




BMEG4450 Project Presentation

Lab-on-a-chip

Group 8



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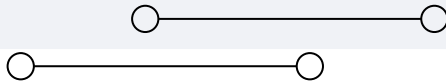



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✦ 01 ✦

Introduction



Lab-on-a-chip

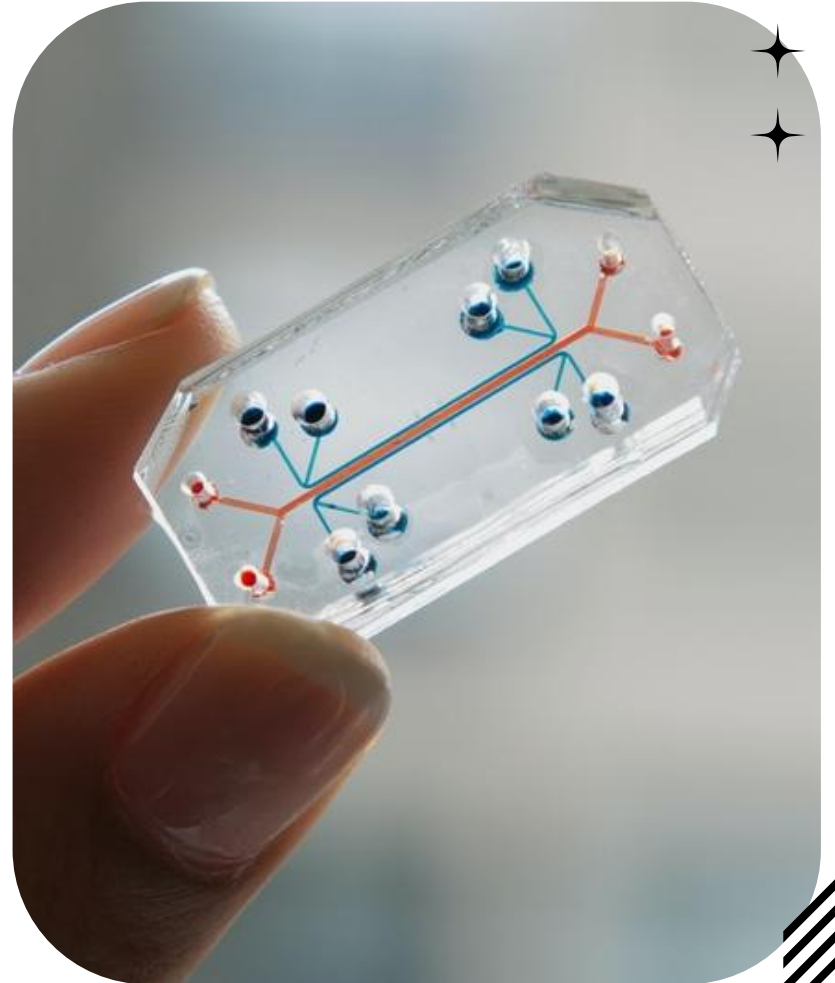
Definition:

Integrated micro electromechanical systems that can carry out all stages of biological and chemical processes

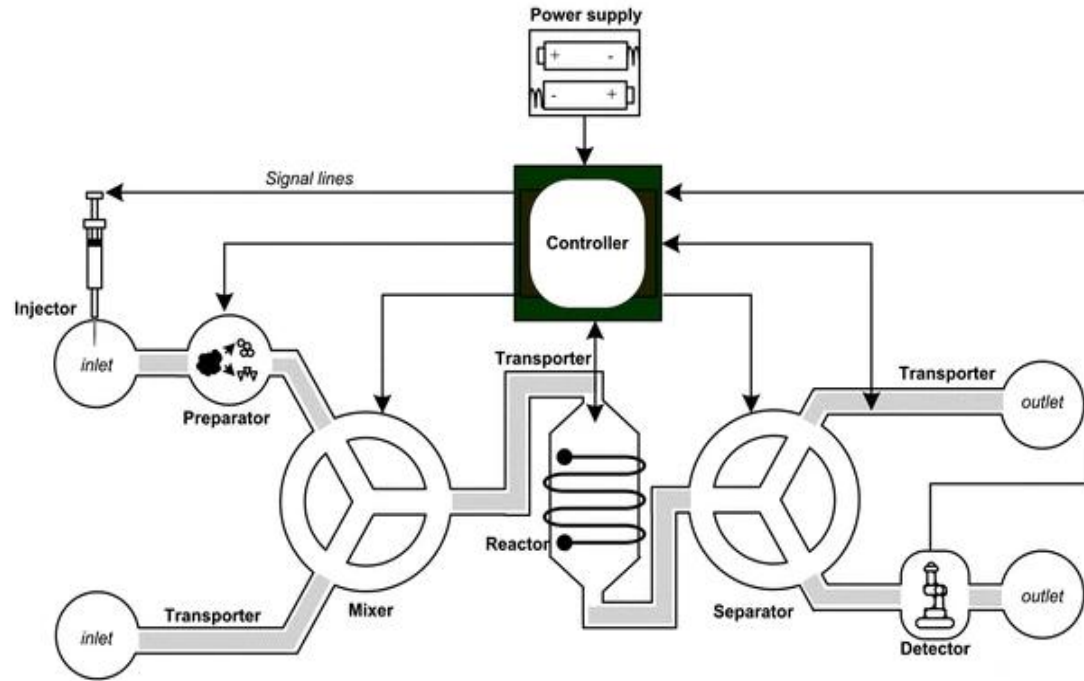
Key Features:

- Point-of-Care Diagnostics
- Biochemical Analysis
- Drug Discovery
- Regenerative Medicine

[1] Lim et al., *Springer Nature Link*, 2010

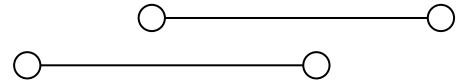


Components of Lab-on-a-chip



1. Injector
2. Transporter
3. Preparator
4. Mixer
5. Reactor
6. Separator
7. Detector
8. Controller
9. Power supply

Sample handling, mixing and reacting with reagent, separation, detecting analyte



Advantages



Miniaturization

Capabilities for working with single small entities

- Reduce the time of analysis
- Reduce reagent consumption
- Less waste generation



Versatility

Integrate complex functions



Automation

Automate repetitive laboratory tasks



02



Diagnostic Applications



Chronic kidney disease diagnosis

Chronic Kidney Disease (CKD) is associated with irreversible kidney function loss

- ✓ We need renal function assessment and monitoring



Conventional method:

Chemical analysis using estimated glomerular filtration rate (eGFR) and urine albumin to creatinine ratio (UACR)

- Expensive
- Limited availability



Lab-on-a-chip device:

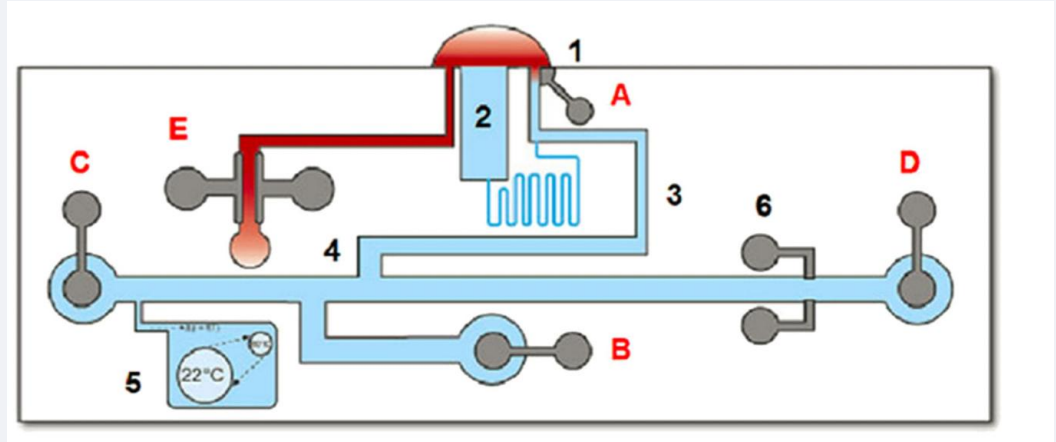
Lab-on-a-chip based detection of creatinine and cystatin C in blood and urine

- [3] Karakuzu et al., *ACS Omega*, 2022
[4] Wu et al., *Npj Digital Medicine*, 2018



Examples

- Detection of elevated creatinine level in blood based on electrophoretic separation and conductivity detection
- **Limit of detection (LOD):**
~100 μ M



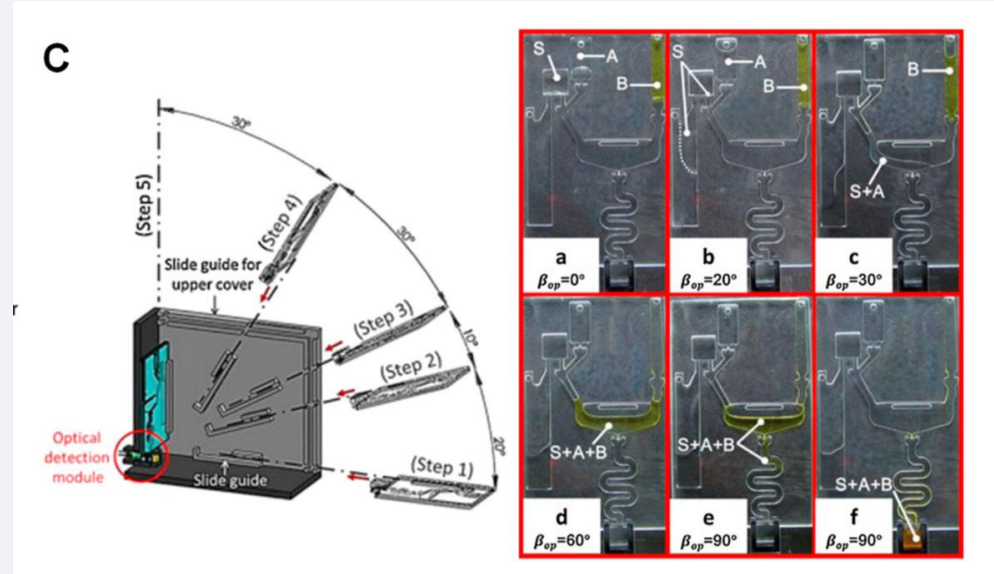
[4] Wu et al., *Npj Digital Medicine*, 2018





Examples

- Detection of creatinine in urine by integrating microfluidic chip with the capillary-gravitational valves



[4] Wu et al., *Npj Digital Medicine*, 2018





Significance



High accessibility

- Avoid the need of sending samples to centralized laboratory
- Can be operate manually by every end user



Small sample volume

- Reduce the sample volume required to micro or nanolitre range.




Higher accuracy


- Better sample processing and avoid interference by other analytes in the sample



03

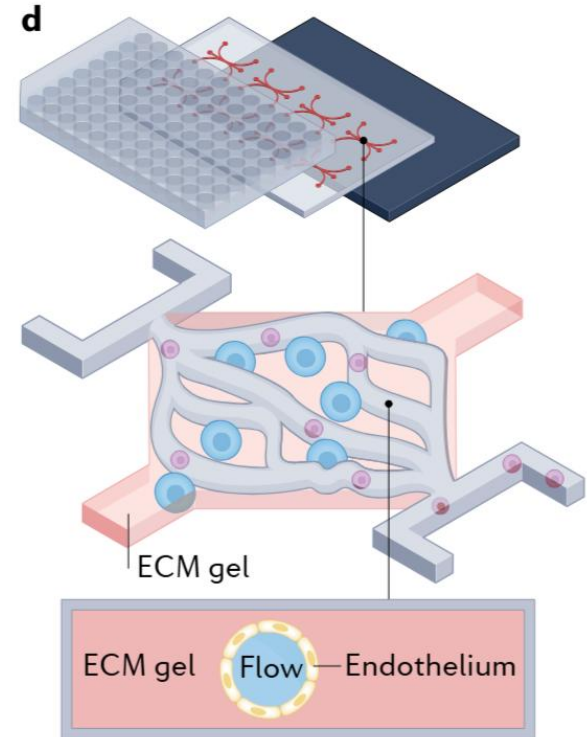
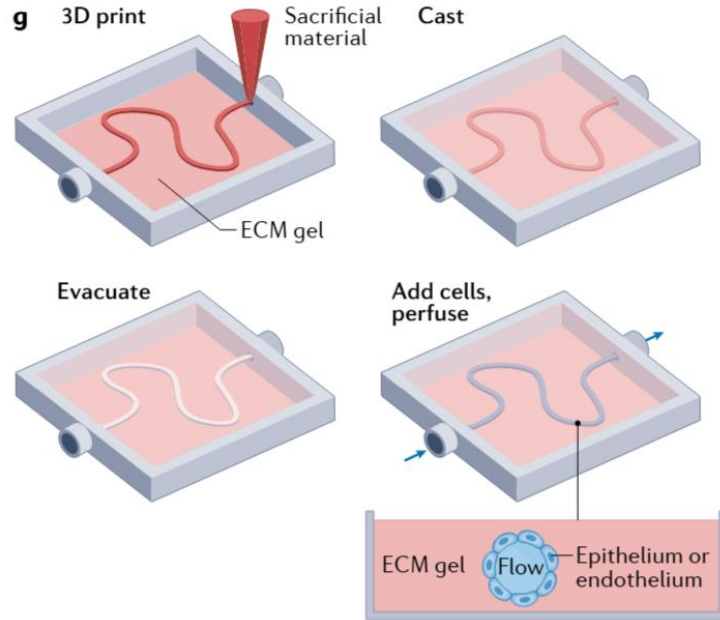


Research Applications





Organ-on-a-chip (OoC)



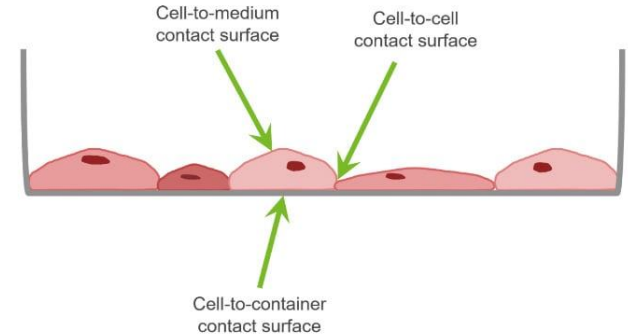
[6] Ingber, *Nature Review Genetics*, 2022

other *in vitro* models?

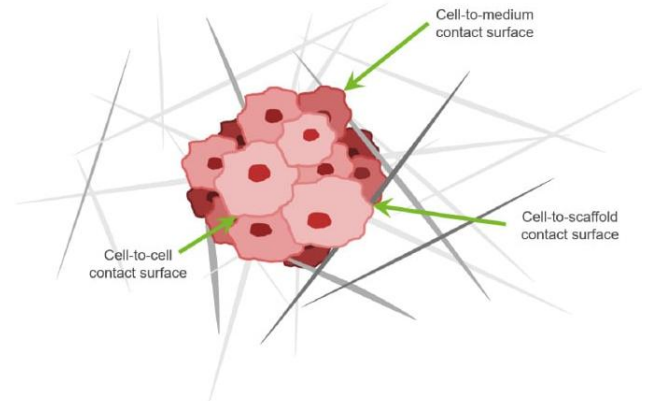
- Unable to simulate **microenvironment**
- Unable to support **complex structures**

⇒ Cannot simulate *in vivo* conditions well

2D Culture

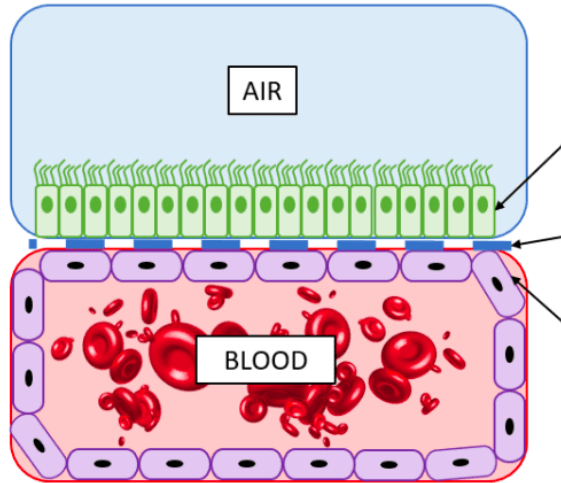


3D Culture



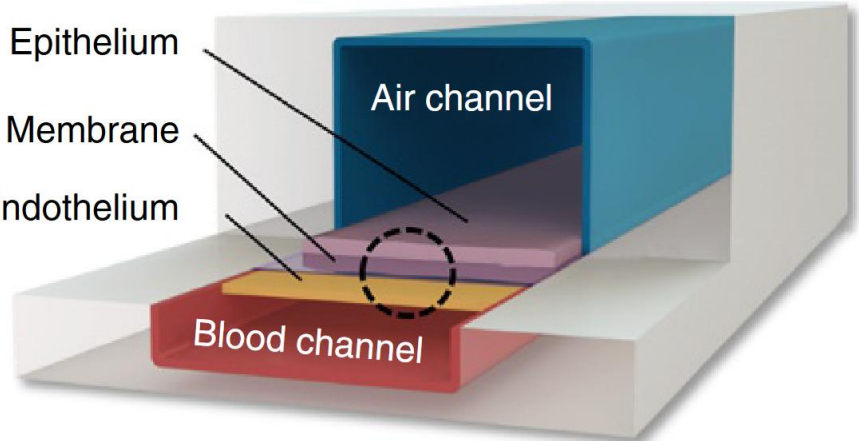
[7] UPM Biomedicals, 2022

other *in vitro* models?



[8] *Microfluidics Innovation Center, 2024*

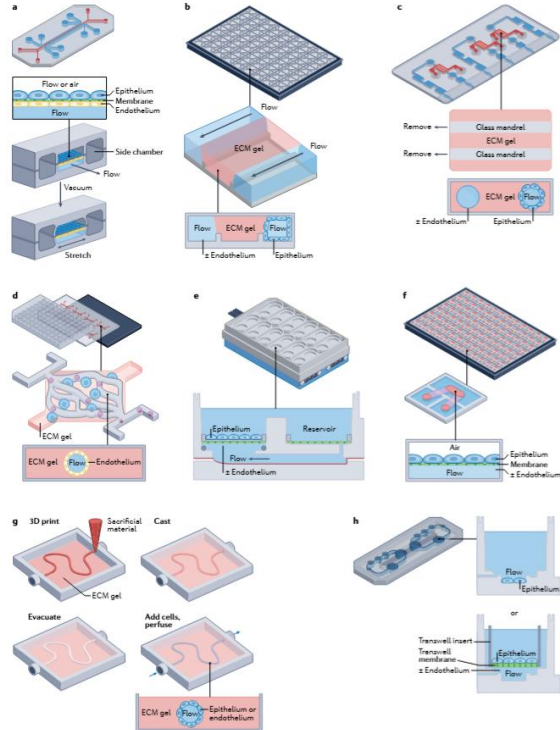
Epithelium
Membrane
Endothelium



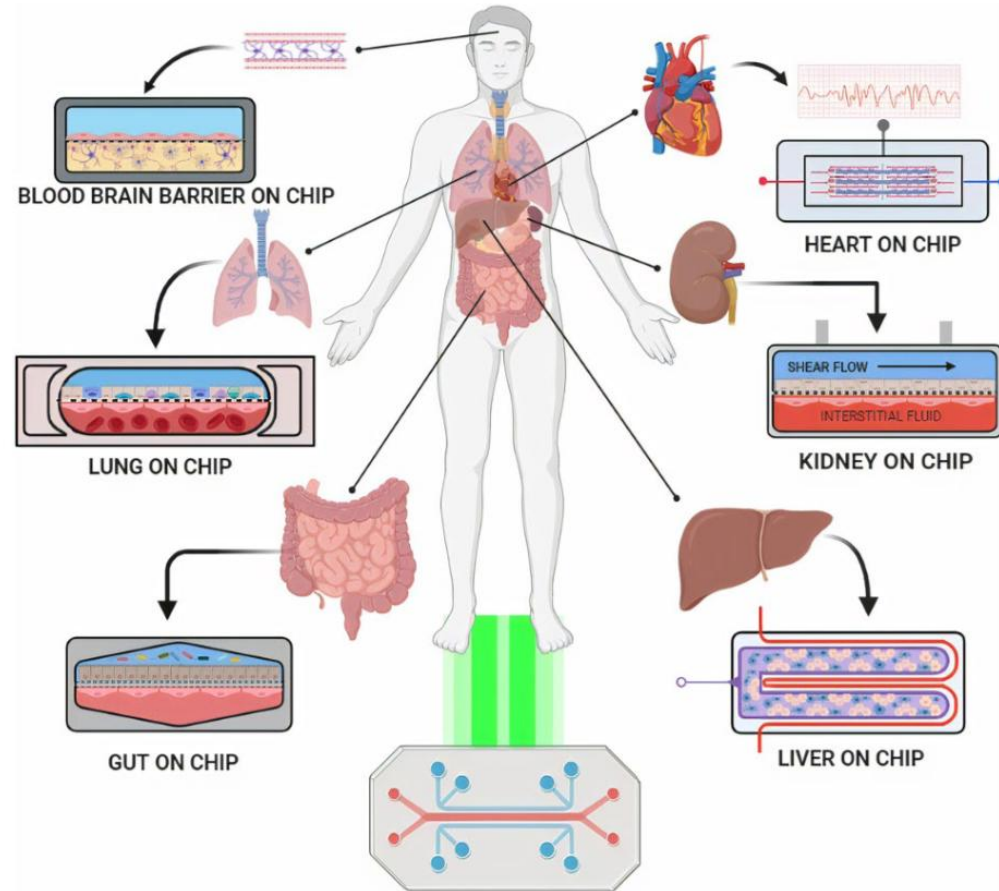
Lung-on-a-chip

[9] *UPM Biomedicals, 2022*

more organs..!

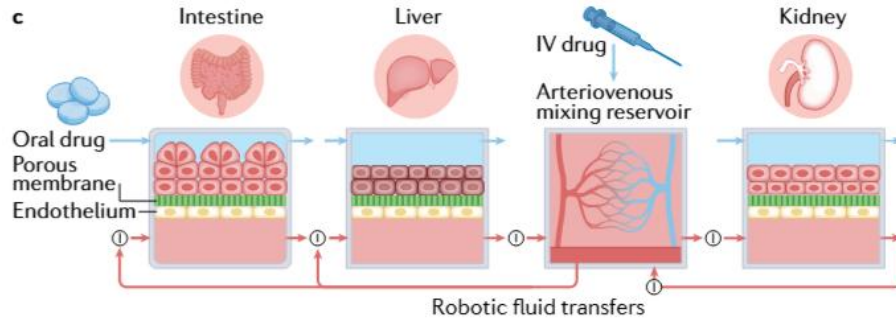
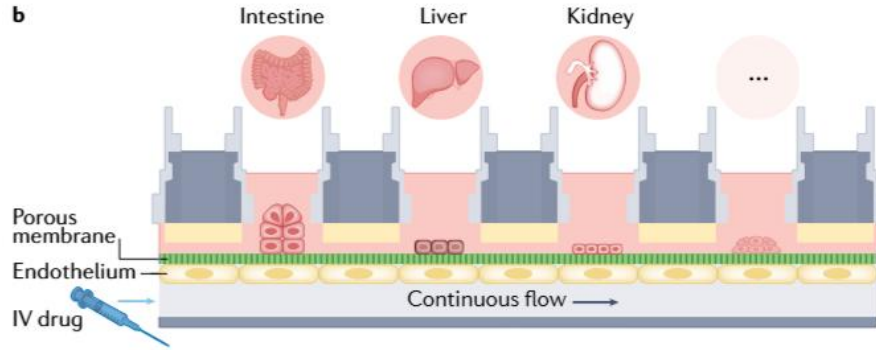


[6] Ingber, *Nature Review Genetics*, 2022

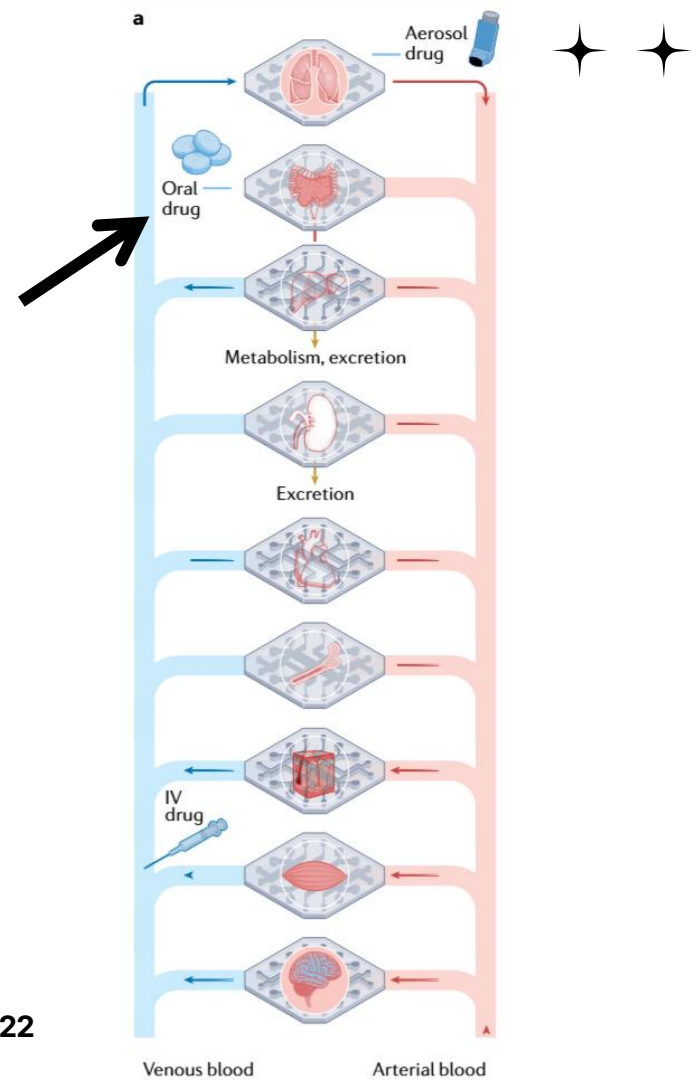


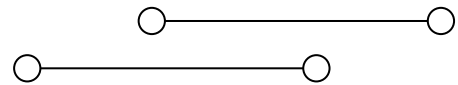
[10] Ingber, *Nature Review Genetics*, 2022

Human-on-a-chip



[6] Ingber, *Nature Review Genetics*, 2022





why not ***in vivo*** animal models?



why not *in vivo* animal models?



Predictive value



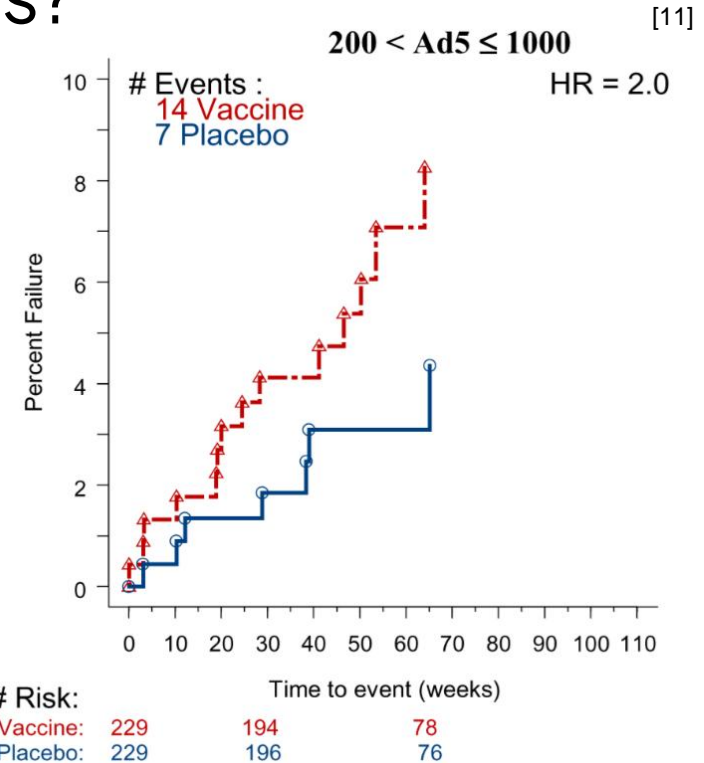
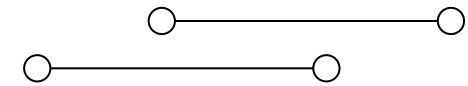
Toxicity

Ebola vaccine:

- 10× fewer induced antibodies in humans than non-human primates^[11]

HIV vaccine:

- Increase risk in humans than non-human primates^[12]



[11] Golding et al., *Cold Spring Harbour Perspectives in Biology*, 2017

[12] Buchbinder et al., *The Lancet*, 2008

why not *in vivo* animal models?



Predictive value



Toxicity

Hu5c8 antibody drug^[13]:

- Binds with FcγRIIIa receptor
- Induced thrombosis in humans
- 2/28 patients suffered heart attack! + pulmonary embolism

hu5c8



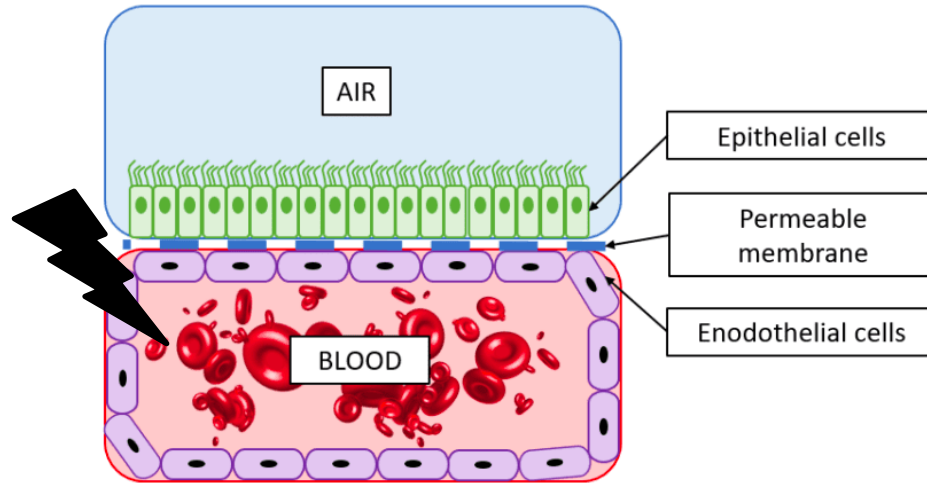
IgG2σ



IV.3

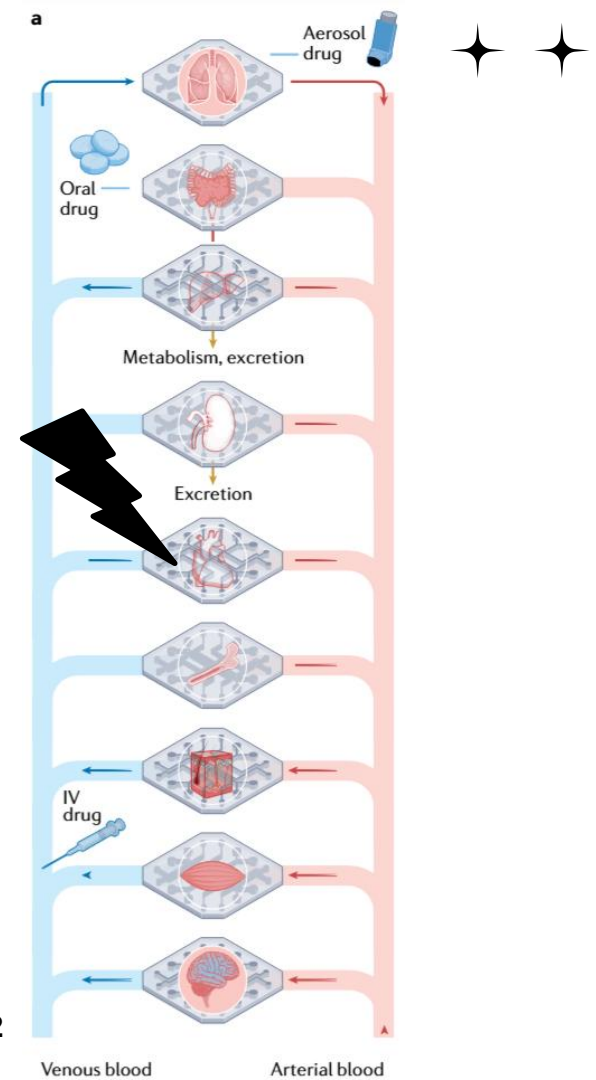


why not *in vivo* animal models?



[8] Microfluidics Innovation Center, 2024

[6] Ingber, *Nature Review Genetics*, 2022



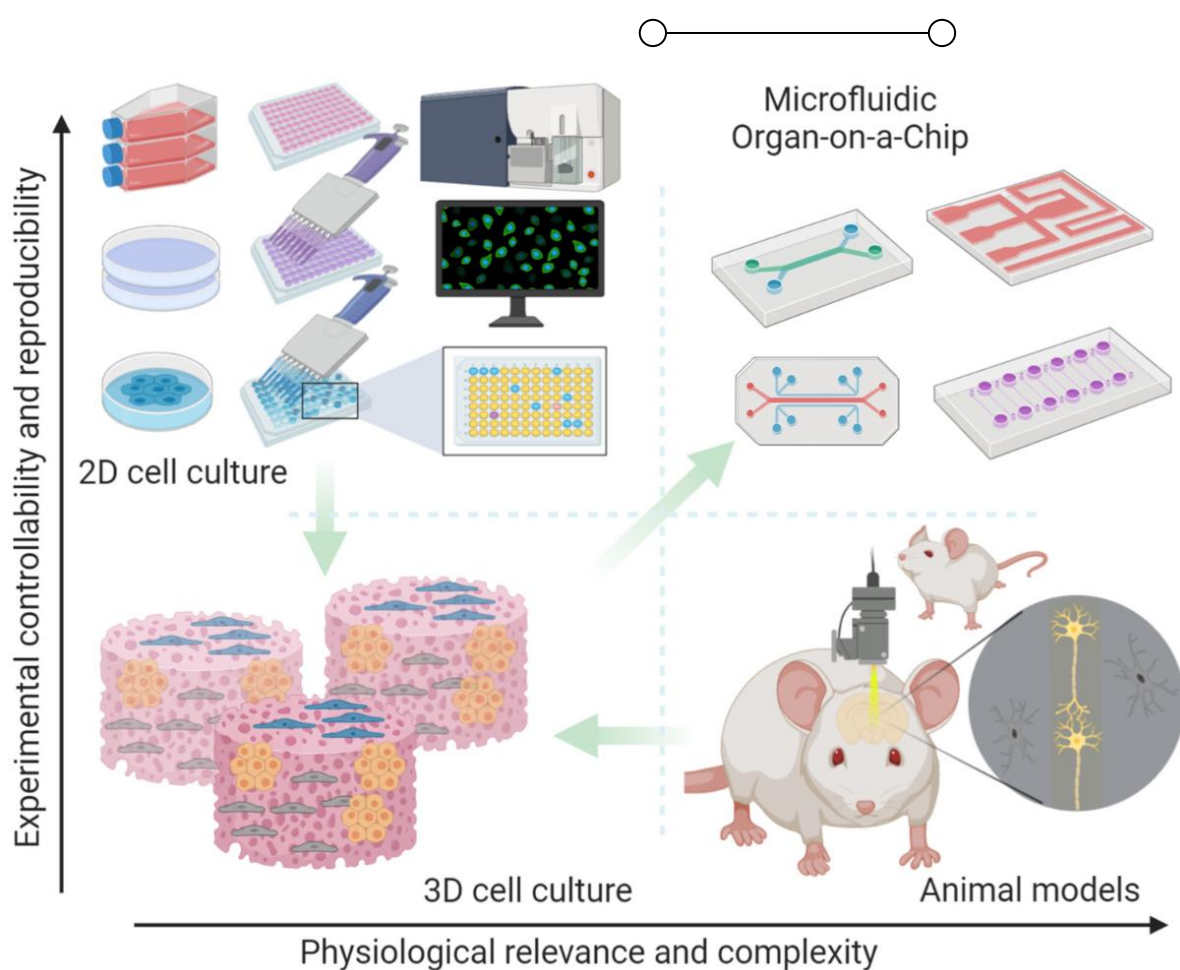
why OoC?

vs 2D testing:

- Better *in vivo* simulation
- More accurate dynamics

vs animal testing:

- Higher predictive power
- Cheaper
- Reproducible
- More ethical

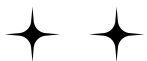




✦ 04 ✦

Future Prospects





what **obstacles** to tackle?



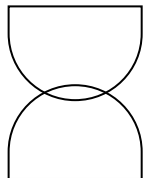
Commercialisation

- Mass production of chips is necessary for self-assessment of patients at home (PoC chips)



Validation

- Large-scale validation is necessary to ensure the applicability of OoC results to humans
- FDA started allowing OoC for proof of DILI drug^[15]



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Thanks

Q&A session

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