# Determining the best method of cell depositing during 3D printing process – Bioprinting

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## What is 3D bioprinting?

-Traditionally done by 3d printing molds and scaffolds and then actual cells must be seeded with printed structure afterwards
-"Bioprinting" = when you  deposit the cells directly during the printing process

## Overview of Dr. Zhang's research

-Dr. Zhang is searching for the best method to print human cardiovascular vessels. His focus is on coronary arteries and capillaries. These printed vessels must be capable of performing like natural vessels, in that they should behave as microfluidic devices and transport blood at high pressures.

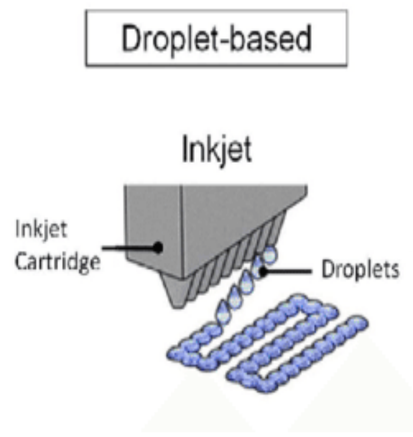
## Extrusion Based

Direct ink writing is an extrusion-based technology that works like a hot glue gun. The bio-ink is extruded through a tube or needle so that it is laid out in the correct orientation, and then the bio-ink undergoes a solidifying process. One standard method is to use heat to liquify the bio-ink as it is passing through the needle, and then allowing it to cool and harden once it has been extruded. Another standard method is called shear thinning, and it takes advantage of the property of some bio-inks that they become less viscous when they are introduced to strong shear forces from being squeezed through a very thin needle.


| Compatible bioinks | strengths | weaknesses |
|---|---|---|
| Collagen, Pluronic, PEG | •Cheap<br>•Simple technology-- easy to make adjustments/fix | •Low fabrication rate<br>•Low resolution<br>•Low cell viability<br>•Requires heating hydrogel or subjecting it to high pressures or shear stresses which can all damage the cells<br>•Often needs support structures or to be frozen post-printing to solidify |

## Droplet-Based

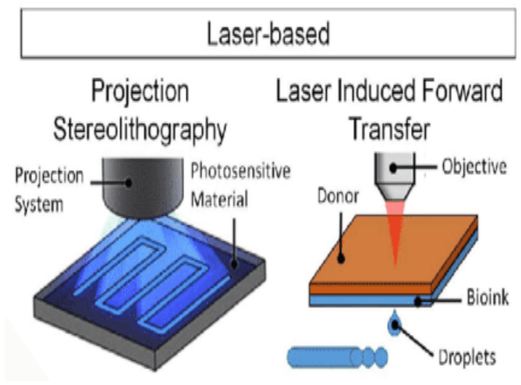
Droplet based 3D printers work like an inkjet printer. Hundreds of tiny needles spread out in a row deposit single drops of bio-ink in the correct locations to form a certain structure. Like with extrusion-based methods, either heat or shear thinning can be used to liquify and re-solidify the bio-ink material.




| Compatible bioinks | strengths | weaknesses |
|---|---|---|
| Alginate, Collagen, PEG | •Moderate fabrication rate<br>•High cell viability<br>•Moderately simple technology | •Low resolution<br>•Requires heating hydrogel or subjecting it to high pressures or shear stresses which can all damage the cells<br>•Often needs support structures or to be frozen post-printing to solidify |

## Laser-Based

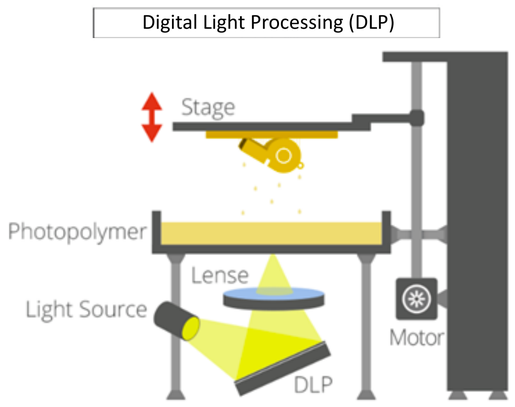
Laser based 3D printers can work in two ways. One style involves laying down a monolayer of powder and using the laser to created patterns of concentrated heat to melt the powder and cause it to stick to itself and form one solid body. The other style makes use of the fact that UV light exposure can cause some polymeric materials to solidify from a liquid resin form to a solid form. This occurs because the individual polymers in the bio-ink are deformed by the UV light in such a way that they tangle with each other and form cross -links to create sturdy polymer structures. Laser-based printers shine the laser to cure the resin one micron-sized dot at a time so that they have the highest resolution of any printing style.




| Compatible bio-inks | strengths | weaknesses |
|---|---|---|
| Alginate, Collagen, Pluronic, PEG | •Very high resolution<br>•A few compatible hydrogels are efficient in mimicking properties of living tissues<br>•Efficiency in cells retaining high long-term viability | •Most compatible solvents are toxic to cells (in this case must only print scaffolding and then add cells afterwards)<br>•UV light curing can generate double-strand DNA breaks in the encapsulated cells<br>•Difficult to get cells to be uniformly suspended within solution throughout entire fabrication process |

## Digital Light Processing (DLP)

Digital light processing 3d printers work similarly to laser-based 3d printers in that they use light to generate crosslinks in polymers in order to convert them from a liquid to a solid. The major difference is that DLP printers use a digital light projector to project a full image onto the liquid resin, curing an entire layer of the part at once. This makes it an exponentially faster printing process than any other method.




| Compatible bio-inks | strengths | weaknesses |
|---|---|---|
| Alginate, Collagen, Pluronic, PEG | •High fabrication rate<br>•High resolution<br>•A few compatible hydrogels are efficient in mimicking properties of living tissues<br>•Efficiency in cells retaining high long-term viability | •Most compatible solvents are toxic to cells-- must only print scaffolding and then add cells afterwards<br>•UV light curing can generate double-strand DNA breaks in the encapsulated cells<br>•Difficult to get cells to be uniformly suspended within solution throughout entire fabrication process |

| General Comparison | Compatible bioinks | resolution | speed | Cell viability | cost |
|---|---|---|---|---|---|
| **extrusion** | **Collagen, Pluronic, PEG** | **50 um** | **um/s (slow)** | **40-80%** | **$200+** |
| **droplet** | **Alginate, Collagen, PEG** | **50 um** | **mm/s (medium)** | **>85%** | **$1000+** |
| **Laser** | **Alginate, Collagen, Pluronic, PEG** | **1 um** | **mm/s (medium)** | **>85%** | **$3,000+** |
| **DLP** | **Alginate, Collagen, Pluronic, PEG** | **6 um** | **mm^3/s (fast)** | **85-95%** | **$3000+** |

## Conclusion: Best method Digital Light Processing

## References

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