ISTITUTO ITALIANO DI TECNOLOGIA
CENTER FOR LIFE NANO SCIENCE

Microfluidic extrusion of cell-laden hydrogel fibers for 3D Bio-printing

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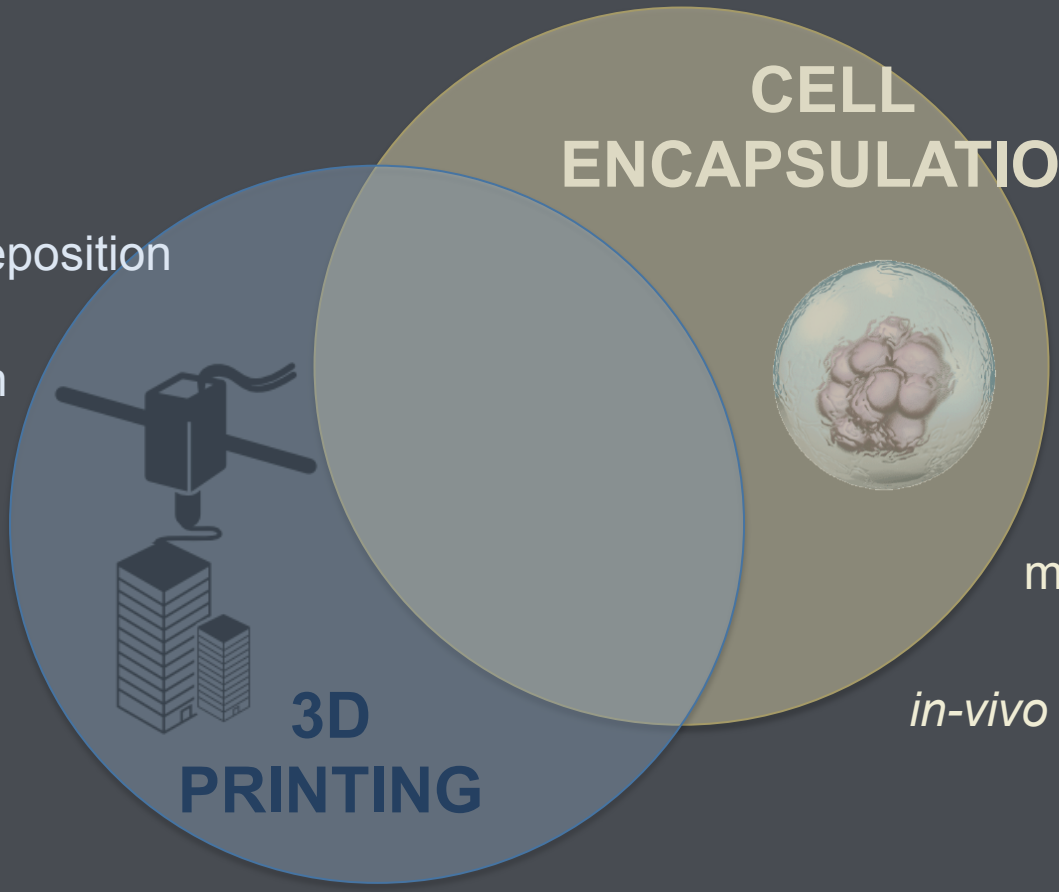
Viale Regina Elena 291 - Roma

Nano Innovation 2016 Rome, 20-23 September
Conference & Exhibition

3D Bio-Printing



layer-by-layer deposition

custom design

repeatability

3D embedding matrix of bioactive, hydrophilic macromolecules

in-vivo like tissues

3D Bio-Printing

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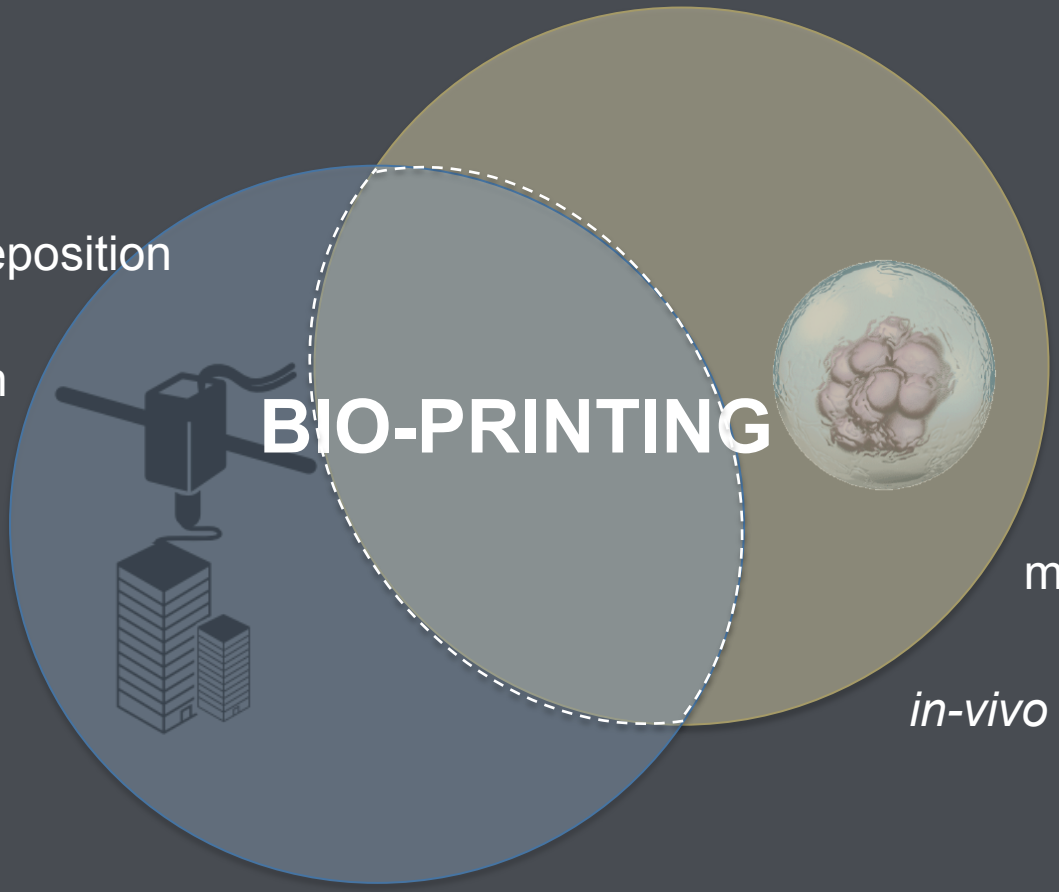


3D embedding matrix of bioactive, hydrophilic macromolecules

in-vivo like tissues

Design and fabrication of custom-designed artificial 3D living tissues

3D Bio-Printing

bio-ink:

living cells
+
supporting hydrogel

I phase

3D PRINTING

performances of the printing strategy

biocompatibility
speed
easy-to-use
multi-material?
multi-cells?
resolution

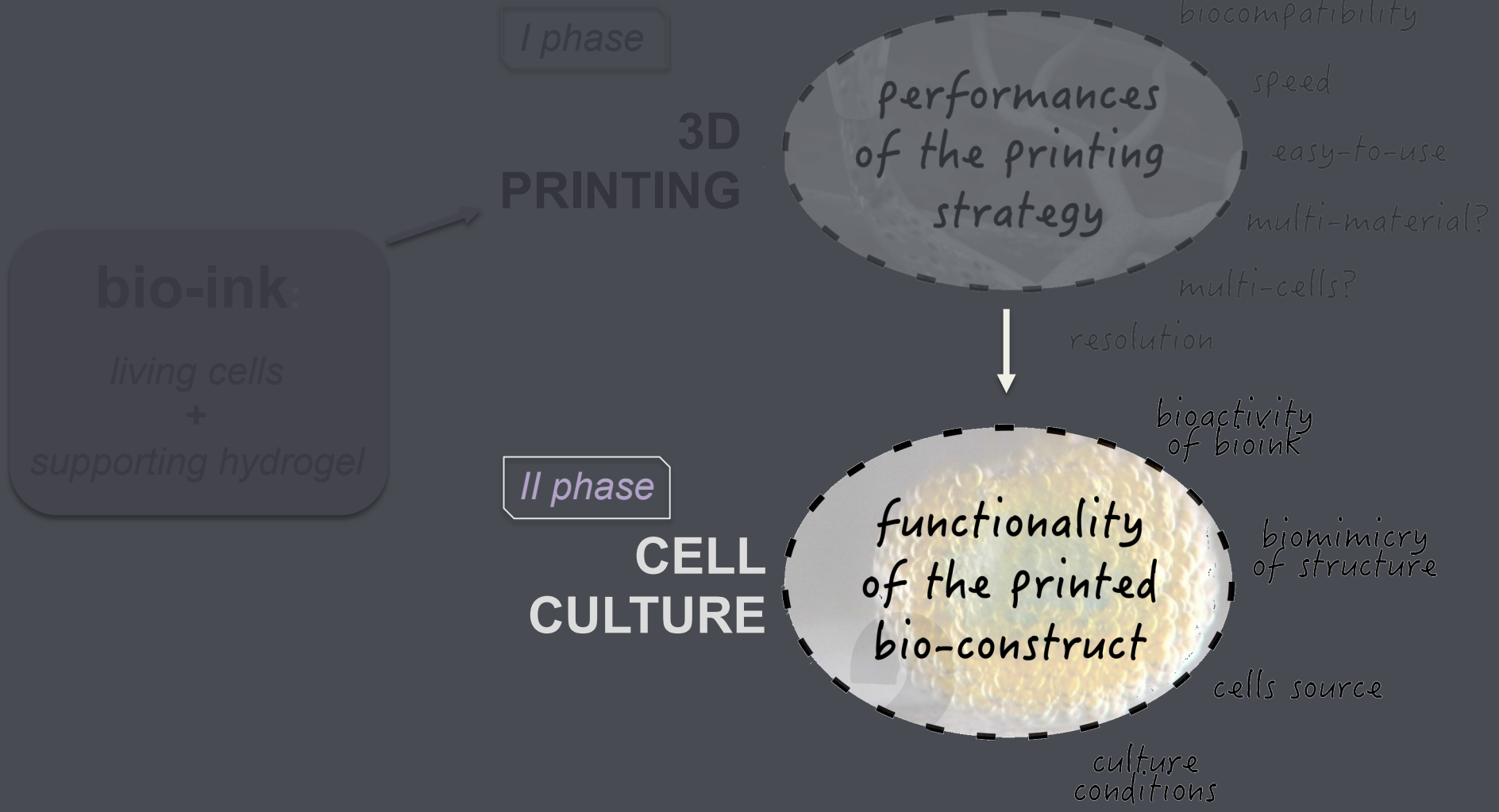
II phase

CELL CULTURE

functionality of the printed bio-construct

bioactivity of bioink
biomimicry of structure
cells source
culture conditions

3D Bio-Printing



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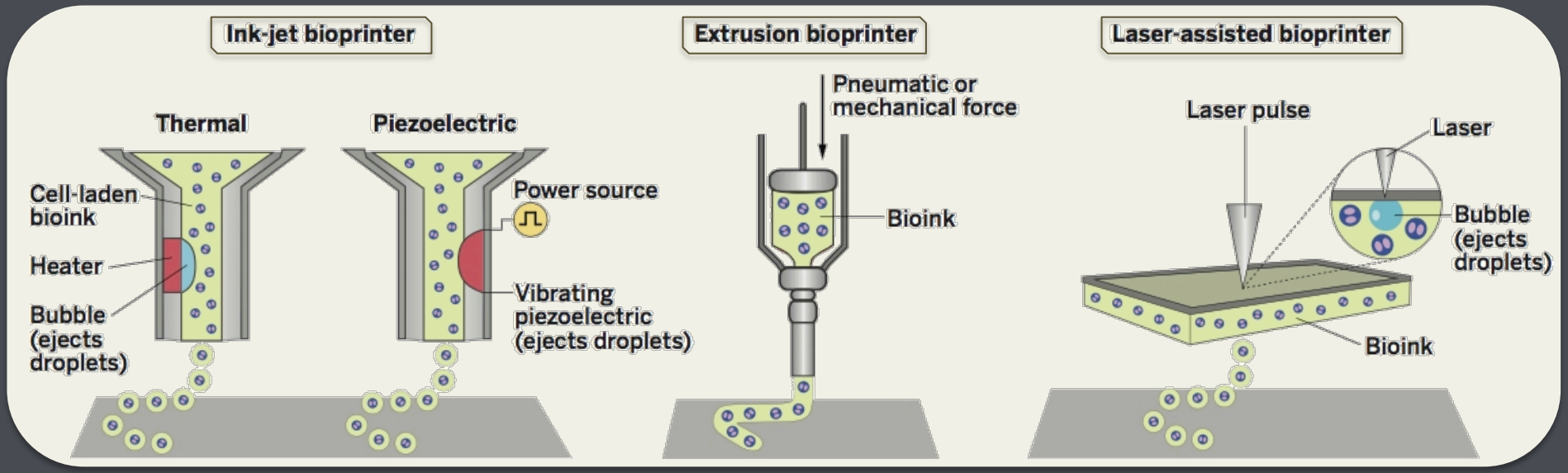

- fast
- low cost
- high precision
- suitable only for low density hydrogels
- poor mechanical properties

- fast
- low cost
- big range of suitable materials
- poor precision

- high precision
- no material limitations
- high costs
- labor expensive

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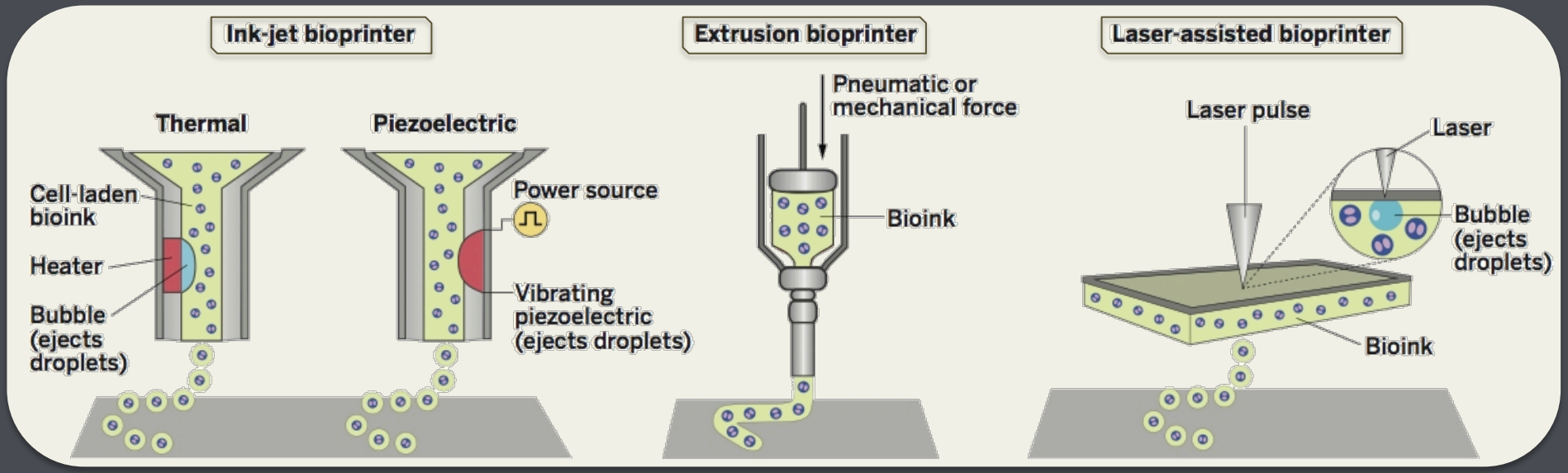

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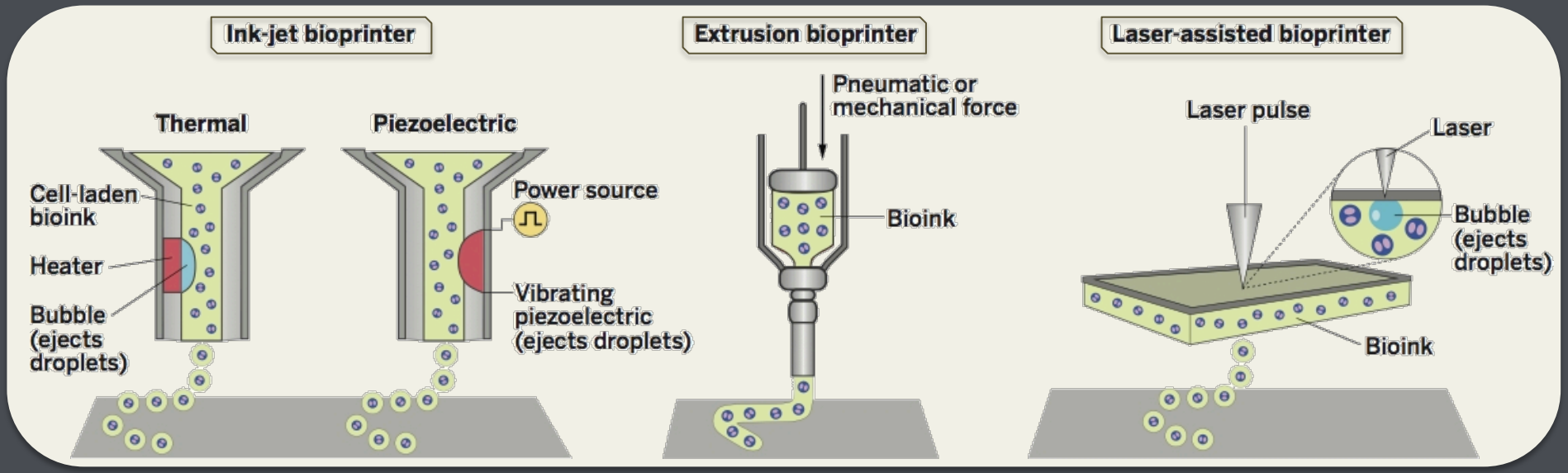

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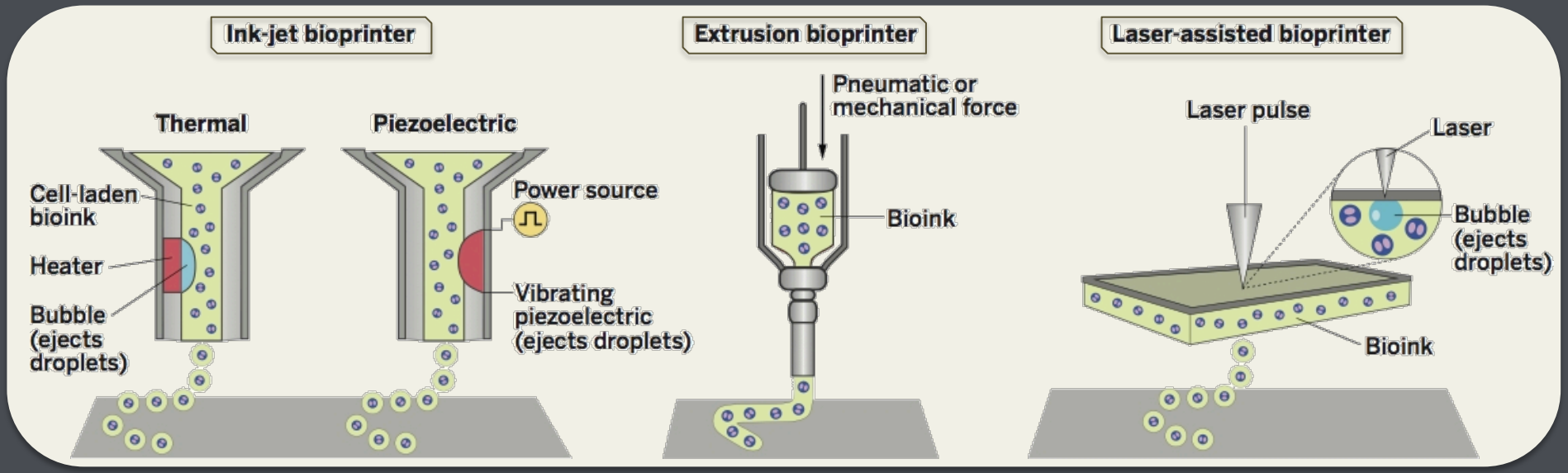
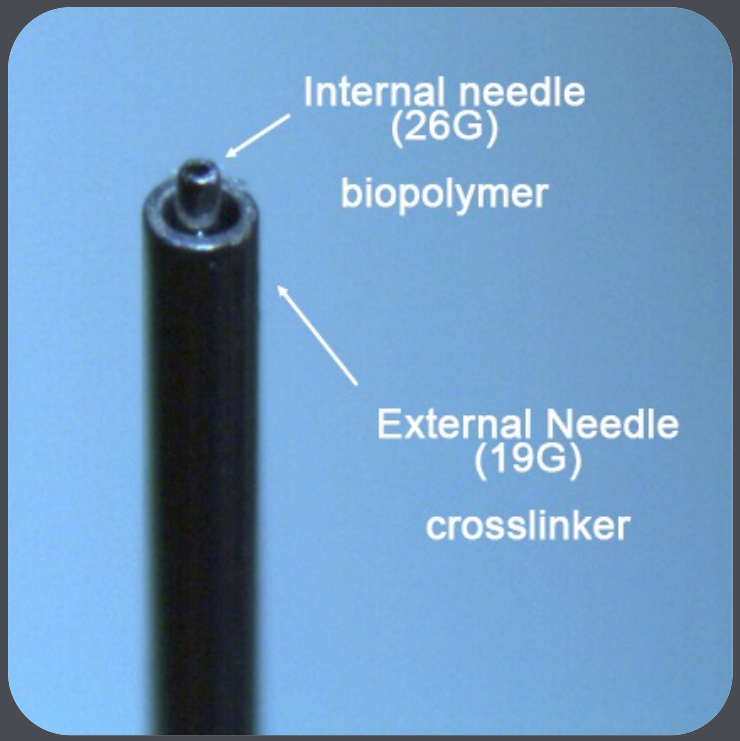
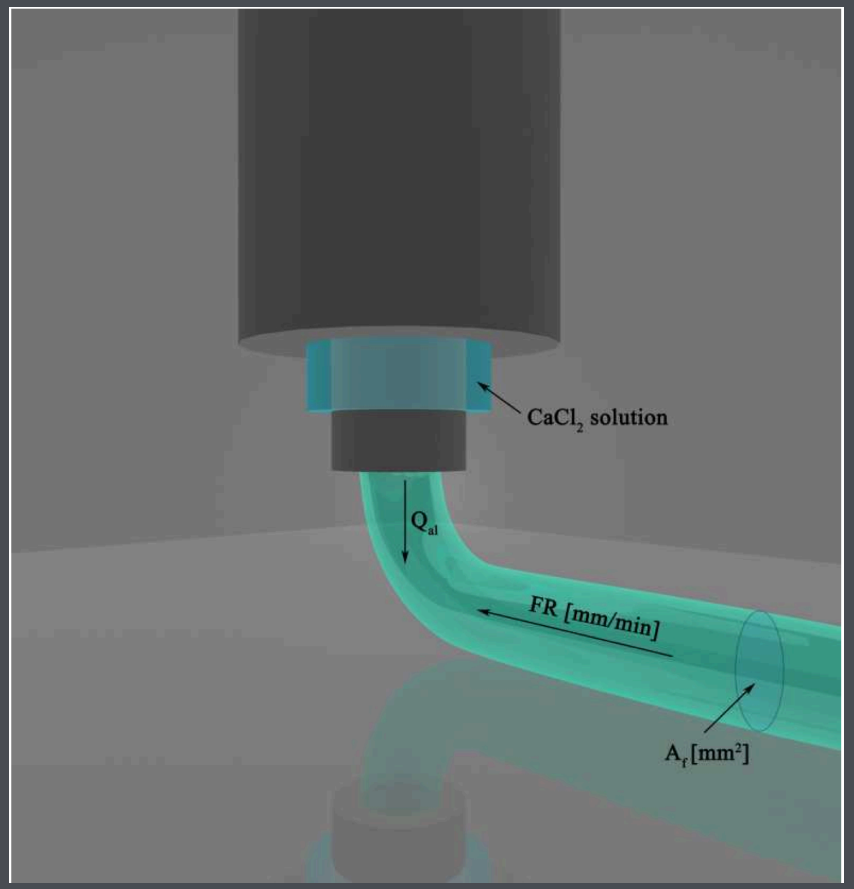


- fast
- low cost
- big range of suitable materials
- ~~poor precision~~ → **Microfluidic extrusion**

Microfluidic Coaxial Extrusion

Coaxial needle extruder for fast gelling macromolecules





Microfluidic Coaxial Extrusion

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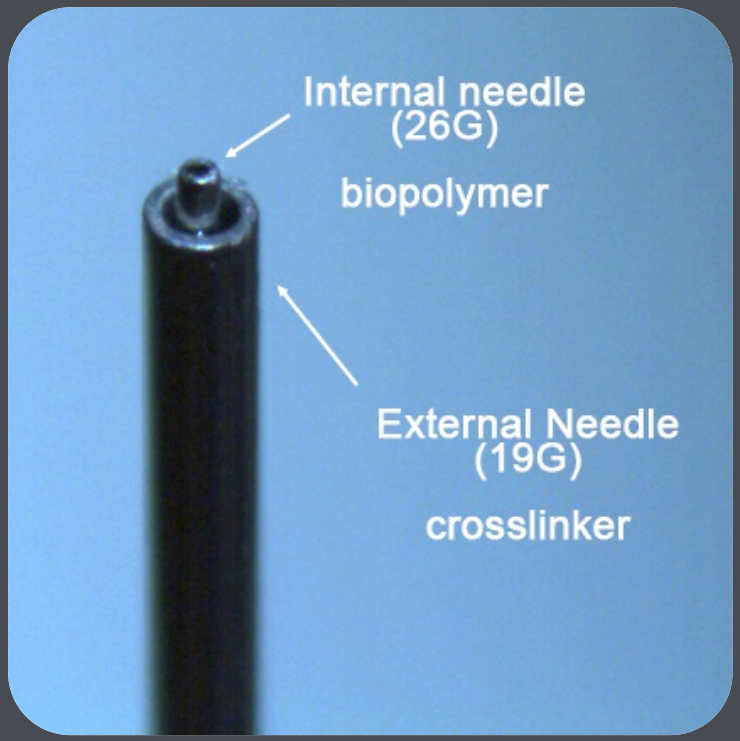
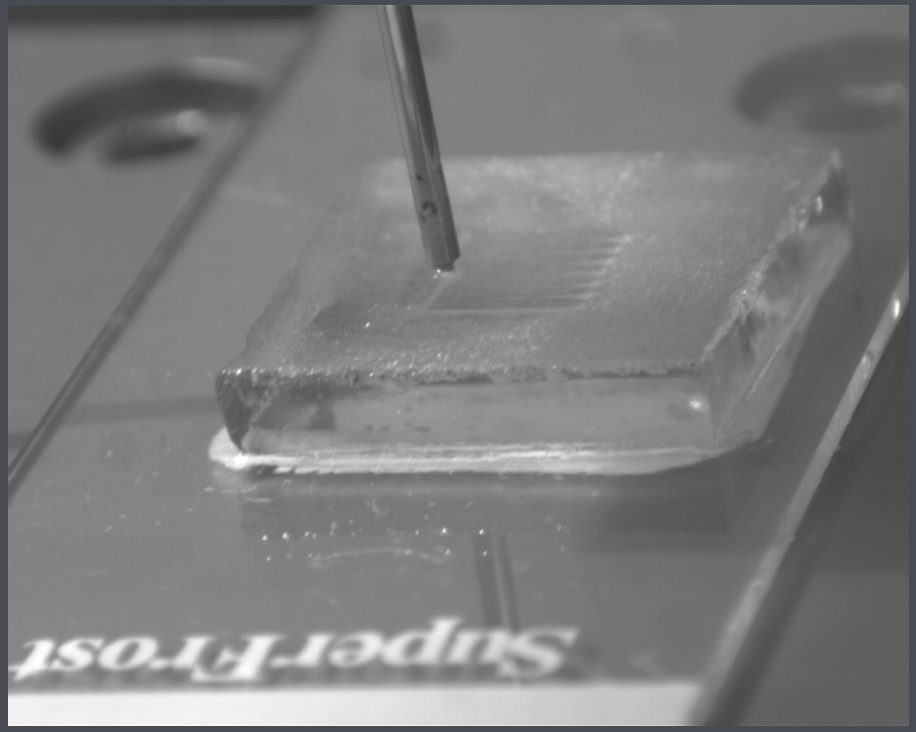
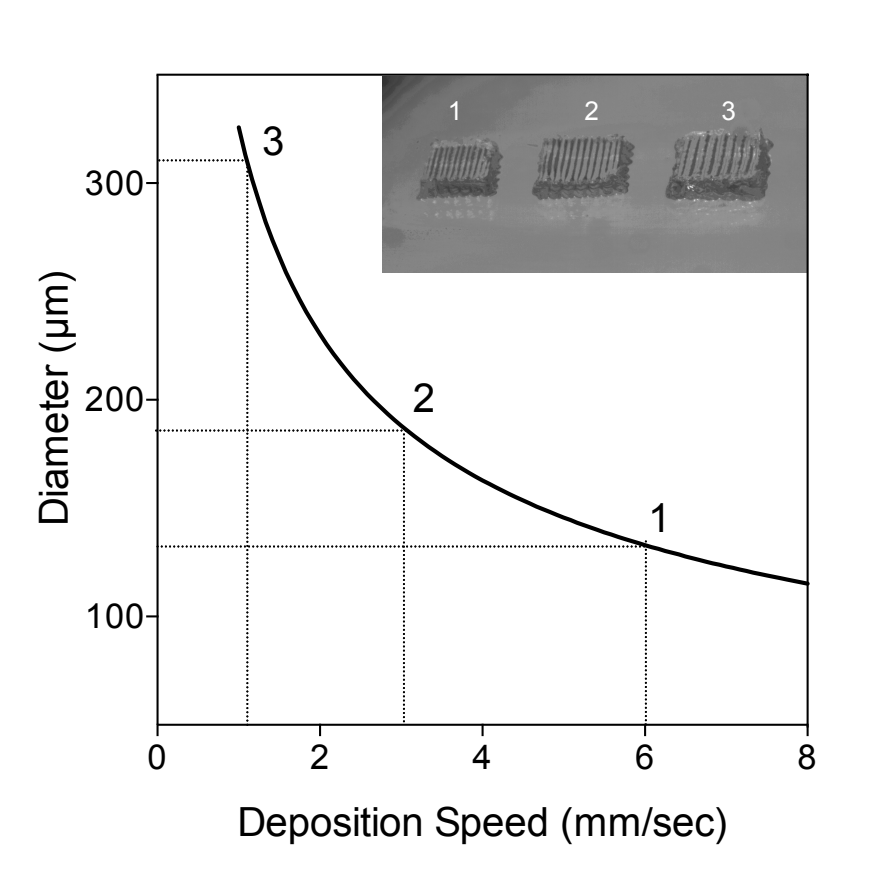
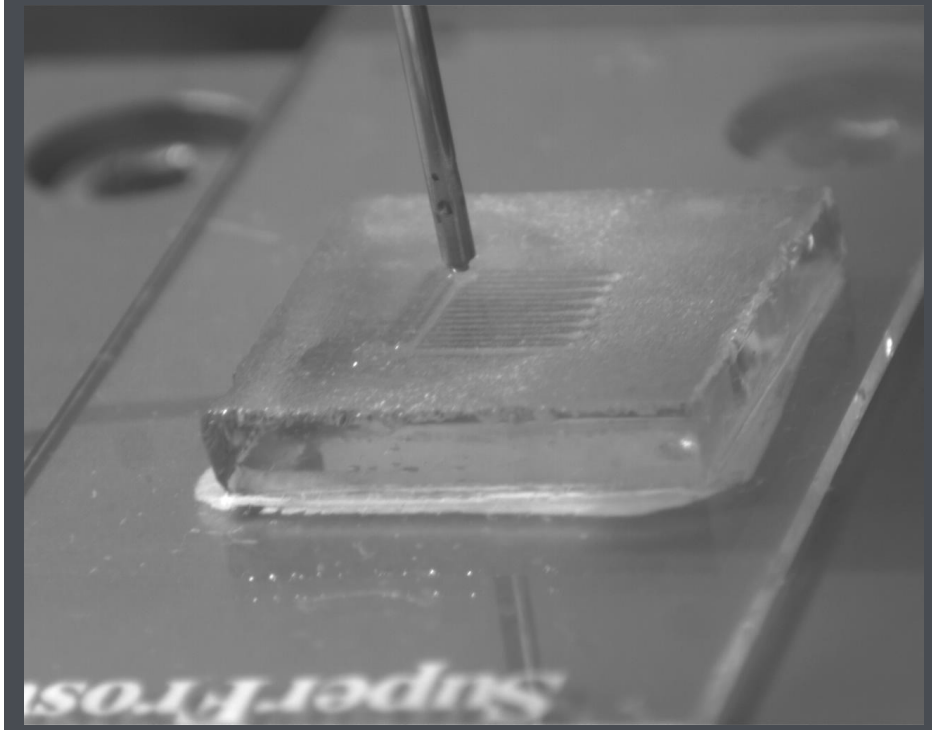




Microfluidic Coaxial Extrusion

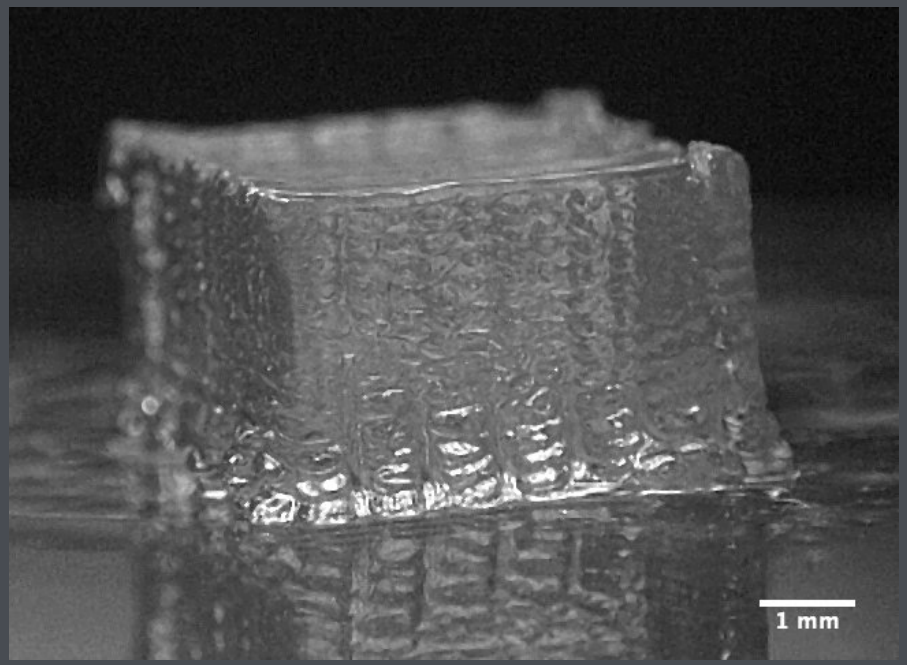
- different fiber diameters (300 - 100 μm)

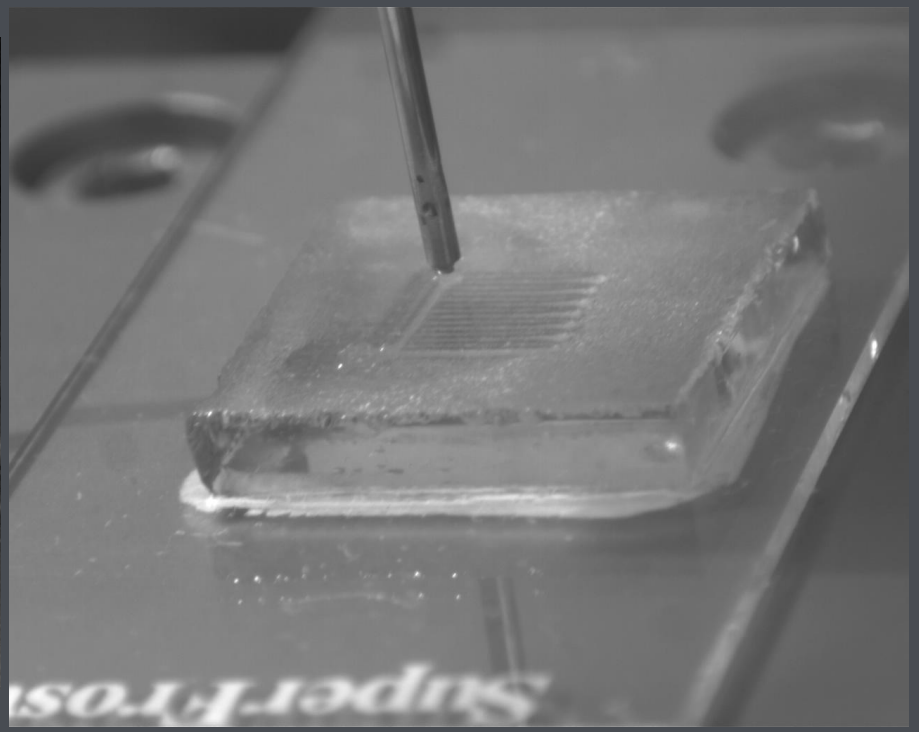




Microfluidic Coaxial Extrusion

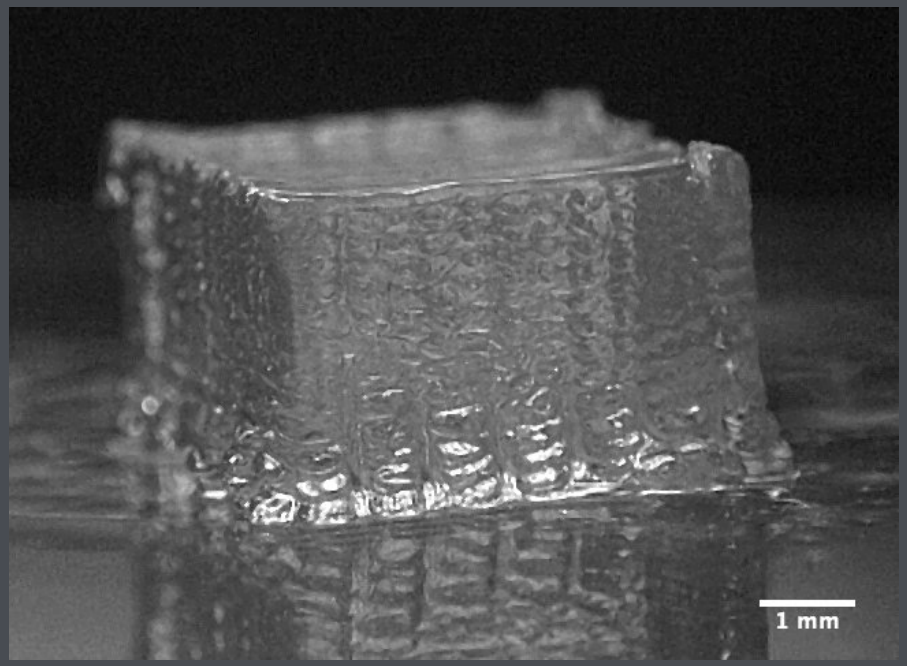
- multilayered structures

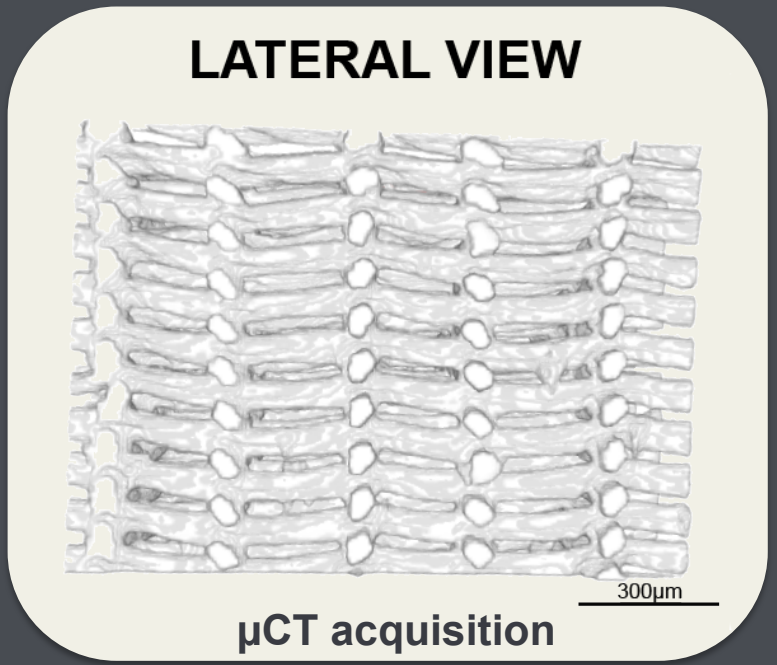




Microfluidic Coaxial Extrusion

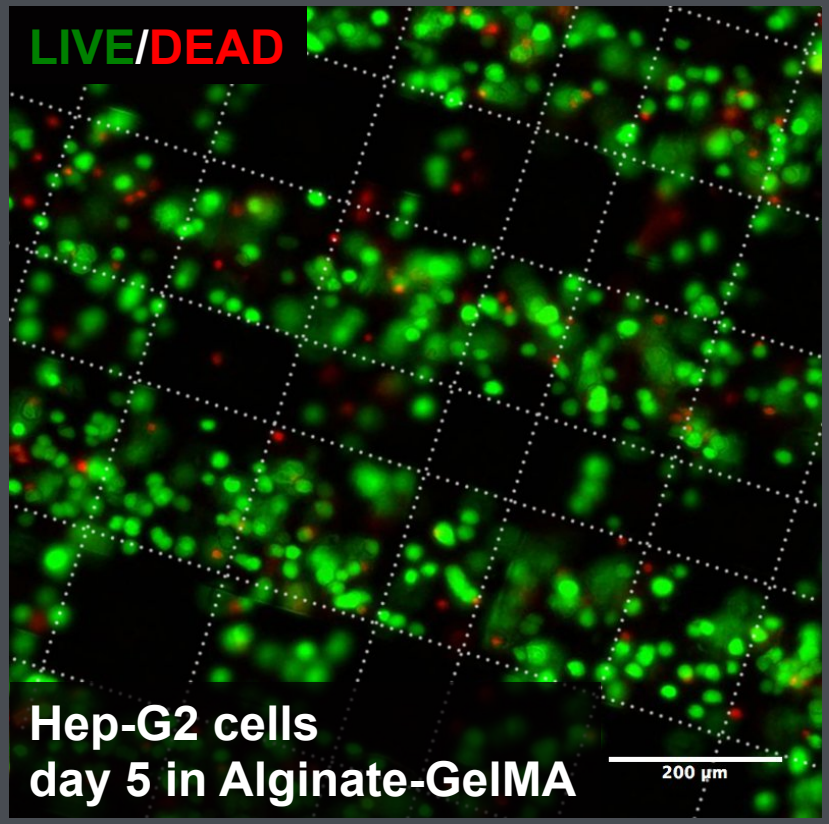
- 3D interconnection among fibers

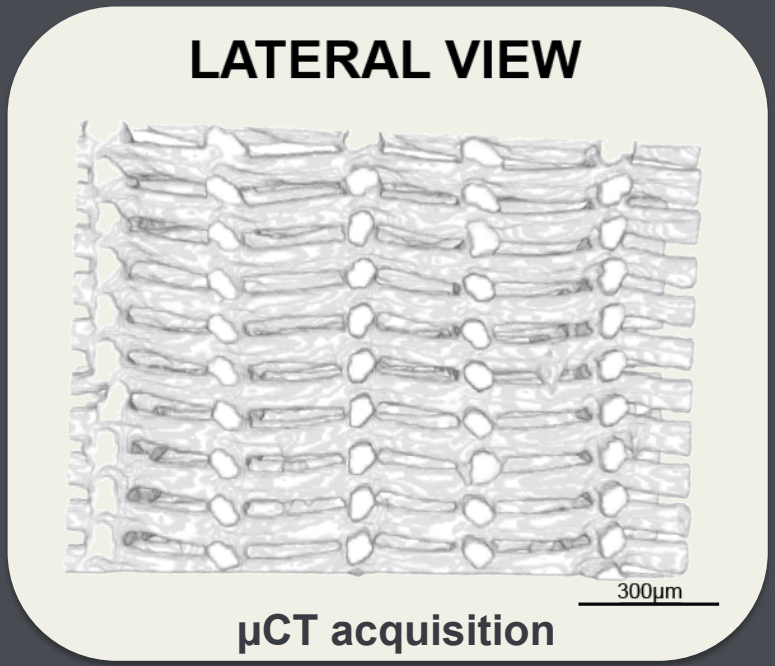




Microfluidic Coaxial Extrusion

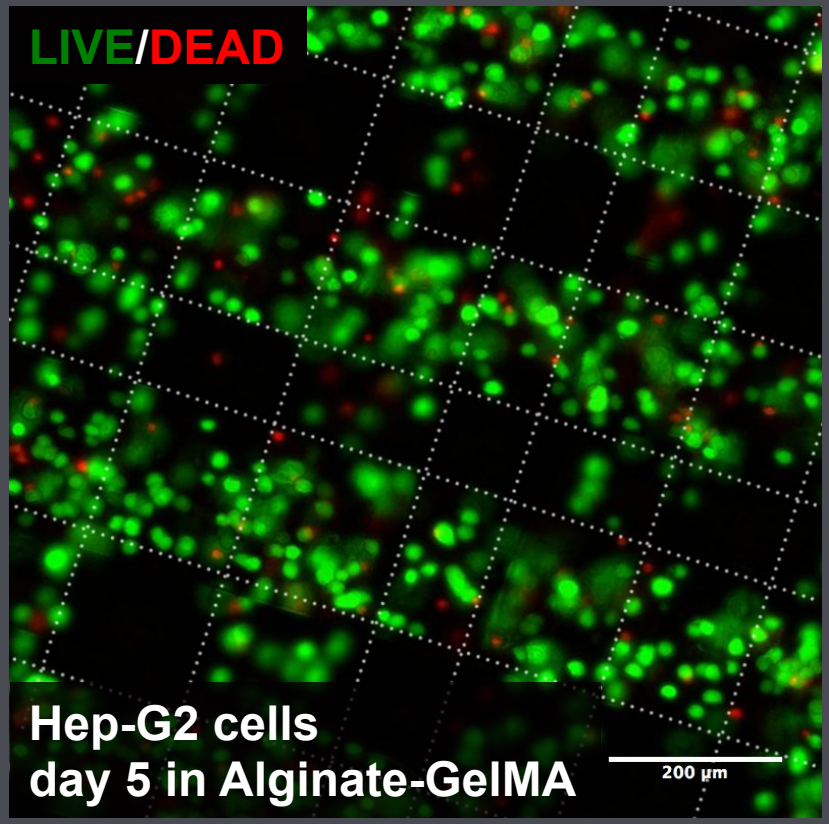
- high cell viability

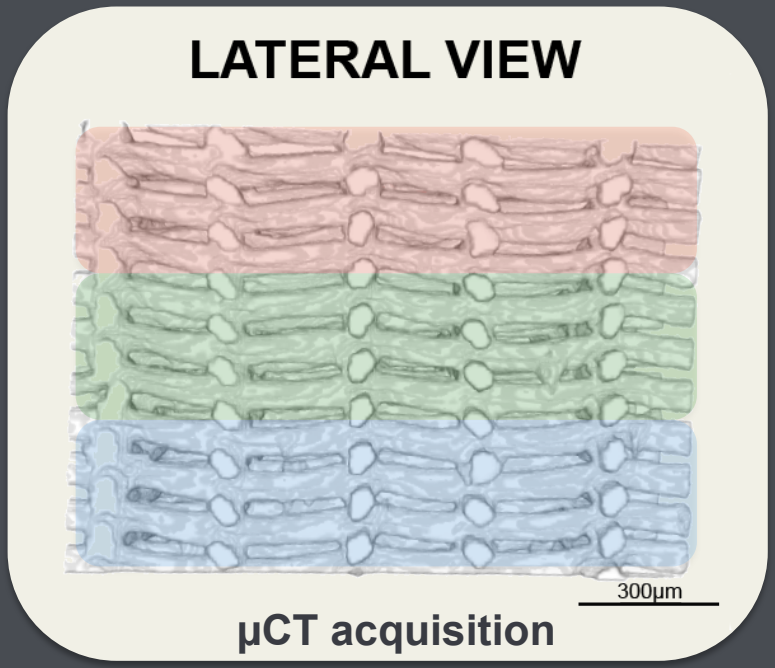




Microfluidic Coaxial Extrusion

- uniform cell viability





Microfluidic Coaxial Extrusion

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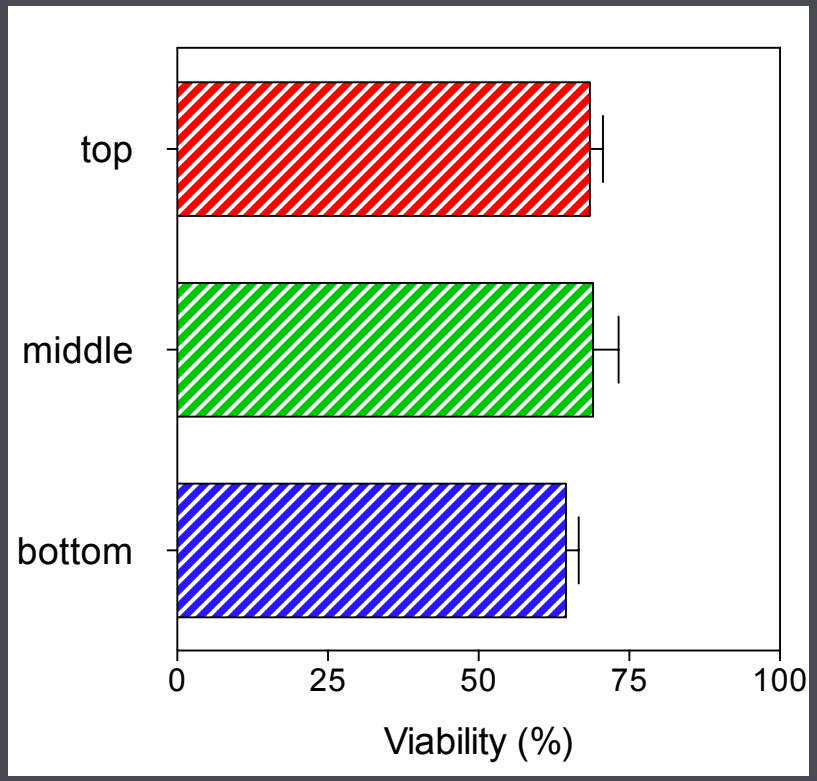
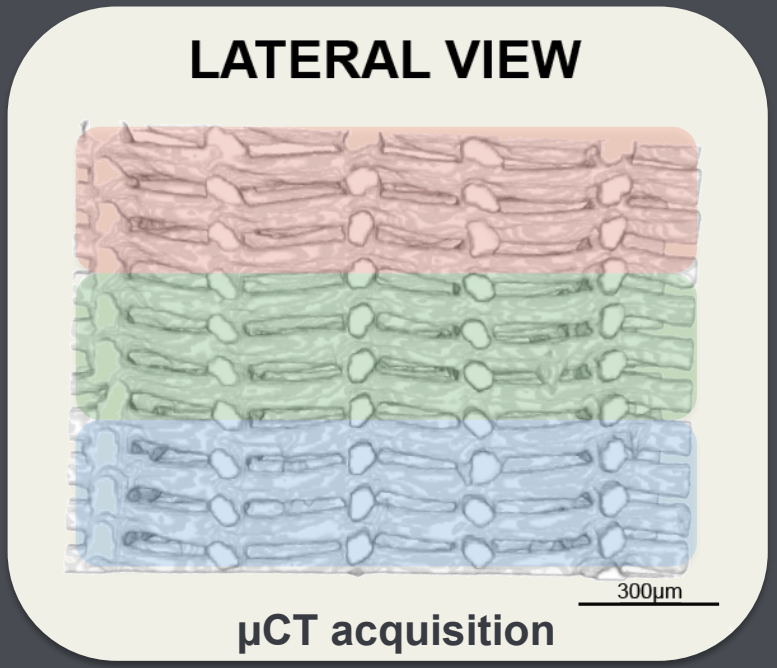
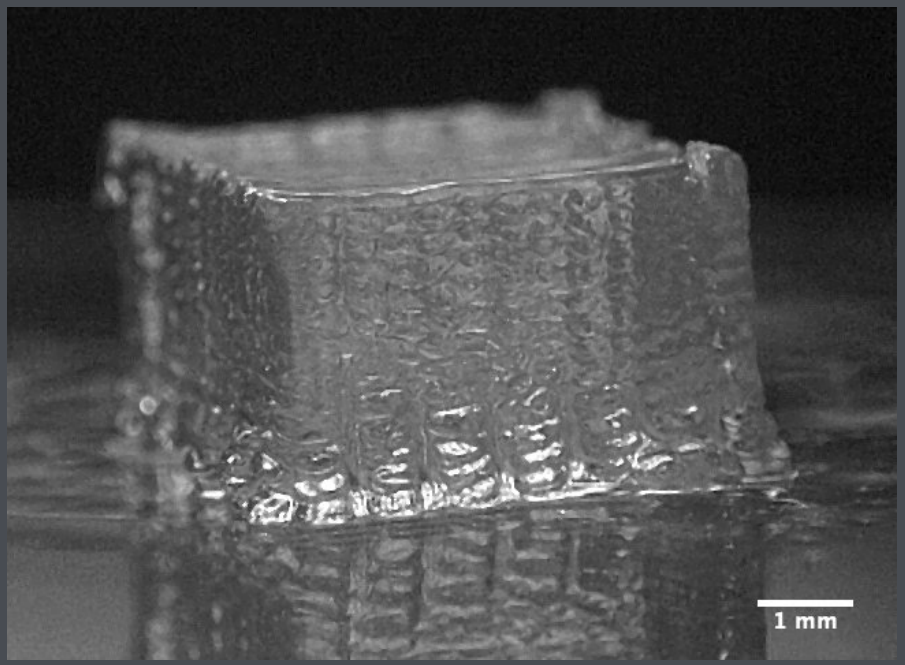




Microfluidic Coaxial Extrusion

- many possible extracellular matrix composition



Radical crosslinking (UV):
- gelatin (methacrylol)
- dextran (metacrylol)

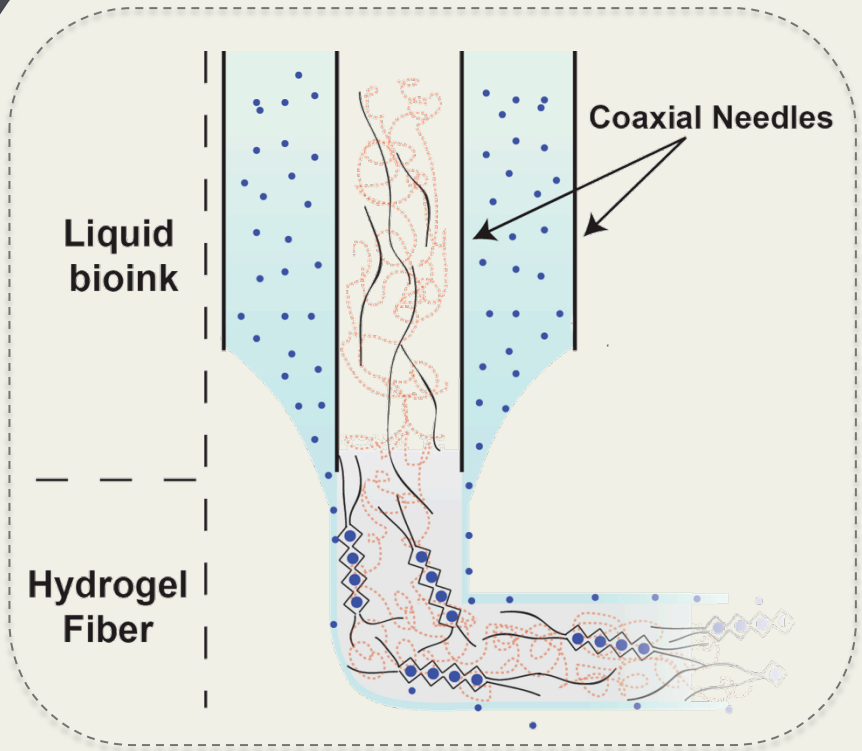
Enzymatic crosslinking:
- fibrinogen

Self-assemby
- collagen
- fibroin

+ alginate

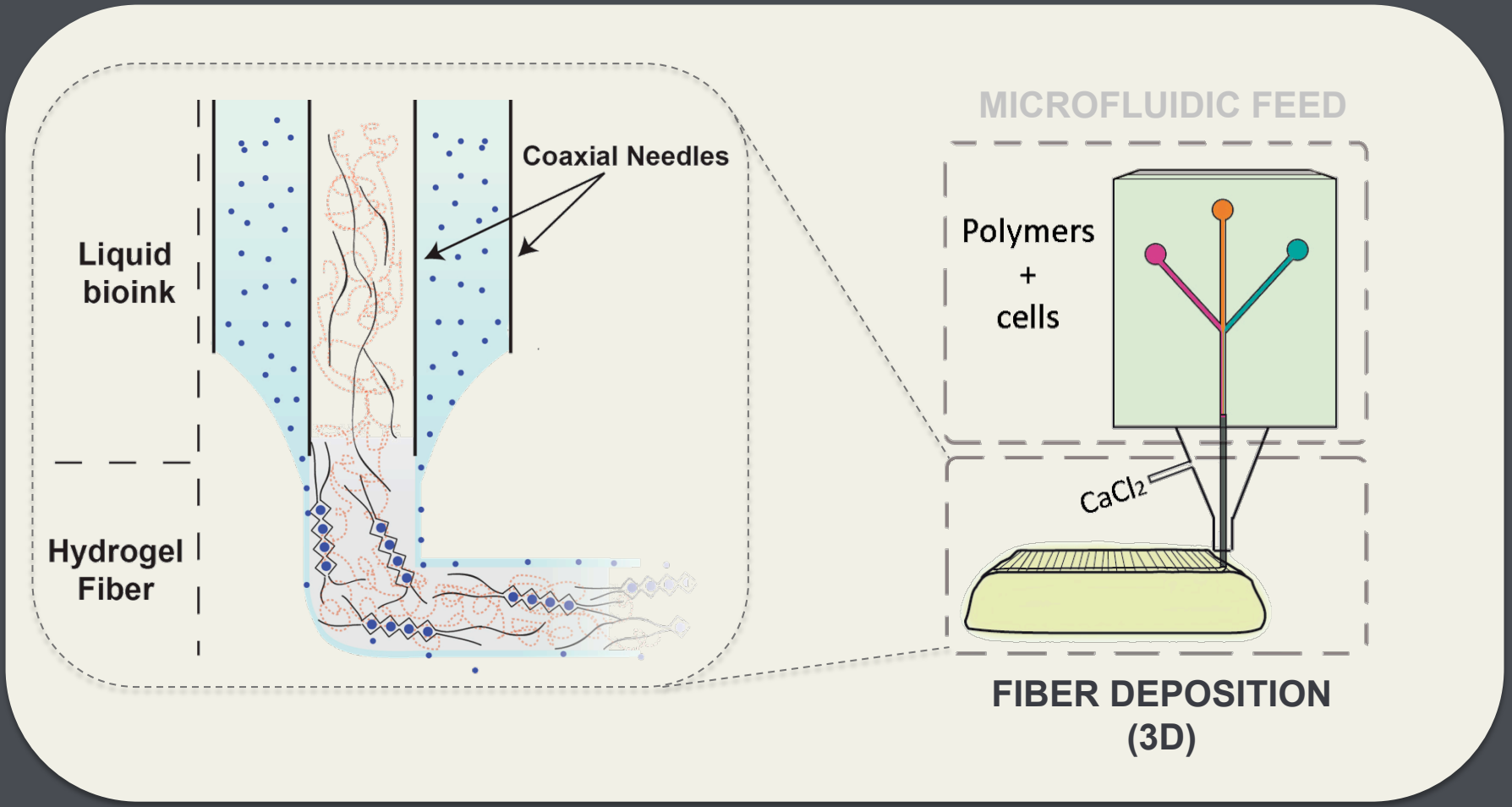
2-step crosslinking

Microfluidic Coaxial Extrusion



- fibers with diam = 300-100μm
- 3D interconnectivity
- high and uniform cell survival
- different possible compositions of embedding hydrogel

Microfluidic feeding



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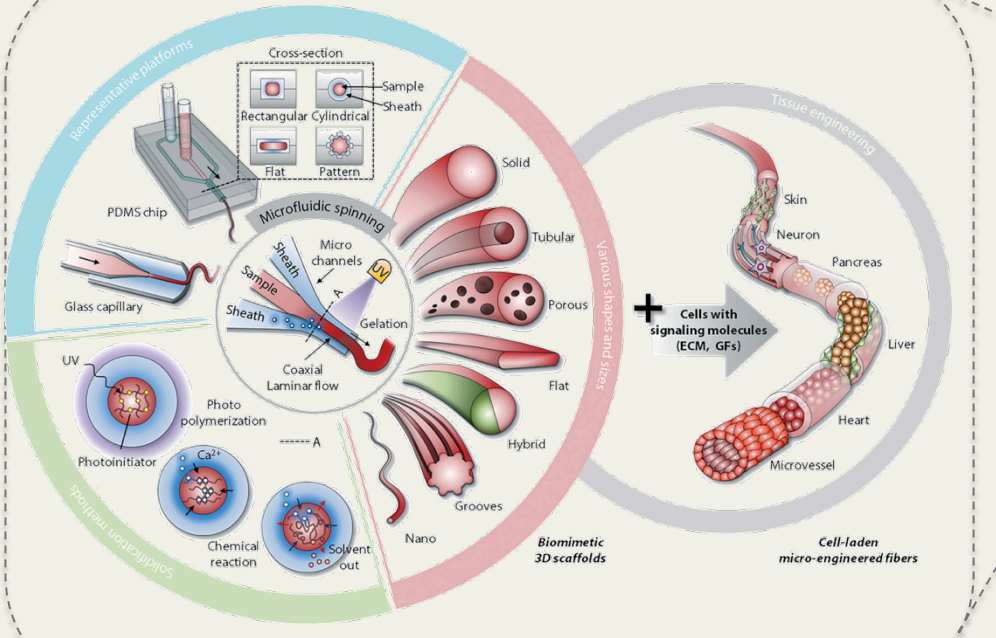
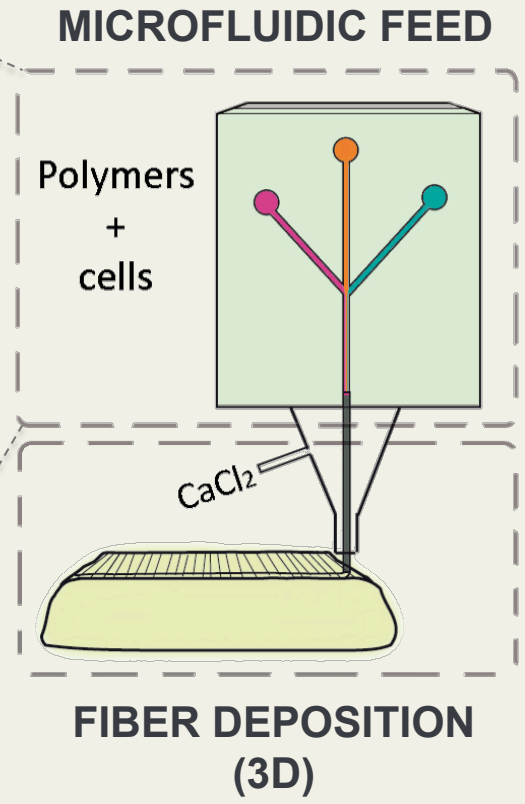


Lab Chip, 2014, 14, 2145



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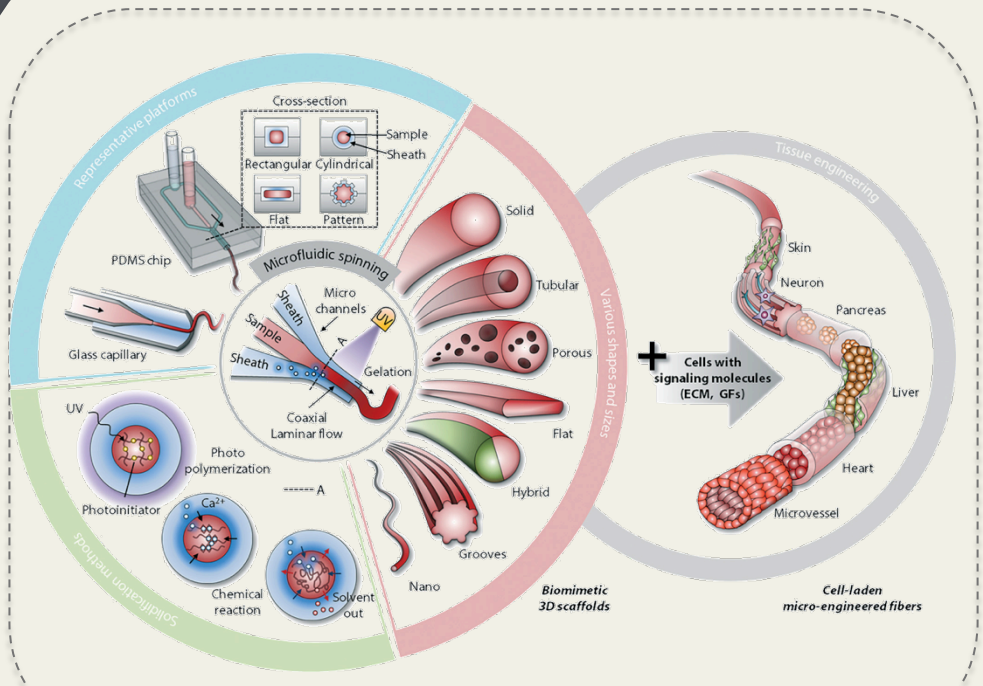

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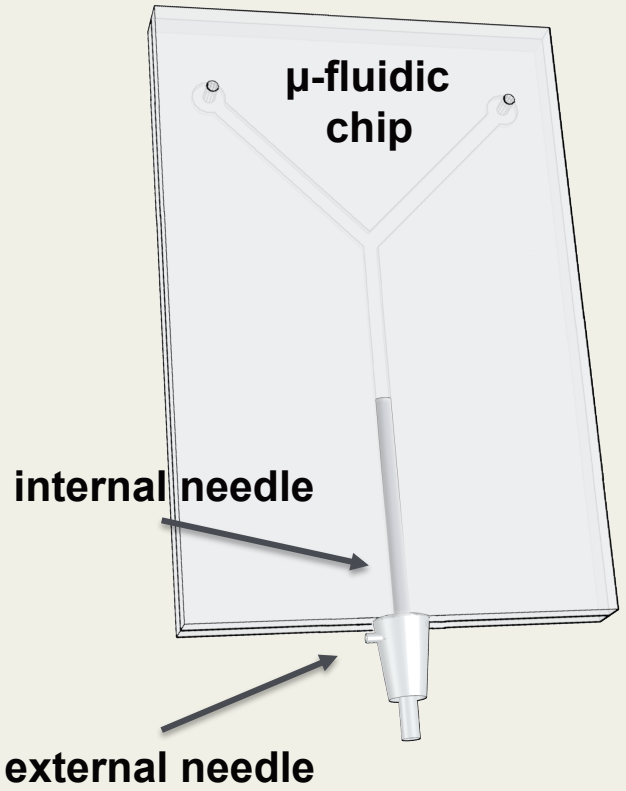

Microfluidic mixing

- Changing composition of the bioink ***on-the-fly***

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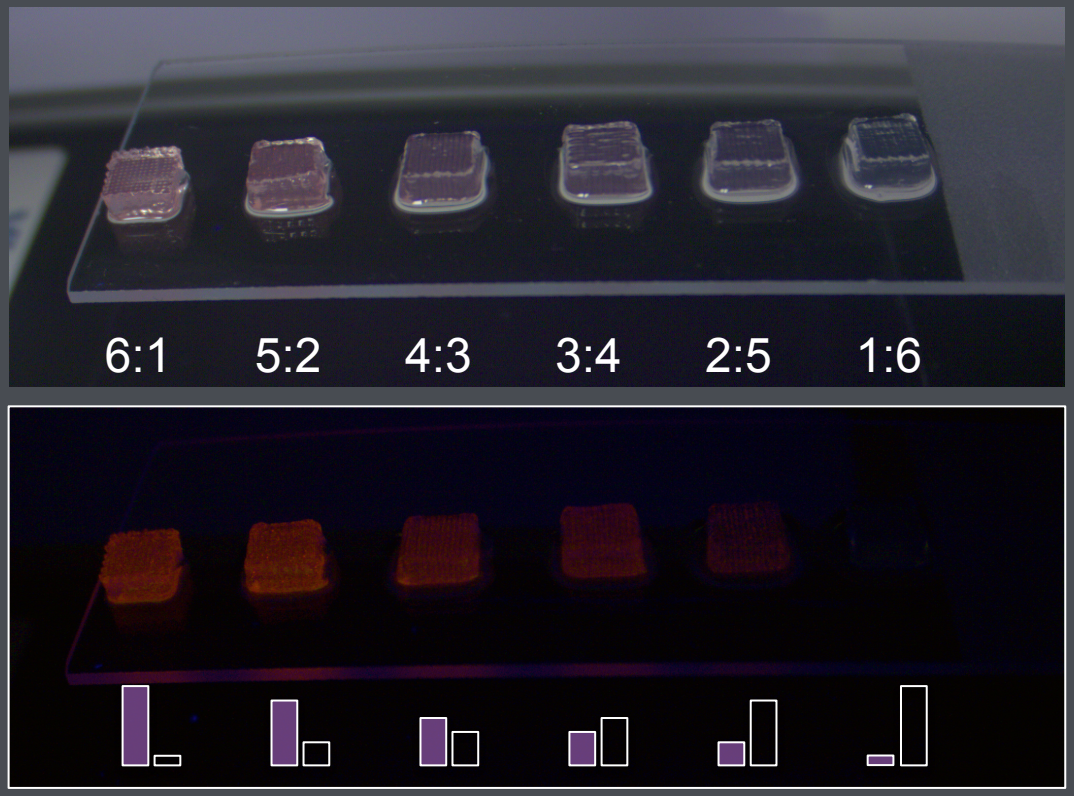

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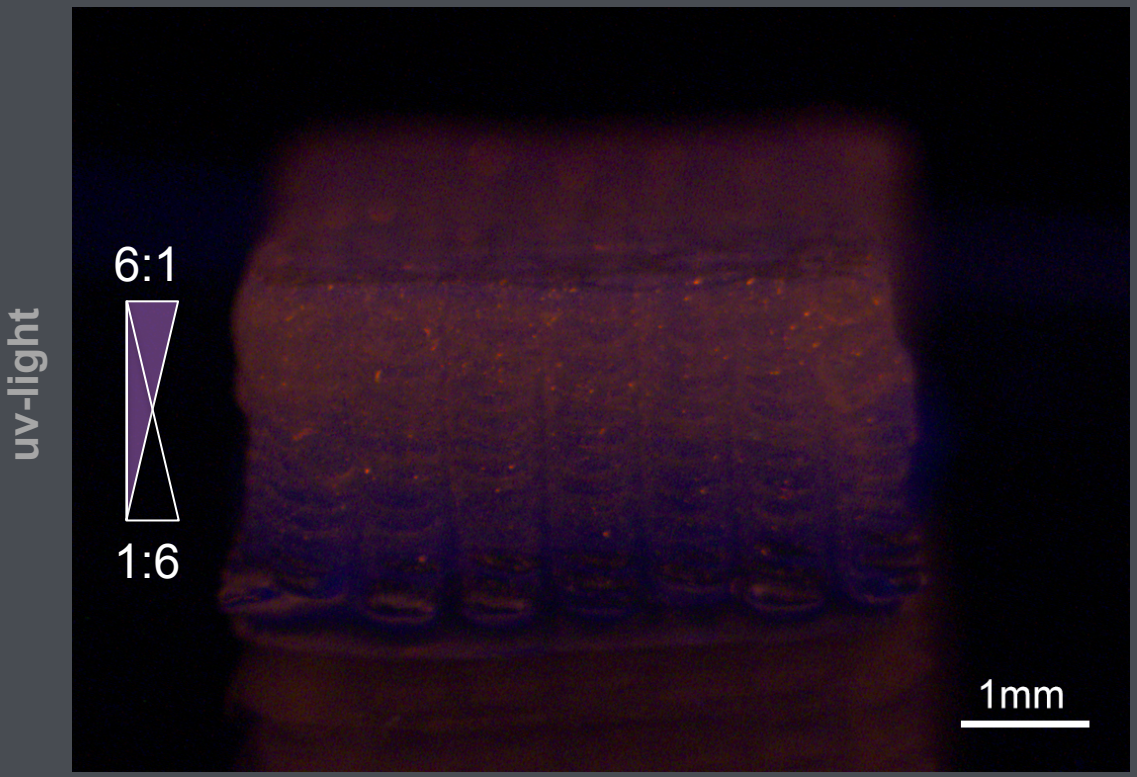
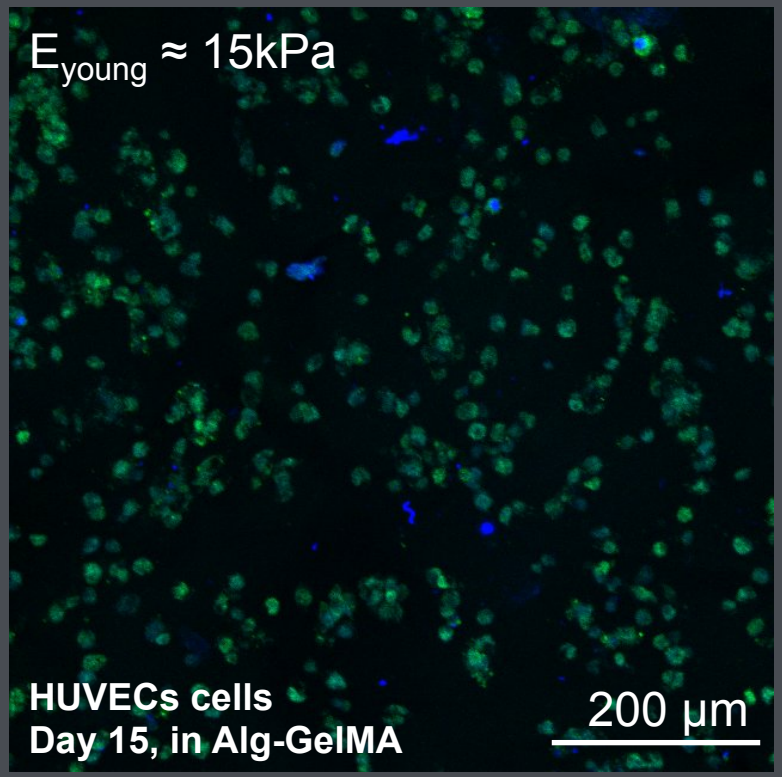
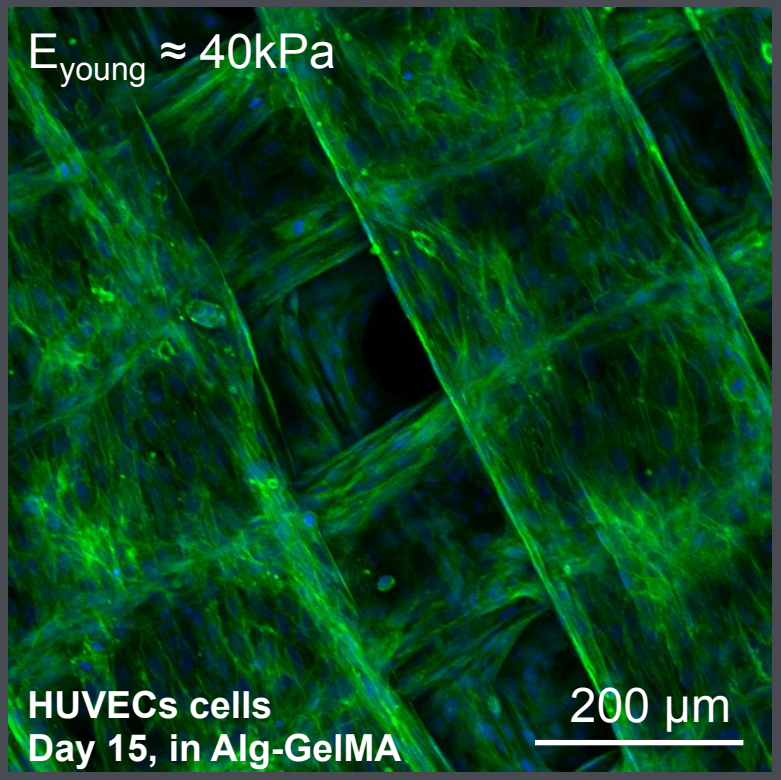


Microfluidic mixing

- Changing composition of the bioink:

  - components of the extracellular matrix



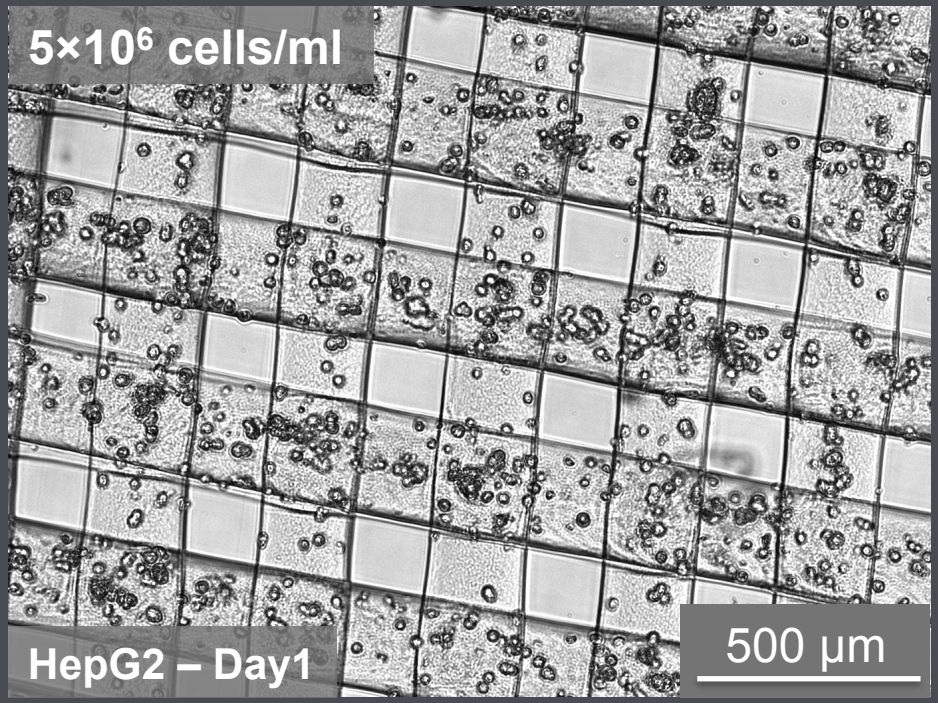


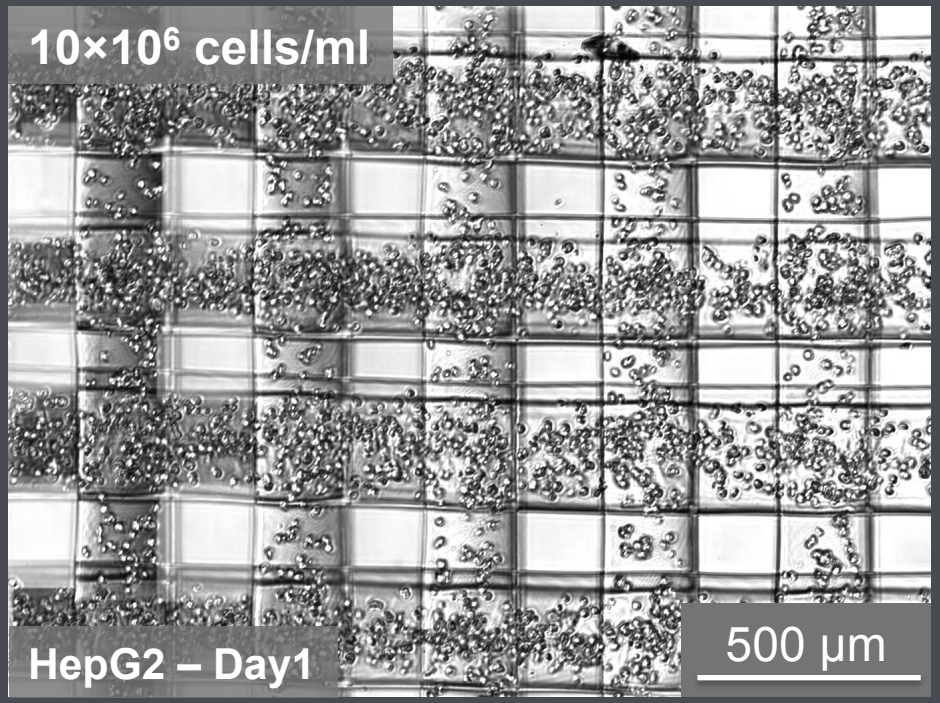
Adv. Mat, 2016, 28, 677

Microfluidic mixing

- Changing composition of the bioink:

  - cell density





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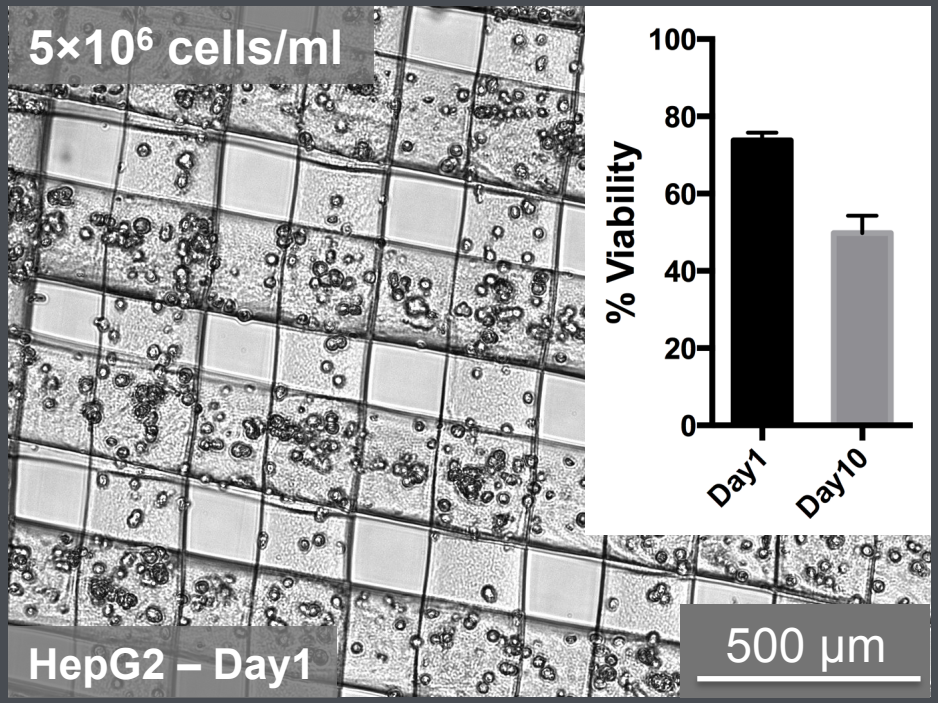
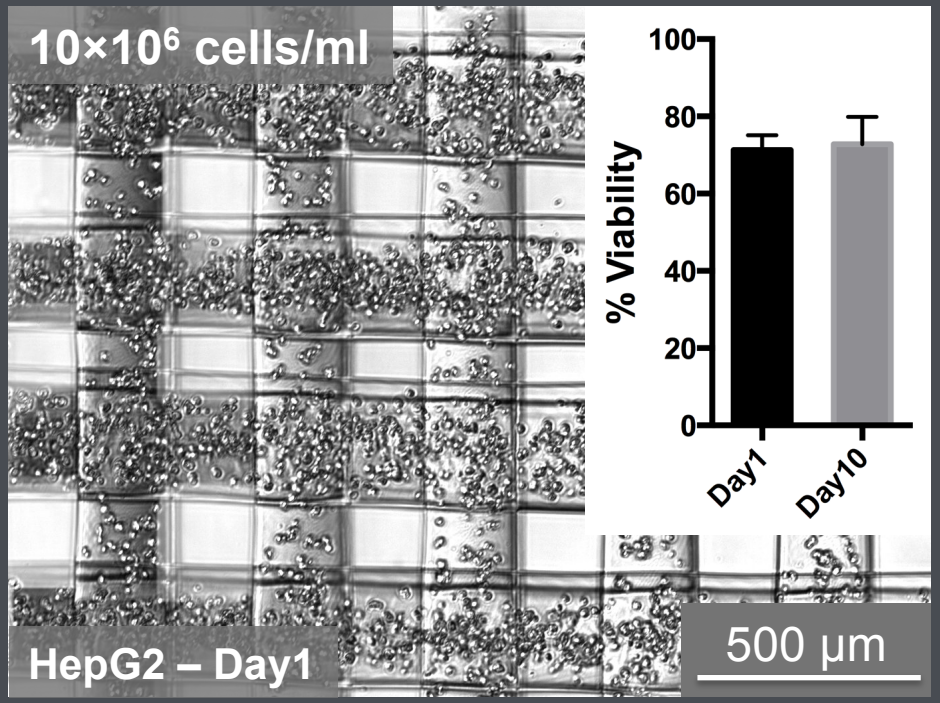
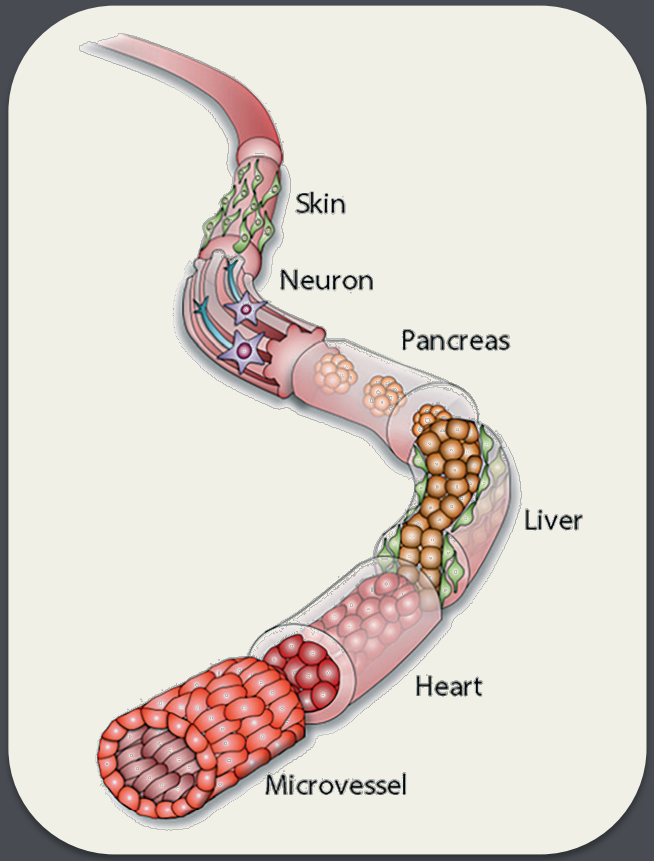




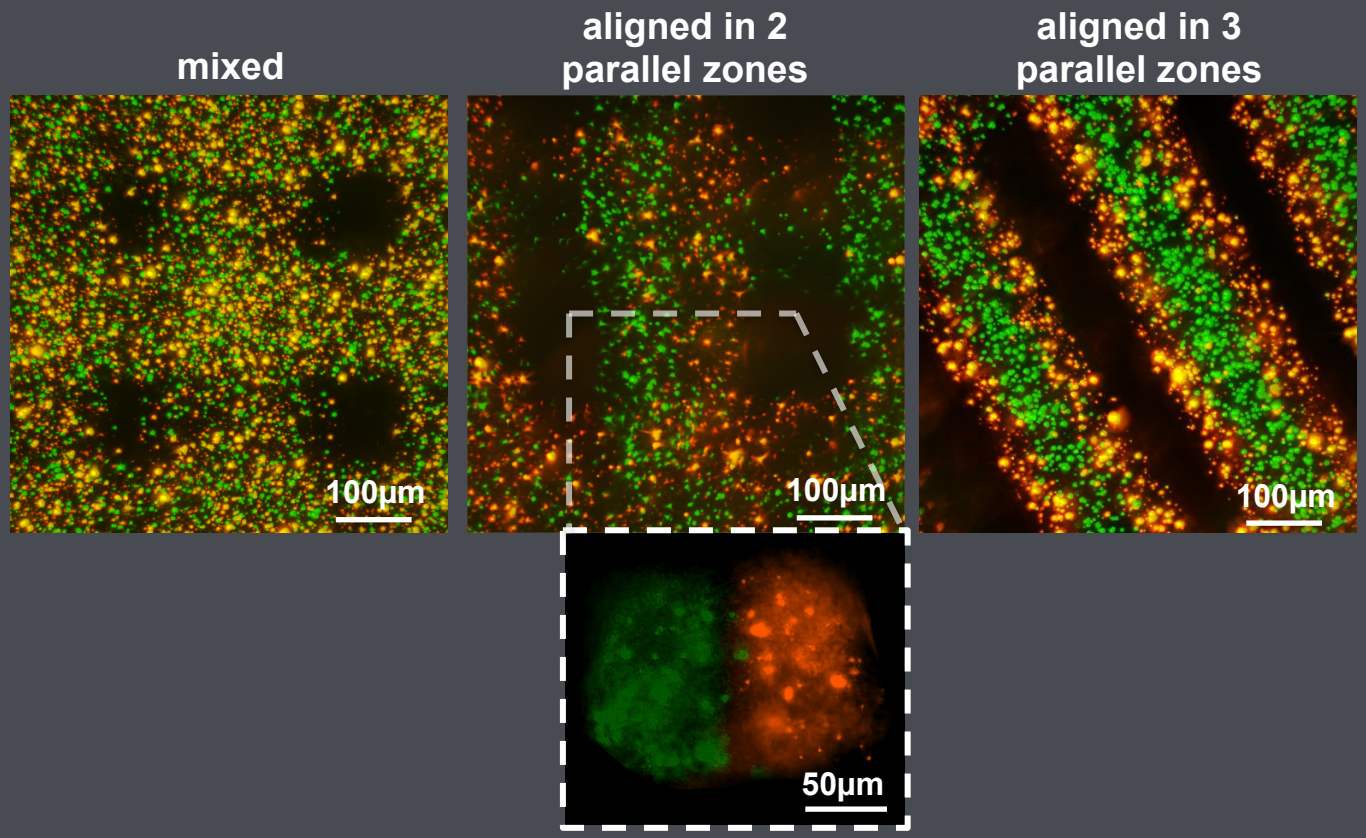
Microfluidic patterning

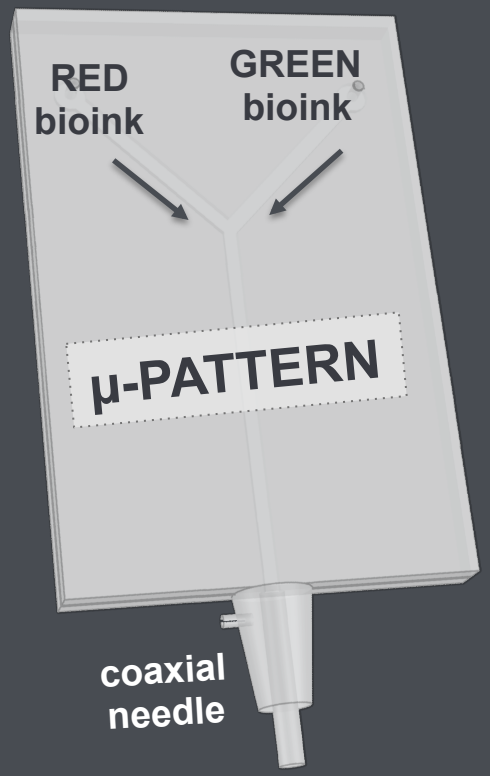
- Creating heterogeneous structures (cells ~ ECM)



Microfluidic patterning

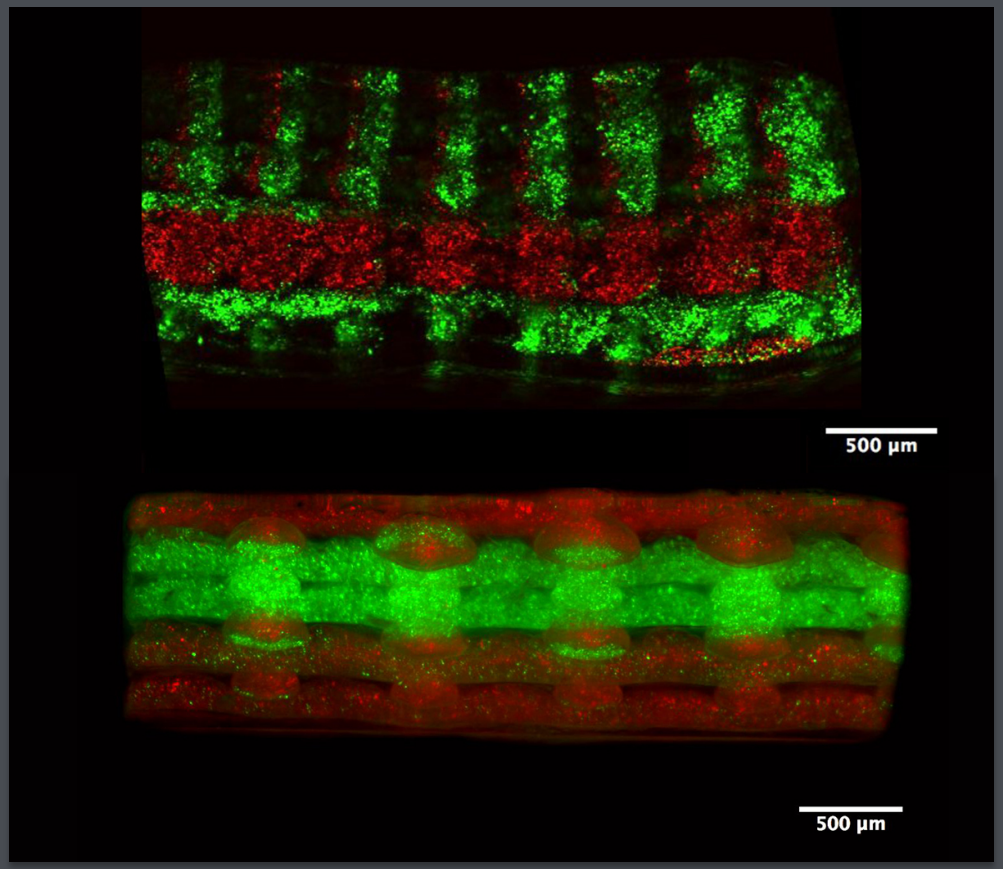
- Creating heterogeneous structures (cells ~ ECM)
  in the same fiber

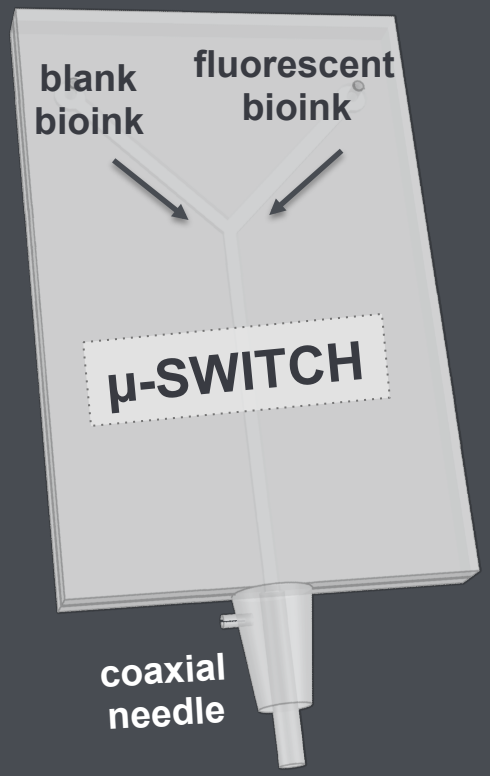




Microfluidic switching

- Creating heterogeneous structures (cells ~ ECM)
  in the same construct





Adv. Mat, 2016, 28, 677

Future perspectives… modular approach

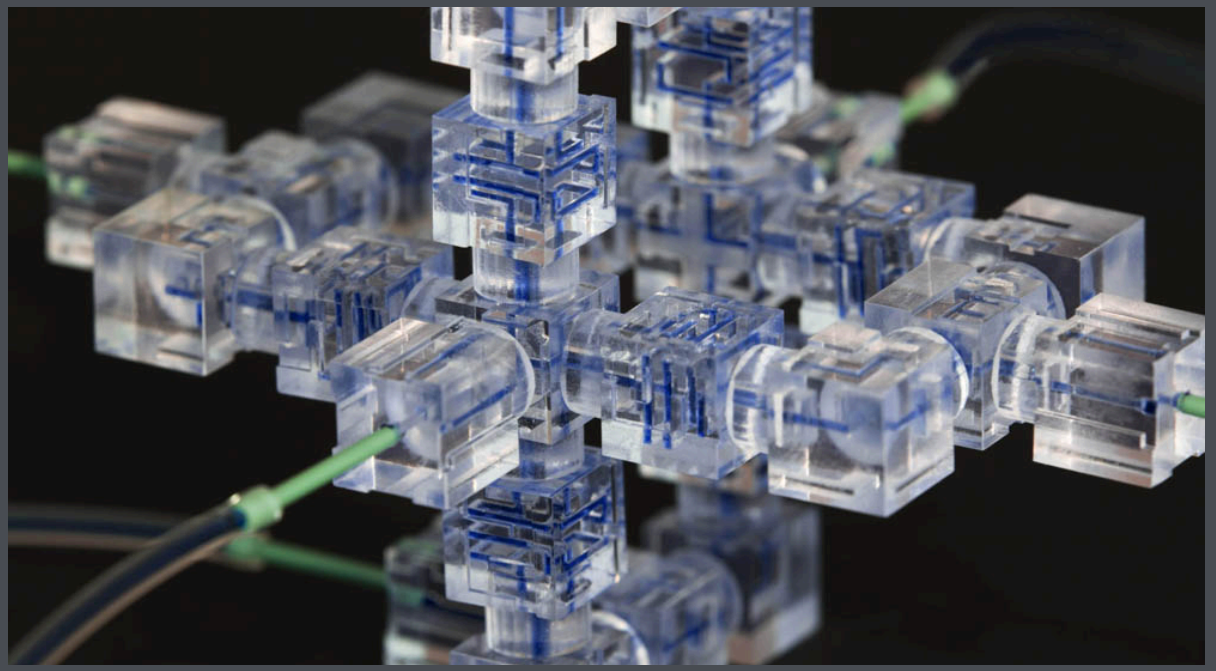
3D-PRINTED

LEGO μFLUIDIC

COMPONENTS

associated with

3D deposition



PNAS, 2014, 111, 42,15013

CUSTOMIZE THE 3D-BIOPRINTER

DEPENDING ON THE SPECIFIC APPLICATION

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CENTER FOR LIFE NANO SCIENCE

thanks to:

iit

G. Ruocco
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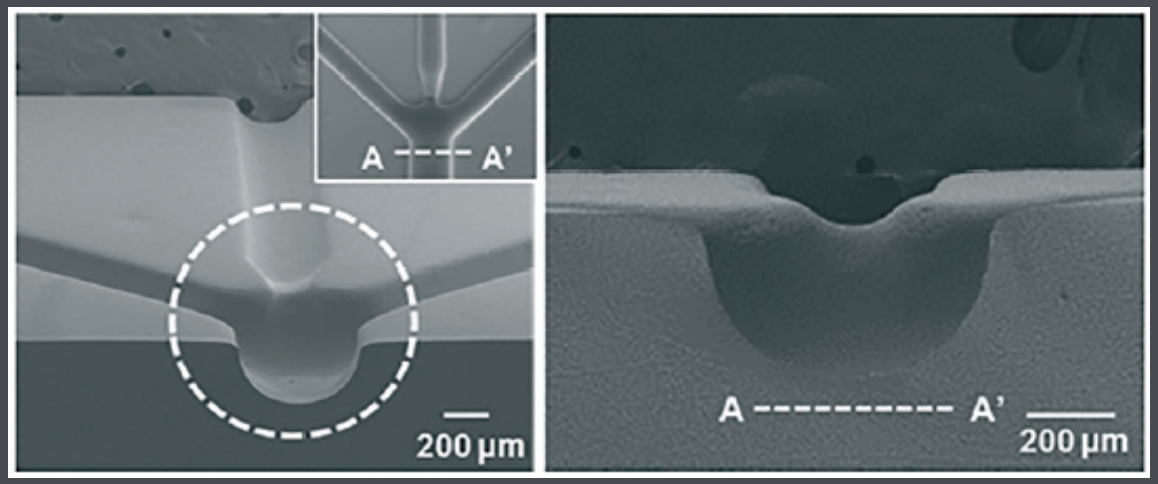
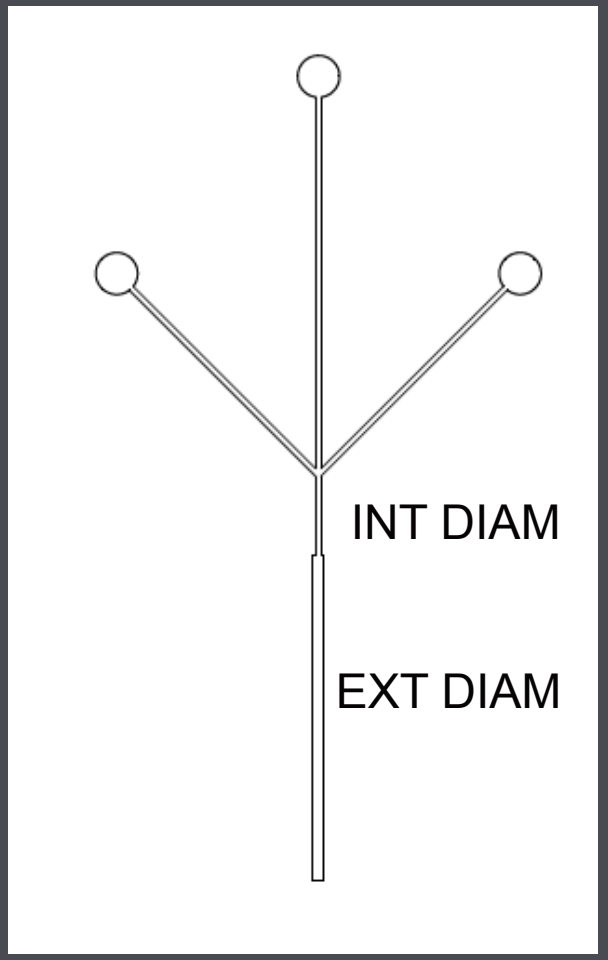

A ---- A'
200 µm
A ---------- A'
200 µm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