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3D bioprinting

The future of tailor-made medicine?

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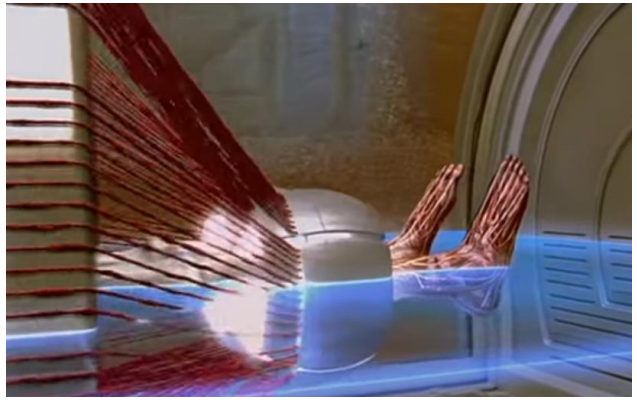
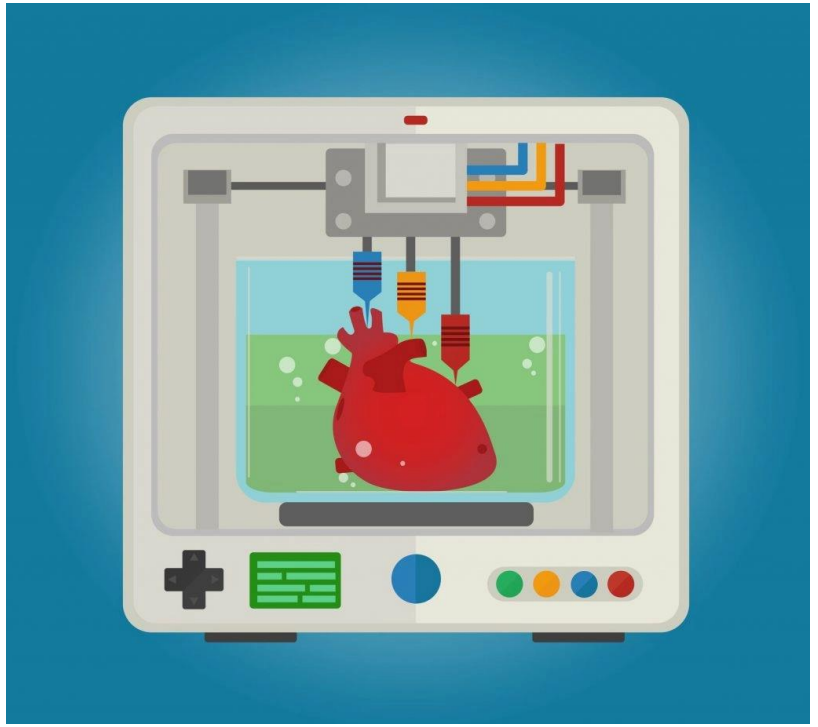
3D bioprinting - Science fiction?



The Fifth Element, 1997, Gaumont

3D bioprinting - Science fiction?

Unfortunately so, but…



…3D bioprinting has great potential in future medicine

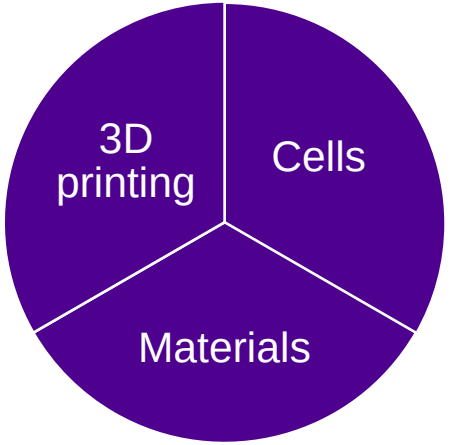
Credit: i000pixels / iStock / Getty Images

What is bioprinting?

"The use of **3D printing** technology with **materials** that incorporate **viable living cells**,

e.g. to produce tissue for reconstructive surgery."

- Oxford Languages -



What is bioprinting?

"the process of producing

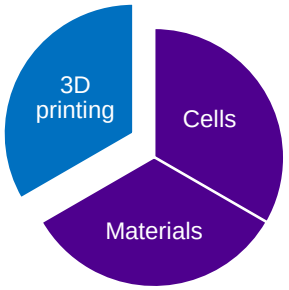
tissue or organs similar to natural body parts

and containing living cells, using 3-D printing

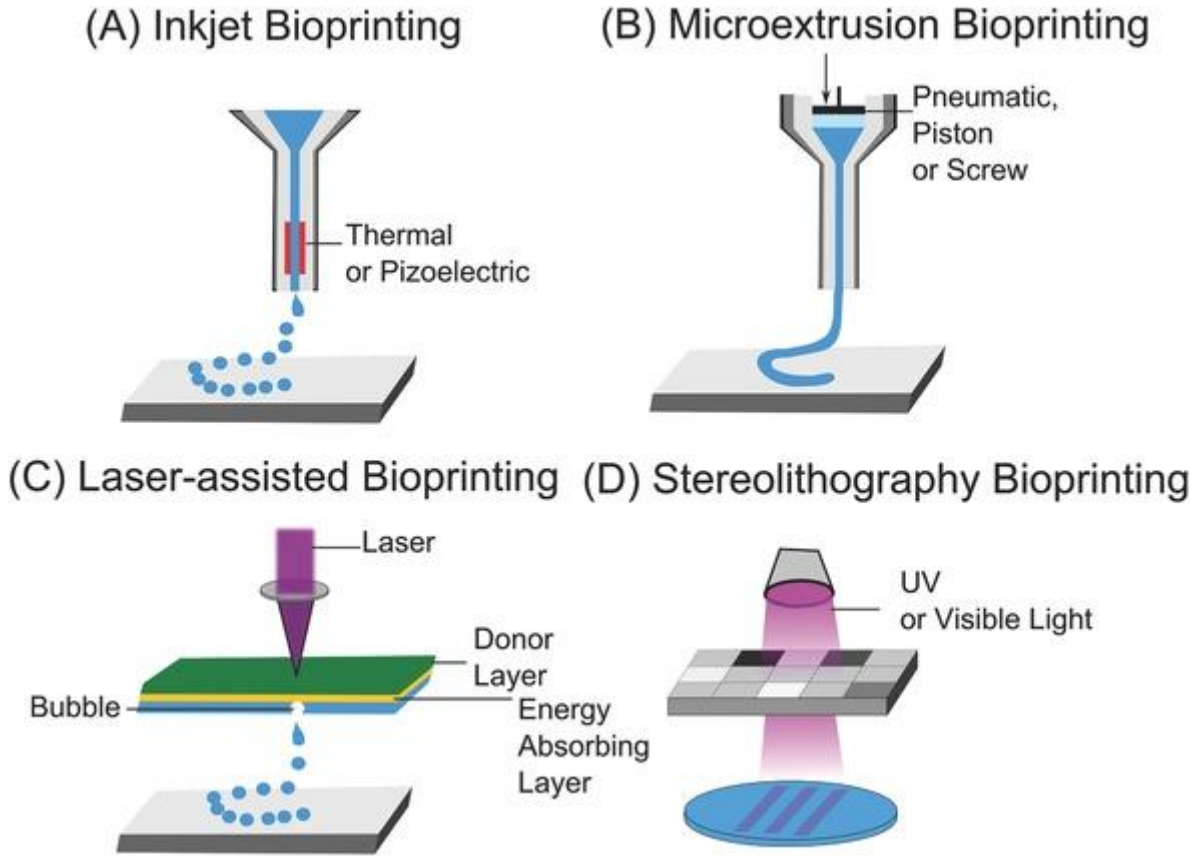
(= a way of creating a solid object from a **digital model** by printing many separate layers of the object)"

- Cambridge Dictionary -

Bioprinting techniques



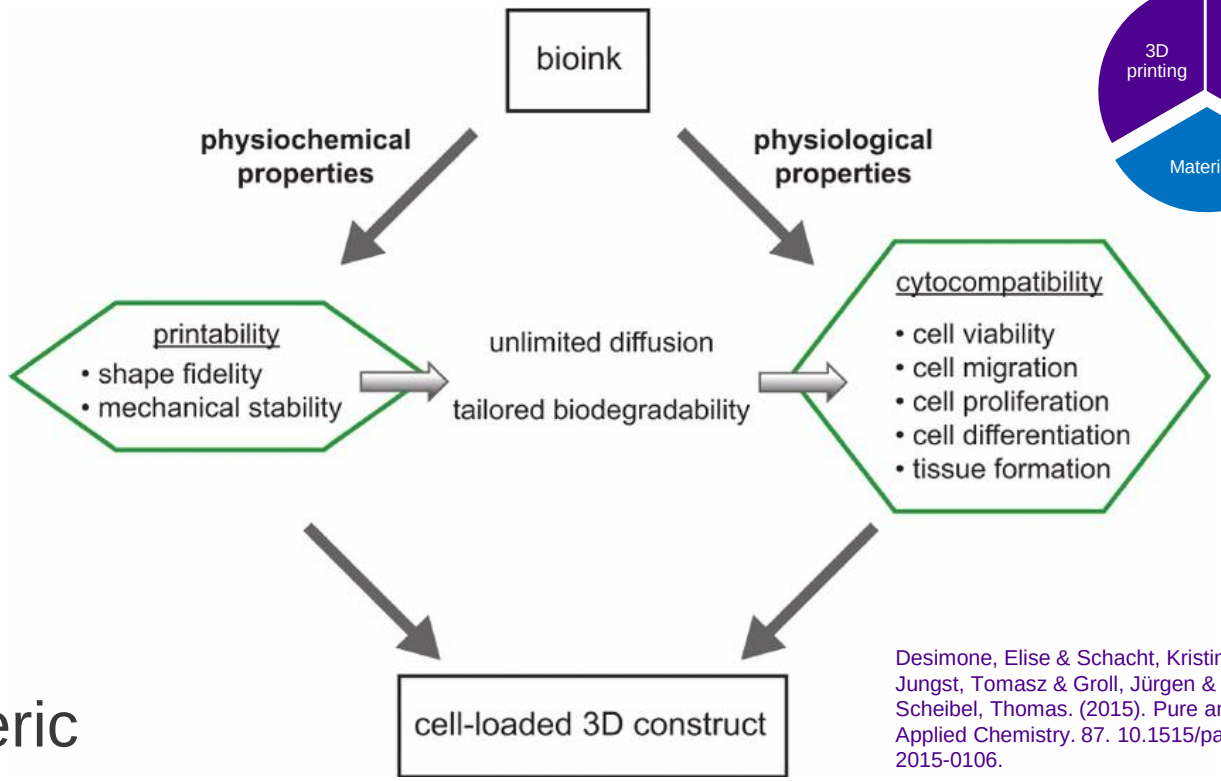
- Classified based on their working principle
  - main techniques
    - Inkjet-based
    - Extrusion-based
    - Light induced
      - Laser-assisted
      - Stereolithography
- Need → Selection of technique
- Ability to print viable and functional cells with precision



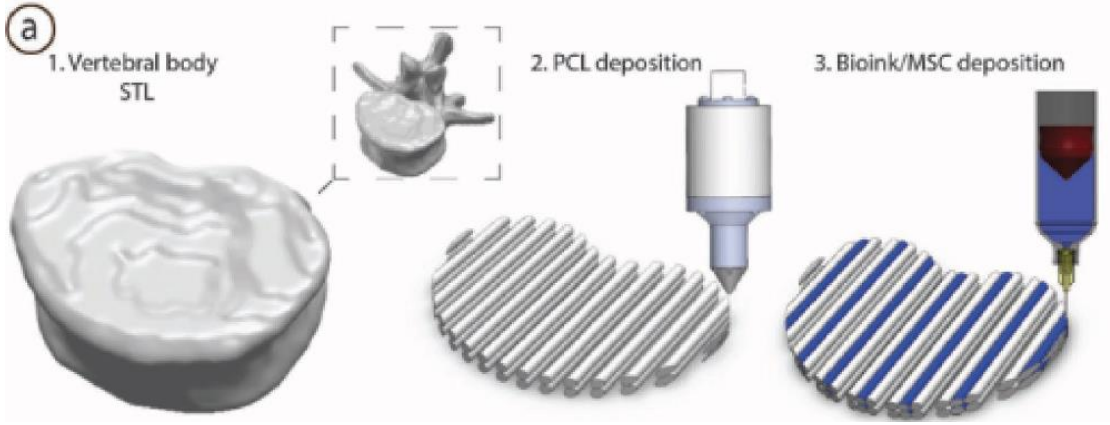
Foyt DA, Norman MDA, Yu TTL, Gentleman E. Exploiting Advanced Hydrogel Technologies to Address Key Challenges in Regenerative Medicine. Adv Healthc Mater. 2018 Apr;7(8):e1700939. doi: 10.1002/adhm.201700939.

Materials & Bioinks

- Bioink
  - Cells alone
  - Usually, cells combined with supportive material
- Printability
  - Viscous fluid, hydrogel, or polymeric solution
- Cytocompatible
- Mechanical support
- Ideal environment for the cells
- Combination of different materials may be needed



Desimone, Elise & Schacht, Kristin & Jungst, Tomasz & Groll, Jürgen & Scheibel, Thomas. (2015). Pure and Applied Chemistry. 87. 10.1515/pac-2015-0106.

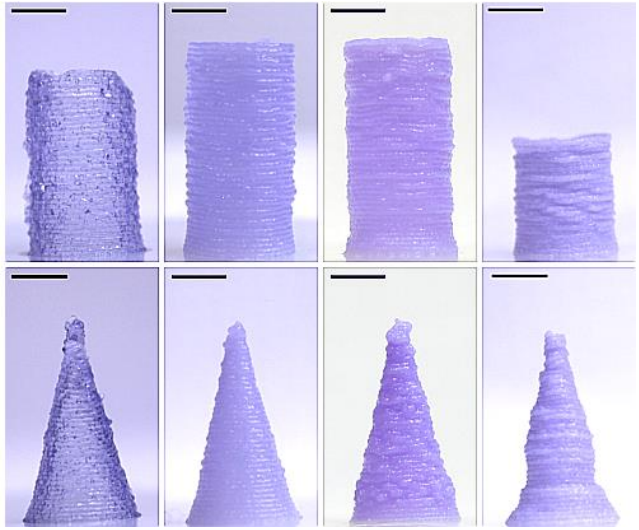


Andrew C. Daly, F. E. Freeman, T. Gonzalez-Fernandez, Susan E. Critchley, J. Nulty, D. Kelly. 3D Bioprinting for Cartilage and Osteochondral Tissue Engineering. Advanced healthcare materials 2017

Materials and crosslinking

https://livforcake.com/simple-vanilla-buttercream/

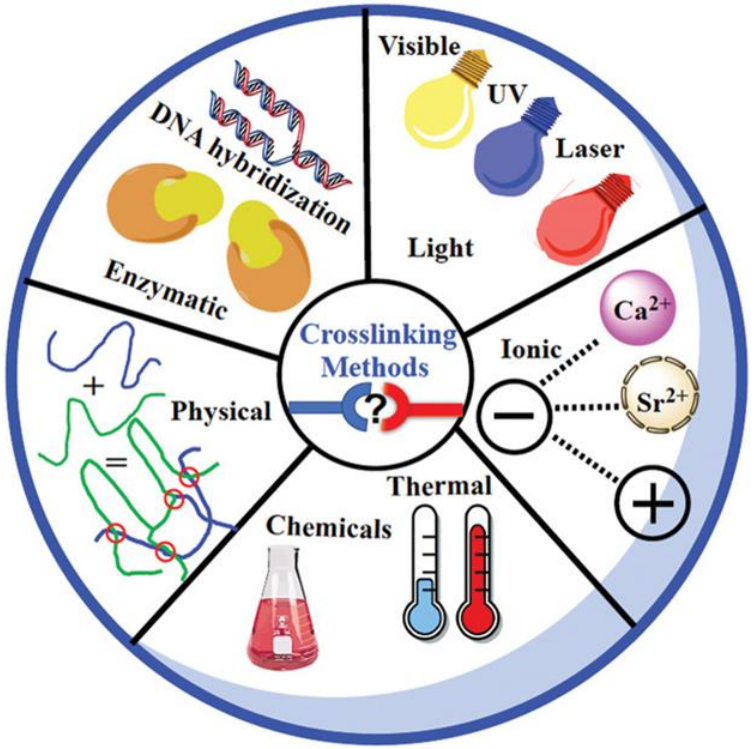
Image from https://www.findlight.net/blog/2018/10/11/3d-bioprinting-transplant-organs/



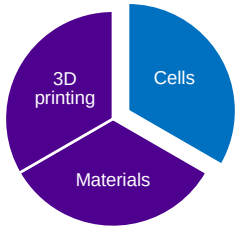
Cylinders and cones. Scale bar 5 mm. Image by Rosanna Silén

Crosslinking

- Polymer solution is transformed into a 3D structure
- Affects the mechanical and physicochemical characteristics of the bioprinted constructs
- Affects the cellular behavior of loaded cells
- Method depends on the polymeric backbone and functional groups of the bioink
  - chemical, physical & enzymatic methods or a combination of these
- A balance between the degree of crosslinking and printability

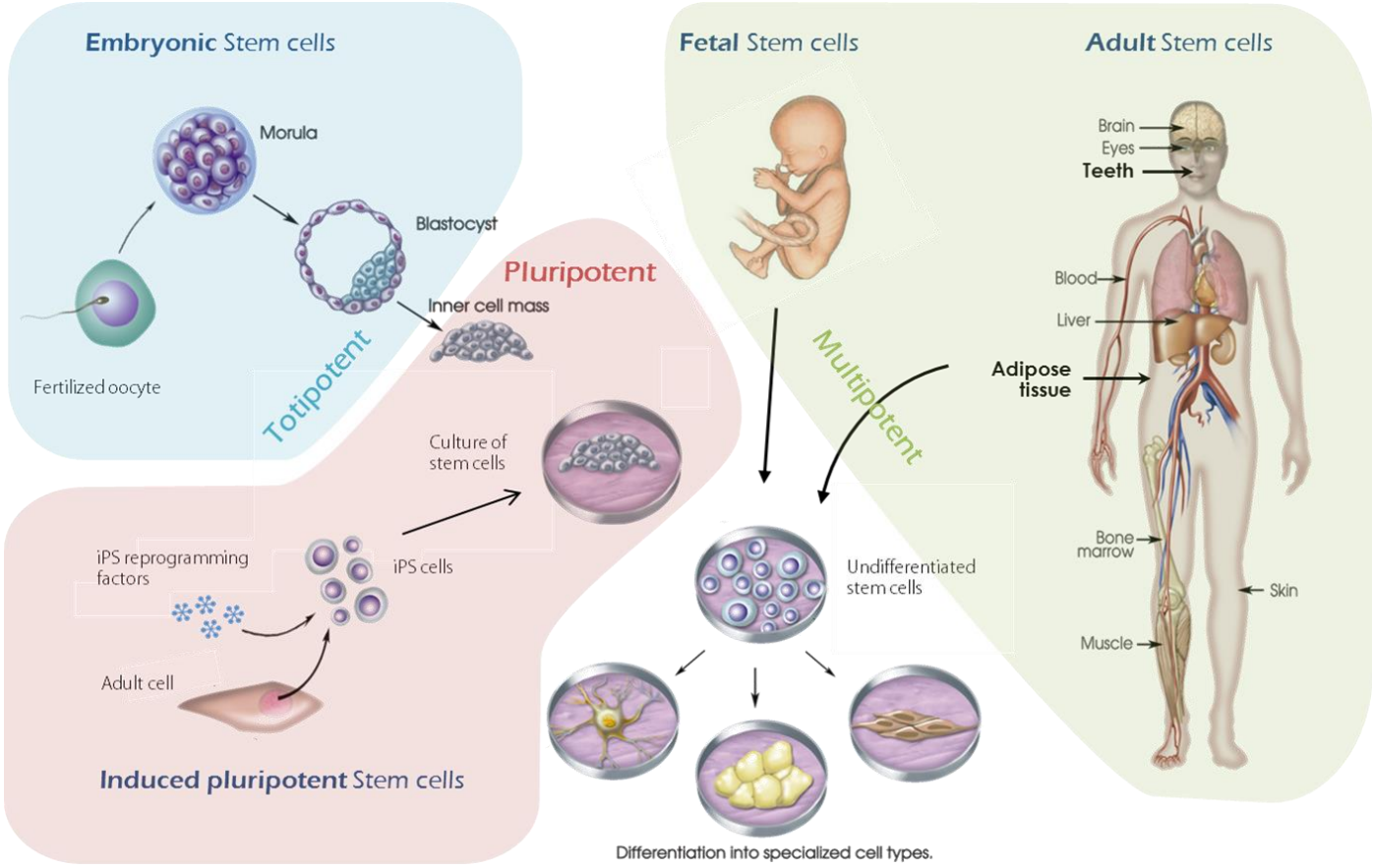


GhavamiNejad, A., Ashammakhi, N., Wu, X. Y., Khademhosseini, A., Crosslinking Strategies for 3D Bioprinting of Polymeric Hydrogels. *Small* 2020, 16, 2002931. https://doi.org/10.1002/smll.202002931

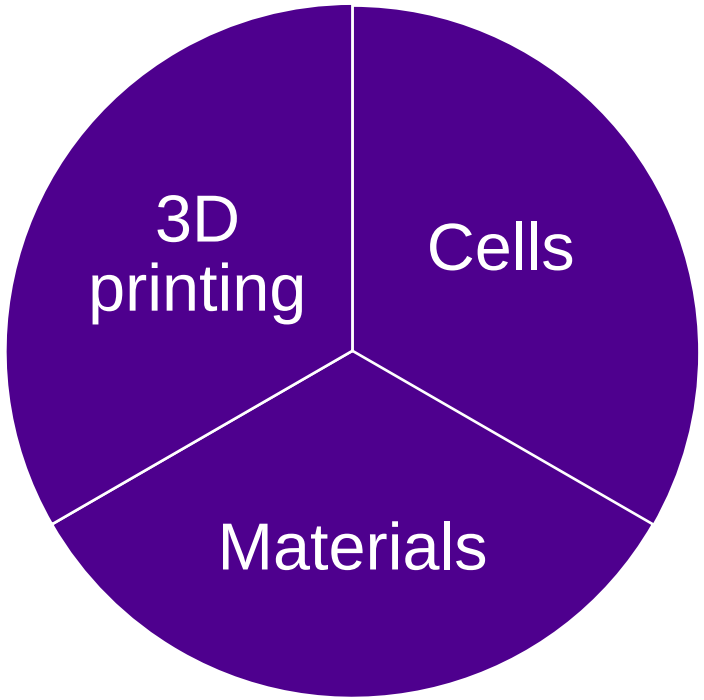


Cells & Long-Term Cell Culture

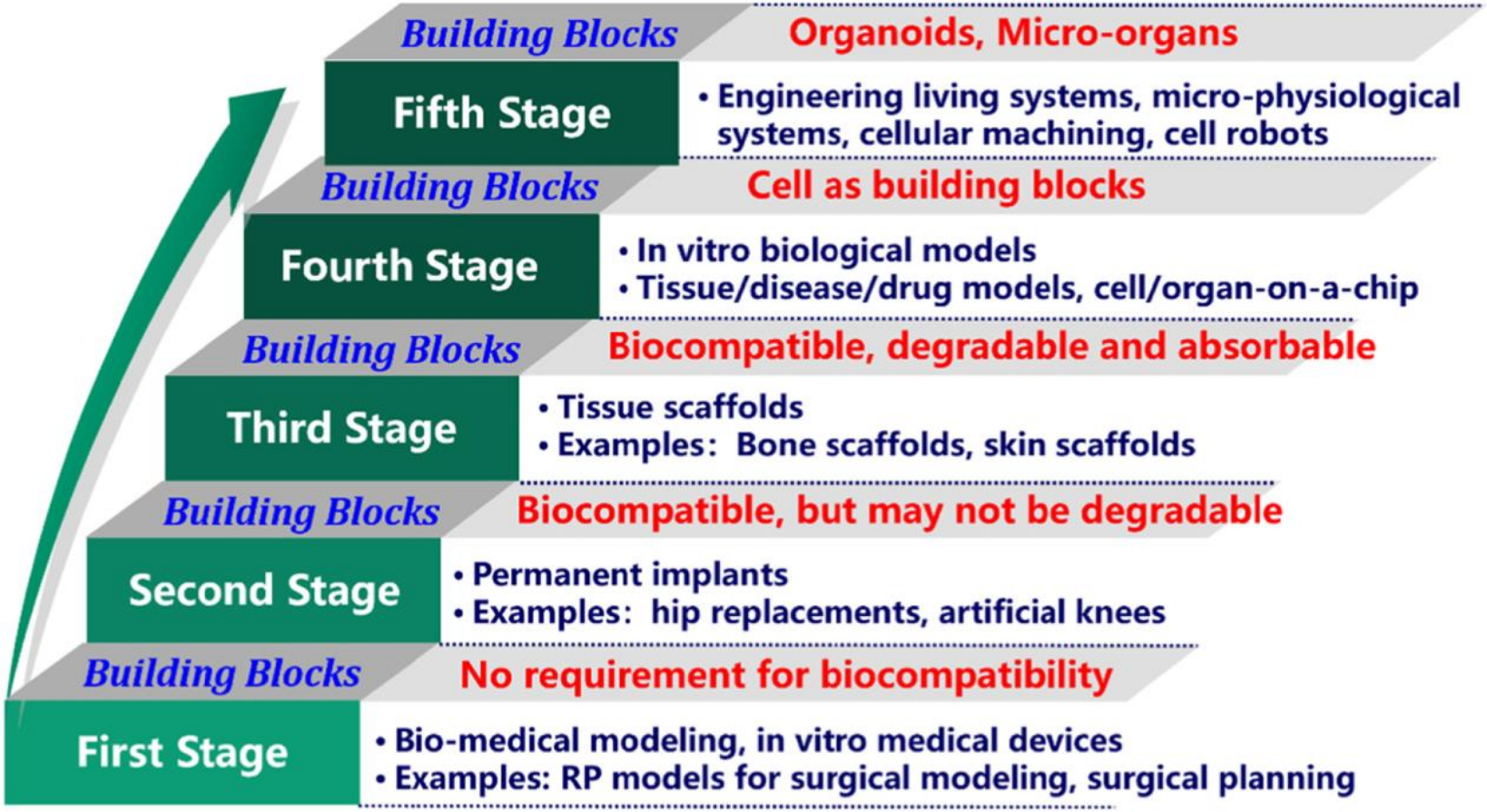
- Stem and progenitor cells
- Differentiation
- Combination of different cell types
- Microfluidic devices & simulated physiological environment to support viability and maturation



Tailor-made tissues and organs



The bioprinting roadmap



Sun W, Starly B, Daly AC, et al. The bioprinting roadmap. Biofabrication. 2020;12(2):022002. Published 2020 Feb 6. doi:10.1088/1758-5090/ab5158

Tissue engineered bone

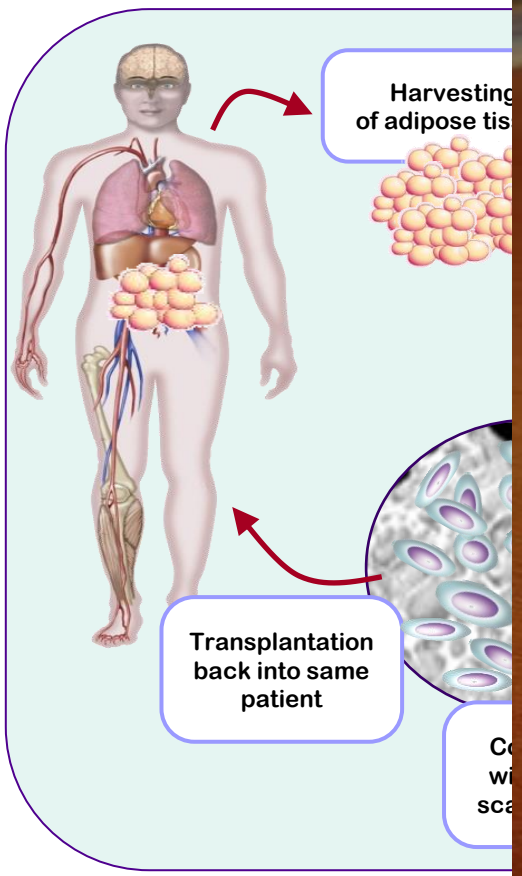
- Major bone defects in cranio-maxillofacial area

TCP and bioactive glass

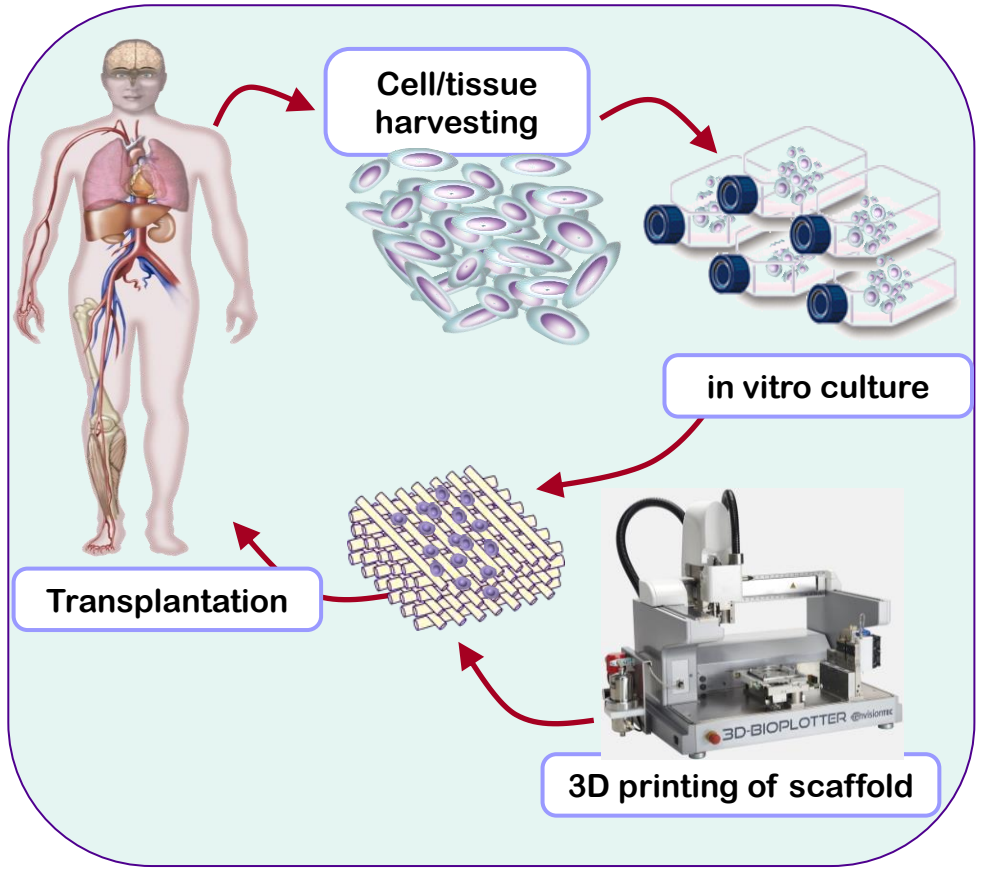
nd size

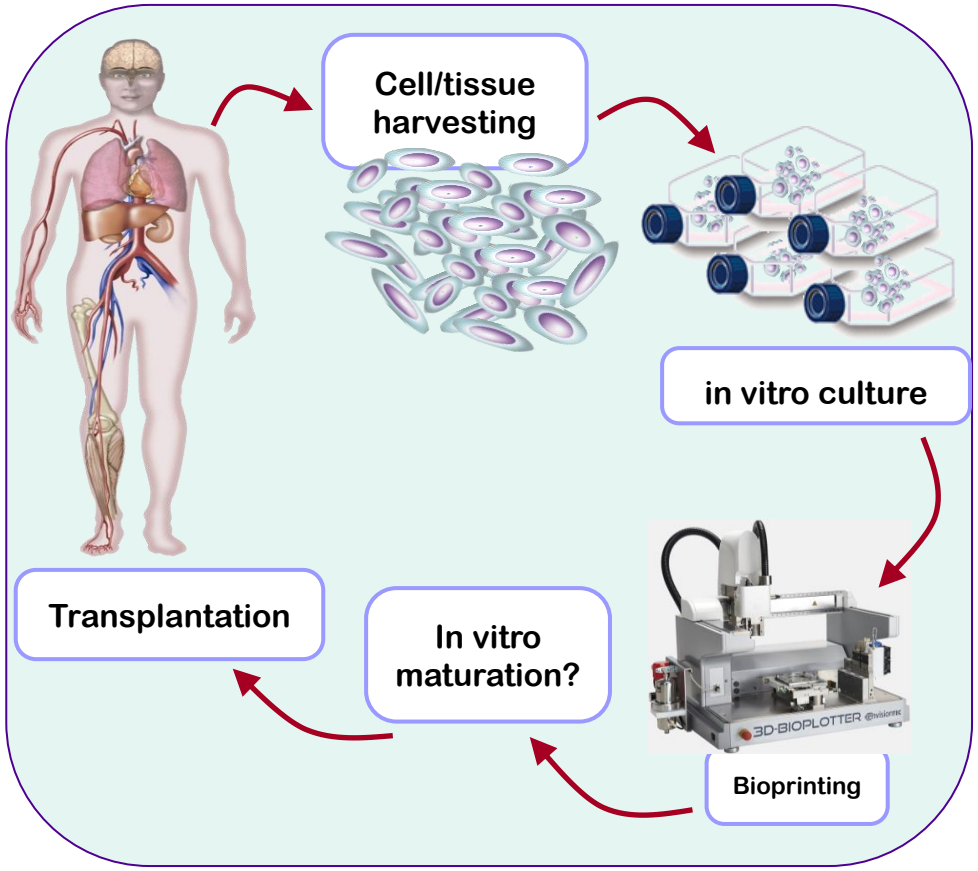
esleff et al 2011; 2017, Sandor

alth Care District, Jyväskylä
rg, Sweden



3D printing and bioprinting transplants





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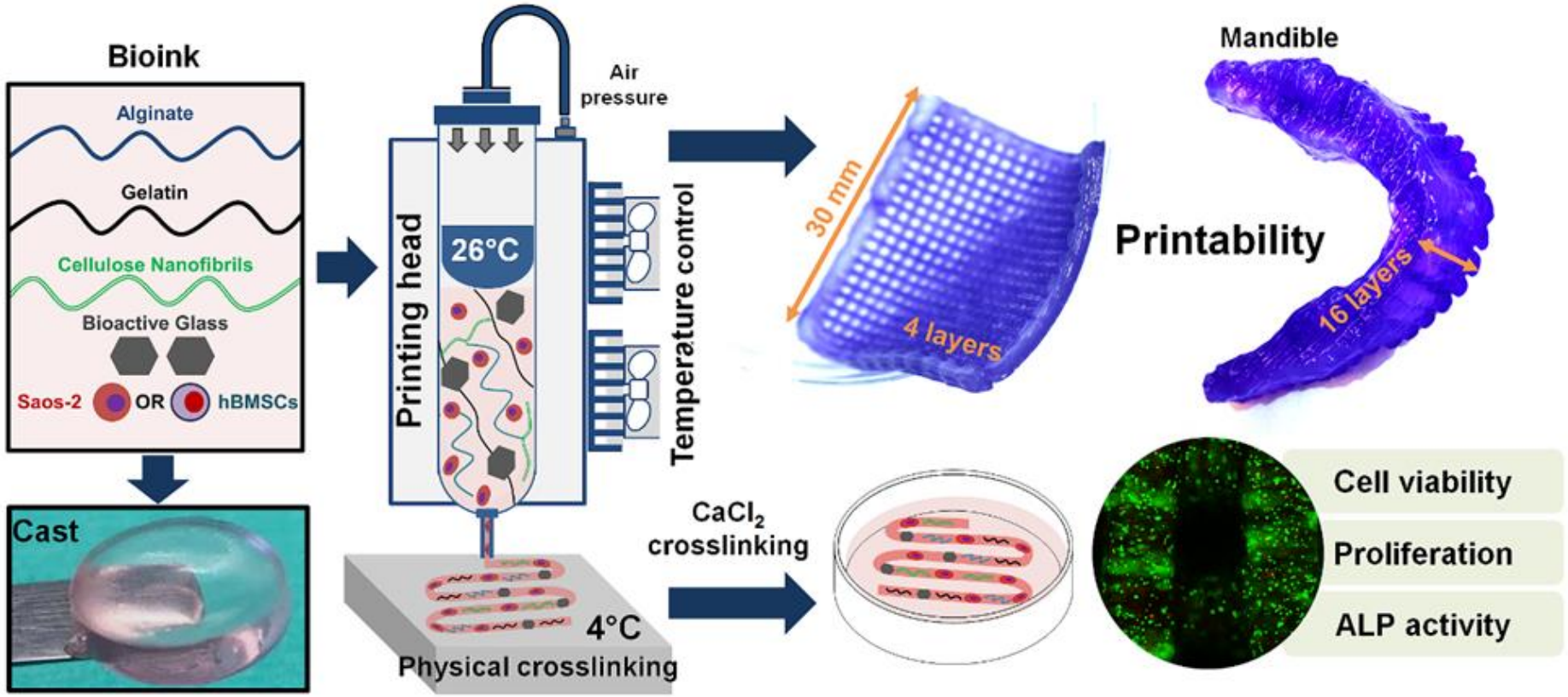
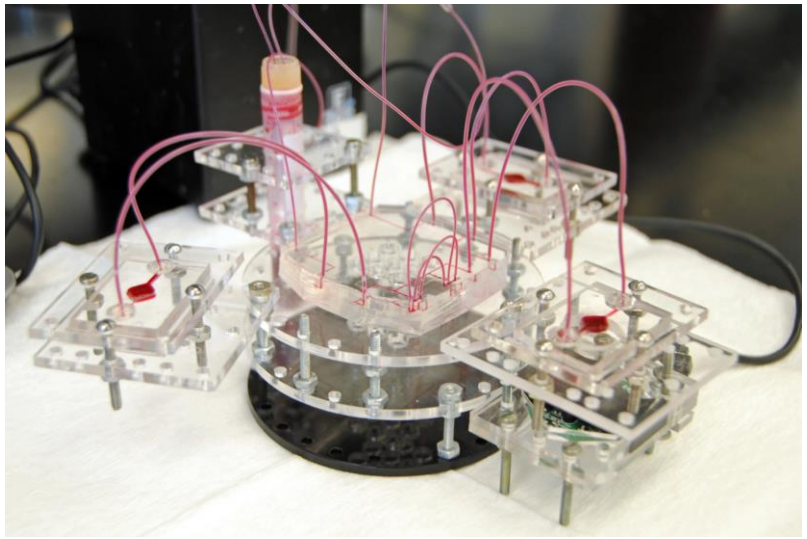
Bioprinting transplants: Bone



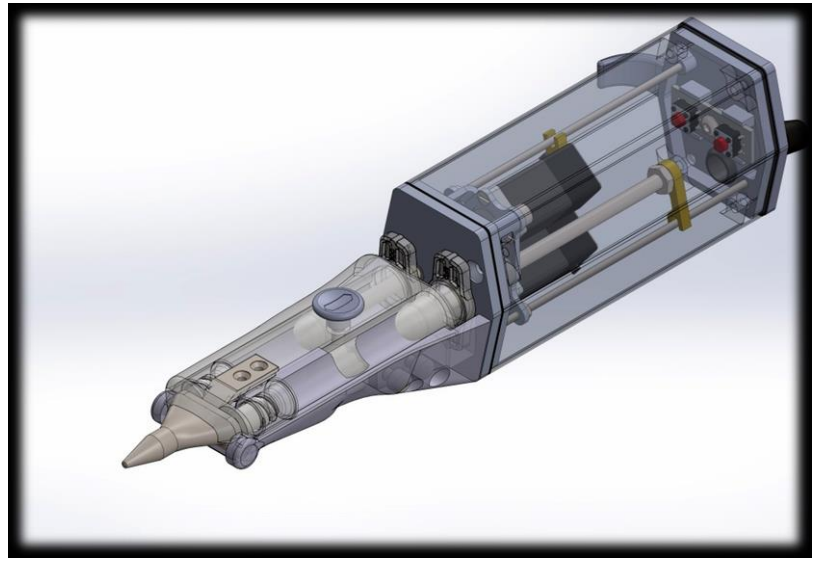
Ojansivu M et al. Wood-based nanocellulose and bioactive glass modified gelatin-alginate bioinks for 3D bioprinting of bone cells. Biofabrication. 2019 Apr 26;11(3):035010. doi: 10.1088/1758-5090/ab0692.

Recent achievements

- Mini-organs and Body-on-Chip platforms for research
  - Lawlor, K.T., Vanslambrouck, J.M., Higgins, J.W. et al. Cellular extrusion bioprinting improves kidney organoid reproducibility and conformation. Nat. Mater. 20, 260–271 (2021). https://doi.org/10.1038/s41563-020-00853-9
- Combination of functional cells with 3D printed scaffolds
- Bioprinting of avascular tissues: skin, cartilage
- Bioprinters into operation room
  - Hand-held bioprinters
    - Di Bella, C, Duchi, S, O'Connell, CD, et al. In situ handheld three-dimensional bioprinting for cartilage regeneration. J Tissue Eng Regen Med. 2018; 12: 611– 621. https://doi.org/10.1002/term.2476.
  - Micro-scale bioprinting through endoscope
    - Wenxiang Zhao and Tao Xu. Preliminary engineering for in situ in vivo bioprinting: a novel micro bioprinting platform for in situ in vivo bioprinting at a gastric wound site. 2020 Biofabrication 12 045020. https://doi.org/10.1088/1758-5090/aba4ff
  - Bionks allowing in situ bioprinting
    - A Asghari Adib et al. Direct-write 3D printing and characterization of a GelMA-based biomaterial for intracorporeal tissue engineering 2020 Biofabrication 12 045006



A heart, liver and kidney structure from 3-D printing at the Wake Forest Institute for Regenerative Medicine.
Credit...Wake Forest Institute for Regenerative Medicine



The design of the Biopen.

Medical 3D printing ecosystem

- Goals
  - Bring together national and international research groups
  - Tighten the link between research groups and industry
  - Share knowledge
  - Provide collaboration opportunities
  - Service platform
  - Business opportunities
  - Find solutions for major challenges that limit the clinical translation of 3D printing
  - Advancement of patient care and diagnostics

Collaboration needed!

Image from https://fi.pinterest.com/pin/591941944748708219/

Medical 3D printing ecosystem

- Funded by Academy of Finland
  - 2021-22
- Co-creation together with *Ideascout* company for building the ecosystem
  - Starts in spring 2021
  - Workshops for defining the needs and mode of action
- Connections with other networks nationally and internationally

ideascout
CO • DES|GN • EXECUTE

3D bioprinting

The Fifth Element, 1997, Gaumont

Interested in networking activities?

Please, contact Susanna Miettinen
susanna.miettinen@tuni.fi

Human
Potential
Unlimited.