

Biomaterials for Orthopedics: Regenerative Hydrogels

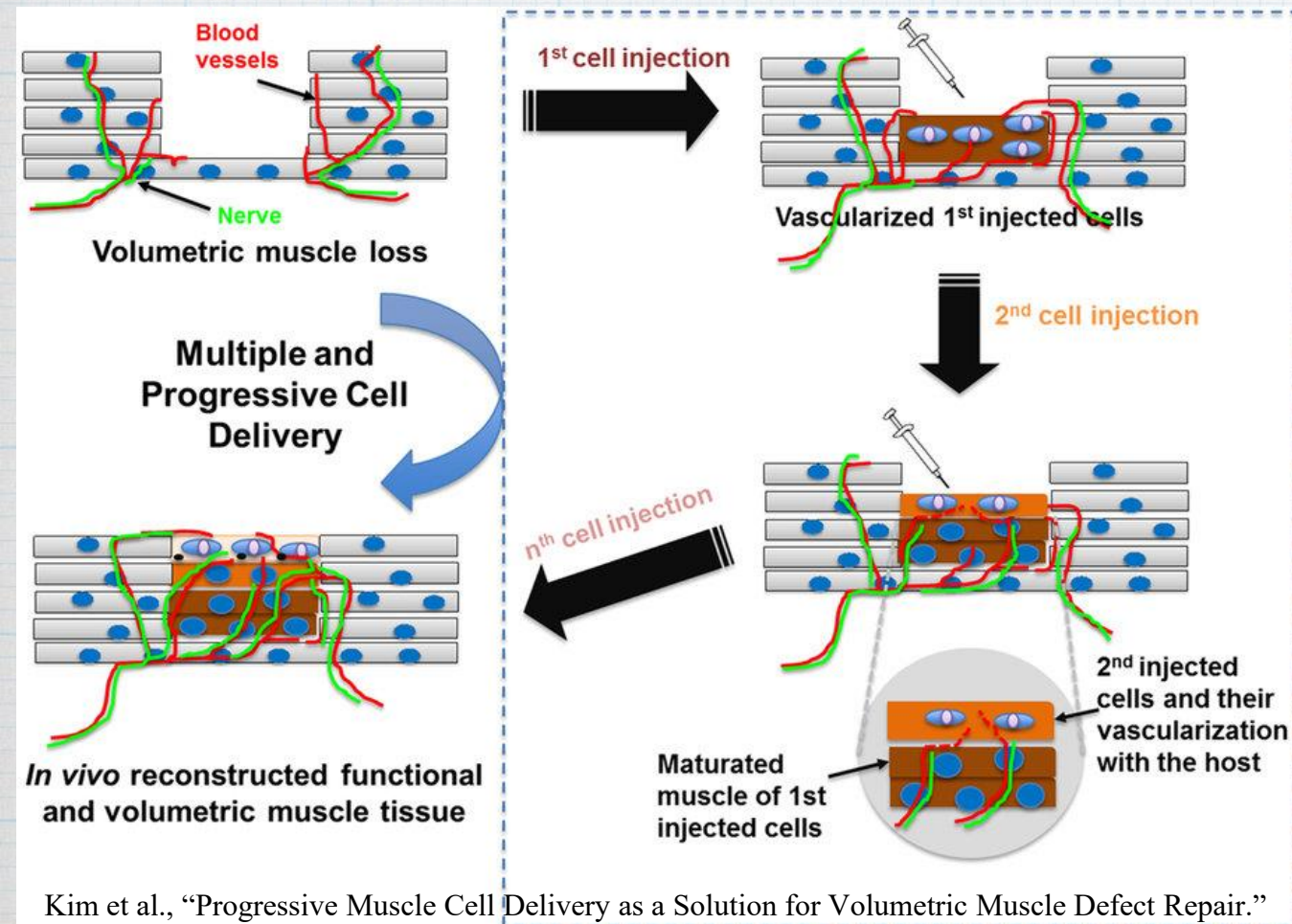
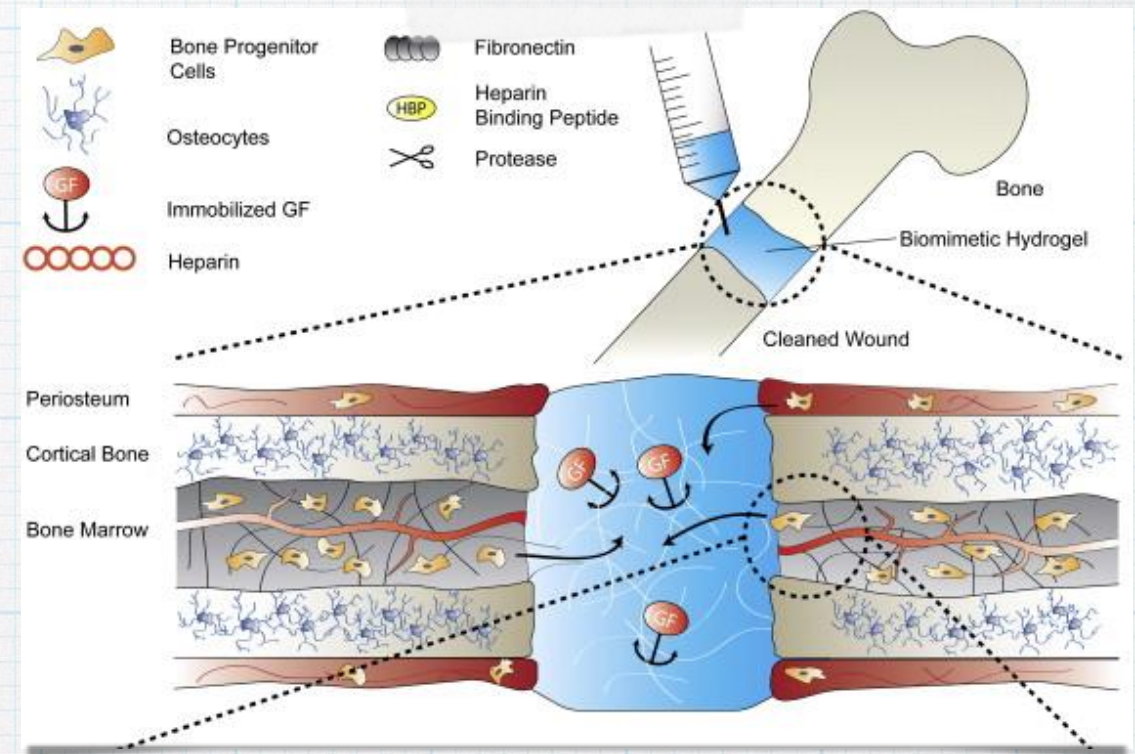
Dr. Don Griffin
UVA Biomedical Engineering

Bone/cartilage/skeletal muscle regeneration

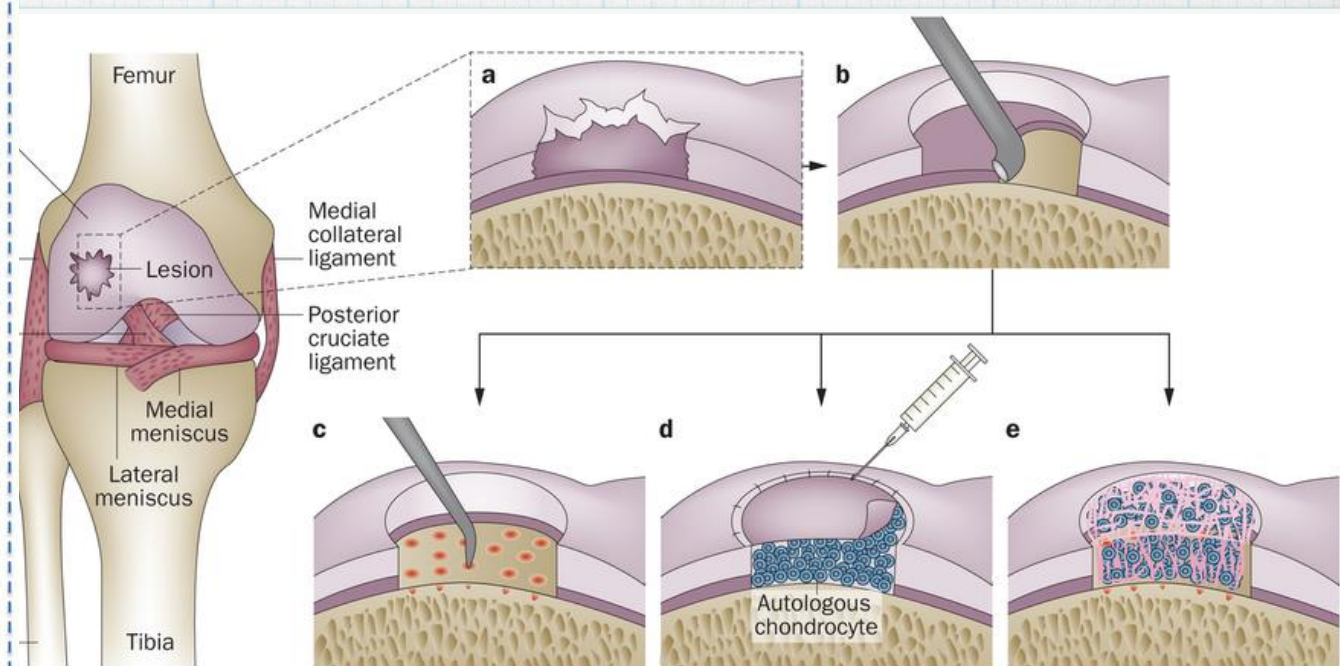
Lienemann, Lutolf, and Ehrbar, "Biomimetic Hydrogels for Controlled Biomolecule Delivery to Augment Bone Regeneration."

* Three main regenerative objectives

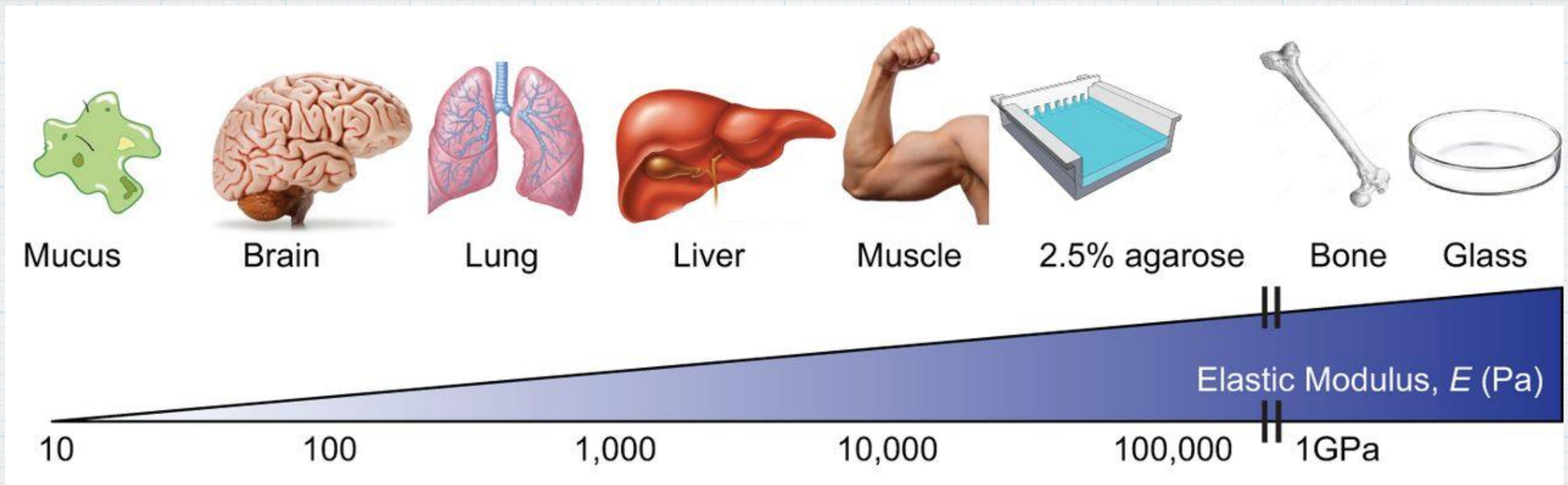
- * Physical scaffold
- * Soluble signal delivery
- * Cell delivery



Kim et al., "Progressive Muscle Cell Delivery as a Solution for Volumetric Muscle Defect Repair."

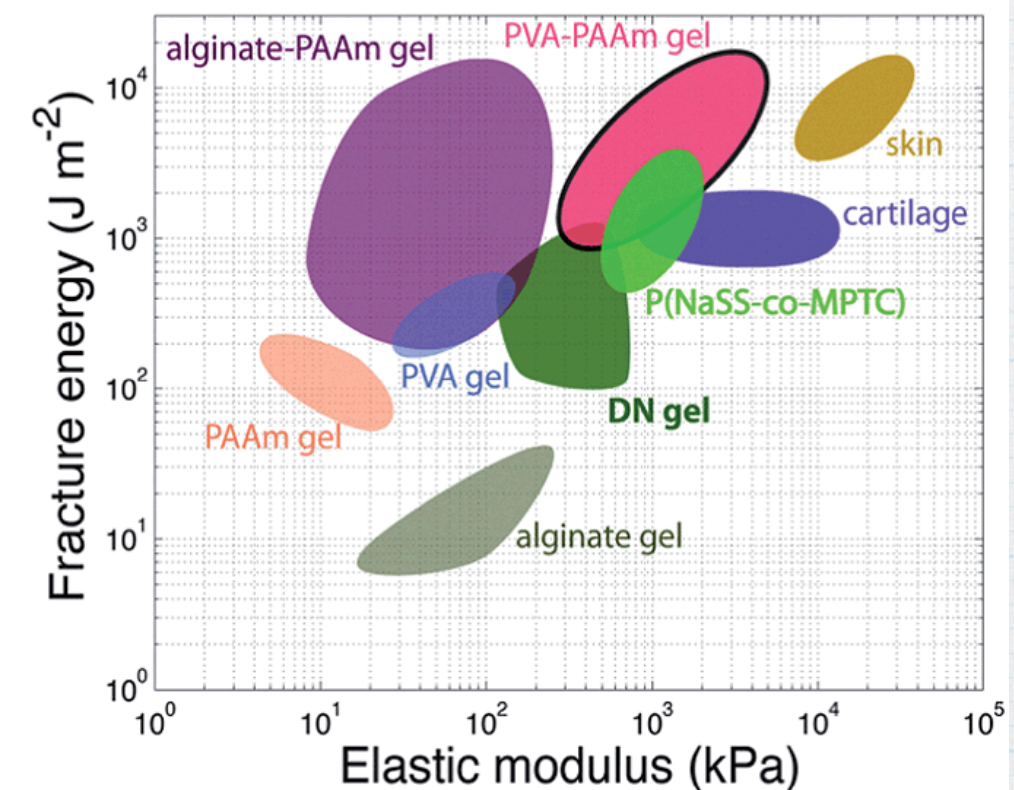
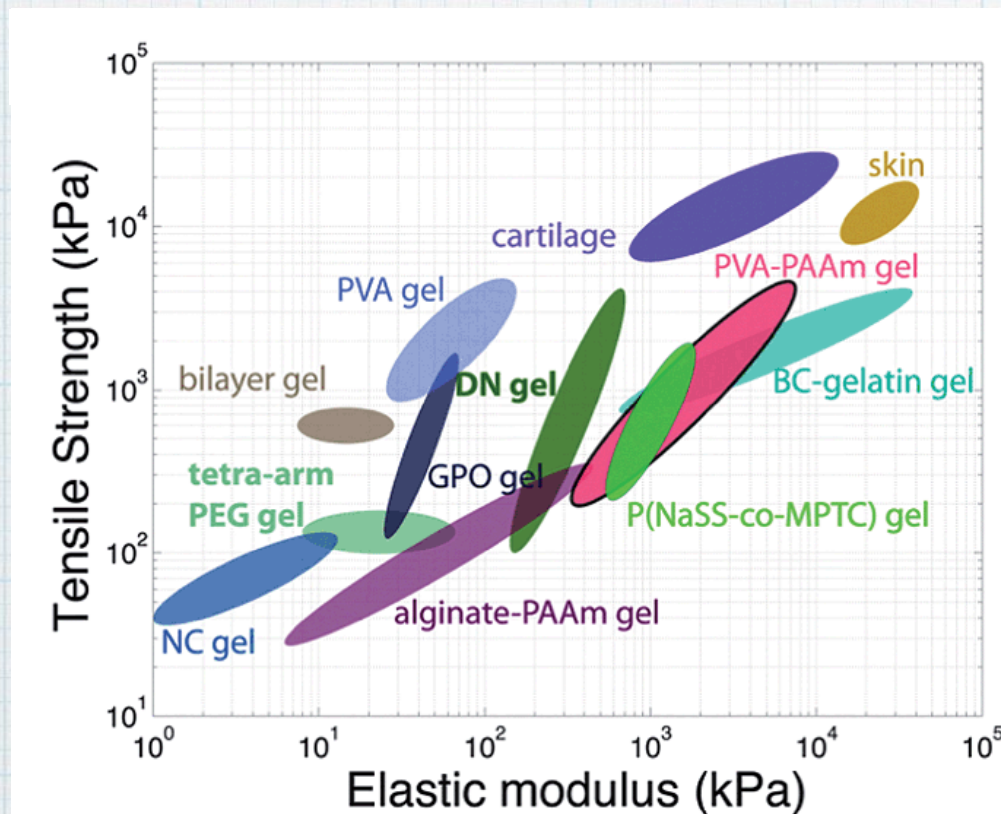


Makris et al., "Repair and Tissue Engineering Techniques for Articular Cartilage."

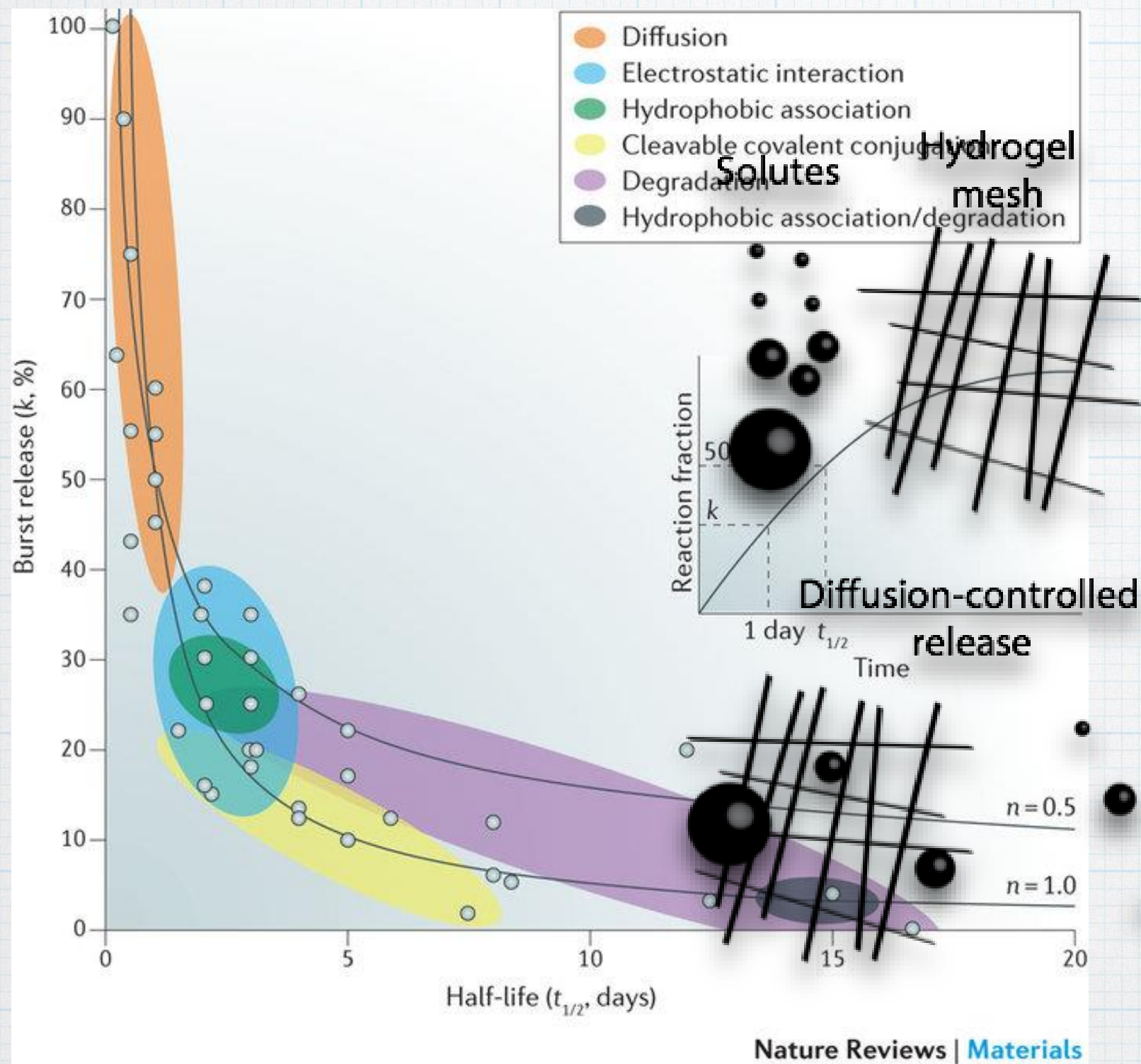


Barnes, Przybyla, and Weaver, "Tissue Mechanics Regulate Brain Development, Homeostasis and Disease."

Li, Suo, and J. Vlassak, "Stiff, Strong, and Tough Hydrogels with Good Chemical Stability."



Hydrogel mechanics



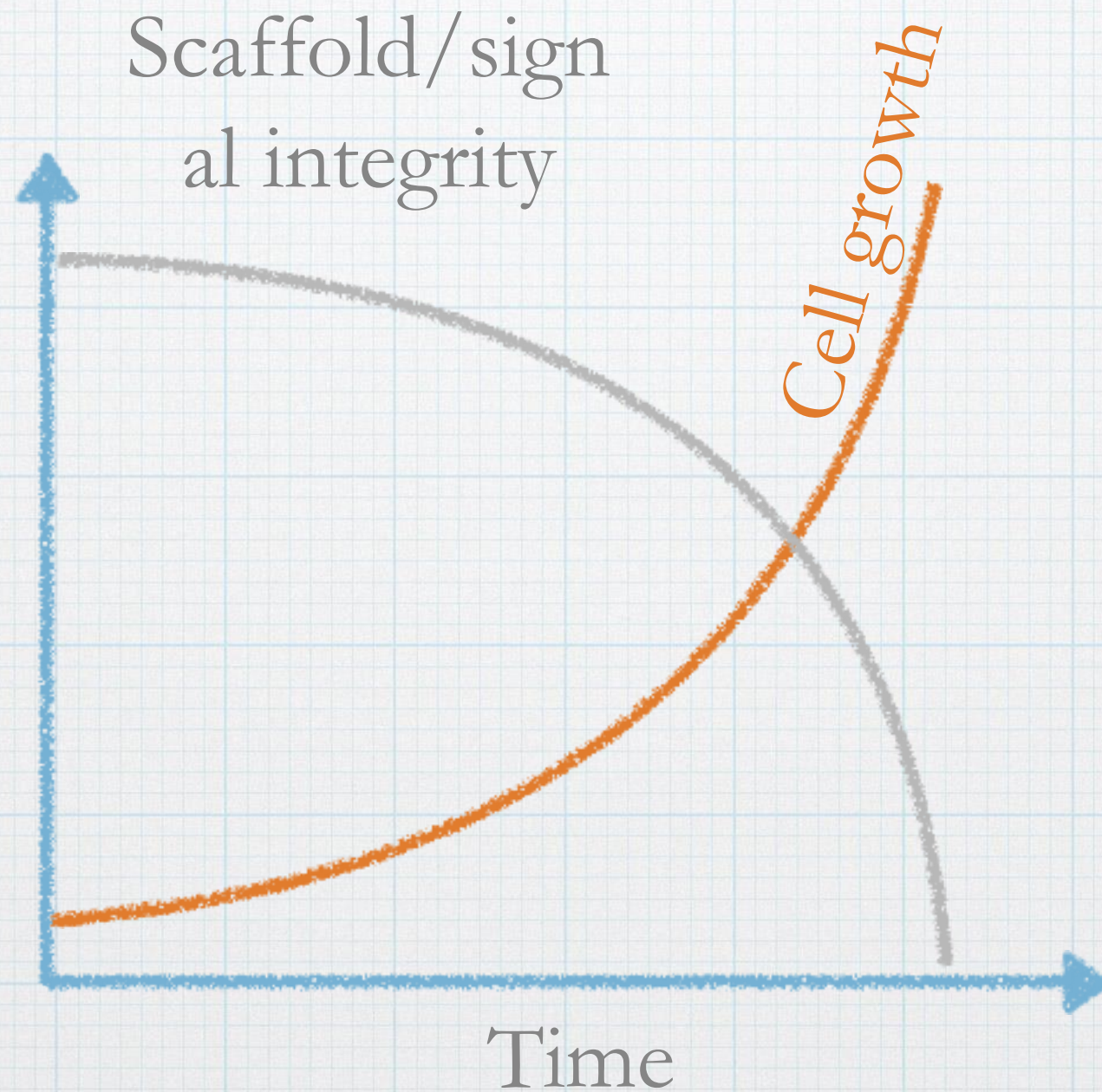
Li and Mooney, "Designing Hydrogels for Controlled Drug Delivery."

Hydrogel delivery

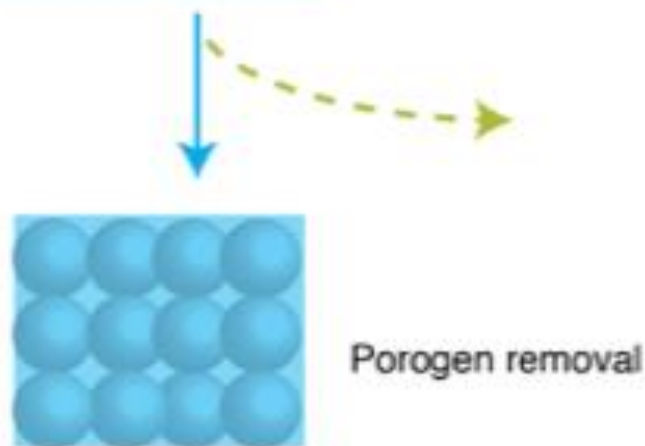
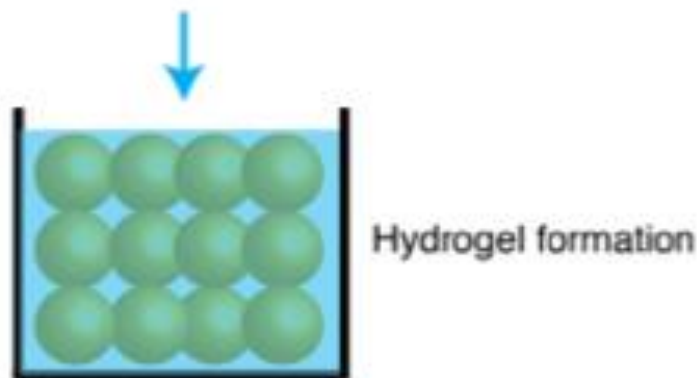
“Major limitations of these gels relate to...a mismatch of biomaterial degradation rate as compared to tissue regeneration (either too fast or too slow).”

–Vilela et al., “Cartilage Repair Using Hydrogels.”

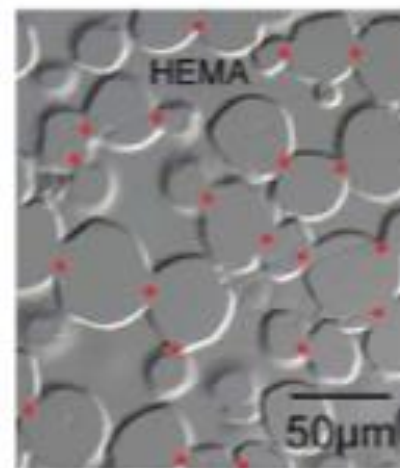
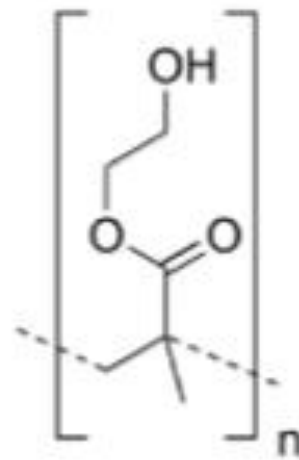
A delicate balance



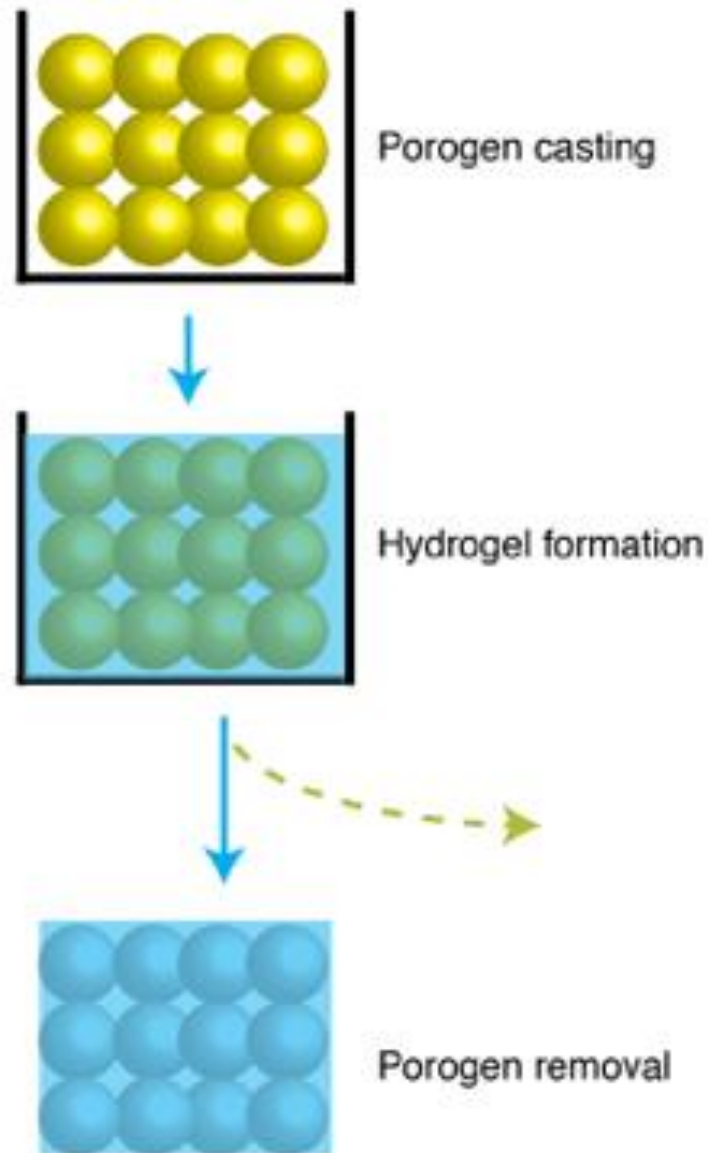
Uncoupling degradation from regeneration



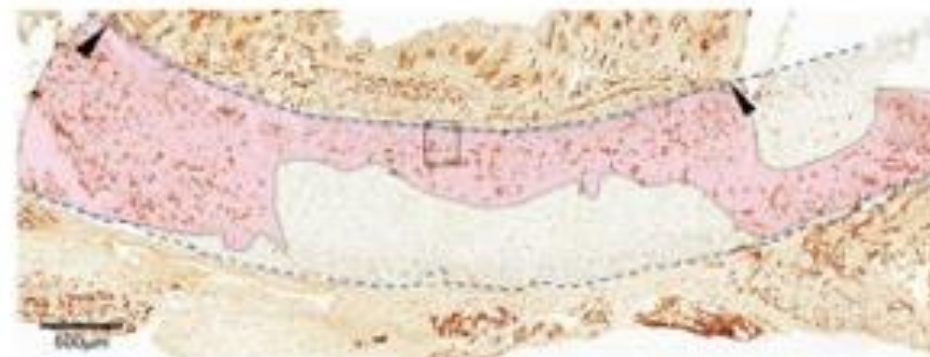
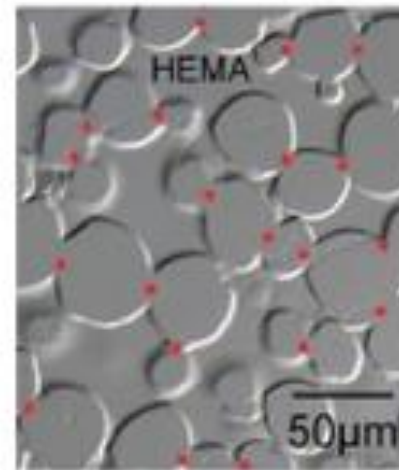
Porosity repurposes poly(HEMA)



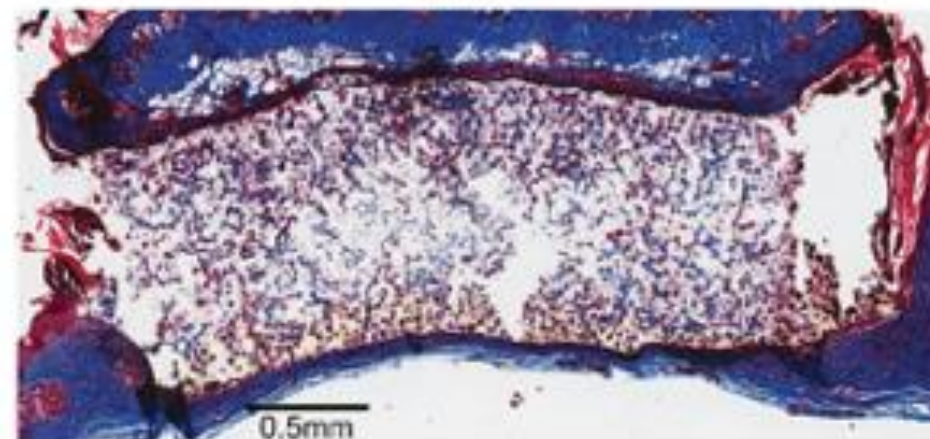
Uncoupling degradation from regeneration



Porosity provides tissue integration without scaffold deterioration

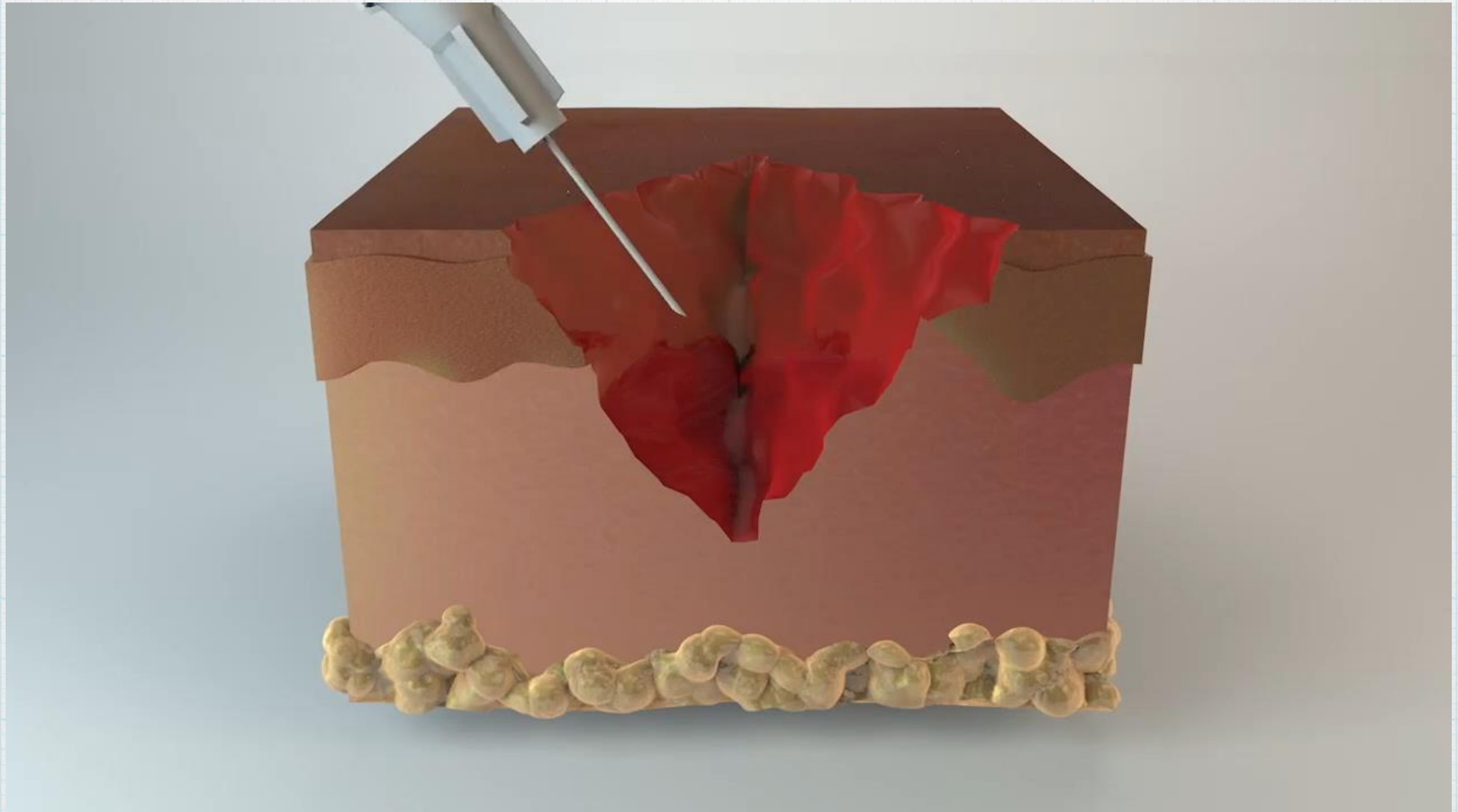


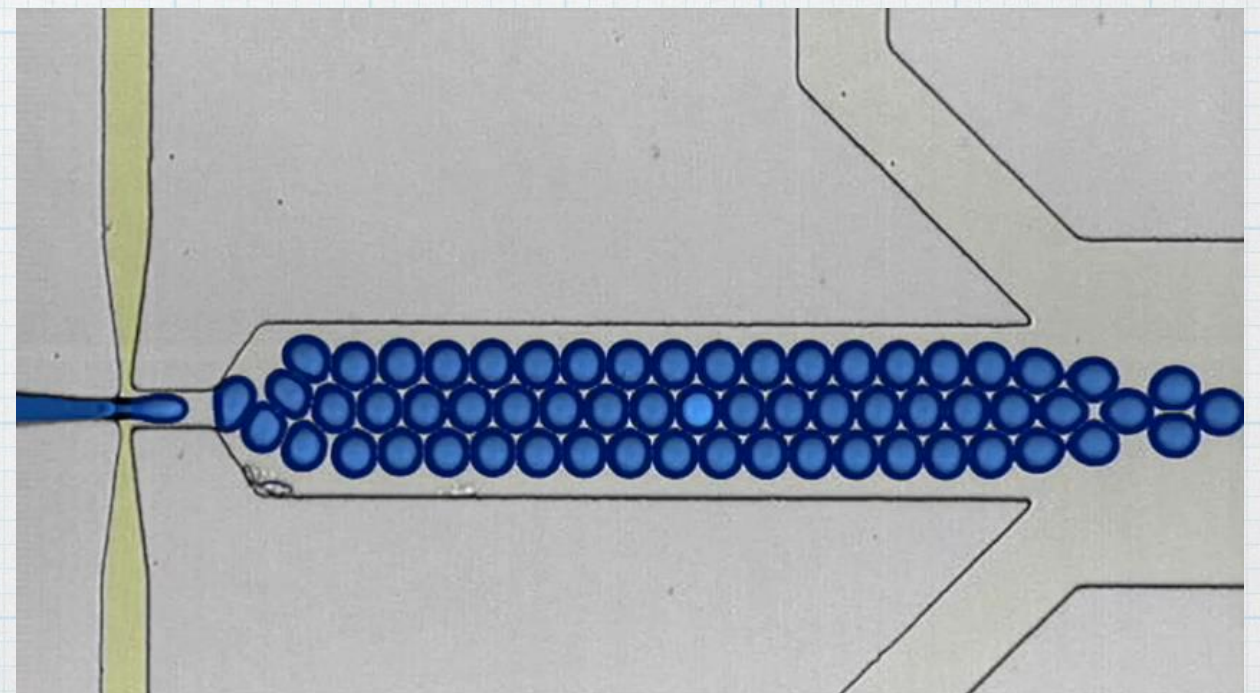
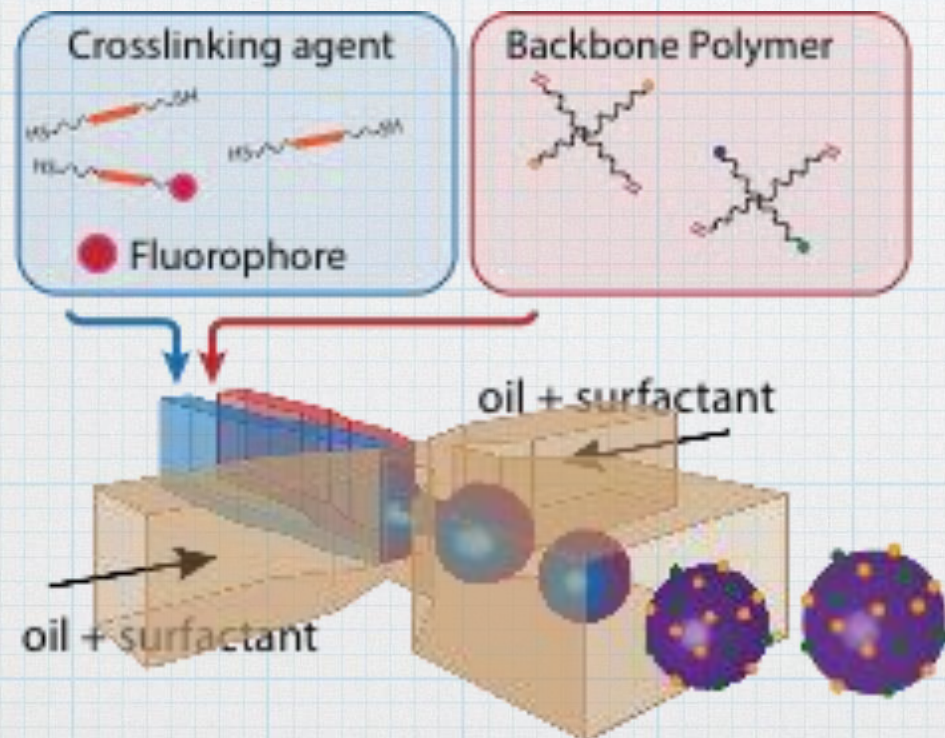
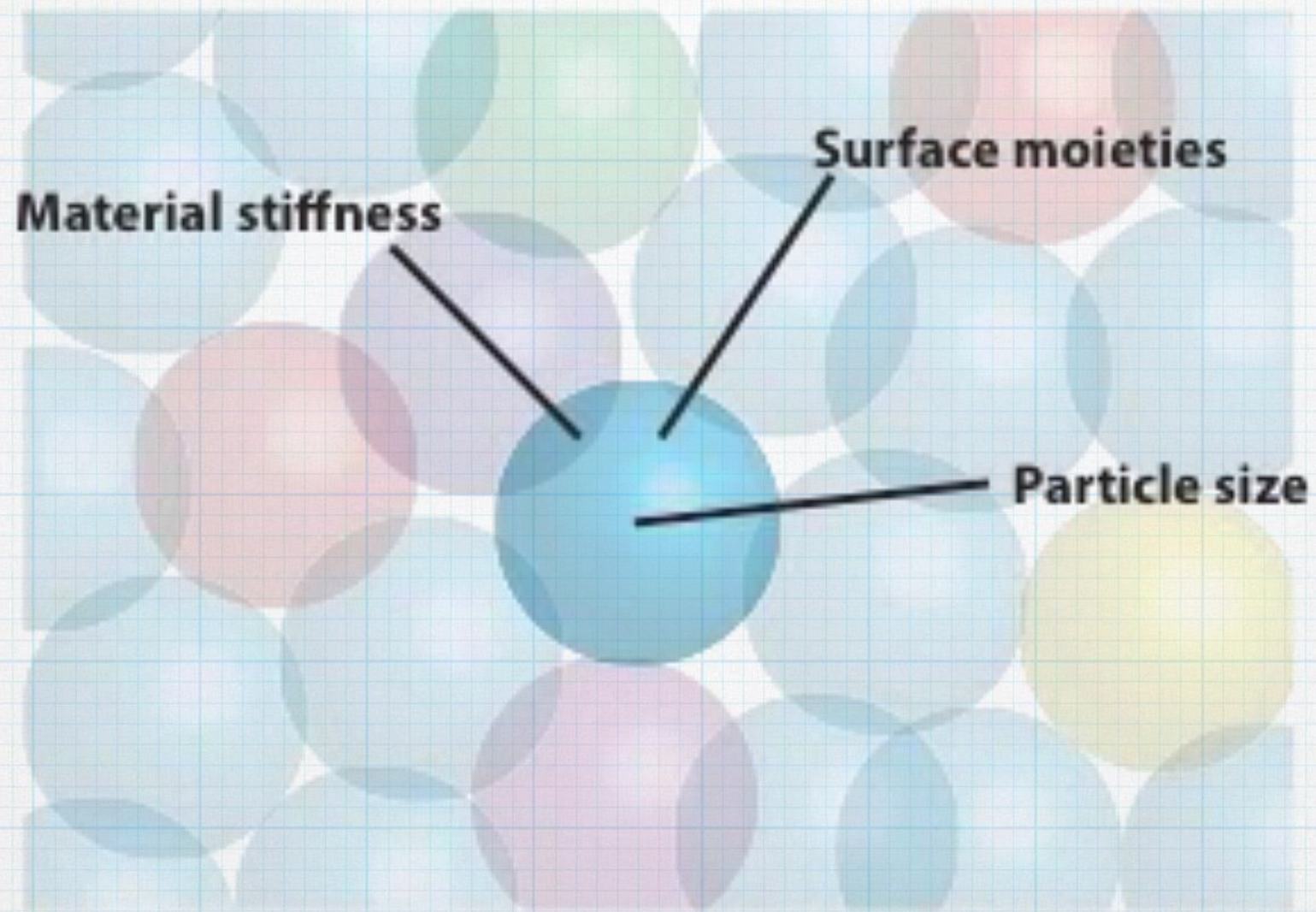
14-days
Vascularization
(PECAM-1)



28-days
Collagen
(Trichrome)

Particle-based hydrogels

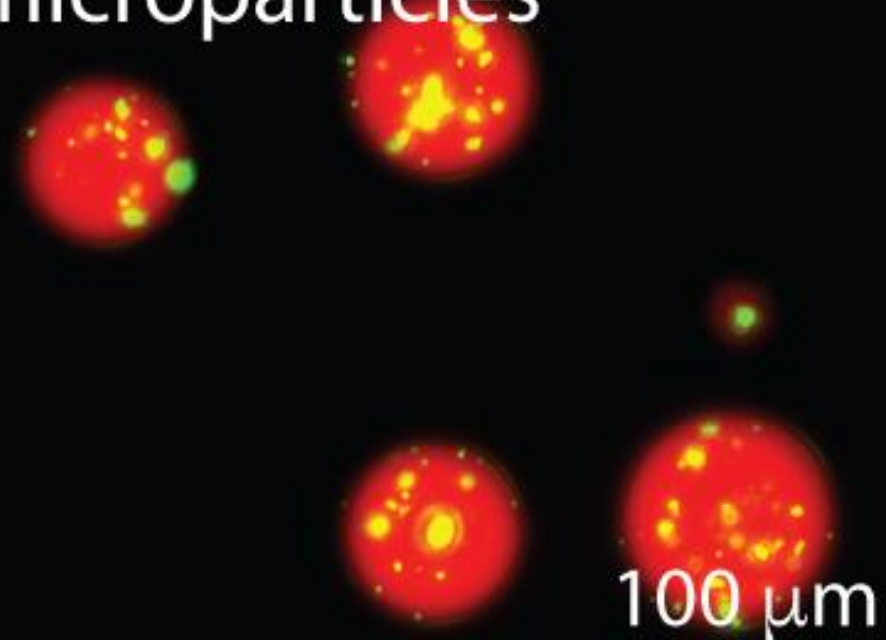




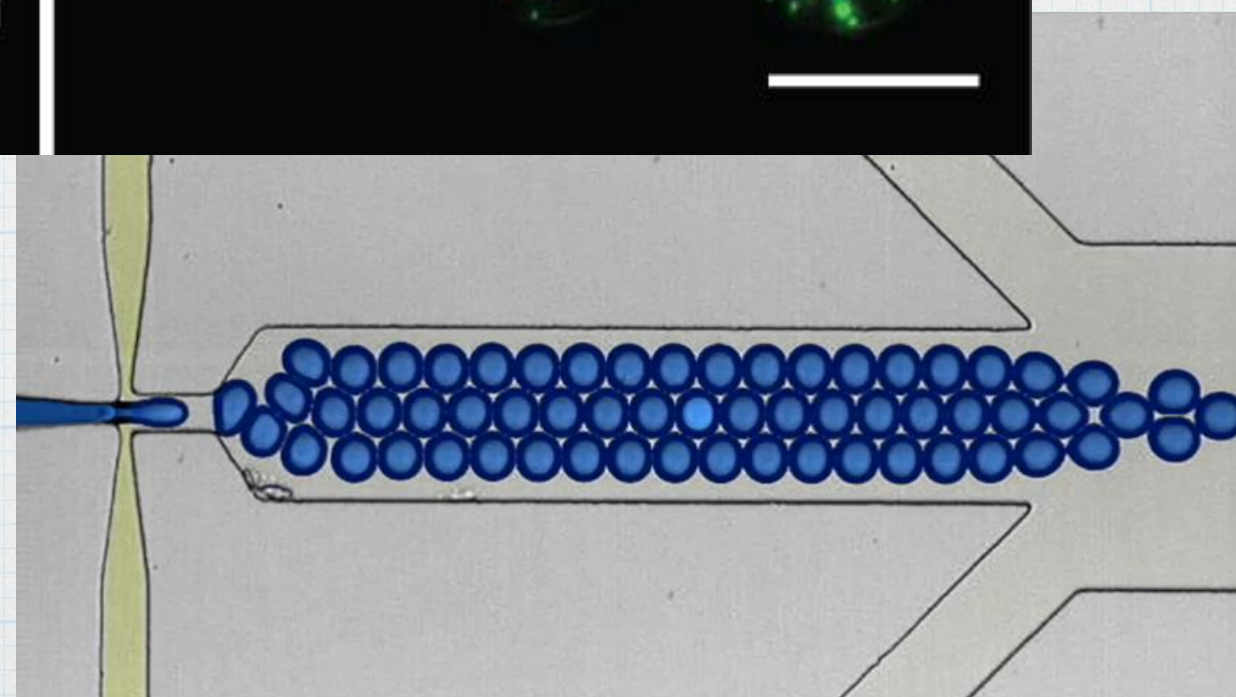
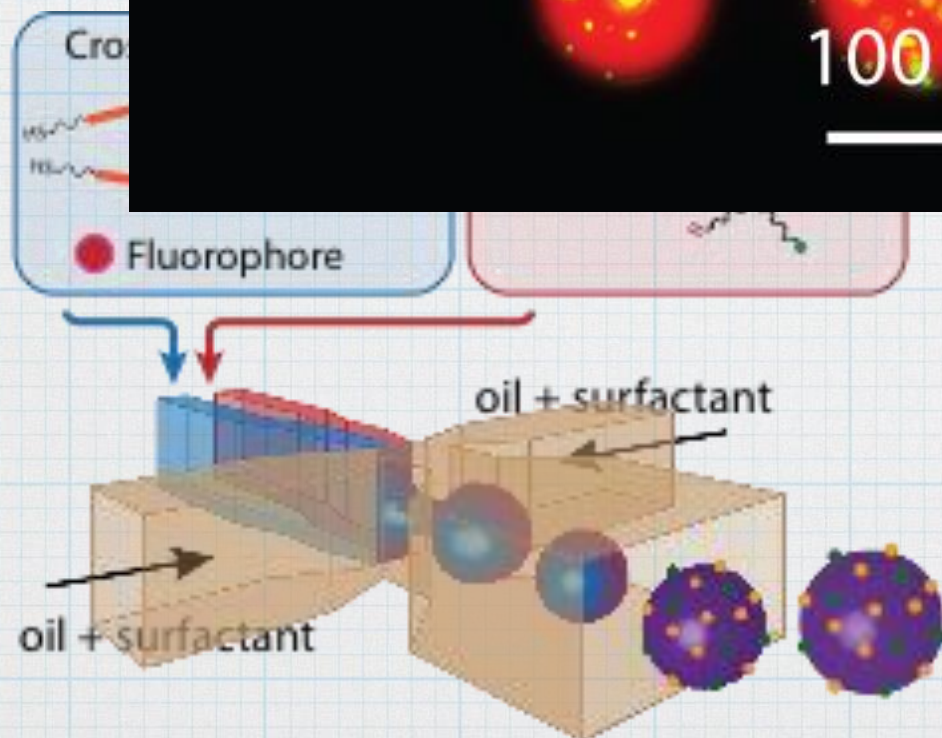
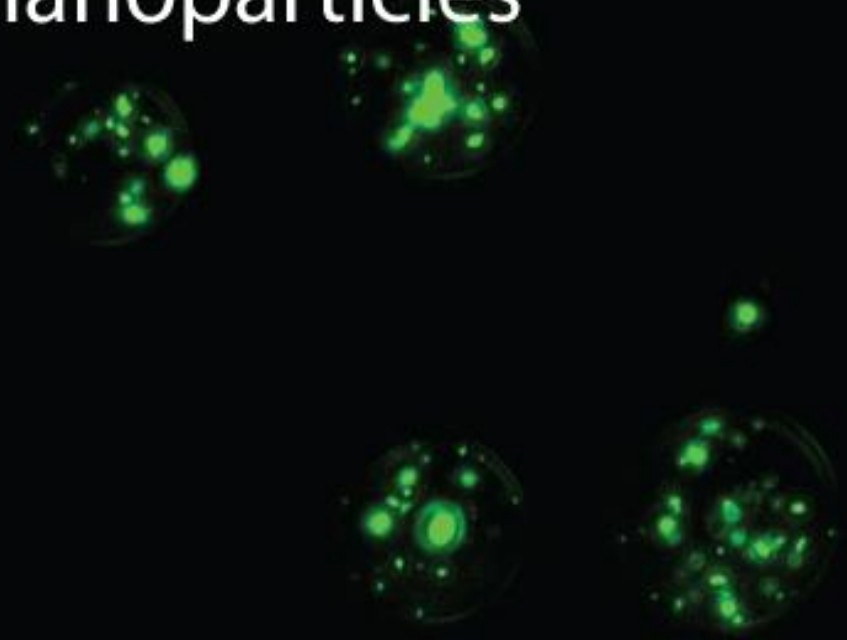
Material stiffness

Surface moieties

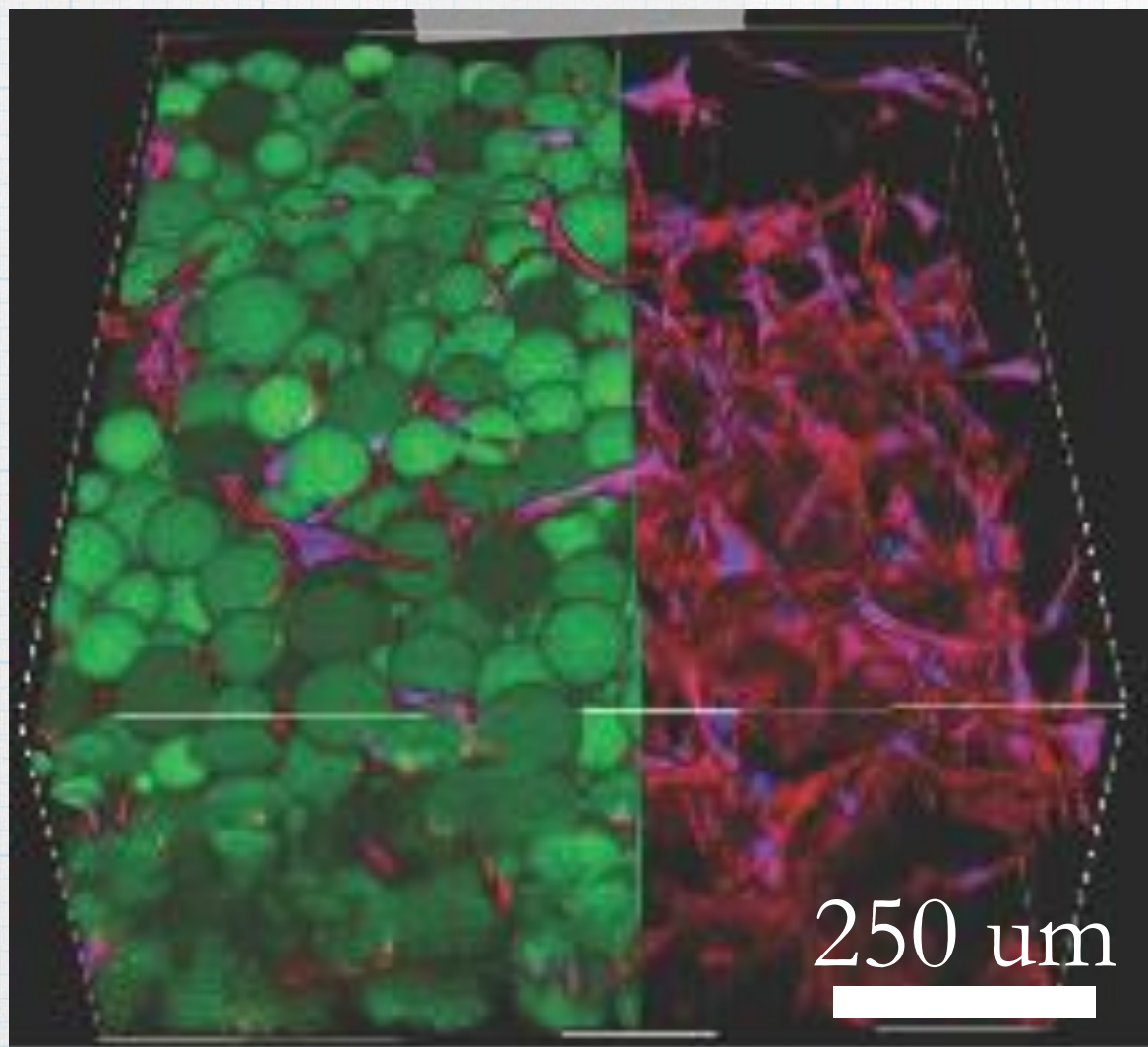
microparticles



nanoparticles

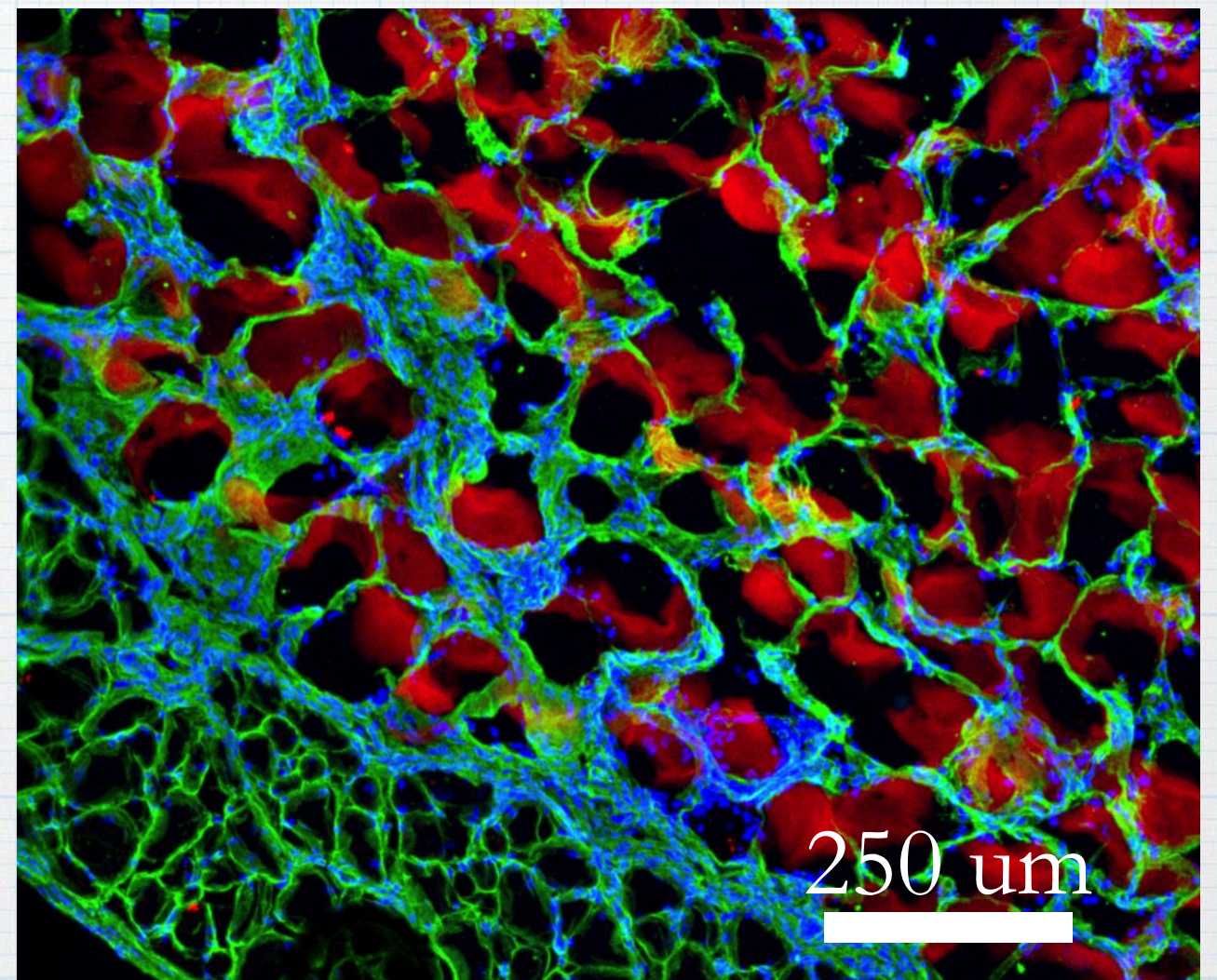


Degradation-independent Integration



Actin
DAPI

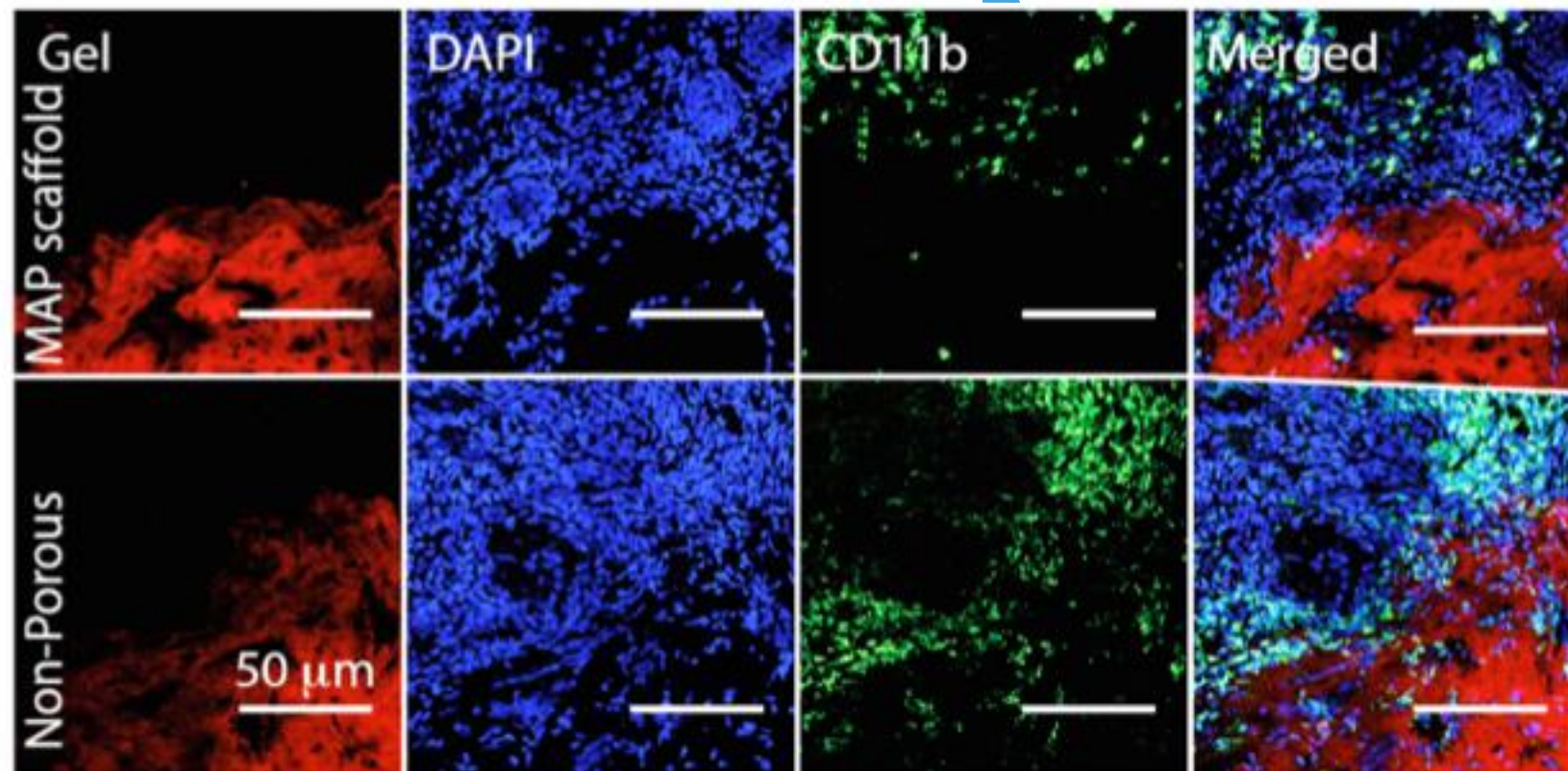
MAP



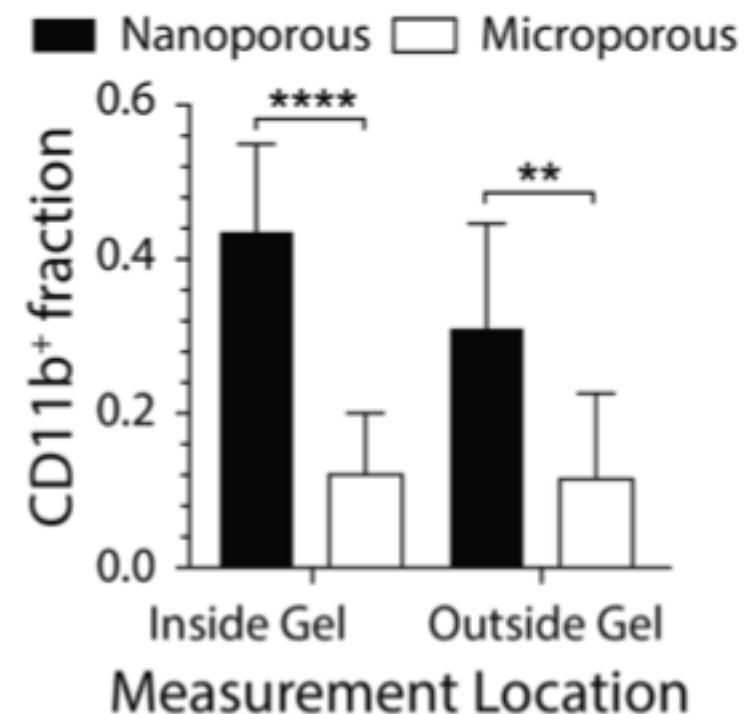
MAP
DAPI

Collagen 4

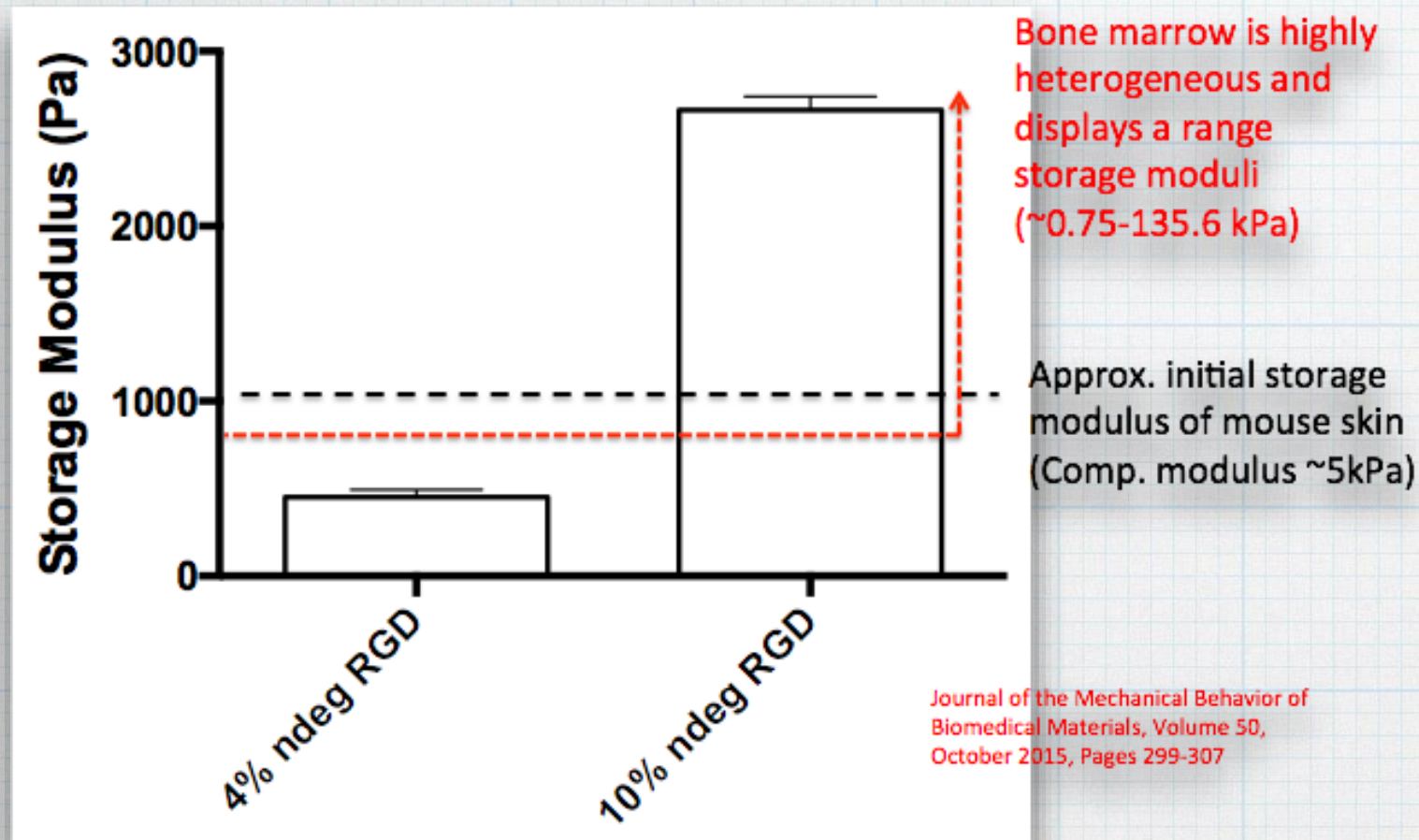
Diminished inherent immune response



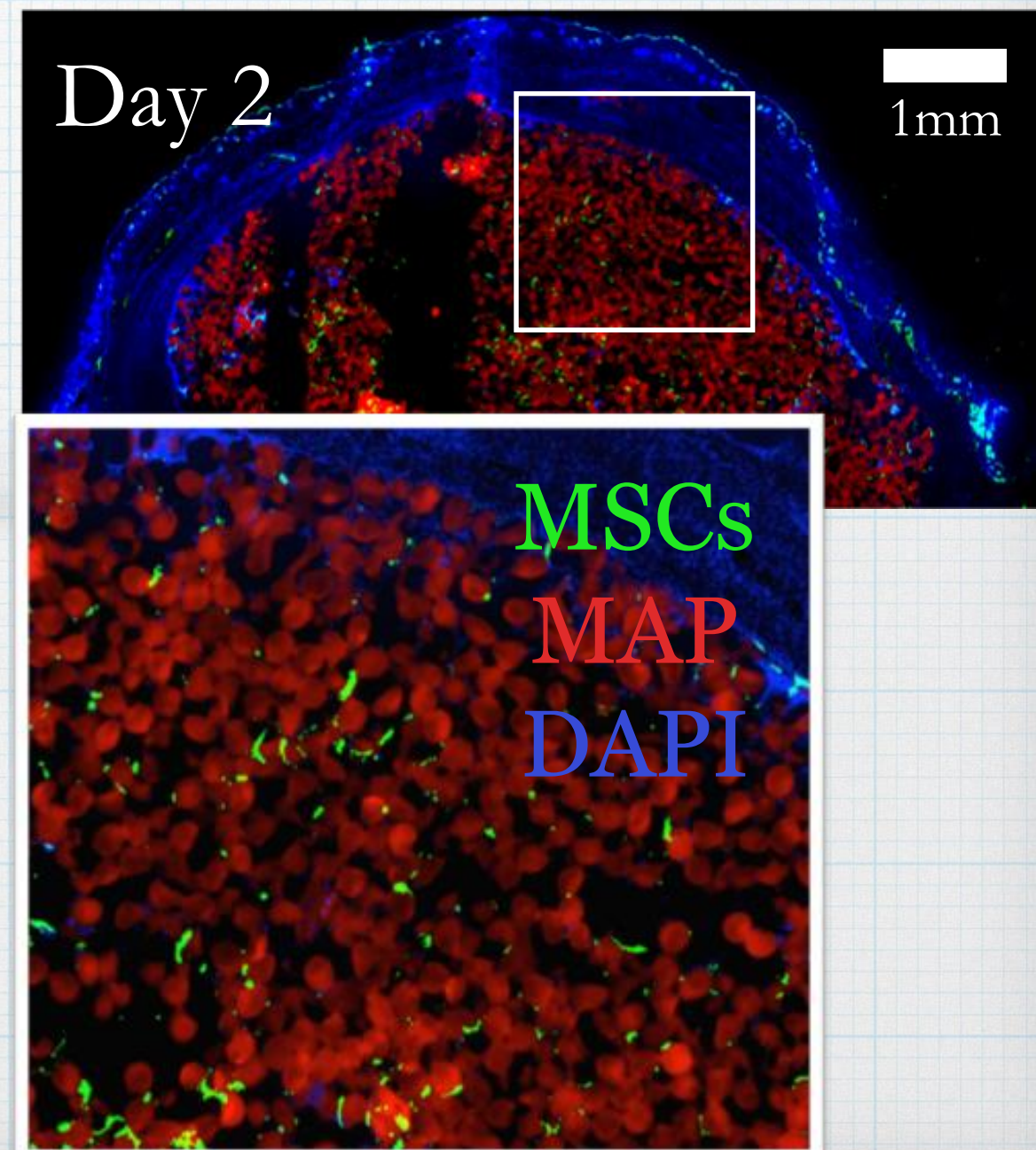
Skin Wound Healing Model
Day 5



Example: Modulating Delivery of BM-derived MSCs



Subcutaneous delivery of MSCs from a mechanically-stable MAP gel



Example: Modulating Delivery of BM-derived MSCs

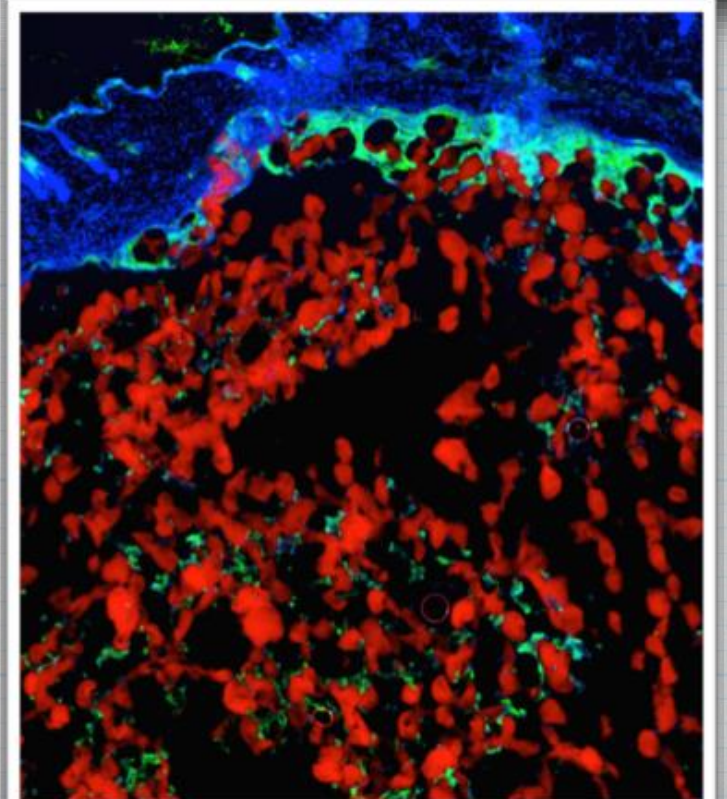
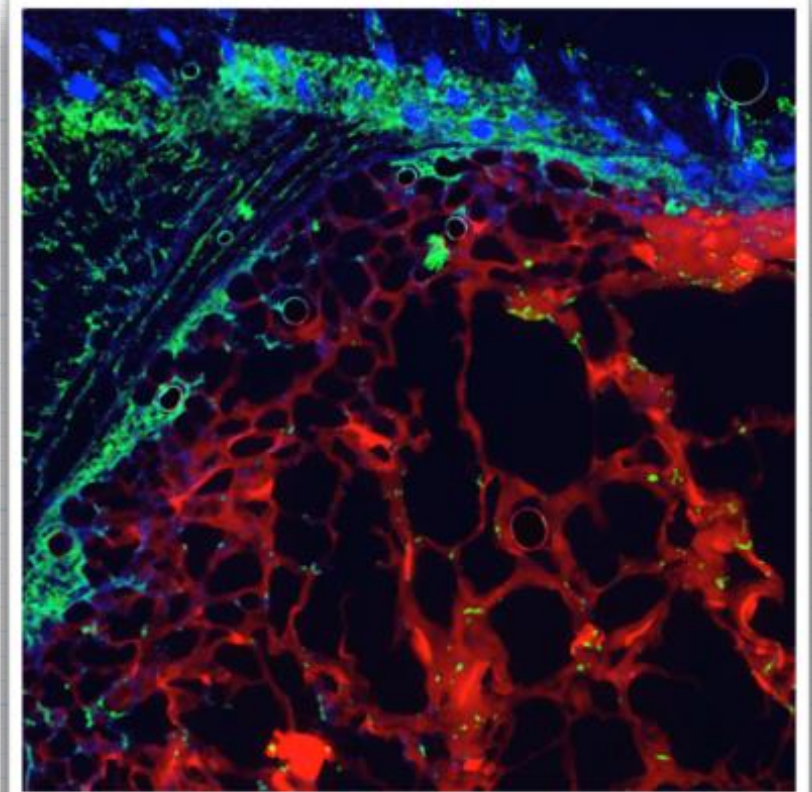
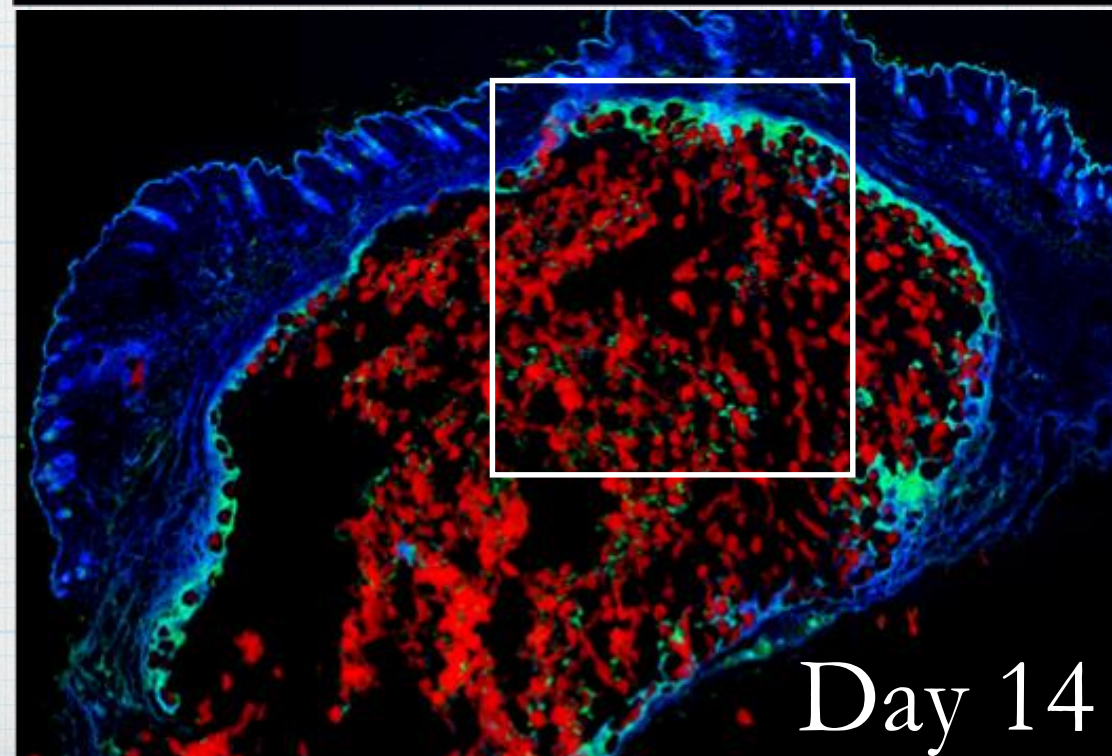
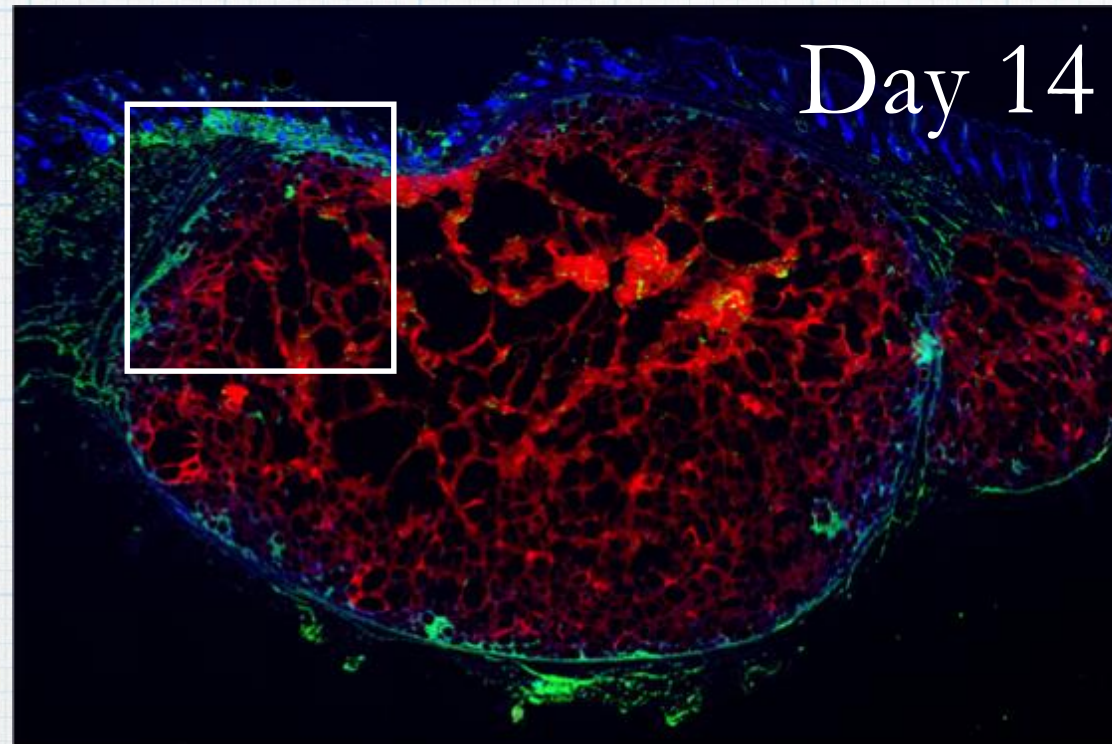
4% NDeg (soft)

MSCs

MAP

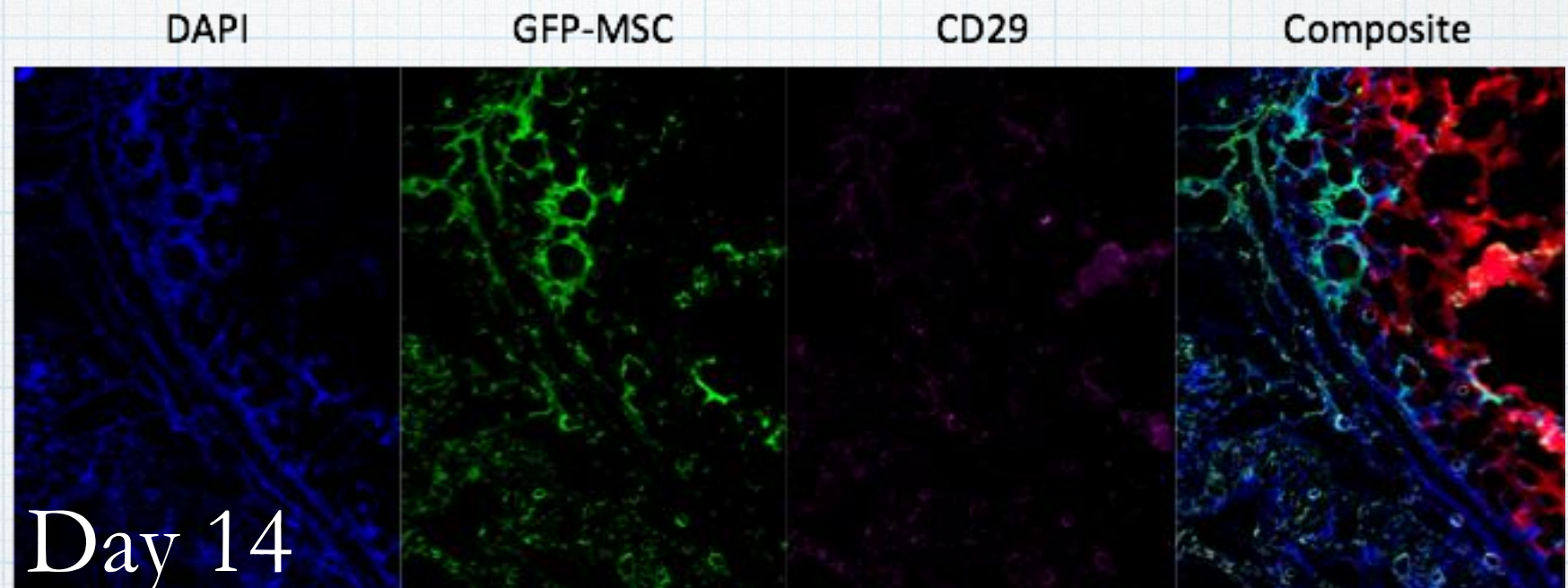
DAPI

10% NDeg (stiff)

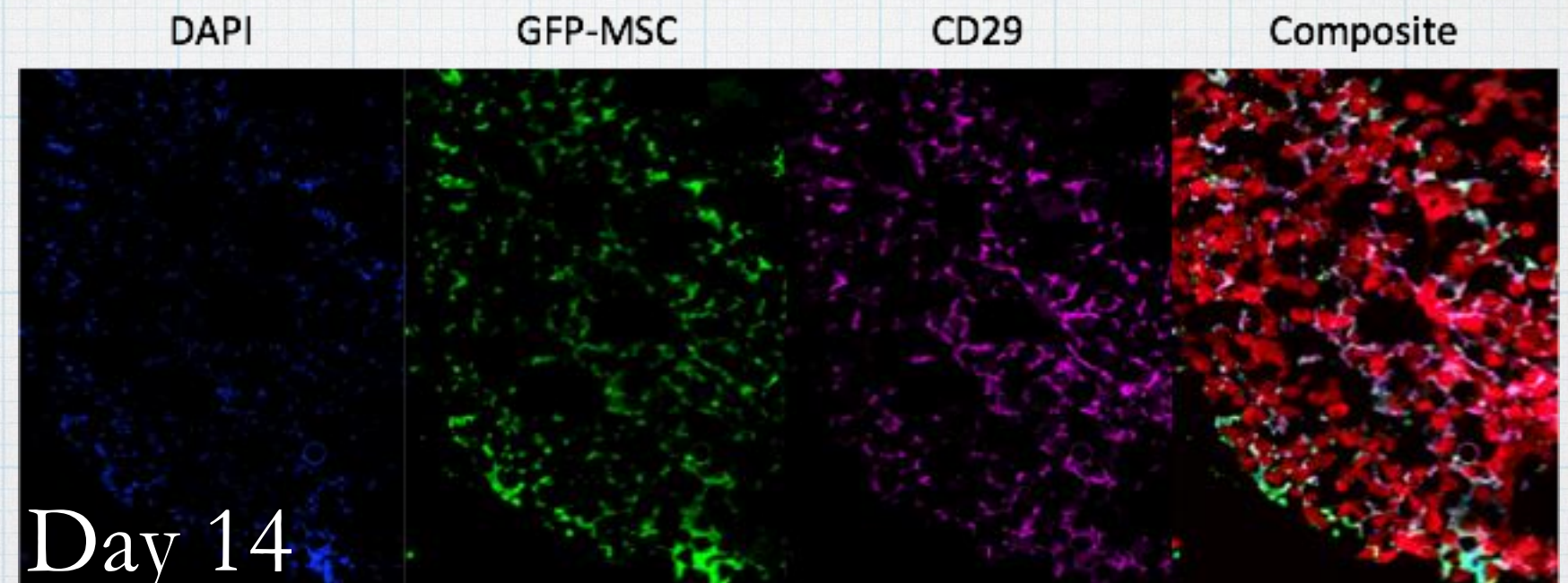


Example: Modulating Delivery of BM-derived MSCs

4% NDeg (soft)



10% NDeg (stiff)



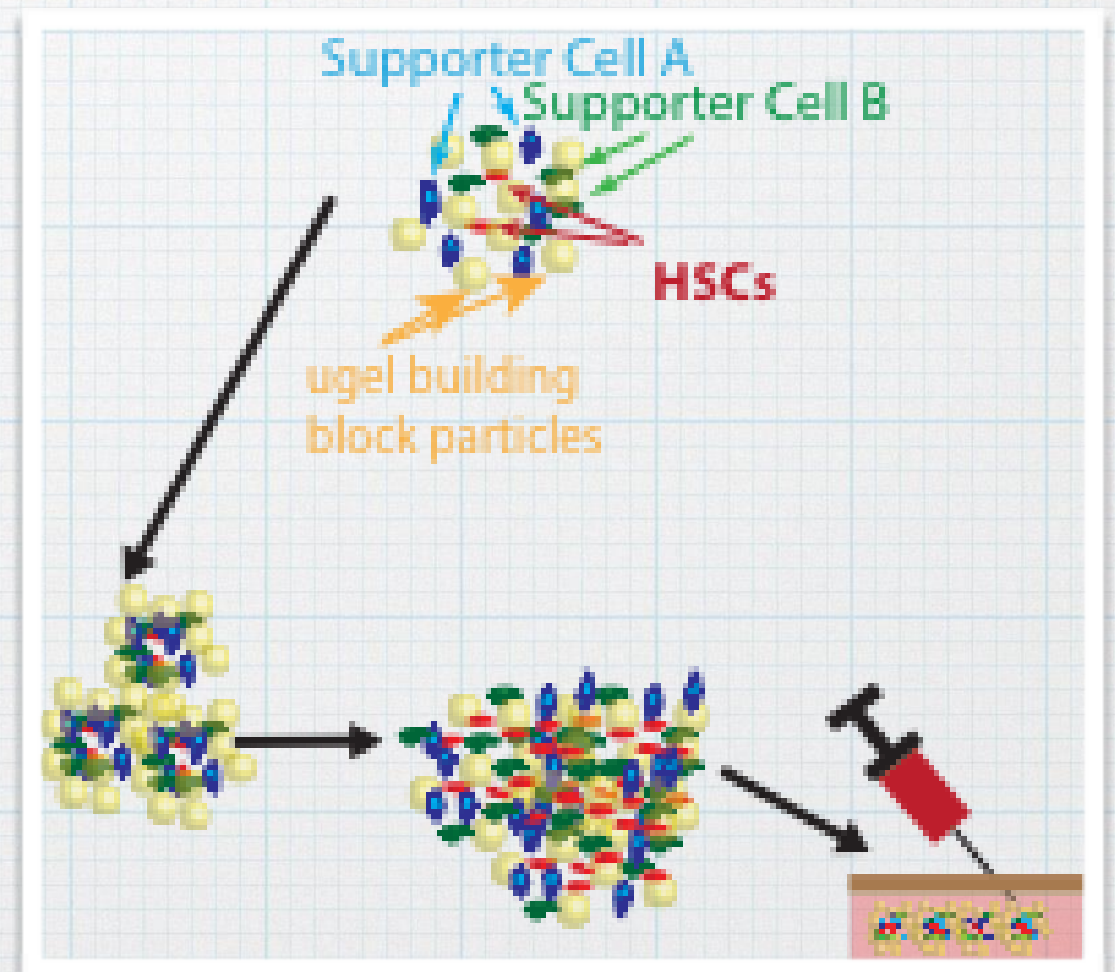
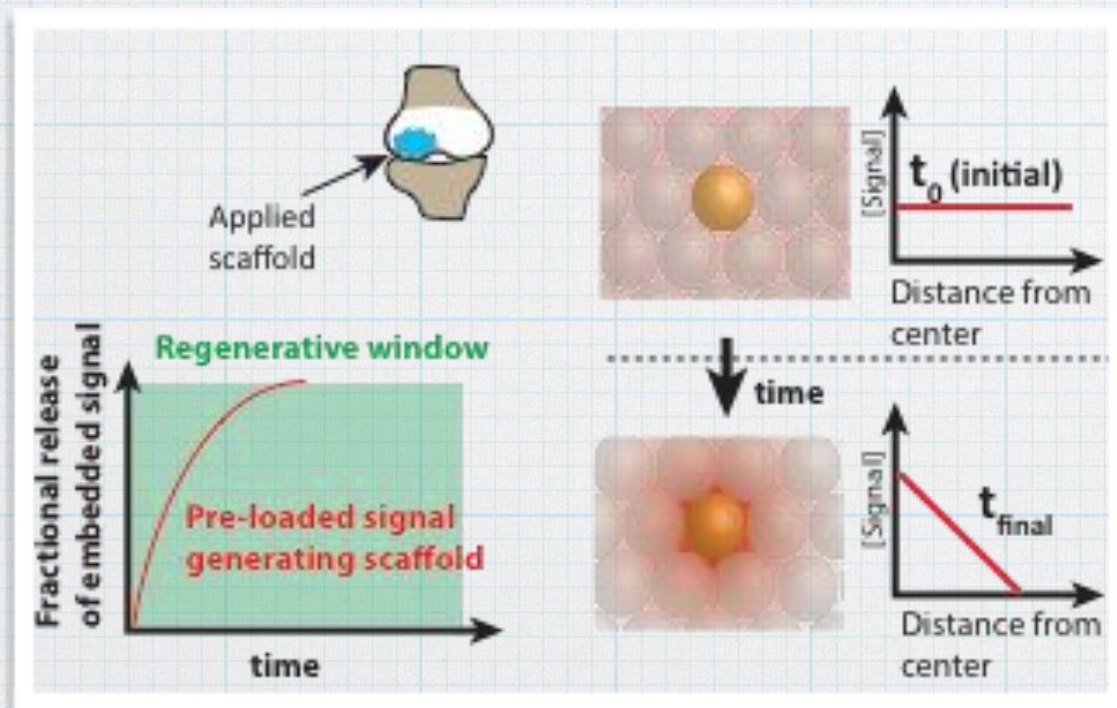
- Stiffness seems to modulate both migration and differentiation

Griffin Research Group

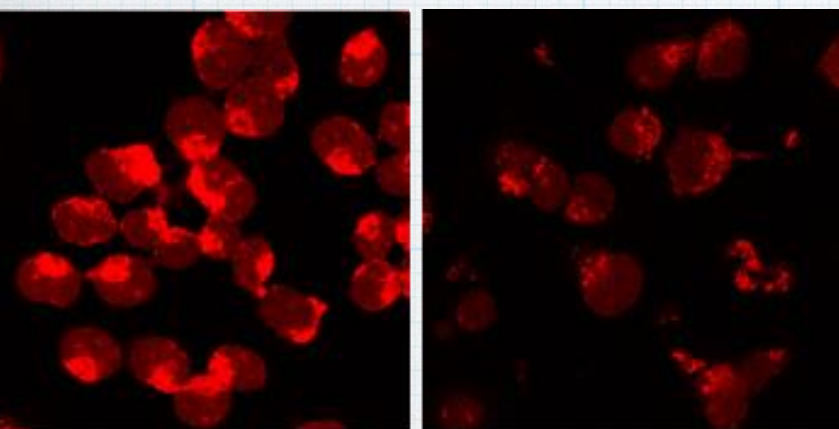
Synthesizing regenerative biomaterials

Acellular scaffolds with renewable microgradients

Customized scaffolds for stem cell niche delivery

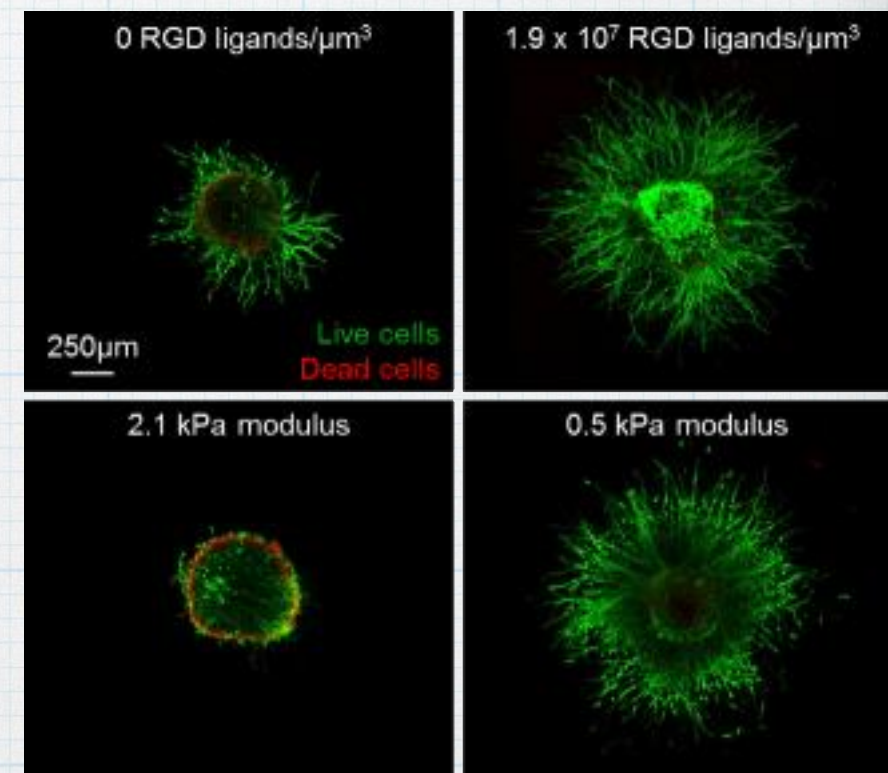
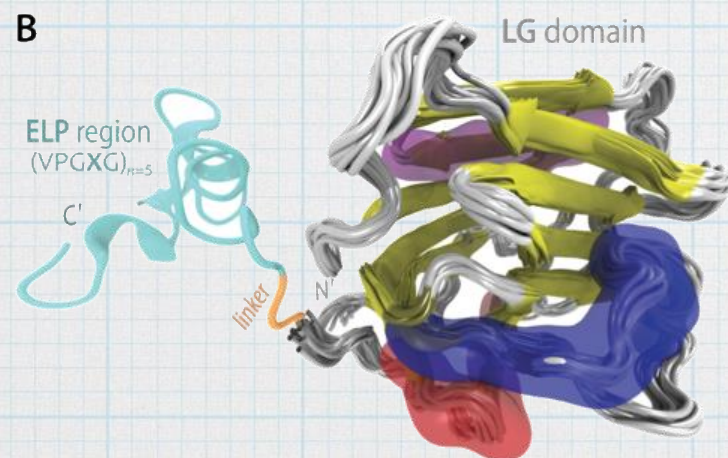
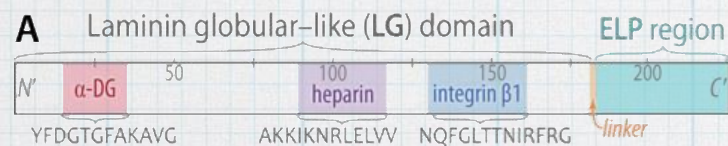
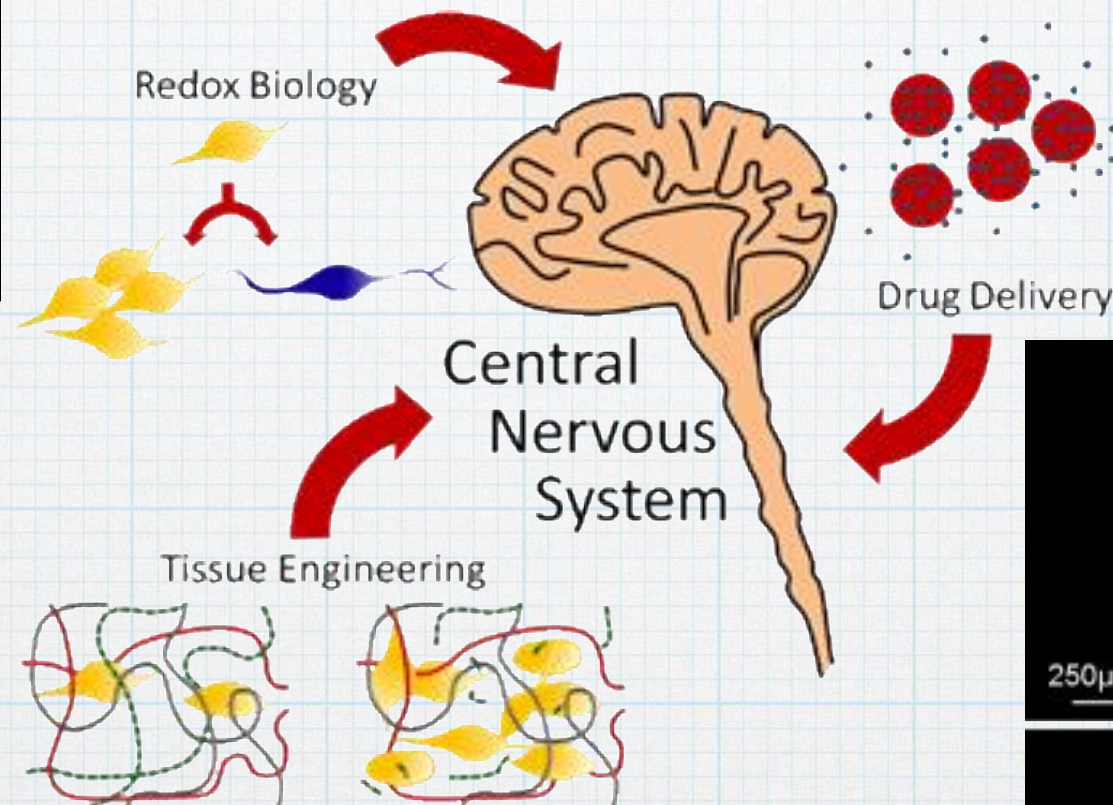


Lampe Research Group



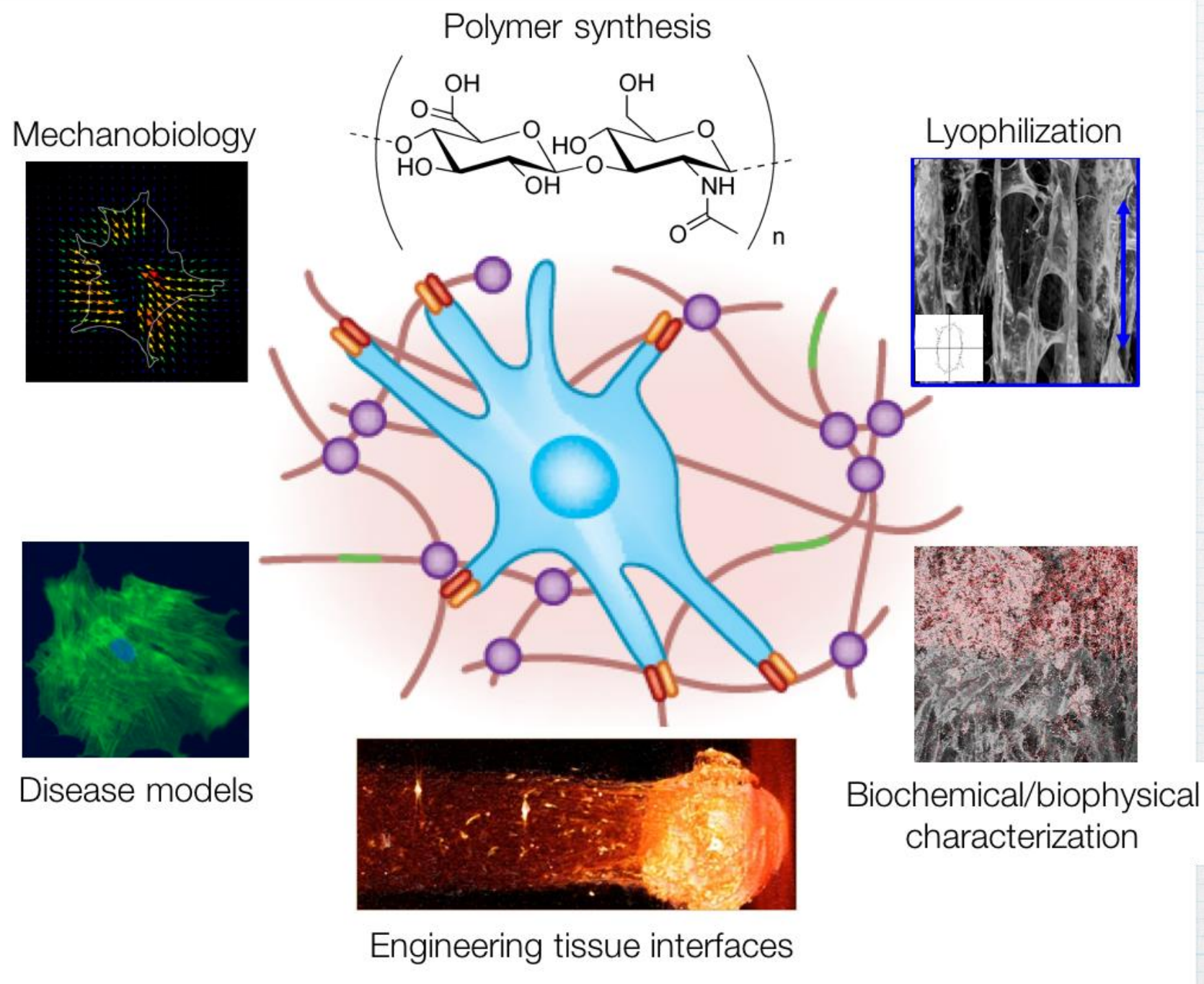
Control

+ Antioxidant



ssue microenvironment/drug delivery and Reactive Oxygen Specie

Caliari Research Group



Tissue interests: MTJ regeneration, fibrotic tissue,
and cancer microenvironment

Acknowledgements



- Segura group
 - Dr. Lina R. Nih
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