

# 3D BIOPRINTING OF ORGAN TISSUES: A PROMISING SOLUTION FOR FUTURE ORGAN TRANSPLANTS

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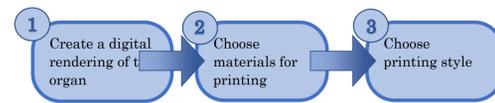


## An Introduction to 3D Bioprinting

### What is 3D Bioprinting?

The use of 3D printing capabilities to construct tissues that function similar to those found in the body. This process incorporates scanning technologies, bio-inks and a variety of printing methods to print layer-by-layer representations of the tissue.

### The Bioprinting Process:



- 1 Computed Tomography (CT)**—Uses x-rays to map out tissue types in the scanned area in slices that when compiled show the whole organ  
**Magnetic Resonance Imaging (MRI)**—Use of a magnetic field to measure changes in the energy of the nuclei that align with the field  
These scans are digitized and optimized by using computer-aided design (CAD) and computer-aided manufacturing (CAM) tools

Biomaterial	What are they?	Pros	Cons
Stem cells	Cells found in the body (such as in bone marrow and adipose tissues) that can change into different cell types	Less likely to be rejected by host	Difficulty removing from the patient/ decreasing count at older ages
Spheroids	Artificially created collections of cells that grow to mimic structures found in the body	Mimic natural cell development	Limited control over their growth
Manufactured bio-inks	Hydrogels created to aid in structuring, supporting, and integrating the organ into the body	Choose the traits most important to the tissue	Cannot form a functioning organ on their own/they need cells to populate the structure

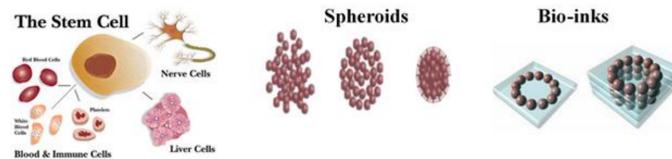
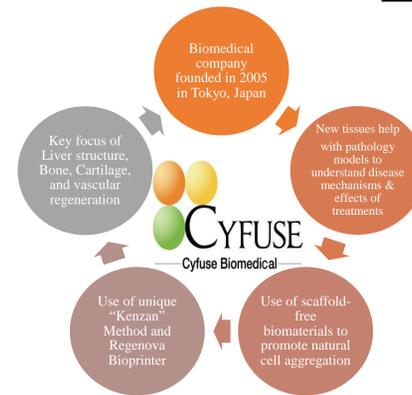


Figure 1: Possible cell types in bioprinting.

Printing Method	Process	Pros	Cons
Biomimicry	Print an organ that imitates the exact structure found in the body	Creates an organ structurally like the old one	Requires a depth of knowledge about the microenvironment that has not yet been researched
Mini tissues	Create small tissues that, when fused together, perform the functions required of the larger tissue	Creates a large tissue that performs the multiple different functions required of it	Growth is uncontrollable while fusing, which makes it harder to replicate the organ structure

## International & Domestic Bioprinting Techniques



### “Kenzan” Method

1. Collect thousands of spheroid cells
2. Transfer cells to “Kenzan” needle array, which allows for circulation of oxygen.
3. Wait for cells to undergo primary maturation (2-3 days)
4. Remove cell structure and relocate to bioreactor for further maturation. The bioreactor helps to deliver oxygen and nutrition to the new cell tissues during development.

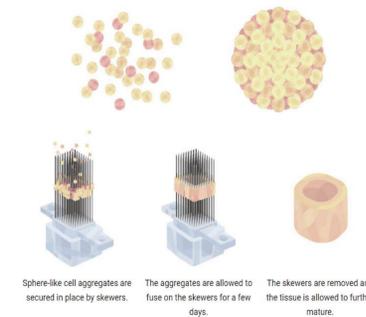


Figure 2: “Kenzan” Method procedure.

### Experimental Progress: Artificial Liver Tissues

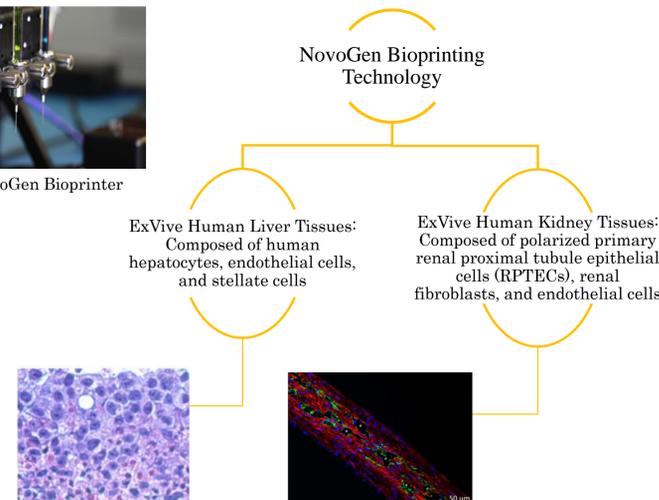
- Liver cells composed of cryopreserved hepatocytes, which are responsible for completing metabolic functions.
- According to the results of a study in July 2017, Cyfuse was able to develop bioprinted liver tissues that maintained proper liver functions, such as drug metabolism and regulation of glucose.



- Founded in 2007, Organovo is a domestic research-based company located in San Diego, California.
- Collaborating with biopharmaceutical companies and hospitals, Organovo aims to develop 3D bioprinted tissues, specifically liver and kidney, to use for disease modeling, toxicology, and a general understanding of organ structures.
- The company’s future goal is to advance their 3D printing technology, so the new tissues can be implemented in to the human body, replacing malfunctioned tissues.



Figure 3: NovoGen Bioprinter



- ExVive Human Liver tissues demonstrated the ability mimic normal liver functions when implanted in mice with an Alpha-1 antitrypsin deficiency. The artificial tissues were able to counteract the mutation
- ExVive Human Kidney tissues showed evidence of structural similarities to normal kidney tissues. Some key findings were the presence of kidney enzymes (CYP450), gamma glutamyl transference activity, and cell networks.

## Future Applications

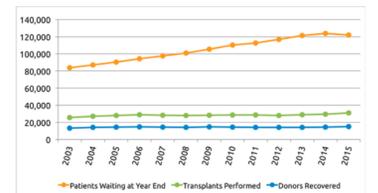
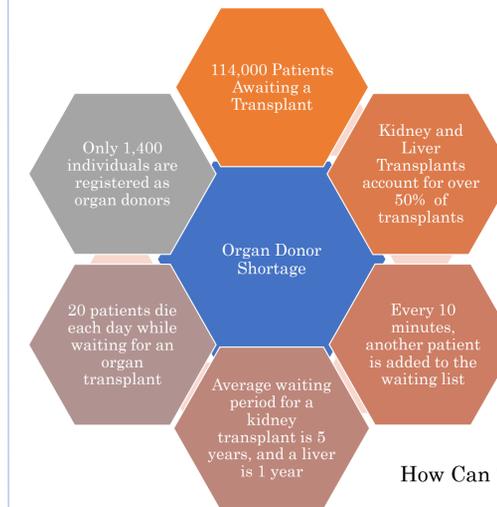


Figure 4: This emphasizes the lack of available donors to support those in need of transplants. As the number of patients needing an organ transplant increases, the number of available donors remains constant. This lack of available donors is one of the main reasons why a new avenue of obtaining organs is necessary, and 3D bioprinting poses a potential solution.

### How Can 3D Bioprinting Help?

- Unique bioinks facilitate an individualized approach for each patient
- Shorter waiting period without the need of a donor
- Biomaterials can be extracted from each patient
- Lower chance of organ/organ tissue rejection

## Sustainability & Ethics

**Social Sustainability:** Reviews the acceptance of a technology by the public and how the technology improves upon a person’s quality of life.



**Economic Sustainability:** Evaluates the costs to both the innovator and consumer. Costs must be balanced between both partners.

- Cell type
  - The use of stem and animal cells is opposed by some religious communities, such as Christians, specifically Catholics, and Muslims
  - Limits social sustainability
- Costs
  - High equipment and procedural costs to print organs limits the number of people able to afford a bioprinted organ and the number of companies researching in this area
  - Limits economic sustainability
- Patient confidentiality
  - The use of stem cell research for other purposes violates the patient’s medical confidentiality

*The increase in quality of life for patients, continued research and development to decrease costs of procedures, and protection of medical confidentiality will make bioprinting sustainable*

Image References:  
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