BioPhotonics

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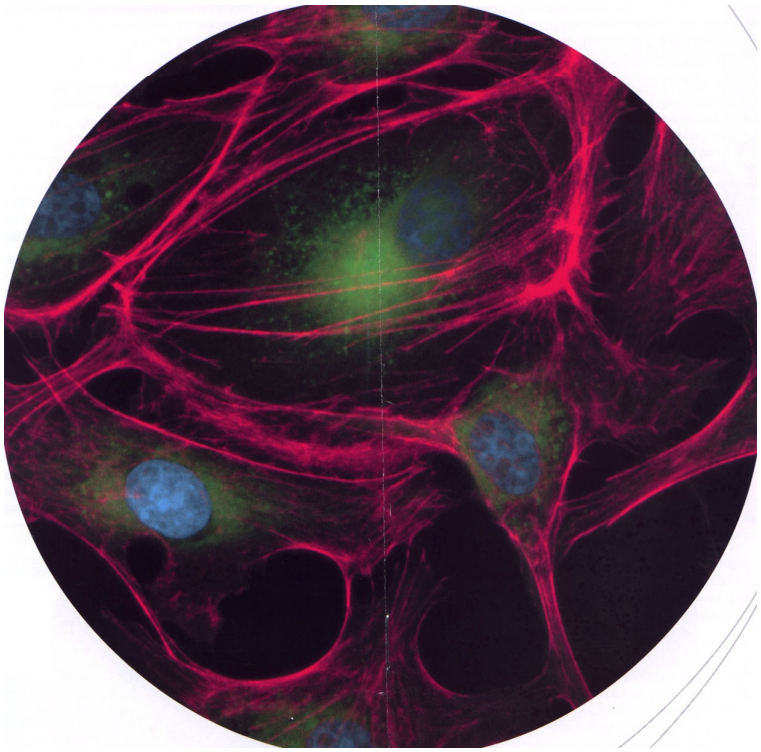
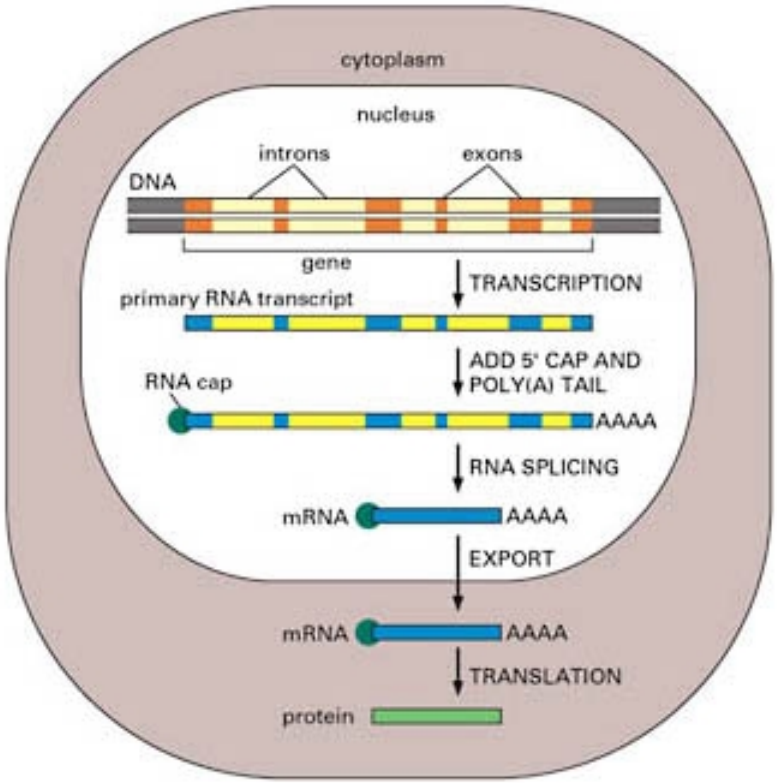
The Cell as a Biological Unit

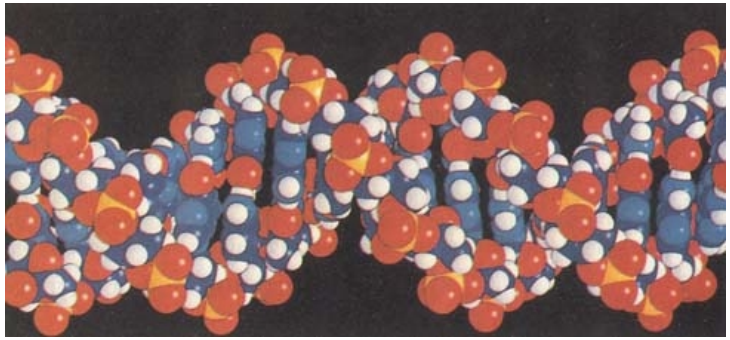


Fluorescently Labeled
Cells in Culture

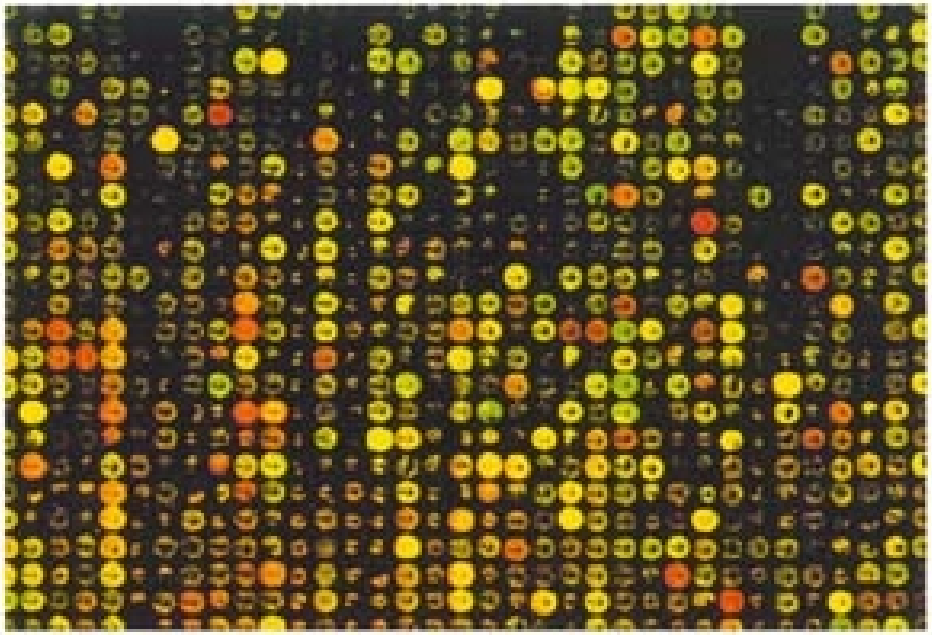


Cell Processes

DNA Microarrays



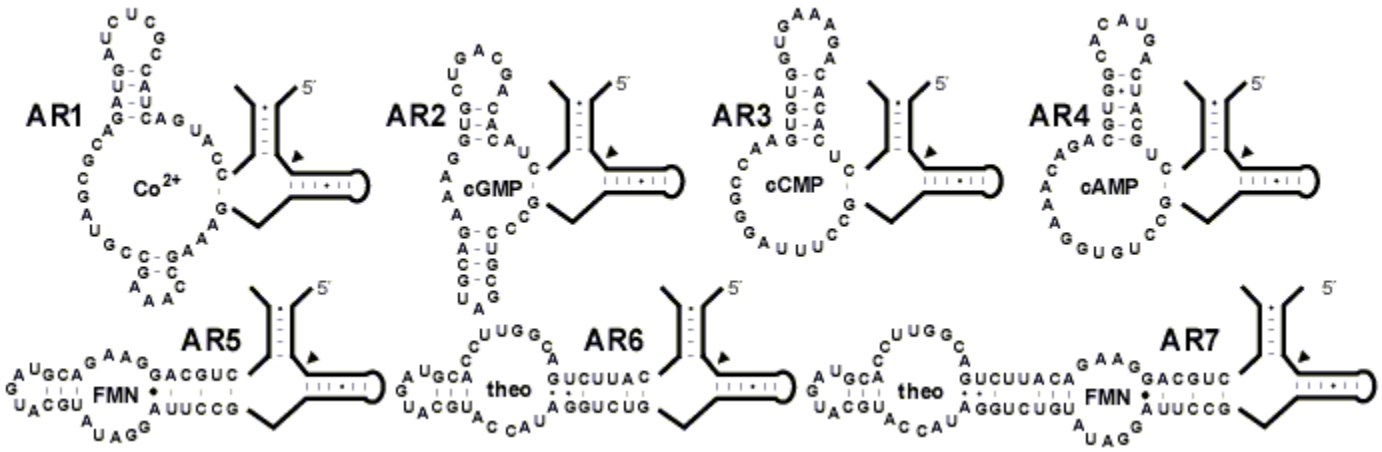
Affymetrix, Inc.
(http://www.affymetrix.com)



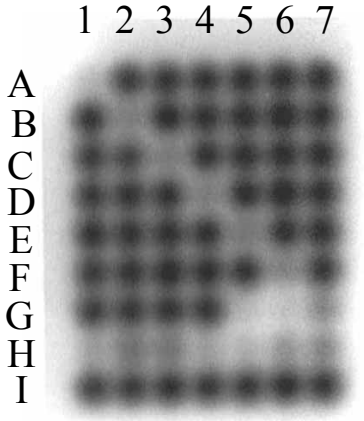
- Drug Discovery
- Cancer Biology
- Aging
- Developmental Biology

B. O. Palsson, UCSD

RNA Microarrays



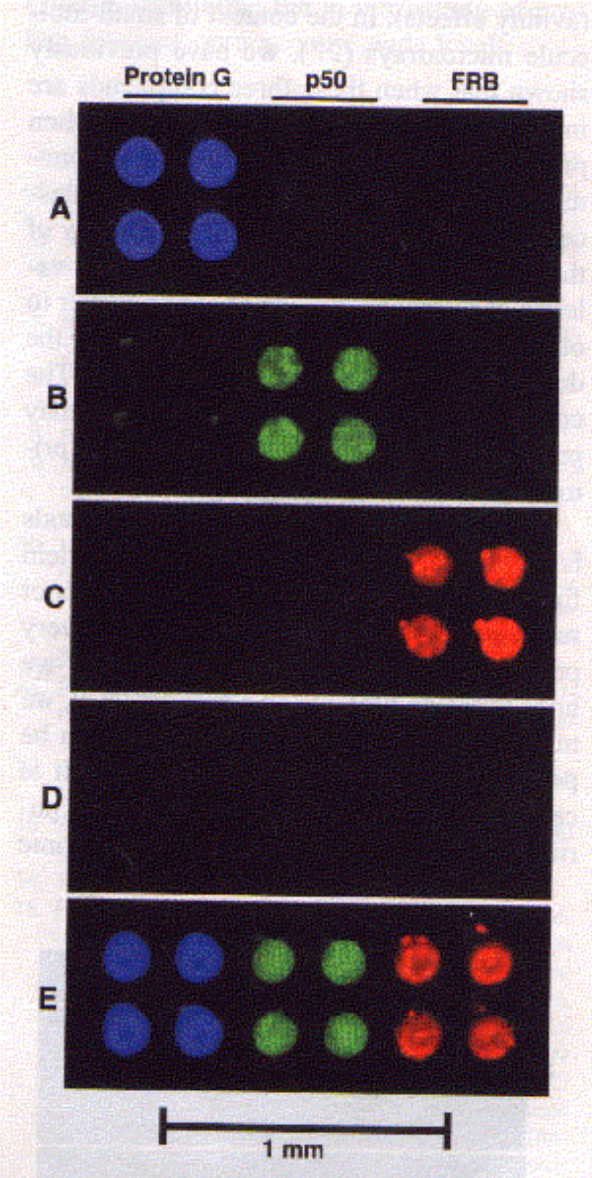
Towards the Construction of an "RNA Biochip"



"Positive" Image

Ronald R. Breaker – Yale University

Protein Microarrays

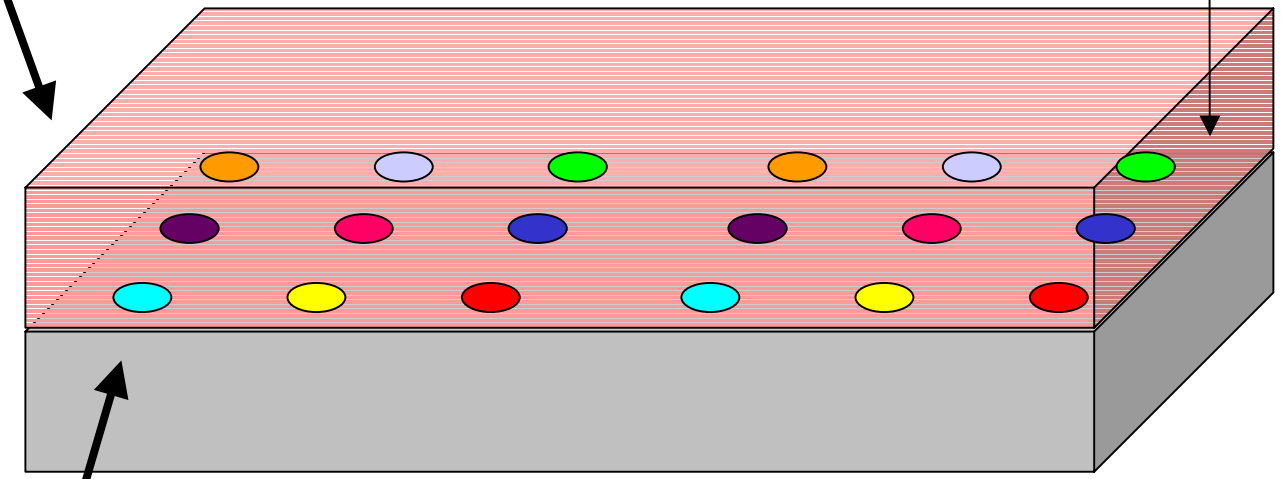


Robotic Printing of nanoliter volumes yields spots of 150-200 microns on aldehyde-coated slides

A. Fluorescent Antibody/ Protein G
B. Fluorescent Protein/ p50
C. Fluorescent Protein/ + Rapamycin
D. Fluorescent Protein/ - Rapamycin (rapamycin-dependent binding)
E. All probes present

MacBeath & Schreiber, *Science*, 289 (2000)

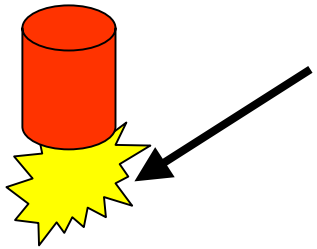
Idealized Cell-Based Microarray



Biocompatible Fluidic Environment

Controllable Fluidics
(valves, switches, Pumps, reagent or object delivery)

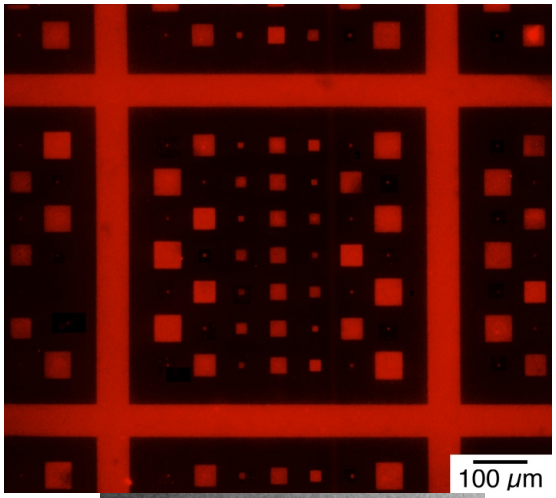
Manipulate Live Cell Arrays that can Respond to Stimuli

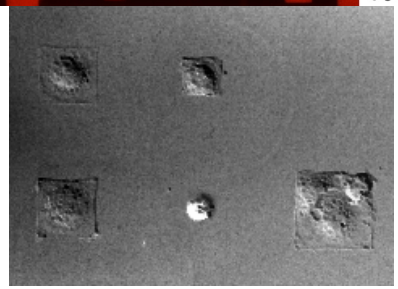


Light Source and Detector (signal or image)

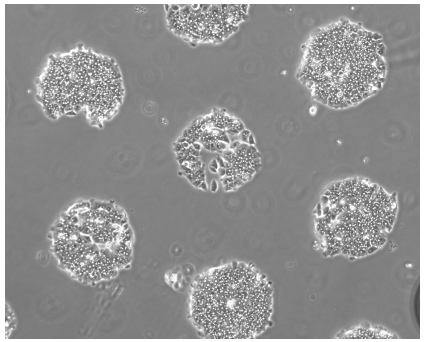
Opportunities for OE
- Sensing
- Actuate/ Control

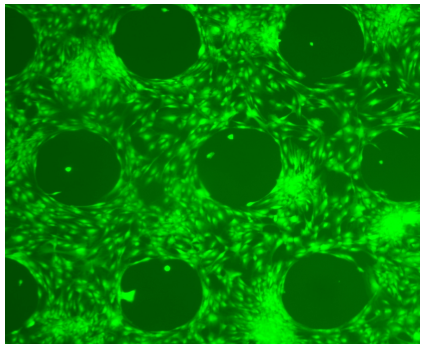
Cell Arraying Technologies



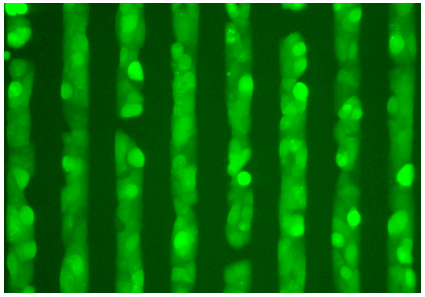


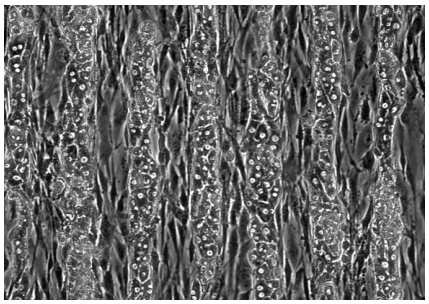
C. Chen, Johns Hopkins U.



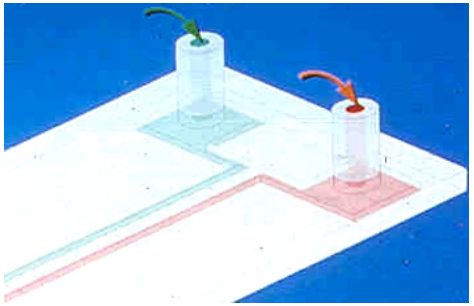


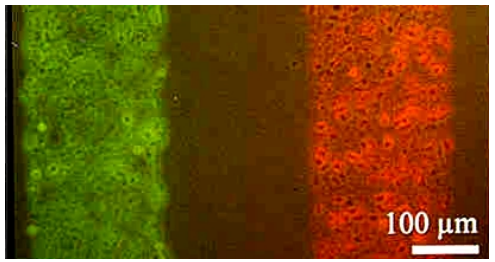
S. Bhatia, UCSD





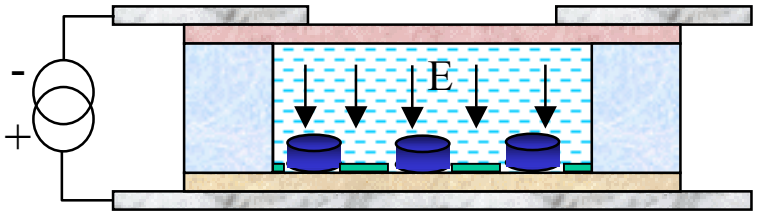
S. Bhatia, UCSD





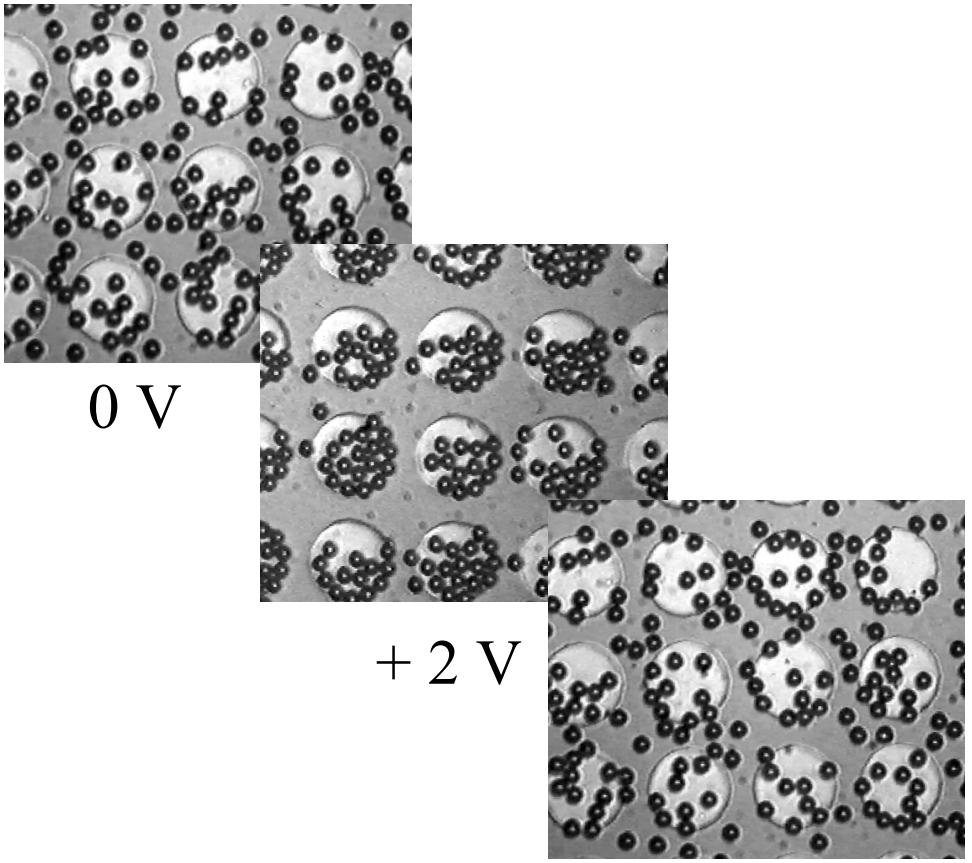
A. Folch & M. Toner, UW/HMS

Electrokinetic Patterning of Beads



Patterned Substrate

Bead or Cell
Si_3N_4 patterned Si
Indium Tin Oxide(ITO) glass
Al plate
Rubber gasket

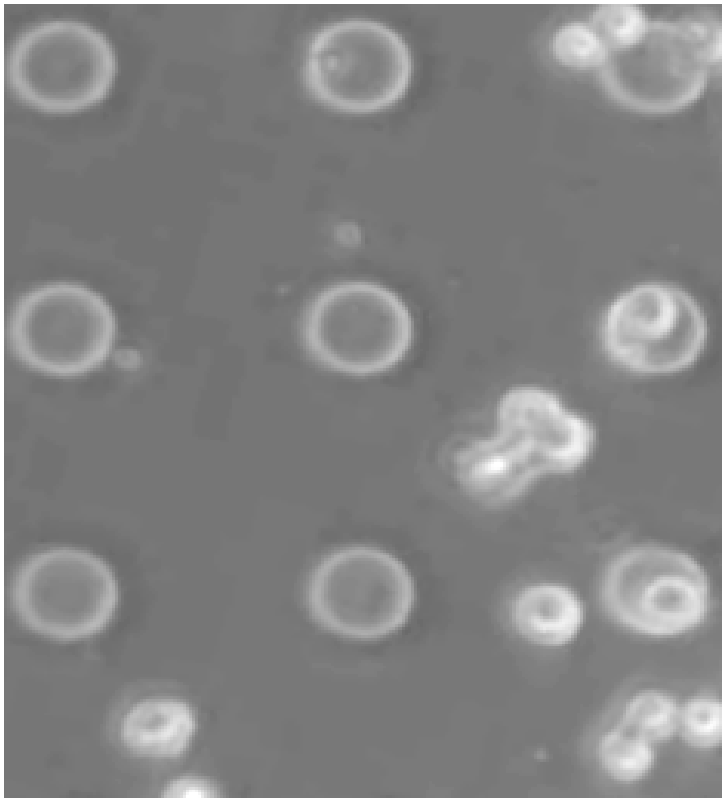


0 V

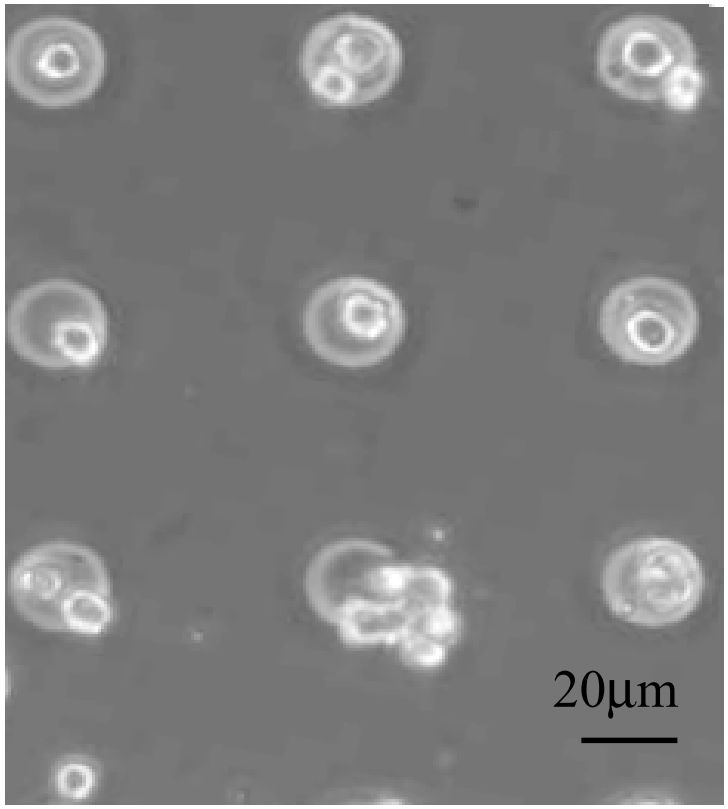
+ 2 V

- 2 V

Live Cell Arraying

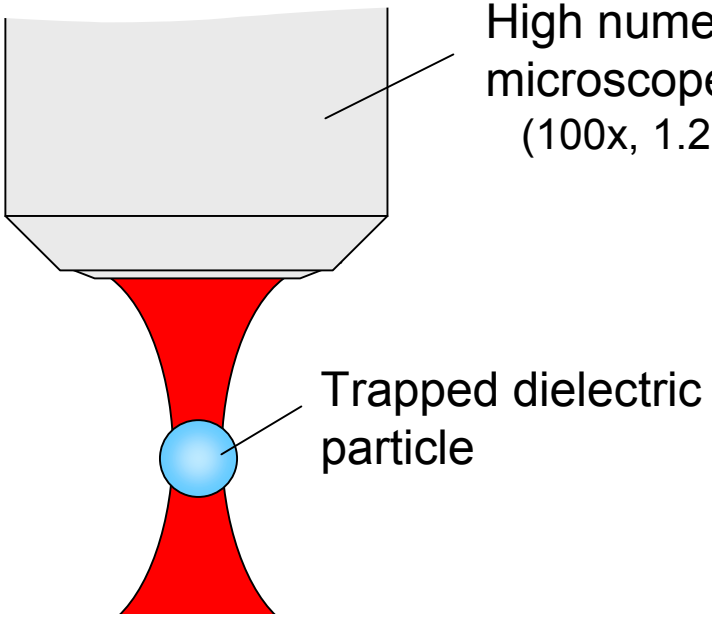


Neural Stem Cells Without E-field



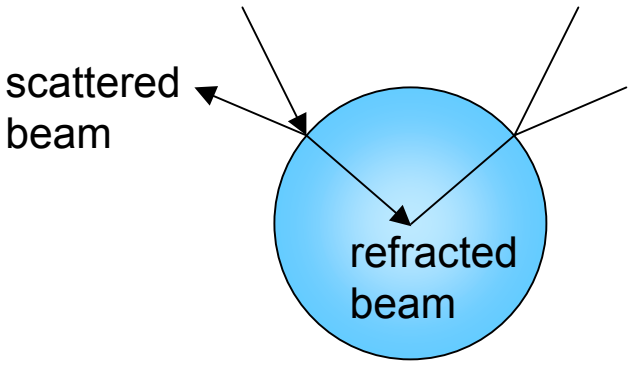
With E-field, Elapsed time 5 minutes

Principle of Optical Tweezers



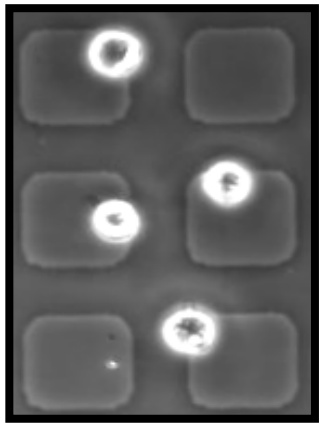
- Gradient force:
  Particle moves to point of highest intensity

$$U = -\vec{P}\vec{E} \sim -\vec{E}\vec{E} \sim -I$$



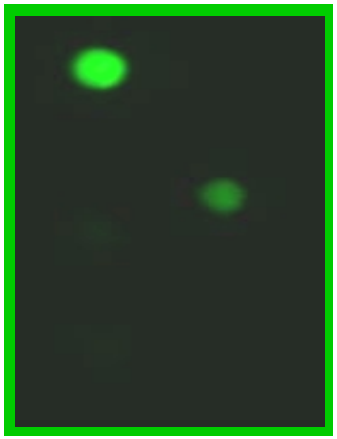
- Scattering force:
  Particle accelerated along direction of beam propagation

Live Cell Visualization and Manipulation



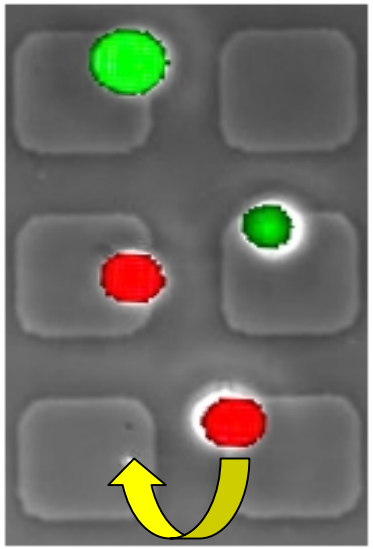
Phase

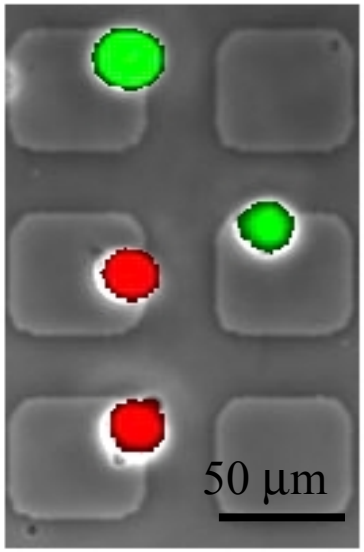
Rhodamine



Fluorescein

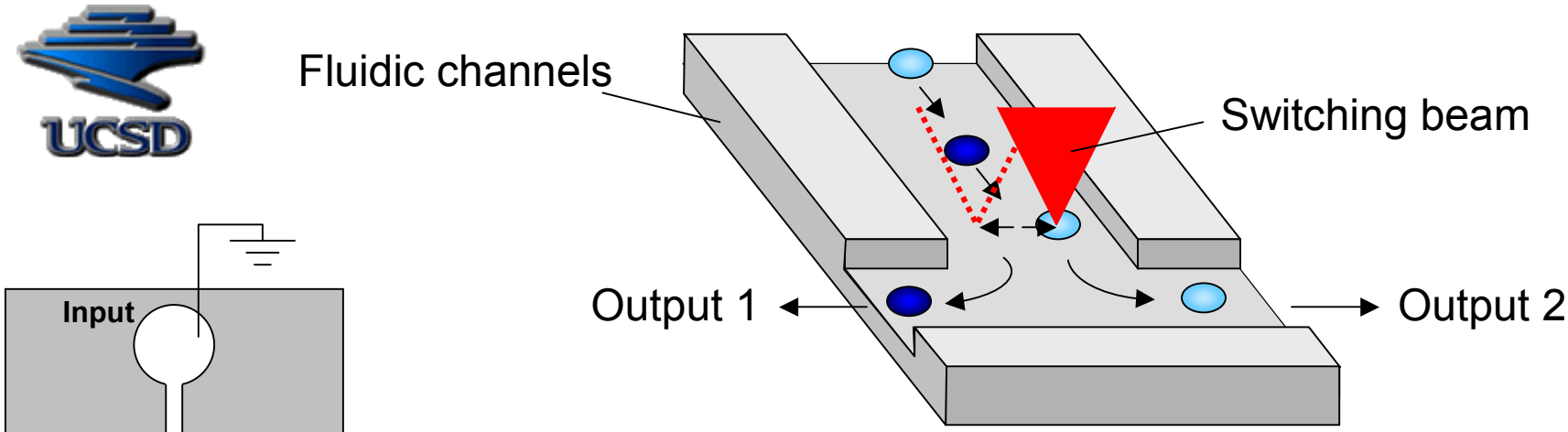
Phase Contrast & Fluorescent Microscopy through ITO

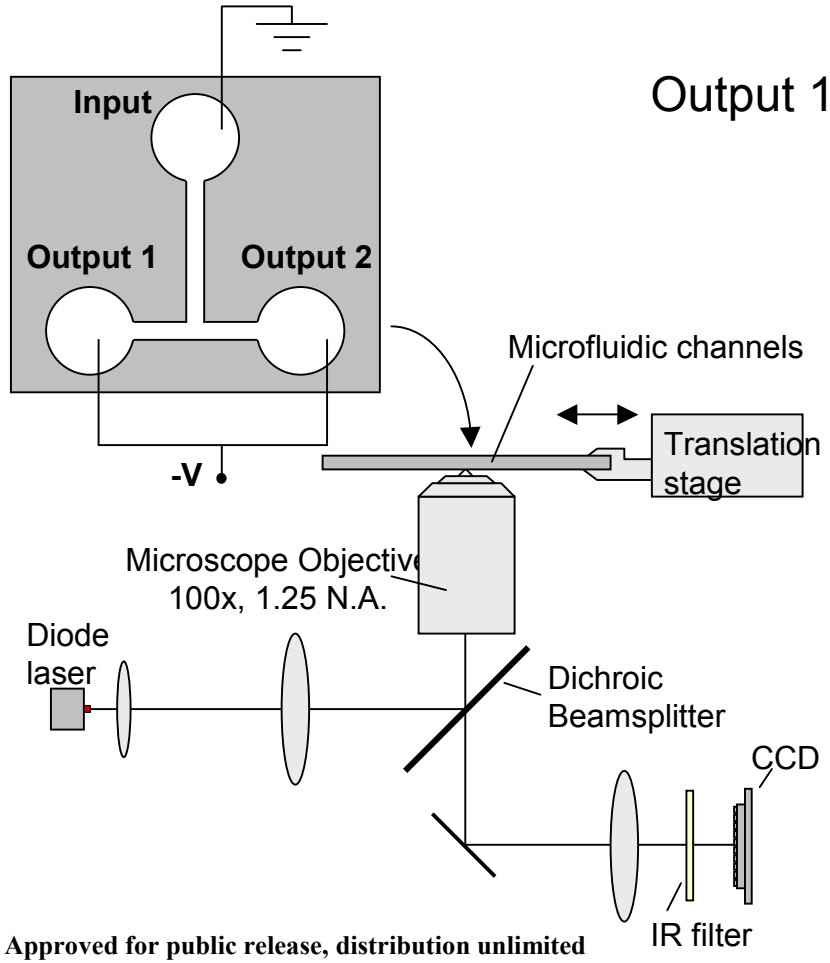




Optical Manipulation

Optical Tweezer Microfluidic Switch

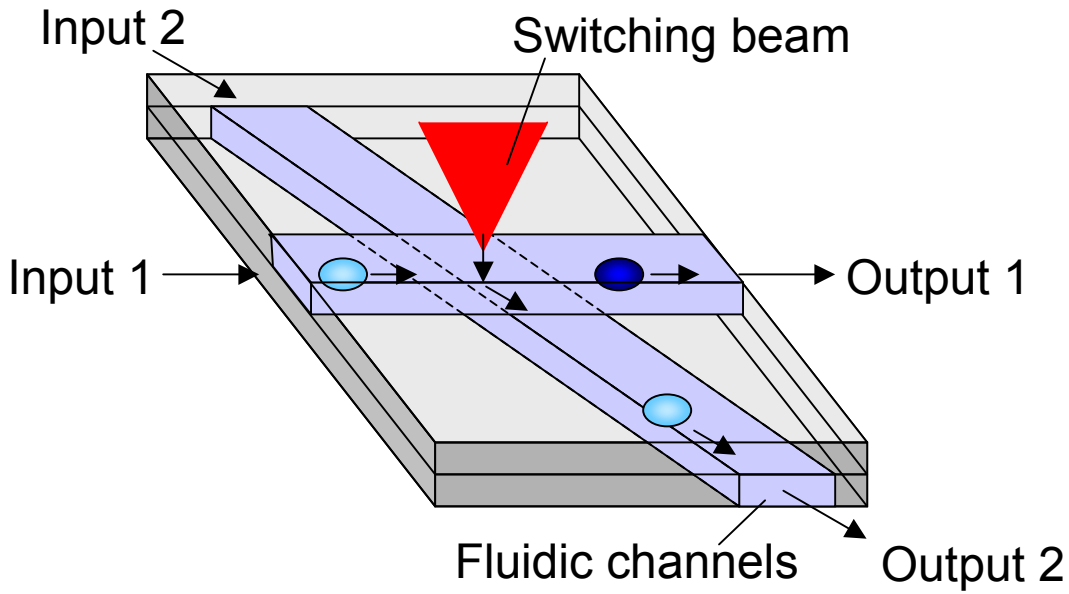




- Continuous fluid flow induced by electro-osmosis. (linear flow rate: 30 μm/sec @ 16 volts)
- Particles directed by optical beam focused at junction.

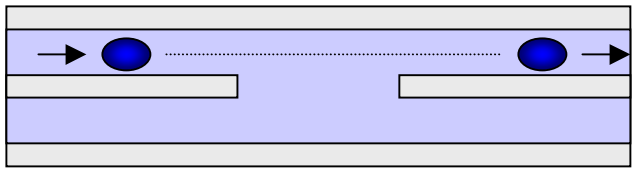
(850 nm diode laser: 23 mW)

Scattering Force Switch

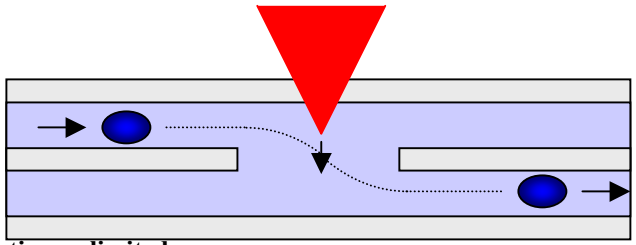


View from the side:

Optical beam **off**:

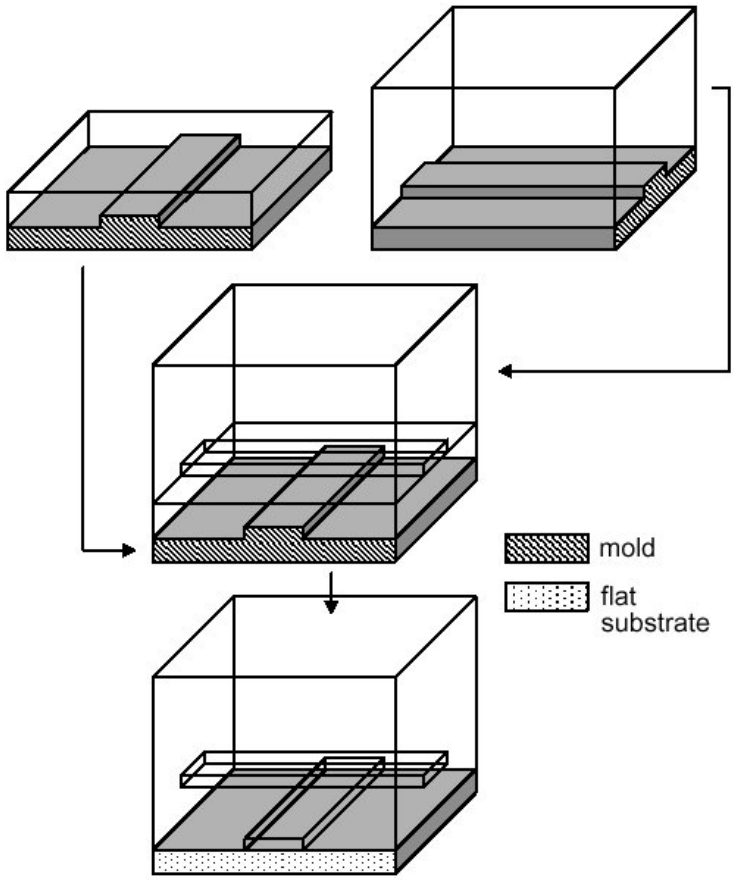


Optical beam **on**:



- Low N.A. optics, therefore low gradient force.
- Dominant scattering force acts as "elevator" between upper and lower levels.

Multilayer Soft Lithography



- **Material:**
  GE RTV 615
- **Lithography:**
  Replication molding
- **Binding:**
  One layer –
  615A : 615B = 3 : 1,
  The other layer –
  615A : 615B = 30 : 1.
- **Heat curing:**
  85ºC for 20–90 min.

Caltech

S. Quake &

A. Scherer

Microvalves

- On/Off Valves :

Condition —

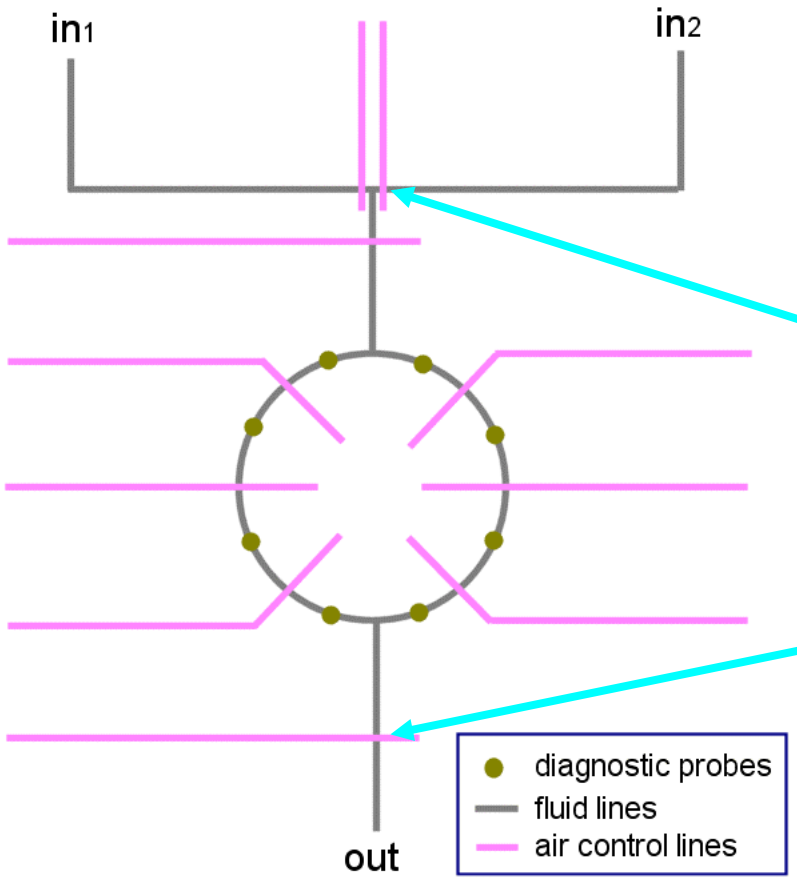
- Fluid channel: 100 µm
- Air control channel: 200 µm
- Flow medium: 1-µm beads.

Caltech

S. Quake &

A. Scherer

Active Chip Detection Design



- Fluid channel
  - a loop
- Switch valves
  - inputs
- On/Off valves
  - inlet/outlet
- Peristaltic pump

We use a micropump to *actively* rapidly move target DNA to pass all the hybridization probes several times instead of using passive diffusion (D~ 10^{-7} cm^2/s or 2 mm/day)

Cell-Based Microarrays

- Live Cell Manipulation & Readout
- Interfacial Chemistry
- Microfluidic Delivery & Control
- Role of photonics
  - Actuation
  - Detection

	Speaker	Topic	(min)
	Esener	CHIPS Overview	20
	Bhatia	Biophotonics	15
→	Jalali	SOI Nanophotonics and bio detection	10
	Dapkus	Nanophotonics	15
	Scherer	Micro-nanofabrication	15
	Bowers	Amplification & tunability	15
	Campbell	Light Detection	10