ENVIRONMENTAL STUDIES AND LIFE SCIENCES

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3D Bioprinting

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3D Bioprinting

- 3D printing, is driving major innovations in many areas, such as engineering, manufacturing, art, education and medicine.
- Recent advances have enabled 3D printing of biocompatible materials, cells and supporting components into complex 3D functional living tissues.
- 3D bioprinting is being applied to regenerative medicine to address the need for tissues and organs suitable for transplantation.
- 3D bioprinting involves additional complexities, such as the choice of materials, cell types, growth and differentiation factors, and technical challenges related to the construction of tissues.
- Addressing these complexities requires the integration of technologies from the fields of engineering, biomaterials science, cell biology, physics and medicine.
- 3D bioprinting has already been used for the generation and transplantation of several tissues, including multilayered skin, bone, vascular grafts, tracheal splints, heart tissue and cartilaginous structures.
- Other applications include developing high-throughput 3D-bioprinted tissue models for research, drug discovery and toxicology.

doi:10.1038/nbt.2958

3D Bioprinting

- 3D printing was first described in 1986 by Charles W. Hull. In his method, which he named ‘sterolithography’, thin layers of a material that can be cured with ultraviolet light were sequentially printed in layers to form a solid 3D structure.
- Development of solvent-free, aqueous based systems enabled the direct printing of biological materials into 3D scaffolds that could be used for transplantation.
- A related development was the application of 3D printing to produce medical devices such as stents and splints for use in the clinic.
- In a typical process for bioprinting 3D tissues imaging of the damaged tissue and its environment can be used to guide the design of bioprinted tissues.
- The choice of materials and cell source is essential and specific to the tissue form and function. These components have to integrate with bioprinting systems such as inkjet, microextrusion or laser-assisted printers.

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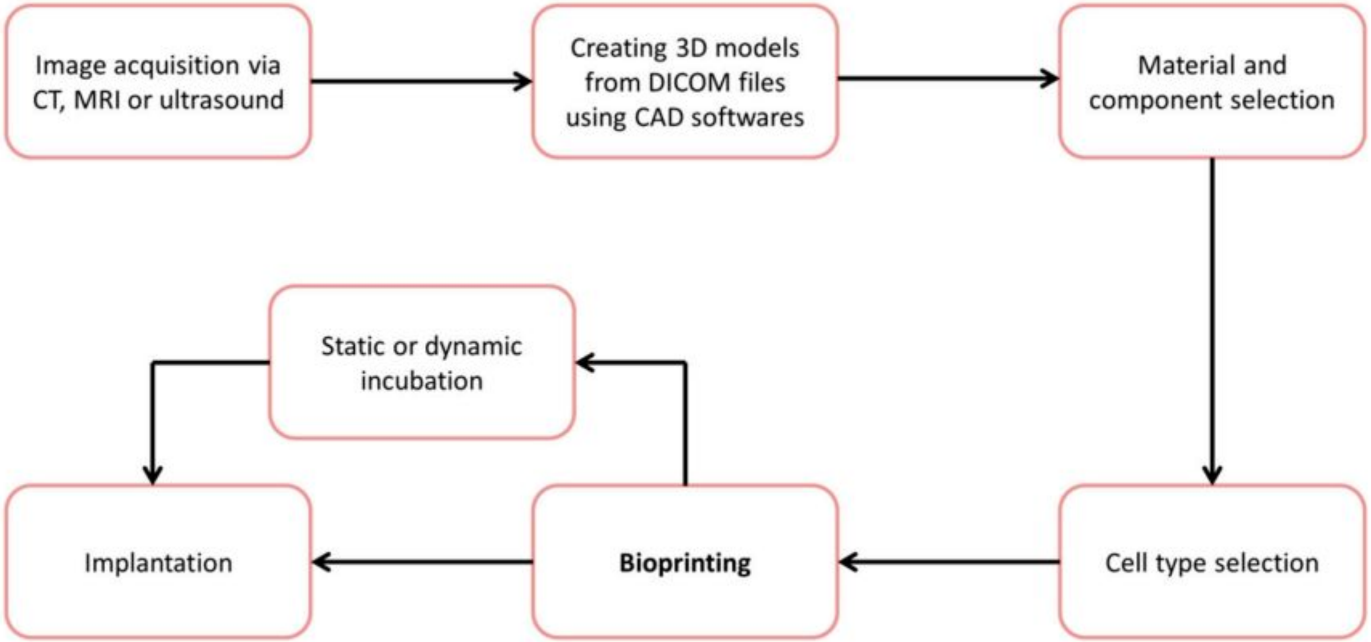
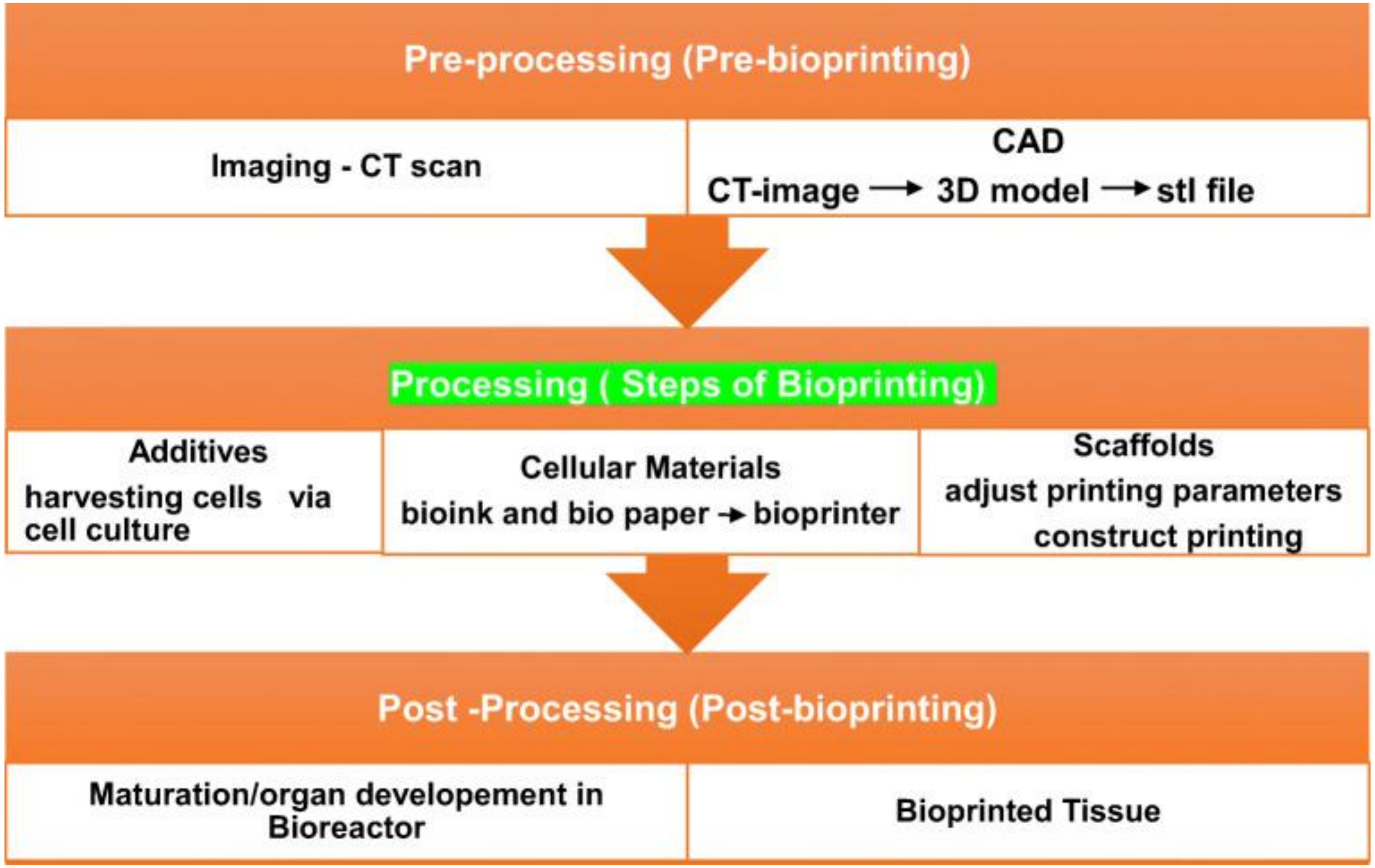
3D Bioprinting Process



Schematic of Bioprinting Scaffolds for clinical use. Digital 3D images obtained from CT, MRI or ultrasound, are used to design a suitable scaffold with 3D slicing and CAD software; materials from printing are chosen depending upon the application, and can consist of polymers, ceramics, and bioactive components; cells are selected dependent on the application, a bioink can consist of singular or multiple cell types.

doi:10.3390/ma11112199

3D Bioprinting Process



Steps In 3D bioprinting: different steps and stages that lead to the production of bioprinted constructs for implantation or in vitro testing

10.1007/s40883-021-00219-w

3D Bioprinting - Bioprinters

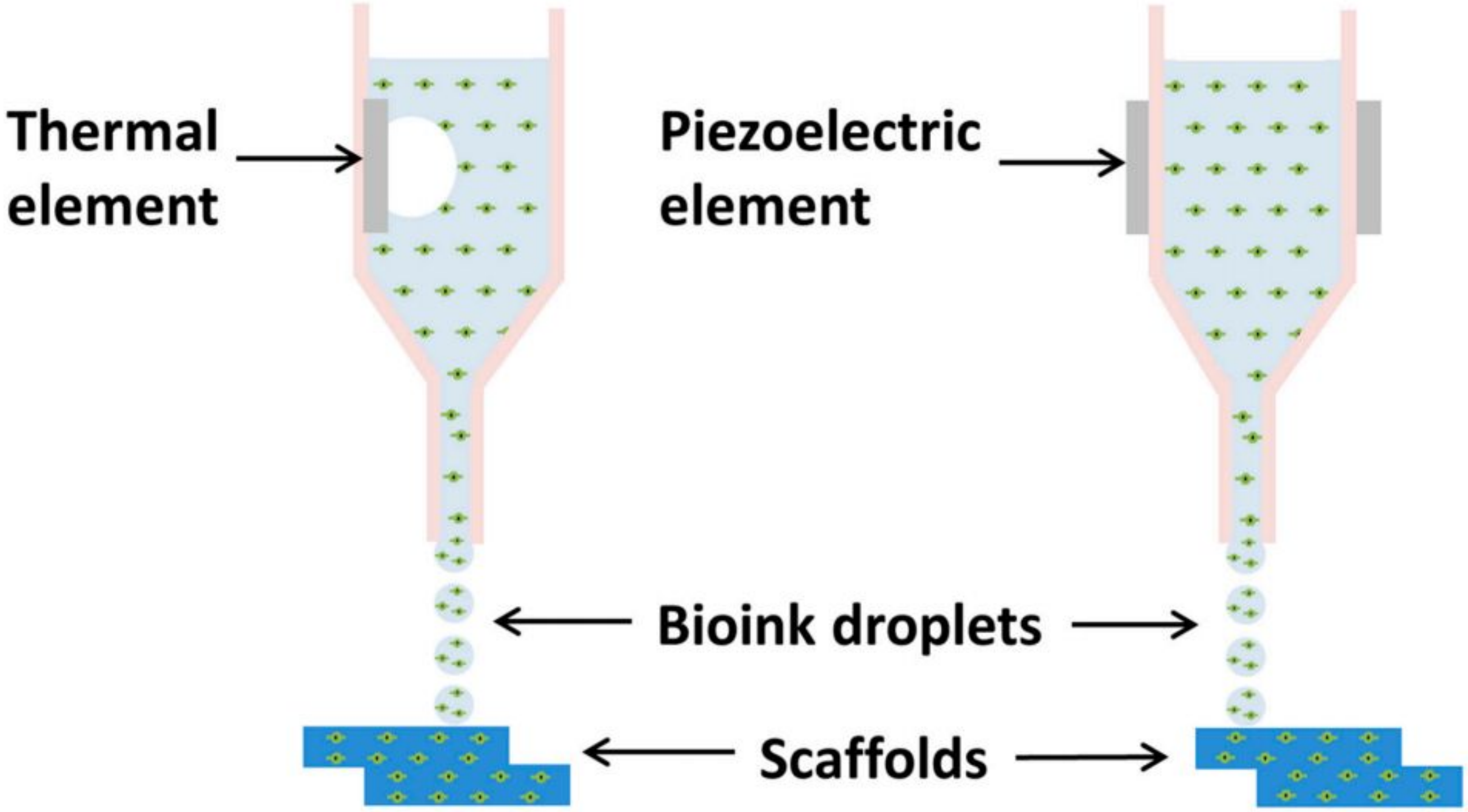


Figure 2. Schematic of Inkjet-based Bioprinting. Thermal inkjet uses heat-induced bubble nucleation that propels the bioink through the micro-nozzle. Piezoelectric actuator produces acoustic waves that propel the bioink through the micro-nozzle.

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3D Bioprinting - Bioprinters

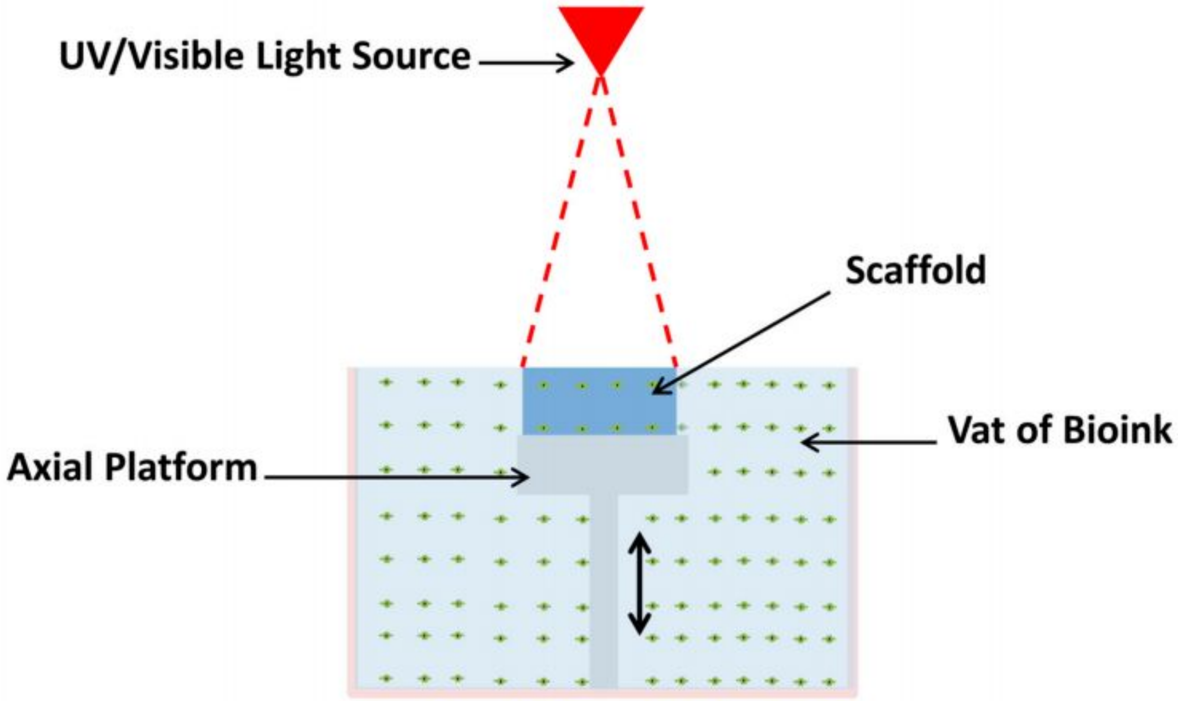

Figure 3. Schematic of Stereolithography Bioprinting. Photopolymerization occurs on the surface of the vat where the light-sensitive bioink is exposed to light energy. Axial platform moves downward the Z-axis during fabrication. This layer-by-layer technique does not depend on the complexity of the design, rather on its height.

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3D Bioprinting - Bioprinters

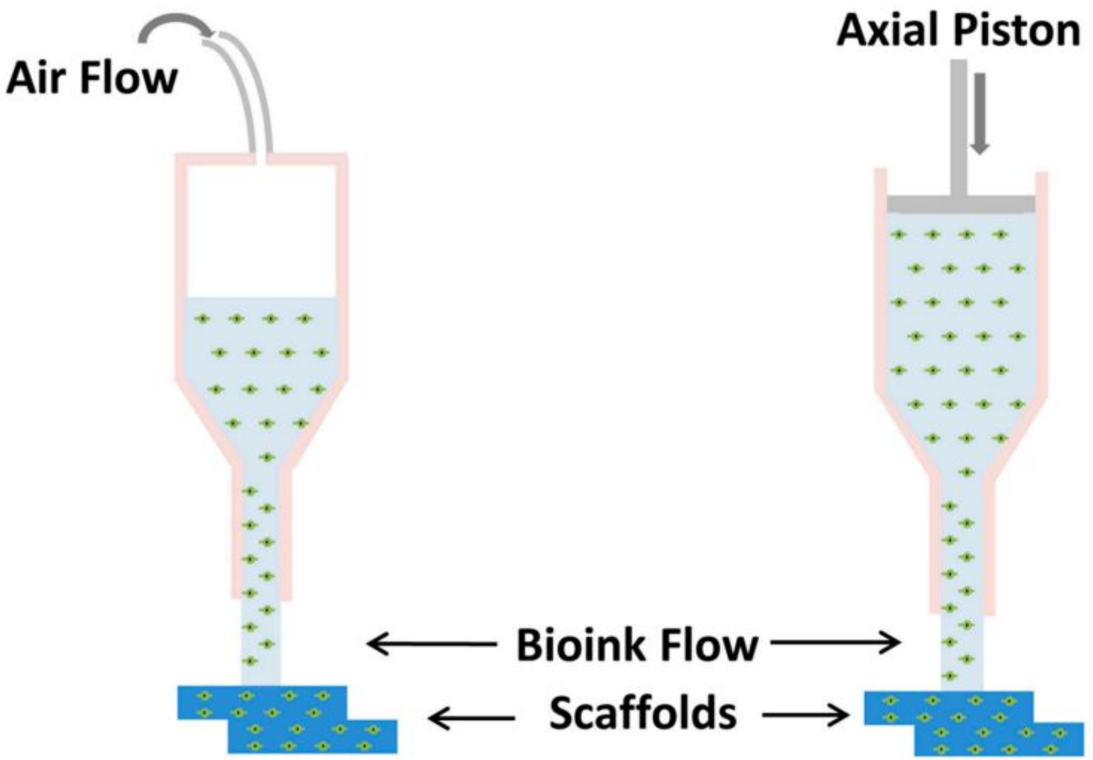

Figure 5. Schematic of Extrusion-based Bioprinting; from left, pneumatic-based and right, mechanical-based. Struts are extruded via pneumatic or mechanical pressure through micro-nozzles. Extrusion-based techniques can produce structures with great mechanical properties and print fidelity.

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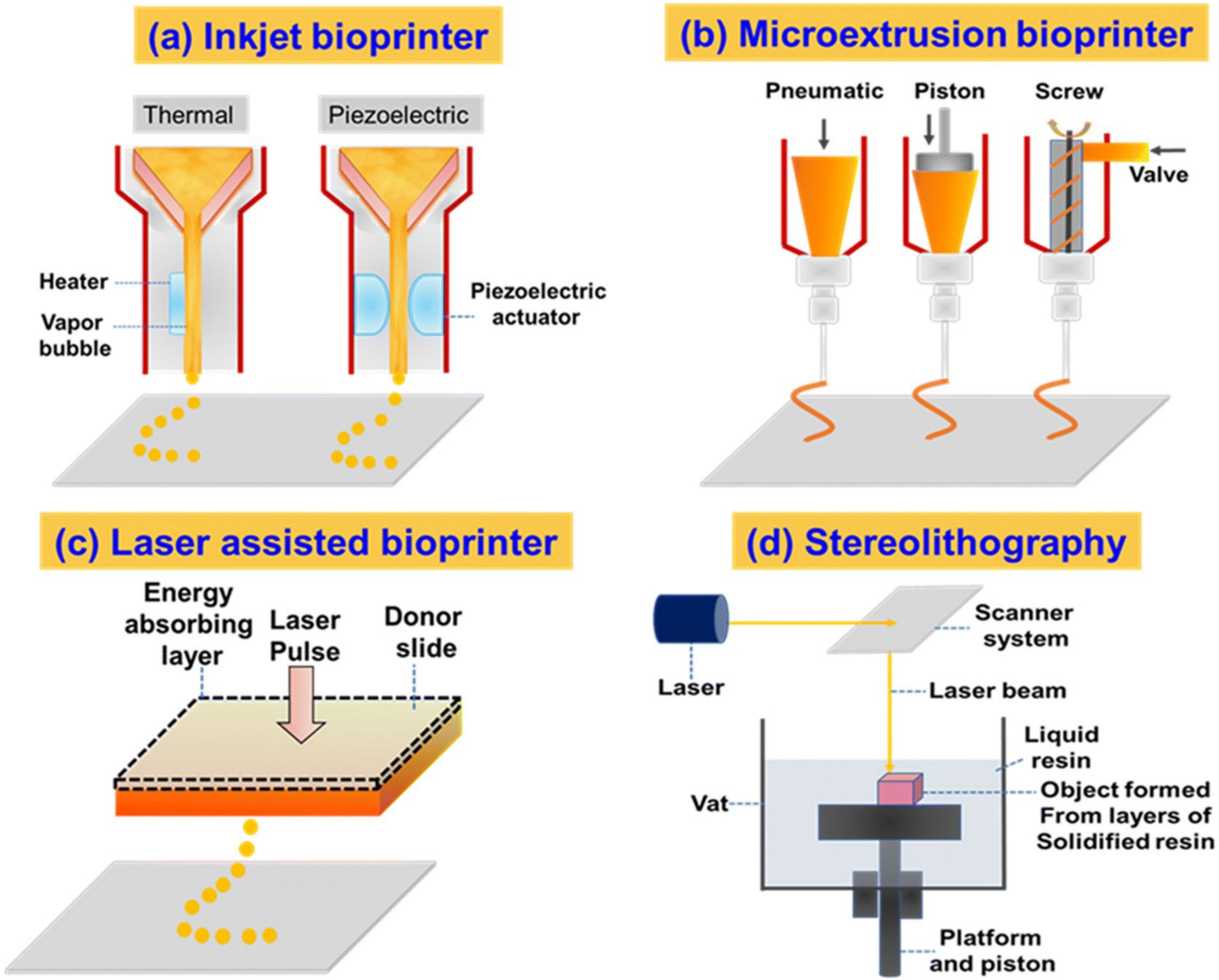
3D Bioprinting - Bioprinters



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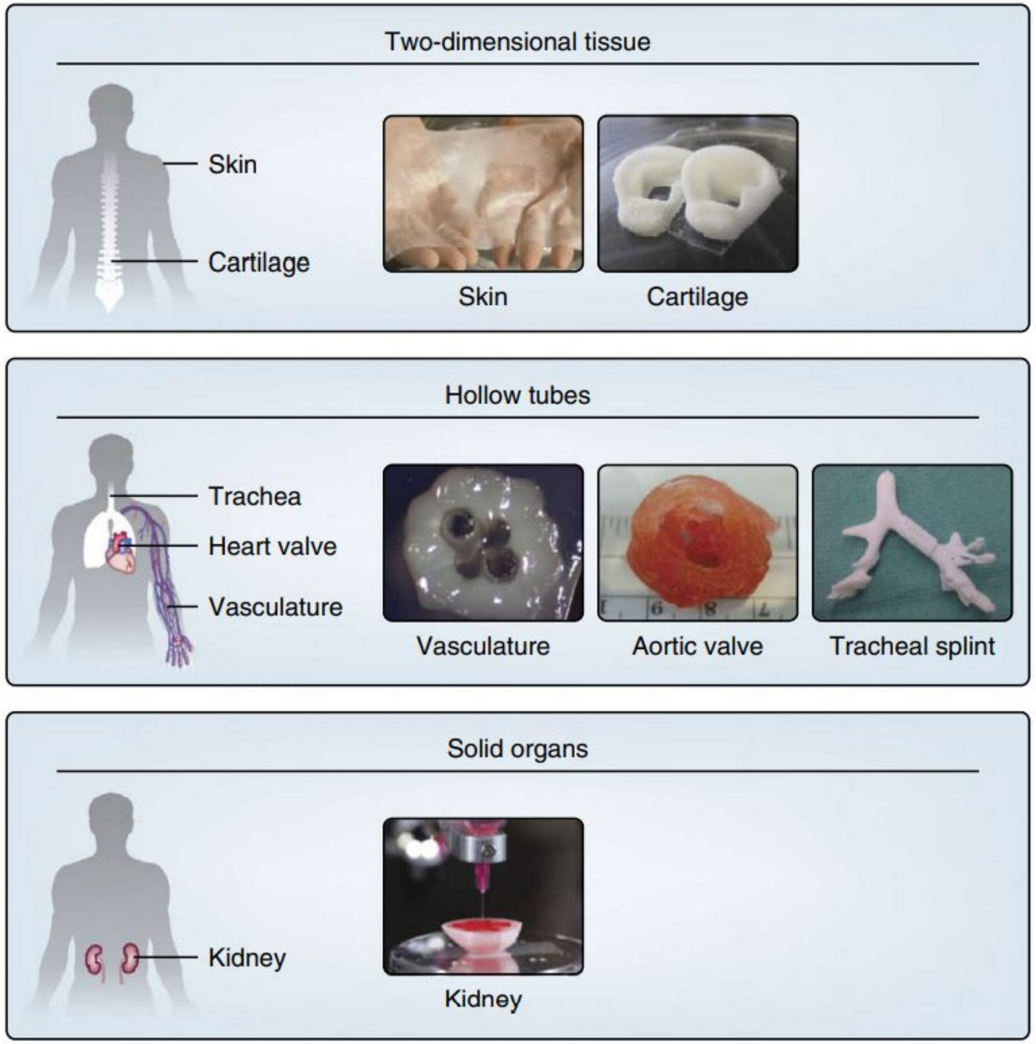
3D Bioprinting (Human scale bioprinted tissue)



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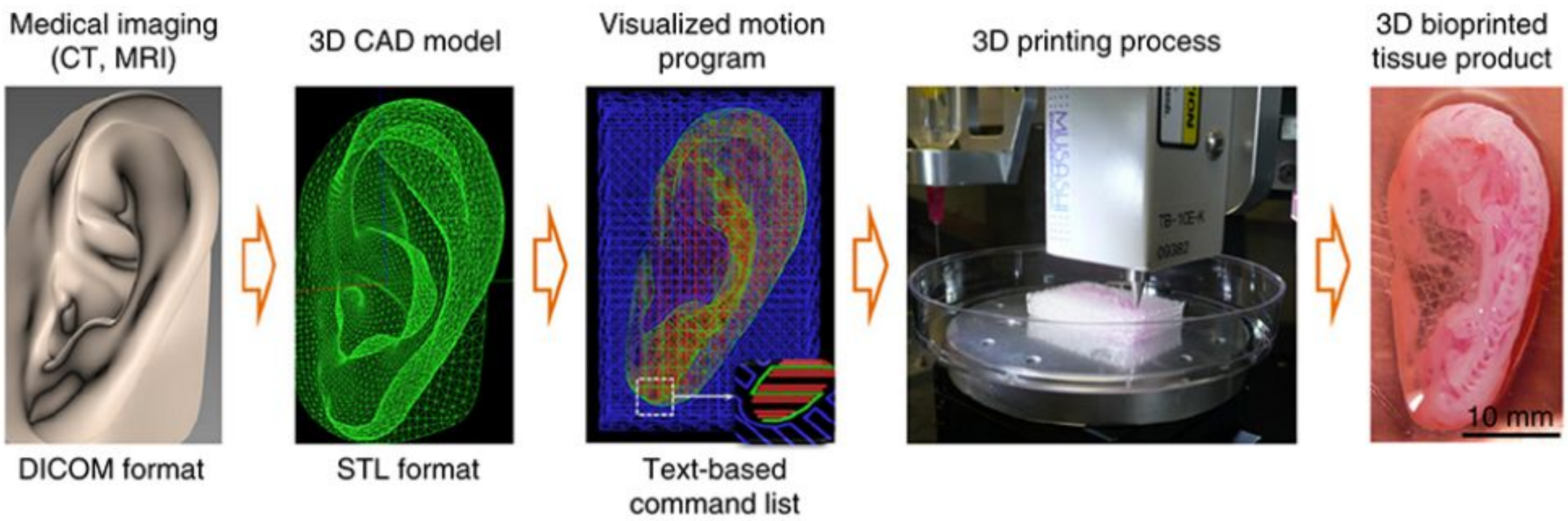
3D Bioprinting (Human scale bioprinted tissue)



The 3D bioprinting process. Image: Wake Forest, *Nature Biotechnology*

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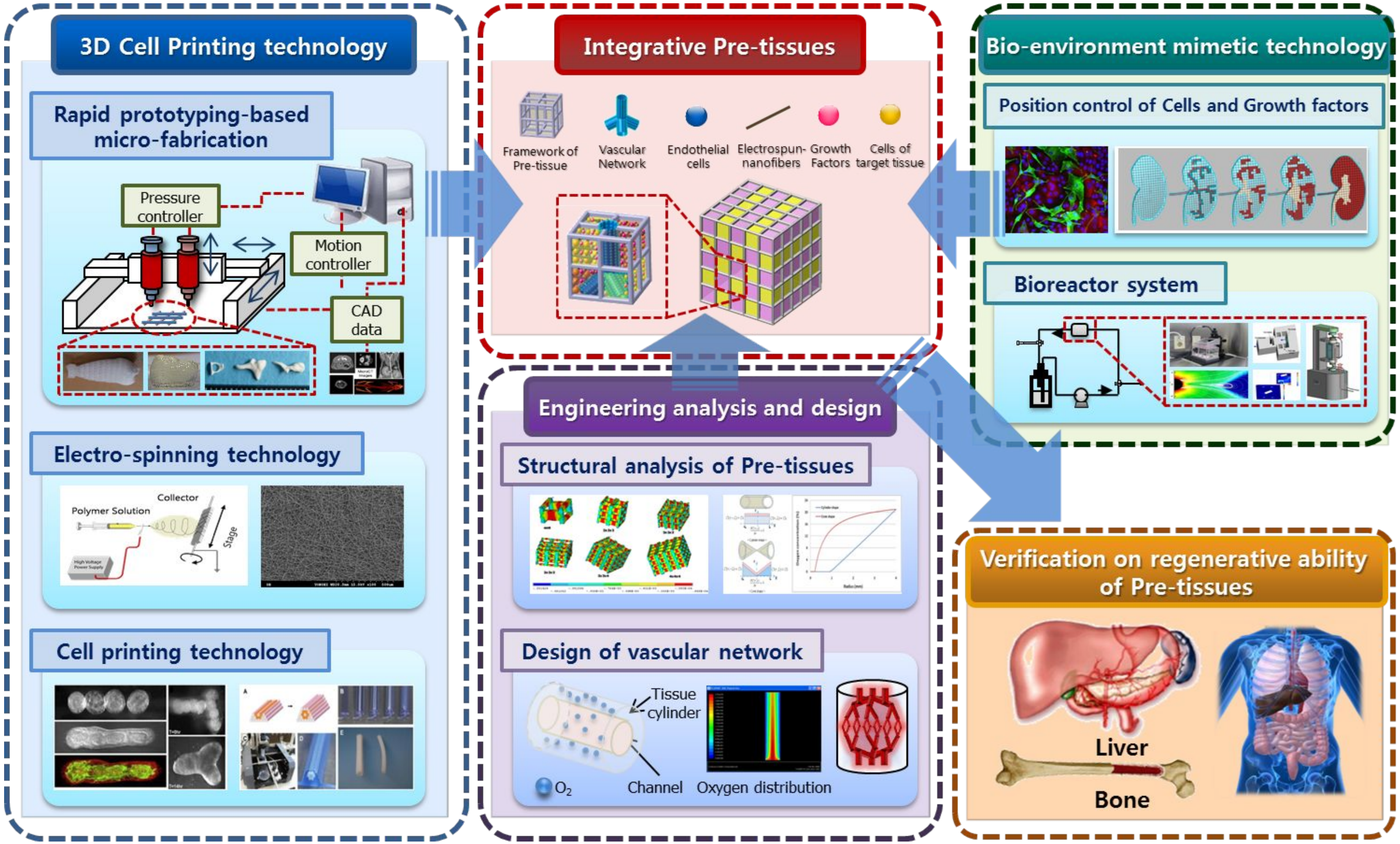
3D Bioprinting



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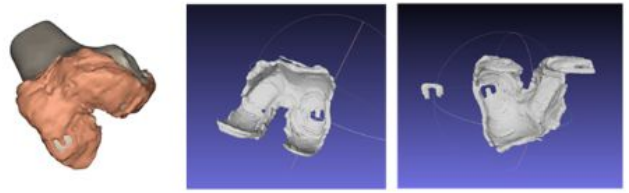
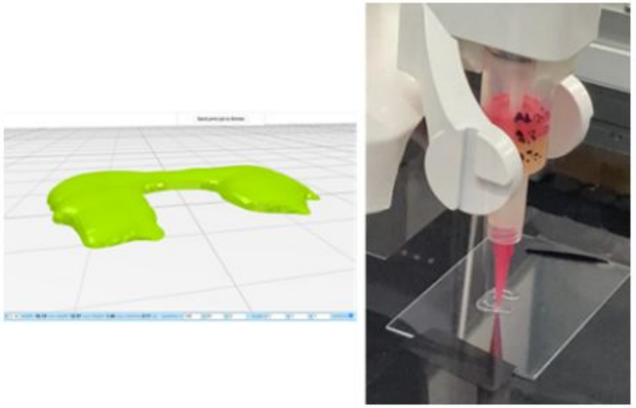
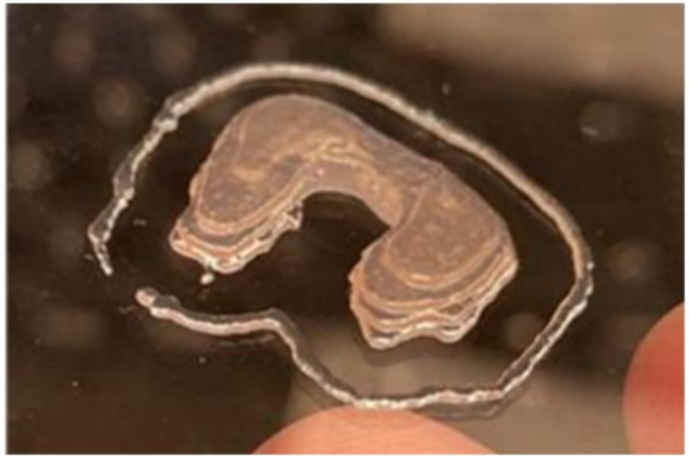
3D Bioprinting



A representative 3D reconstructed model of the osteoarthritic knee joint from the RESTORE Project's online database, together with STL models of the femoral cartilage with a horse-shoe-shaped cartilage patch designed to fit the lesion.

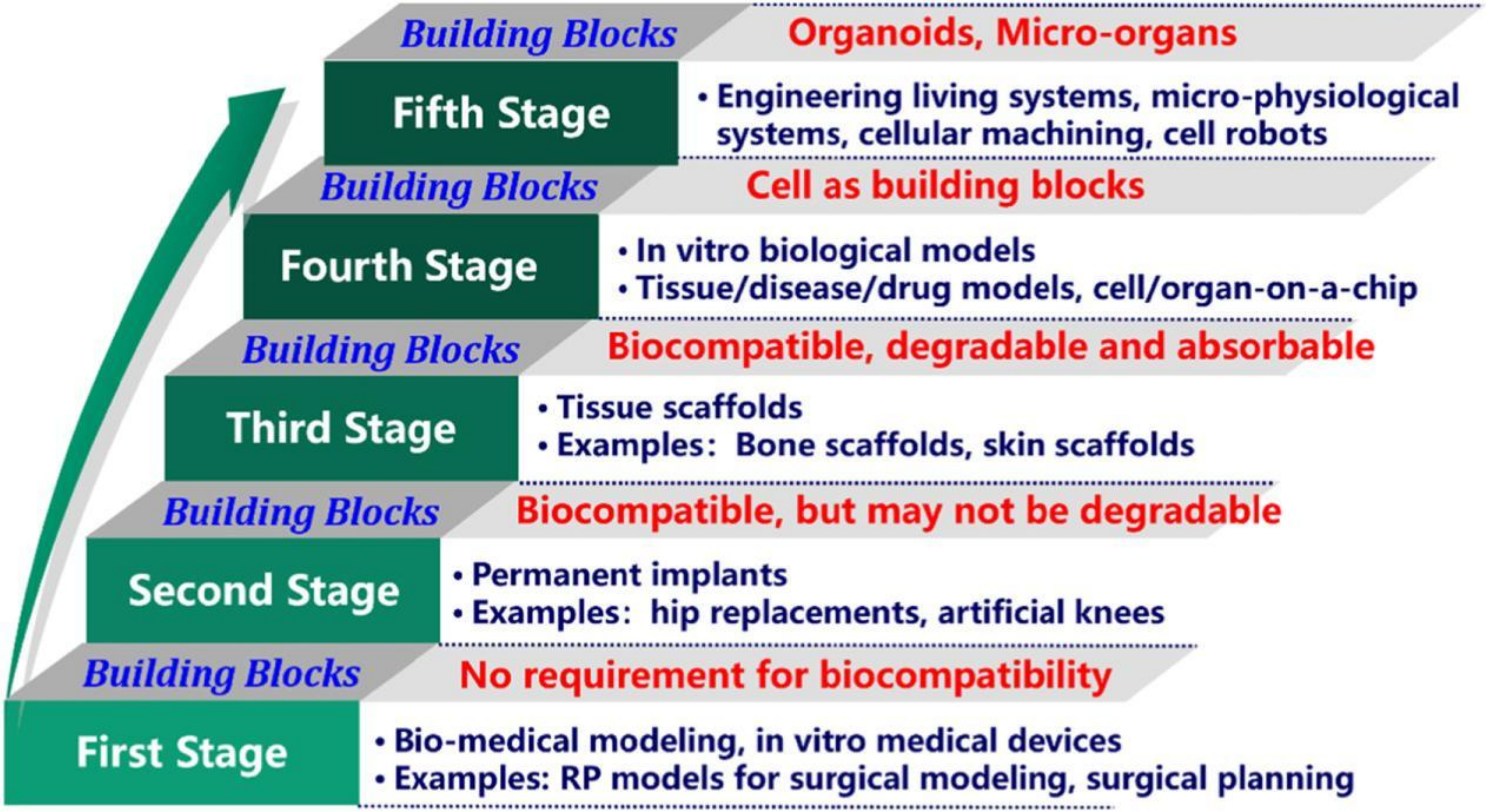


(Left): The horse-shoe-shaped cartilage patch model was created using various imaging techniques to unravel the 3D architecture of the tissues and control the positioning of print heads to place bioink in a 3D shape for a patient-specific match. (Right): 3D bioprinting process of the patch using Brinter® Rotary Tool print head and bioink material mixed with cells, spheroids or organoids.



The completed cartilage patch bioprinted using the Brinter® Rotary Tool print head.

3D Bioprinting



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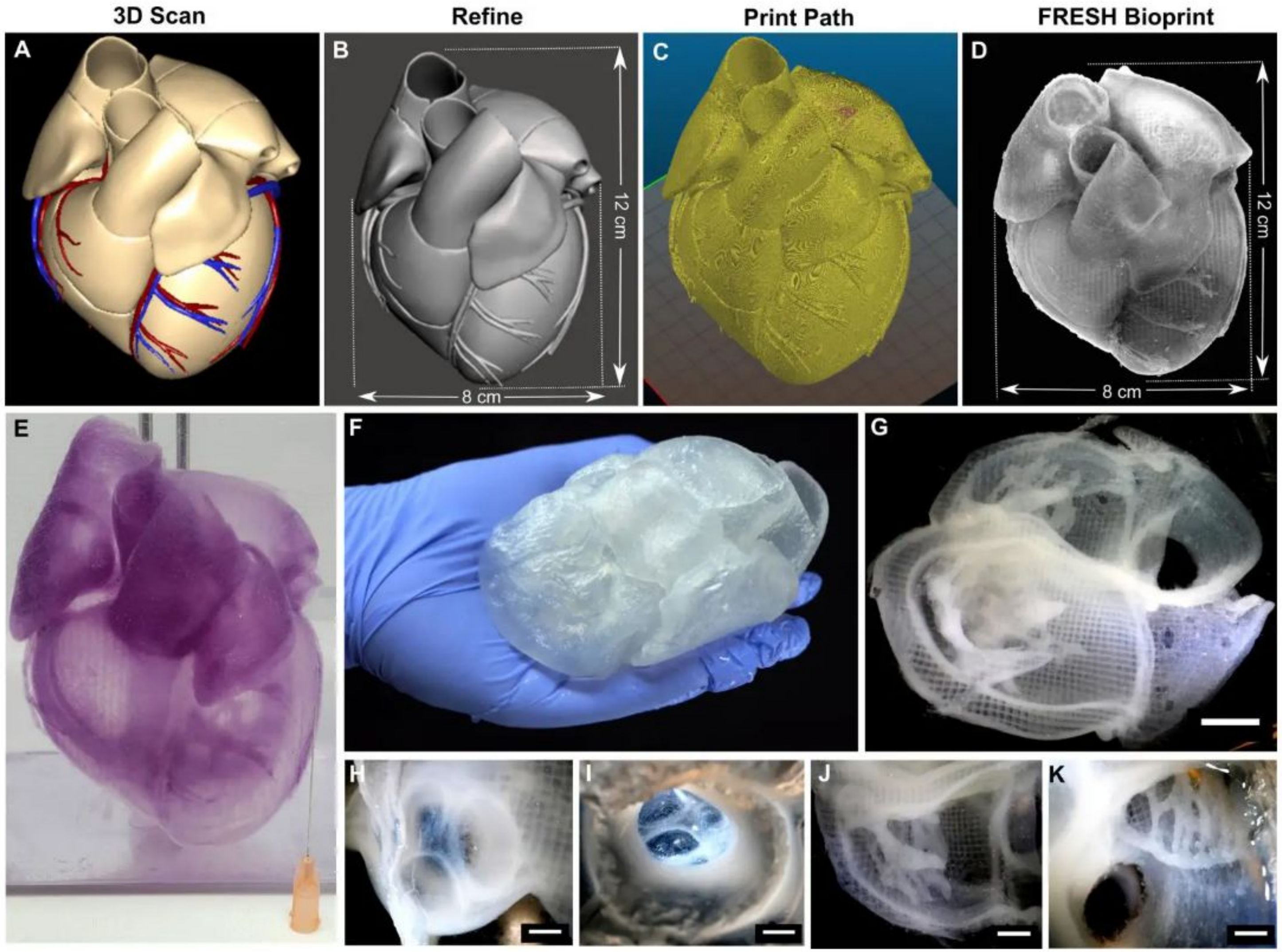
3D Bioprinting



Modeling incorporates imaging data into the final 3D printed object. Credit: Carnegie Mellon University College of Engineering

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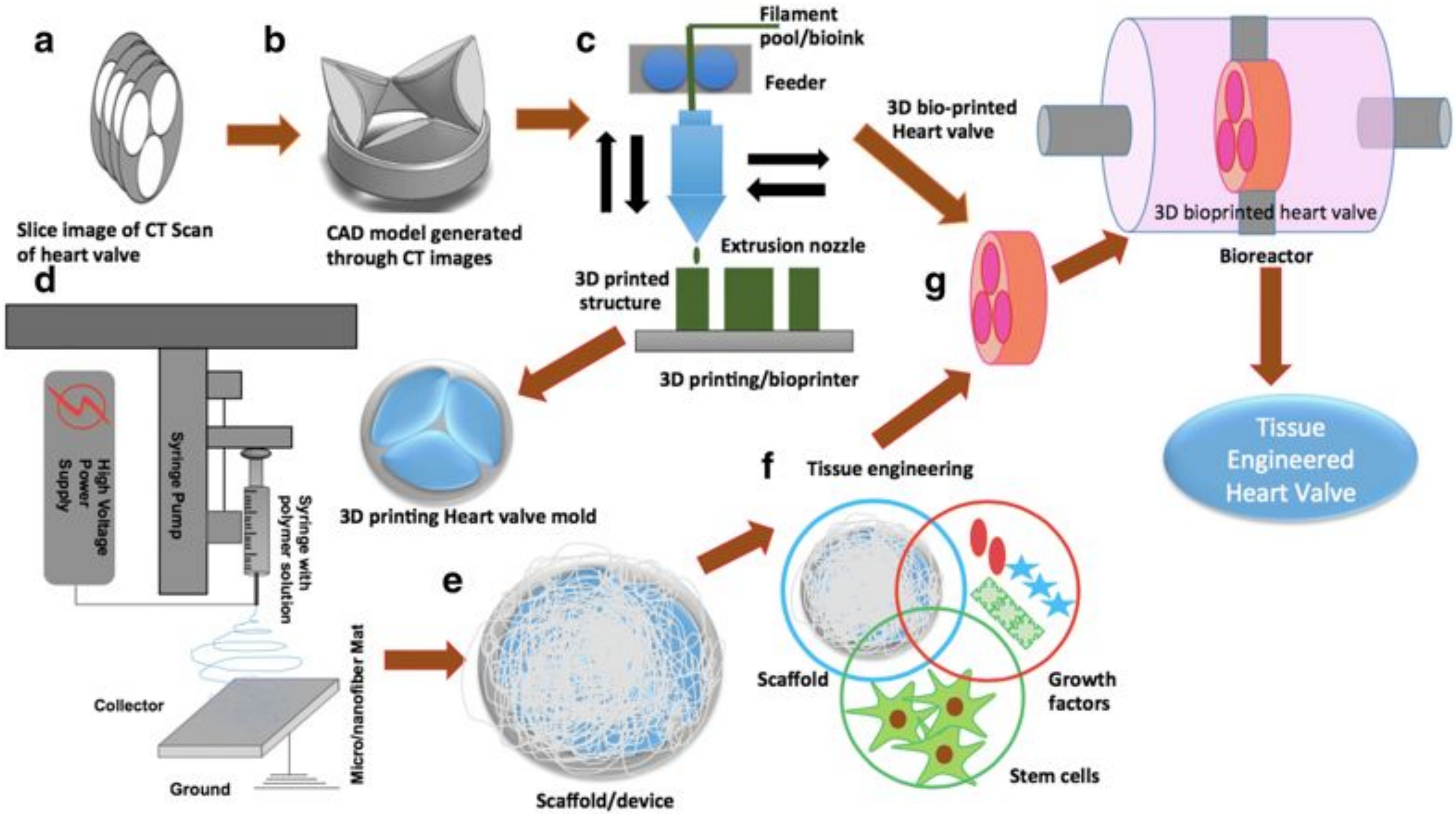
3D Bioprinting



https://3dprint.com/

3D Bioprinting

Proposed process for the generation of 3D heart valves through bioprinting to arrive at functional tissue engineered heart valves

(a) slice of CT images,

(b)3D CAD model generation,

(c)3D bioprinting through bioink/ 3D printing through polymer scaffold,

(d)3D printed scaffold,

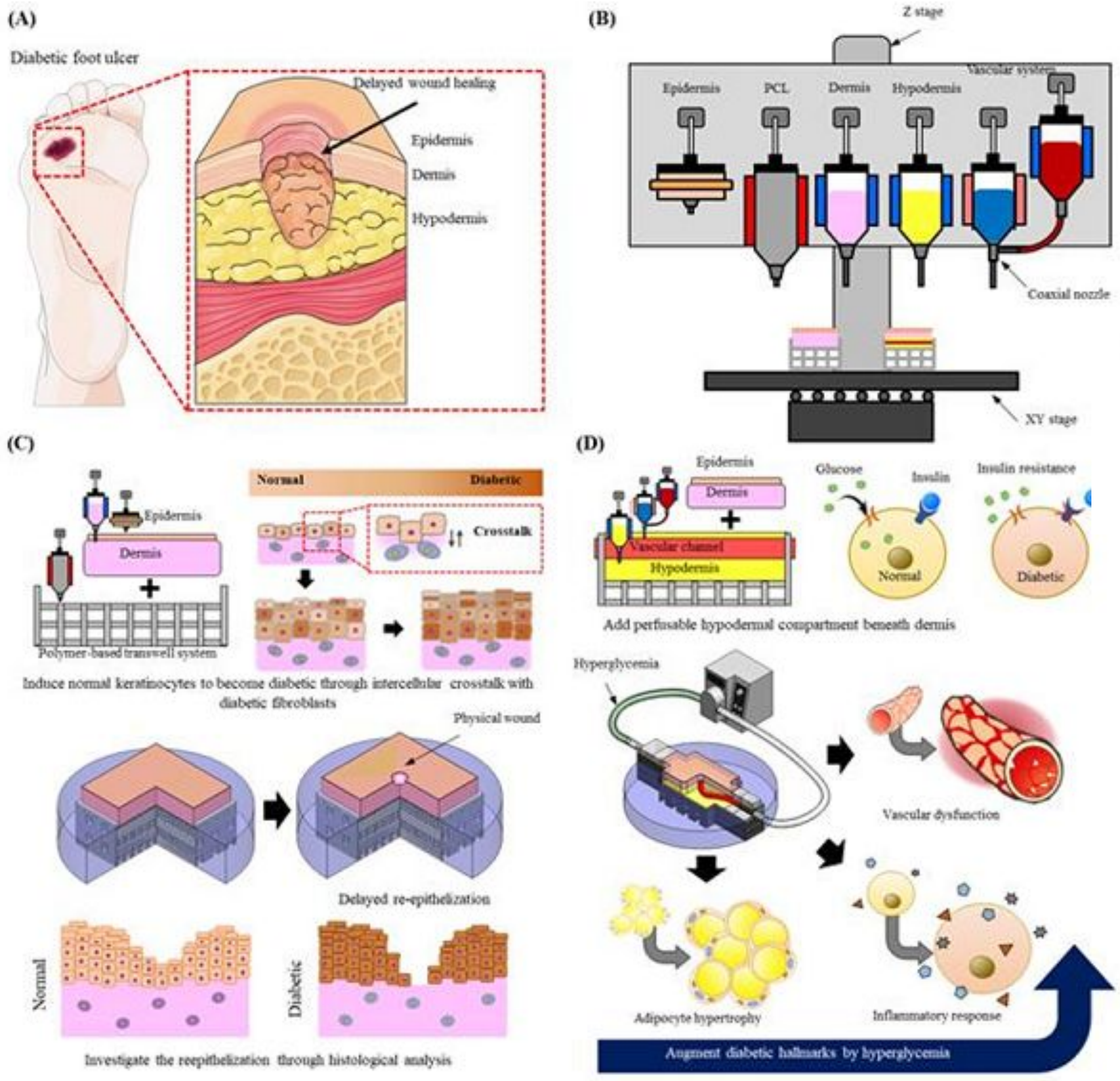
(e)scaffold ready

(f)Development of tissue through combining cells, growth factors and developed scaffold,

(g)Development and initial tissue remodeling in bioreactor

https://3dprint.com/

3D Bioprinting



(A) Representative image showing diabetic foot ulcer caused by delayed wound healing in diabetic patients. (B) 3D cell printing system showing the materials and printing methods required for this study. (C) Modeling diabetic epidermis through intercellular interaction between diabetic human dermal fibroblasts and normal human epidermal keratinocytes, and a wounded skin model with delayed reepithelization. (D) Adding subcutaneous layer (blood vessel + fat) to better recapitulate pathophysiological functions of diabetes and to test applicability to drug screening platform.

https://3dprintingindustry.com/

3D Bioprinting (other application areas)

Personalized Medicine

With 3D bioprinting, you can develop patient-specific models with cell-friendly biofabrication methods and be a part of the paradigm shift in healthcare.

Cell Cultured Food

Apply bioprinting to develop the next era of nutritional sources. Explore sustainable methods of producing cell cultured and synthetic foods.

Drug Discovery

Accelerate drug candidate discovery through high-throughput biofabrication of more physiologically relevant and biomimetic models.

Regenerative Medicine

Combine multiple materials and cell types to recreate in vivo like conditions and unlock greater understanding of human and animal biology.

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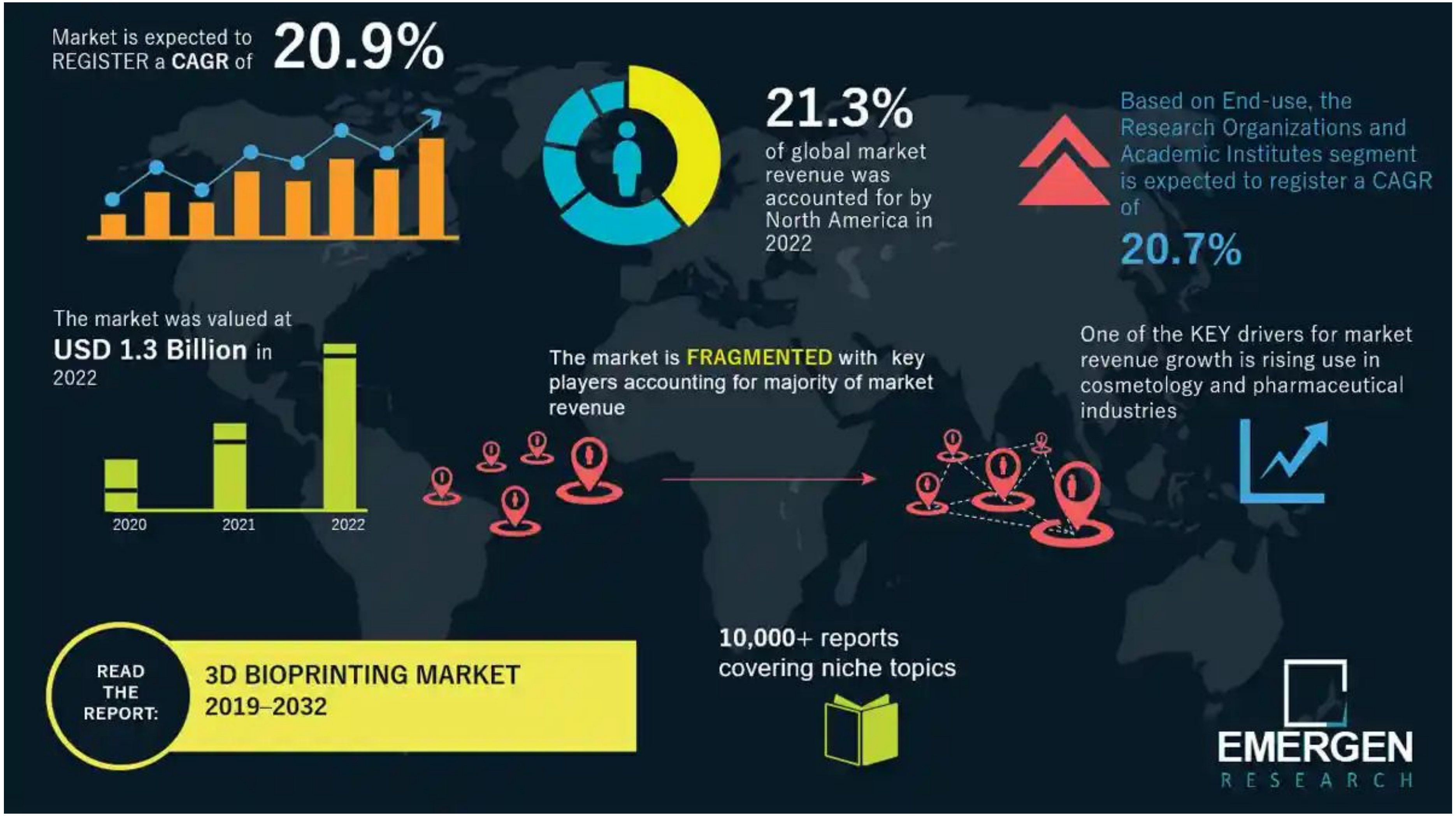

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THANK YOU

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