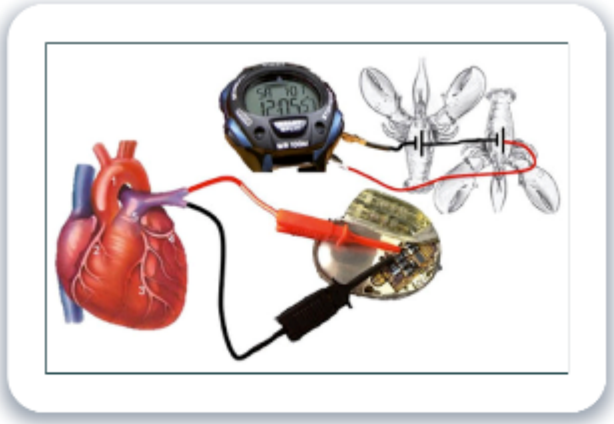
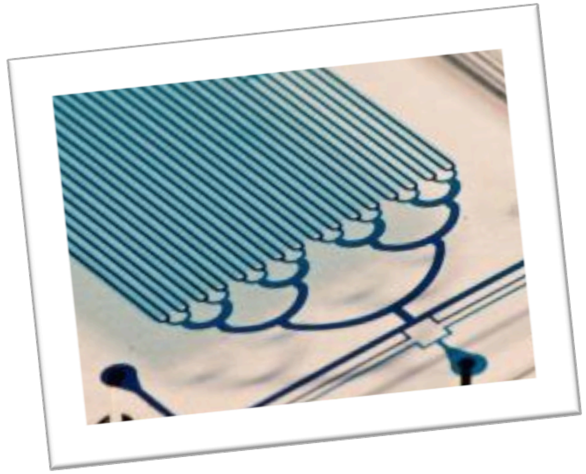




Department of Bioengineering

http://www.scu.edu/engineering/bioengineering/index.cfm

Santa Clara University

School of Engineering

Ismail Emre Araci, Ph.D.

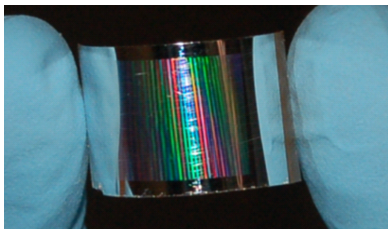
Assistant Professor

Personal background

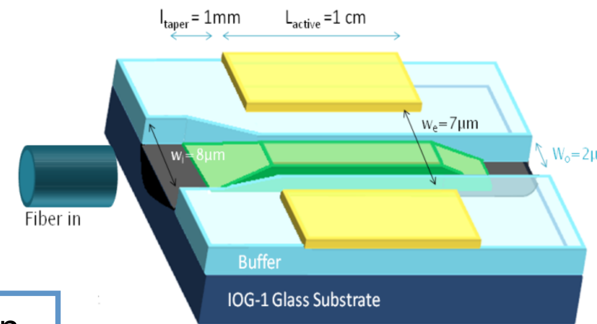
- Computational Modeling
- WDM Components/Systems

- **Araci** et al, IEEE, J. of Lightwave Tech., 2003
- **Araci** et al, Optics Express, 2005

Light-matter interaction



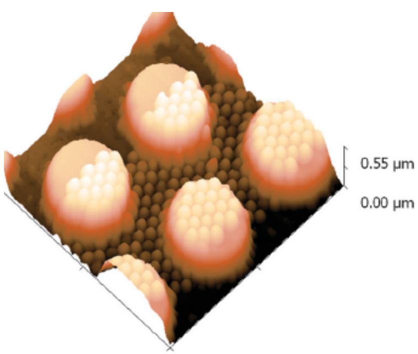
- **Araci** et al, Applied Physics Letters, 2010
- Demir V, **Araci** et al, Applied Optics, 2011
- Patent: “Tunable Infrared Emitter”, US20120235067 A1, licensed by Intex Inc.



- **Araci** et al, Optics Express, 2007
- **Araci** et al, Optics Express, 2010

- Micro/nanofabrication
- Photonics
- Plasmonics

Fluidic manipulation



- Thomas, Gangopadhyay, **Araci** et al, Advanced Materials, 2011

- Implantable microfluidic devices
- Digital biology
- Single cell analysis

What is Bioengineering?

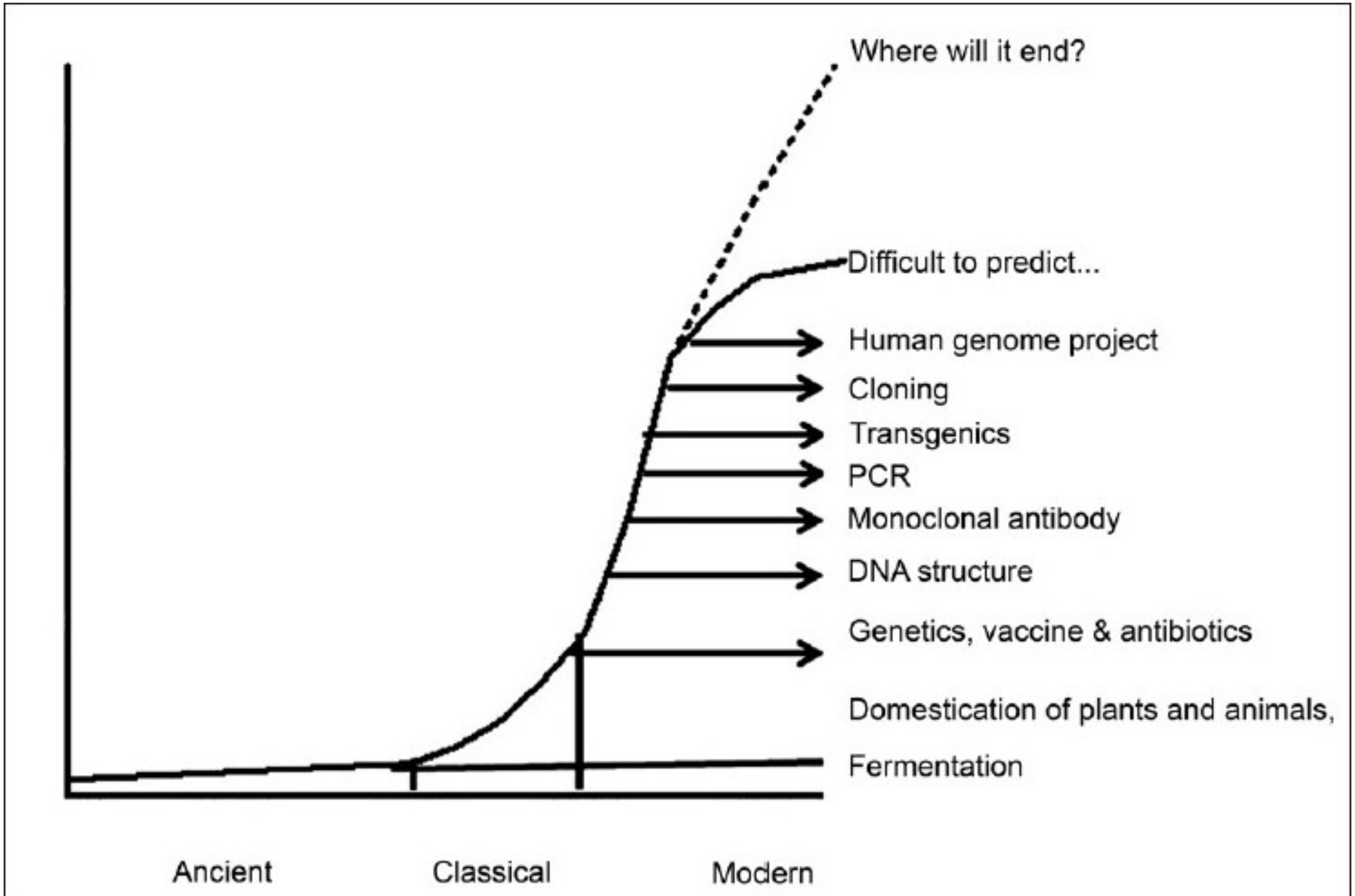
Definition from NIH

- Integrates physical, chemical, mathematical, computational sciences and engineering principles to study biology, medicine, behavior, and health

- Advances fundamental concepts and creates knowledge from the *molecular* to the *organ systems* levels

- Develops innovative biologics, materials, processes, implants, devices, and informatics approaches for the prevention, diagnosis and treatment of disease, for patient rehabilitation, and for improving health

Biotechnology in History



Diversity in Bioengineering Jobs

- Bio-Imaging Engineer
- Validation Engineer
- Vaccine Development Scientist
- Manufacturing Development Engineer
- Regulatory Affair Specialist
- Biostatistician
- Bioinformatics programmer
- Stent Engineer
- Fermentation Engineer
- Biomedical Engineer
- Membrane Scientist
- Bio-MEMS researcher
- Environmental Bio-safety Engineer
- Automation Engineer
- Tissue Engineer
- Formulation Scientist
- And many others……..

Biotechnology Occupations at a Glance: Employment Change and Job Openings

Key Occupation	Annual Average Employment		Employment Change		Average Annual Job Openings			Percent of Occupation in designated Biotech Industry [5]
	2010	2020	Numerical [1]	Percent	New Jobs [2]	Replace-ment Needs [3]	Total Jobs [4]	
Biochemical Engineers [6]	--	--	--	--	--	--	--	--
Biochemists and Biophysicists	6,400	8,800	2,400	37.5	250	140	390	87.5
Biological Technicians	11,400	13,300	1,900	16.7	180	390	570	84.2
Biologists [7]	--	--	--	--	--	--	--	--
Biomedical Engineers	4,000	6,700	2,700	67.5	270	90	360	96.3
Chemical Engineers	1,900	2,200	300	15.8	30	60	90	66.7
Chemical Technicians	6,200	7,100	900	14.5	90	90	180	22.2
Chemists	10,900	12,100	1,200	11.0	120	360	480	41.7
Compliance Officers	25,900	30,000	4,100	15.8	410	310	720	36.6
Electrical Engineers	21,000	23,200	2,200	10.5	230	510	740	13.5
Environmental Scientists and Specialists, Including Health	13,000	16,000	3,000	23.1	290	390	680	80
Epidemiologists [8]	--	--	--	--	--	--	--	--
Management Analysts	82,800	101,400	18,600	22.5	1,870	1,350	3,220	60.2
Market Research Analysts and Marketing Specialists	53,700	78,300	24,600	45.8	2,450	1,430	3,880	30.9
Medical and Clinical Laboratory Technicians	16,900	19,400	2,500	14.8	250	330	580	72
Medical and Clinical Laboratory Technologists	11,800	13,200	1,400	11.9	140	230	370	71.4
Medical Scientists, Except Epidemiologists	27,800	39,300	11,500	41.4	1,150	170	1,320	76.5
Microbiologists	3,600	4,400	800	22.2	80	80	160	75
Natural Sciences Managers	8,800	10,300	1,500	17.0	150	530	680	93.3
Statisticians	3,000	3,600	600	20.0	50	180	230	50
Technical Writers	6,400	7,700	1,300	20.3	120	130	250	38.5

Source: Employment Development Department, California

Projected Biotechnology Jobs by Economic Region, 2010–2020

Industries with Projected Biotechnology Jobs

- Pharmaceutical and Medicine Manufacturing
- Navigational, Measuring, Electromedical, and Control Instruments Manufacturing
- Medical Equipment and Supplies Manufacturing
- Professional and Commercial Equipment and Supplies Merchant Wholesalers
- Chemical and Allied Products Merchant Wholesalers' Management
- Scientific and Technical Consulting Services
- Scientific Research and Development Services
- Postsecondary Colleges, Universities, and Schools
- Medical and Diagnostic Laboratories
- Federal, State, and Local Government

This map will be updated as projections are completed for additional counties.

Greater Sacramento does not include projections for Sutter County or Yuba County.

Bay Area does not include projections for Napa County, Santa Cruz County, or Solano County.

San Joaquin Valley does not include projections for Madera County, Merced County, or Tulare County.

Southern California does not include projections for Ventura County.

Southern Border does not include projections for Imperial County.

Data Source:
Occupational Research Group
Labor Market Information Division
California Employment Development Department

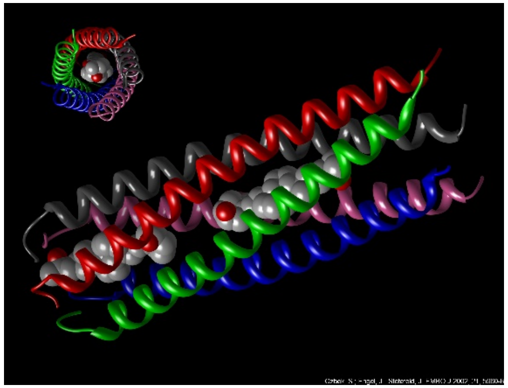
Cartography by:
Labor Market Information Division
California Employment Development Department
June 2013

Source: Employment Development Department, California

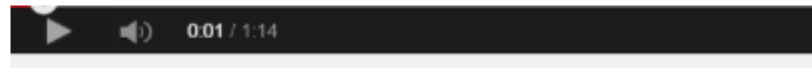
Commonly encountered bioengineering technologies and recent advances

Biomaterials

SMART POLYMERS

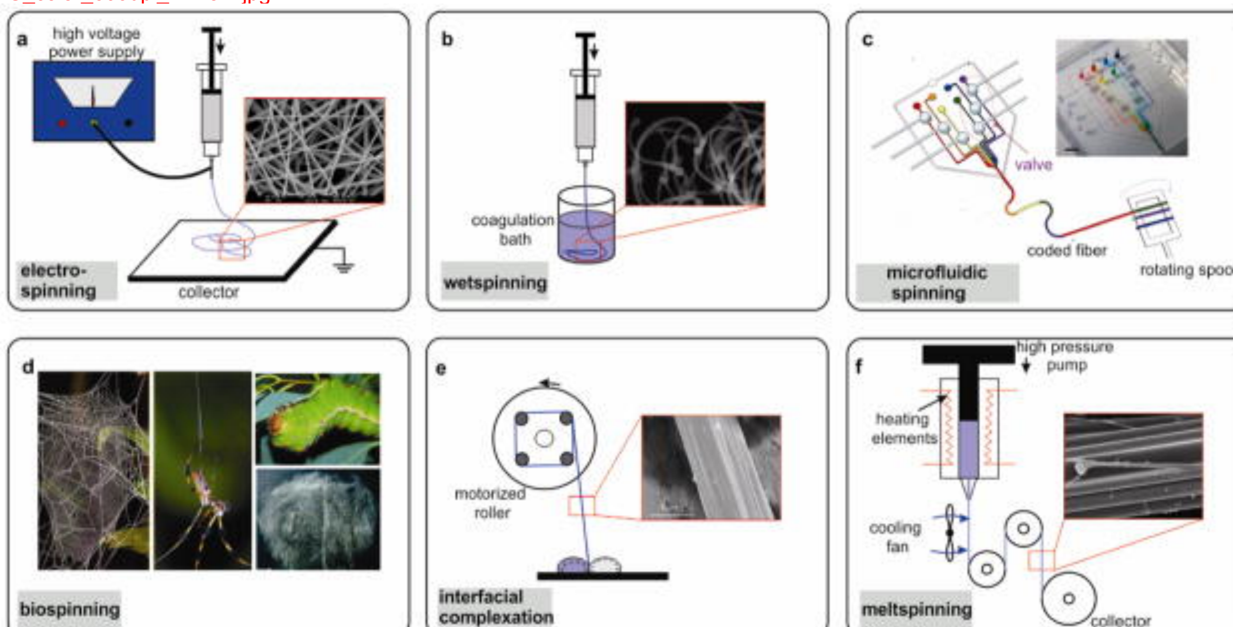


http://engineering.nyu.edu/files/pressrelease/COMPcc_blackBG_color_600dpi_4inx3in.jpg



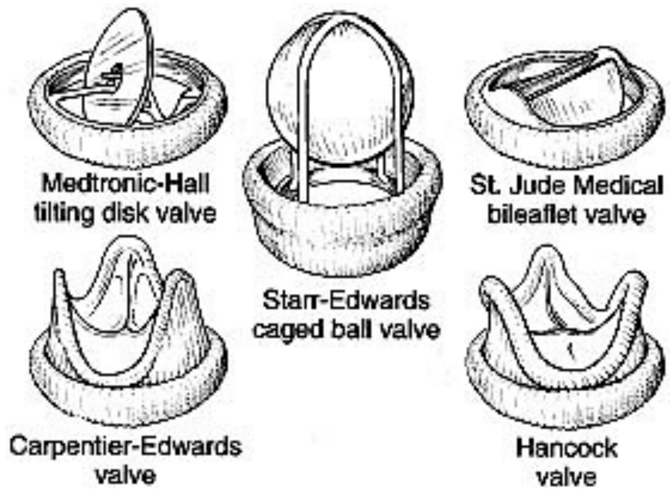
Light-Activated Glue for A Broken Heart

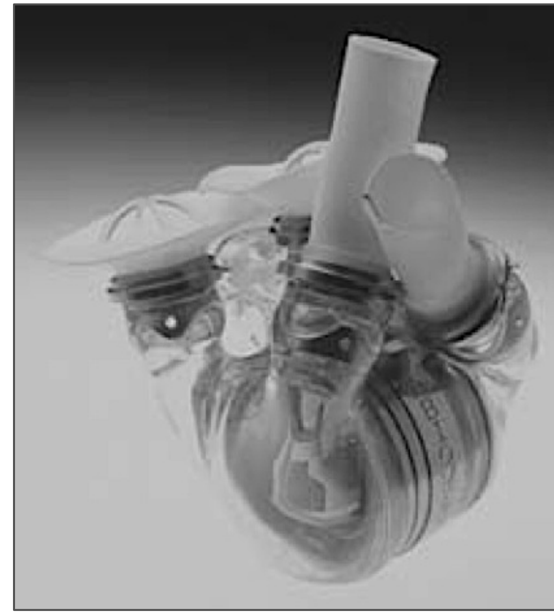
http://www.youtube.com/watch?v=iaZhJuxPNpA



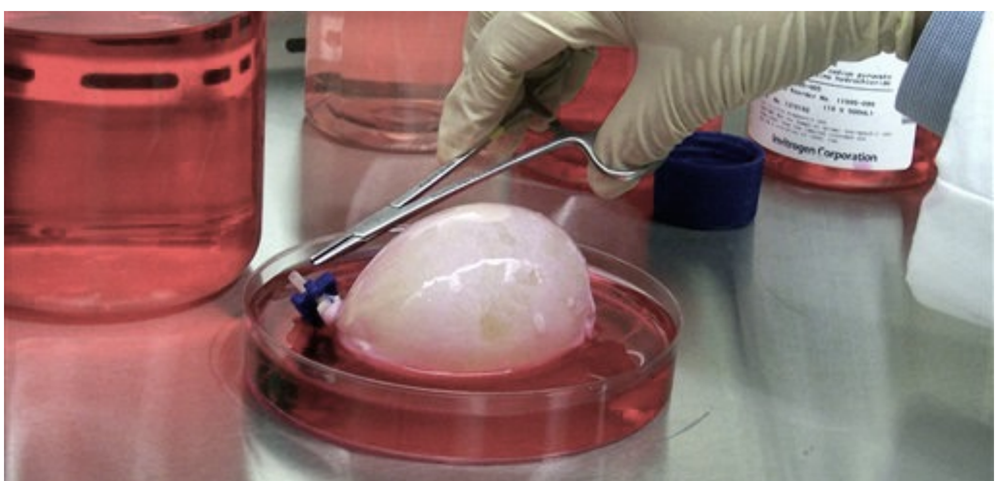
http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3631569/

Artificial organs & Tissue engineering



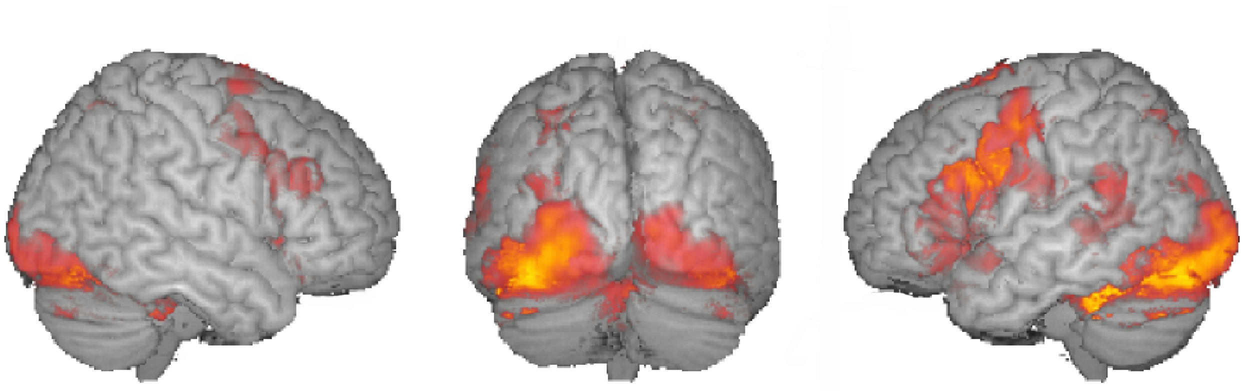


Source: Texas Heart Institute

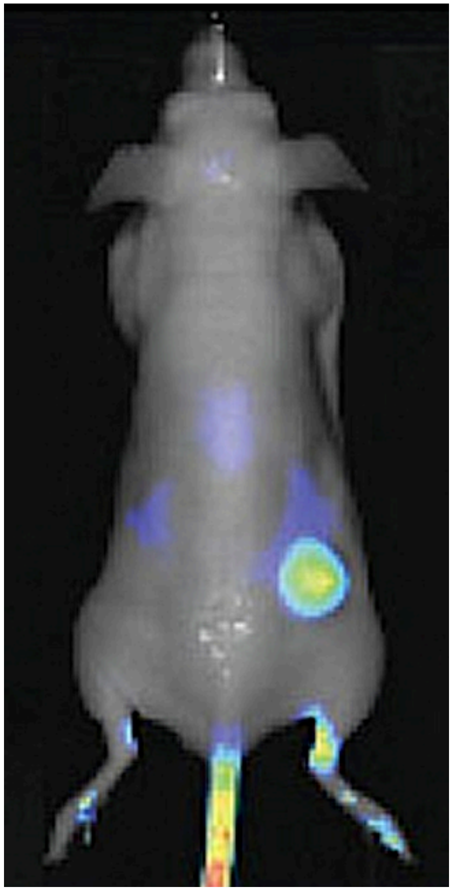


Source: Antony Atala Lab

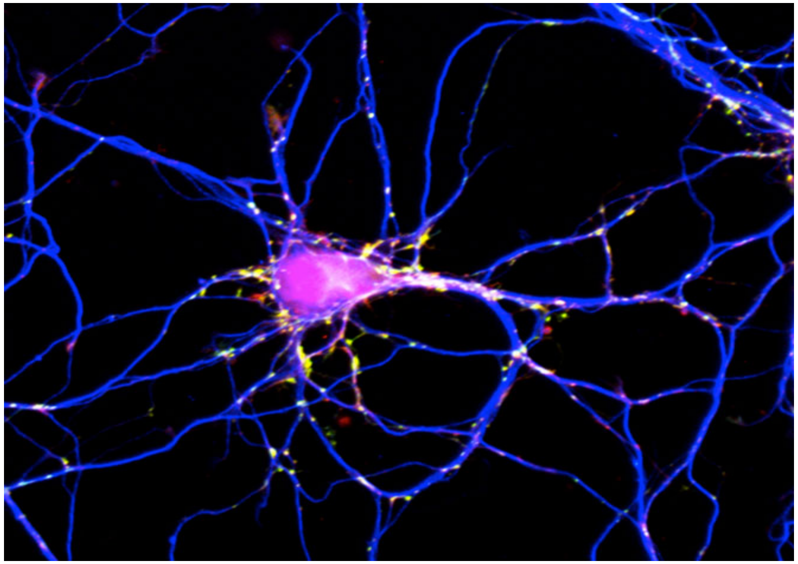
Biomedical imaging



Source: New York University

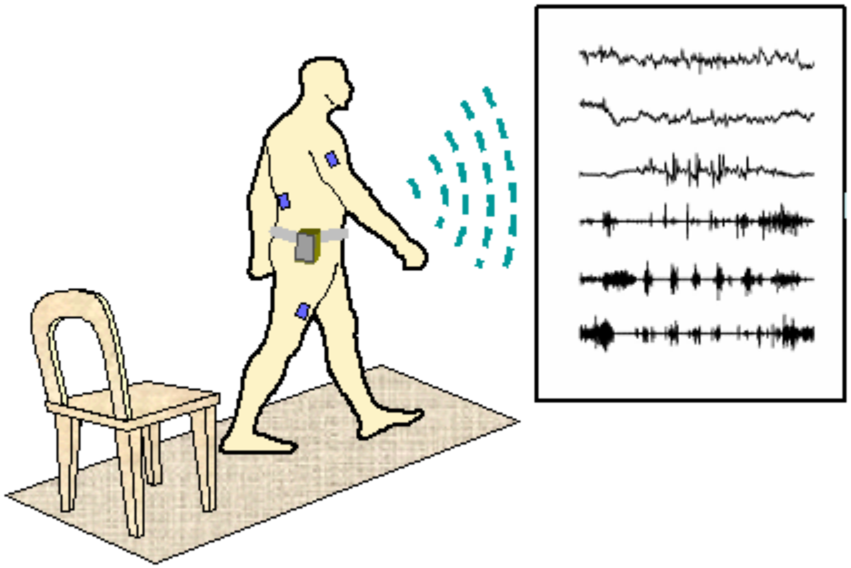


Source: LI-COR Biosciences



Source: British Society for Cell Biology

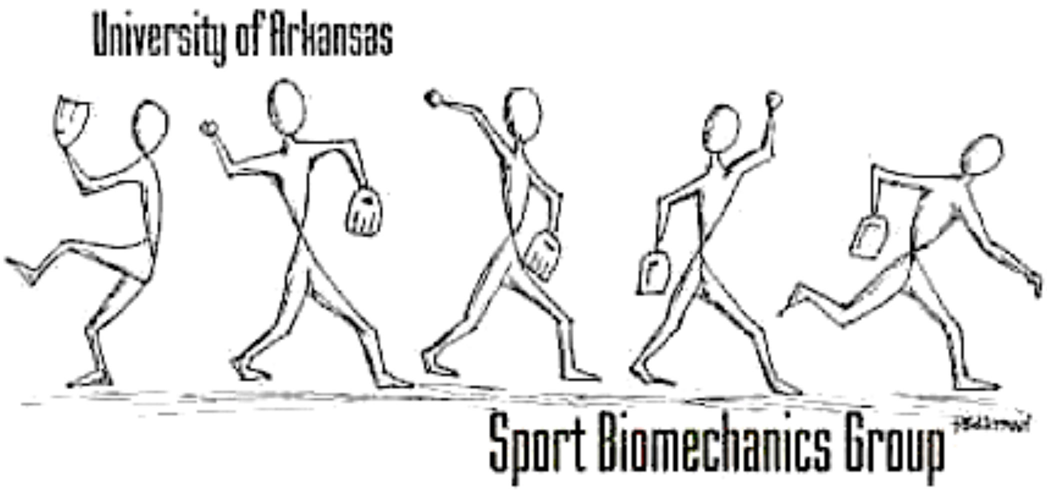
Bio-Signals

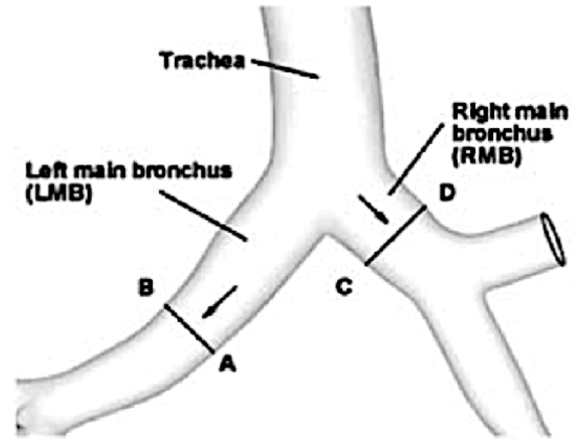


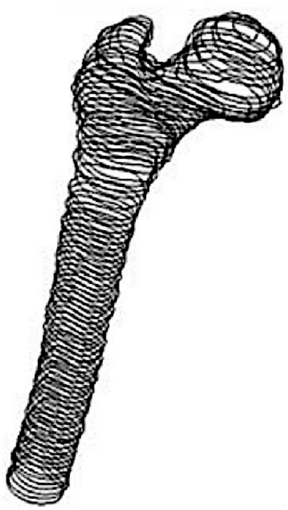
https://youtu.be/CDsNZJTWw0w?t=9m58s

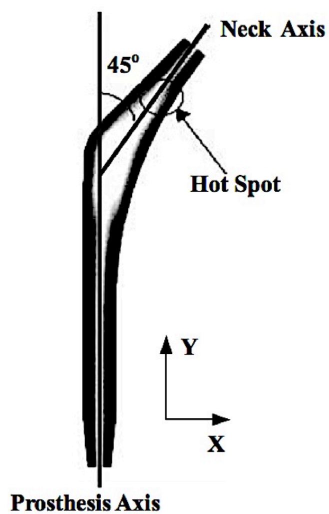
http://sites.ieee.org/scv-mems/files/2014/01/TSensors-1-22-14_final.pdf

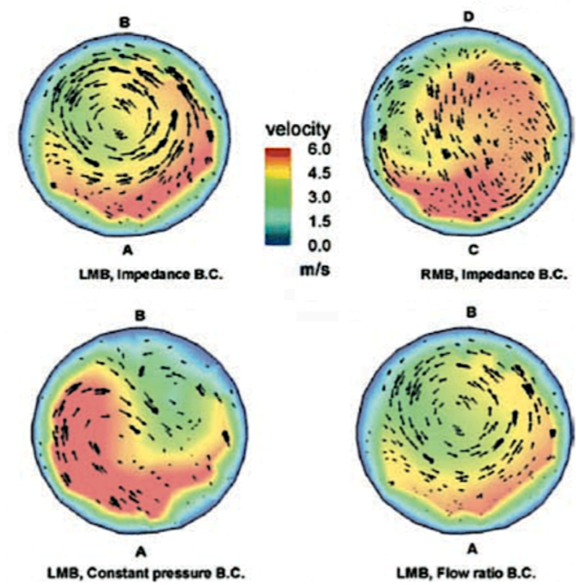
Biomechanics & Physiological Modeling



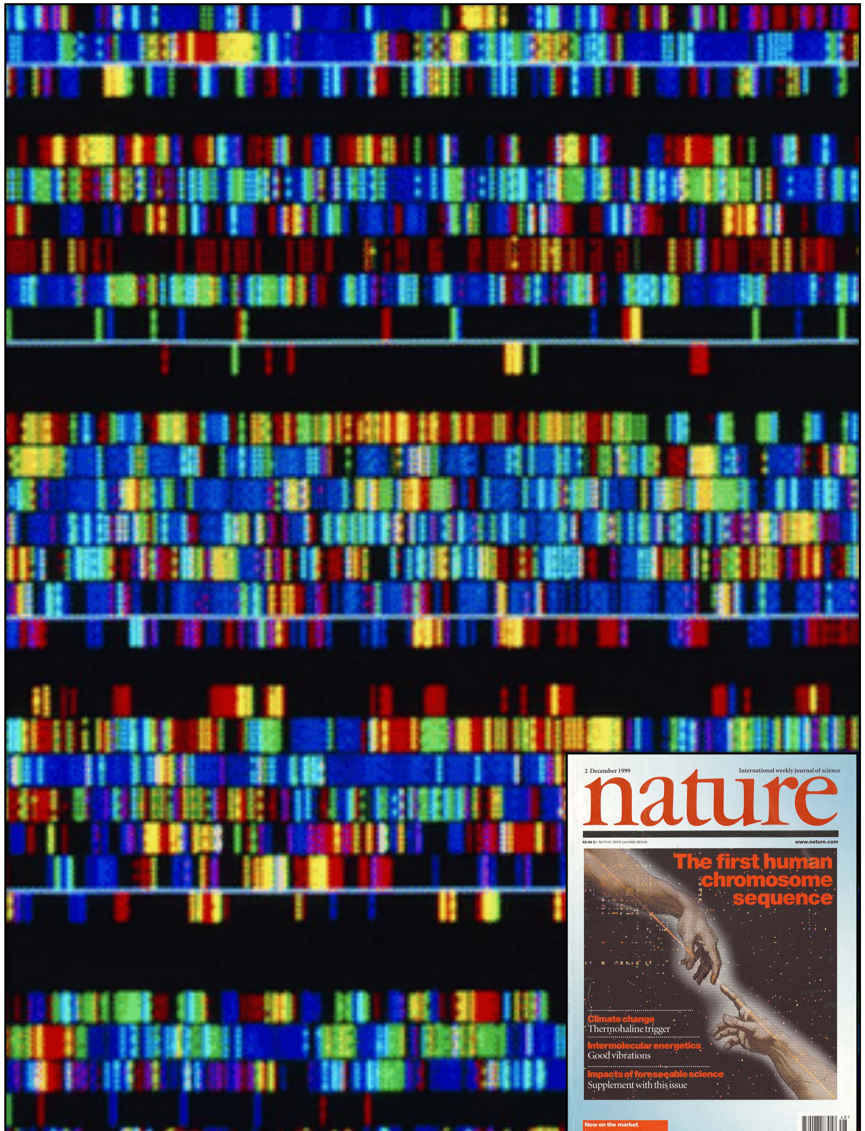


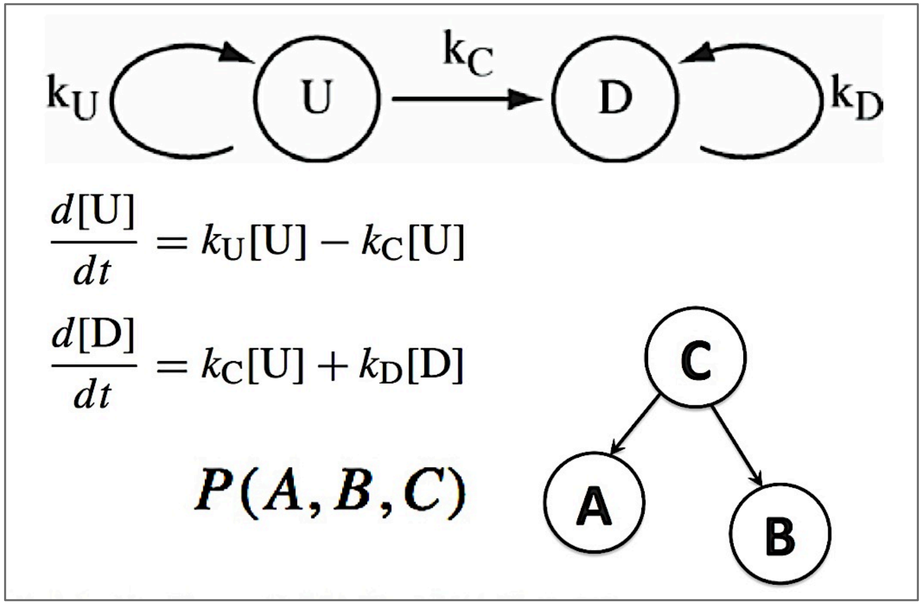


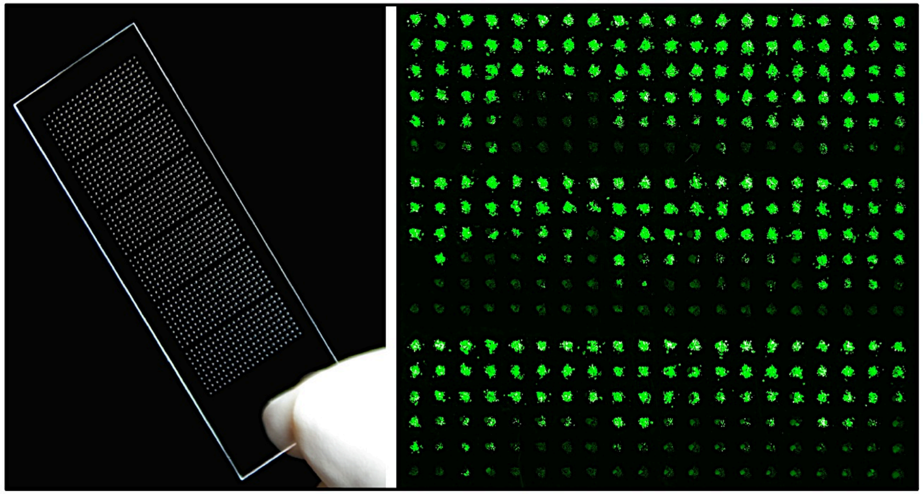




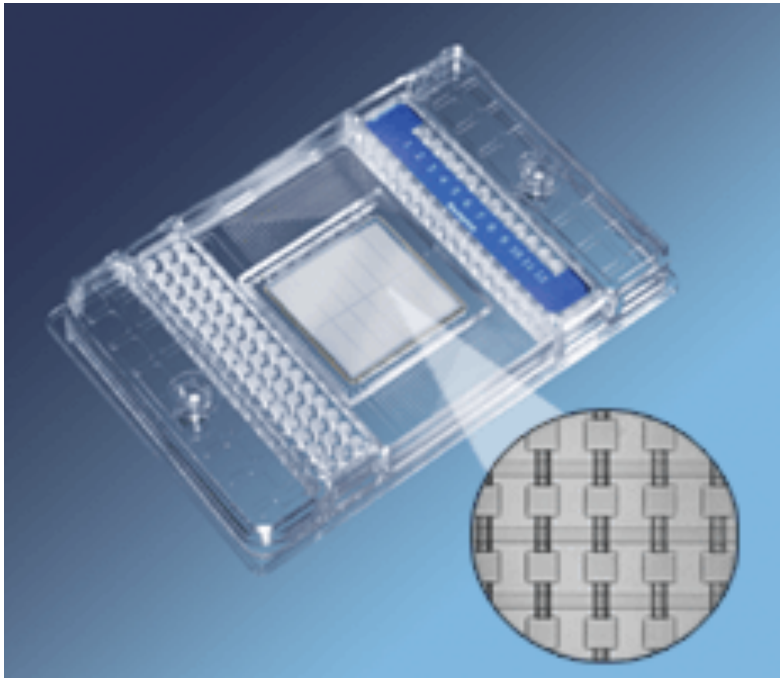
Genomics and Bioinformatics



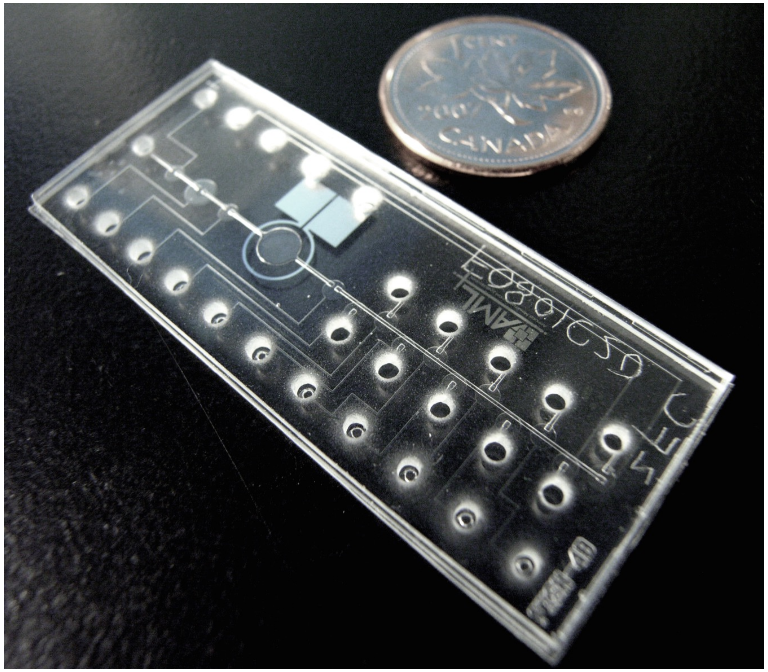




Microfluidics and Bio-MEMS



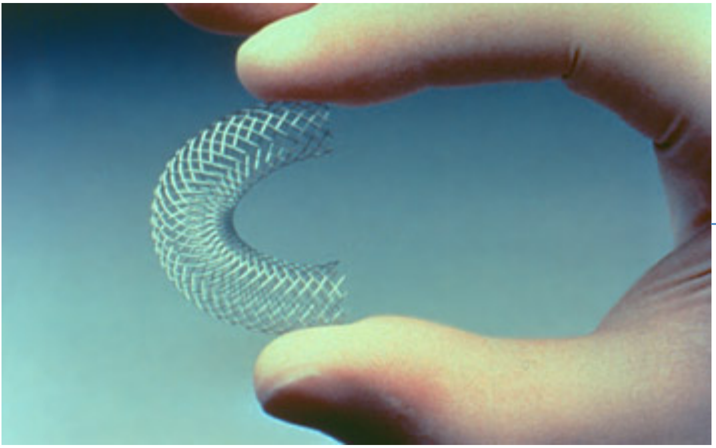
Source: Fluidigm



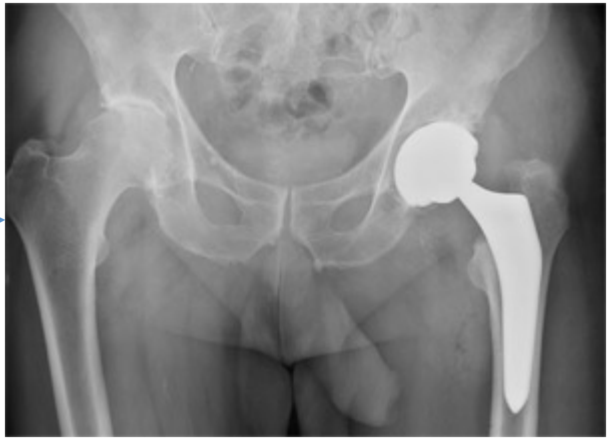
Source: Wikipedia

Bio-Medical Devices

A broad range of surgical devices and equipment used in cardiovascular, orthopedics, respiratory, ophtalmic, neurology, urinary, disposable and other applications.



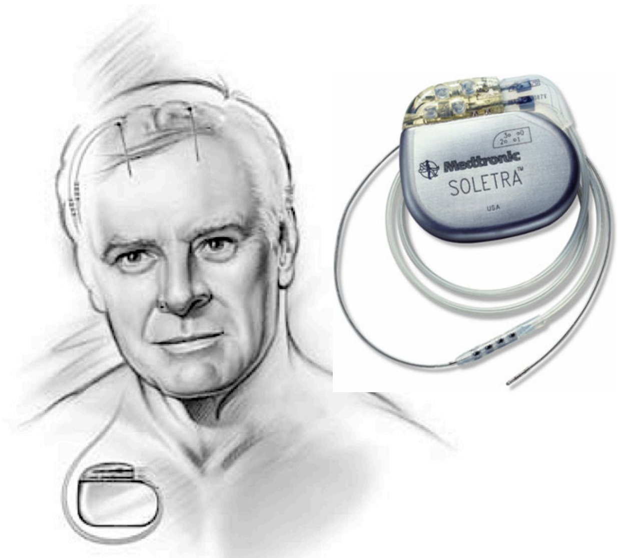
http://virchicago.com/carotid-artery-blockage/



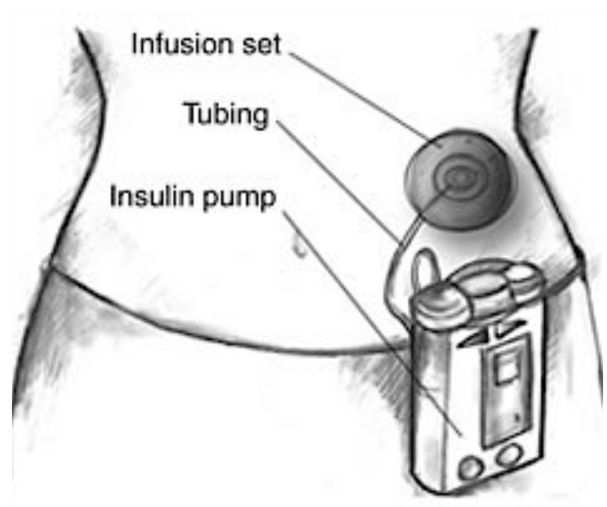
Medical devices and implants

- blood glucose testing
- blood gas and electrolytes analysis
- rapid coagulation testing
- rapid cardiac markers diagnostics
- abuse of drugs screening
- urine strips testing
- pregnancy testing
- fecal occult blood analysis
- food pathogens screening
- hemoglobin diagnostics
- **infectious disease testing**
- cholesterol screening

Gerald J. Kost: Principles and Practice of Point-of-Care Testing, 2002



Source: Medtronic



Source: NIH NIDDK

Bringing 21st century Bioengineering to Santa Clara University

SCU Bioengineering faculty

Dr. I. Emre Araci
Implantable, miniaturized microfluidic technologies

Dr. Prashanth Asuri
in vitro platforms that mimic *in vivo* conditions

Dr. Ashley Kim
Integrated microfluidic sensors and devices

Dr. Bill Lu
Molecular sensors and genome engineering

Dr. Yuling Yan
Biomedical imaging; Image and signal analysis

Dr. Jonathan Zhang
Protein engineering; Bio-device engineering

Dr. Maryam Mobed-Miremadi
Bio-membrane characterization and transport modeling

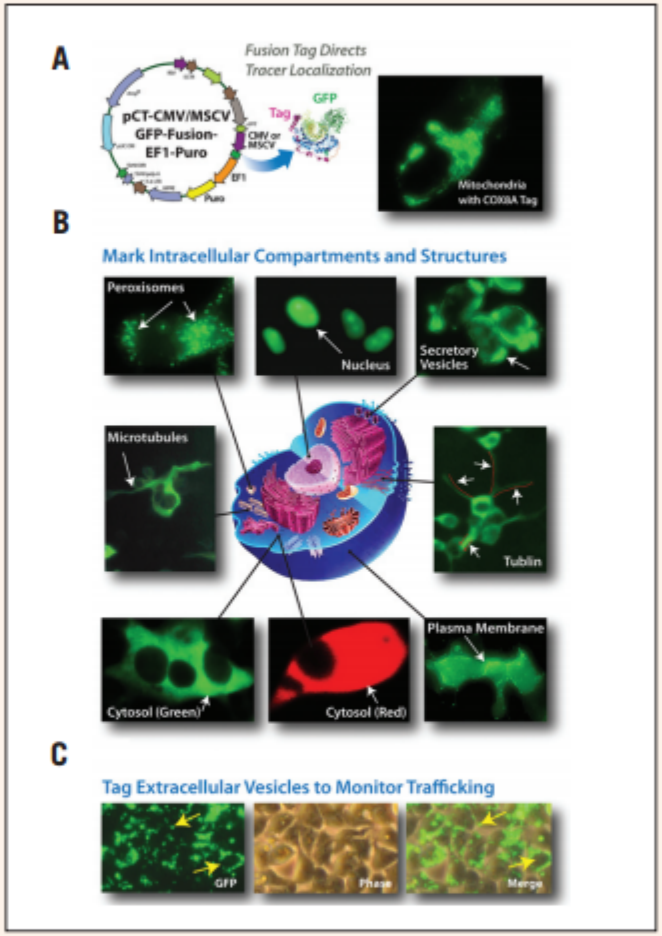
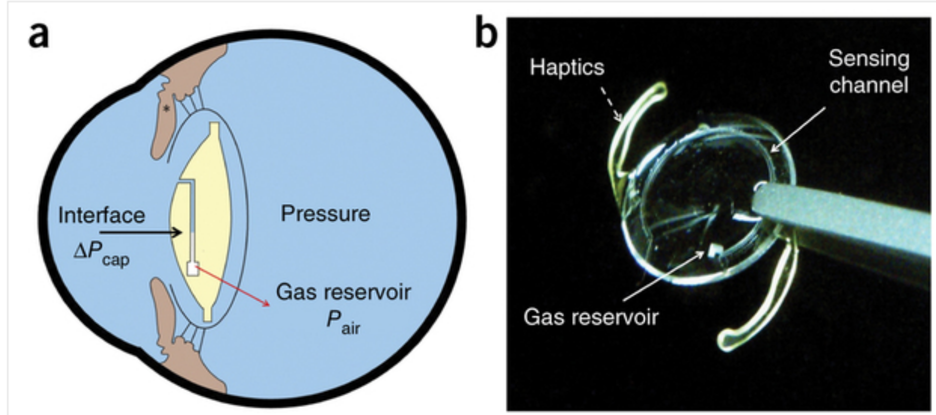


Figure 1. Construction and expression of Cyto-Tracers. Vector configuration and expression of fluorescent fusion proteins using Cyto-Tracers (A). Transient transfection of HEK293 cells shows the specific GFP lighting of various intracellular organelles or structures (A and B). Viral transduction of human fibroblastoma HT1080 cells with CD63-Cyto-Tracer GFP fusion construct shows the formation of intracellular vesicles and subsequent secretion of the exosomes (C).

http://www.biotechniques.com/multimedia/archive/00108/BTN_A_000113553_O_108677a.pdf

Figure 1: IOP measurement system embedded in an intraocular lens.



(**a**) The embedded IOP sensor can be implanted into the eye of a patient with glaucoma during a routine cataract surgery or as a stand-alone implant. Intraocular fluid (aqueous) enters the sensor channel and fills it until equilibrium between IOP and the air inside channels is achieved. The gas-liquid interface (solid black arrow) is captured by a camera or a smartphone equipped with optical and illumination adaptor. The gas-fluid interface is detected by image processing and the pressure (P) is calculated and recorded for follow up and can be optionally sent to the patient's eye care givers. ΔP_{cap}, capillary pressure within the channel; P_{air}, air pressure within the reservoir. *, iris. (**b**) Photograph of the microfluidic pressure sensor embedded within the intraocular lens. A 50-μm-wide channel is connected on one side to the eye aqueous and on the other side to a 500 × 500 × 300 μm^3 volume gas reservoir. Lens arms (haptics, dashed white arrow) are used for stabilizing the lens in place within the eye.

http://www.nature.com/nm/journal/v20/n9/full/nm.3621.html

Bioengineering Laboratories

Biomolecular Engineering Laboratory
Facilitates processing of synthetic biomolecules towards biomedical and industrial applications.

Tissue Engineering Laboratory
Equipped to design & develop *in vitro* functional biological substitutes and toxicity screening models.

Micro/Nanosystems Laboratory
Develops innovative microfluidic platforms for applications in diagnostics and cellular engineering.

Biosignals Laboratory
Wide range of instrumentation and computational systems to analyze and interpretate various human biosignals.

Examples of Senior Design Capstone projects

- Engineering mammalian cells as biosensors to detect diseases
- Detecting baby at home: detect fetal movement using ultrasound
- Probing mechanical properties of stem cells using AFM
- SAFire: Gas sensing mechanism to prevent surgical airway fires during electrosurgery *(In collaboration with Medtronics)*
- Pathogen detection using microfluidic electrochemical DNA sensors
- Improving mechanical strength of biological glues using nanotubes
- Recognition of blood vessel proximity using Doppler Ultrasound
- Transcutaneous transfer of radio frequency energy as an alternative power source for implantable medical devices
- TheraPE - a minimally invasive pulmonary embolectomy device *(In collaboration with GVMED)*

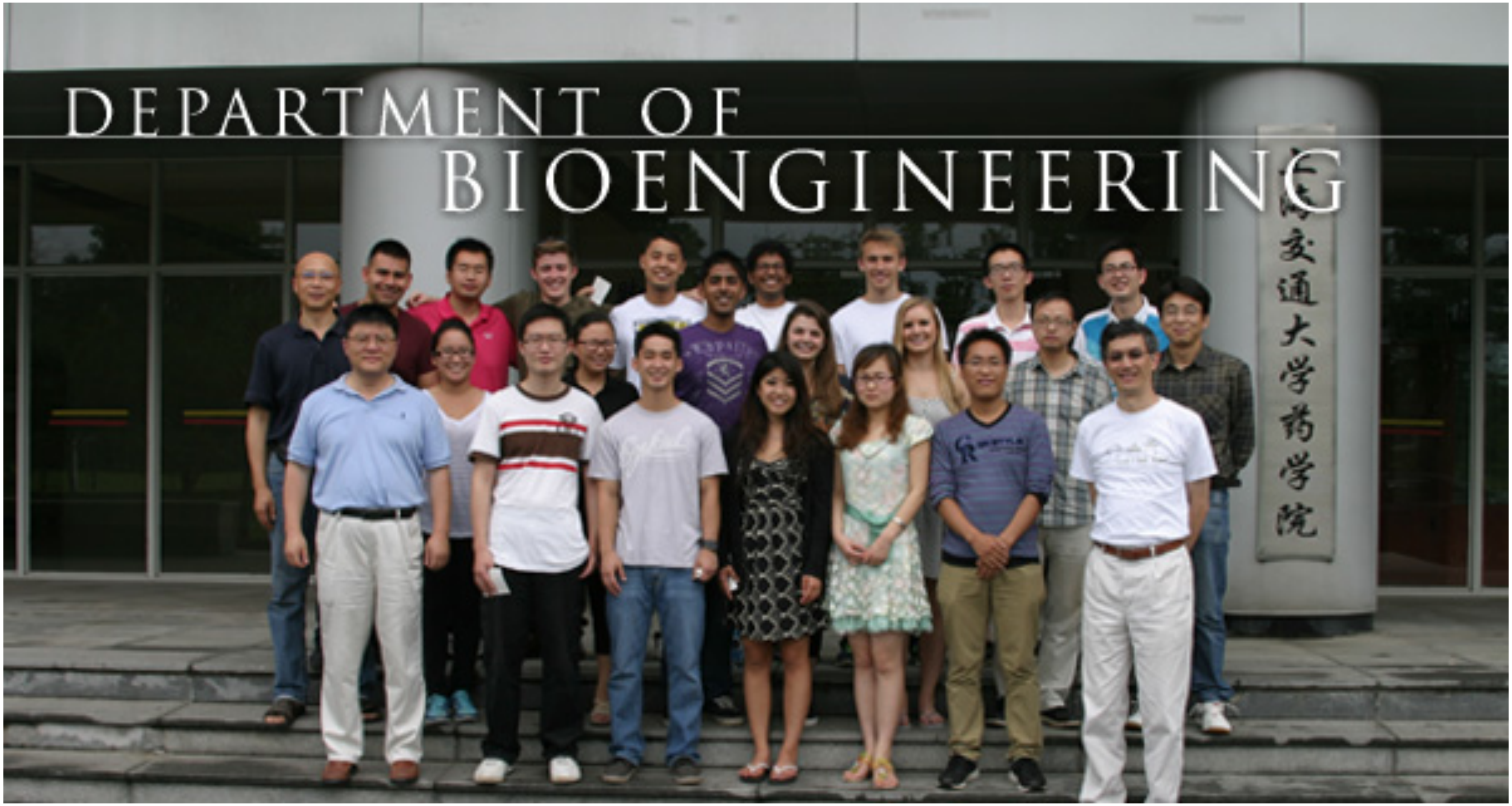
Student presentations at National & International conferences

- Miniaturized Systems for Chemistry and Life Sciences (µTAS)
- American Chemical Society
- Materials Research Society
- American Institute of Chemical Engineering
- Biomedical Engineering Society
- IEEE Engineering in Medicine and Biology Society
- International Conference on Bioinformatics & Bioengineering
- International Conference on Computational & Mathematical Biomedical Engineering
- Annual Pacific Voice & Speech Foundation Conference

Student research published in peer-reviewed journals

- Biotechnology & Bioengineering
- Protein Science
- Proceedings of the IEEE Biomedical Circuits and Systems
- PloS One
- Cellular and Molecular Bioengineering
- AIChE Journal
- Journal of Experimental Biology and Medicine
- World Journal of Stem Cells
- IEEE Journal of Translational Engineering in Health and Medicine

International summer exchange program



Jointly organized by Department of Bioengineering, Santa Clara University and Shanghai Jiao Tong University School of Pharmacy

SCU BIOE students – where are they now?

- UC-Berkeley, UCSF, UCLA, UCSC
- Johns Hopkins
- Columbia University
- Stanford University
- Rensselaer Polytechnic Institute
- University of Kentucky
- Oregon State University
- John A. Burns School of Medicine, Hawaii

BIOE students - where are they now ?

TESLA

Acclarent

MULTISPAN

avinger

MAXIM

spiracur

AMGEN

Complete genomics

CSS-Dynamac

Genentech
A Member of the Roche Group

Boston Scientific

Medtronic

stryker

INTUITIVE SURGICAL®
da Vinci Surgery

CARDIODX

Google

HITACHI
DATA SYSTEMS

NASA

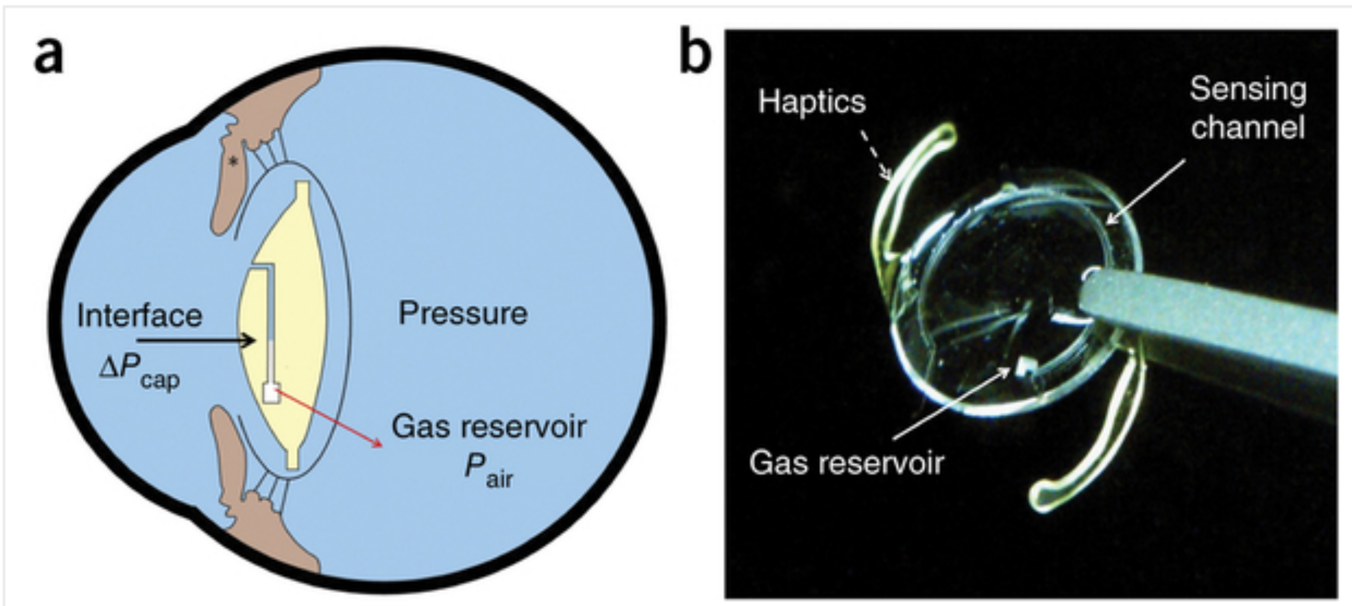
Bioengineering – next steps

- Mobile health, telemedicine, remote monitoring
- Implantable & wearable medical devices
- Biocircuits and Bioelectronic systems
- Biological photovoltaic devices
- Total simulation of the human body
- Personalized and precision medicine
- 3D bioprinting of tissues and organs

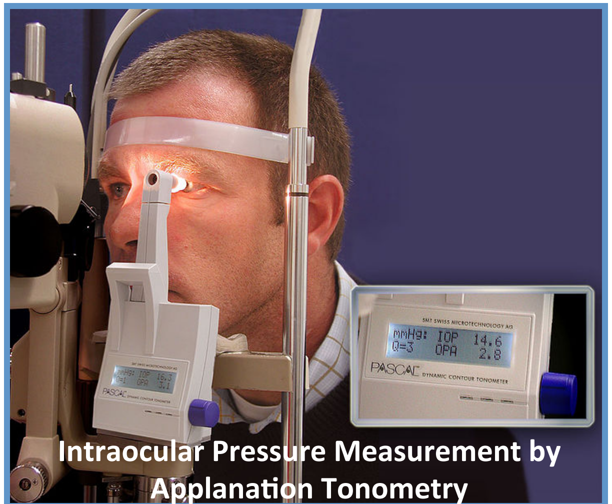
Thank You

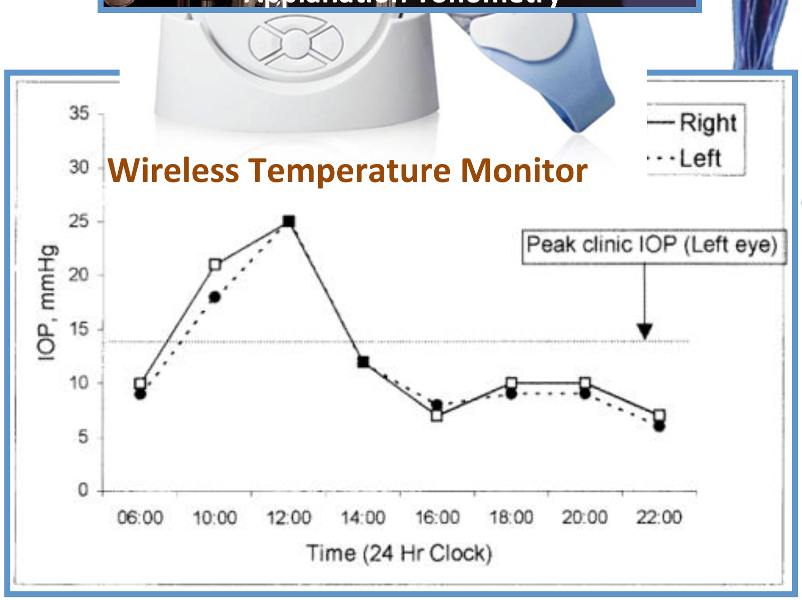
Any Questions?

Intraocular pressure sensing lens using microfluidics

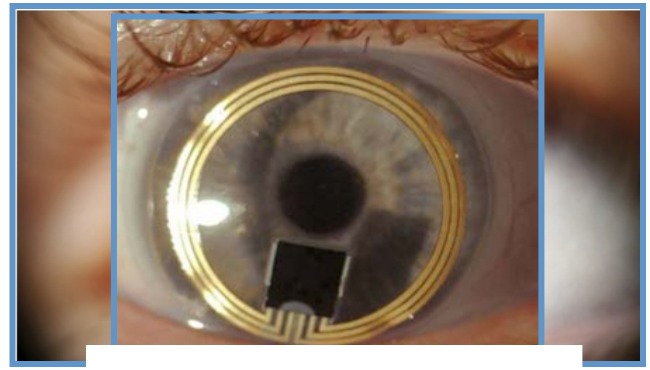


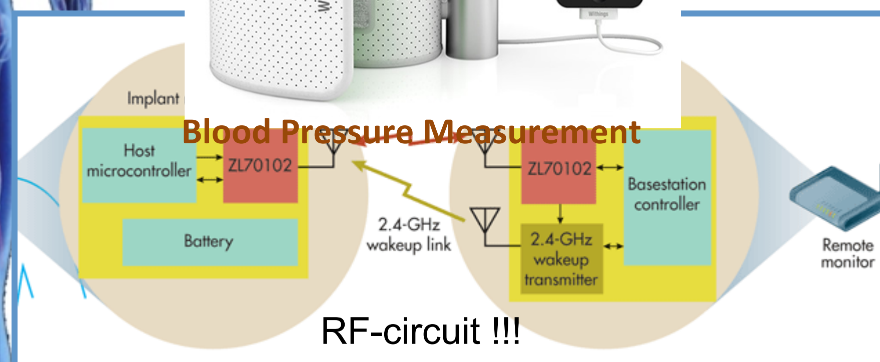
Continuous Monitoring for Healthcare Management



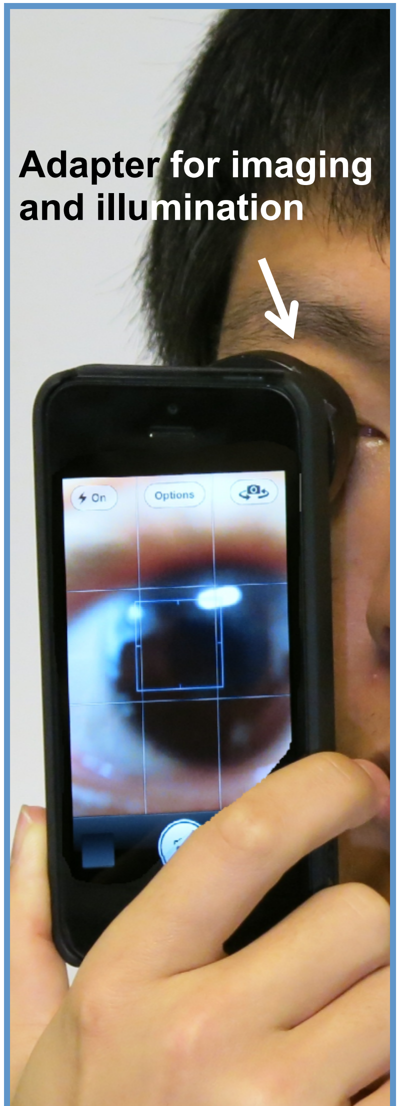


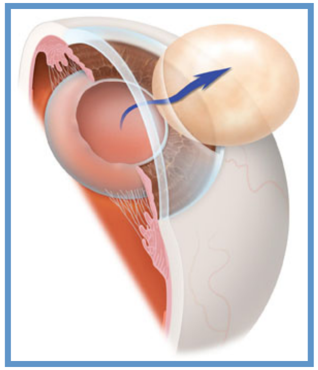
Hughes et al, J. of Glaucoma, 2003



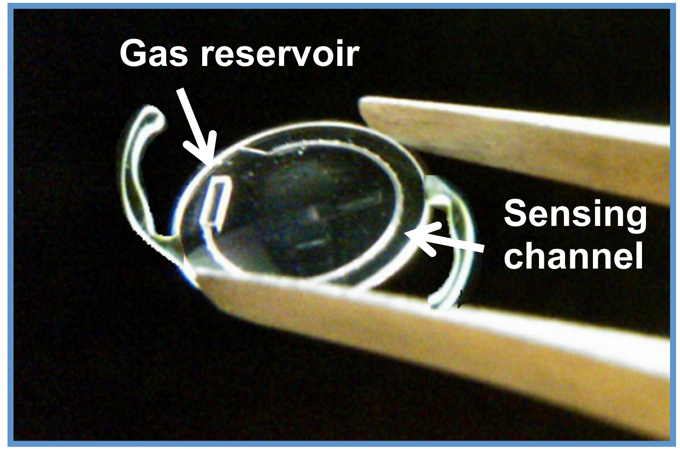


Conceptual Workflow of Our Technique





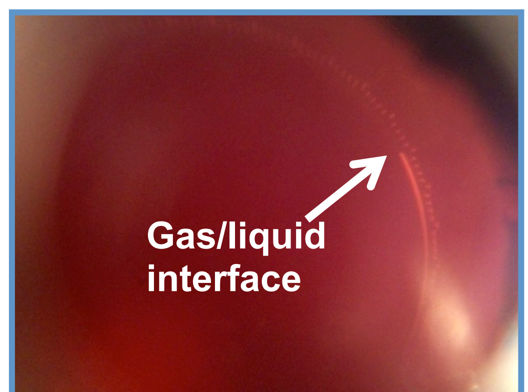
www.glaucoma.org



IOP sensor embedded IOL

Implant

Detect



Smart phone image of an implanted IOP sensor

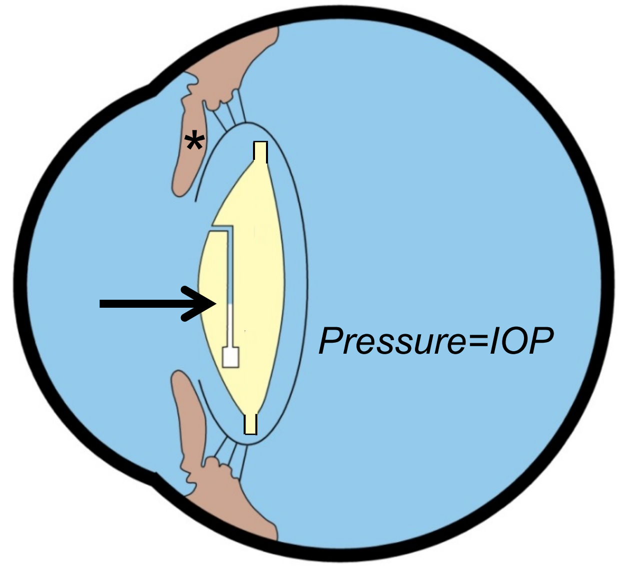
Readout

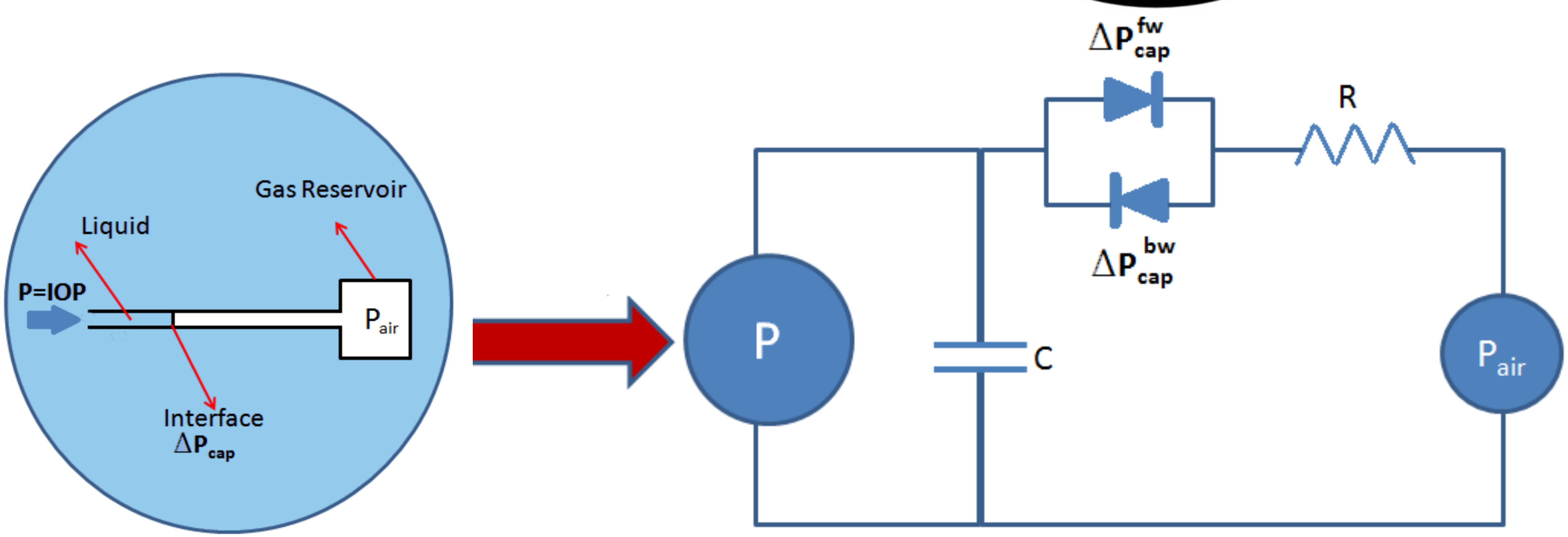
IOP Sensor Operates Based on Fluidic Physics

Boyle's Law:

P x V is always constant

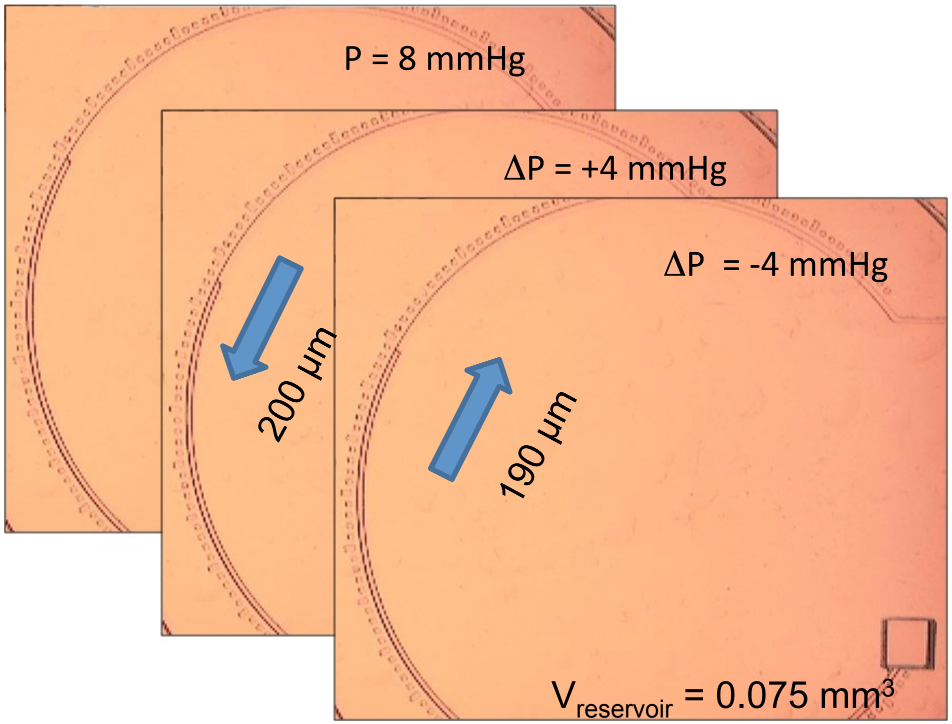
$$\text{Sensitivity} \quad \propto \frac{V_{res}}{A_{ch}}$$

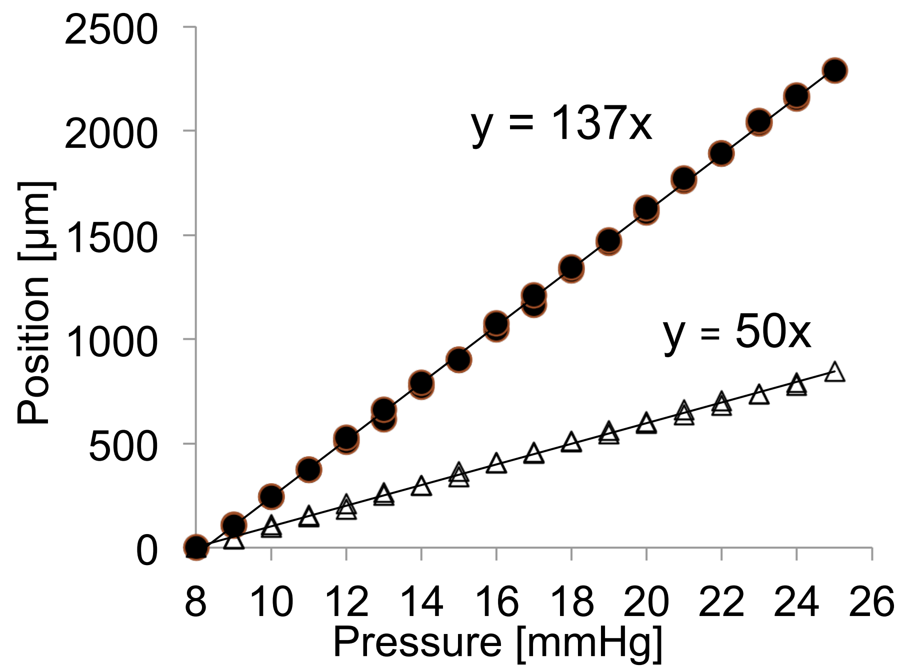




- **Araci** et al, Nature Medicine, 2014
- Patent "Implantable microfluidic based intra-ocular pressure monitoring", PCT/US2014/019660.

Sensor Response is Linear Inside Pressure Chamber

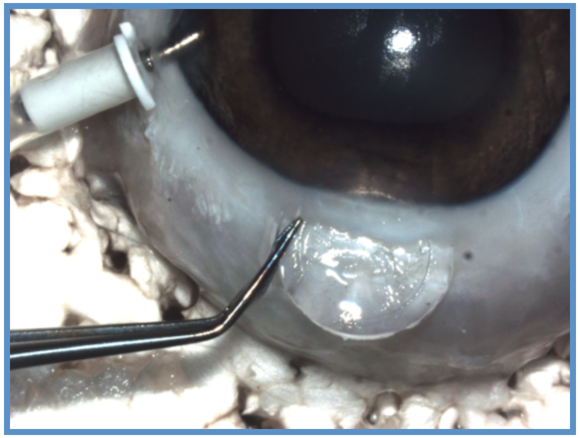


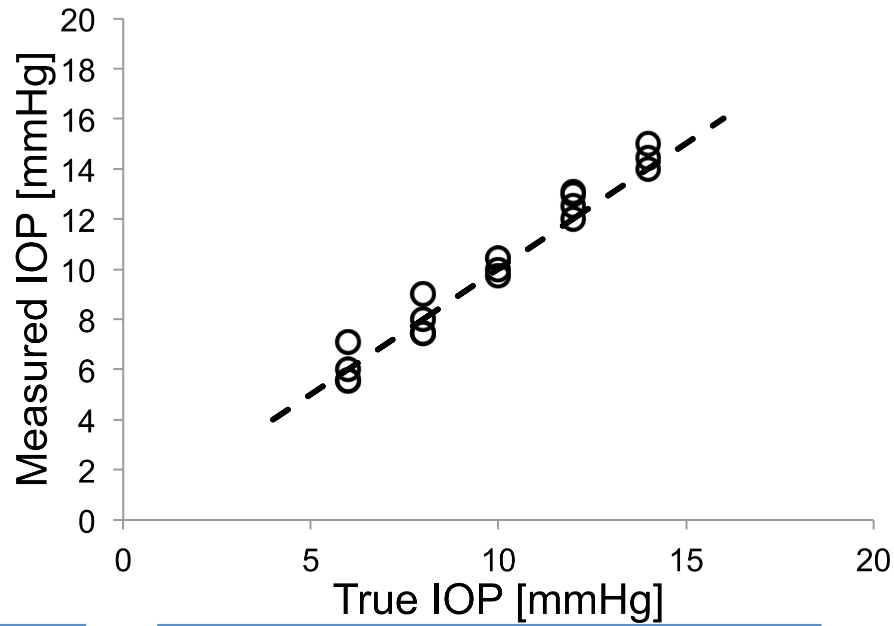


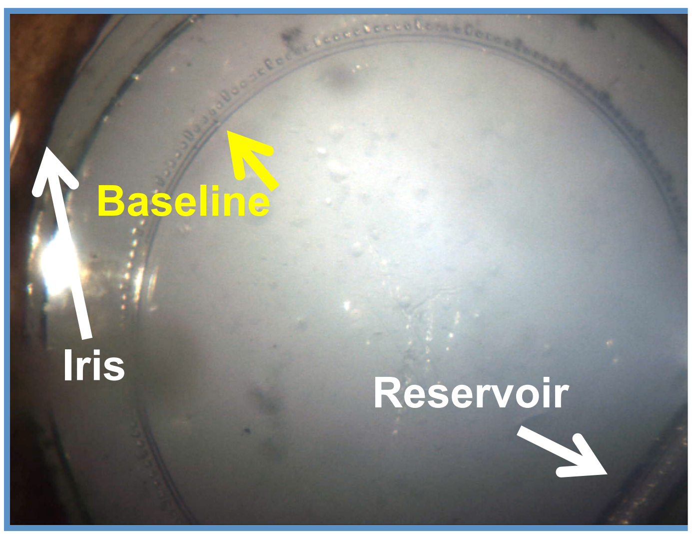
- **Araci** et al, Nature Medicine, 2014
- Patent "Implantable microfluidic based intra-ocular pressure monitoring", PCT/US2014/019660.

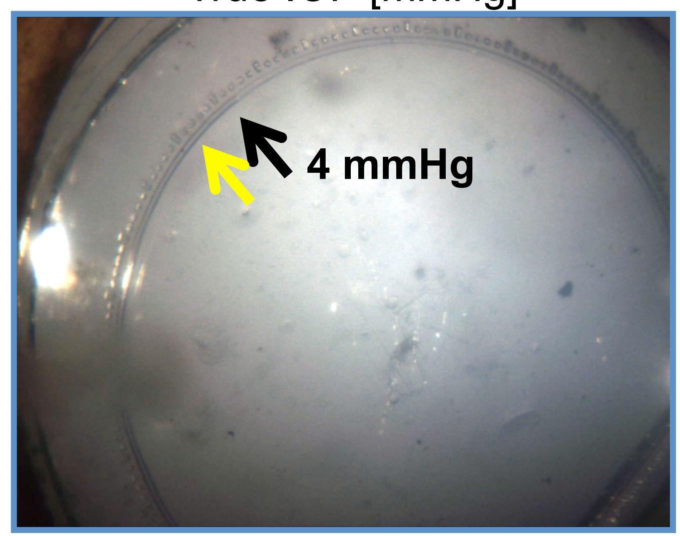
Real-time Sensor Response to Pressure Changes

Sensor Implanted into Enucleated Porcine Eye

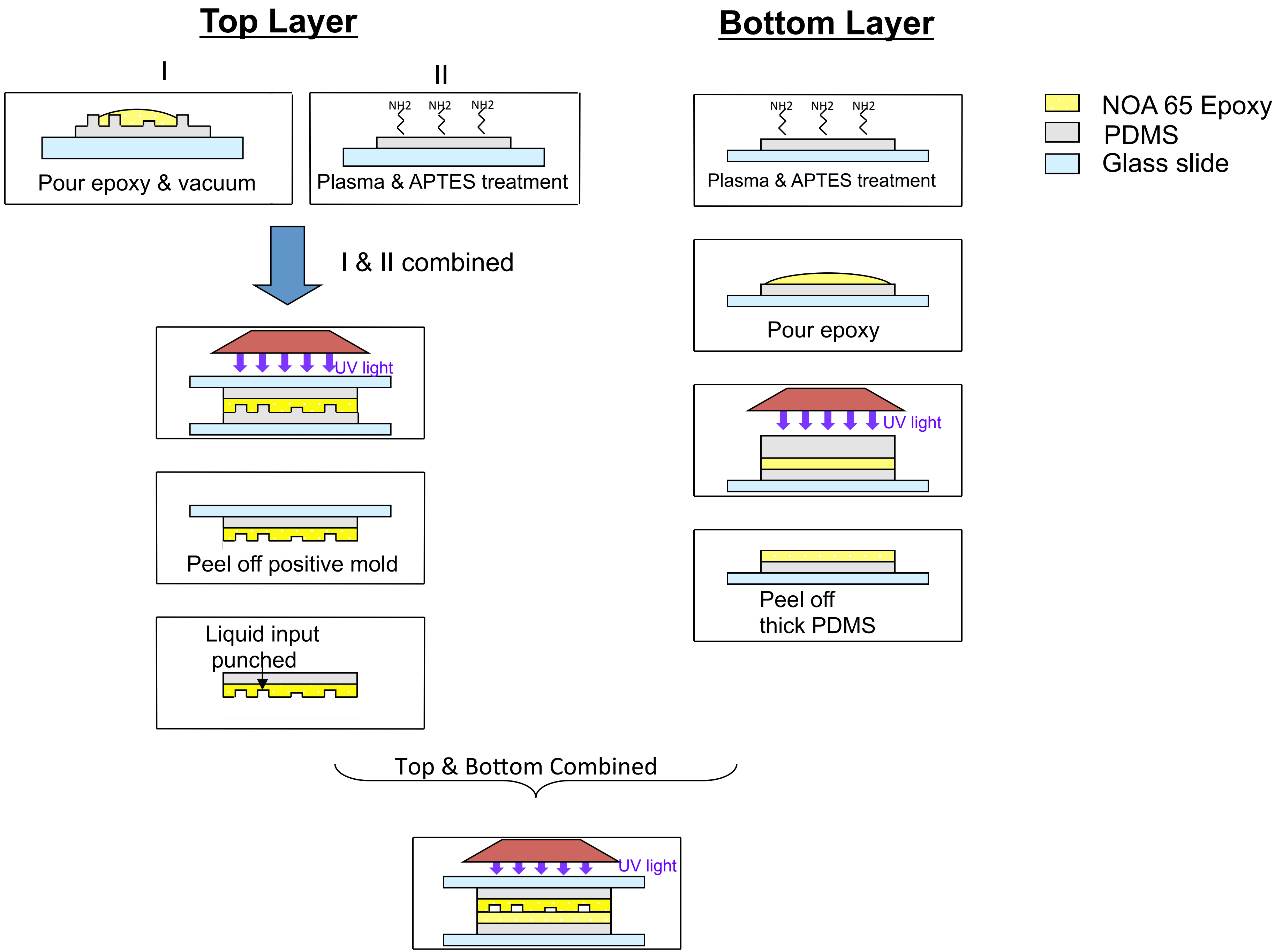








Araci et al, Nature Medicine, 2014

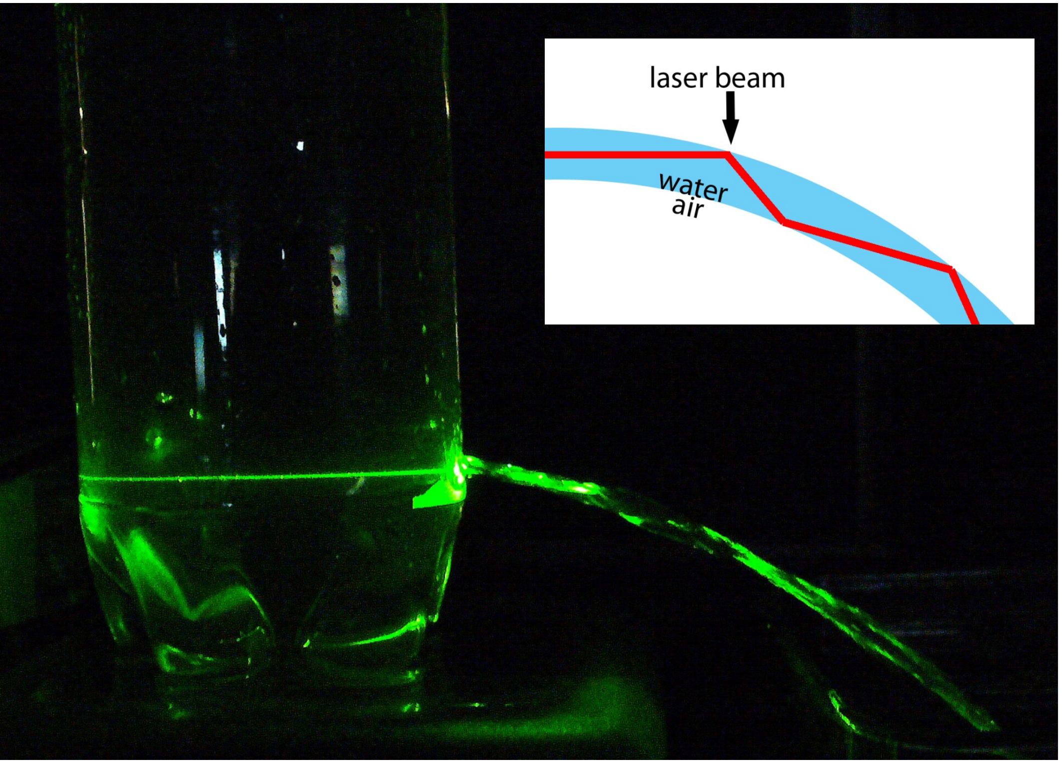


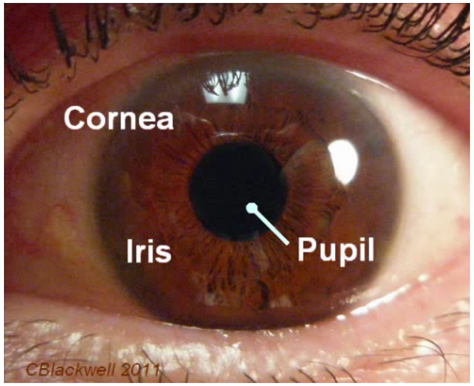
Top Layer
Bottom Layer
I
II
Pour epoxy & vacuum
NH2 NH2 NH2
Plasma & APTES treatment
NOA 65 Epoxy
PDMS
Glass slide
I & II combined
UV light
Pour epoxy
Peel off positive mold
Peel off
thick PDMS
Liquid input
punched
Top & Bottom Combined

Thank You

Any Questions?

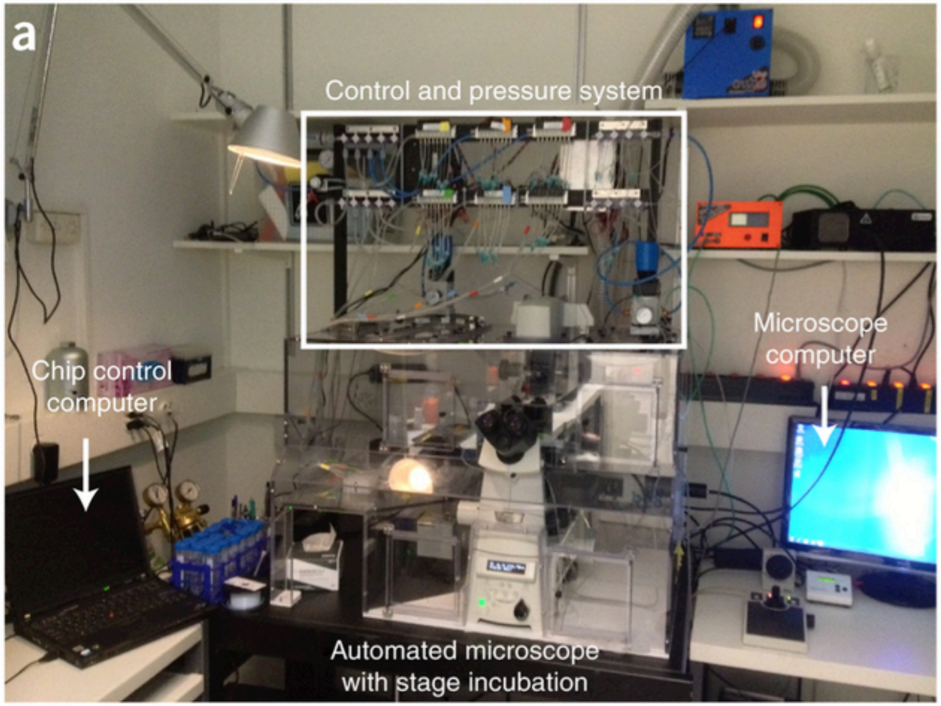
Optofluidics





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