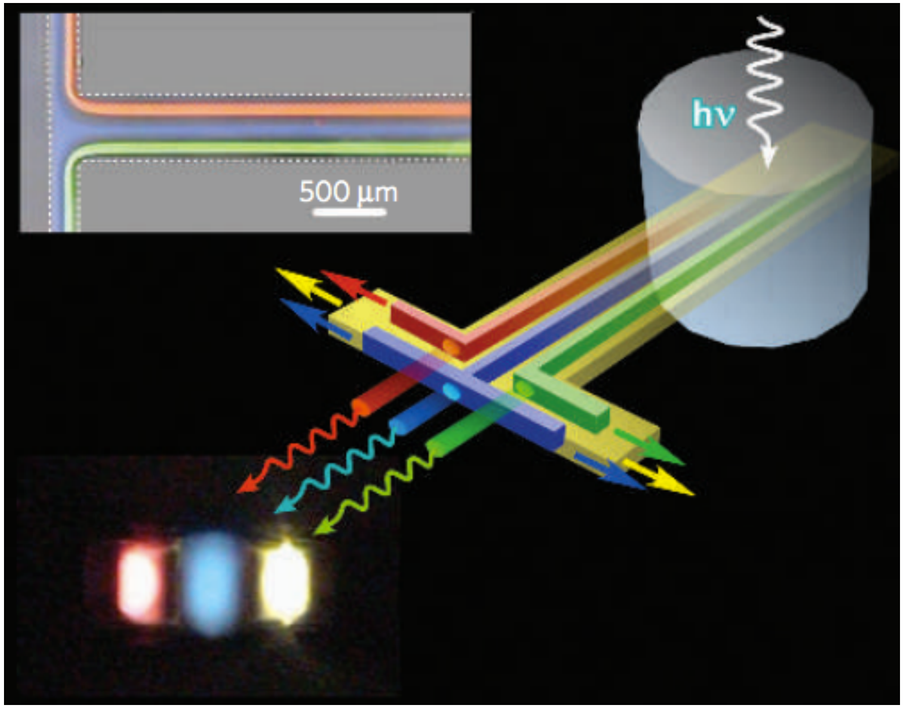


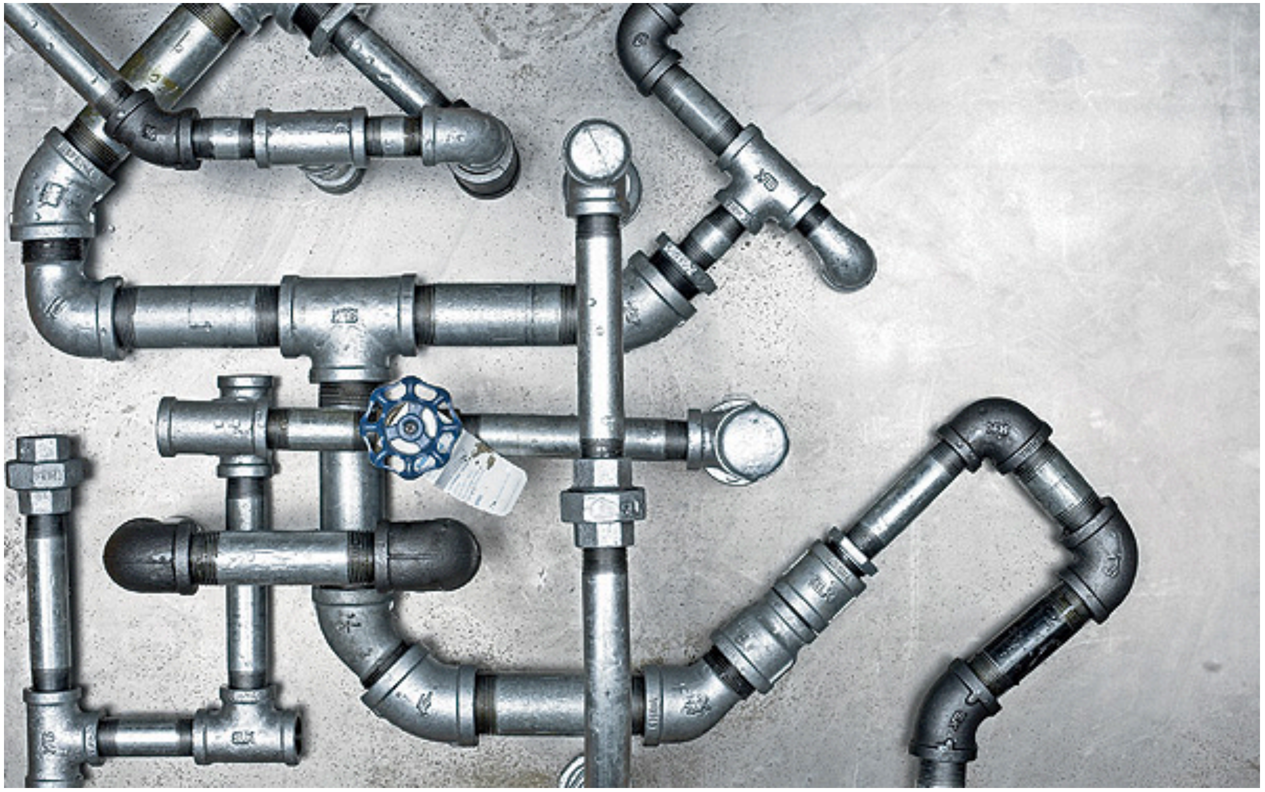
Optofluidics

Ismail Emre Araci, Ph.D.

- Microfluidics
- Optics
- Three demonstrations of where these merge!

Microfluidics:

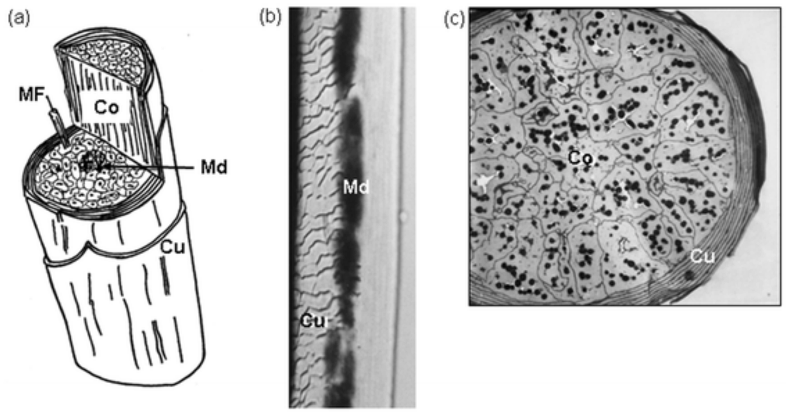
SMALL PLUMBING!!!



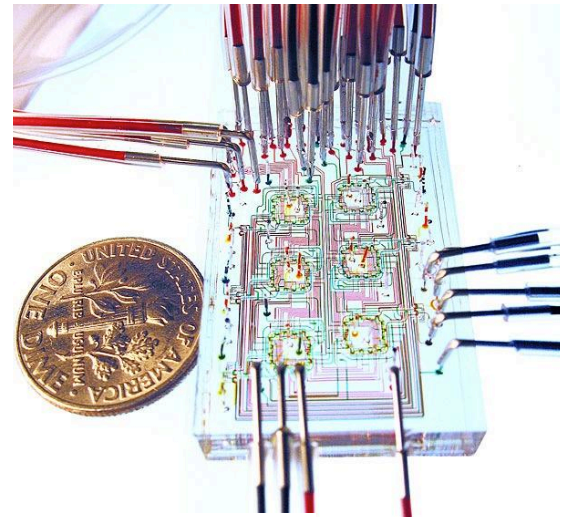
How SMALL?

Scale

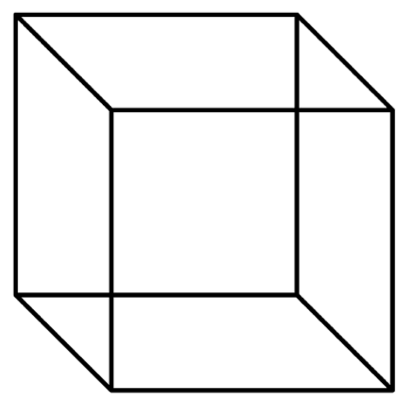
Human hair ~ 100 um



Channel size ~ 10-100 um



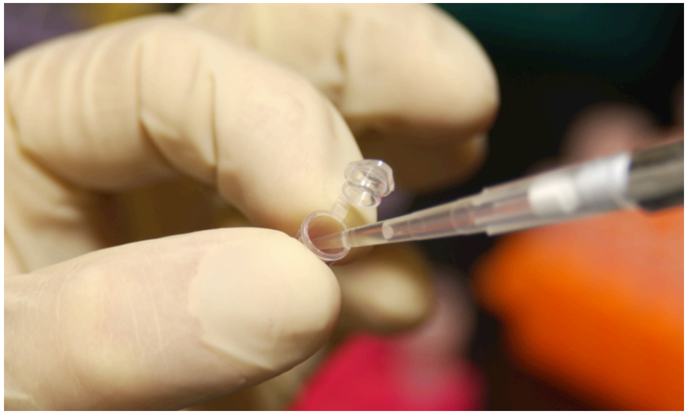
Single poppy seed volume 1 uL

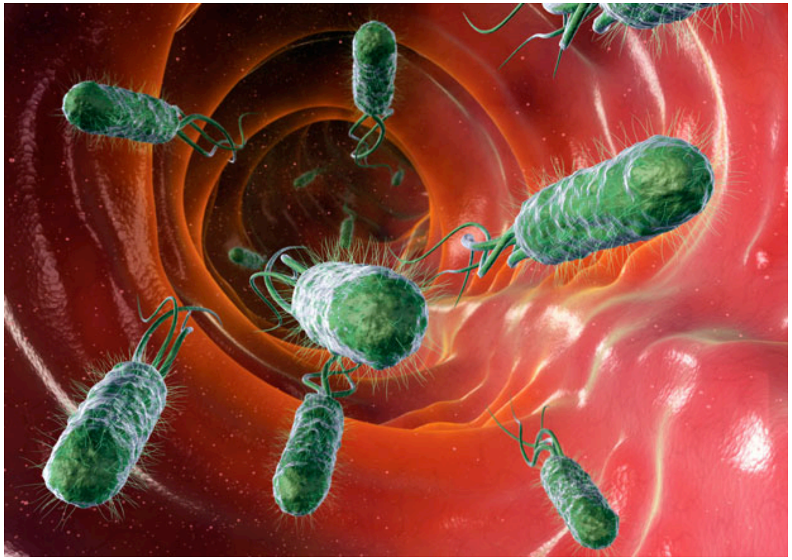


$(100\ \text{um})^3 = 1$ nL

$(10\ \text{um})^3 = 1$ pL

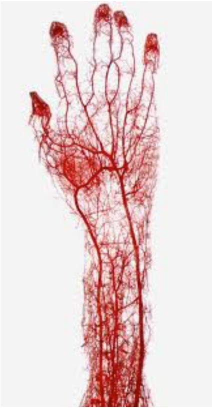
Laboratory experiment scale





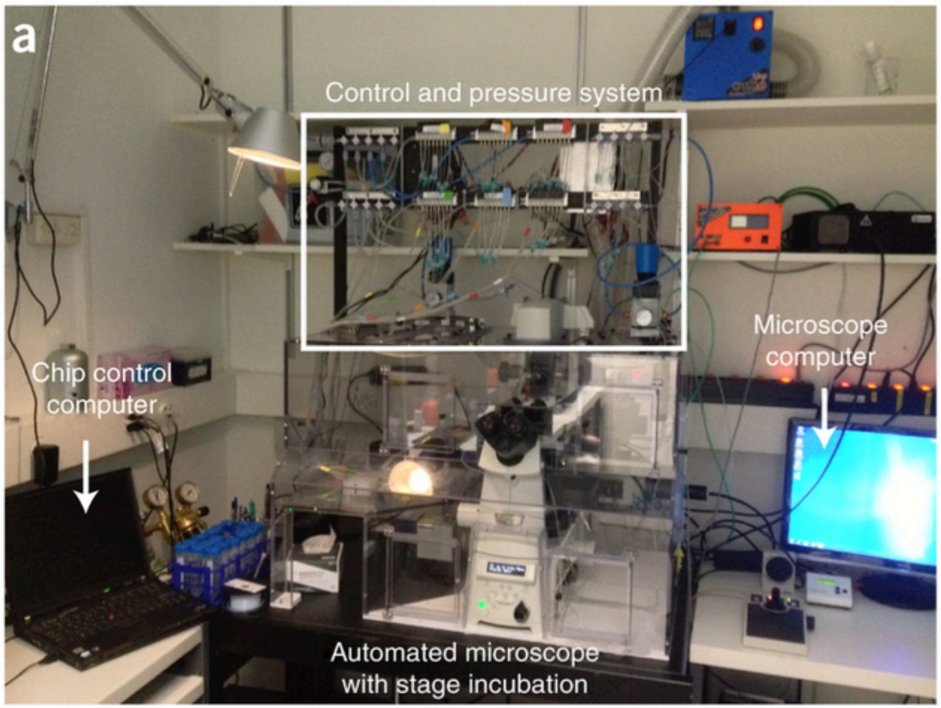
Examples of microfluidics in everyday life

- Human body
- Trees
- Ink-jet printers



Motivation in Studying Microfluidics

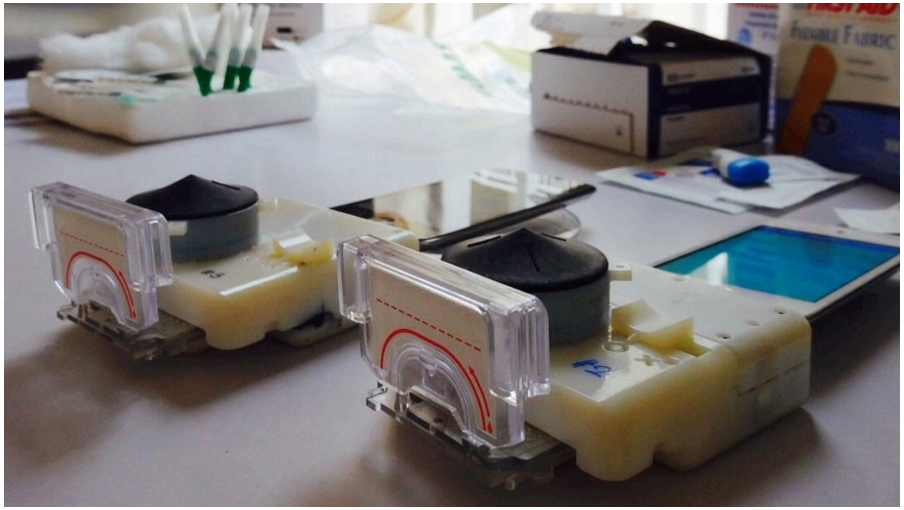
Biological and Biochemical research



Main requirements:
Automation, High throughput

Home diagnostics and Point-of-care testing

Main requirements:
Low cost, easy to use, no maintenance, sample in result out



Flow in microfluidic chips is laminar

- **Fundamentals of laminar flow:** https://www.youtube.com/watch?v=_dbnH-BBSNo
- **Turbulent flow:** https://youtu.be/kmjFdBxbV08?t=104
- **Laminar flow in action:** https://www.youtube.com/watch?v=UVSDRglikuM

Reynolds number is used to characterize fluid flow

$$Re = \frac{\text{(inertia force)}}{\text{(viscous force)}} = \frac{\rho V D}{\eta}$$

Reynolds number is a dimensionless quantity

Density, ρ [kg/m^3]
Viscosity, η [Pa.s = N.s/m^2 = kg/m.s]
Flow speed, V [m/s]
Characteristic size (~channel diameter), D [m]

For Re < 2000, laminar flow !!!

2000<Re<4000 transition

Re>4000 turbulent

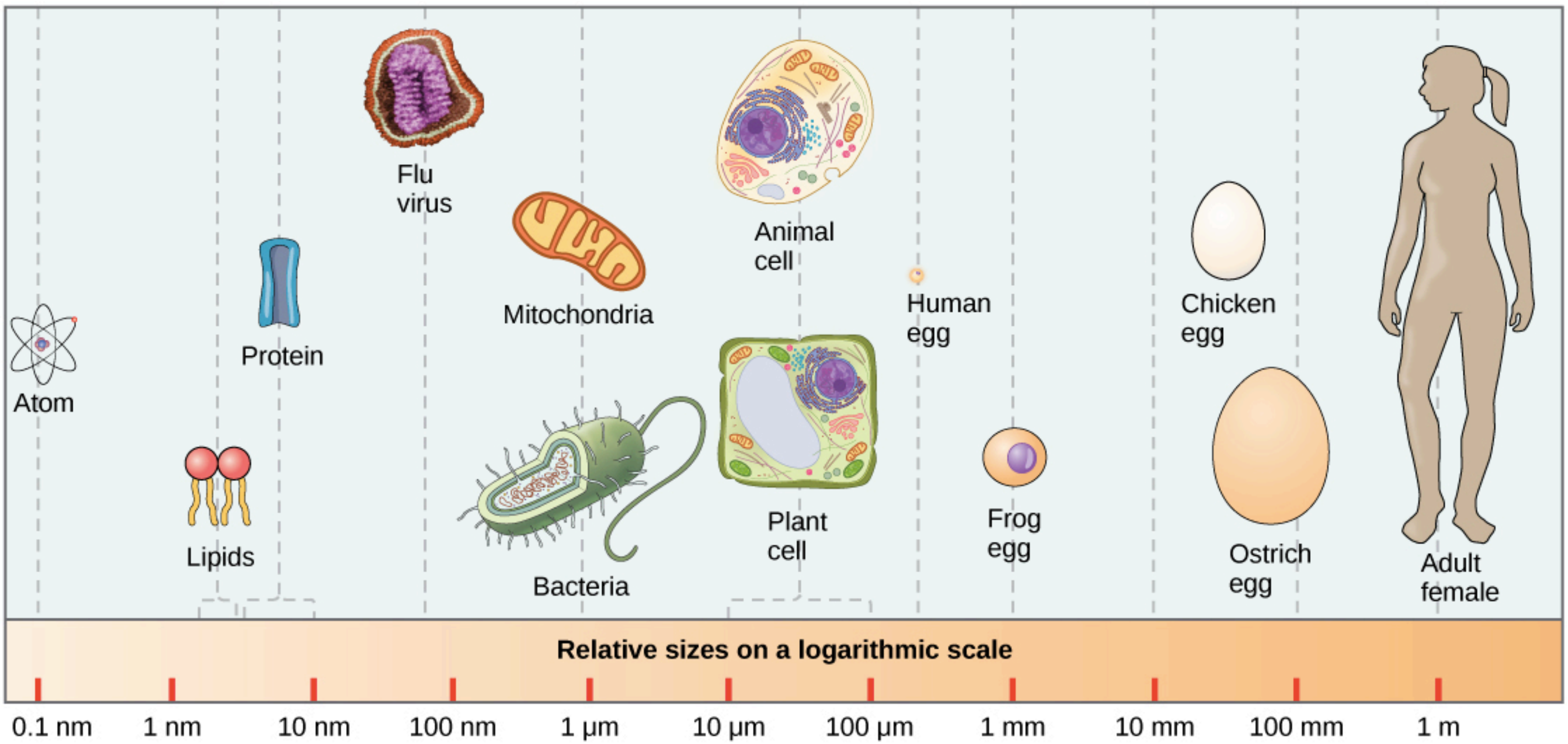
Viscosity

Viscosity is due to internal friction

As an example the viscosity η of water at 20°C is written as

$\eta = 1.002 \times 10^{-3}\ kg\ m^{-1}s^{-1} = 1.002\ mPa\ s$

Exercise 1



$Re_{man} = 10^{6}$ and $Re_{bacteria} = 10^{-5}$.

Discussion

How does the laminar flow help microfluidic design? Why?

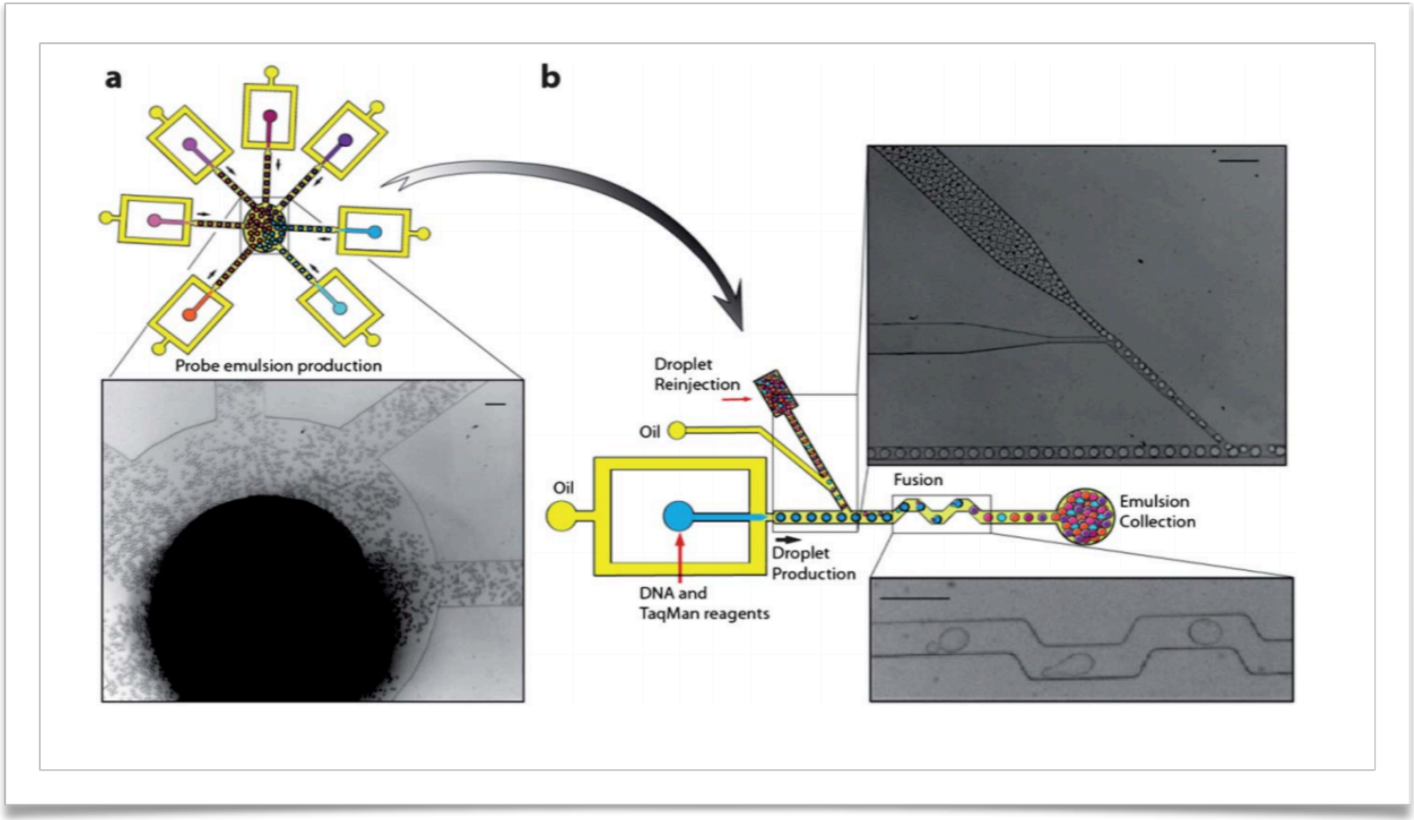
Microfluidic Flow/Control Techniques

- Paper based microfluidics
- Droplet based microfluidics
- Electrowetting based microfluidics
- Continuous flow based microfluidics: mLSI

Paper: Low cost

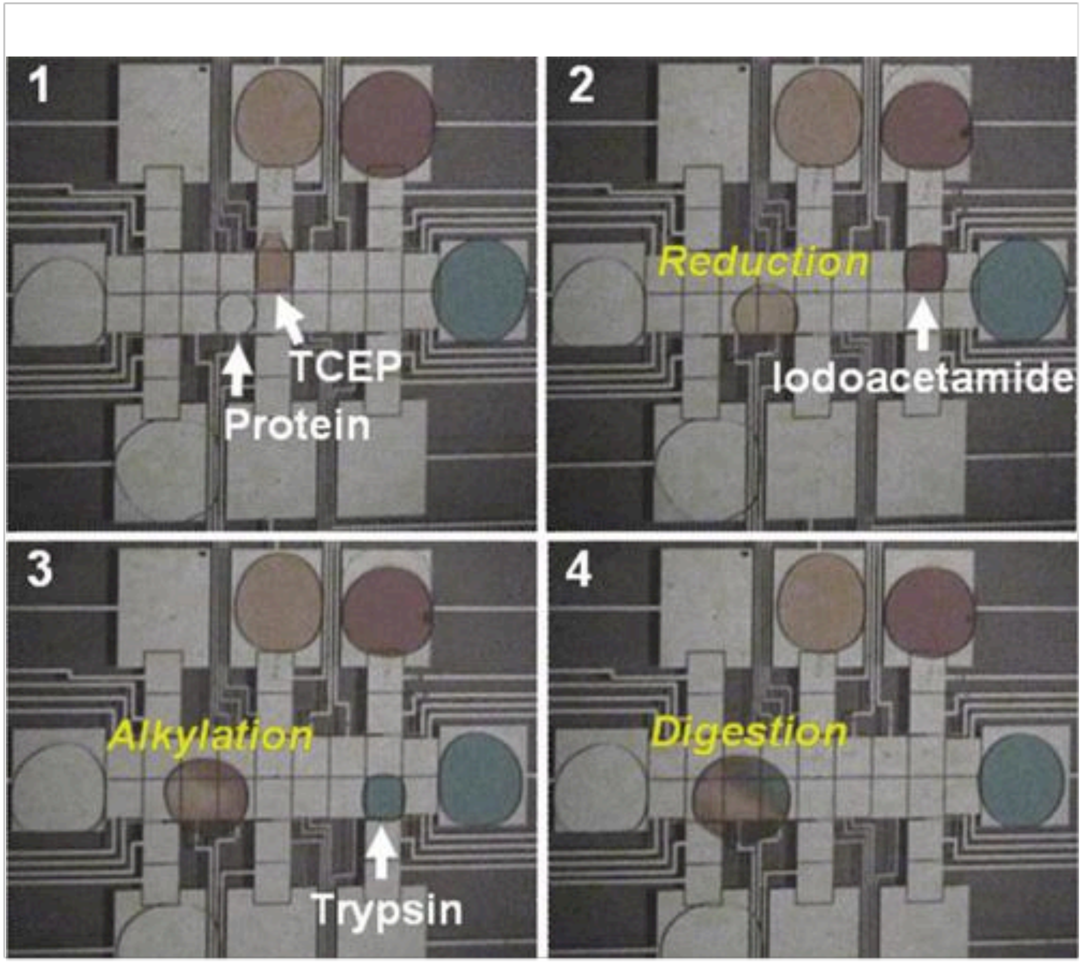
https://youtu.be/J5LwNGm0tbw?t=99

Droplets: High throughput



https://www.youtube.com/watch?v=O7rqq4DHckM

Electrowetting: Programming

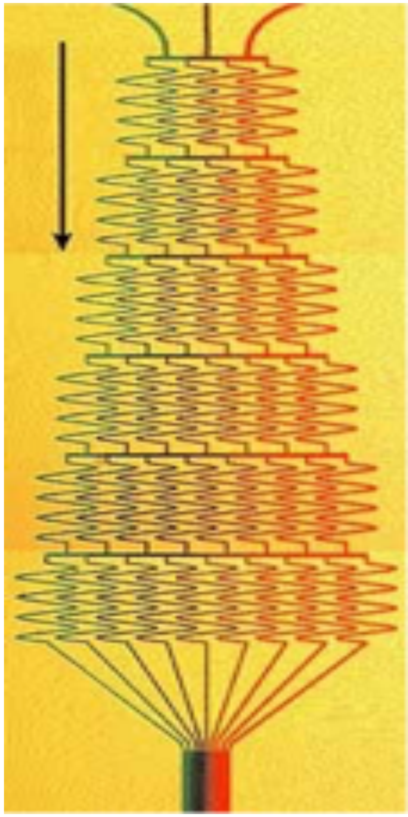


http://www.liquid-logic.com/technology

Continuous flow based microfluidics

- Continuous as opposed to droplet-based
- Applications: Mixing, Cell trapping, sorting

- What do you need to make this technology more powerful

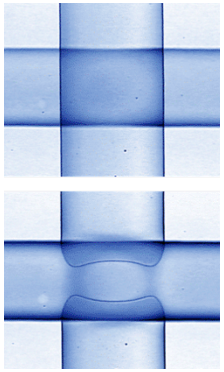


Control elements, aka valves

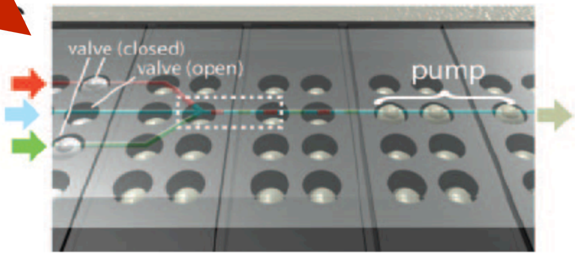
Microfluidic Valving Technology

Micro-Plumbing

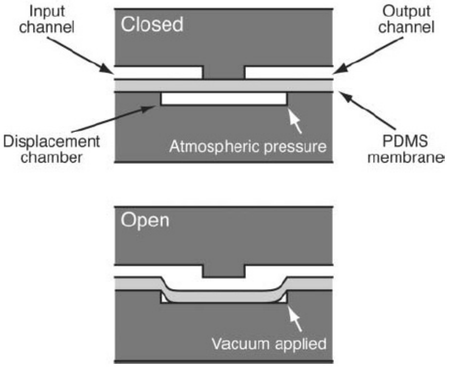
Normally-open polymer monolithic valves (Fluidigm)



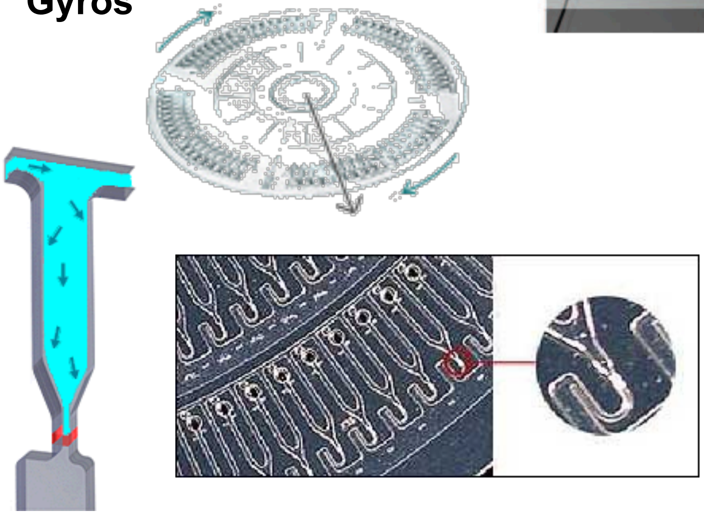
Braille valves (Takayama)



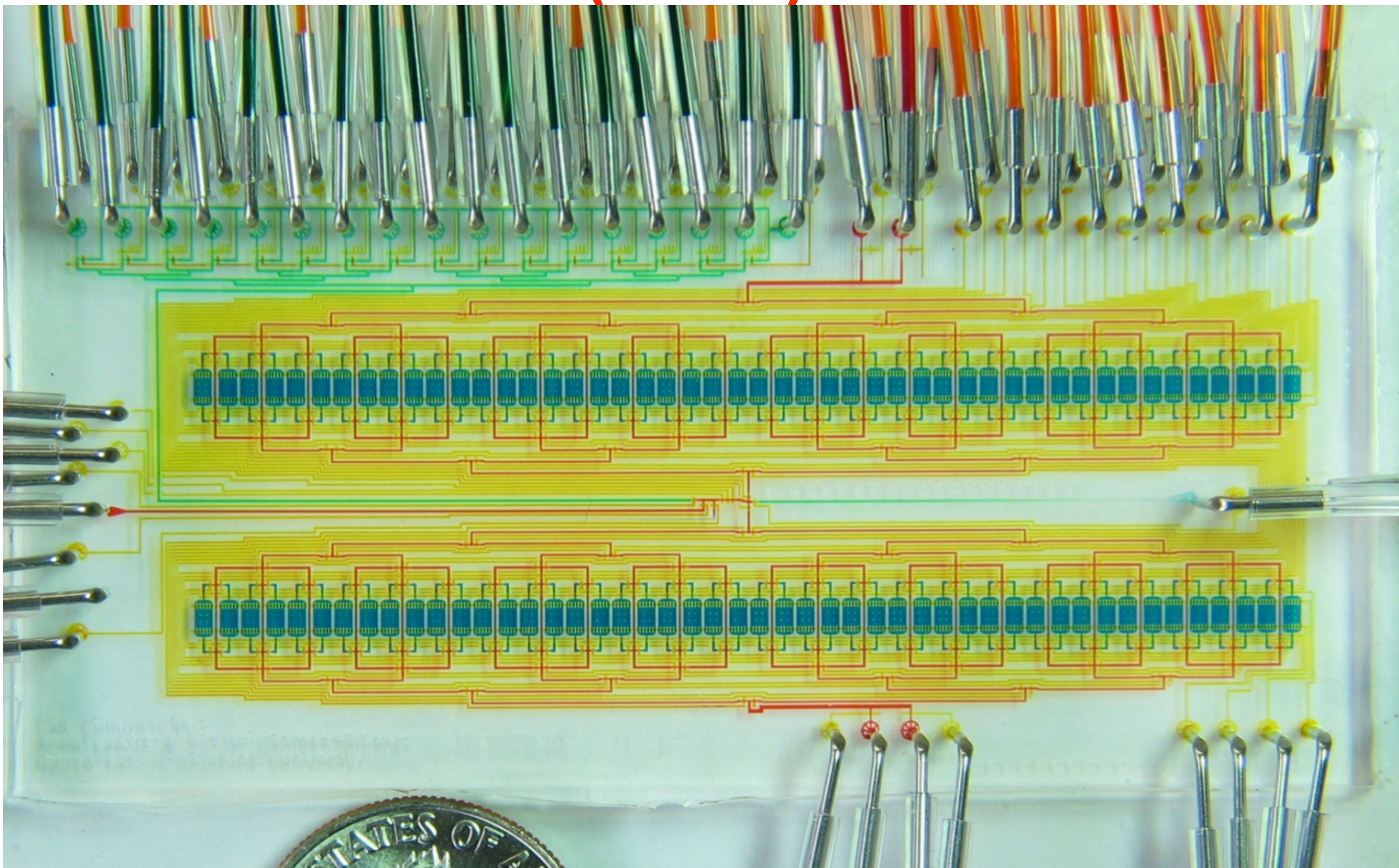
Normally-closed polymer valves (Mathies)



Gyros



Microfluidic Large Scale Integration (mLSI):



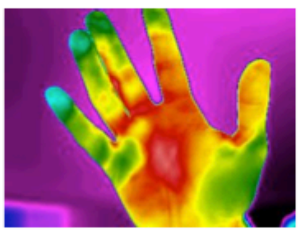
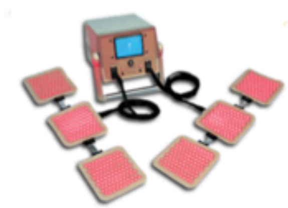
Optics

Ismail Emre Araci, Ph.D.

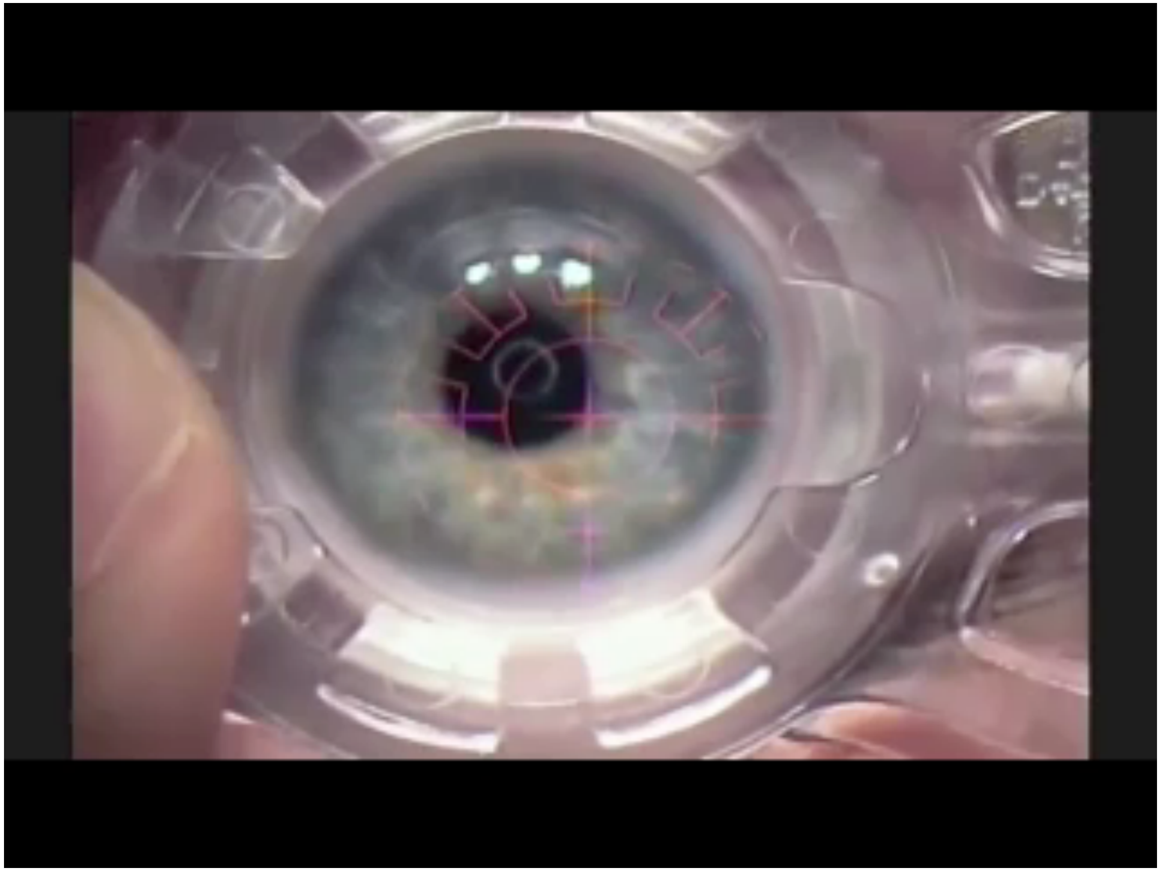
BioPhotonics

BioPhotonics: interaction of living cells (bio) with electronic control or detection of light (photonics)

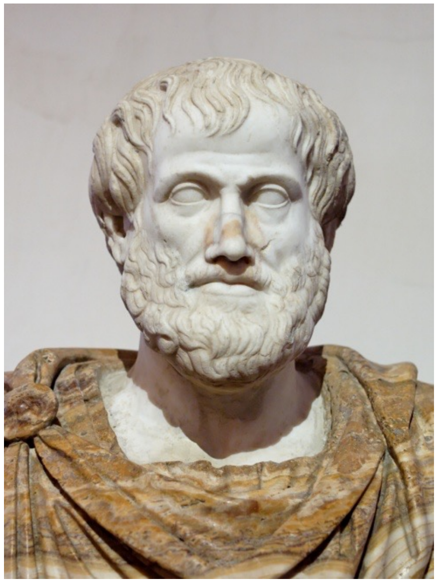
Initial ABP Focus

Imaging	Biometrics	Therapeutics	Detection	Surgery
2D & 3D examination of cells, tissue, and organs	noninvasive biophysical parameter measurement	photonic treatment of injured or diseased cells	detecting the presence of injury, disease & distress	laser cutting, ablation, removal of cells & tissue
				
example : *IR thermography*	example : *blood oxygen sensor*	example : *ABP phototherapy*	example : *UIUC cancer detection*	example : *laser hand-piece scalpel*

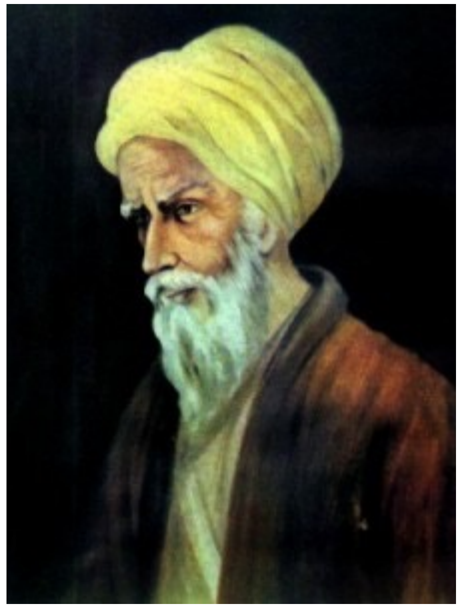
LASIK



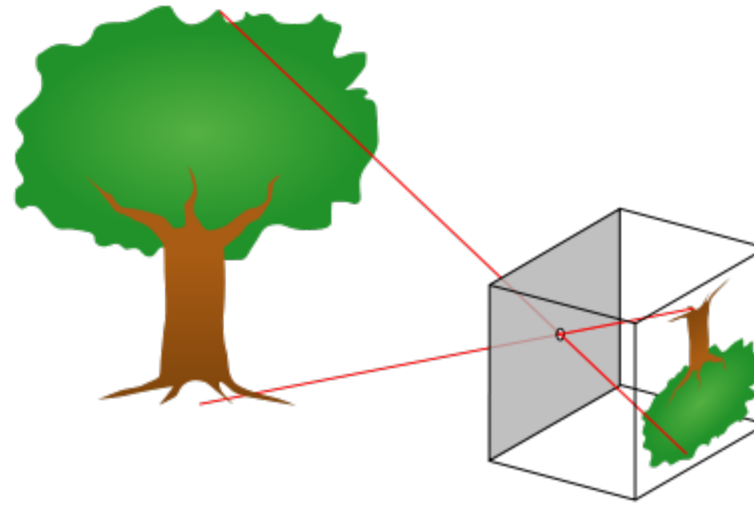
History of Optical Vision



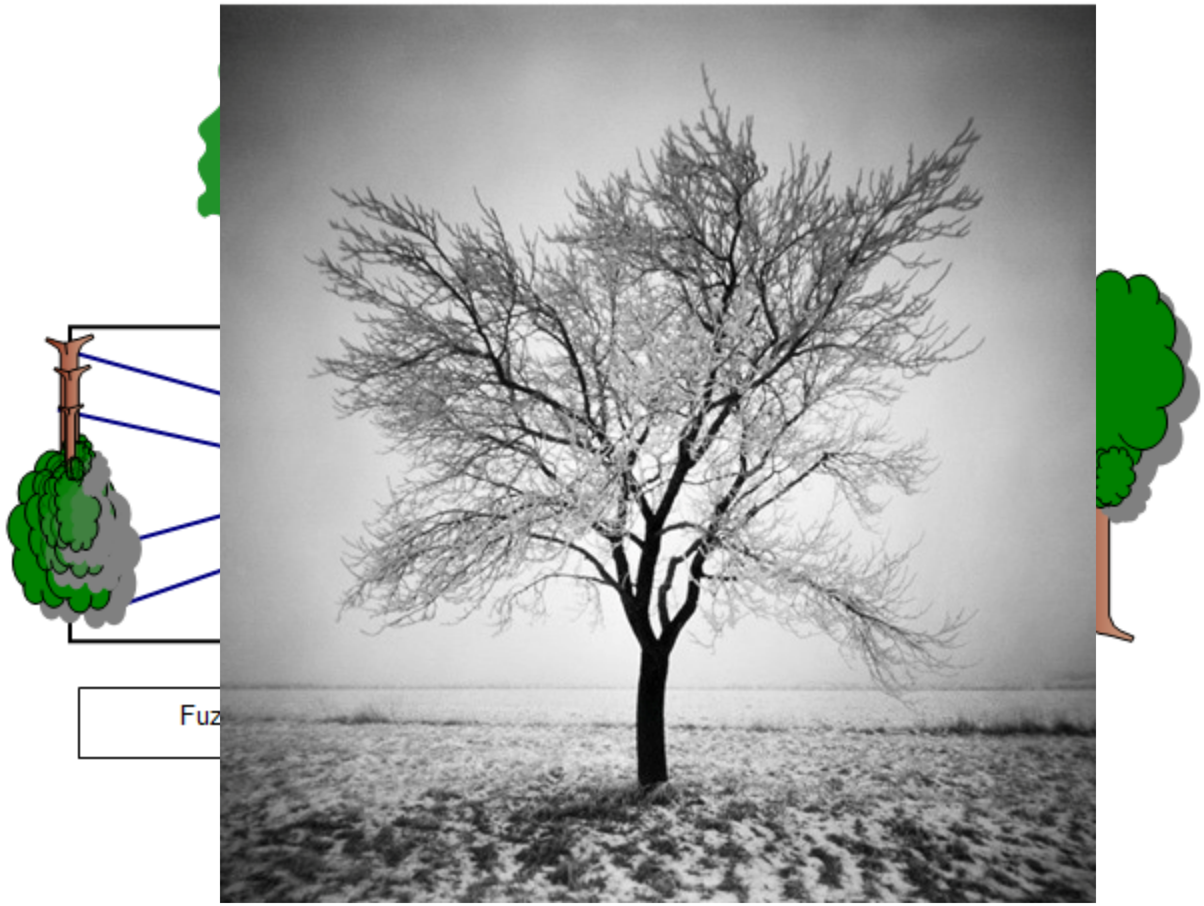
Aristotle, 4th BC



Alhazen, 10th AD

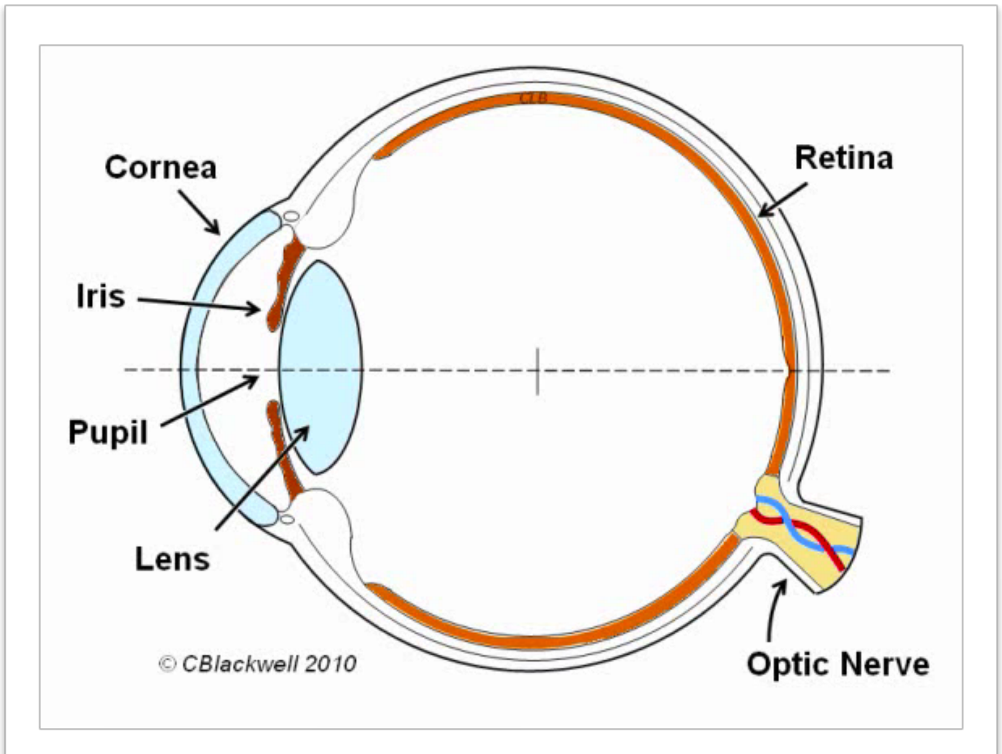


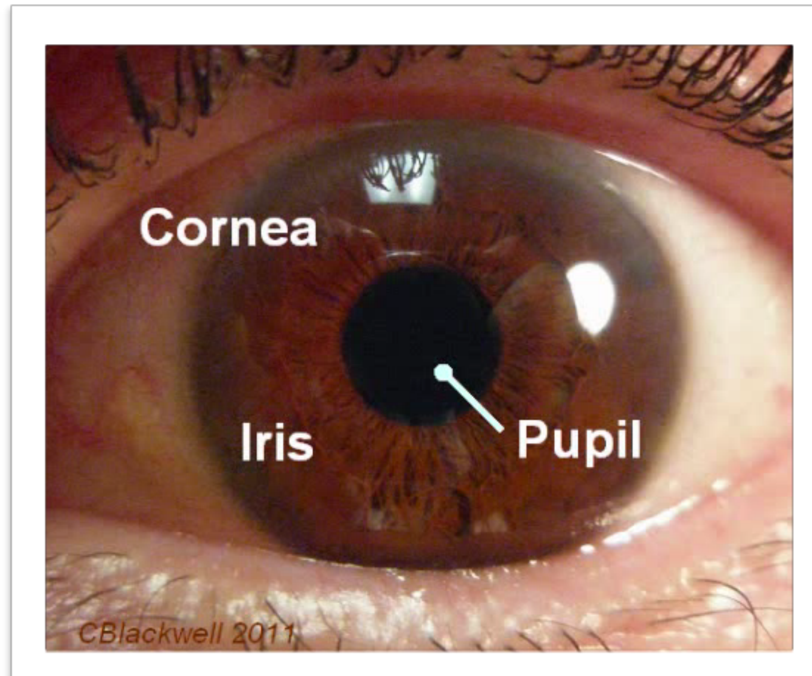
Camera Obscura



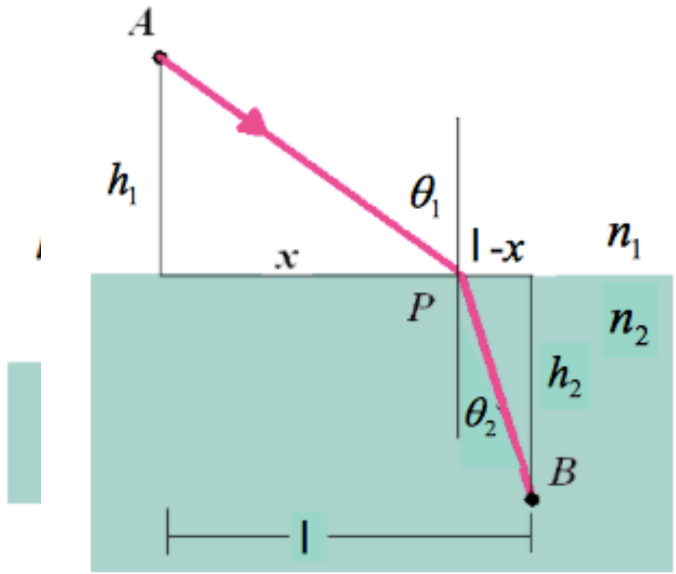
Small pinholes and long exposure times necessary

Eye as a pinhole camera





Building a lens

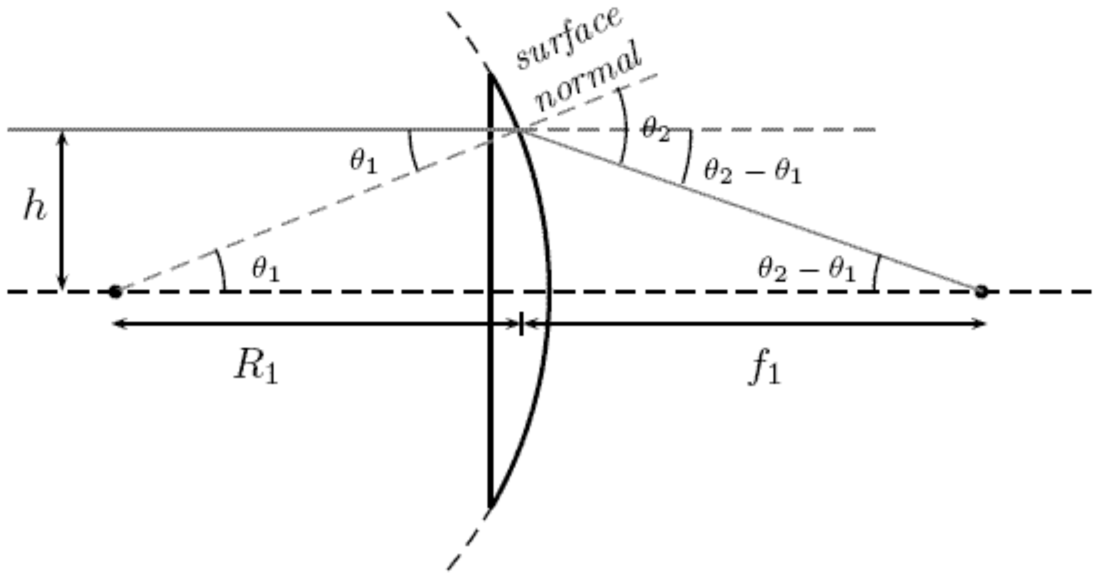


Law of refraction
Law of Reflection
Snell's Law

$\theta_1 = \theta_2$

$n_1 \sin(\theta_1) = n_2 \sin(\theta_2)$

Lens Maker's Equation

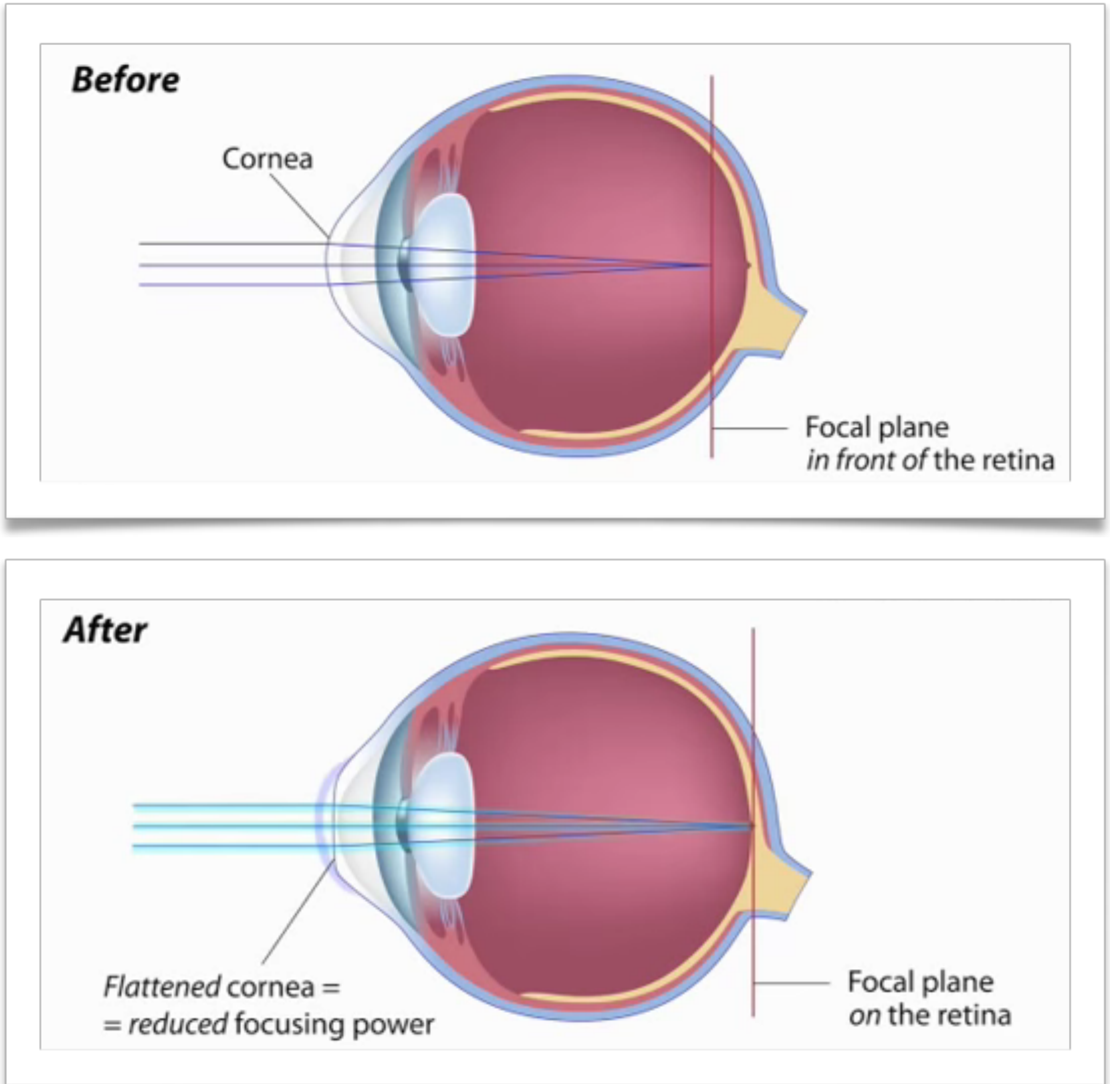


$$\frac{1}{f_1} = \frac{n-1}{R_1}$$

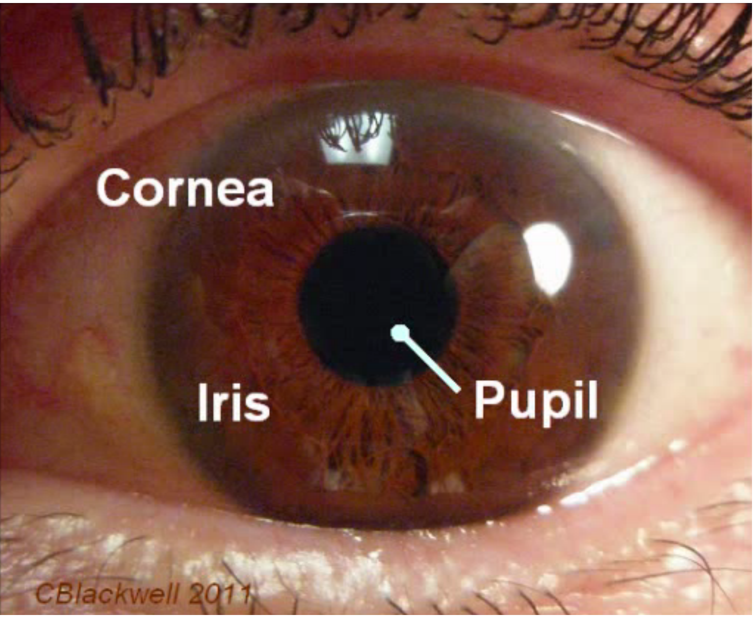
Optical Power

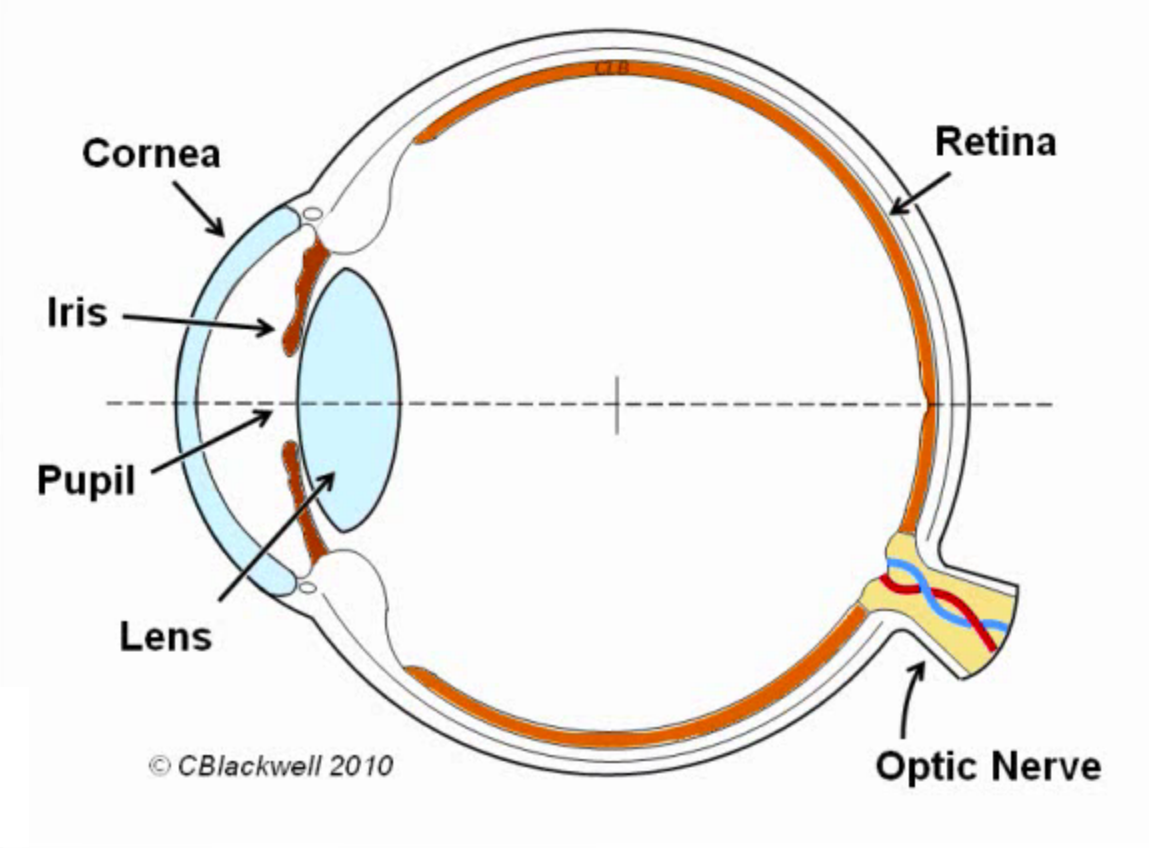
What determines the optical power of a lens?

LASIK (Laser-Assisted in situ Keratomileusis)

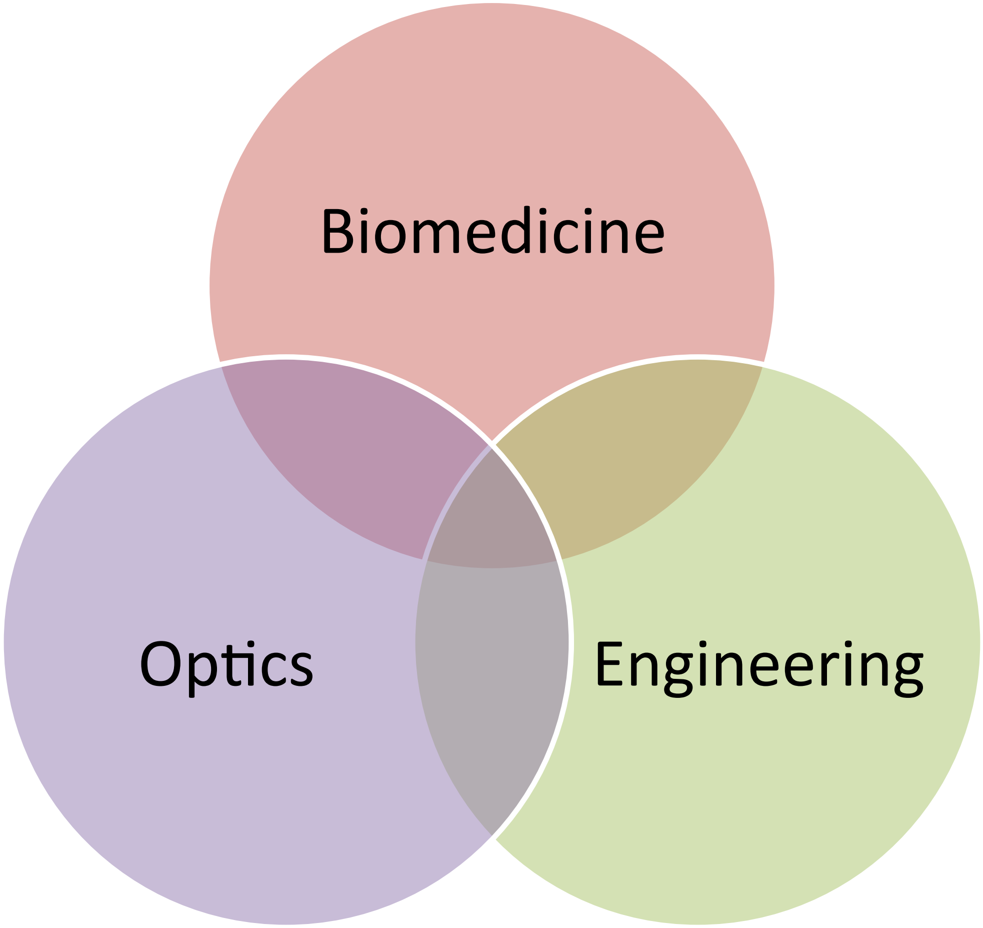


Focusing parts of the eye

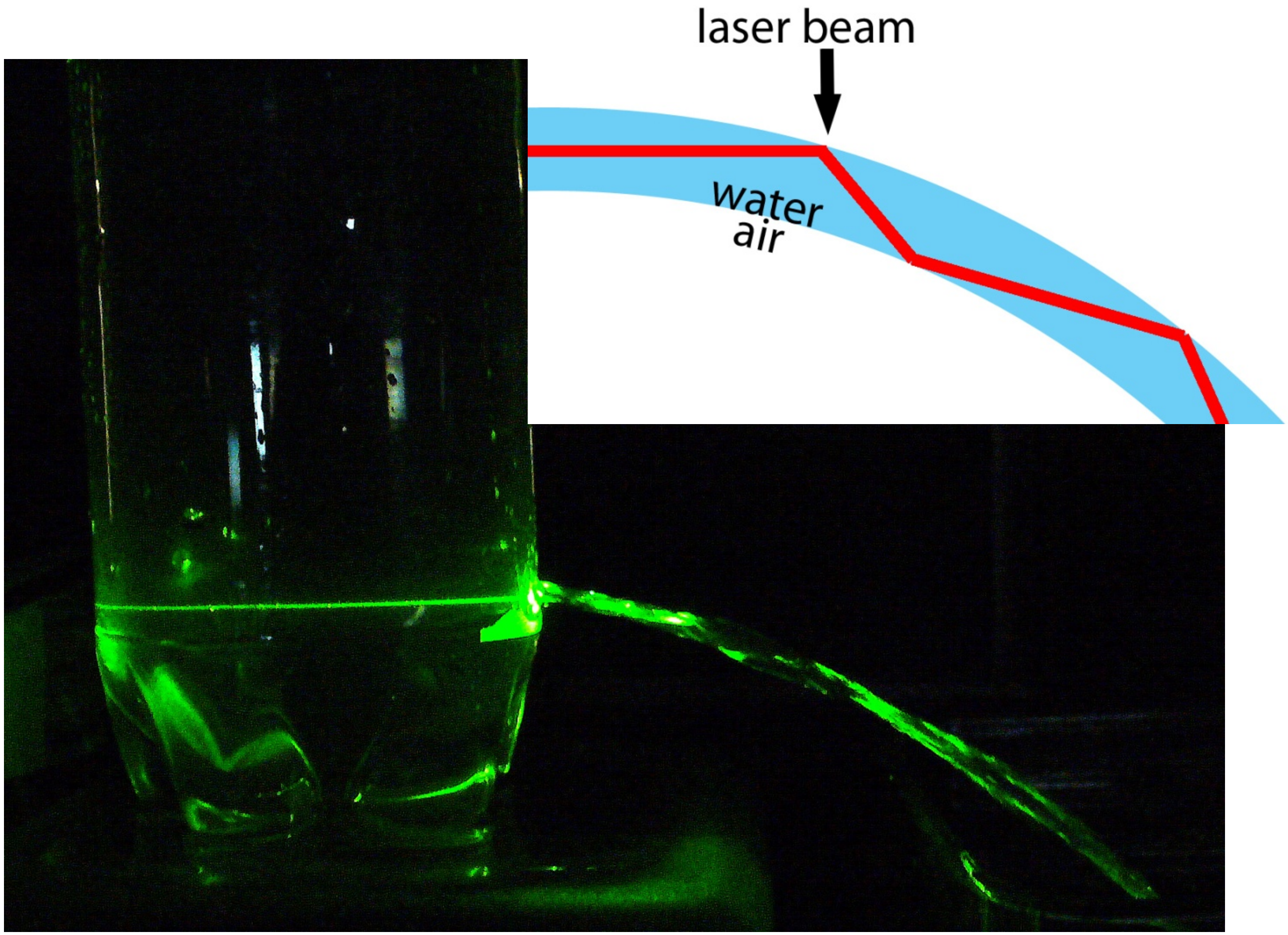




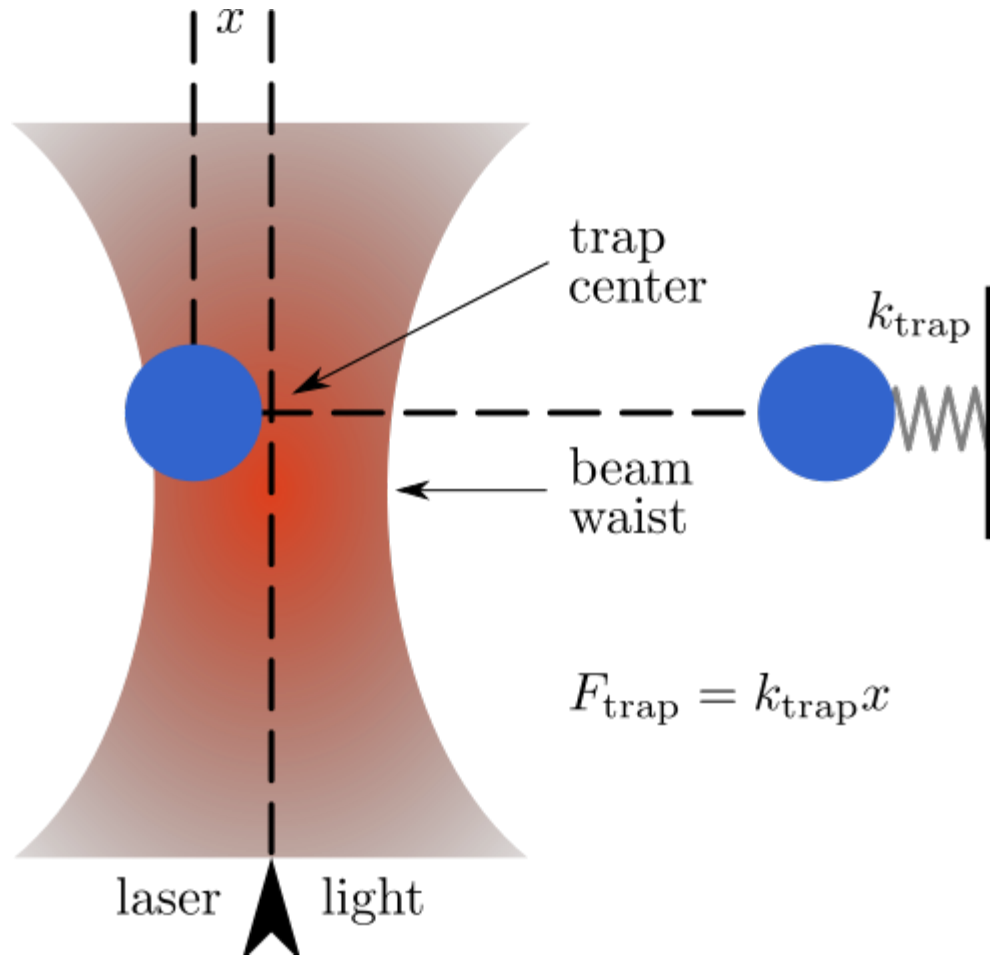
Exploring Light-matter Interaction



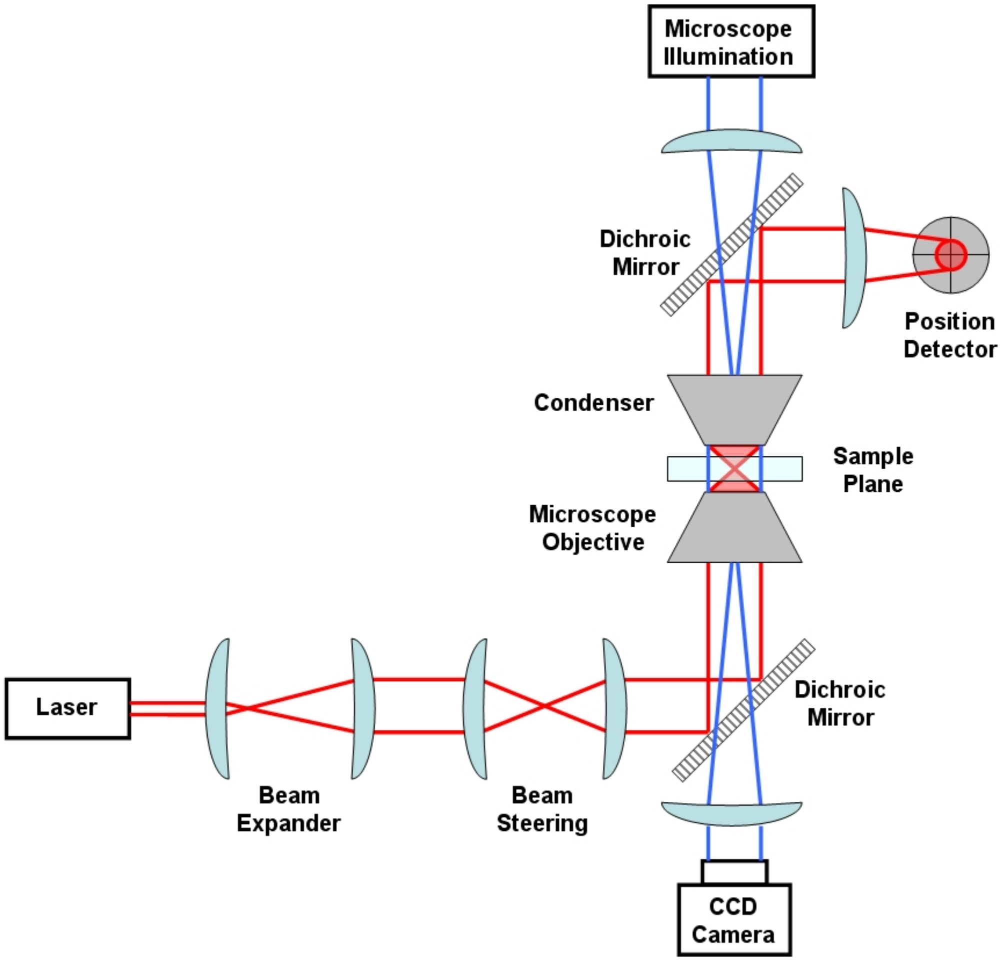
Light reflection from water



Optical Tweezer

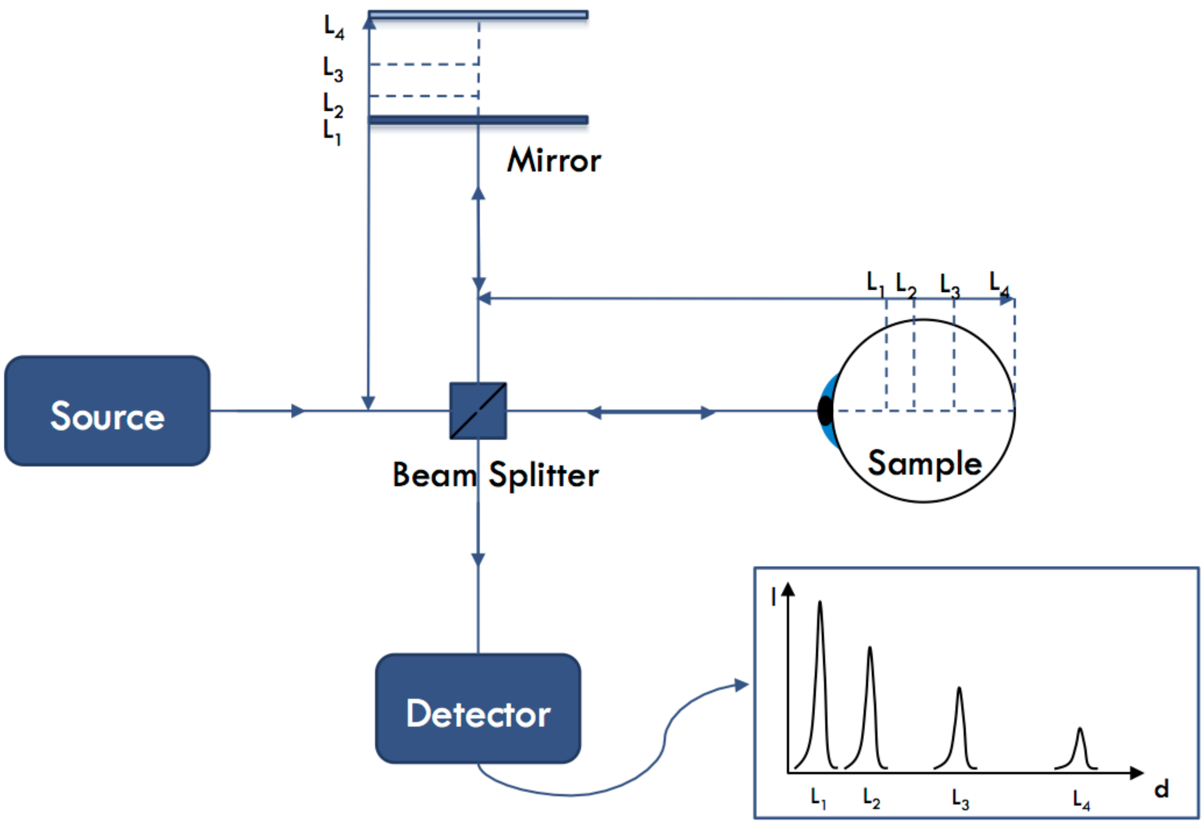


Optical Tweezer Setup

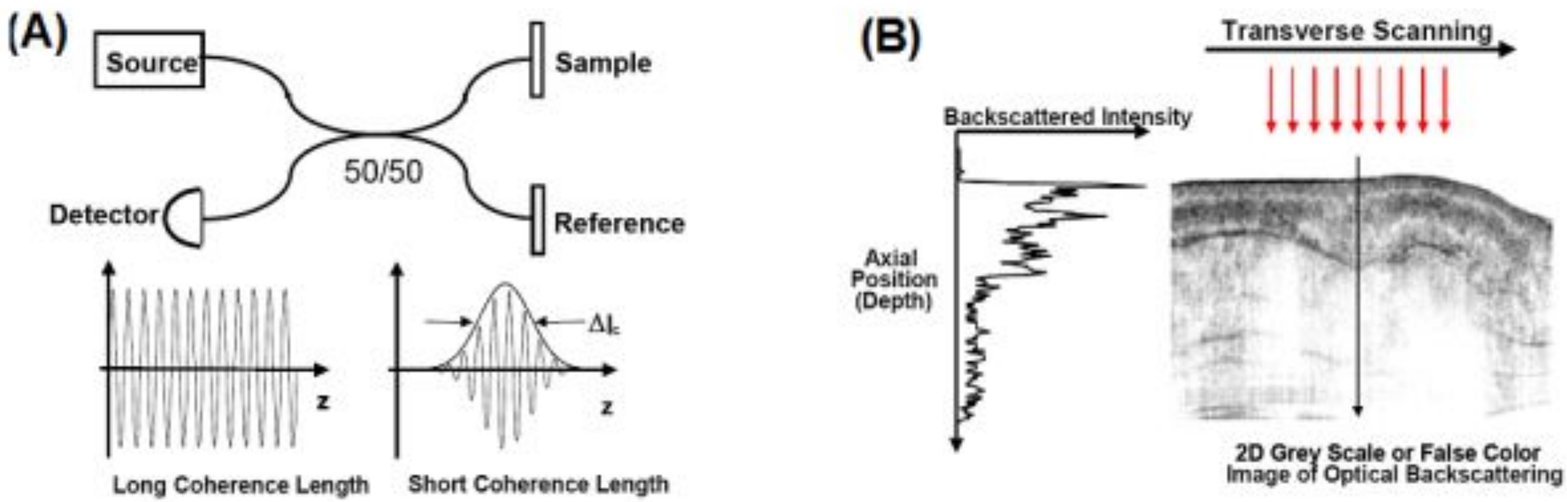


Optical Coherence Tomography

https://youtu.be/Iuv6hY6zsd0?t=4m37s



Optical Coherence Tomography



Thanks

Questions???