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Natural-derived biopolymers in 3D bioprinting for biomedical applications: Case of cellulose, chitosan, and lignin

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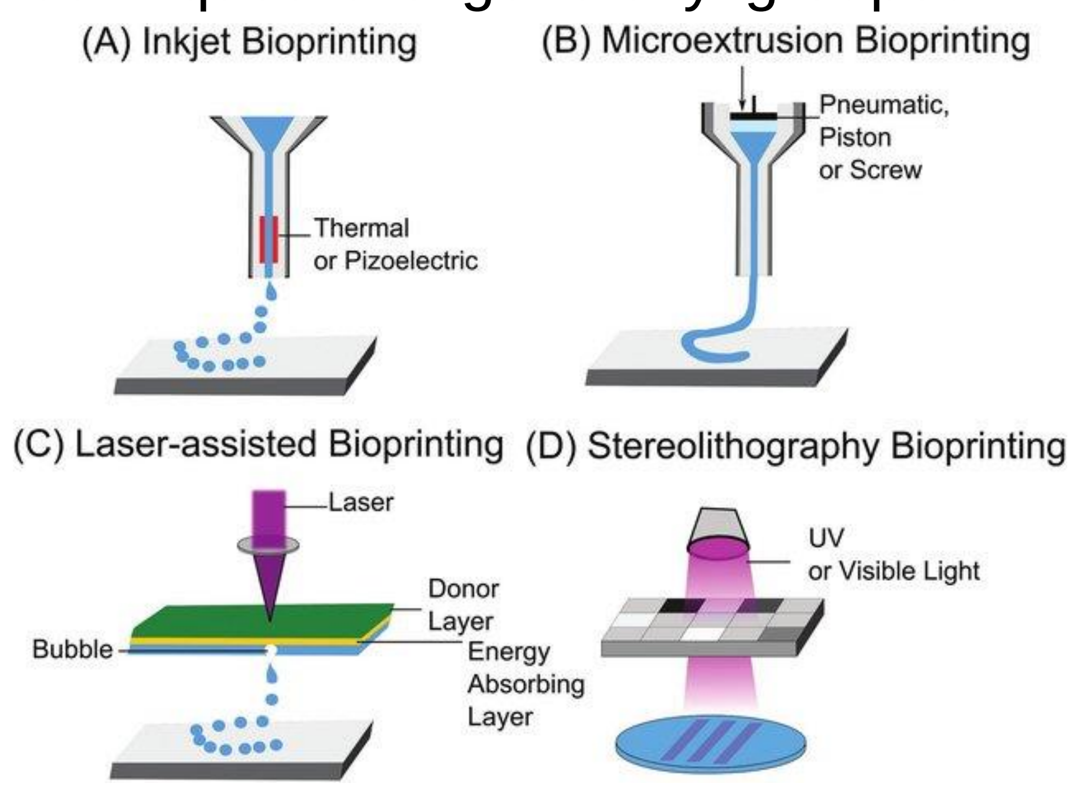
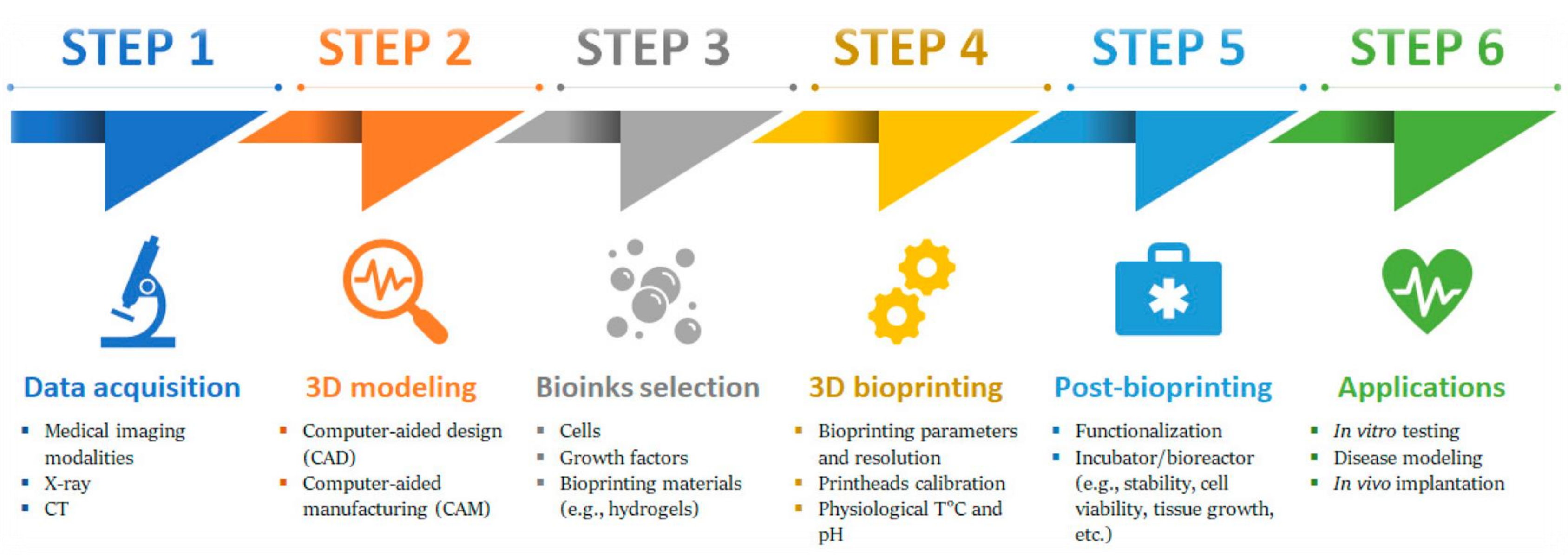
INTRODUCTION

- Tissue engineering and regenerative medicine have new meanings. Thanks to 3D bioprinting, it has become one of the most advanced and useful innovations that allows the creation of personalized macroscopic and microscopic constructs at different scales that match the patient's anatomy, using a bioink that includes living biological cells, hydrogels, chemical factors, and biomolecules.
- 3D bioprinting techniques are generally grouped into four categories[1,2].



- Generally, the process of 3D bioprinting consists of several steps, namely pre-bioprinting, cell and bioink preparation, the bioprinting process, and post-bioprinting/applications[1].



BIOPOLYMERS PROPERTIES

- Finding an appropriate bio-inks is of paramount importance in 3D printing, as it provides a specific microenvironment that can support cellular growth and maturation.
- Hydrogels are the most commonly used biomaterials for obtaining bio-inks. They can be obtained from a variety of water-soluble materials including both synthetic and natural polymers.
- Natural hydrogels, using biopolymers as building blocks, have beneficial properties that are favored by researchers in terms of biocompatibility, cost-effectiveness, and biodegradability[3,4,5]. This is the case with cellulose, chitosan, and lignin biopolymers.

Biopolymer	Properties
Cellulose	-The most abundant in nature; -Made up of (1-4) linked β-D-glucopyranosyl units; -Insoluble in water; -Favorable water retention ; -High cell viability after printing; -Favorable biocompatibility.
Chitosan	-Chitin-derived biopolymer; -Comprised of poly- β(1–4)-N-acetyl-D--glucosamine; -Soluble in an aqueous acidic medium; -Favorable flexibility; -Non-toxic.
Lignin	-10–25 wt.% of lignocellulosic biomass; -Highly crosslinked aromatic biopolymer synthesized mainly from three primary monolignols; -Antioxidant and antimicrobial properties, -Thermal stability; -Anti-inflammatory effect; -Biocompatibility, and low cytotoxicity.

NATURAL-DERIVED BIOPOLYMERS IN 3D BIOPRINTING

Biopolymer	Bioink formulation	Applications
Cellulose	Carboxymethyl cellulose, hydroxyapatite, gelatin, Chitosan	Bone tissue regeneration
	Hydroxyethylcellulose, Sodium alginate	Cervical tumor model
	Surface-modified cellulose nanocrystals, Collagen	Articular cartilage regeneration
Chitosan	Chitosan, PCL	Cartilage regeneration
	Chitosan, Cellulose nanocrystals, Hydroxyethyl cellulose	Bone tissue engineering
	Chitosan, Gelatin, PEG	Skin regeneration
Lignin	Lignin, Gellan gum	Cartilage repair
	Lignin, cellulose, and alginate	Soft-tissue engineering
	Alkali lignin, Pluronic F127	N/A

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