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3D Bioprinting and Nanobioinks for Complex Tissue and Organ Regeneration

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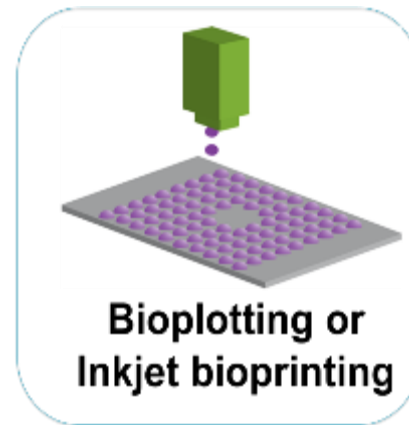
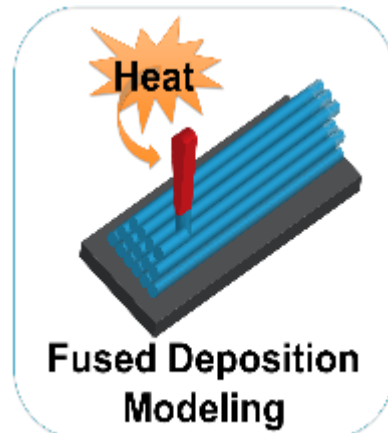
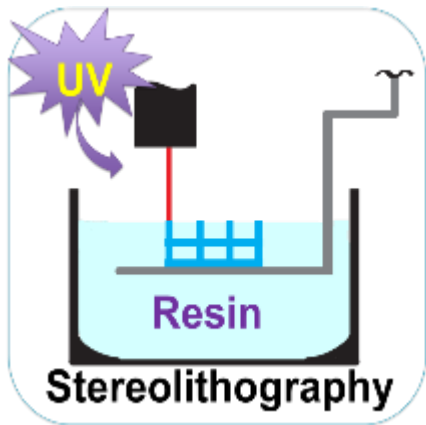
Department of Medicine

The George Washington University

March 17, 2016

3D Bioprinting: Custom Designed Complex Tissue and Organ Constructs

- Printing cells, bioactive factors and biomaterials
- 3D microfabrication for patient specific complex tissue and organ design



C. O'Brien, B. Holmes, S. Faucett and L.G. Zhang. *Tissue Engineering*, 21(1): 103-114, (2015)

<http://www.engineering.com/3DPrinting/3DPrintingArticles/ArticleID/6688/3D-Printing-Organs-with-the-Bioficial-Technique.aspx>

Several Challenges

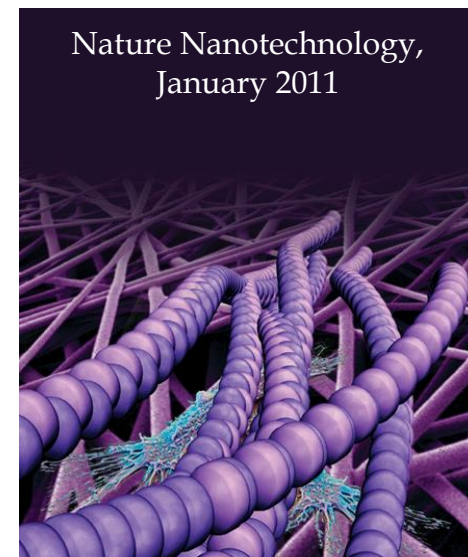
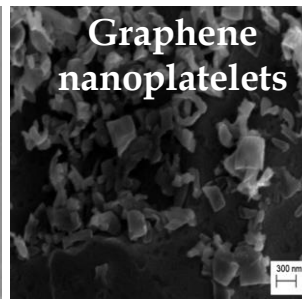
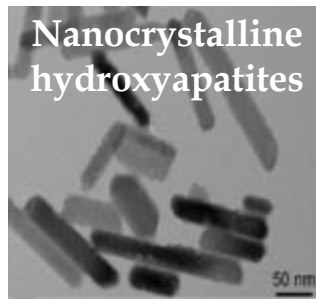
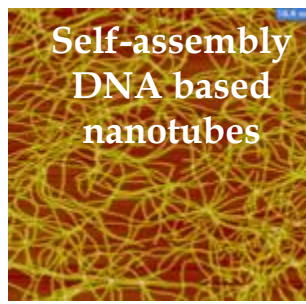
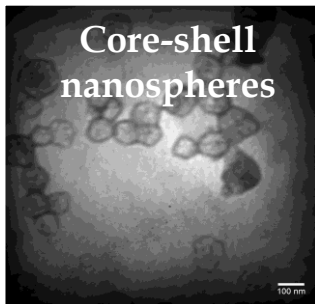
- Bioprinting “inks”: not biomimetic and bioactive for maximal cell growth and tissue integration.
 - Bioprinting platforms: low resolution, low cell viability and low yield.
 - Low efficient 3D perfused vascular network
 - Lack of 3D neural network
- “Functional”
Organ**

Nanotechnology in 3D Bioprinting

Nanomaterials are materials with basic structural units, grains, particles, fibers or other constituent components **smaller than 100 nm** in **at least one dimension**.

Human tissue structure: **nanostructured extracellular matrix (ECM)** and various cells

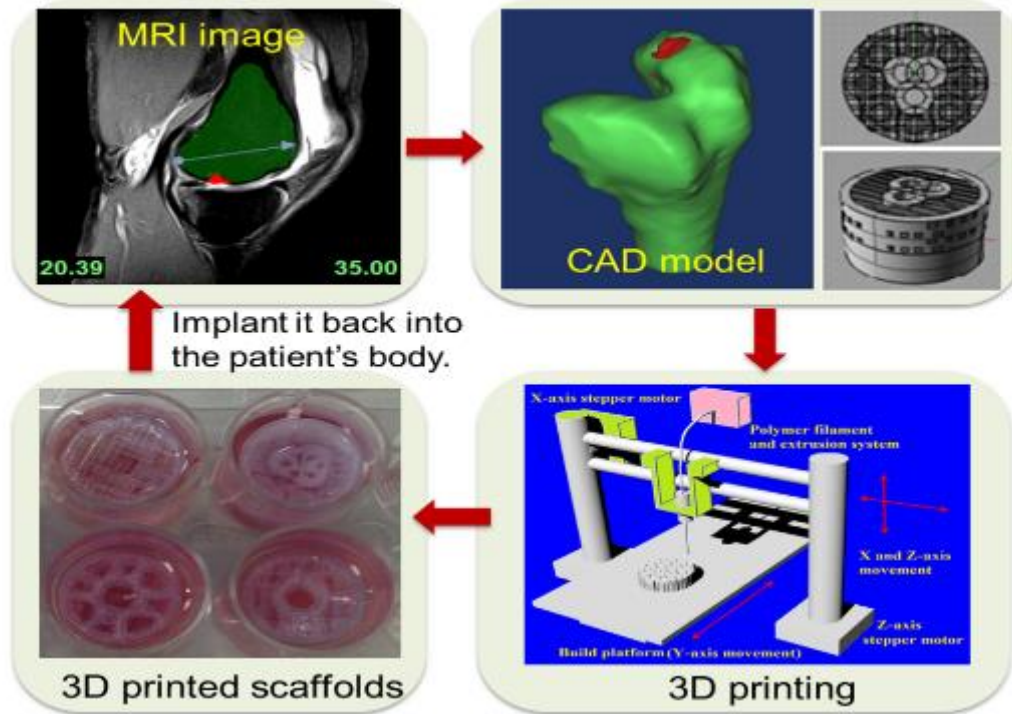
Nanoinks: Nanoparticles, Nanotubes, Nanofibers, Nanocrystals, Nanorods...



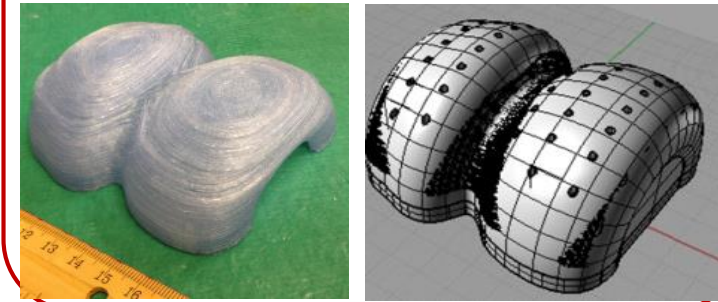
L. Zhang and T.J. Webster. Nanotechnology and Nanomaterials: Promises for Improved Tissue Regeneration. Nanotoday, 4(1):66-80 (2009).

Regeneration I: 3D Bioprinting Cartilage and Osteochondral Tissue

3D Printing Patient Specific Osteochondral Construct



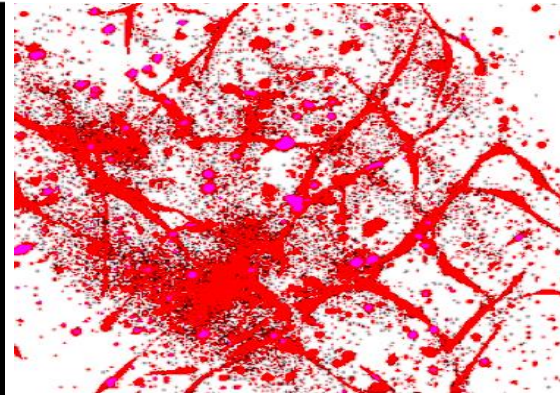
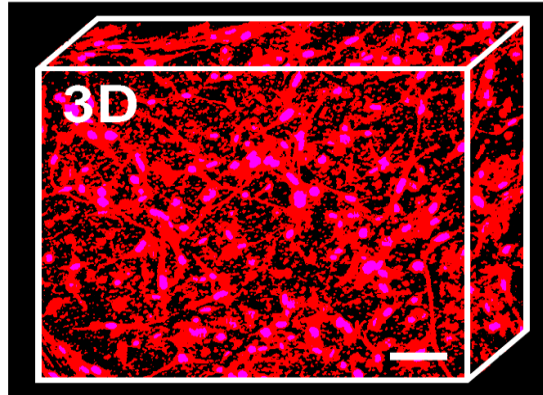
3D Bioprinted Knee Construct



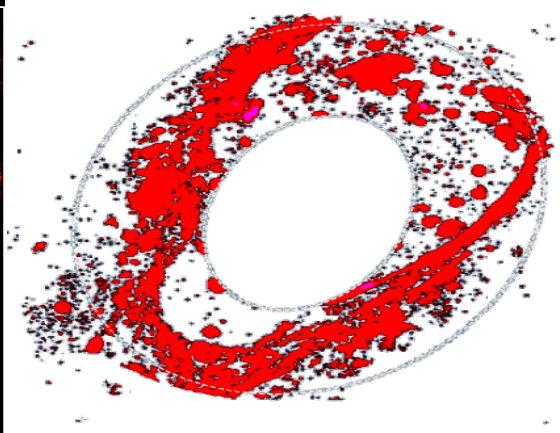
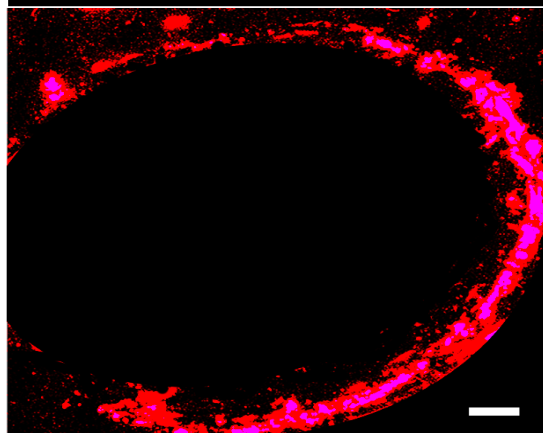
B. Holmes, W. Zhu, J. Li, J. D. Lee and L.G. Zhang. Tissue Engineering Part A, 21(1-2): 403-415 (2015).

Regeneration II: 3D Bioprinting Vascularized Tissue

Capillary Network



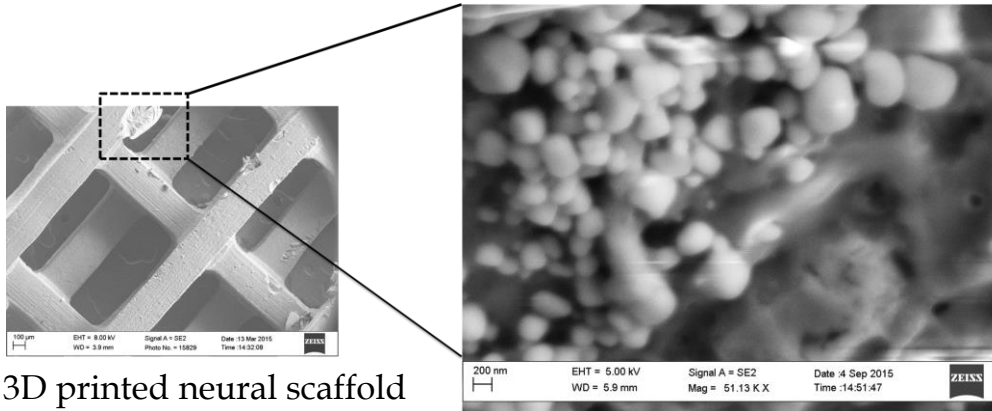
Vascular Lumen



Regeneration III: 3D Bioprinting for Neural Engineering

3D bioprinting conductive neural guidance scaffolds

3D nanostructured scaffolds for brain and spinal cord repair

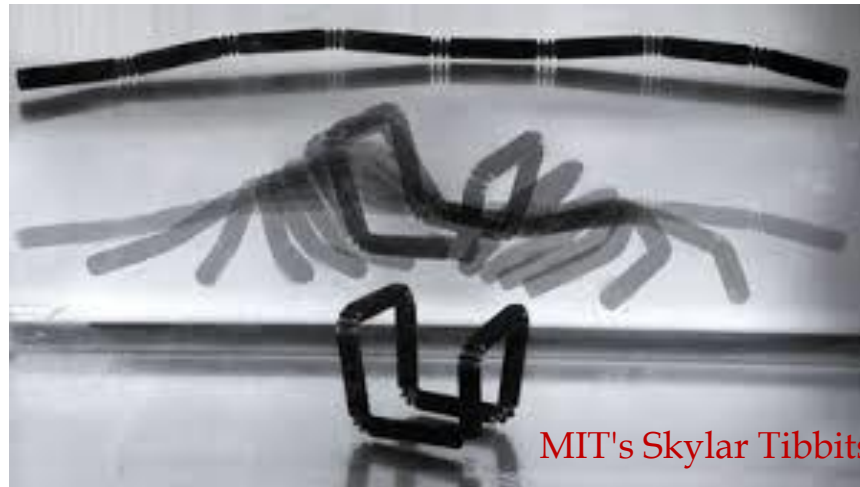


3D printed neural scaffold with core shell nanospheres



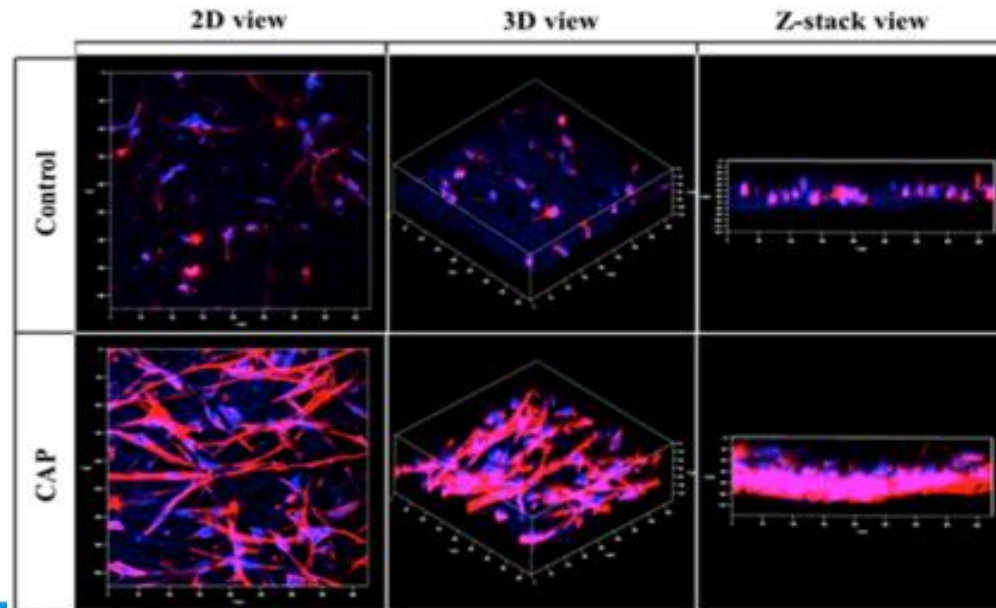
New Frontier I: 4D Bioprinting

- The printed constructs are able to change and mutate **over time**.
- Smart biomaterials for 4D bioprinted tissue constructs.

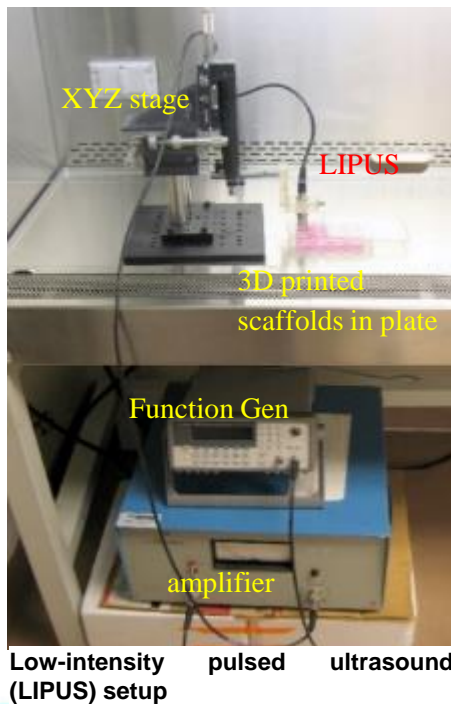


New Frontier II: The Combination of Cold Plasma and 3D Bioprinting

Design advanced cold plasma 3D bioprinters
Cold plasma modified 3D bioprinted constructs...



New Frontier III: The Combination of Ultrasound and 3D Bioprinting



To stimulate cell functions in 3D bioprinted constructs

To improve spatiotemporal bioactive factor delivery in the 3D bioprinted tissue constructs.

Questions?

