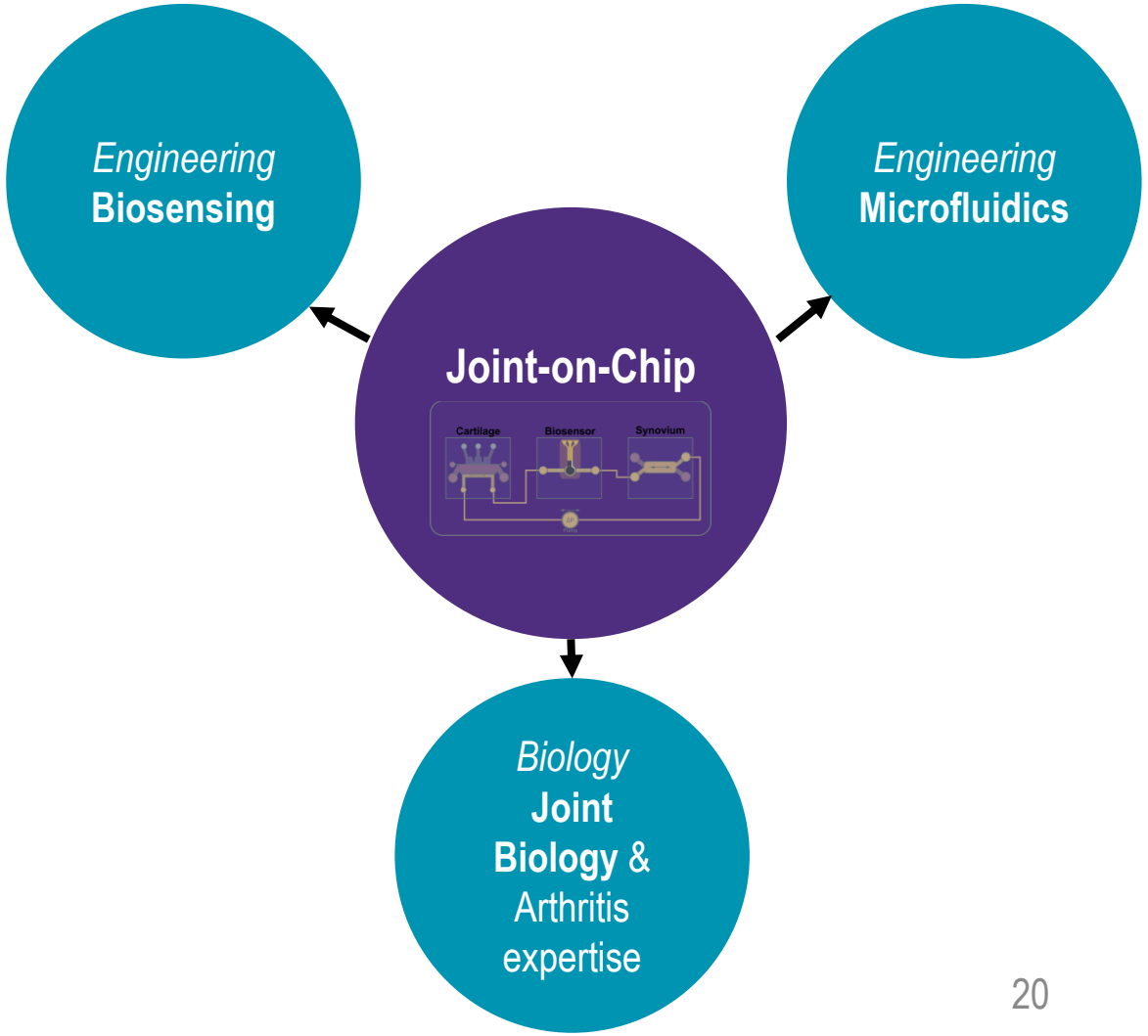
Sellam, J. & Berenbaum, F. *Nature Reviews Rheumatology* **6**, 625–635 (2010).
Pap, T. & Korb-Pap, A. *Nature Reviews Rheumatology* **11**, 606–615 (2015).
Liu-Bryan, R. & Terkeltaub, R. *Nature Reviews Rheumatology* **11**, 35–44 (2015).
Guo, Q. *et al. Bone Research* **6**, 15 (2018).
Sanchez-Lopez, E. *et al. Nature Reviews Rheumatology* **18**, 258–275 (2022).

THE ROAD TO FUNDING: *TGS AWARD 2022*

What do we need to make this succeed?

- The idea was there at the end of my MSc…
- … But how do we make this happen?





THE ROAD TO FUNDING: *TGS AWARD 2022*

Who do we need to make this succeed?

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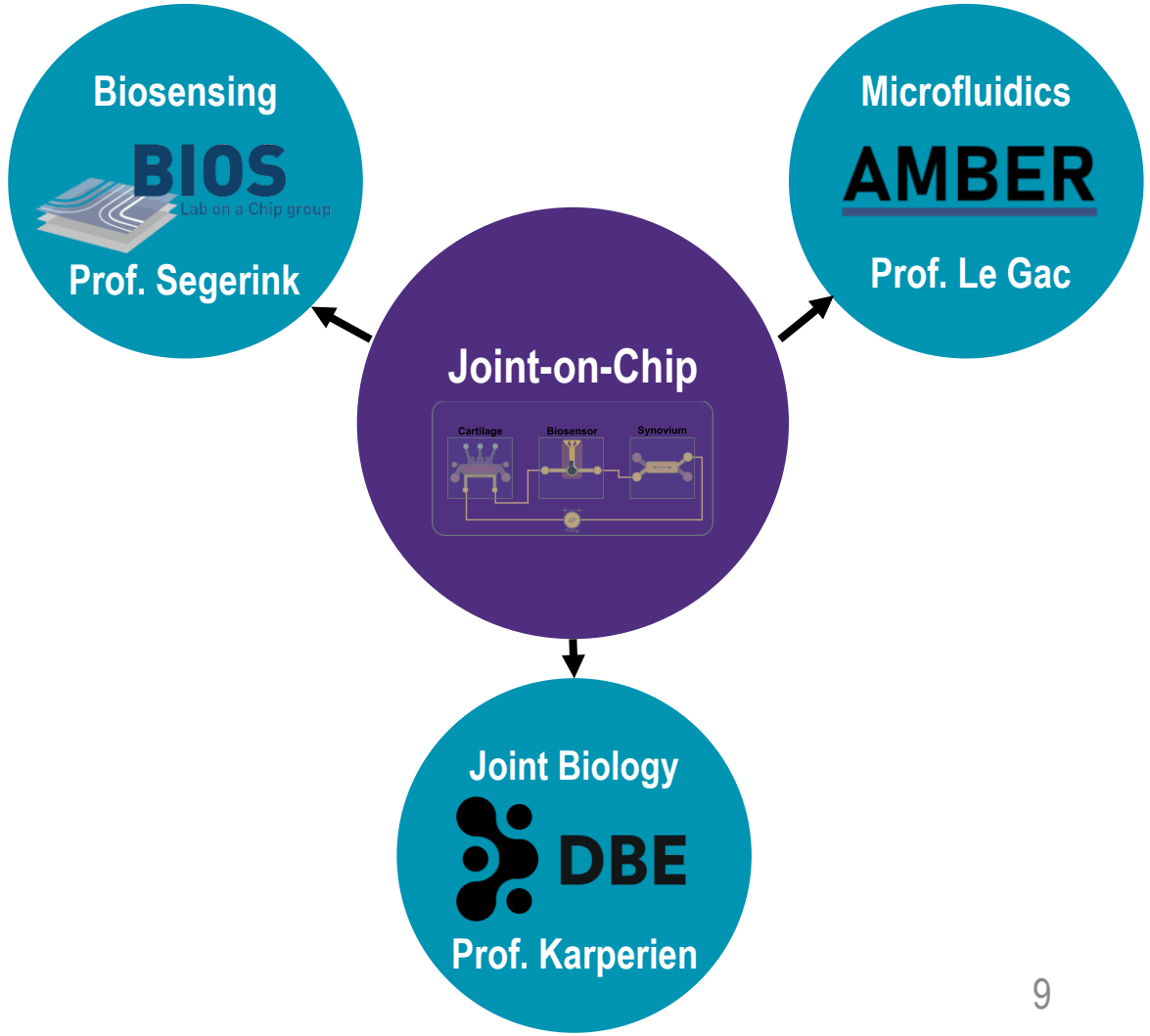
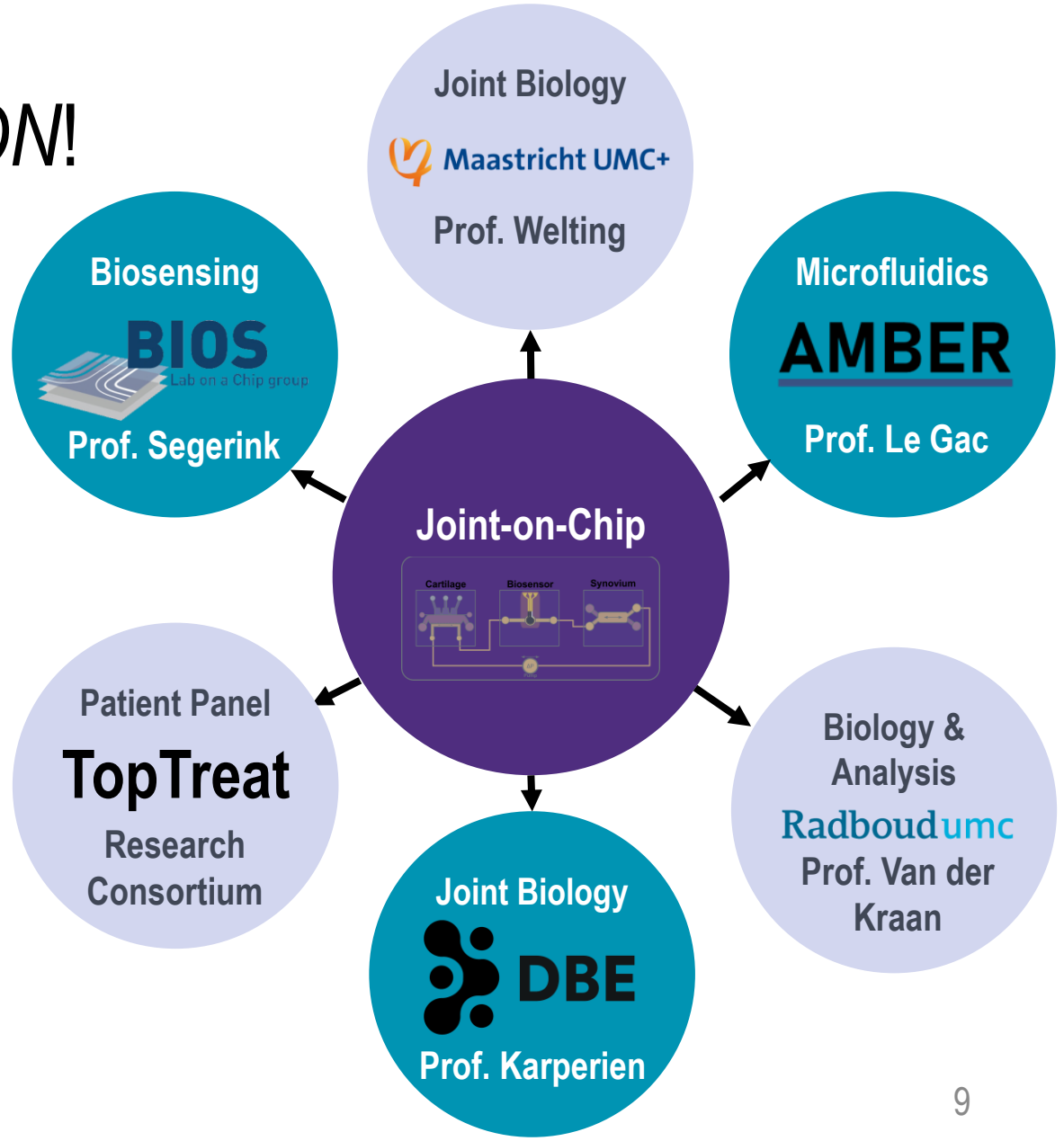
- … But how do we make this happen?
- → Proposal to TGS Jury
- → **PhD Contract through TGS Award**



REALIZATION: *COLLABORATION*!

Who do we need to realize the Joint-on-Chip?

- A **successful project** needs **partners**:
  - Patient materials
  - Incorporation of latest research findings
  - Connection to 'reality' → What is the most important for the stakeholders?
- **TopTreat consortium:**
  - Joint-on-Chip as a *phenotyping* and *drug testing tool*
  - Partners: *Radboudumc*, *Sint Maartens Kliniek*, *ReumaNederland*, Roessingh R&D, ATRO Medical, Moveshelf, Ministry of Defence



ORGAN-ON-CHIP DEVELOPMENT IS *MULTIDISCIPLINARY*…

From *engineering concept* to *biological complexity* & *clinical relevance*

“Multidisciplinary collaboration is key in developing Organ-on-Chip models!”