PRECISION BIOPRINTING OF PREVASCULAR ARCHITECTURES THROUGH DETERMINISTIC CELL PATTERNING



Open to work!

Linkedin

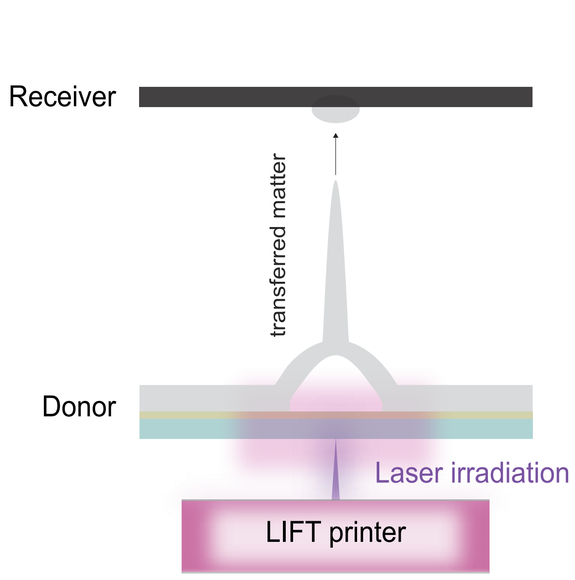
cecilebosmans@gmail.com

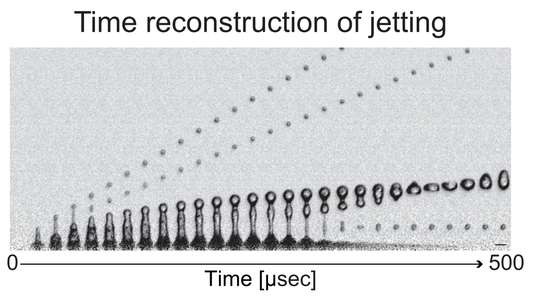
C.Bosmans[1], Núria Ginés Rodriguez[2,3], U. J. Gutiérrez Hernández[4], David Fernandez Rivas[4], Marcel Karperien[1], Jos Malda[2,3], L. Moreira Teixeira[1], R. Levato[2,3], J. Leijten[1]

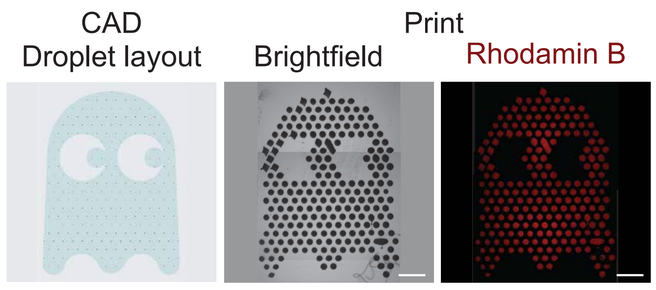
[1]Dept. BioEngineering Technologies, University of Twente, The Netherlands, [2]Dept. of Orthopaedics, University Medical Center Utrecht, The Netherlands, [3]Regenerative Medicine Center Utrecht, Utrecht, The Netherlands, [4]Mesoscale Chemical Systems Group, University of Twente, The Netherlands

- Generating **reproducible and well-organized vascular-like networks** remains a key challenge in reducing the variability and unpredictability of culture models
- High-resolution vascular structures are primarily achieved through **self-assembly**. However, self-assembly is **inherently stochastic**, limiting reproducibility and control
- There is a need to **guide this process** to obtain defined and repeatable architectures: strategies that enable **deterministic spatial patterning** are highly beneficial in addressing this issue
- **Laser-induced forward transfer (LIFT)** enables spatially controlled deterministic cell patterning to direct self-assembly into reproducible vascular-like networks

Controlled spatial positioning





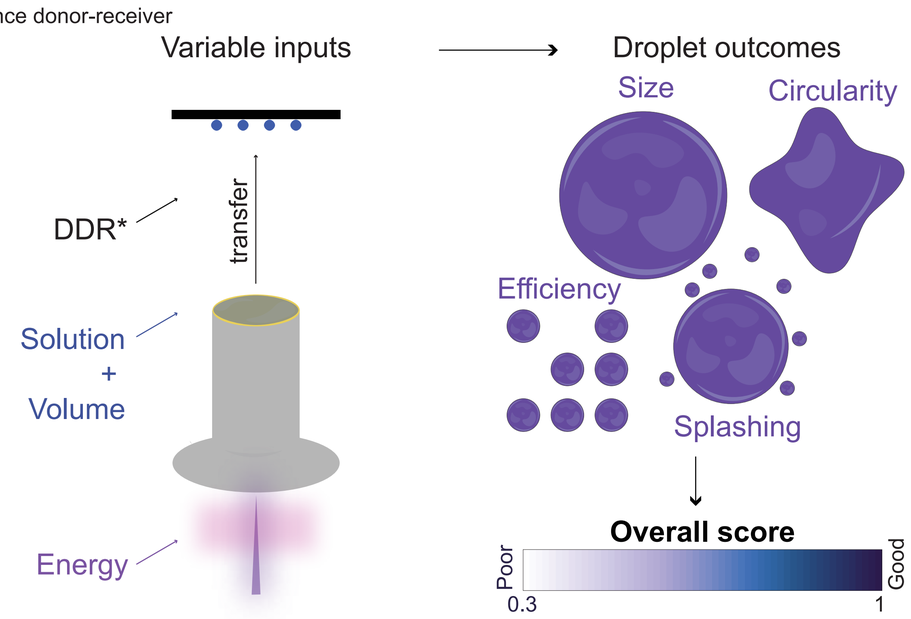


*Scale bar = 500 µm

- LIFT: Nozzle-free micropatterning technique
- Rapid transfer of matter with a high degree of design freedom
- Spatially-controlled and accurate deposition of biological materials

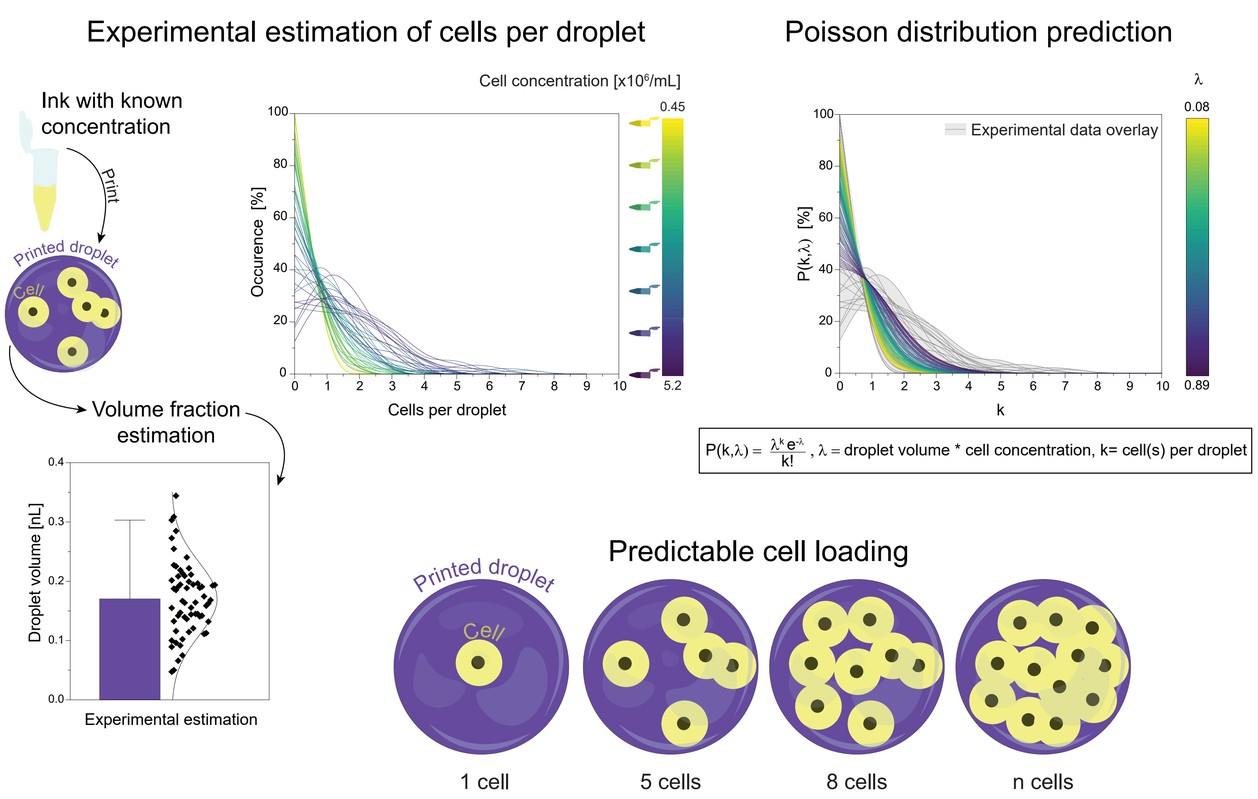
Controlled printability and pixel size

*DDR: distance donor-receiver



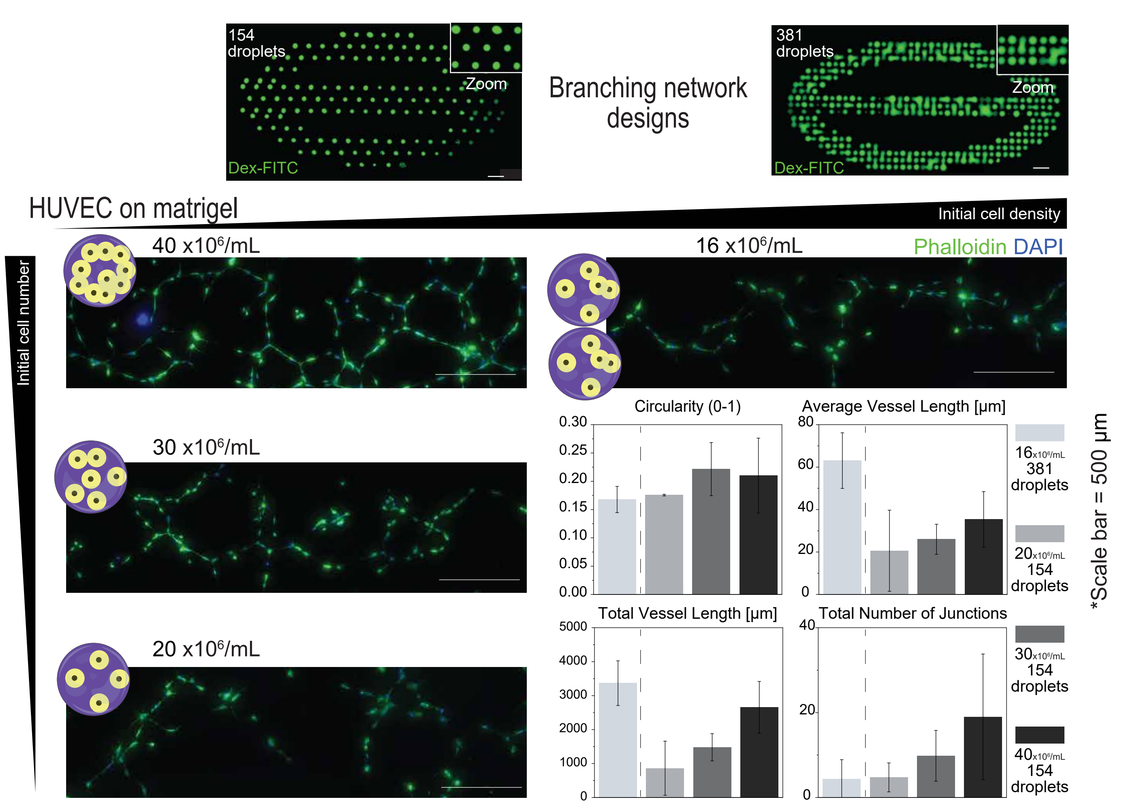
- Systematic characterization of the LIFT printability window
- Developed unified quantitative biofabrication score integrating key droplet metrics
- Predictive framework for parameter optimization across ink formulations

Controlled pixel content



- Cell number per droplet quantified across concentrations
- Distributions follow Poisson predictions (based on droplet volume), enabling prediction of cell loading

Optimizing vascular pattern density



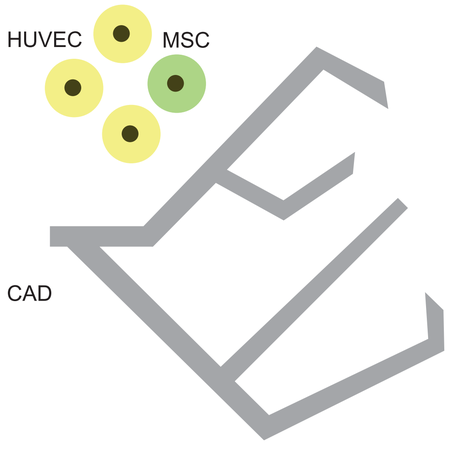
*Scale bar = 500 µm

- Leverage printing control to LIFT-print endothelial patterns at different cell densities
- Both cell number per droplet and spacing govern early vascular assembly; higher density increases connectivity

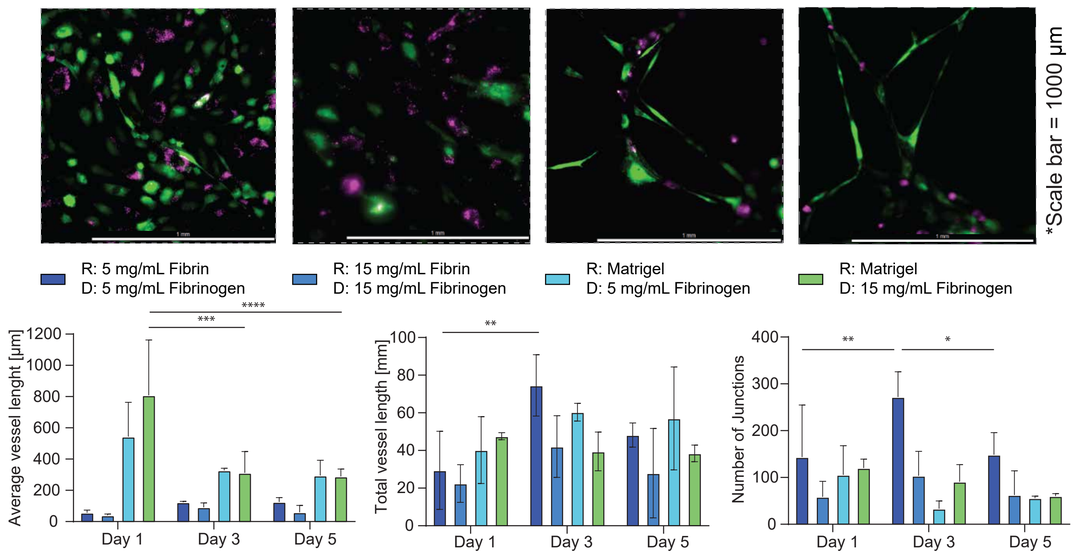
Coculture micropatterning to guide vasculogenesis

Coculture system design

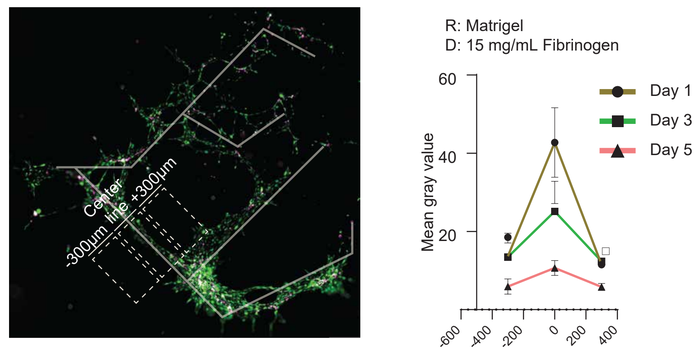
Receiver: Matrigel + Thrombin or Fibrin
Donor bioink: Fibrinogen and 3 HUVEC : 1 MSC



Donor (D) - receiver (R) tuning on vascular-like network metrics



Pattern maintenance over time



- Spatially defined patterning of endothelial and supporting cells yields hierarchical, branched vascular-like networks
- Donor–receiver substrate optimization stabilizes pattern integrity over time

- Precise spatial patterning of cell-laden droplets via LIFT
- Quantitative framework linking printing parameters to droplet formation and cell loading
- Predictable cell encapsulation governed by Poisson statistics
- Control of vascular network formation and interconnectivity through pattern design
- Tunable donor-receiver systems enable co-culture and reproducible microvascular architectures
- Framework for extending early 2D networks toward functional, and perfusable 3D vascular systems

This work was published in Advanced Healthcare Materials,2025, DOI: 10.1002/adhm.202503665

This work is funded by the NWO-TTW Perspective Program of the Dutch Research Council (NWO; project number P19-03)

Leijten Laboratory | Developmental BioEngineering | UNIVERSITY OF TWENTE. | TECHMED CENTRE | SMART OoC | NWO