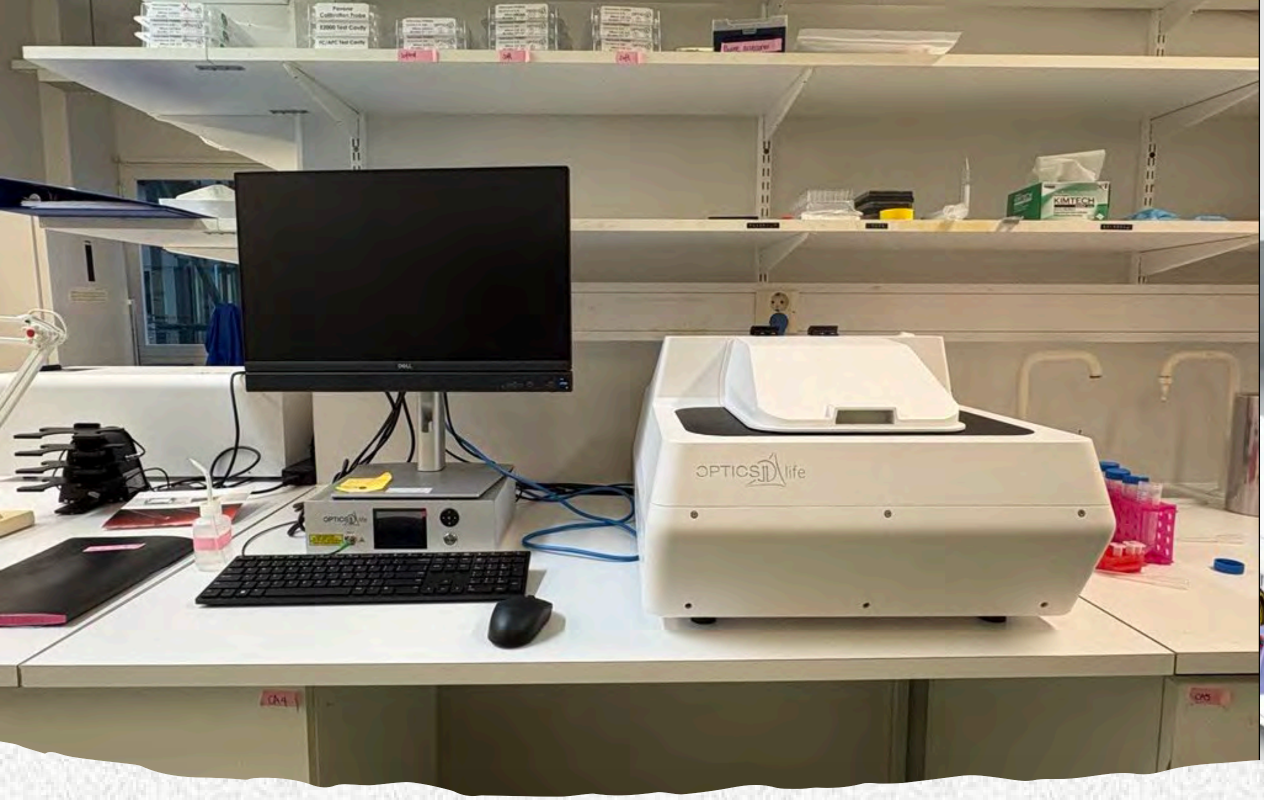



# PAVONE Nanoindenter_manufactured by Optics11 Life

- Located in Room 2060 /2$^{nd}$ Floor Biocity/Department of Cell Biology
- Contact Professor Cecilia Sahlgren (cecilia.sahlgren@abo.fi) for instrument access
- https://www.optics11life.com/products/pavone-nanoindenter/

# Mechanobiology

## Bridge the gap between biology, physics, engineering, and material science

- **Explore the biomechanics of biological systems**

How physical forces and mechanical properties shape living organism’s structure, function and behavior, from single cells to complex tissues.

- **Tuning biomaterial mechanics to guide biological response**

Biomaterials are designed not only to provide structure support

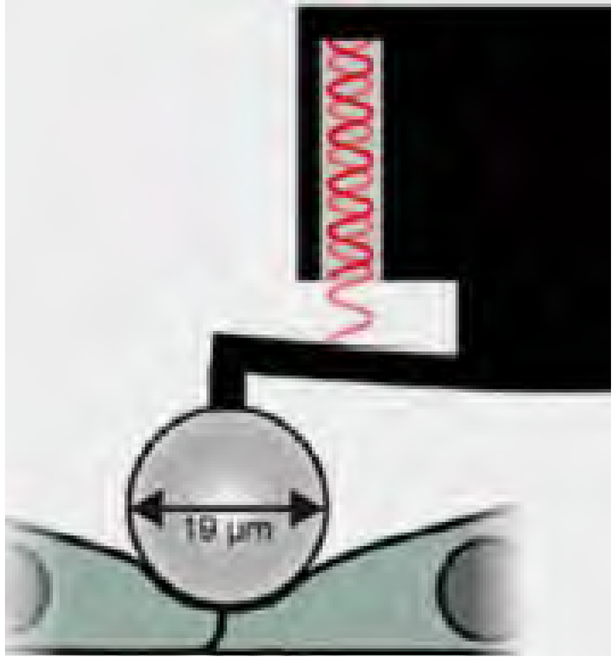
By manipulating mechanical cues, biomaterials are engineered to regulate specific biological responses and to create 3D structure that closely replicate native tissues

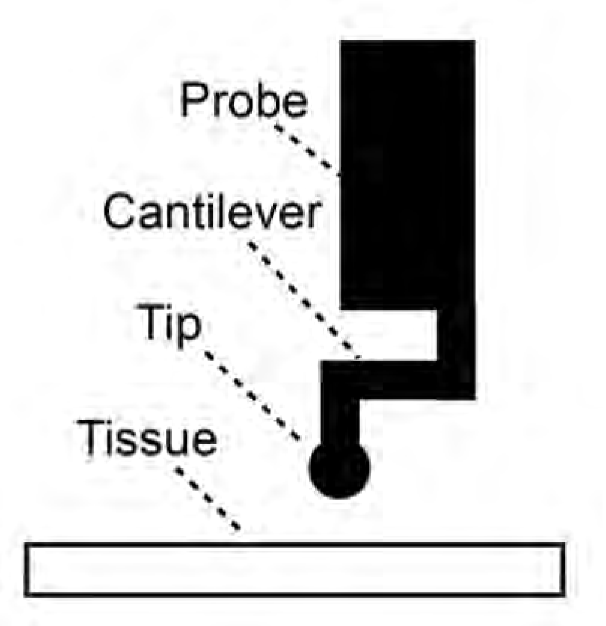
# Microscale indentation to probe soft- and living matter at the microscale

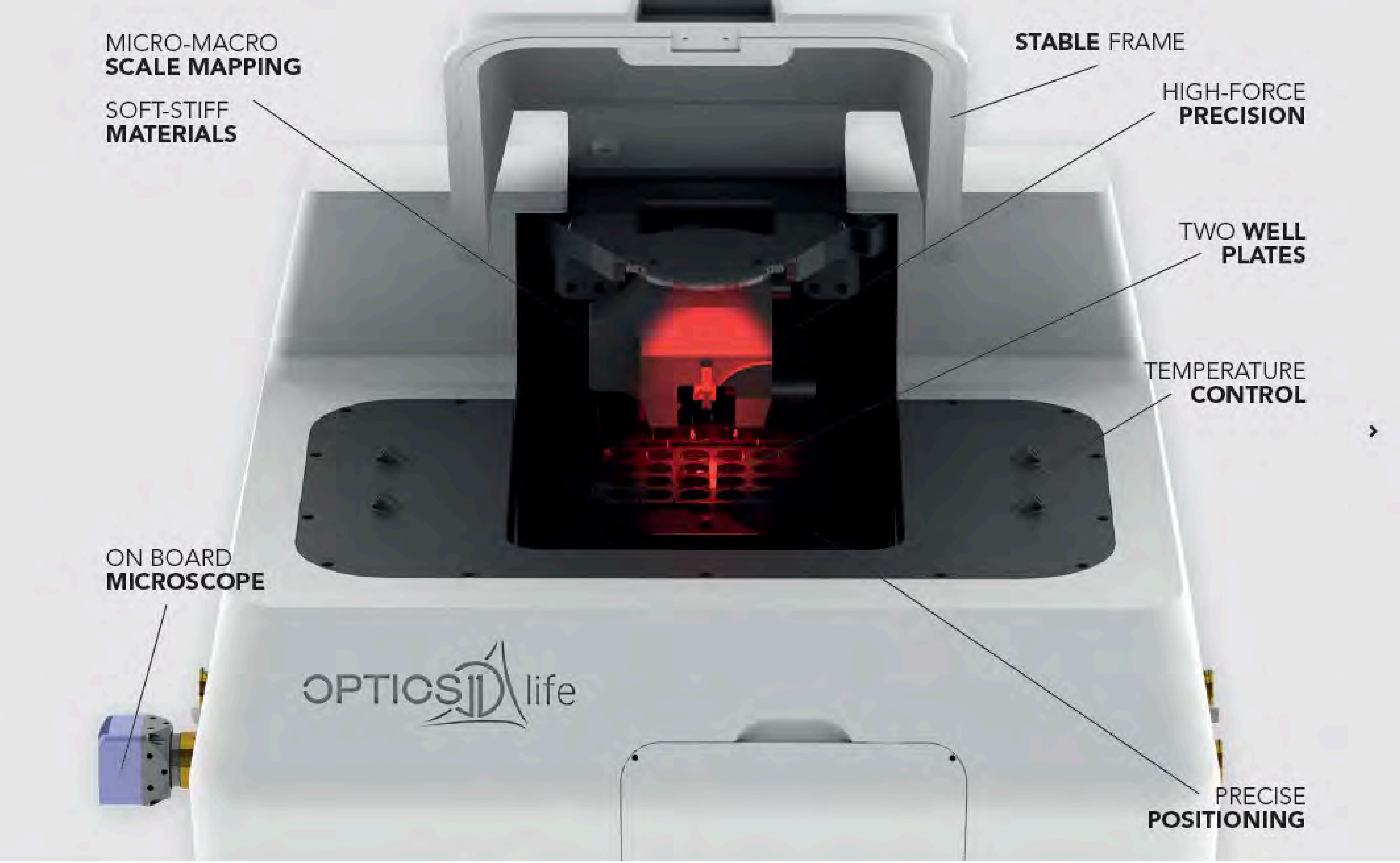
- Optics11 Life developed advanced indenters for high-resolution measurement of large biological samples, such as cells, tissues, organoids, and biomaterials.
- This technology enables property mapping across scales, from 1 to over 200 μm contact areas, and continuous mapping over large regions up to tens of $cm^2$.
- Atomic force microscopy is confined to small areas, while rheometry measures bulk properties, missing local variations.

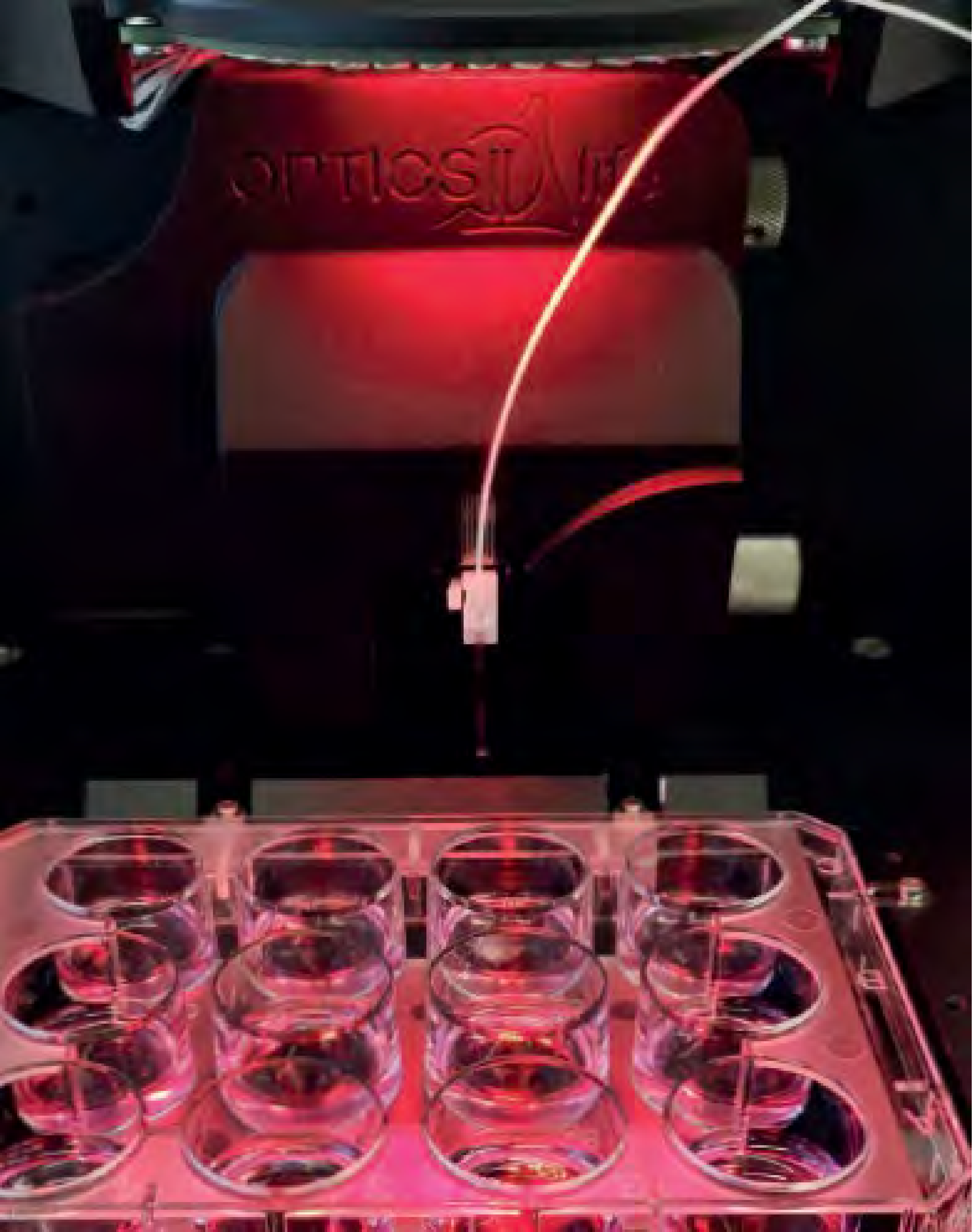
**Optics11 Life Technology**

- ❑ Unique fiber sensors - optical interferometry
- ❑ Silicon cantilevers, glass sphere
- ❑ Measure force & depth of indentation
- ❑ In any culture medium or in air




MICRO-MACRO SCALE MAPPING
SOFT-STIFF MATERIALS
STABLE FRAME
HIGH-FORCE PRECISION
TWO WELL PLATES
TEMPERATURE CONTROL
ON BOARD MICROSCOPE
OPTICS11 life
PRECISE POSITIONING



# Key Functions and Features

- **Micro-rheology**
- **Integrated functions**

Mechanotesting, microscopy, and environmental control into one device

Indentation locations can be overlapped with the image of sample for structure-stiffness correlation analysis

Bright-field; Phase-contrast; Fluorescence (optional)

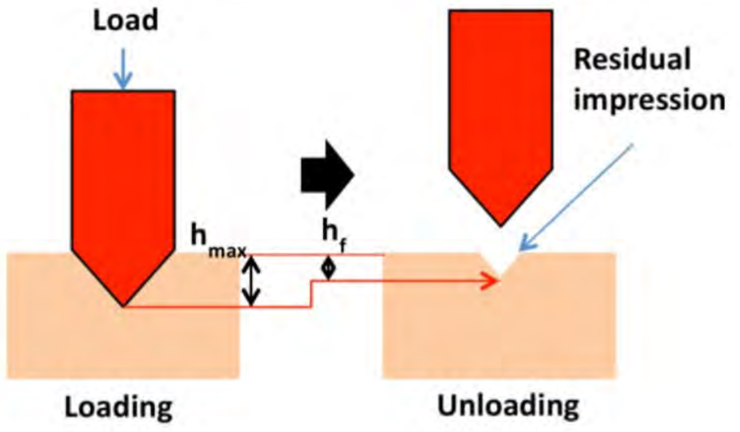
- **High-throughput automation**

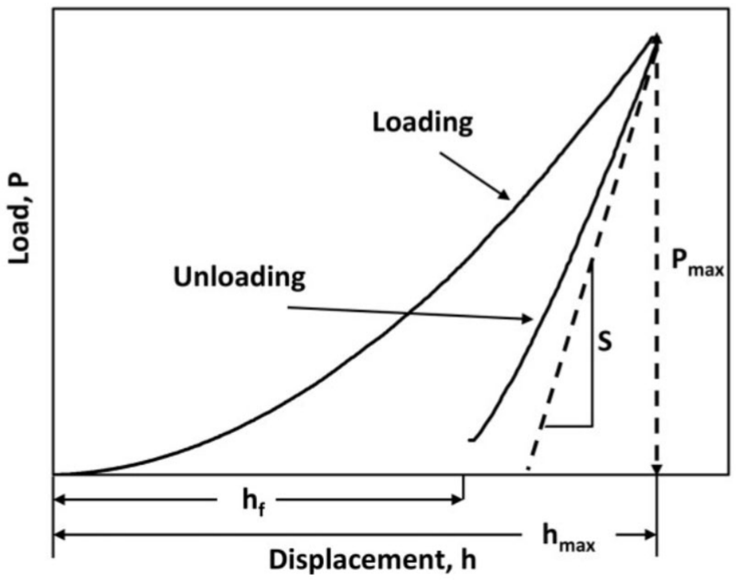
Precise stage control and surface finding of the sample

Automated experimental workflows in micro-plates without the need of user supervision

# It follows similar principles as nanoindenters probe hard surfaces with sharp diamond tip (Berkovich)

A diamond probe indents the sample surface, measuring the applied load and penetration depth to calculate the contact area, which determines material hardness.




$$E_r = \frac{\sqrt{\pi}}{2\beta}\frac{S}{\sqrt{A_c}}$$

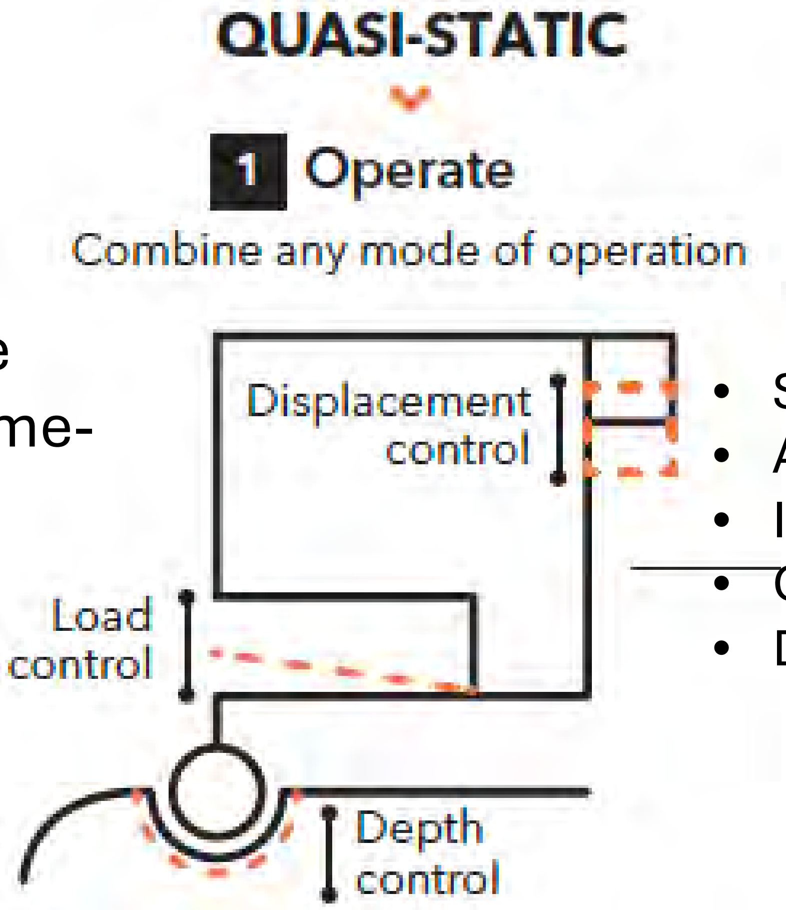
Where:

- $S = dP/dh$ = unloading stiffness
- $A_c$ = contact area
- **β = geometric correction factor**

1. Load-displacement curve showing the process of loading and unloading. S is the contact stiffness of unloading.
2. The Oliver–Pharr method extracts hardness and elastic modulus as a reduced modulus, from nanoindentation by analyzing the elastic unloading stiffness and correcting for contact geometry and area.
3. Nanoindentation measures elastic response, not tensile modulus directly

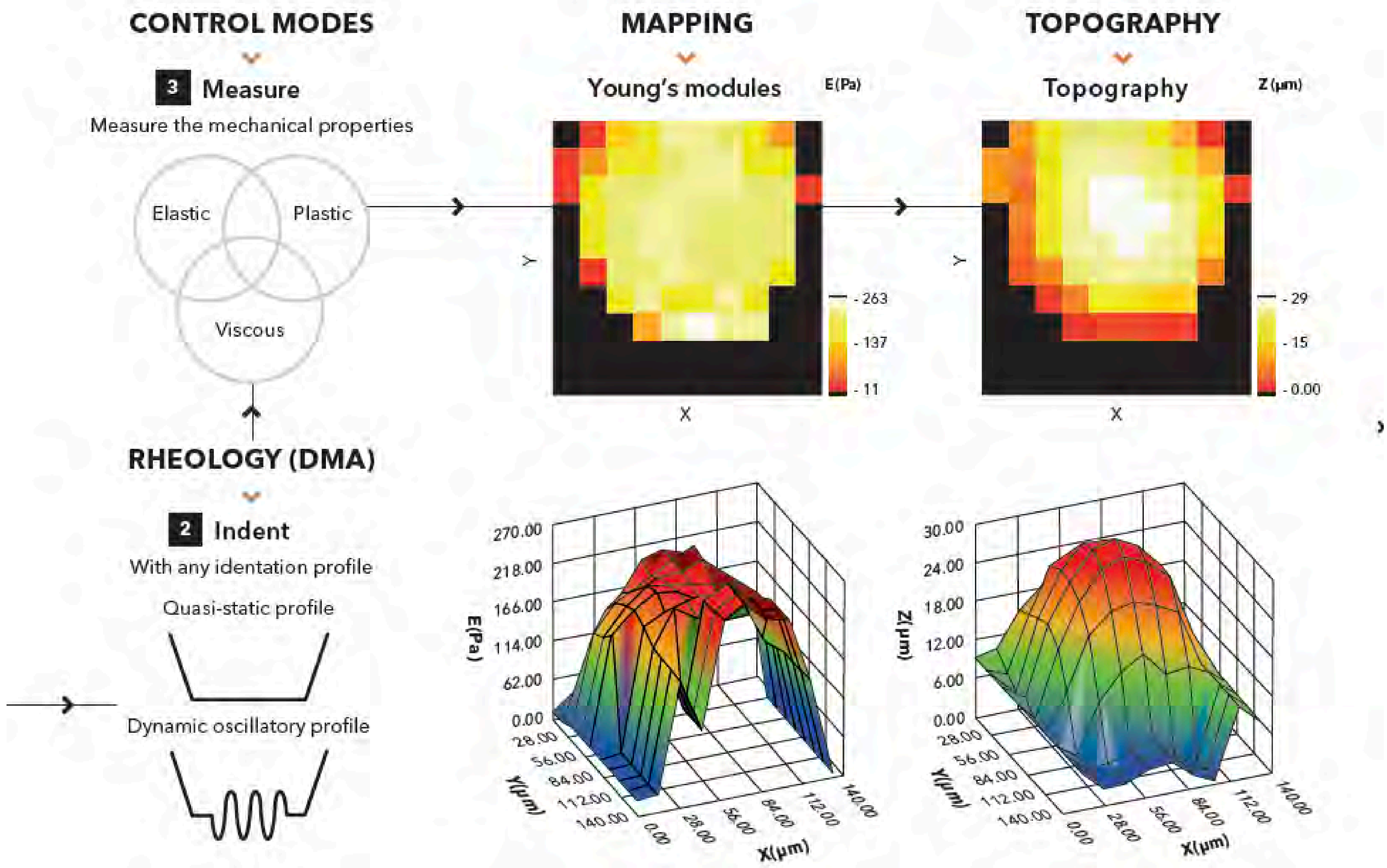
# Micro-rheology

- Quasi-static
- Dynamic oscillatory profile
- Stress-relaxation/creep (time-dependent deformation)




- Stiffness range: 10Pa-1GPa
- Applied load: 0.2 nN-1.5mN
- Indentation speed: 0.01 to 100 $\mu$m/s
- Oscillatory frequency: 0.01 Hz to 75 Hz
- Deformation scale: sub-$\mu$m to 100 $\mu$m

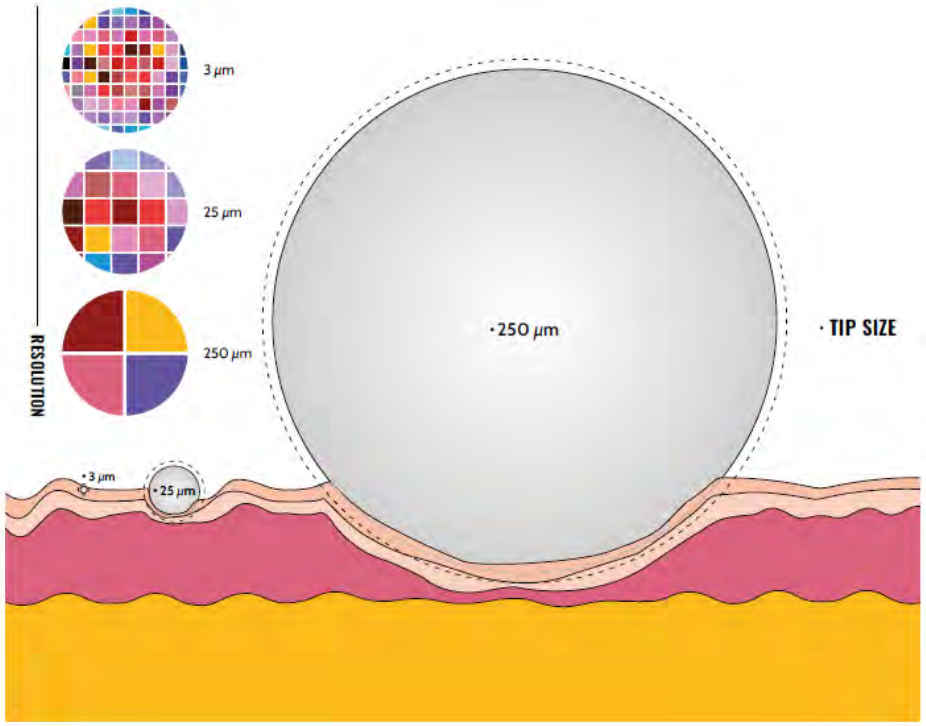
"A tiny, controlled poke that reveals how elastically stiff and how plastically resistant a small volume of material is." (Suggested by ChatGPT)



CONTROL MODES
3 Measure
Measure the mechanical properties
Elastic
Plastic
Viscous
RHEOLOGY (DMA)
2 Indent
With any identation profile
Quasi-static profile
Dynamic oscillatory profile
MAPPING
Young's modules
E(Pa)
Y
X
- 263
- 137
- 11
TOPOGRAPHY
Topography
Z (µm)
Y
X
- 29
- 15
- 0.00
270.00
218.00
166.00
114.00
62.00
0.00
E(Pa)
28.00
56.00
84.00
112.00
140.00
Y(µm)
0.00
28.00
56.00
84.00
112.00
140.00
X(µm)
30.00
24.00
18.00
12.00
6.00
0.00
Z(µm)
28.00
56.00
84.00
112.00
140.00
Y(µm)
0.00
28.00
56.00
84.00
112.00
140.00
X(µm)

# Tip size and cantilever stiffness are specific

- Cantilever stiffness, in terms of  the spring constant, needs to match the measuring system
- Large tips can measure bulk properties over large areas, minimizing the effect of irregularities on rough surfaces.
- Smaller tips offer higher resolution and can distinguish topological and mechanical heterogeneities at a fine scale.

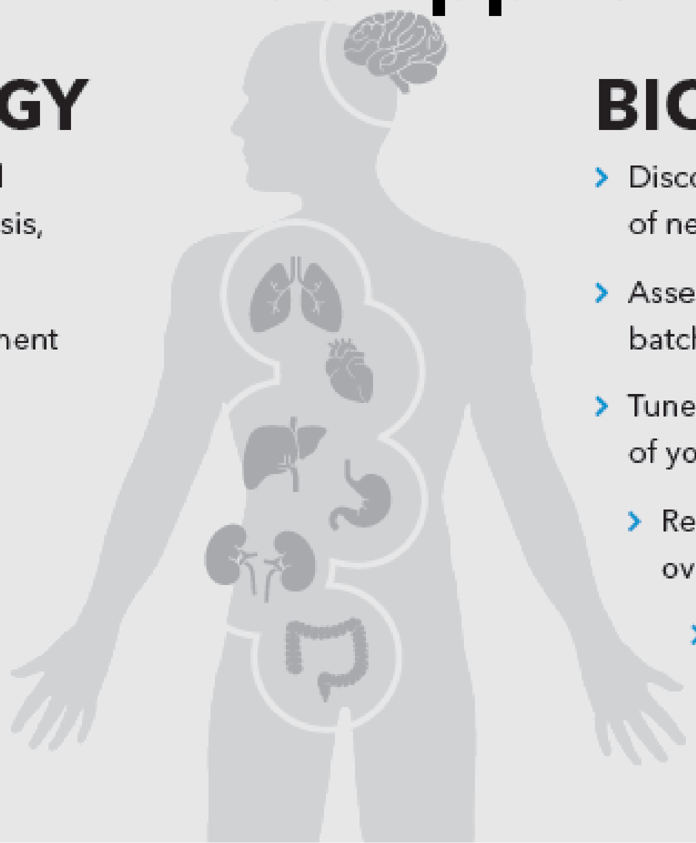




# Where PAVONE can be applied?

## MECHANOBIOLOGY

- Engineer disease models with abnormal mechanical microenvironment e.g. fibrosis, cancer, inflammation.
- Mimic in vivo mechanical microenvironment (compare with native tissues).
- Assess mechanical phenotype of your cell culture.
- Mechanically characterized pathological tissues.
- Study effects of drugs to mechanical integrity of cells and tissue constructs.



## BIOFABRICATION

- Discover mechanical implications of new biofabrication procedures.
- Assess reproducibility of your batch processing.
- Tune mechanical properties of your biomaterials.
- Report mechanical degradation over time.
- Characterize swelling behavior.
- Build mechanically relevant modular tissues.

**Samples**

- ❑ Single cells and monolayers
- ❑ Spheroids and organoids
- ❑ Ex vivo tissues
- ❑ 3D cell culture models
- ❑ Embryos

**Samples**

- ❑ Hydrogels, gels, micorgels
- ❑ Scaffold, ECM
- ❑ Thin films, coatings
- ❑ Polymers

# **HIGH-THROUGHPUT WORKFLOW FOR** CELL OR SPHEROID TESTING

Cell seeding

Incubation

Mechanical testing and imaging

Other bioassays and omics

Data analysis and correlations

Microplate coating