Cell and Biologics Printing

3D Printing Workshop

Sarah Van Belleghem

WELCOME 3D PRINTING WORKSHOP

Sarah Van Belleghem/ PhD Candidate

- 4th year PhD candidate - Bioengineering Department
- Graduated from MIT in Mechanical Engineering (2015)
- Very interested in progressing advances pertaining to the women's health world.

PRESENTATION MAP

- Project Development
- Bioinks
- Impact of Material Properties
- What you can/not print
- Examples
- Conclusions

Project Development

1 **Unique Architecture is Necessary**

No other forms of traditional fabrication can create desired object.

2 **Feasible Fabrication**

The chosen 3D printing technology should be able to create desired object (materials, size/shape)

3 **Central Biological Question**

Must be investigated, either cellular mechanism/furthering knowledge of fundamental biology.

4 **Apparent Clinical Need**

Gives value to your research and a necessary personal connection to drive focused research efforts.

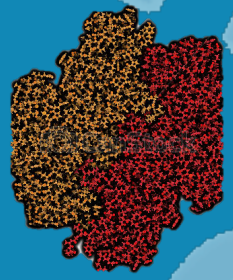
Bioinks-Natural

Protein-based | **Polysaccharides** | **Decellularized Matrix**

Gelatin/Collagen

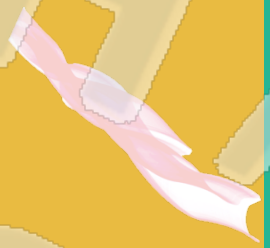
Most abundant protein in body

Fibrin



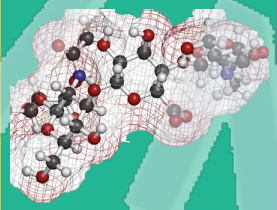
Blood-clotting protein

Silk



Protein fiber made by insect larvae

Hyaluronic Acid



Glycos-aminoglycan

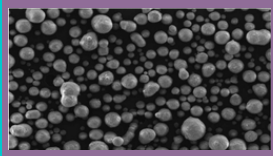
Chitosan

Polysaccaaride made from chitin shells

Alginate

Polysaccaaride in walls of brown algae

Hydroxyapatite

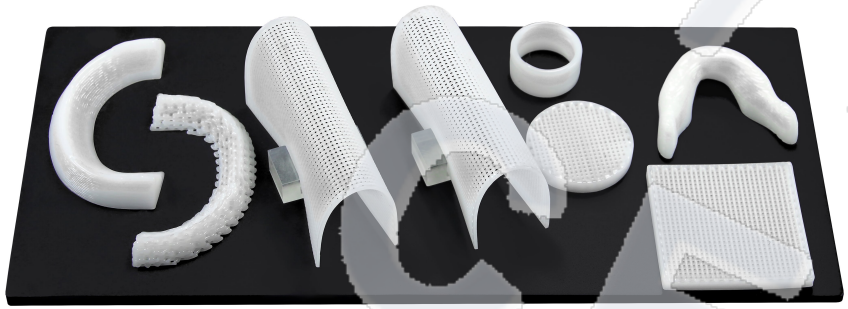


Mineral form of calcium apatite (bone)

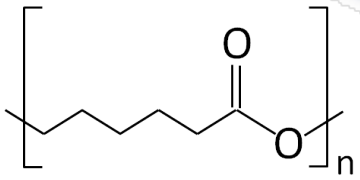
Bioinks-Synthetics

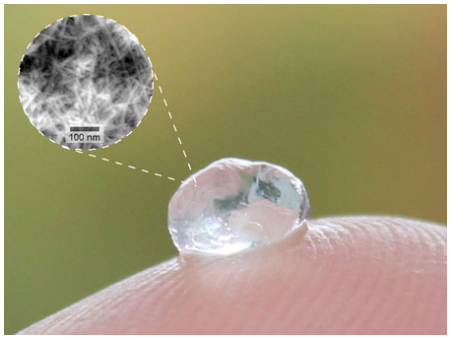
*Polymers are **easy to synthesize**, display controllable **degradable properties**, and experience **minimal** inflammatory response*

Increasing Stiffness

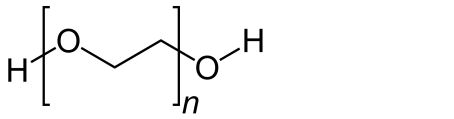


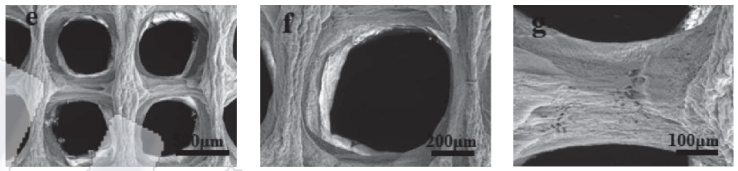
Polycaprolactone



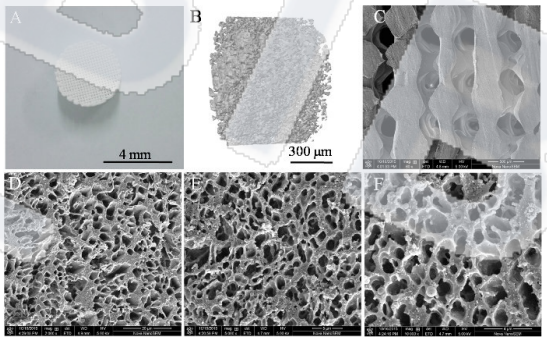


Polyethylene glycol

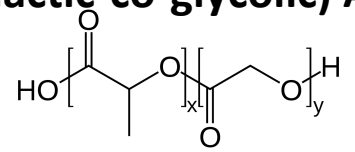




Poly(L-Lactide-co-ε-caprolactone)



Poly(lactic-co-glycolic) Acid



Impact of Material Properties

MATERIAL PROPERTIES

Some materials are incompatible with extrusion-based printing (low viscosity, Newtonian fluid)

BIO-COMPATIBILITY

Some materials can be cytotoxic and thus should not be used in tissue regenerative practices

Z-AXIS MISALIGNMENT

If strand deposition is not accurate, the printed part will become ‘off’ by a layer, and all proximate layers. This renders an ill-printed part

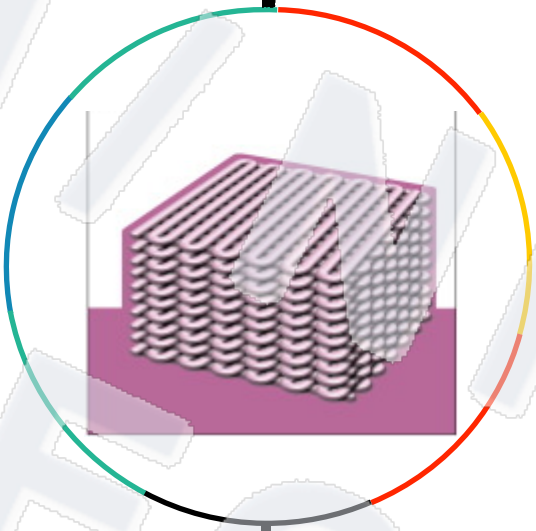
Printing Limitations

Can

Robust synthetic, biocompatible scaffolds that promote tissue formation

Soft hydrogels that promote water absorption

Live Cell Delivery (bioink encapsulation)



Can't

Full Complex and Functioning Organ

Fully Vascularized Grafts

Immune Response

Examples

A wide array of tissues can be regenerated with 3D printed constructs

Aorta

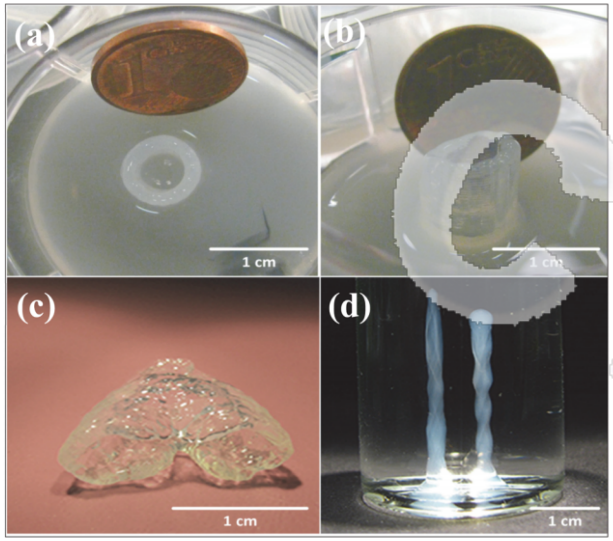


Fig. 7 Robotic and manual printing of 3D constructs by using an agarose bioink under fluorocarbon. (a) Top and (b) side view of printed cell-laden constructs. (c) 3D construct mimicking a vascular bifurcation that was printed while submerged in perfluorotributylamine. (d) Printed cylinders without cells.[92] Reprinted with permission Copyright IOP Publishing, 2013.

Bone

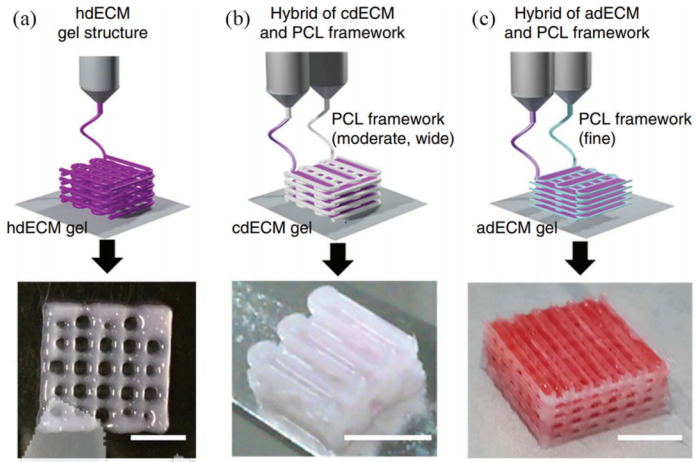


Fig. 8 Utilizing various dECM bioinks for bioprinting 3D tissue constructs. (a) Heart tissue construct was printed with only heart dECM (hdECM). (b) Cartilage and adipose tissues were printed with cartilage dECM (cdECM) and (c) adipose dECM (adECM), respectively, and in combination with PCL framework (scale bar, 5 mm).[99] Reprinted with permission Copyright Nature Publishing Group, 2014.

Breast

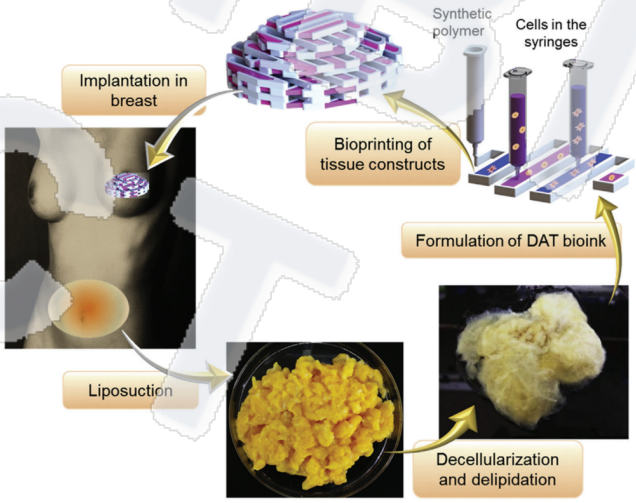


Fig. 9 Adipose tissue obtained by surgery and used as a bioink after a decellularization process for soft tissue reconstruction.[100] Reprinted with permission Copyright Elsevier, 2015.

Conclusions

- Intricate process in developing 3D print project
- Materials (natural and synthetic)
  - Print properties
- Printing limitations
- Examples

Questions?