3D tissue printing

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What is 3D bioprinting?

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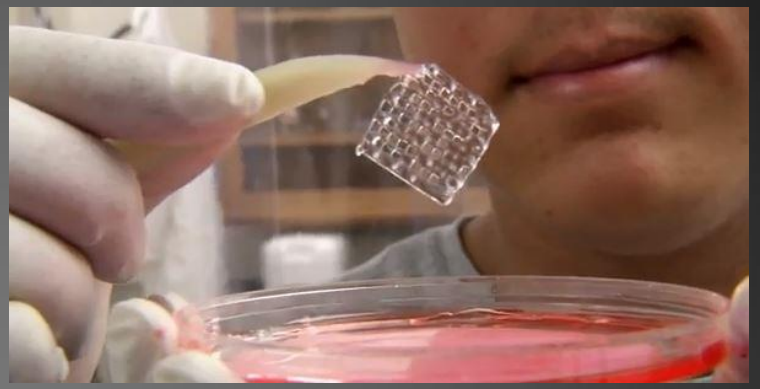


- 3D bioprinting is a way of printing tissues, layer by layer. This printed tissue contains two parts: the cells and the unique mixture of fibers that makes up the structure and shape of the printed tissue.
- These structures may vary in size and shape, like the simple, symmetrical grid in the top right photograph, or the more complex, as seen in the bottom right image.

Some facts pro bioprinting

114,000+

Number of men, women and children on the national transplant waiting list as of August 2017.

34,770
transplants were performed in 2017.

20
people die each day waiting for a transplant.

We All Need to Register. Here's Why:

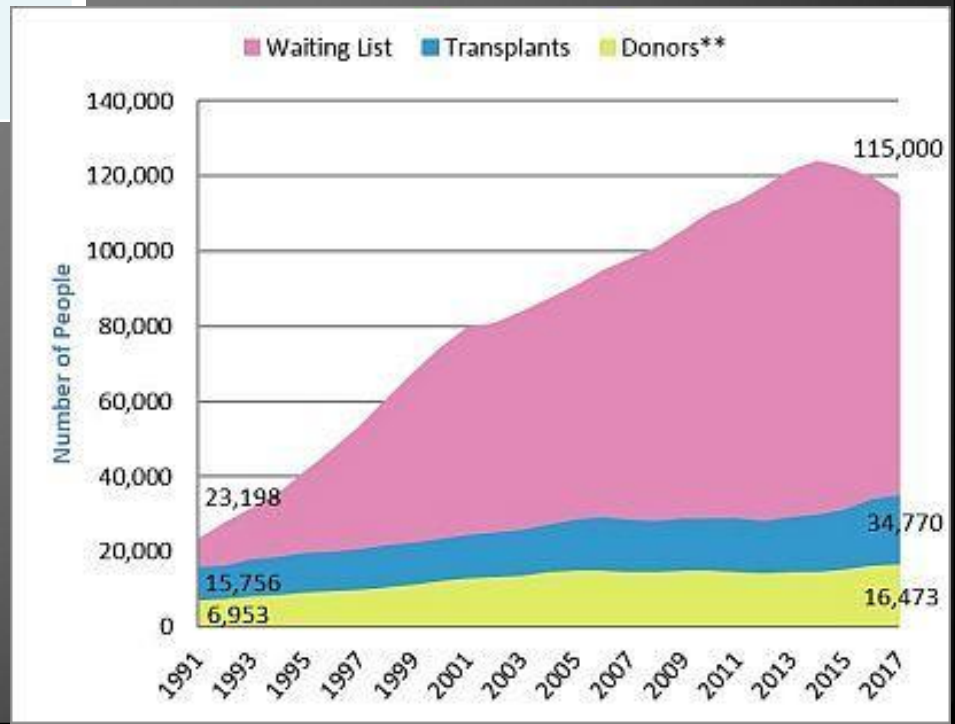
95%
of U.S. adults support organ donation

but only

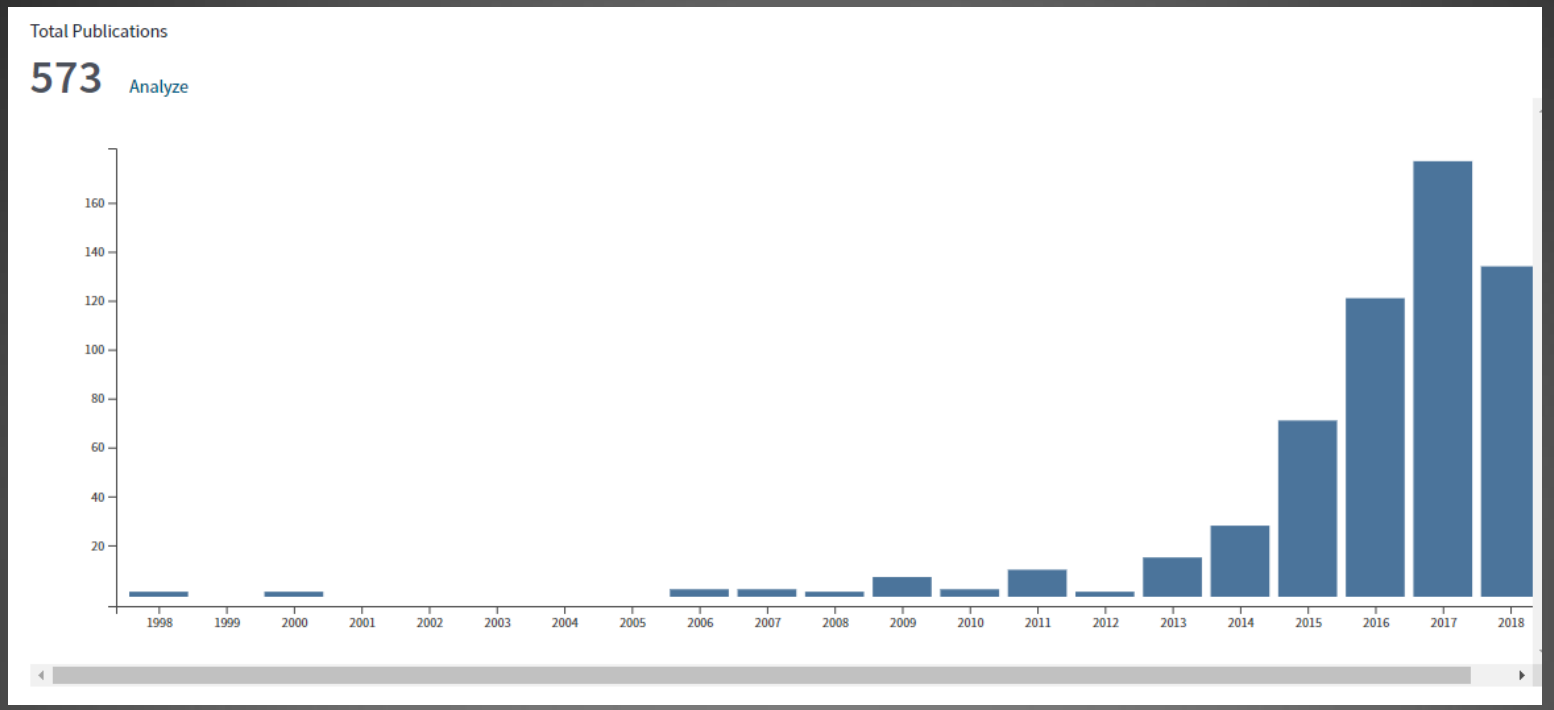
54%
are actually signed up as donors.

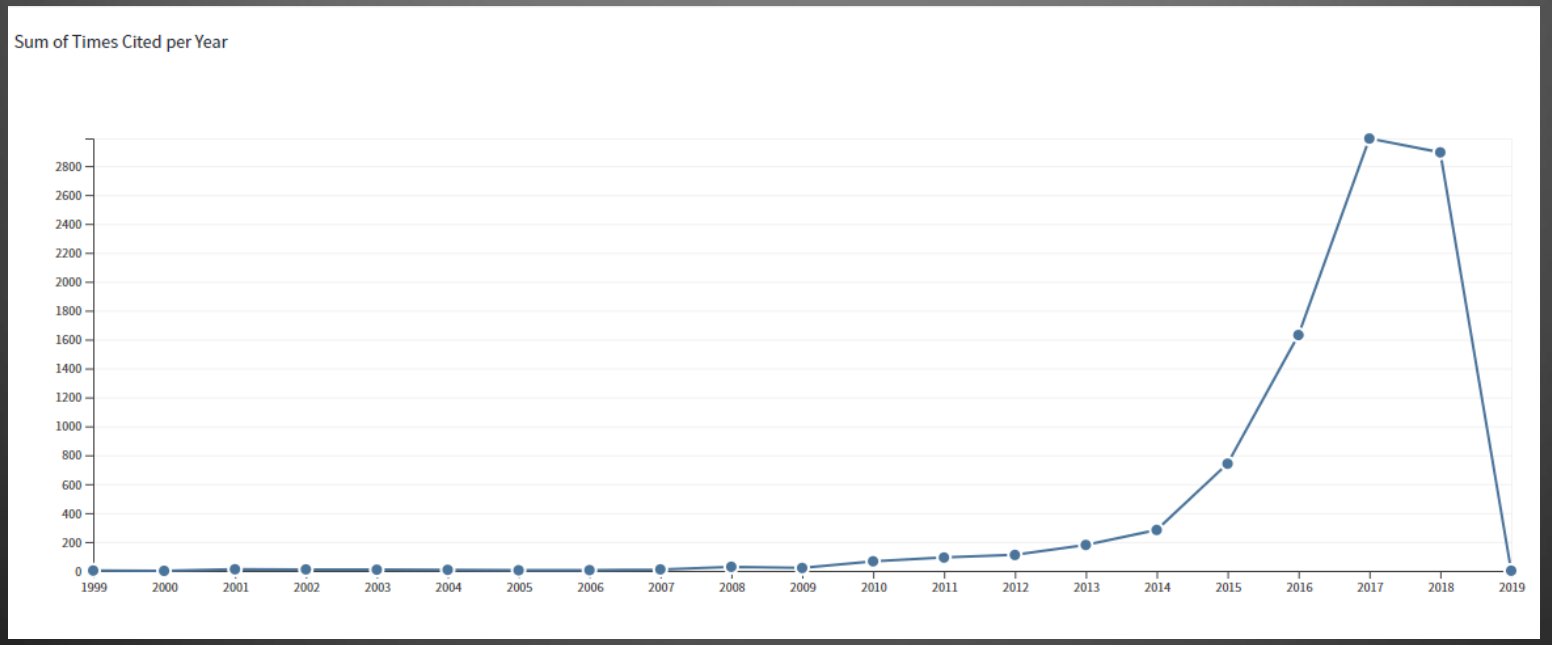
every 10 minutes
another person is added to the waiting list.

only 3 in 1,000
people die in a way that allows for organ donation.

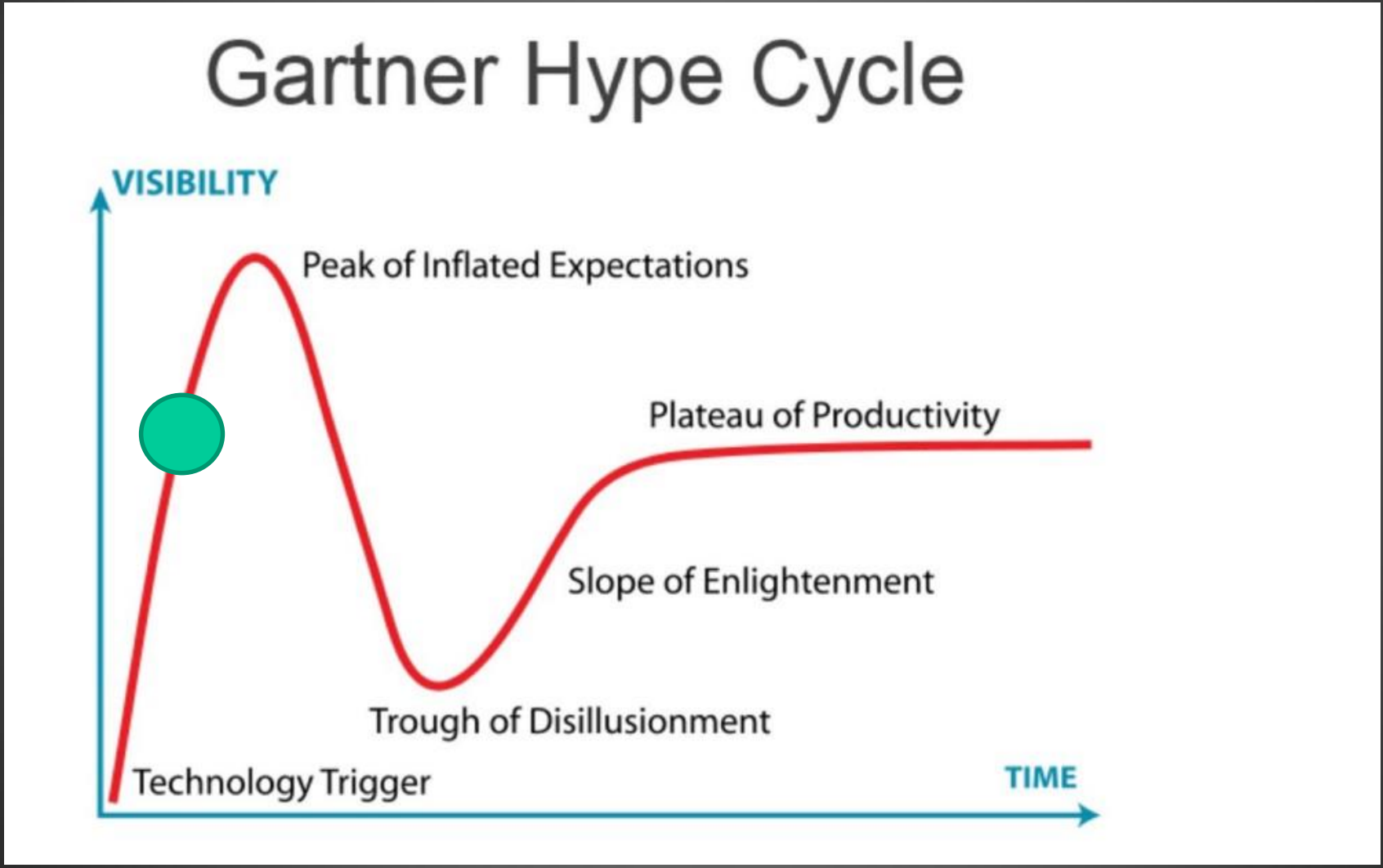


3D printig AND Medicine





Where are we now?



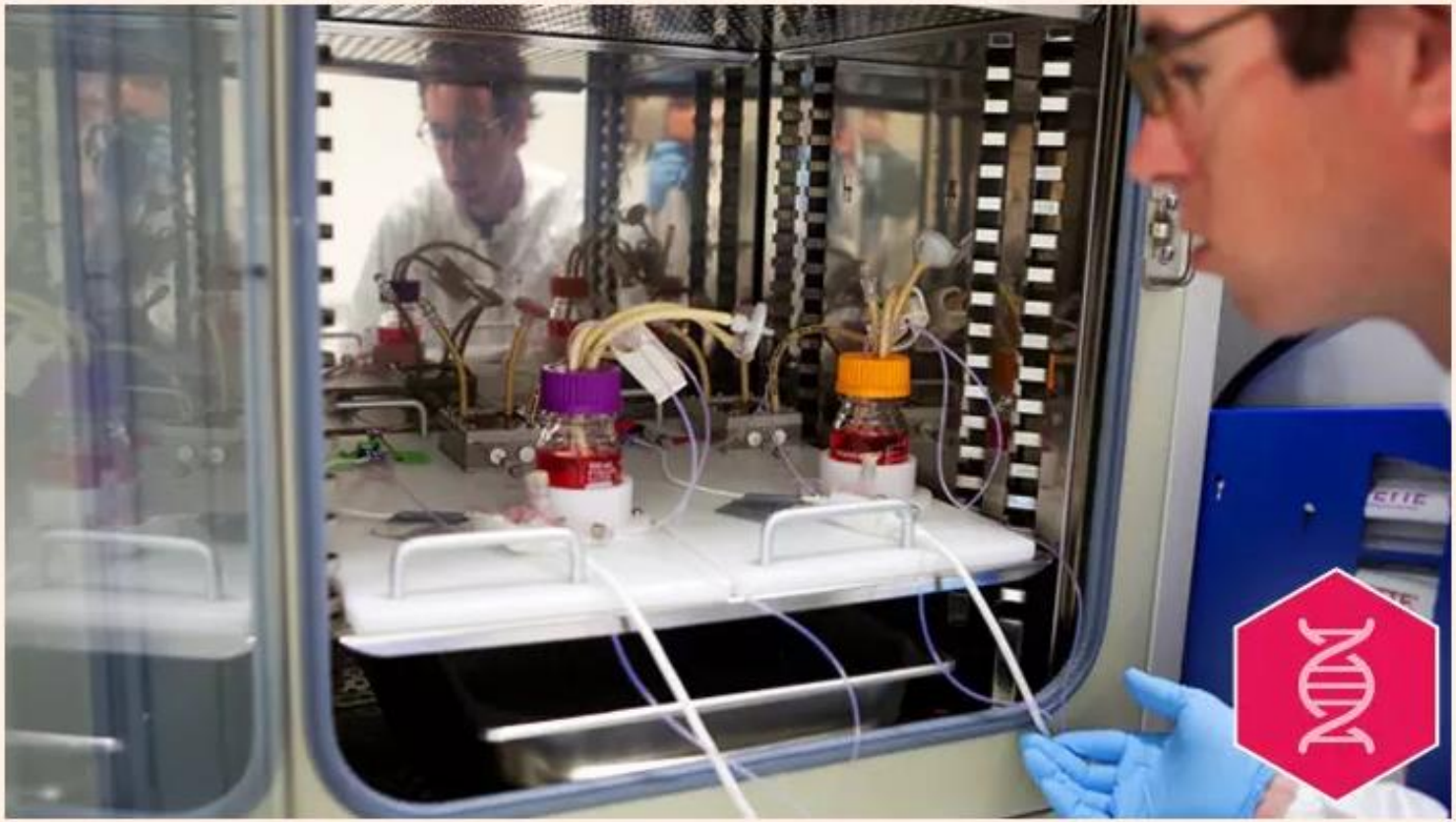
What is Organ Printing?

-Integrating biology and 3-D printing technology
-A process where an artificial organ can be created using a 3-D printer/bioprinter
-Currently NO real organ has been successful created, but scientists are currently working on this idea and are making progress

-First commercial bioprinter company is Organovo
-Printed blood vessels and cardiac tissue from chicken cells in 2008

Liver success holds promise of 3D organ printing

Small 'organoids' grown in the lab could be used to treat chronic conditions



The process of 3D printing liver tissues © Organovo

Hasan Chowdhury MARCH 5, 2018

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New livers, hearts, kidneys: the idea of one day being able to 3D print

We need to learn about the different types of bioprinters!

inkjet

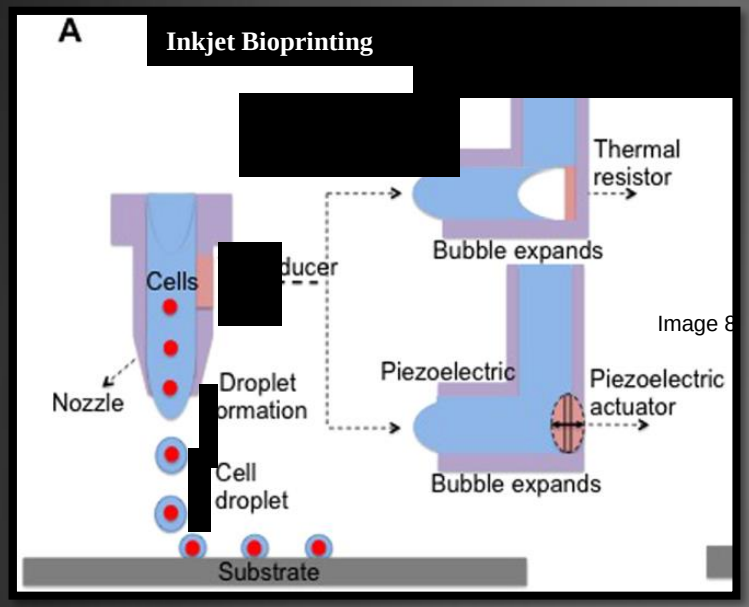


Image 8

laser

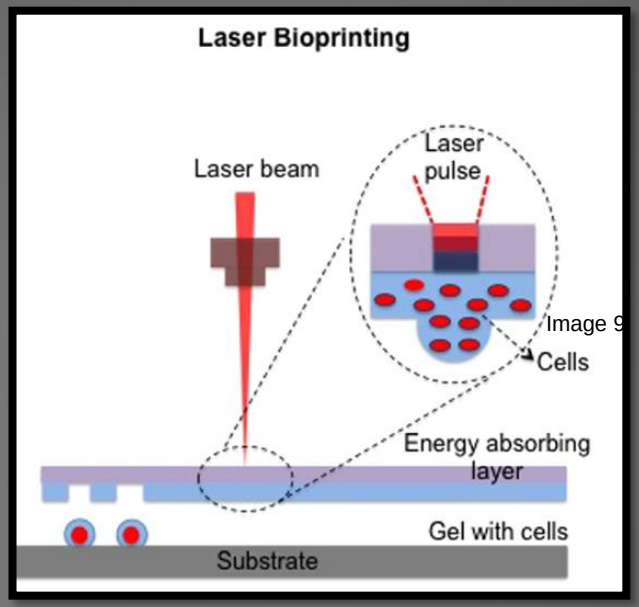
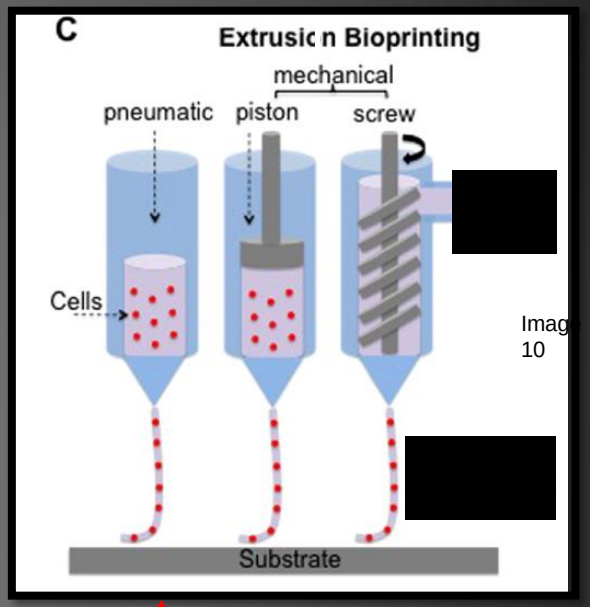


Image 9

extrusio



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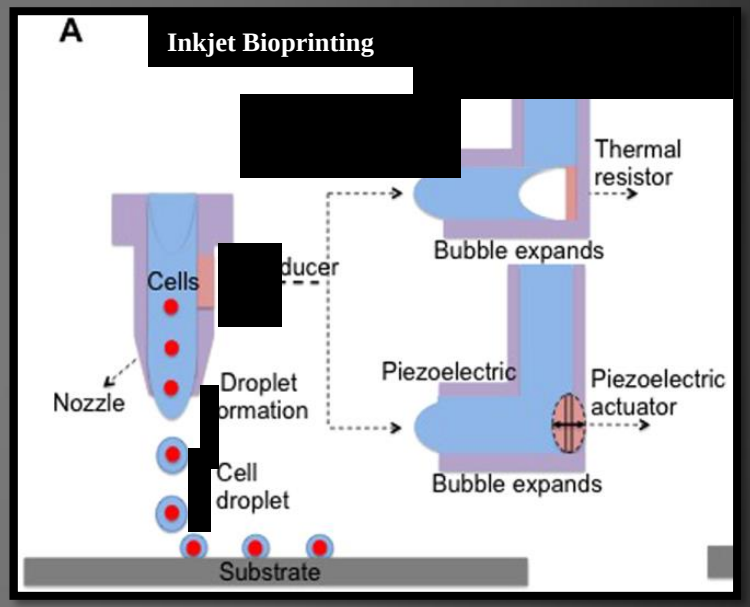
Will be used in the activity

Three different types of bioprinters are inkjet, laser and extrusion. Each has its own strengths and weaknesses. (Activity connection: knowing which one to use will help us better treat Bill.)

We will go over the different types in the next couple of slides. On each slide, we will discuss an analogy, limitations and the best application for each bioprinter type.

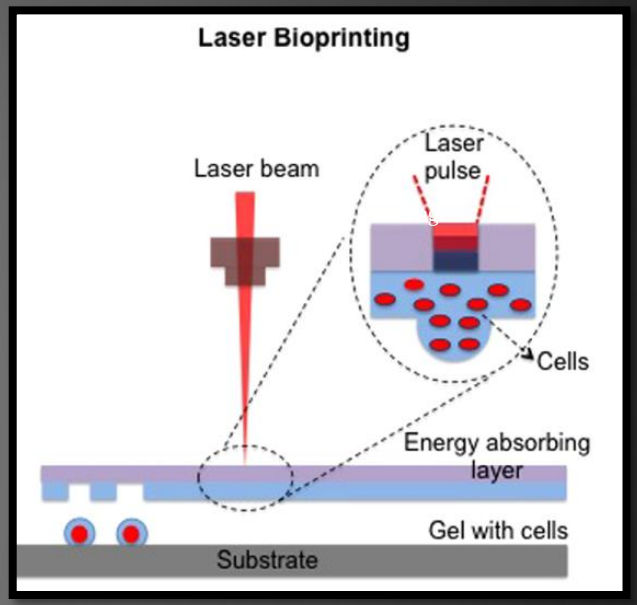
Types of bioprinters: Inkjet

- Analogy: inkjet printer
- Limitations
  - Low viscosity
  - Bio-ink must solidify
  - Cell densities
- Best application = quickly creating skin grafts

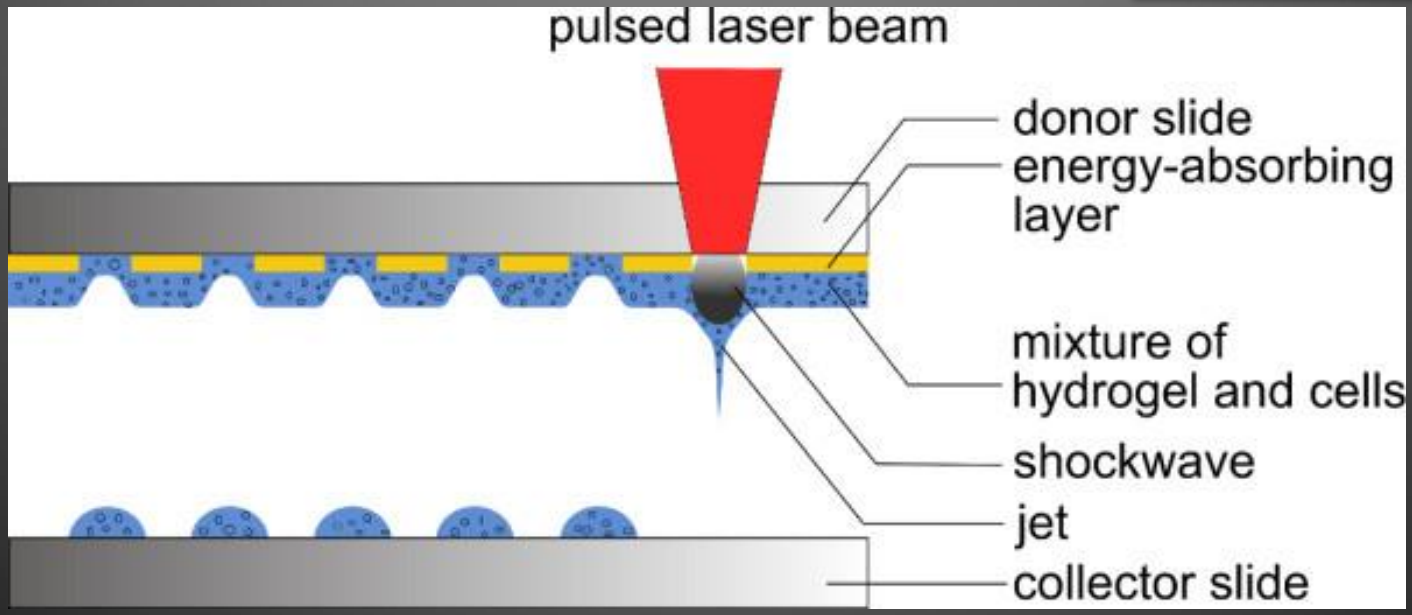


Types of bioprinters: Laser Assisted

- Analogy: placing polka dots on a dress to create a pattern



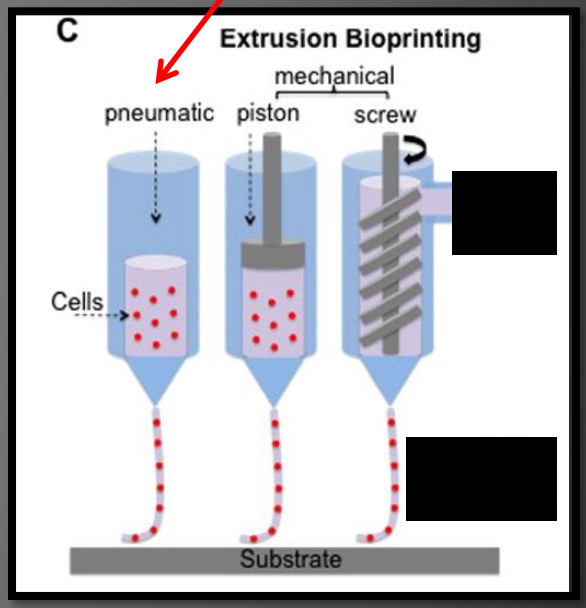
- Limitations
  - Low printing speed
  - Cannot print multiple layers easily
  - Wasteful
- Best application = placing cells precisely into solid structures



Types of bioprinters: Extrusion

- Analogy: squeezing ketchup out of a bottle
- Limitations
  - Lower cellular viability
  - Low resolution
  - Slow print speed
- Best application = creating large 3D structures

Will be used in the activity



Parts of an extrusion bioprinter

Reservoir 2

Reservoir 1

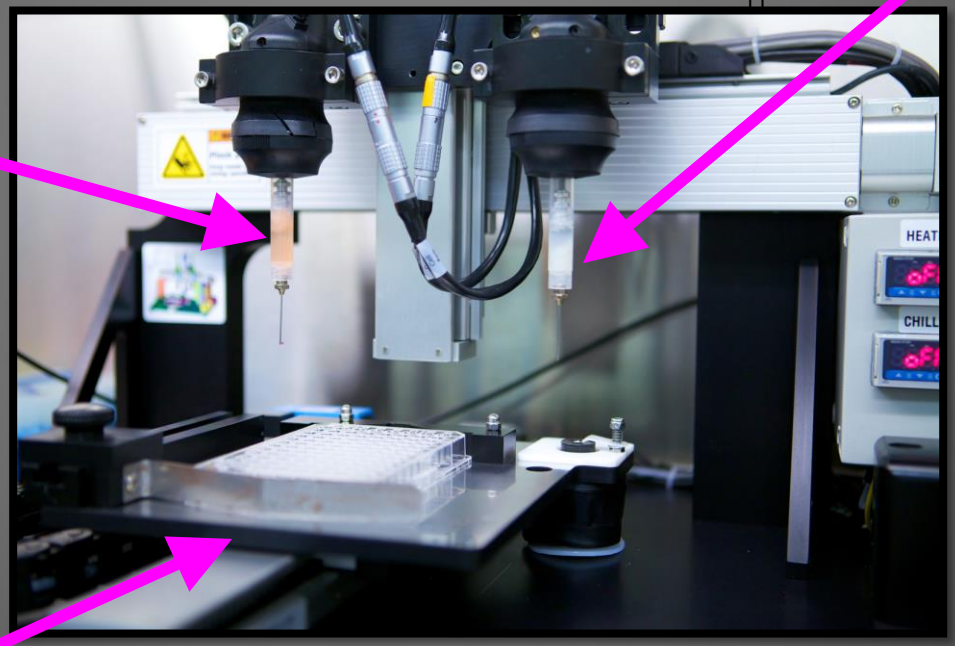
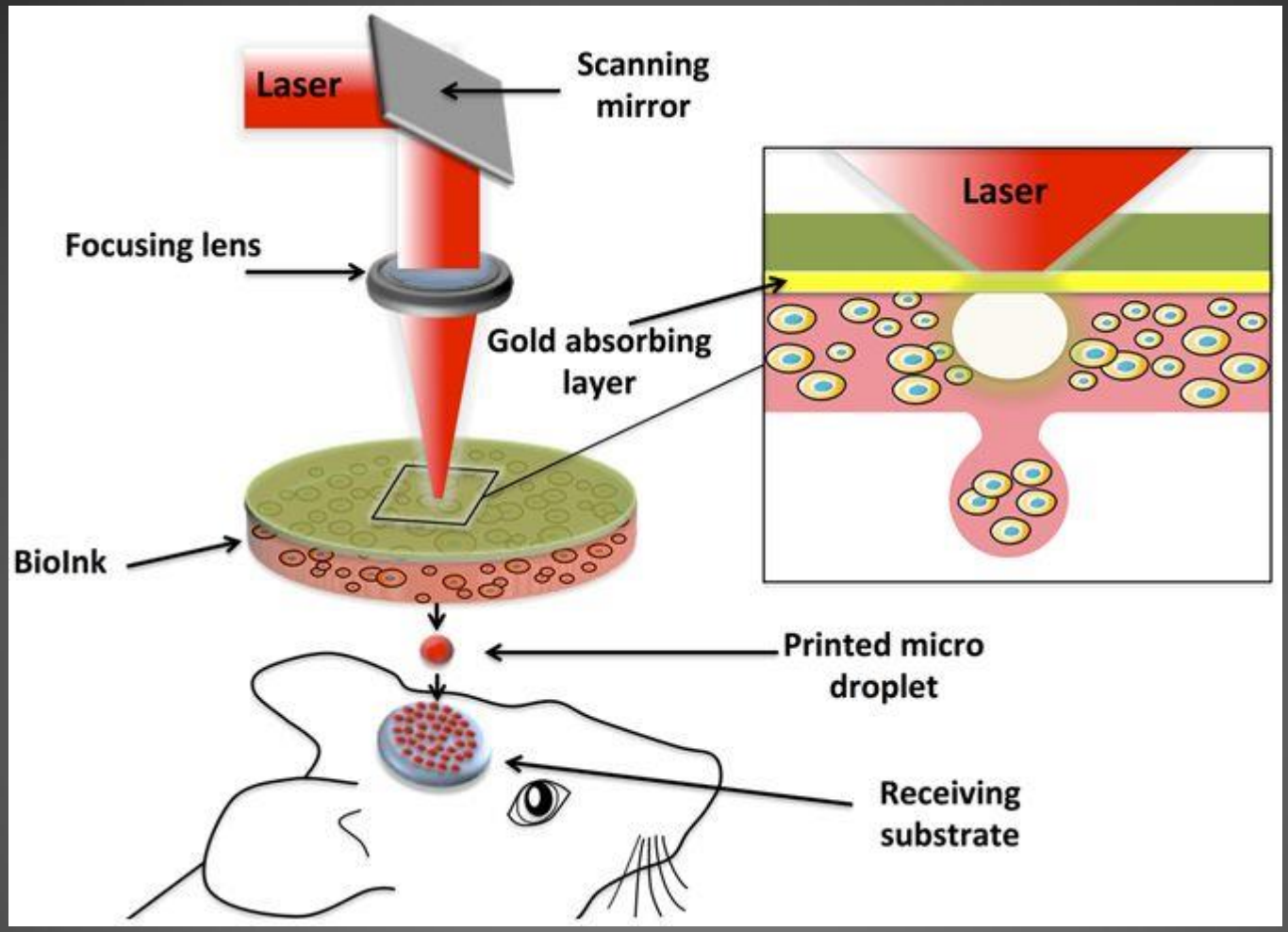


Image 11

Printing stage

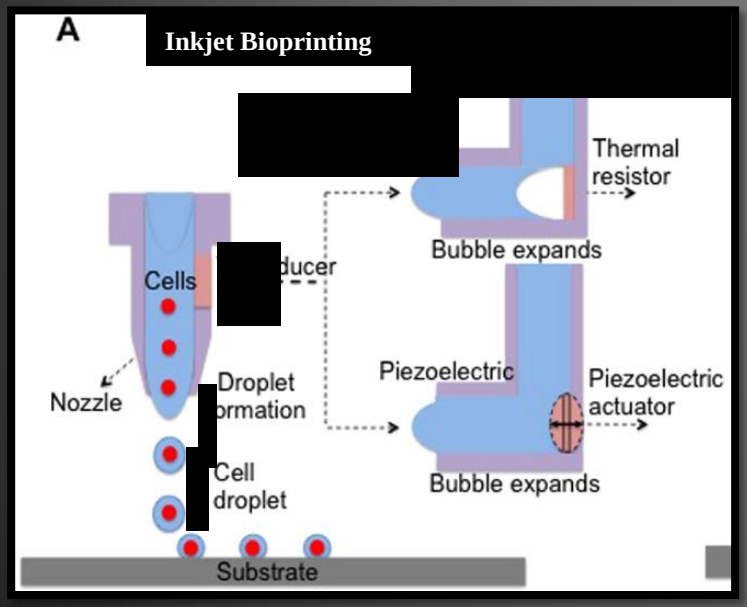
+ Control system



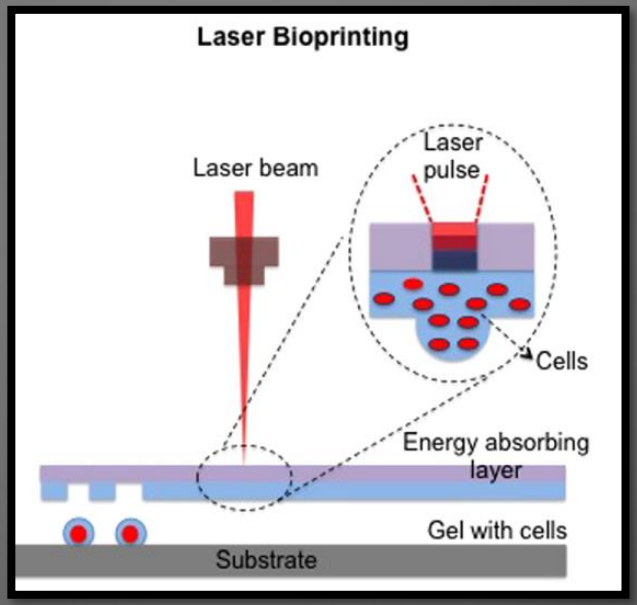
Schematic representation of the laser assisted bioprinting (LAB) approach. A typical LAB setup comprises a pulsed laser beam, a focusing system, a ribbon (a transparent glass slide, coated with a laser-absorbing layer of metal, onto which a thin layer of bioink is spread, and a receiving substrate facing the ribbon. The physical principle of LAB is based on the generation of a cavitation-like bubble, into the depth of the bioink film, whose expansion and collapse induces the formation of a jet and, thereby, the transfer of the bioink from the ribbon to the substrate (here a bone defect on the mouse calvaria), forming a microdroplet.

Types of bioprinters: Summary

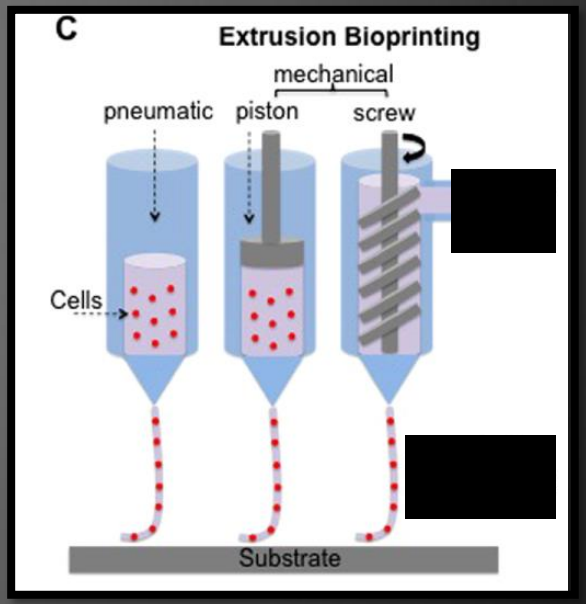
inkjet

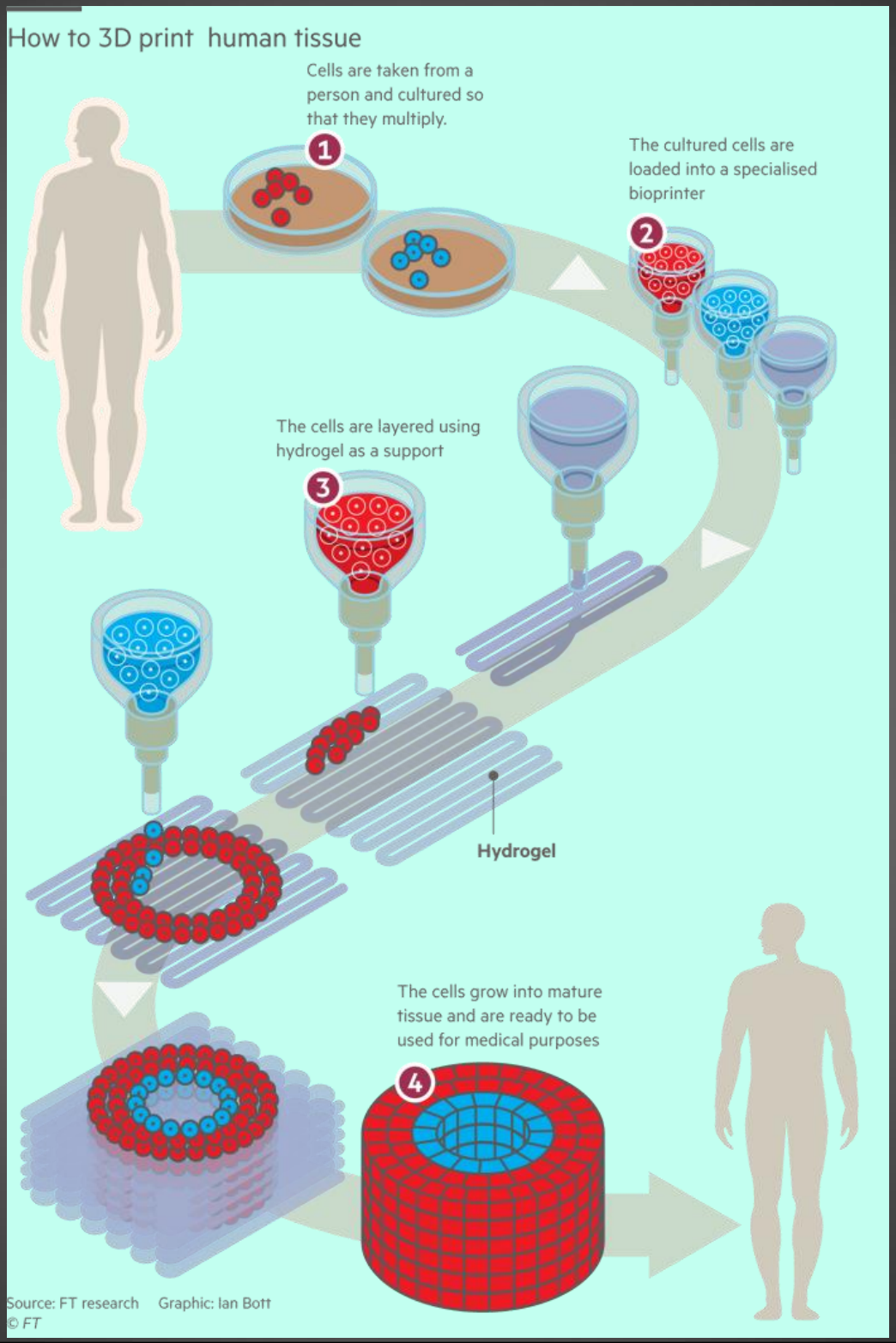


laser



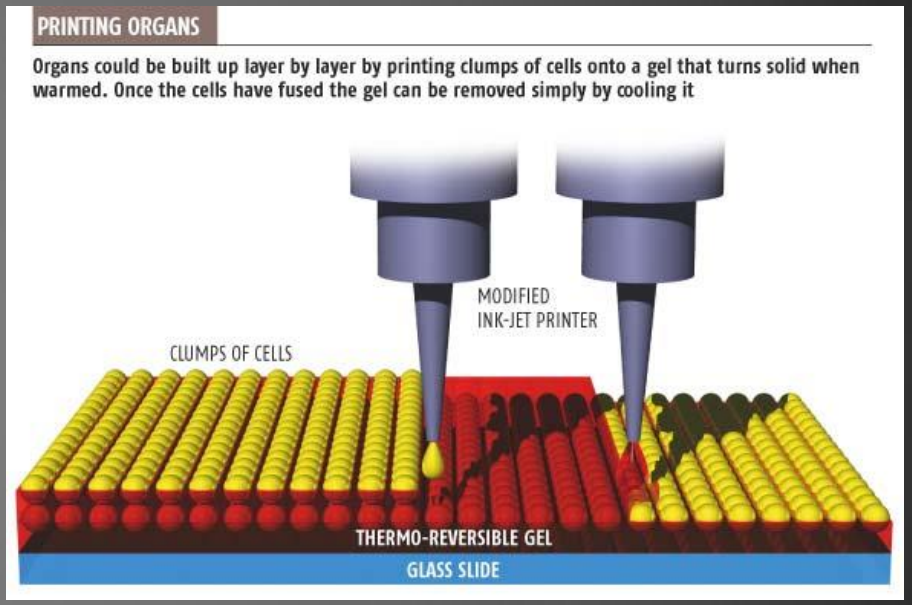
extrusion



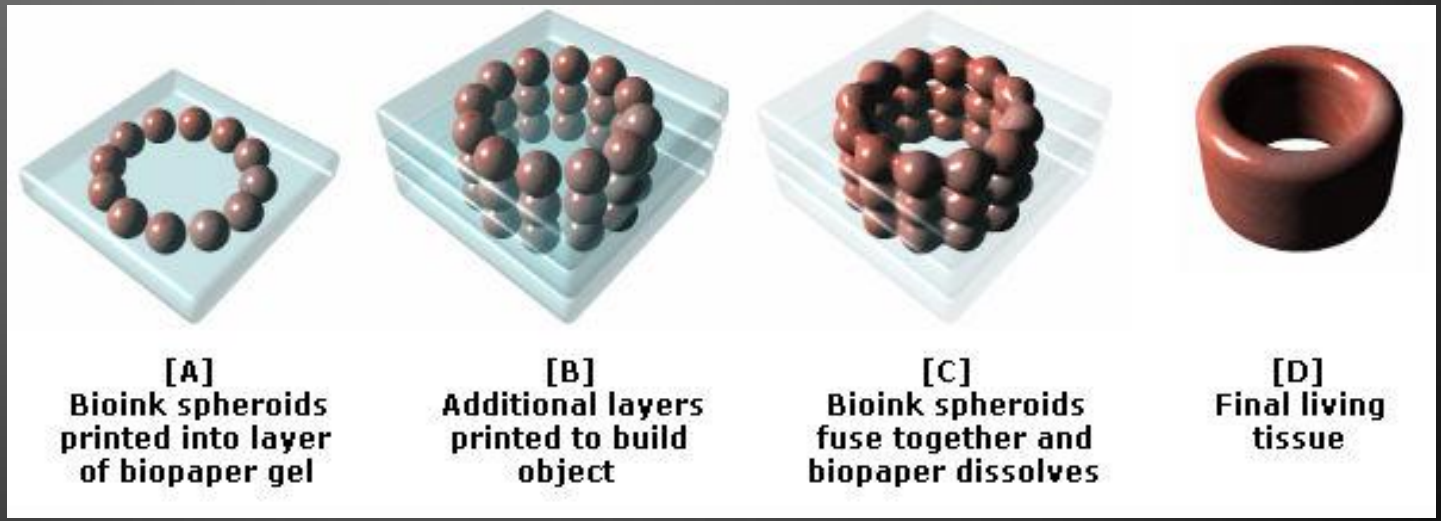

How to 3D print human tissue
Cells are taken from a person and cultured so that they multiply.
1
The cultured cells are loaded into a specialised bioprinter
2
The cells are layered using hydrogel as a support
3
Hydrogel
The cells grow into mature tissue and are ready to be used for medical purposes
4
Source: FT research Graphic: Ian Bott
© FT

How Does It Work?

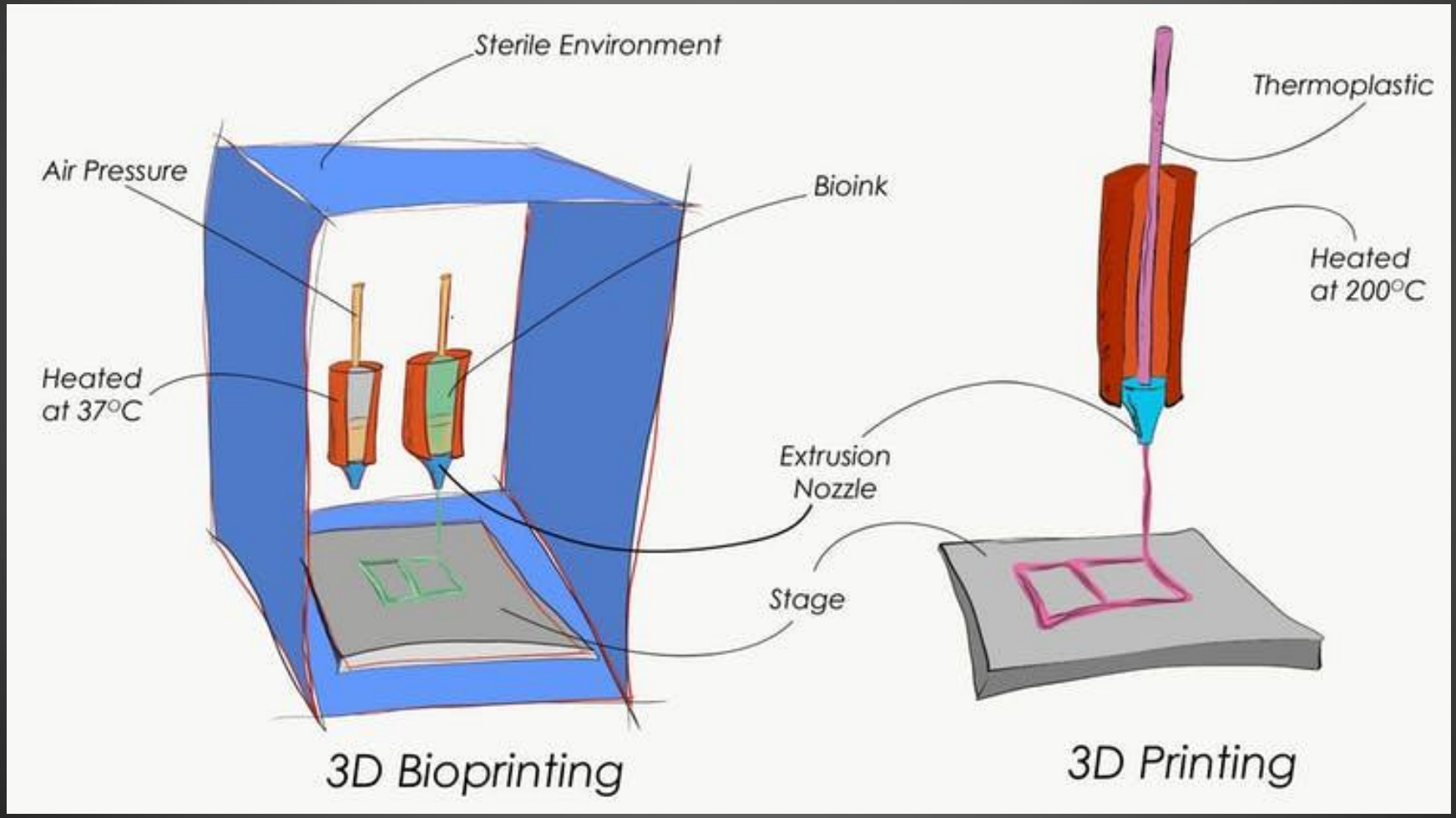
-Uses bioink, mixture of stem cells
-Printer moves back and forth dropping out one bioink particle at a time to form one layer

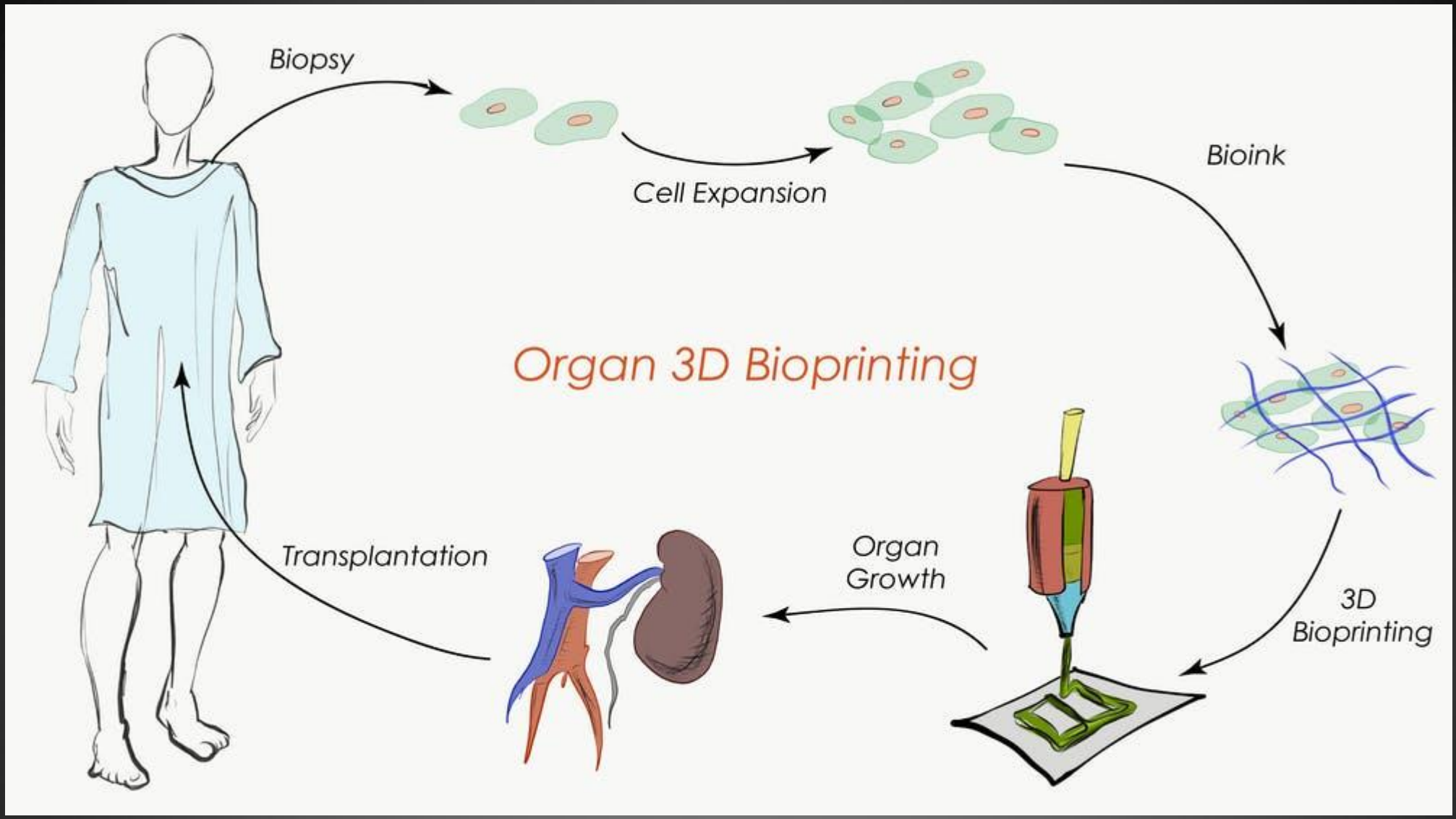


-Printer prints out one layer of cells at a time on biopaper, which is made up of collagen, water, and hydrogels
-Layers are printed one top of each other
-After cells fuse, biopaper is removed

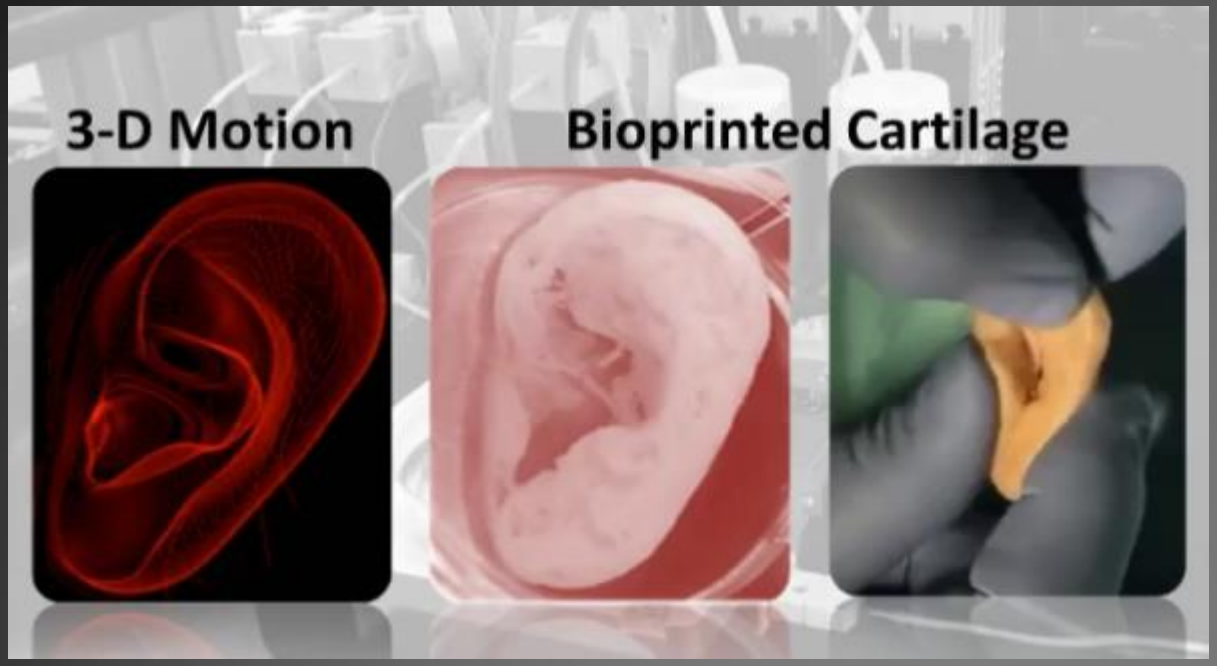


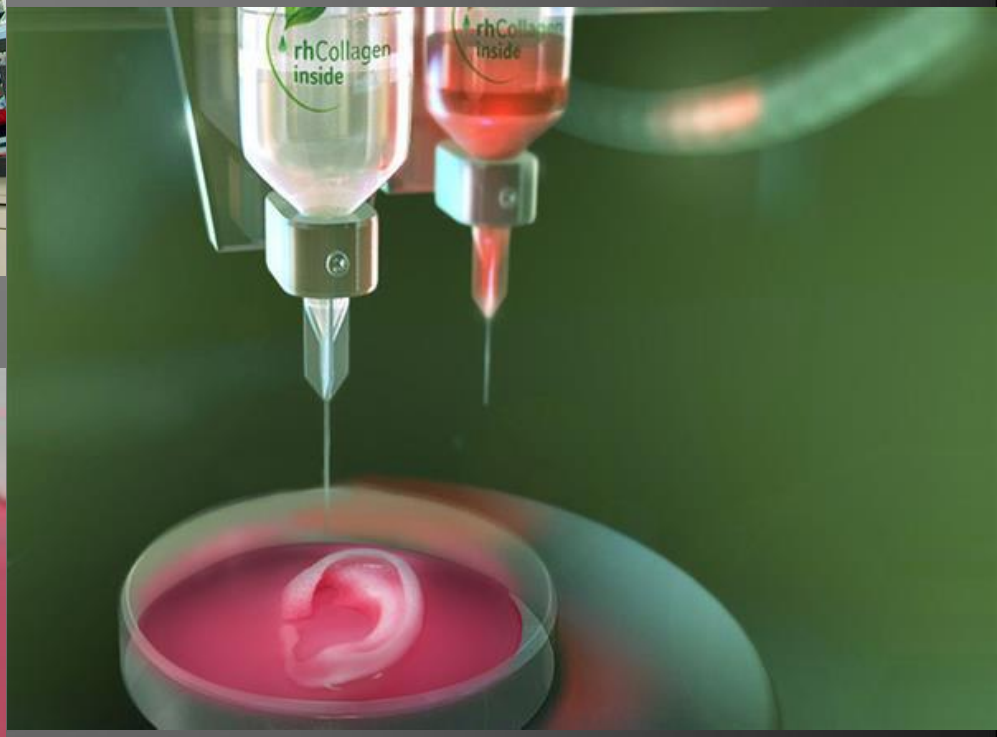
The bioprinting process is performed under sterile conditions and using milder temperatures than are used in 3D plastics printing.

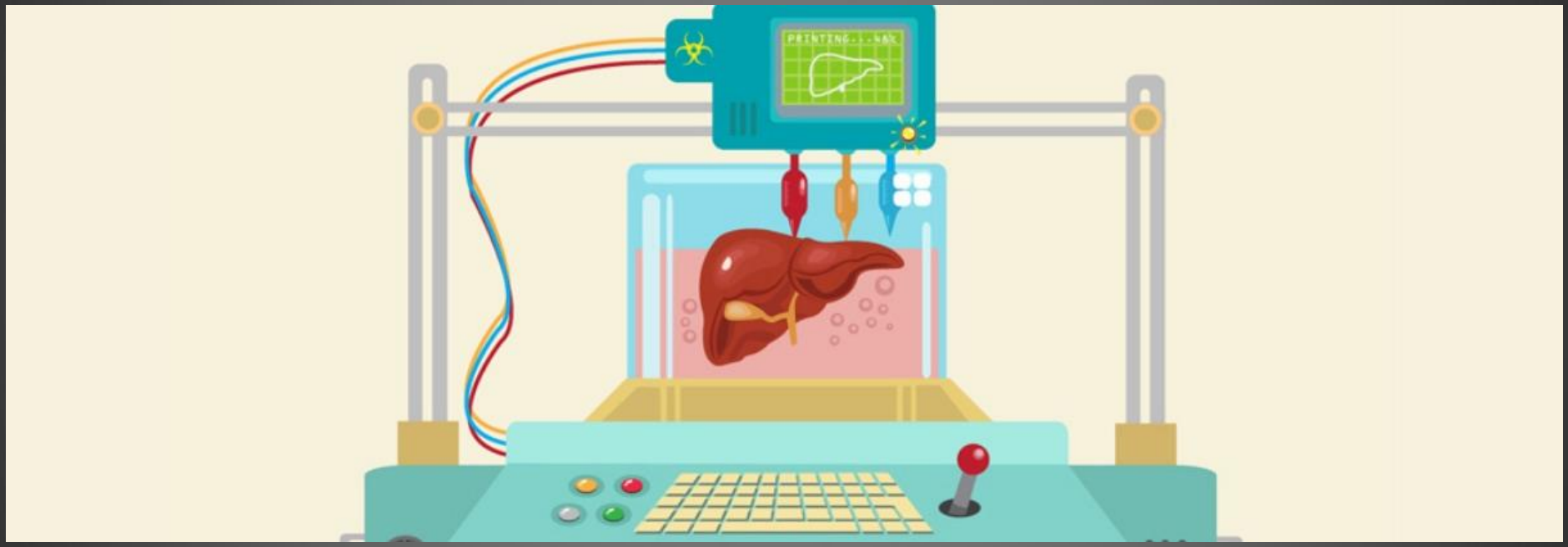




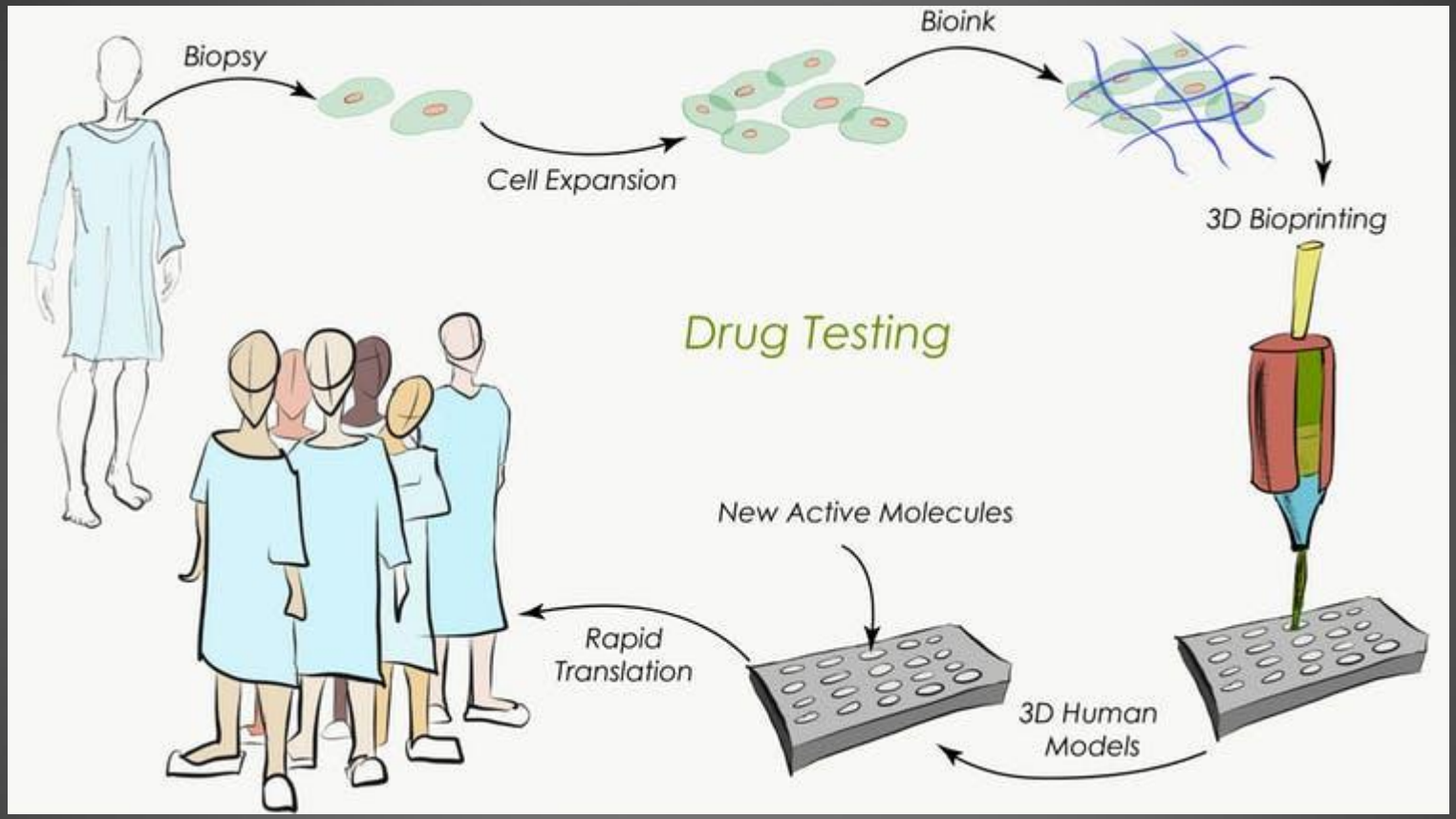
How to print whole organs for transplantation: cells from the patient are extracted and cultured in the laboratory. An organ is printed with several type of cells, then grown and transplanted into the same patient.


3-D Motion
Bioprinted Cartilage


rhCollagen
inside
rhCollagen
inside



Poietis has partnered with the pharma company Servier to develop a 4D bioprinted liver model that could predict liver toxicity of drugs better than current methods.



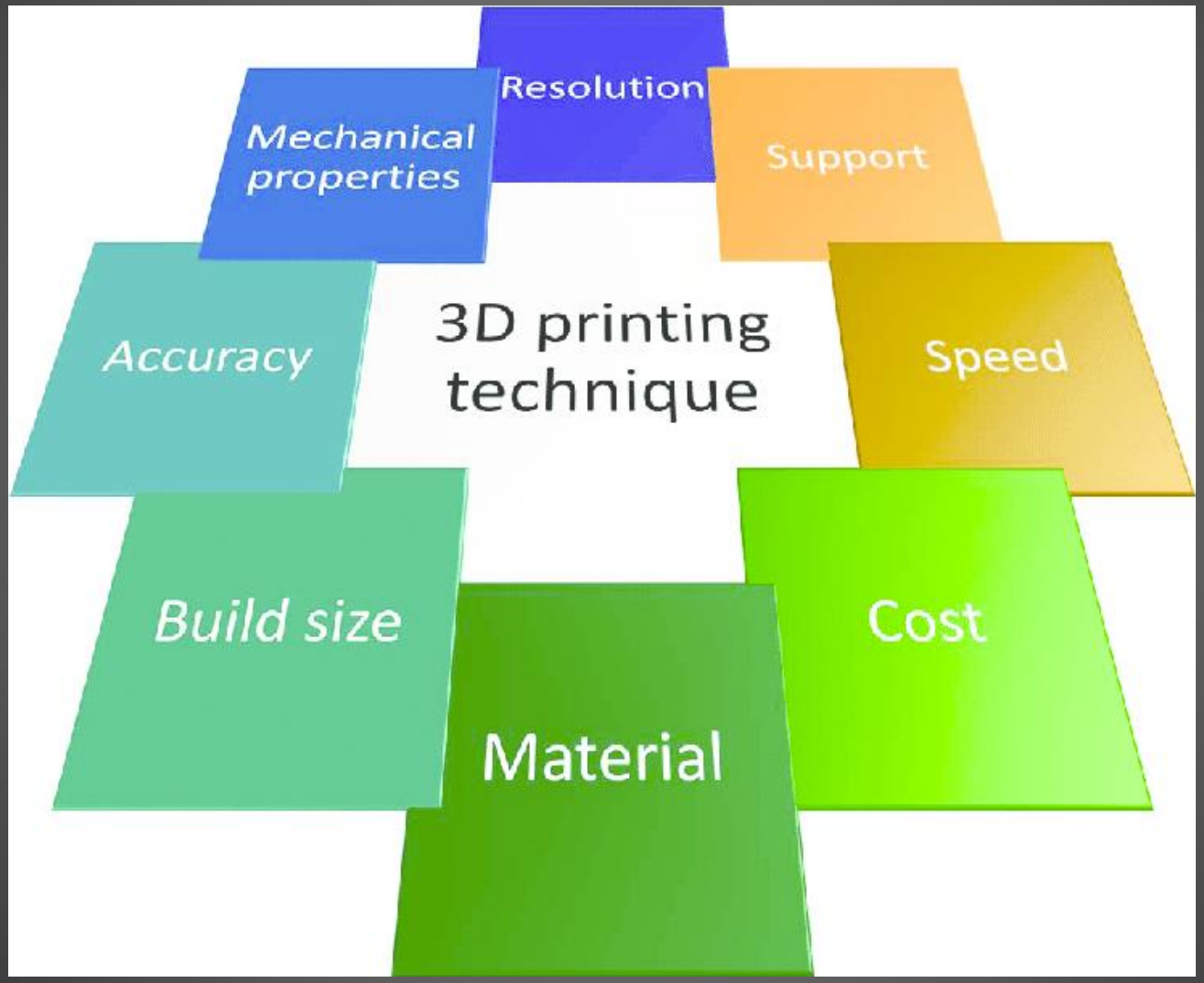
3D bioprinting could revolutionising drug discovery: cells from one patient are extracted and cultured in the laboratory. A tissue sample is printed, on which new molecules can be tested as treatments for whole populations.

Benefits and Disadvantages

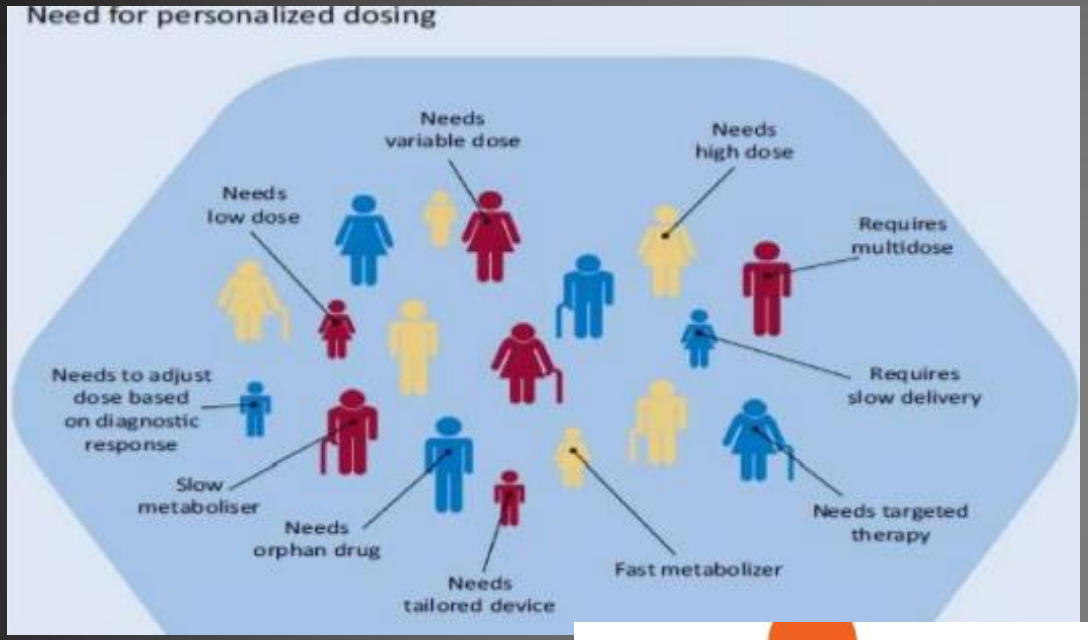
-Artificial organ personalized using patients own cells
-No DNA rejection
-Eliminate need for immunosuppressant drugs needed after a regular organ transplant
-Eliminate organ donation
-No waiting period

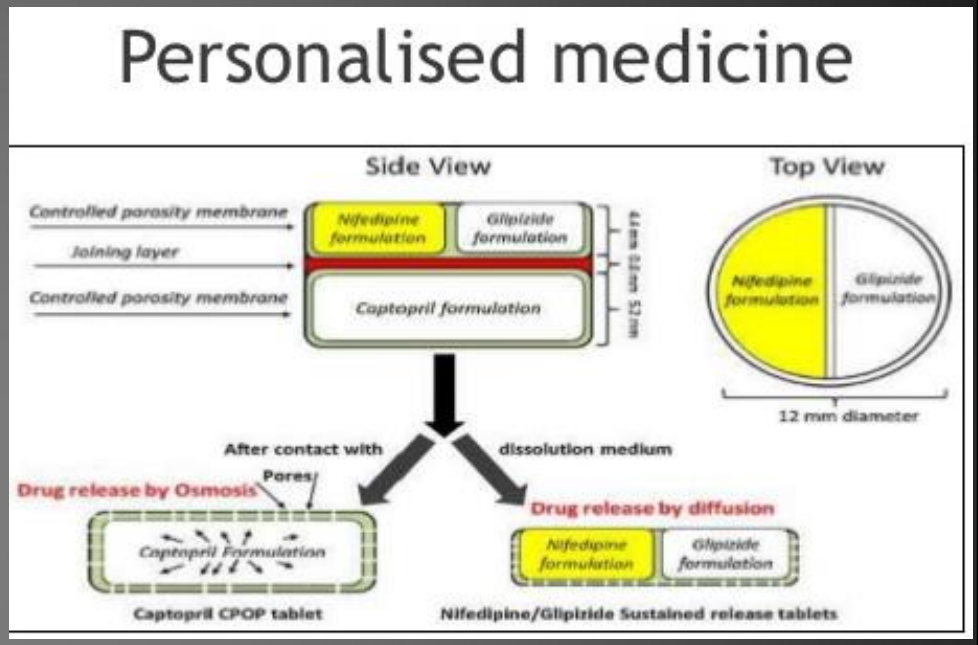
-Printers cost hundreds of thousands of dollars
-Possibly more expensive than regular organ transplant
-Use of stem cells is still controversial
-Cost of using stem cells
-Not successfully created yet

Some problems to be considered



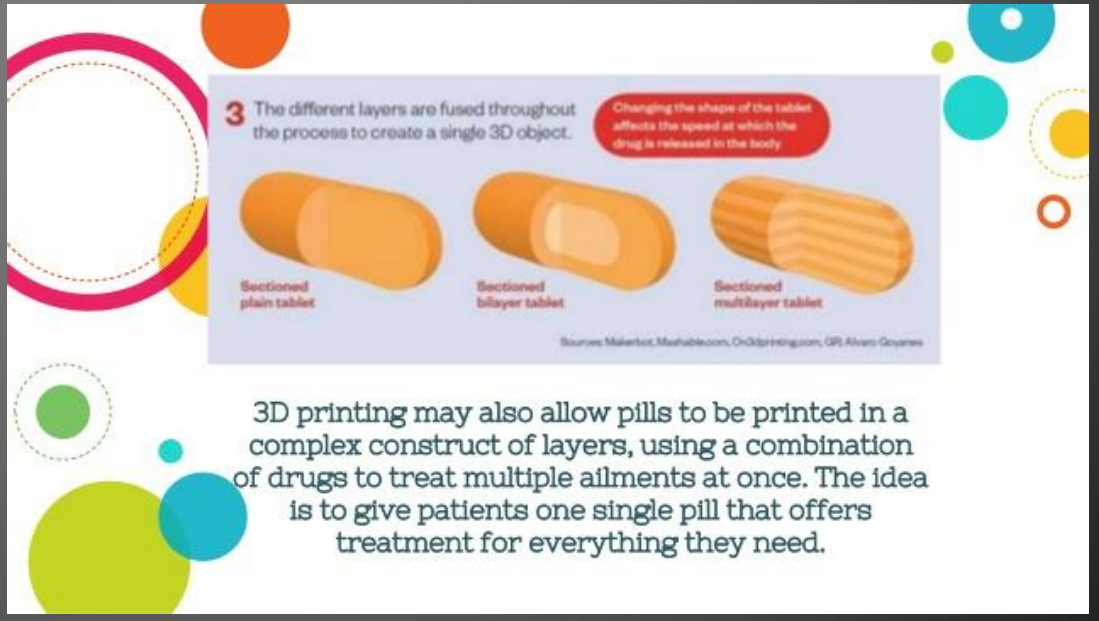
3D printing and personalized medicine





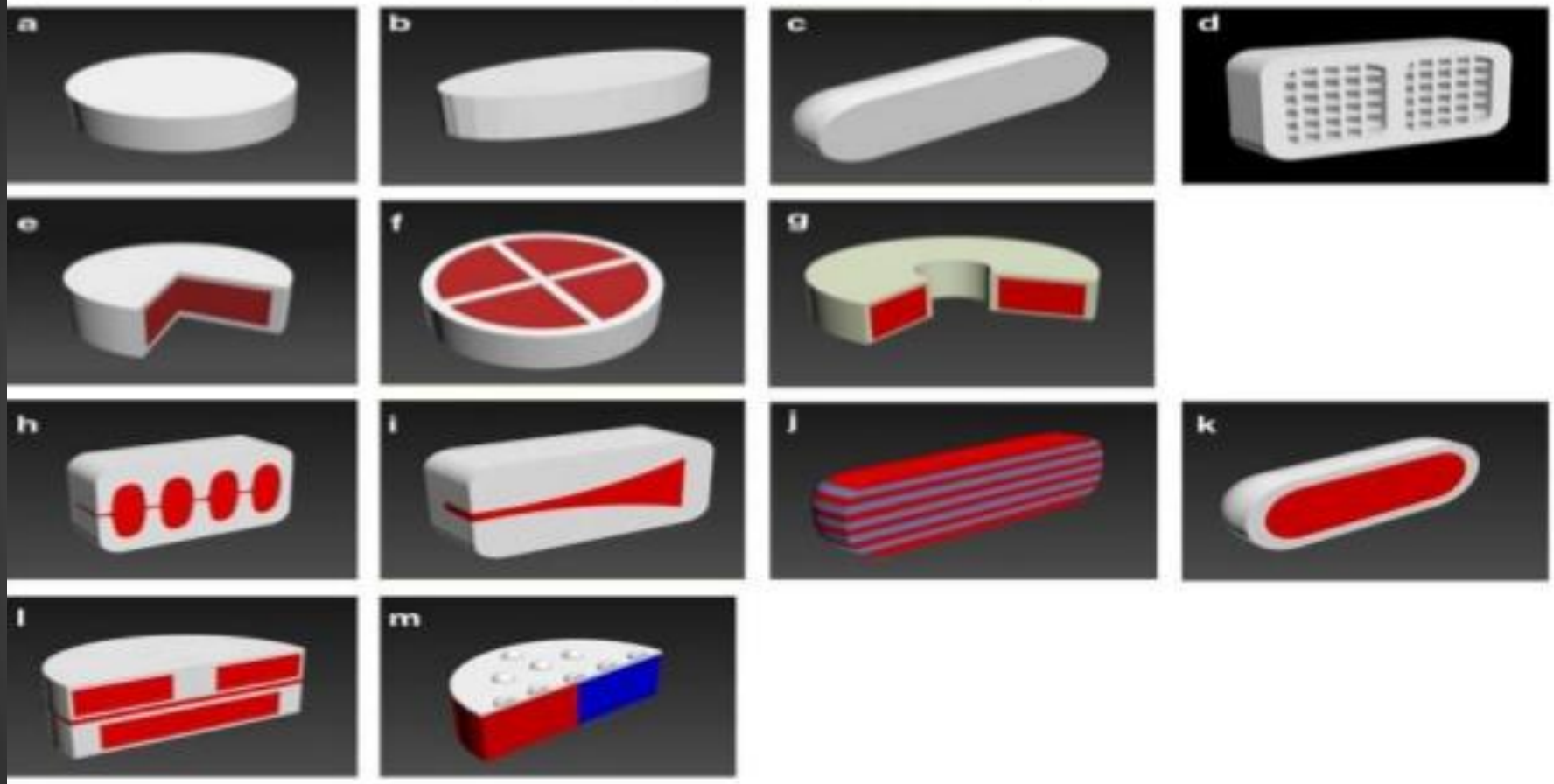
Current and Projected Uses

- PERSONALIZED DRUG DOSING
- UNIQUE DOSAGE FORMS
- COMPLEX DRUG RELEASE PROFILES
- PRINTING LIVING TISSUE



3D printing may also allow pills to be printed in a complex construct of layers, using a combination of drugs to treat multiple ailments at once. The idea is to give patients one single pill that offers treatment for everything they need.

Novel designs made possible



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3DMedNet Newsletter

5 July 2019

EXPERT INSIGHT

Dietmar Hutmacher, Editor-in-Chief of the *Journal of 3D Printing in Medicine*, reflects on how 3D printing is set to disrupt today's surgical practice in this editorial.

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Editor's pick

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