



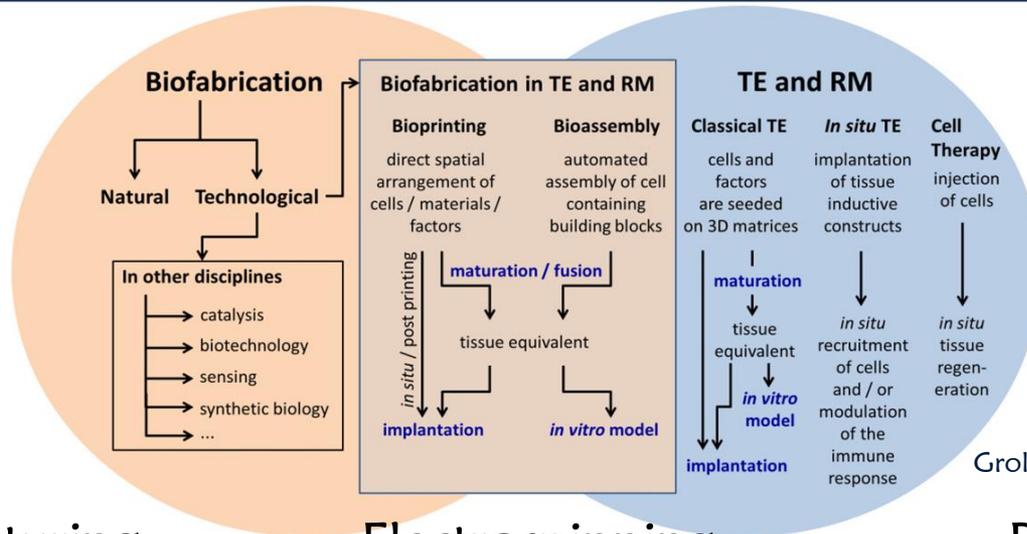
**Maastricht University** *Leading in Learning!*

# BIOFABRICATION IN SPACE: NEW OPPORTUNITIES FOR GLOBAL HEALTH

**LORENZO MORONI**

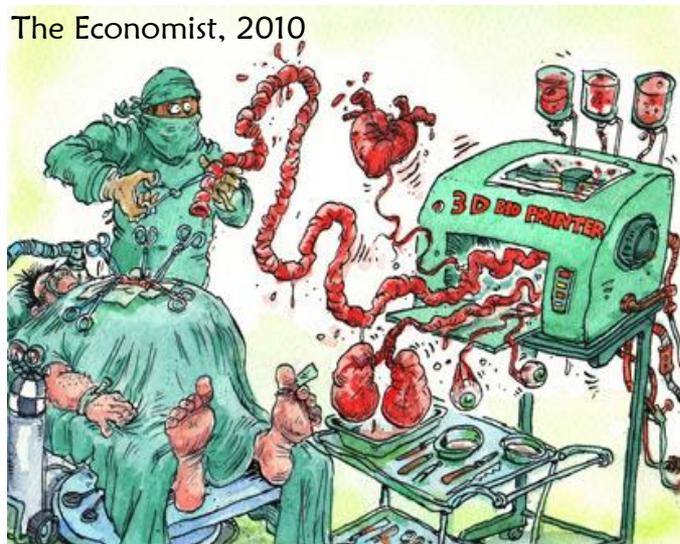
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Groll J et al., Biofabrication 2016

## Additive Manufacturing



Moroni L et al., J Biomed Mater Res 2005  
Giordano RA, et al., J Biom Sci Polym Edn, 9; 1996

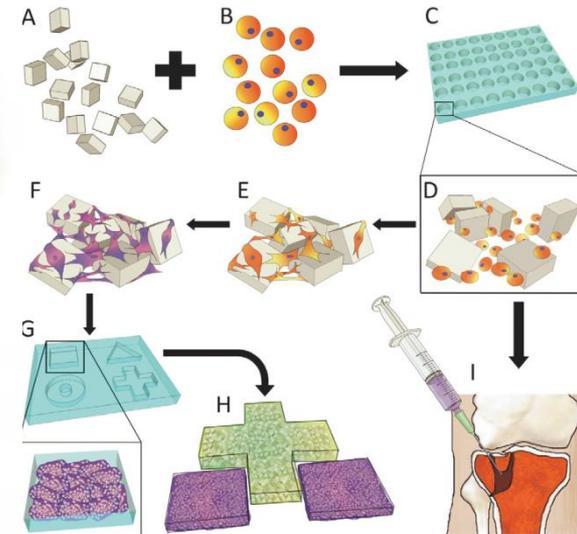
## Electrospinning



www.dvices.com

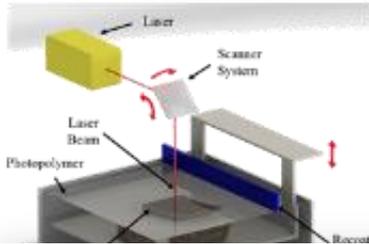
Moroni L et al., Biomaterials 2006  
Li WJ et al., J Biomed Mater Res 2002

## Bottom-up

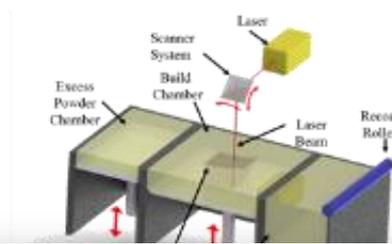


Leferink AM et al., Adv. Materials 2014

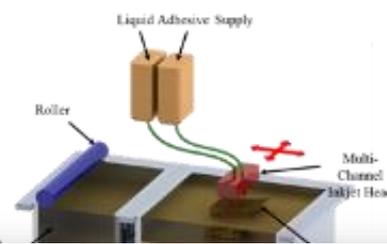
a) Stereolithography (SLA)



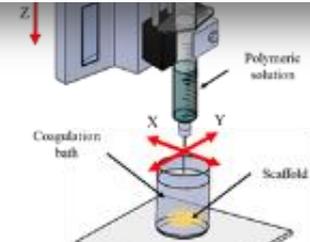
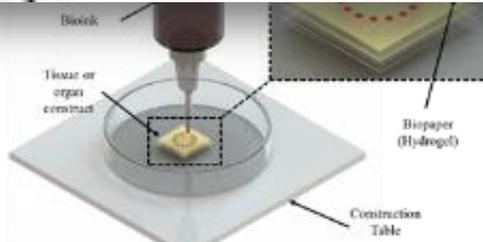
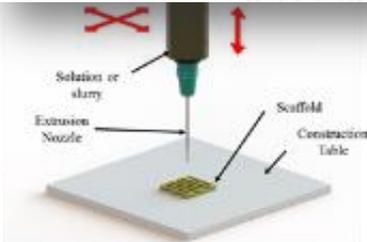
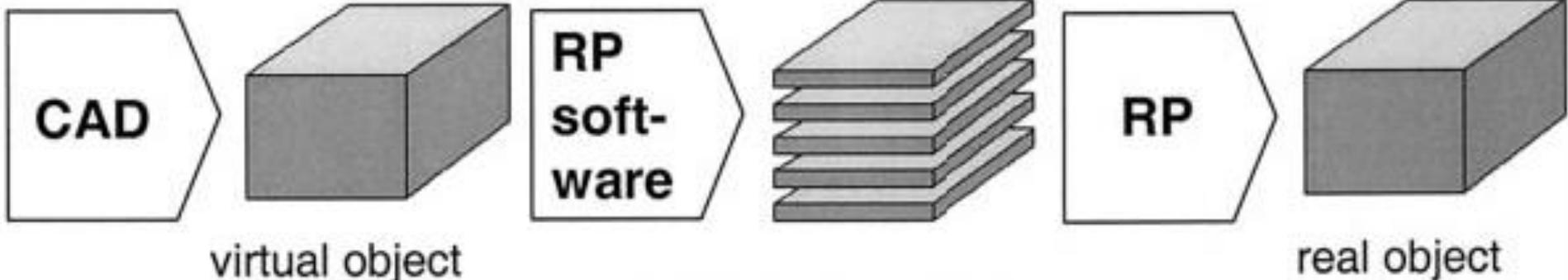
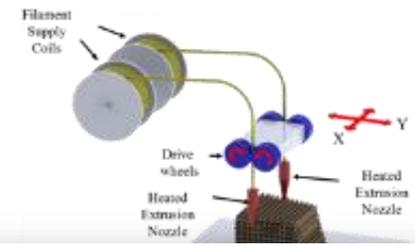
b) Selective Laser Sintering (SLS)



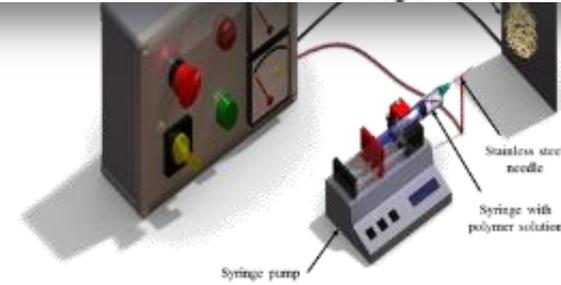
c) Three Dimensional Printing (3DP)



d) Fused Deposition Modelling (FDM)



Mota et al, 2012, Doi: 10.1002/term.1635

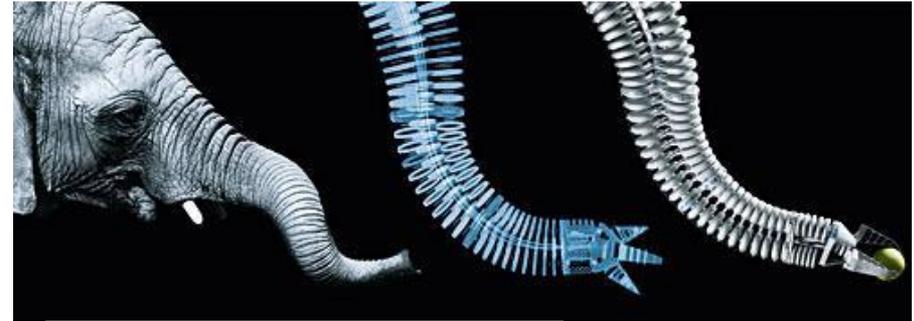


Moroni L et al., J Biomed Mater 2005

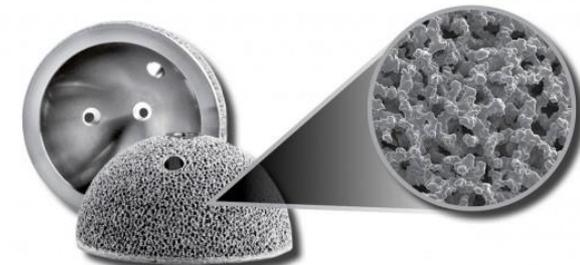
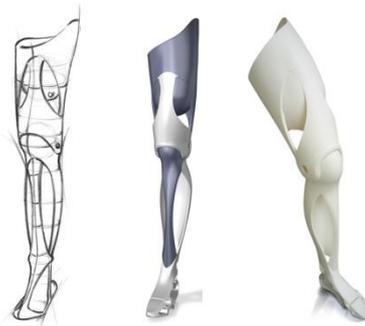
Pfister A, et al. J Polym Sci, 42; 2004

Sun W, et al., Comp Meth Prog Biomed 2002

- Supporting Tools (e.g. exoskeletons)
- Instrumentation
- Dental (e.g. crowns & Bridges; > 10.000 produced daily)
- Ear Implants
- Prostheses
- Visualization supporting tools
- Implants

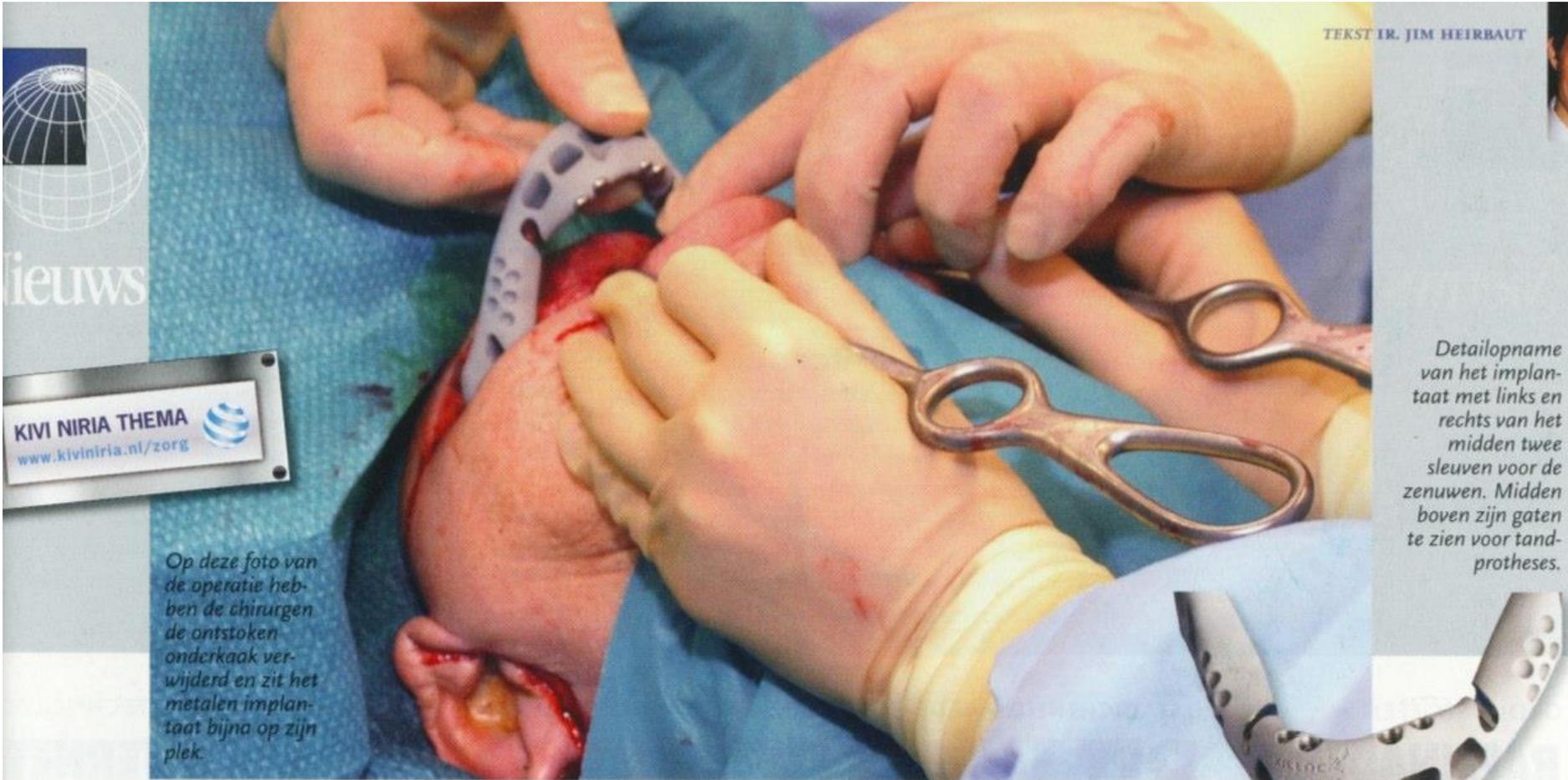


**Hettich**  
ZENTRIFUGEN



**ACETABULAR CUPS: > 40.000  
PRODUCED WITH EBM WHERE ~  
50% ARE IMPLANTED IN PATIENTS**

# First AM Customized Mandible Implanted in a Patient



TEKST IR. JIM HEIRBAUT



KIVI NIRIA THEMA  
[www.kiviniria.nl/zorg](http://www.kiviniria.nl/zorg)

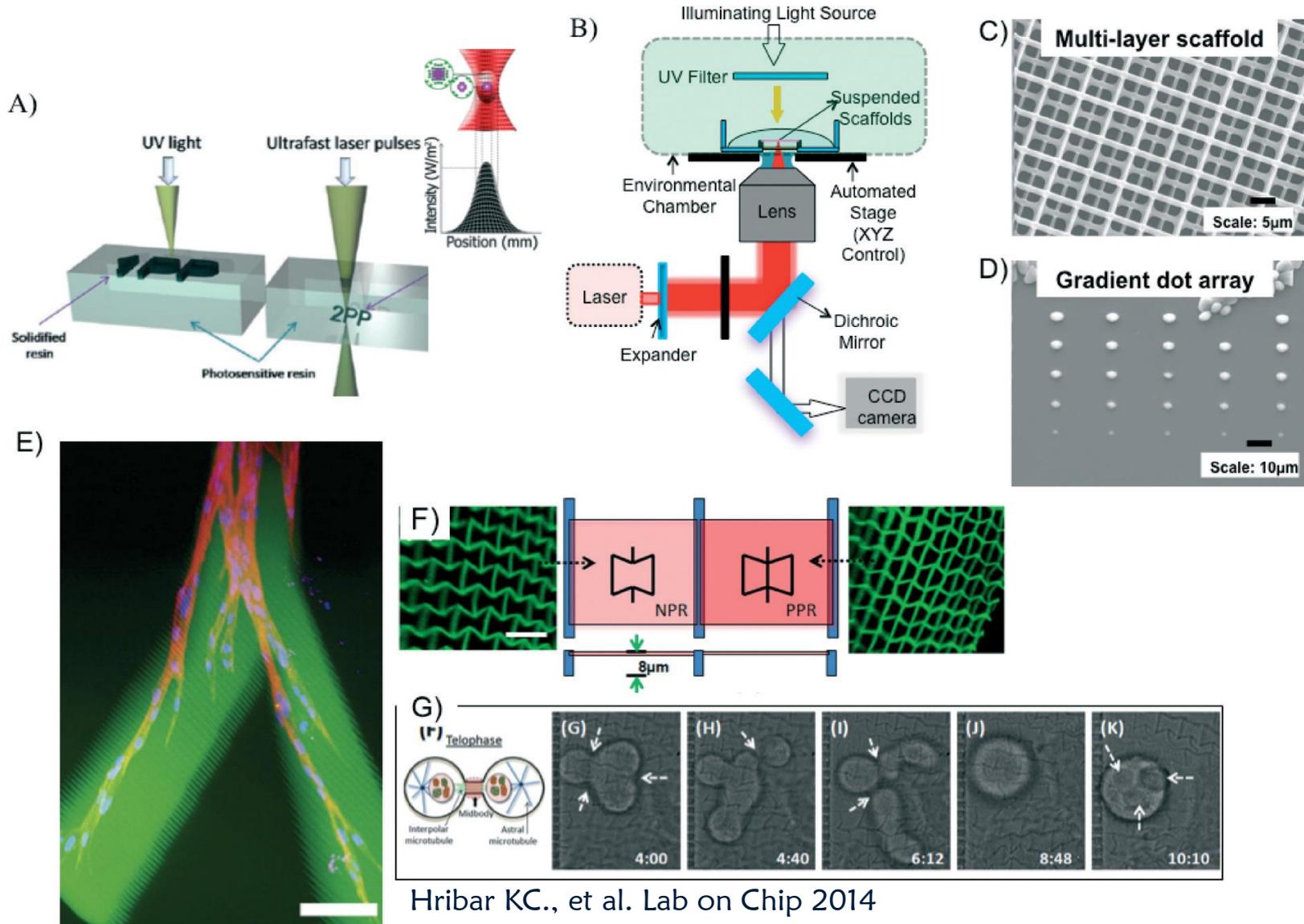
Op deze foto van de operatie hebben de chirurgen de ontstoken onderkaak verwijderd en zit het metalen implantaat bijna op zijn plek.

Detailopname van het implantaat met links en rechts van het midden twee sleuven voor de zenuwen. Midden boven zijn gaten te zien voor tandprothesen.



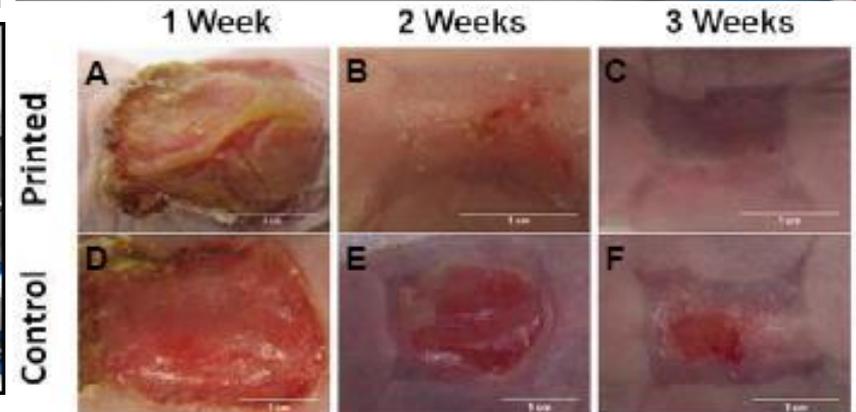
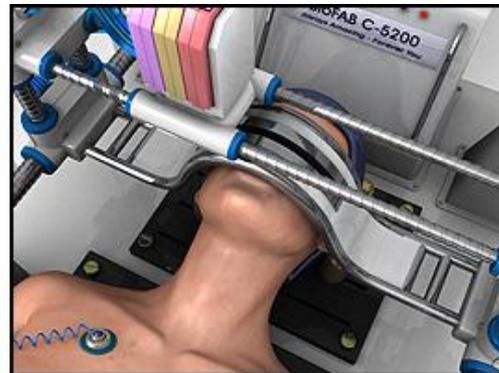
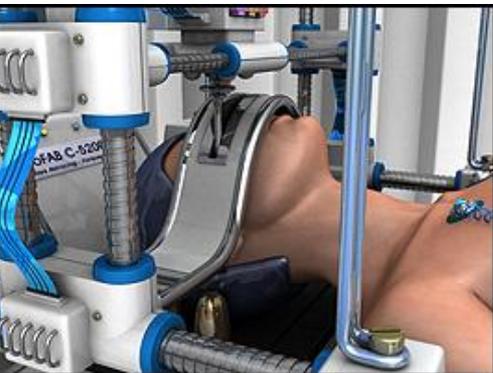
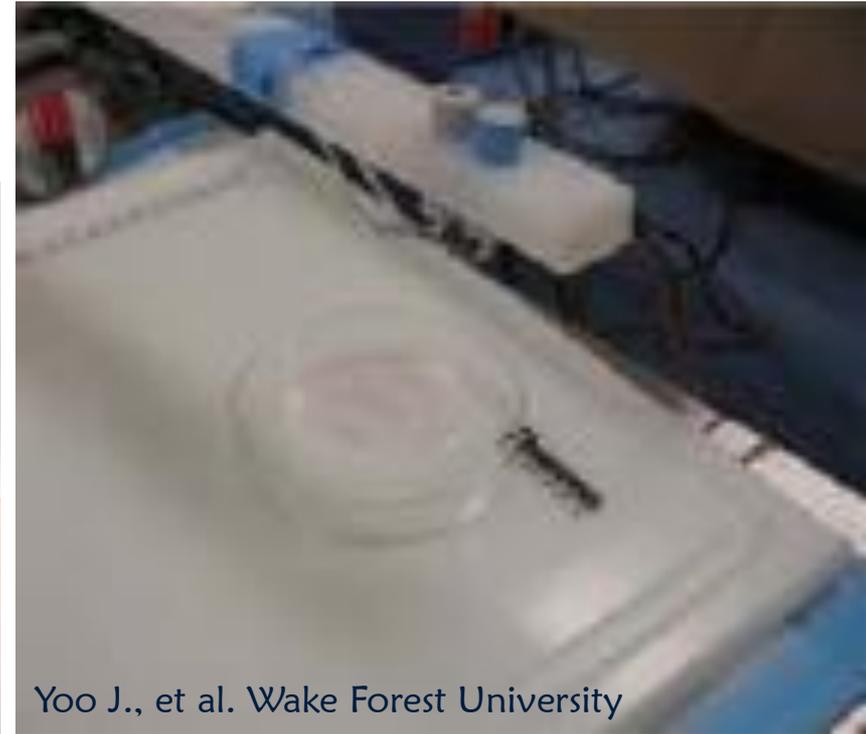
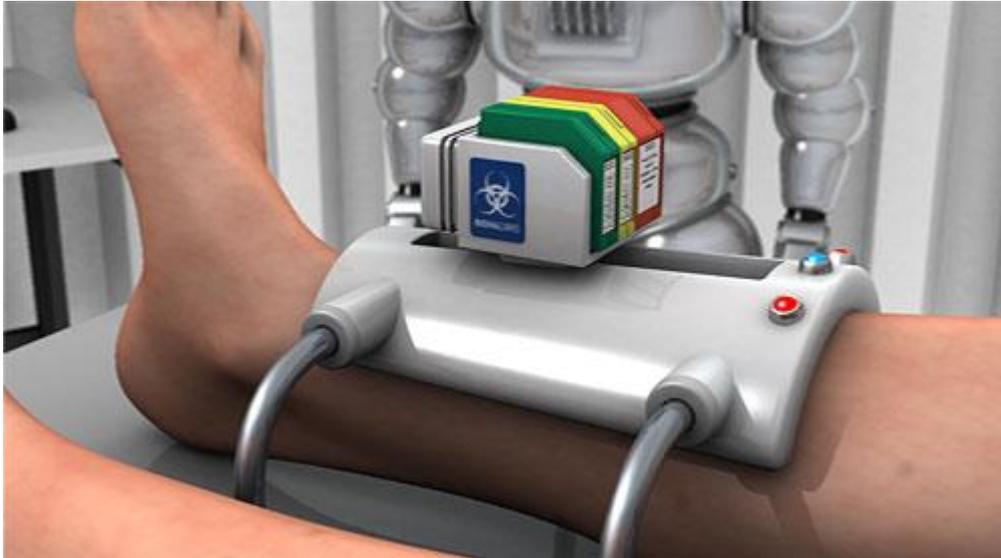
METALEN IMPLANTAAT OPGEBOUWD UIT DUIZENDEN LAAGJES

## ONDERKAAK IN 3D GEPRINT



Hribar KC., et al. Lab on Chip 2014

# Additive Manufacturing in the Biomedical World

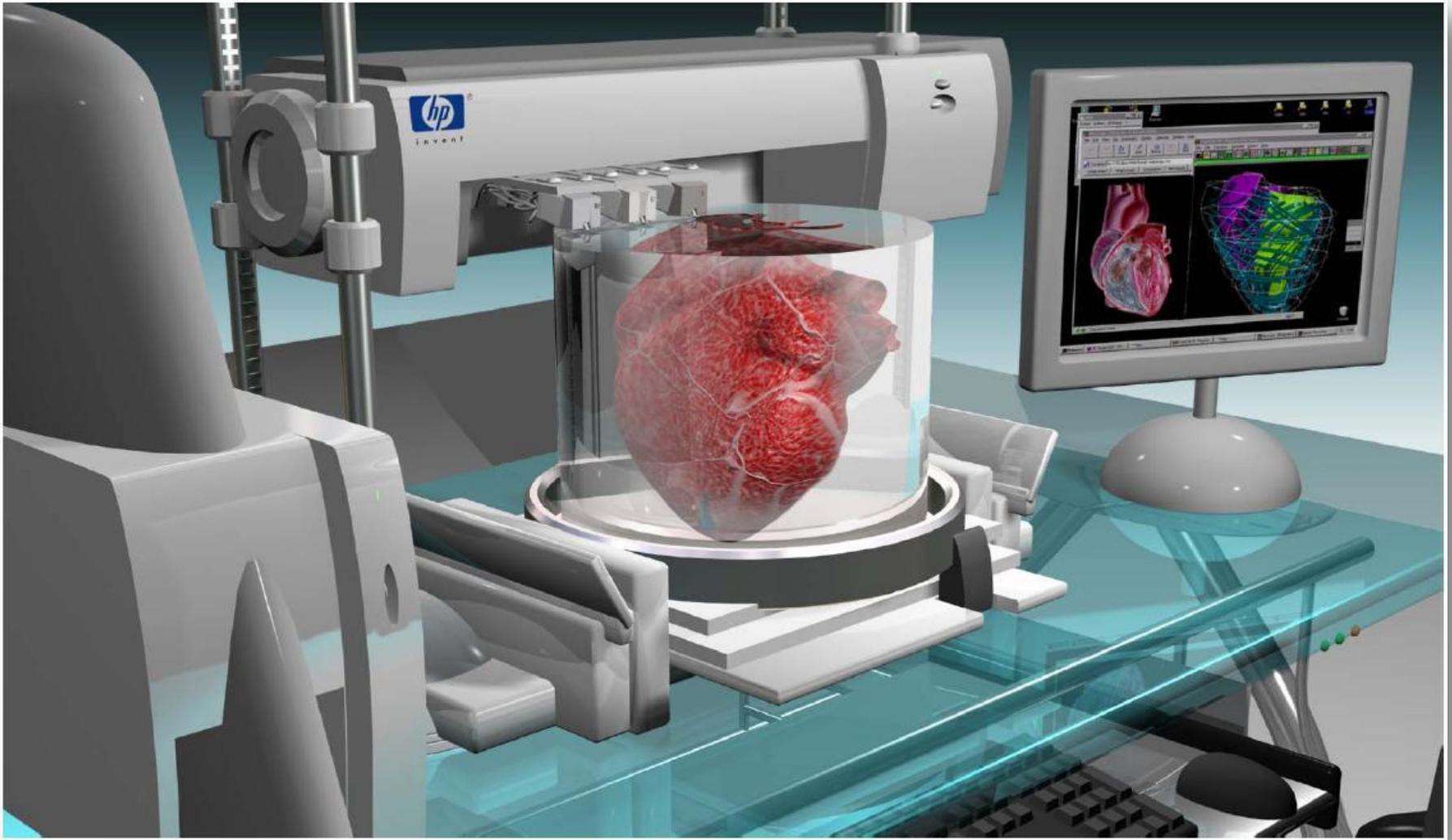


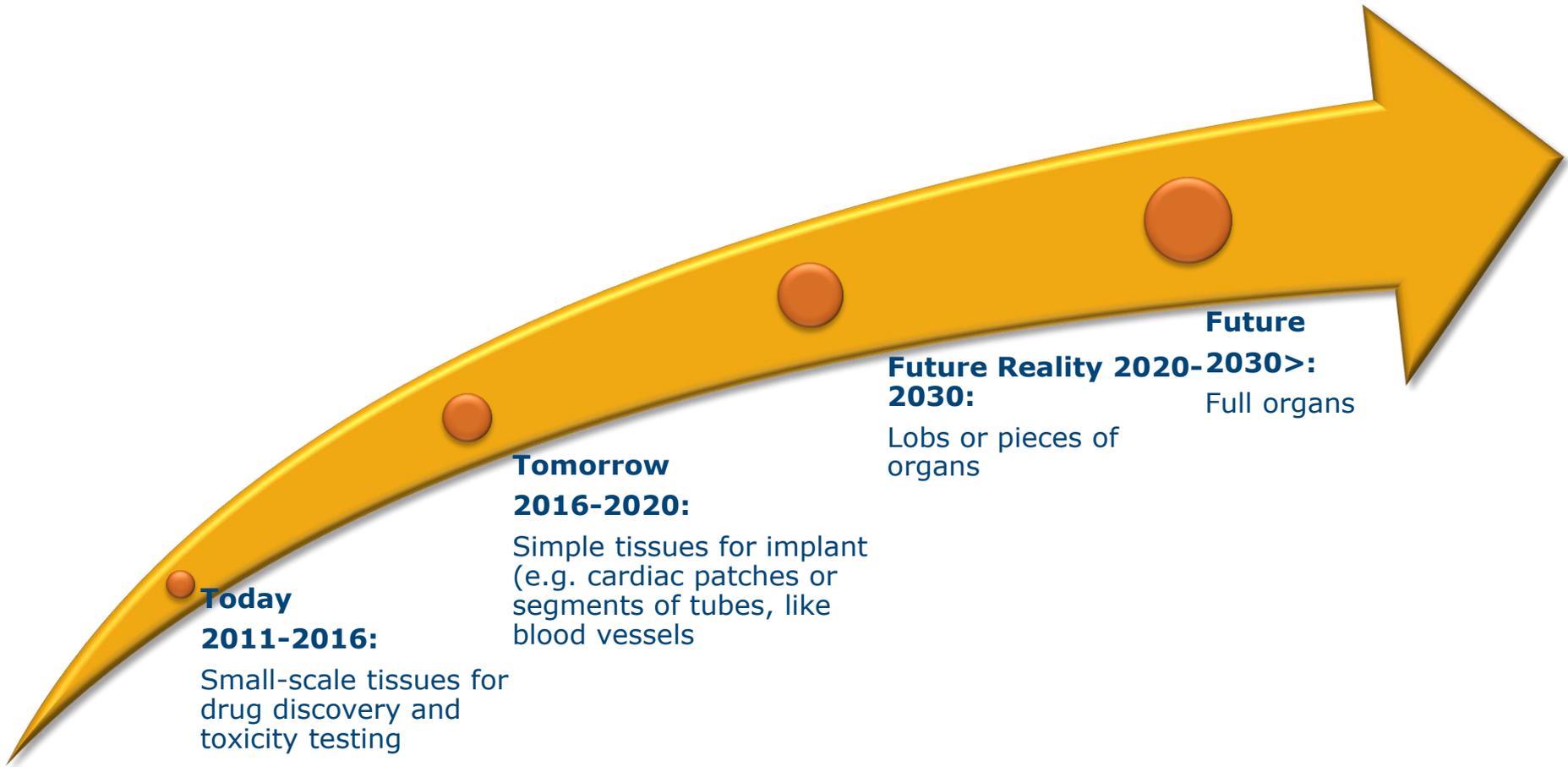
# Evolution of Additive Manufacturing

## INDUSTRY 4.1

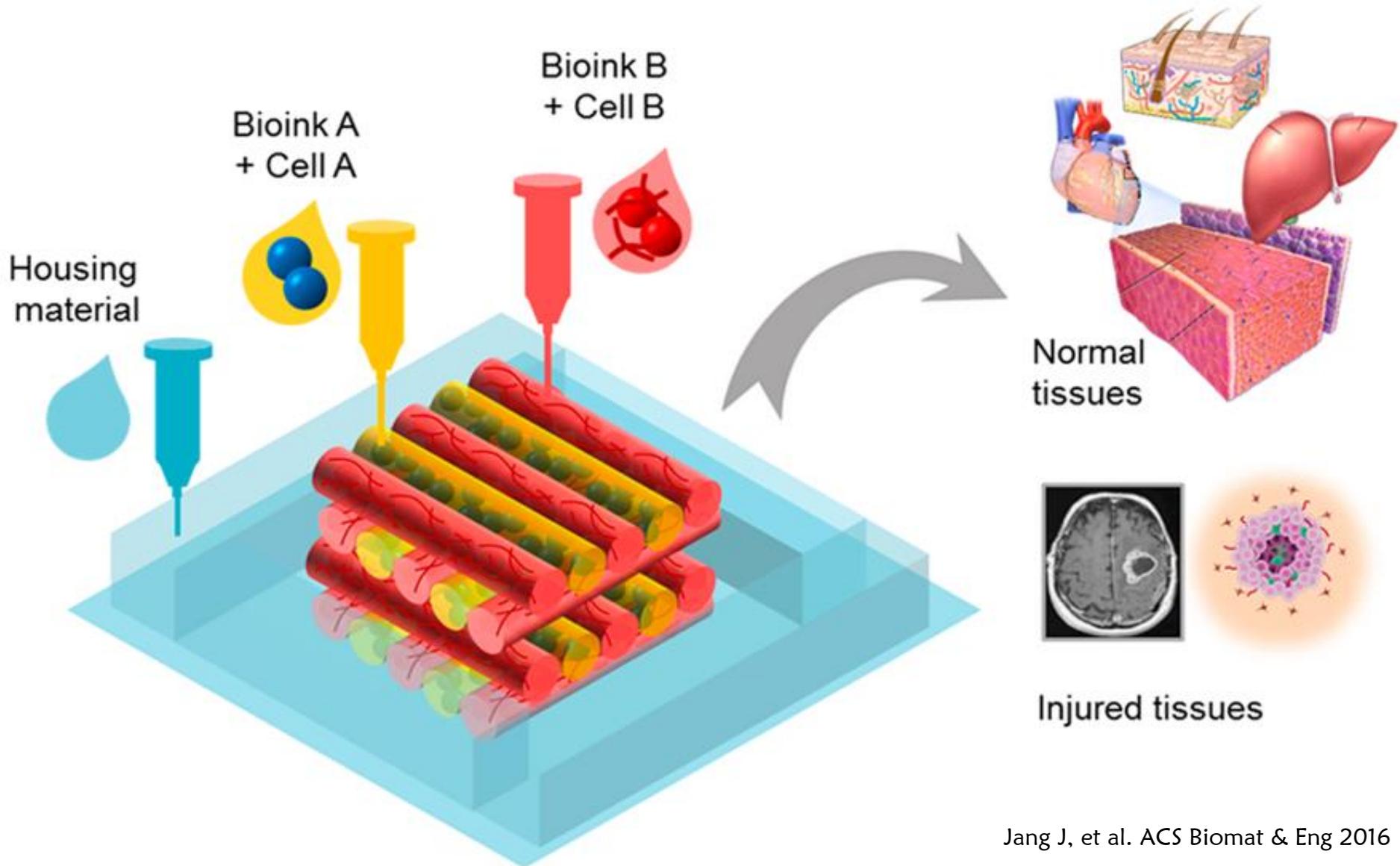


Source: 3D Printing: Second Edition (2014)





# The Future of Biofabrication – in vitro models



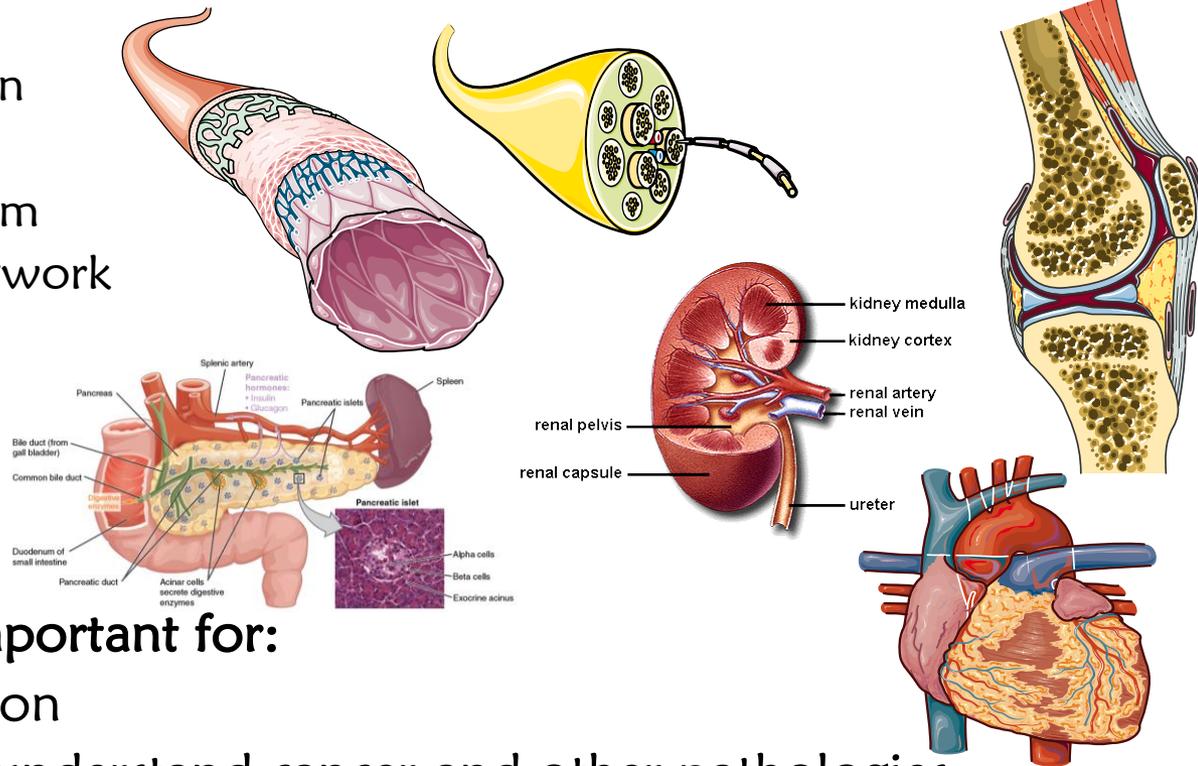
Jang J, et al. ACS Biomater & Eng 2016

- Develop material-based technologies that enable the regeneration of complex tissues:

- moving from homogeneous single tissues, to heterogeneous multi-tissues.

Towards organs

- Role of vascularization
- Role of innervation
- Role of immune system
- Role of lymphatic network



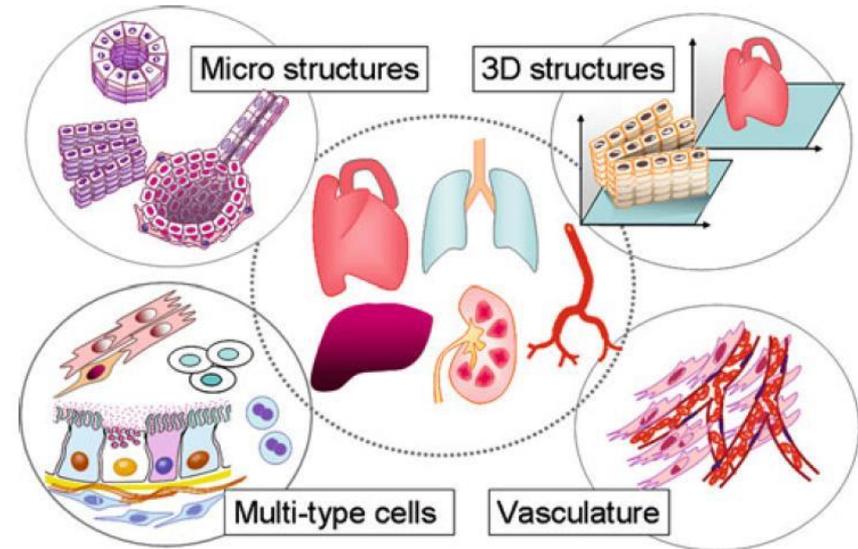
- Implications are equally important for:

- tissue/organ regeneration
  - 3D in vitro models to understand cancer and other pathologies



## What is necessary to print an organ ?

- The need to consider:
  - Histology and anatomy in general
  - What cells should be used?
  - Conservation of functionality
  - What scaffold should be printed?
  - What technology should be used?



- Organs:
  - 1) 3D structures
  - 2) They have characteristic **multi-scaled structures** required to fulfill diverse functions
  - 3) They are composed of **multiple type of cells and extra-cellular matrices**
  - 4) They have a **complex vascular, neural, and lymphatic network** to support cell activity

## MULTIPLE 3D PRINTERS ARE USED

*PatentYogi*



- **For Human Space Actiivities:**

- 3D Models to study treatments for:
  - microgravity related diseases (e.g. osteoporosity, muscle loss);
  - Radiation related diseases (e.g. galnds and reproductive system);
  - ...

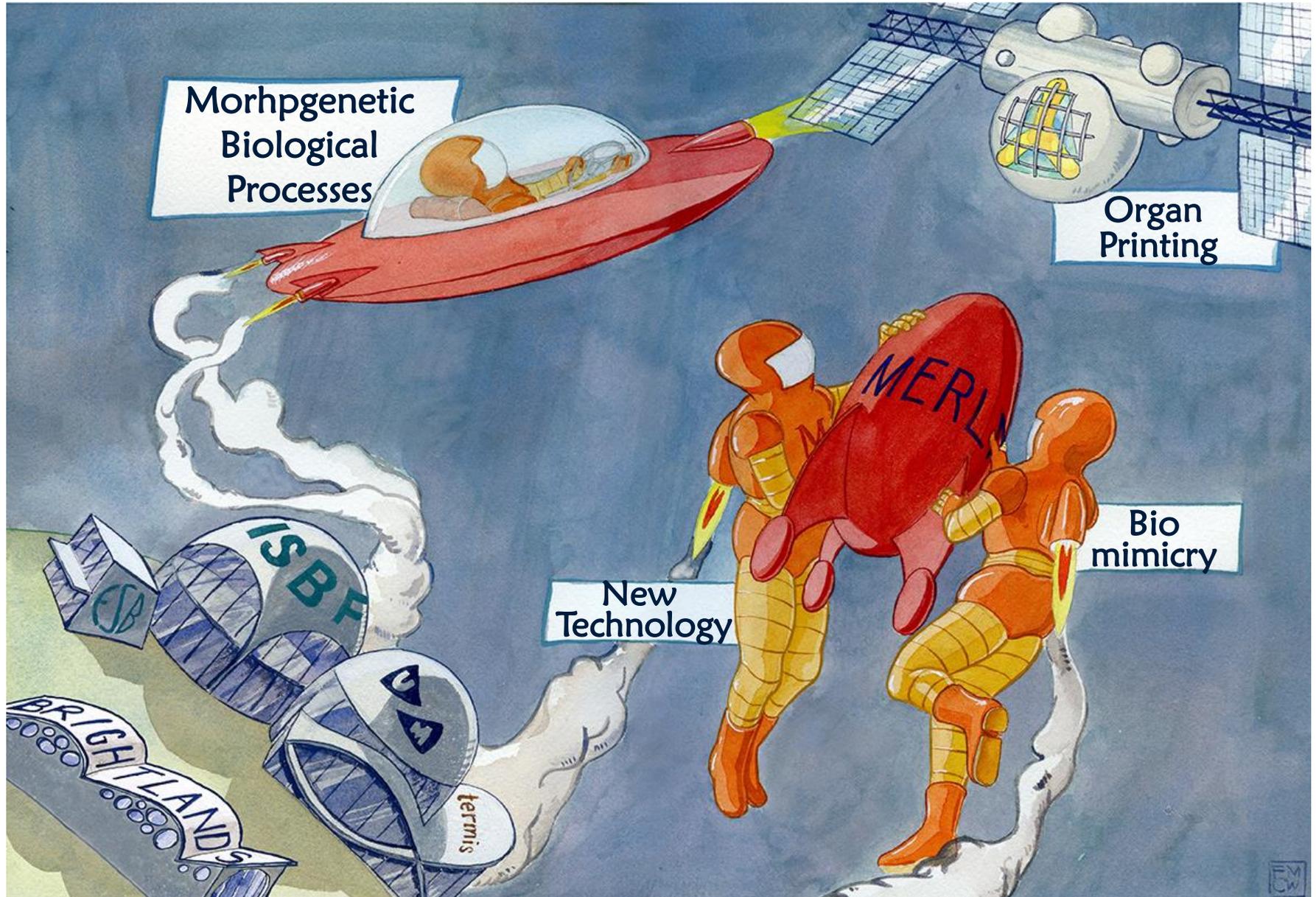
- **Organ Shortage:**

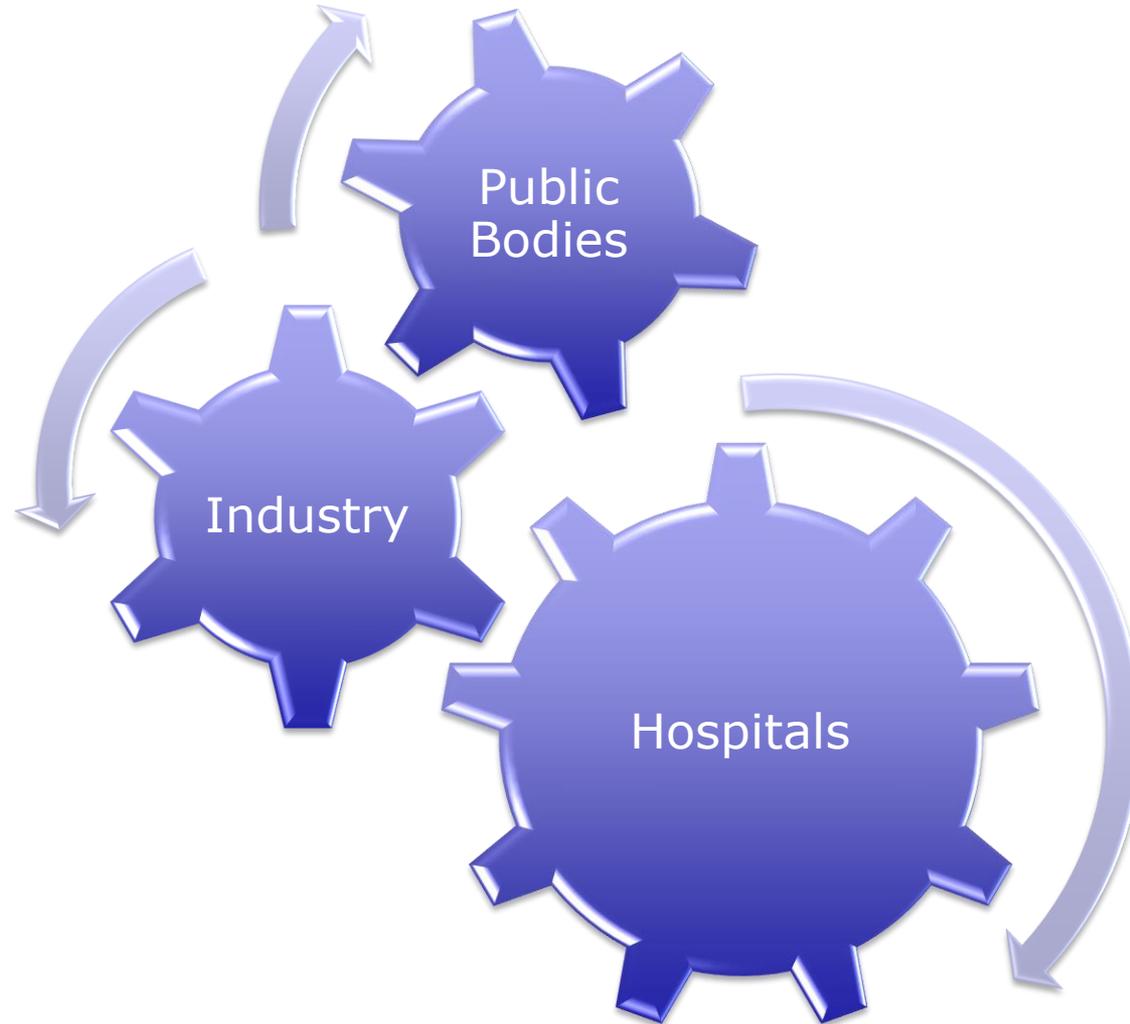
- 1) Kidney;
- 2) Liver;
- 3) Pancreas;
- 4) Heart;
- 5) ...



- **For Global Health:**

- 1) 3D models for pandemic diseases;





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provincie limburg



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