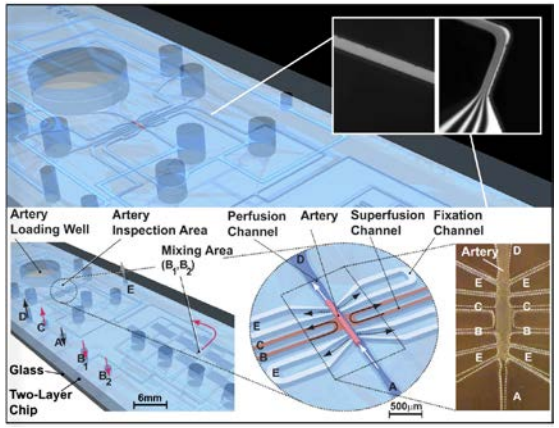
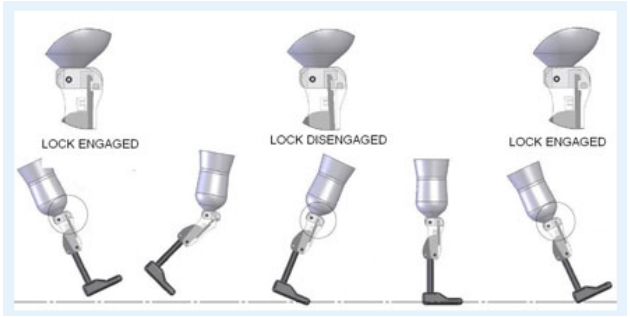
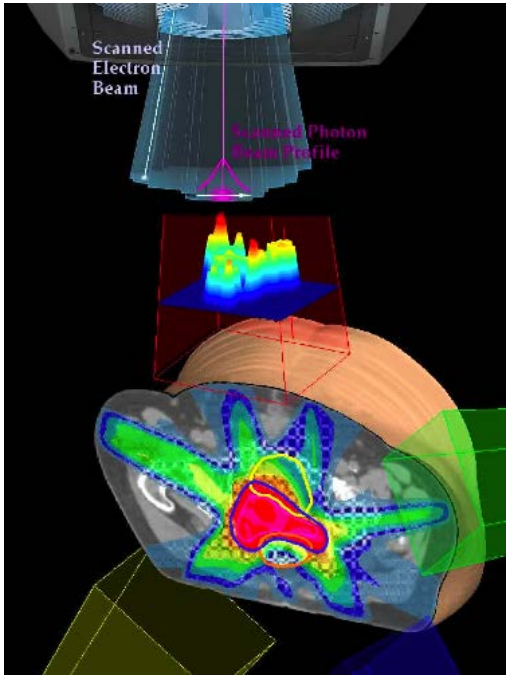
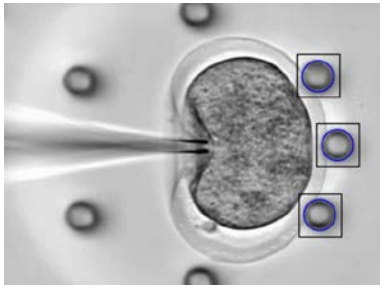
Mechanical & Industrial Engineering
Course and Option Talk - **Bioengineering**

Bioengineering: *Application of the methods of engineering, physical sciences, and mathematics to solve problems in clinical and life sciences; and use of the principles and techniques of the life sciences in engineering.*









3rd Year Curriculum Overview

FALL

- MIE301: Kinematics and Dynamics of Machines
- MIE312: Fluid Mechanics I
- MIE342: Circuits with Applications to Mechanical Engineering Systems
- MIE358: Engineering Economics and Accounting
- **Natural science requirement**

WINTER

- MIE315: Design for the Environment
- MIE313: Heat and Mass Transfer
- MIE334: Numerical Methods I
- **Two stream option courses**

4th Year Curriculum Overview

FALL

- MIE491: Capstone Design
- **Two stream option courses**
- One Technical Elective
- Other: HSS or CS Elective

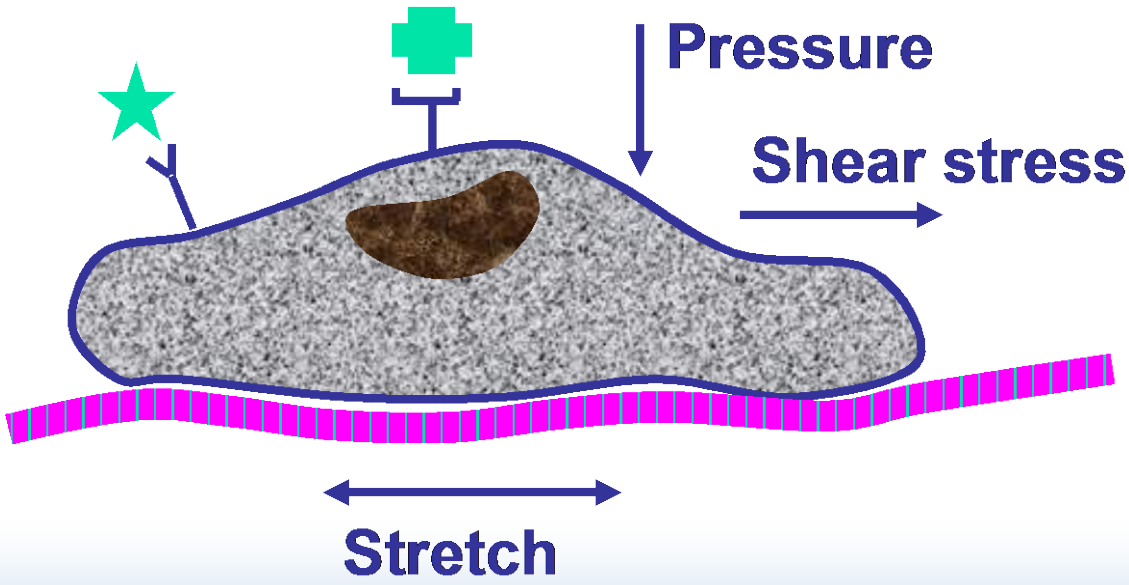
WINTER

- MIE491: Capstone Design
- Three Technical Elective courses
- Other: HSS or CS Elective

Bioengineering – Natural Science Elective

3F Term – **CHE353 – Engineering Biology**

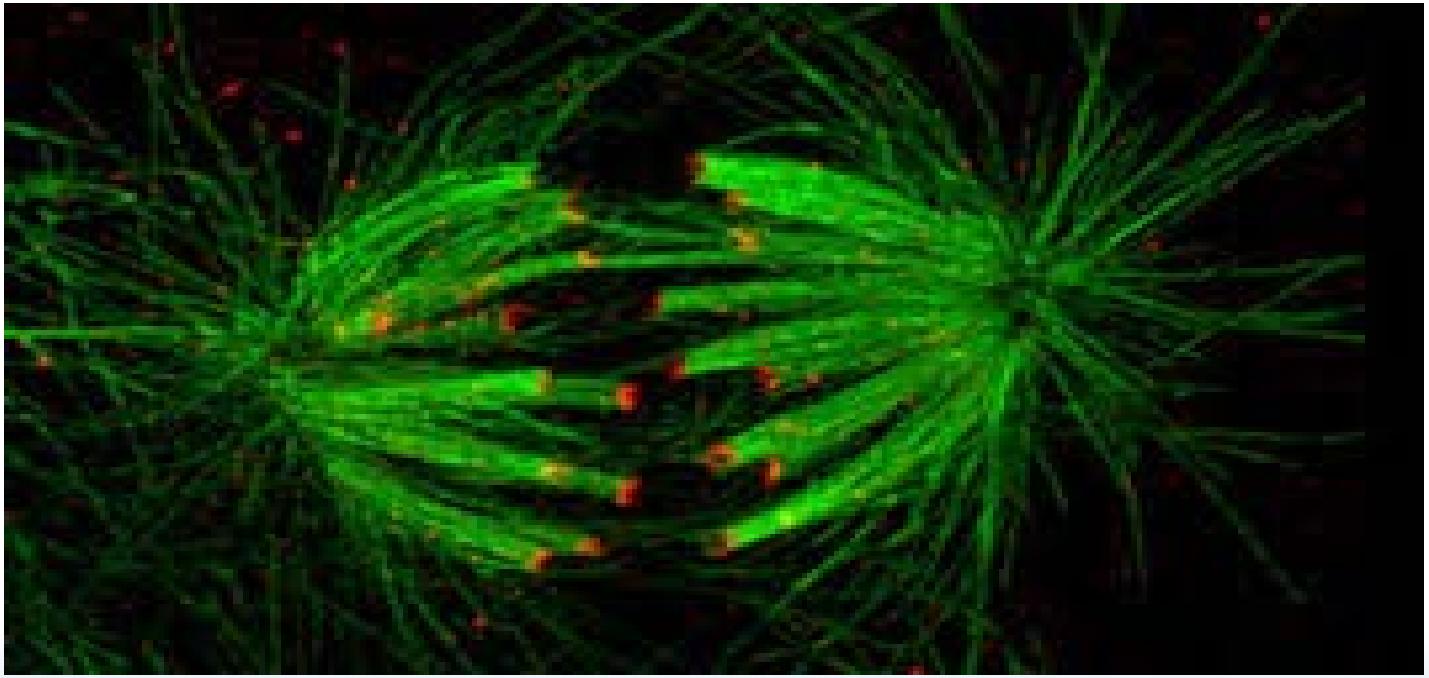
- Problem solving, engineering modelling approach to introduce basic concepts in cell biology and physiology like cell growth and metabolism, transport across cell membranes, protein structure, homeostasis, nerve conduction and mechanical forces in biology.



Bioengineering – Core Courses

3S Term – **CHE354 – Cellular and Molecular Biology**

- Cell structure/function/motility/growth; genetic analysis; immuno-histochemistry; cloning. For students interested in environmental microbiology, biomaterials, tissue engineering, and bioprocesses.



Bioengineering – Core Courses

3S Term – **MIE331 – Physiological Control Systems**

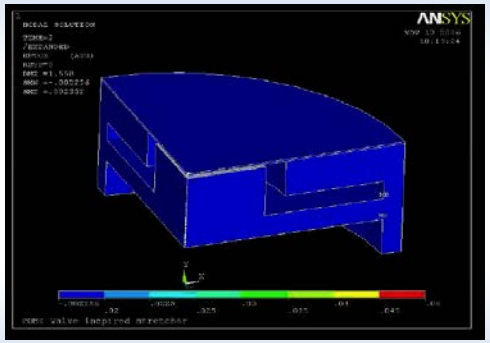
- Combines linear control theory, physiology, and neuroscience with the objective of explaining how neuromuscular, cardiovascular, and endocrine systems operate in a healthy human body.

Bioengineering– Core Courses

4F Term – **MIE520 – Biotransport Phenomena**

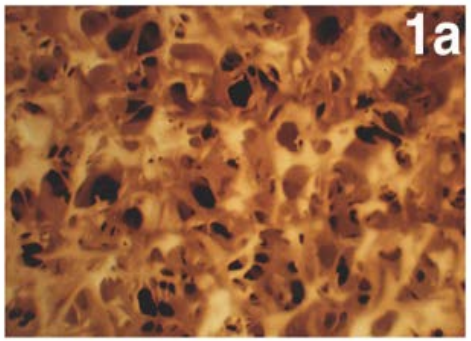
- Mass transfer, heat transfer, and fluid flow to biological systems, including: transport in the circulation, porous media and tissues, gases between blood and tissues, and in organs and organisms.

Notable Technical Electives



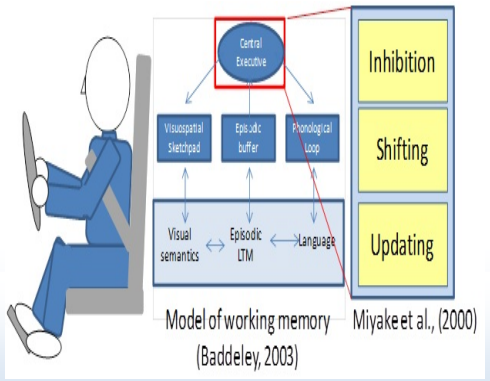
MIE439 – Biomechanics

- Introduction to the application of the principles of solid mechanics, fluid mechanics, and dynamics to living systems. Topics include cellular mechanics, blood rheology, circulatory mechanics, respiratory mechanics, skeletal mechanics, and locomotion. Applications of these to biomimetic and biomechanical design are emphasized through case studies and a major, integrative group project.



MSE440 – Biomaterials Processing and Properties

- Currently used biomaterials for formation of surgical implants and dental restorations include selected metals, polymers, ceramics, and composites Materials used for forming scaffolds for tissue engineering, and strategies for repair, regeneration and augmentation of degenerated or traumatized tissues will be reviewed with a focus on biocompatibility issues and required functionality for the intended applications.



MIE448 – Engineering Psychology and Human Performance

- An examination of the relation between behavioural science and the design of human-machine systems, with special attention to advanced control room design. Human limitations on perception, attention, memory and decision making, and the design of displays and intelligent machines to supplement them. The human operator in process control and the supervisory control of automated and robotic systems. Laboratory exercises to introduce techniques of evaluating human performance.

Bioengineering Opportunities

From the US Bureau of Labor Statistics Occupational Outlook Handbook 2008-2018:

Table 1. Occupations with the fastest growth

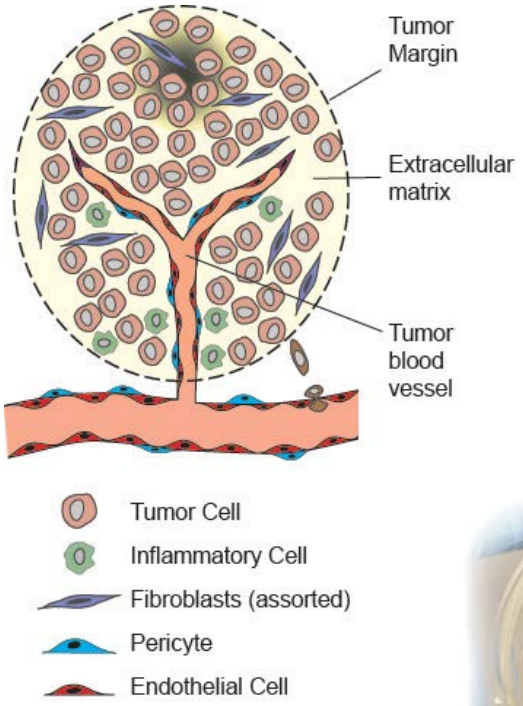
Occupations	Percent change	Number of new jobs *(in thousands)*	Wages (May 2008 median)	Education/training category
Biomedical engineers	72	11.6	$ 77,400	Bachelor's degree
Network systems and data communications analysts	53	155.8	71,100	Bachelor's degree
Athletic trainers	37	6.0	39,640	Bachelor's degree
Physical therapist aides	36	16.7	23,760	Short-term on-the-job training

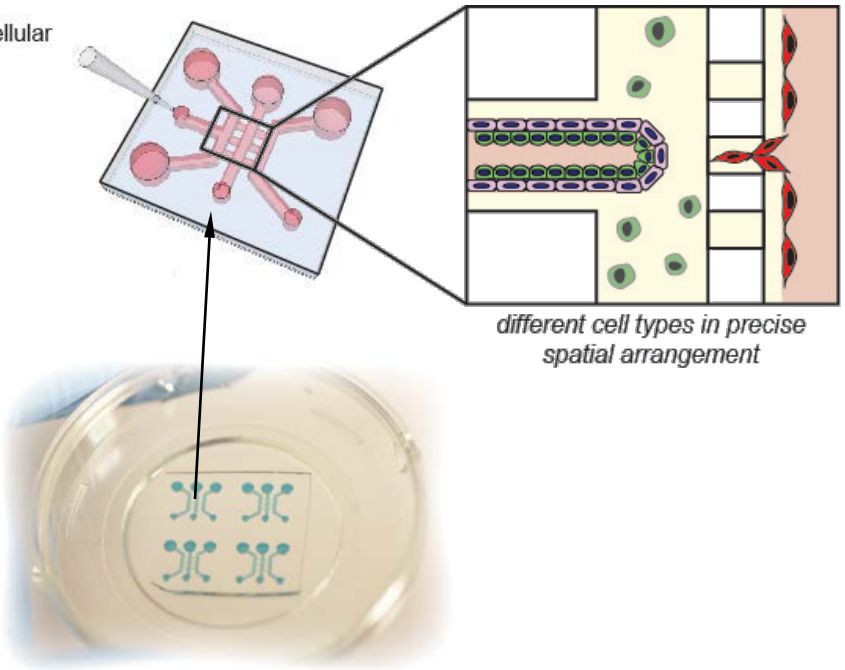
Job opportunities after graduation:

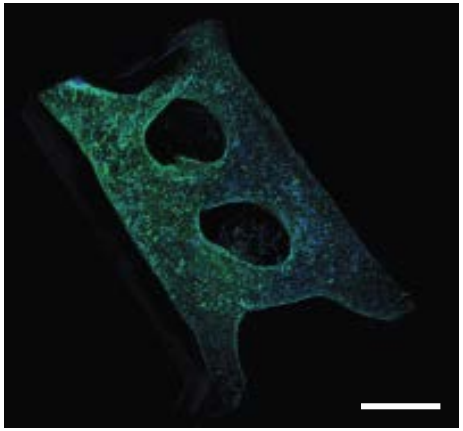
- Medical device industry
- Biotechnology industry
- Human factors/ergonomics
- Consulting
- Research laboratory
- Graduate school
- Medical school

The Young Lab: Modeling the Human Body

TUMOR MICROENVIRONMENT

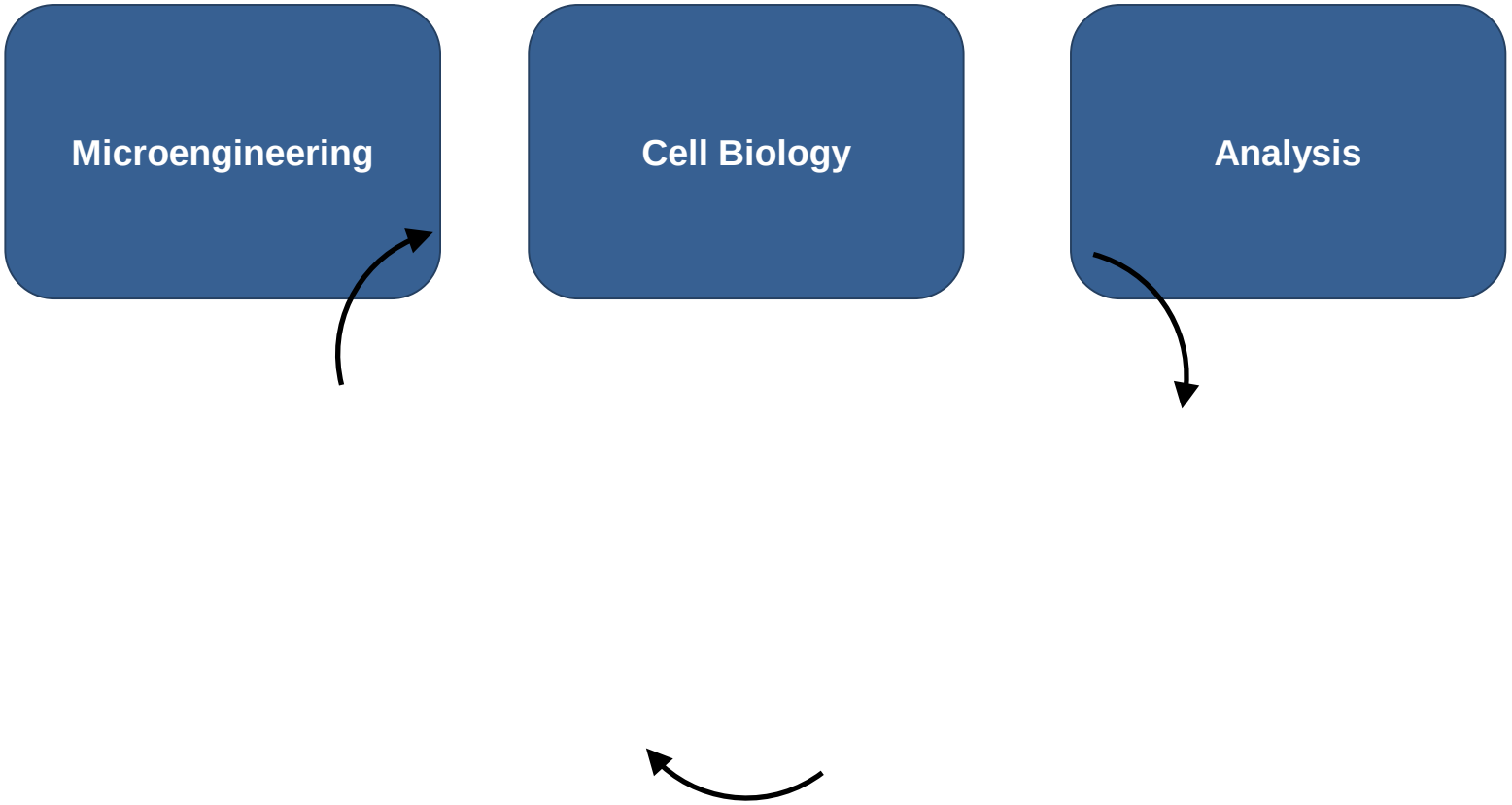




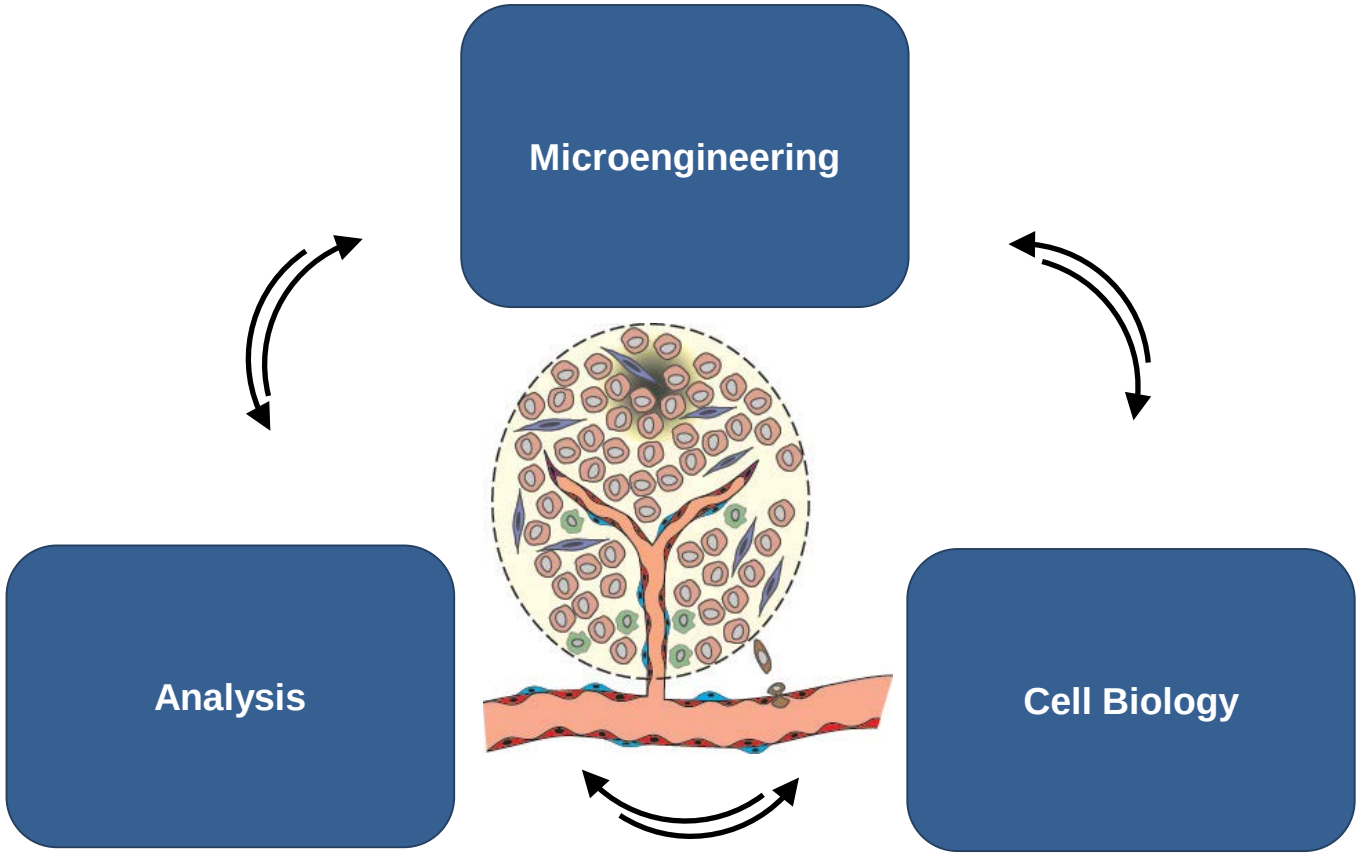


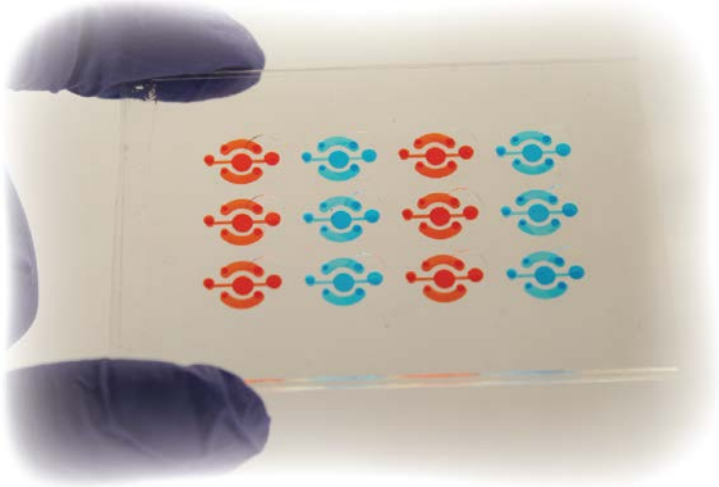
The Young Lab

The Young Lab

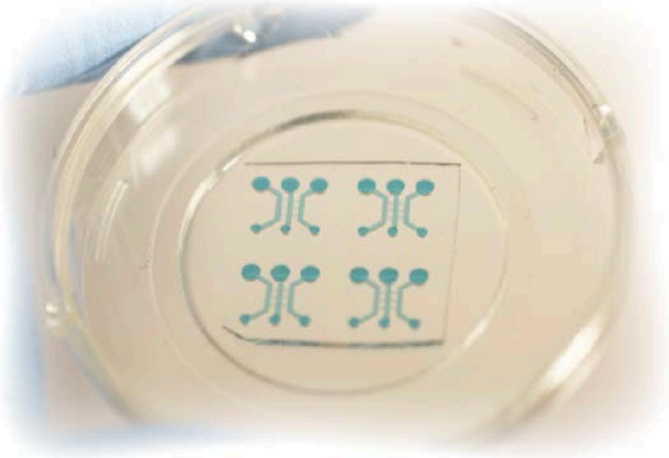


The Young Lab

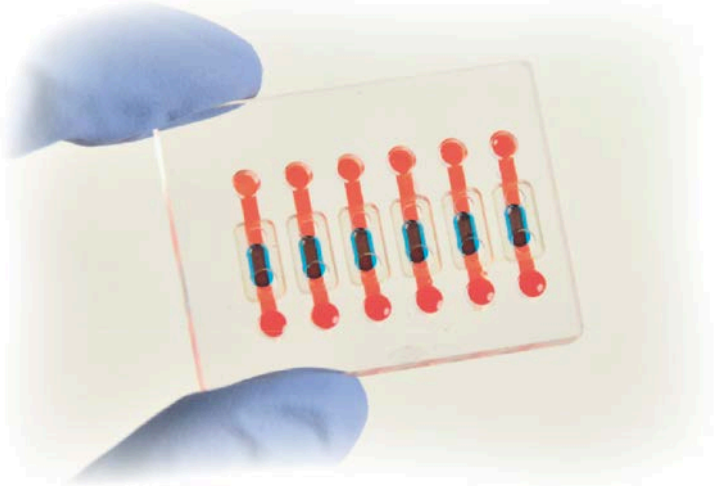




Multiple Myeloma
(Liquid Tumours)

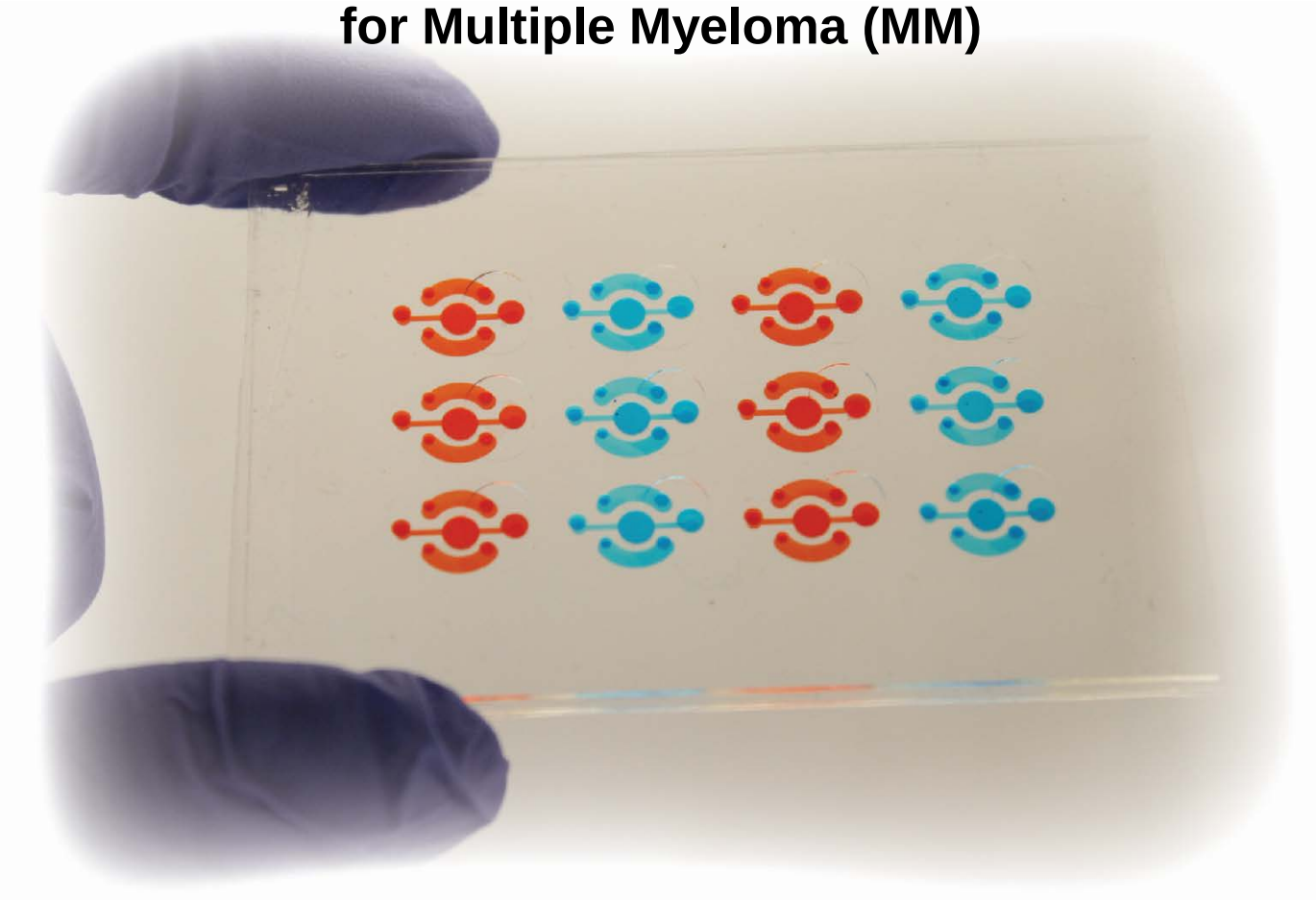


Angiogenesis
(Solid Tumours)

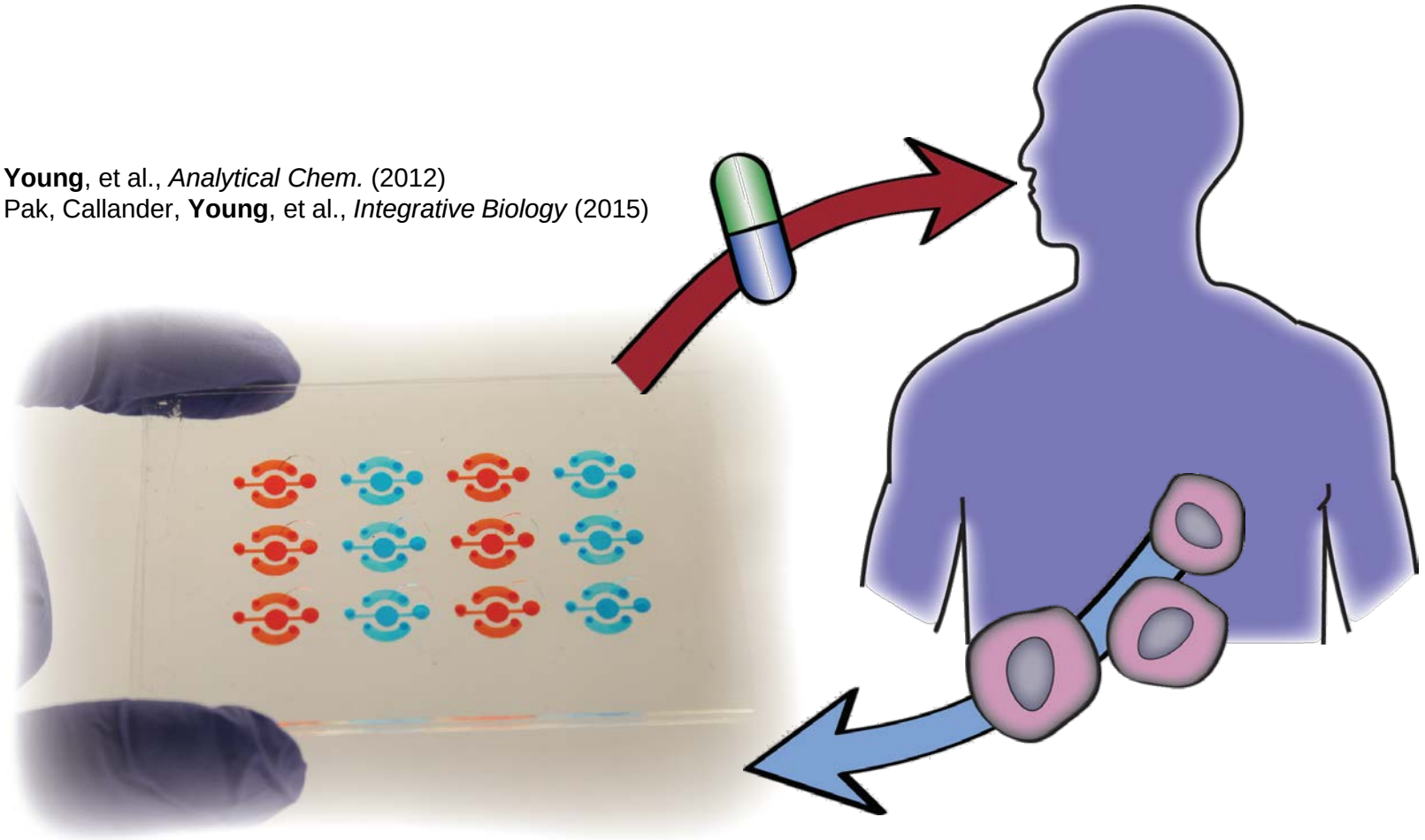


Lung Airway

Chemo-Sensitivity and Resistance Assays (CSRAs) for Multiple Myeloma (MM)

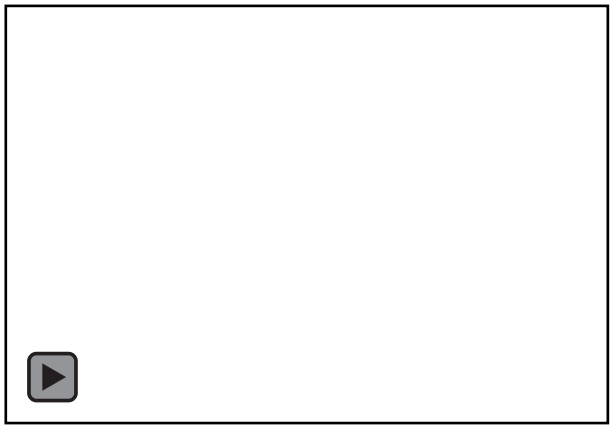


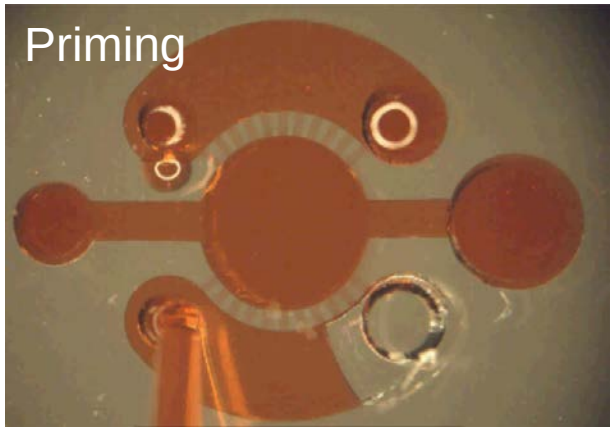
Young, et al., *Analytical Chem.* (2012)
Pak, Callander, **Young**, et al., *Integrative Biology* (2015)

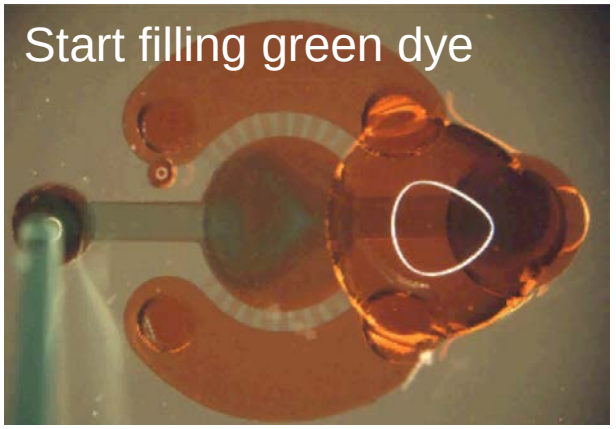


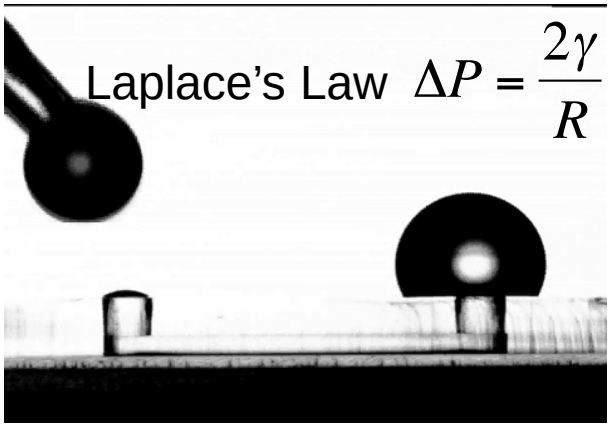
Application: Pick the right drug for a cancer patient

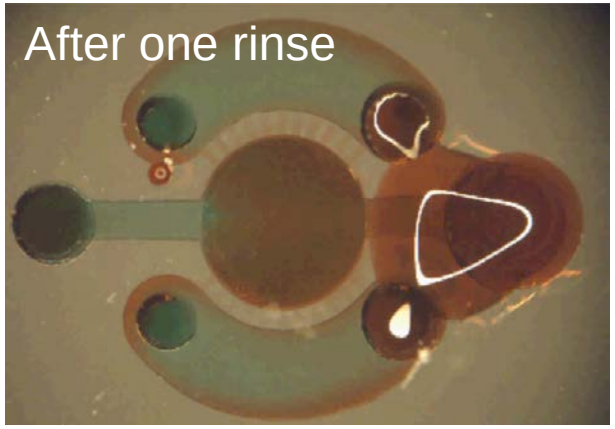
Fluid mechanics heavily involved: microliter flows

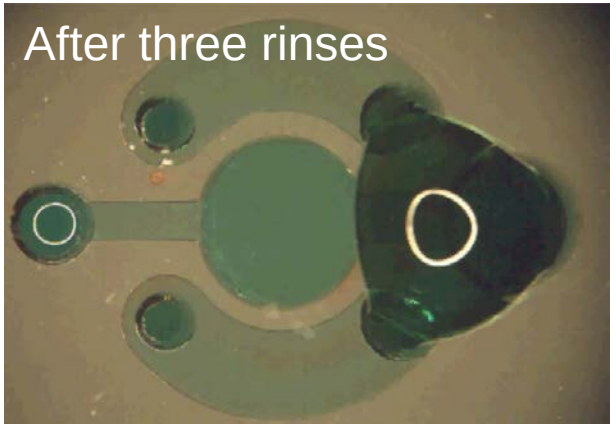






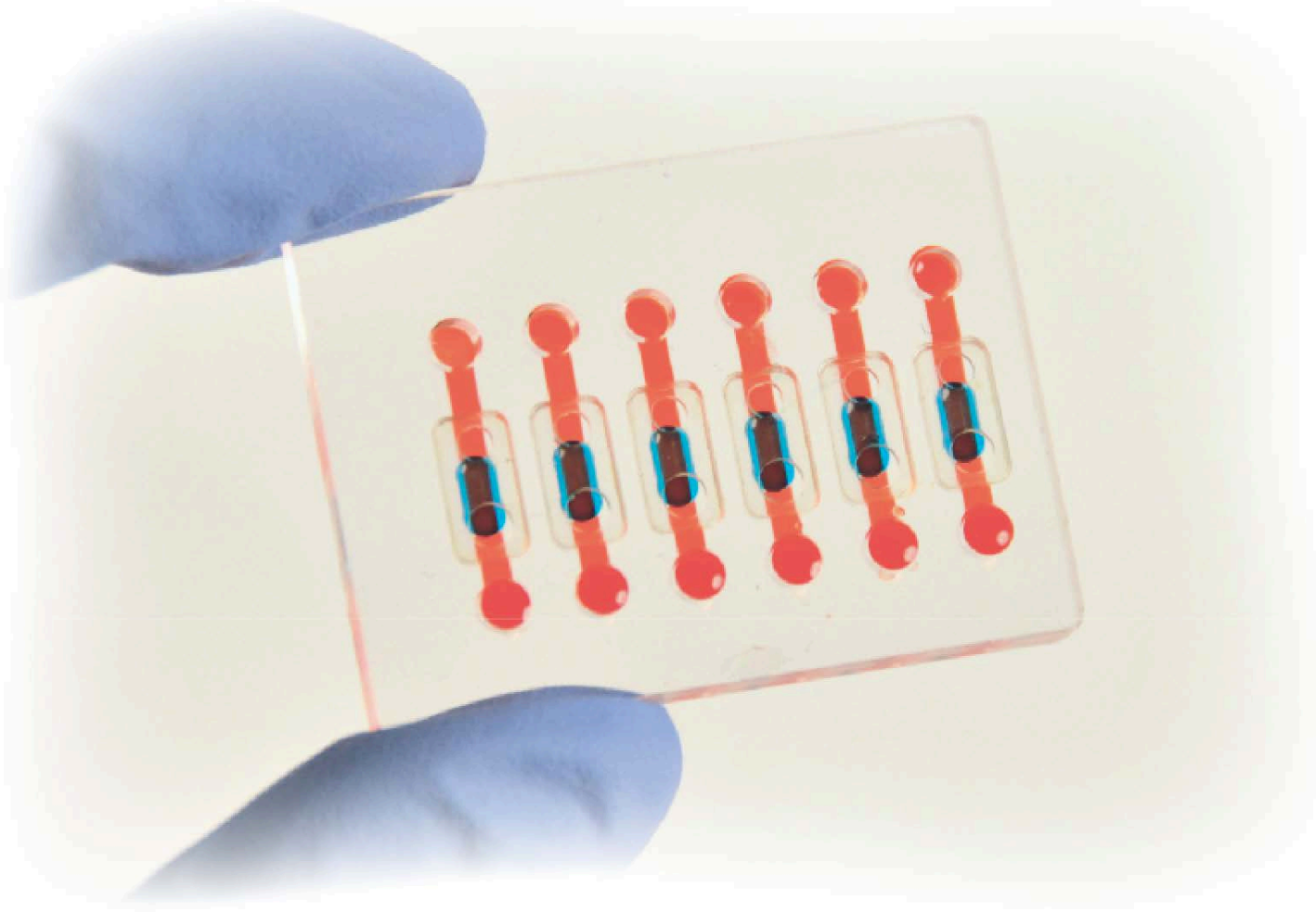




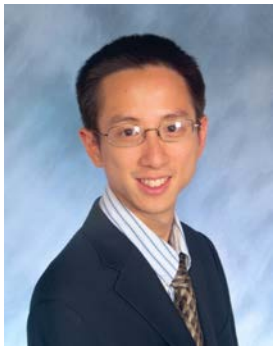


Young et al., *Blood*, 119 (10): E76-E85 (2012).

Airway-Chip for Studying Air Pollution



Problem: Chronic Lung Diseases (CLDs)



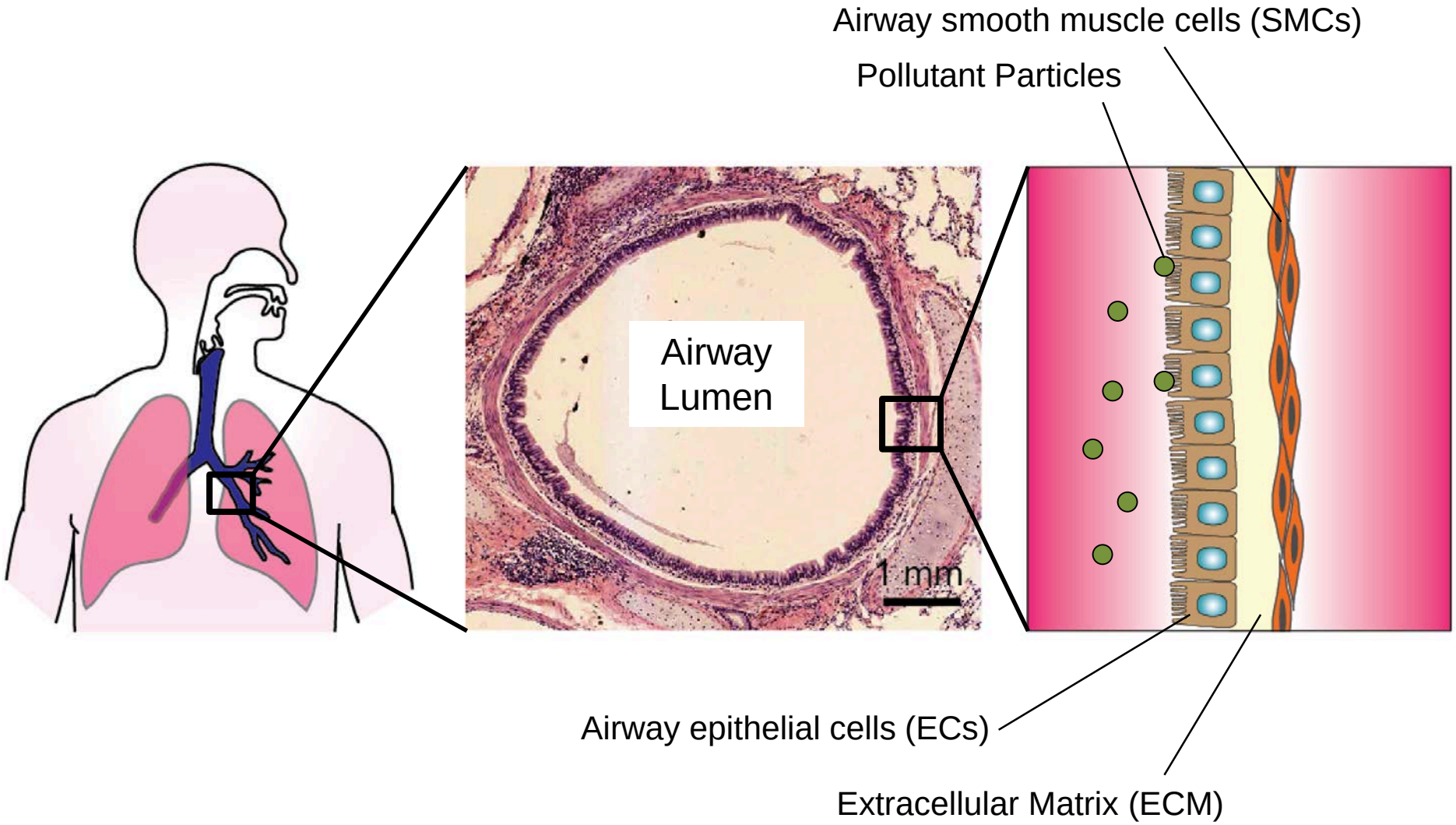
Dr. Arthur Chan
(Chem Eng.)

Dr. Chung-Wai Chow
(Medicine)

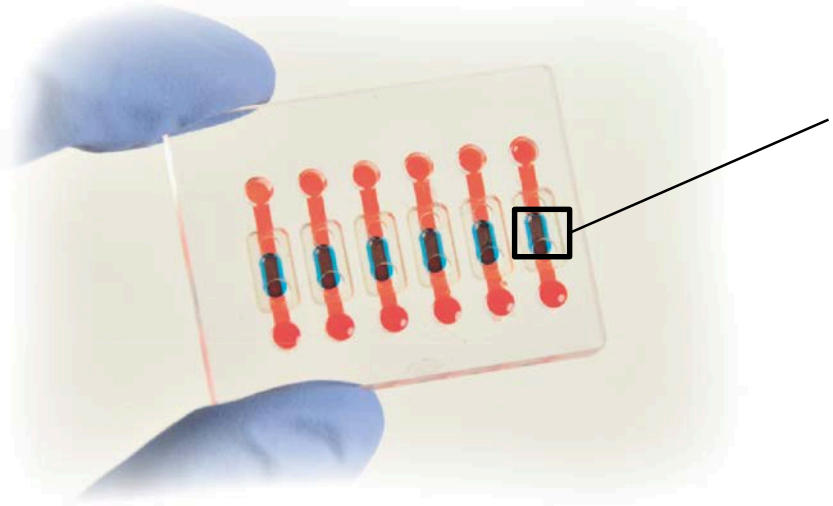
- Asthma
- Chronic Bronchitis
- Emphysema
- 5.6 million Canadians with CLDs (2020)
- $17 billion CAD healthcare burden (2020)

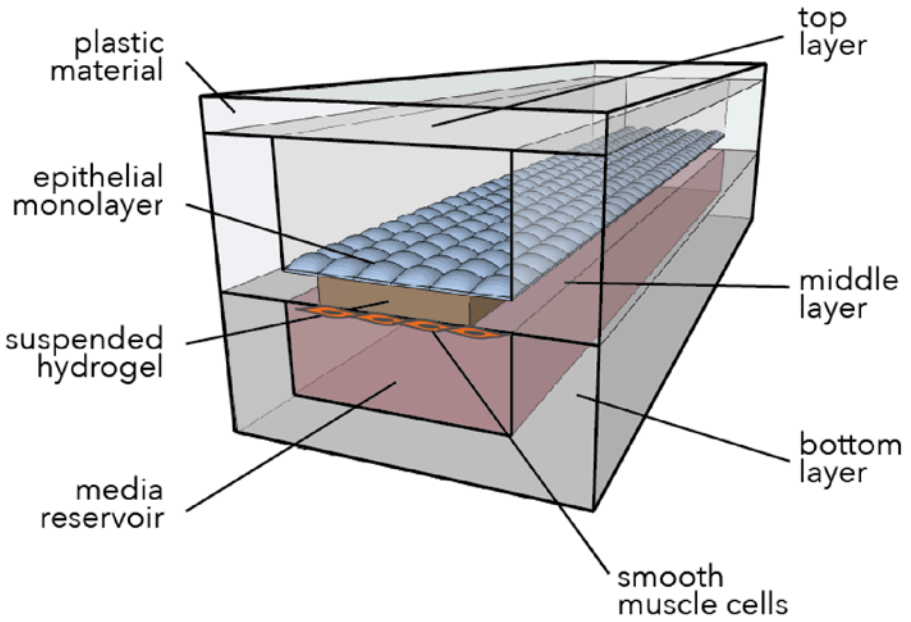
- Natural disasters (Fort McMurray Wildfires) create health risks from fire ash particles (CIHR)

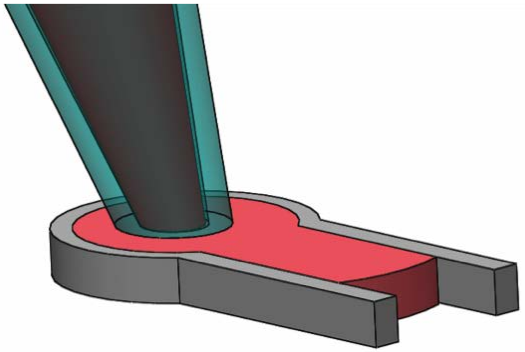
Two cell types communication to repair/remodel

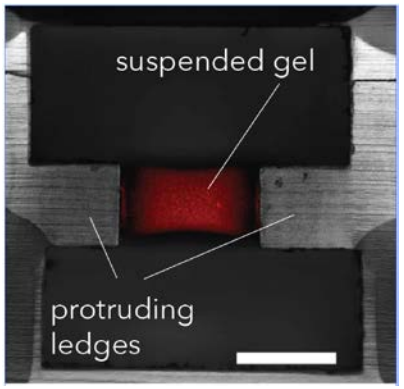


Our Airway Chip can position the cells accurately

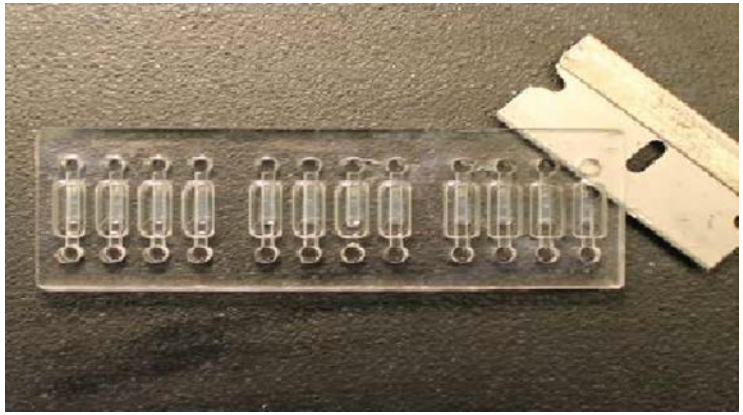


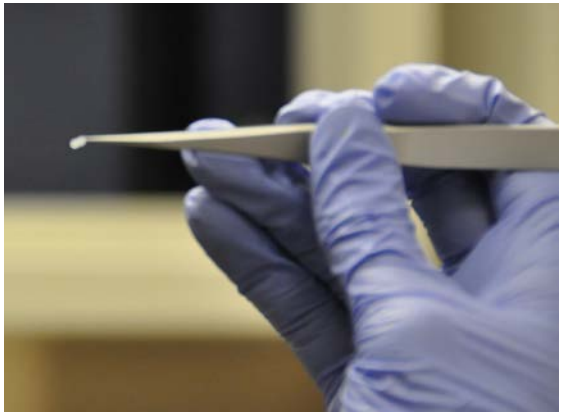


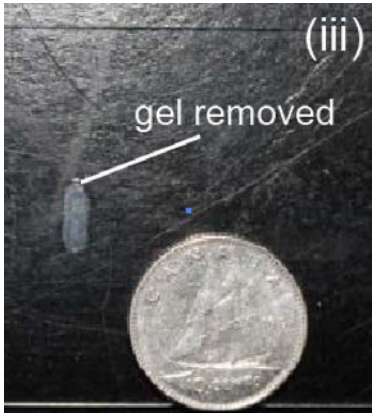




Disassemble device and remove gel with cells …

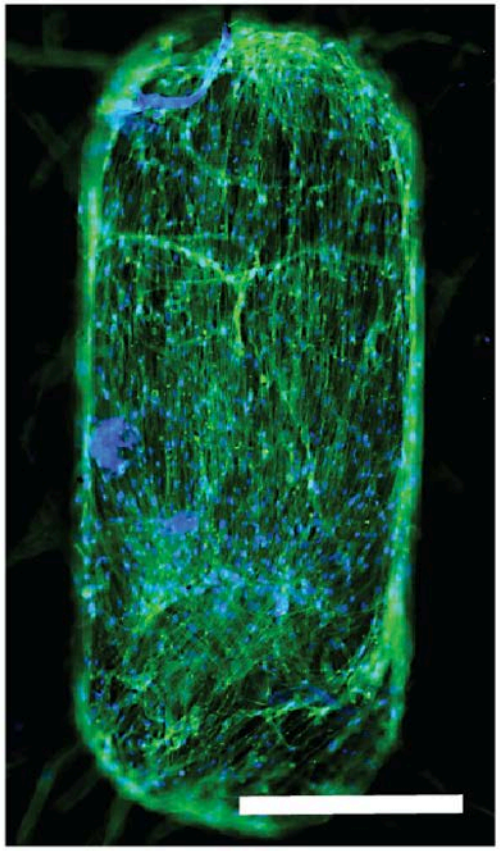


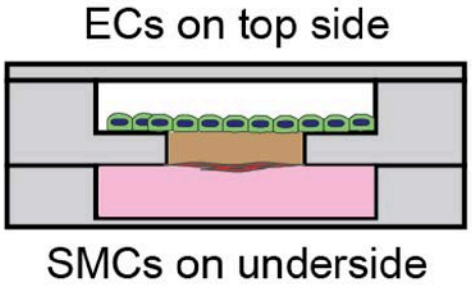


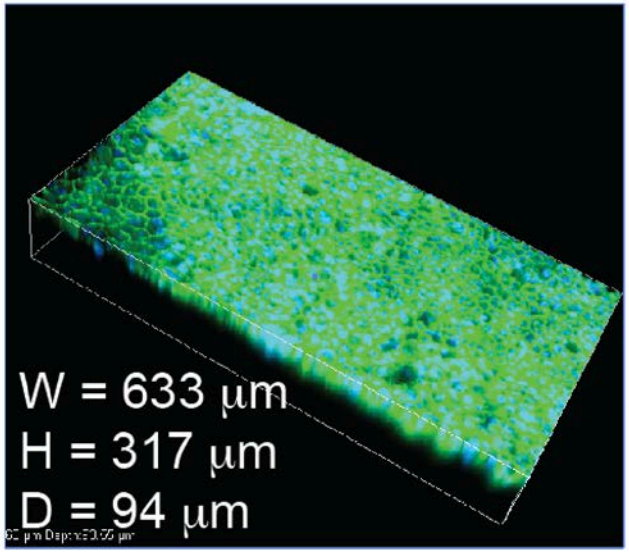


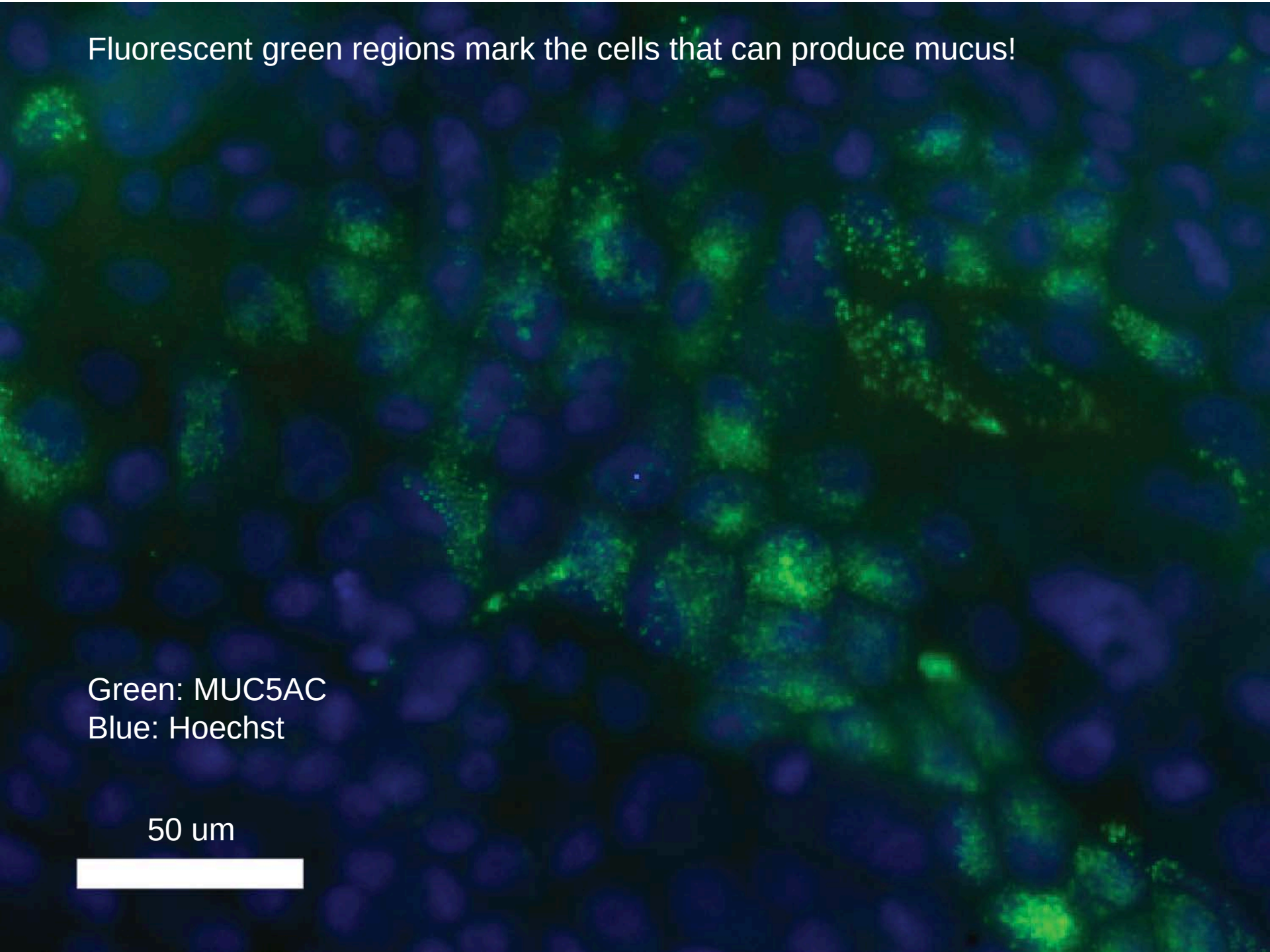
… and the gel is like a piece of lung tissue!

The cells stay alive for 5 weeks



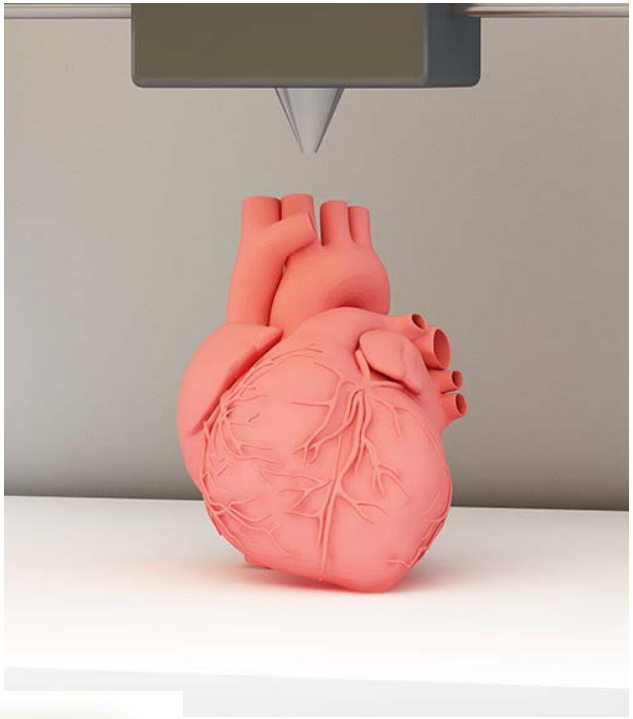




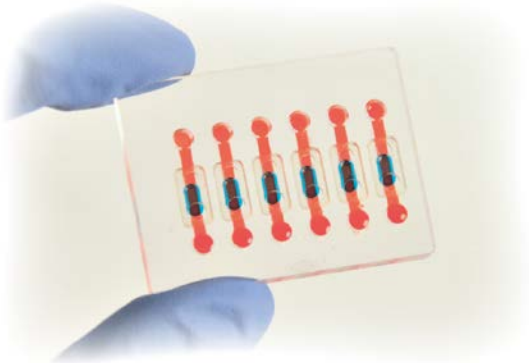

Fluorescent green regions mark the cells that can produce mucus!
Green: MUC5AC
Blue: Hoechst
50 um

Era of “bio-inspired” engineering

The early dream of human flight, inspired by flight of birds



A 3D-printed heart model



Simple lab test of accurate lung airway

Questions?