

Optofluidics for Energy

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Demetri Psaltis

EPFL

Outline

- Optofluidics
- Optofluidics of Plants
- Microreactors for Solar Fuels
- Vesicles
- Conclusion

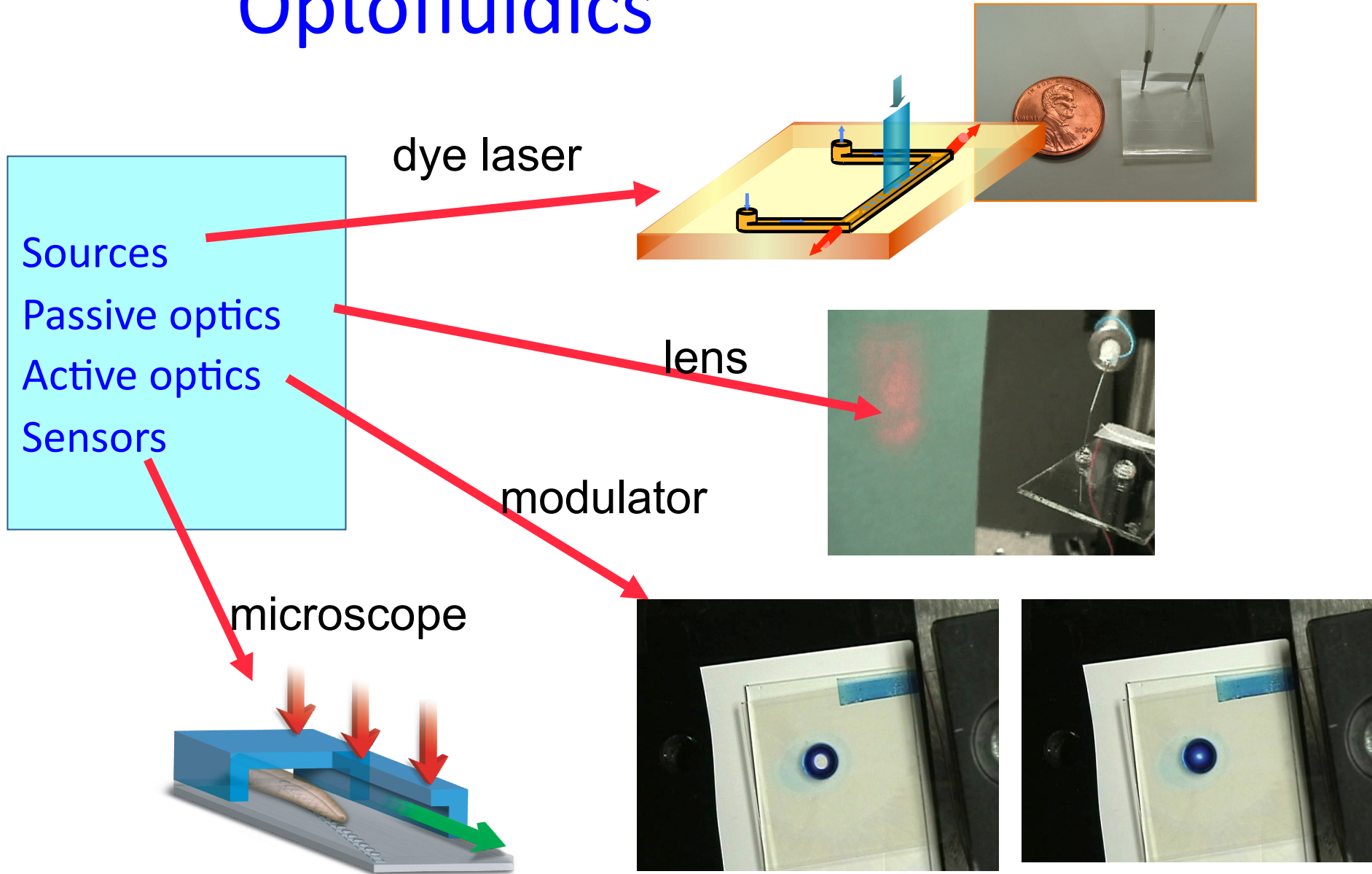


Optofluidics = optics + fluidics

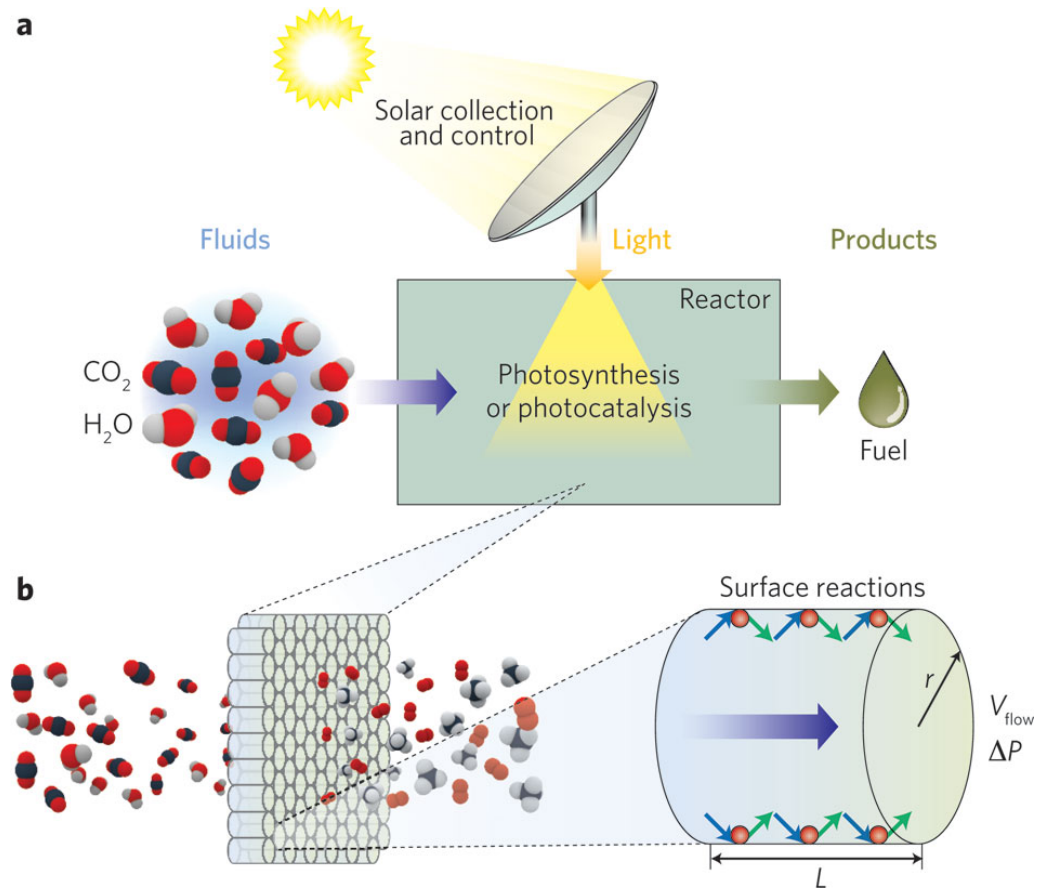


Demetri Psaltis, Steven Quake, Changhui Yang
'Developing optofluidic technology through the fusion of microfluidics and optics'
Nature 442, 381-386 August (2006)

Optofluidics



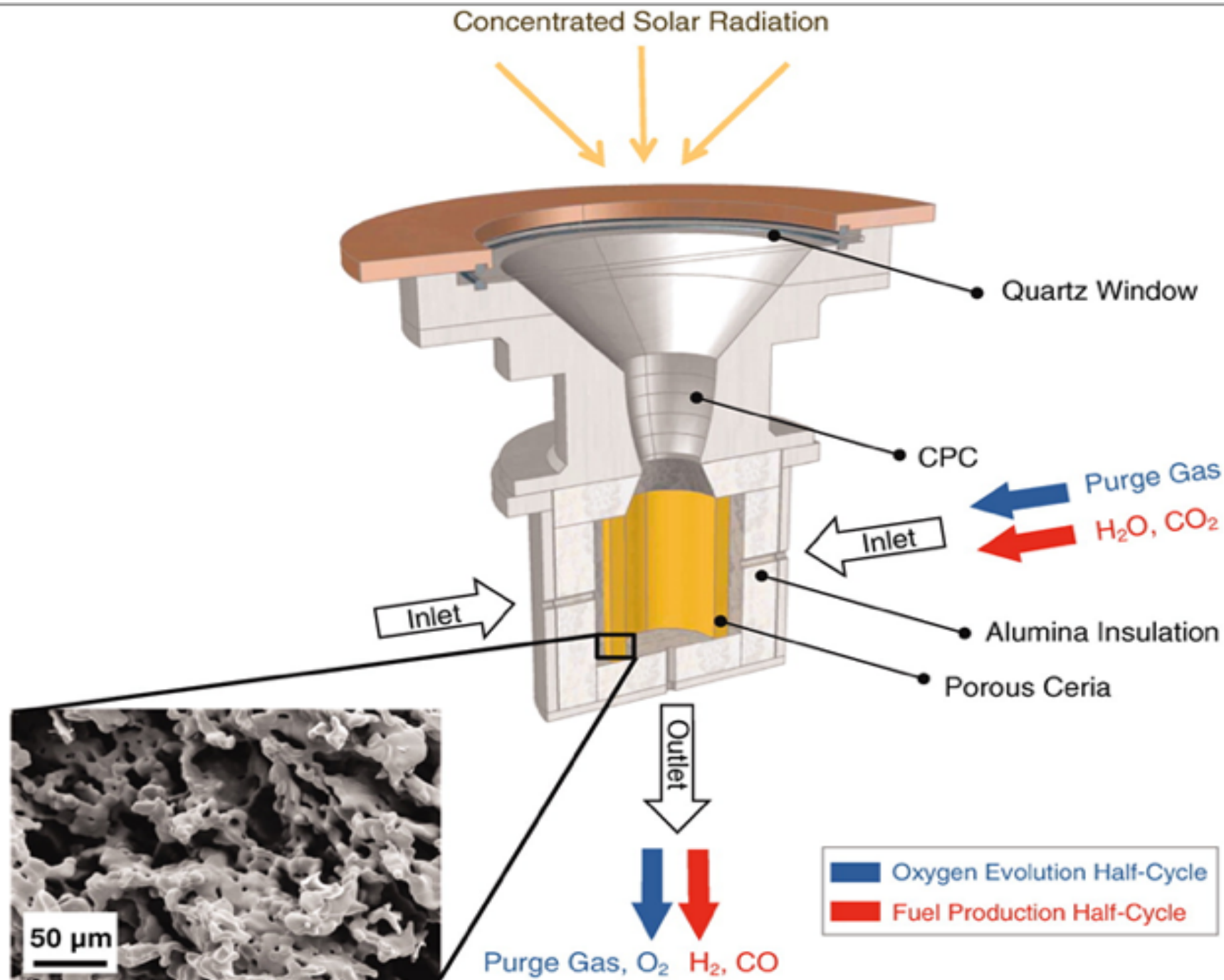
Optofluidics for Energy Applications



“Optofluidics for energy applications”, Erickson, Sinton, Psaltis
Nature Photonics 5, 583–590 (2011)

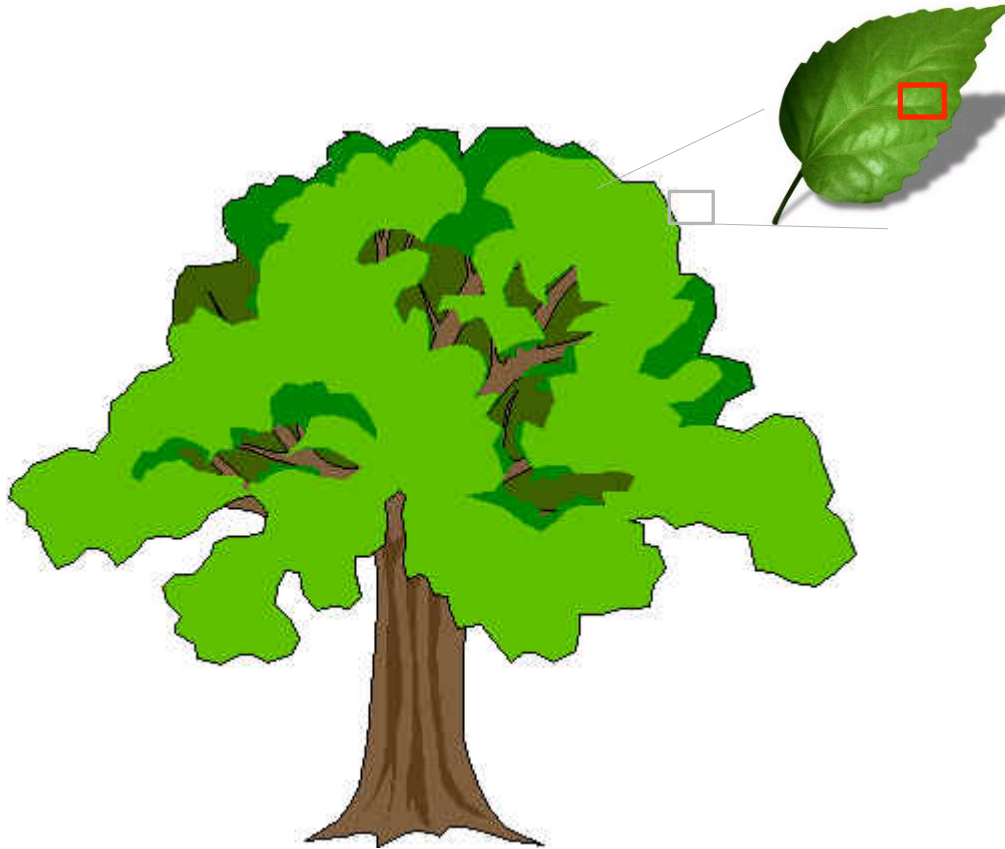
Solar Power Plant, Seville, Spain



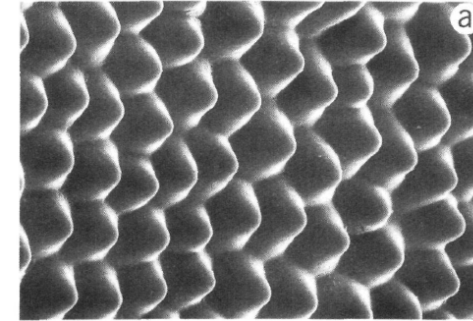


W C Chueh et al. Science 2010;330:1797-1801

Optics of Leaves

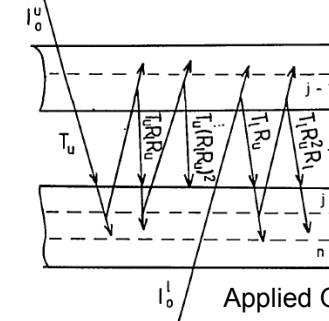


Focusing



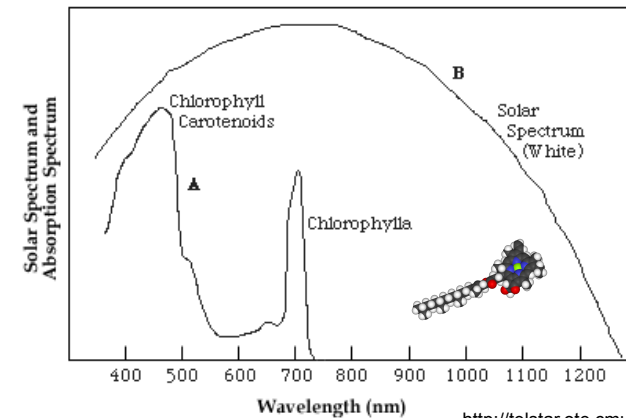
PHYSIOLOGIA PLANTARUM **98** 43 (1996)

Trapping

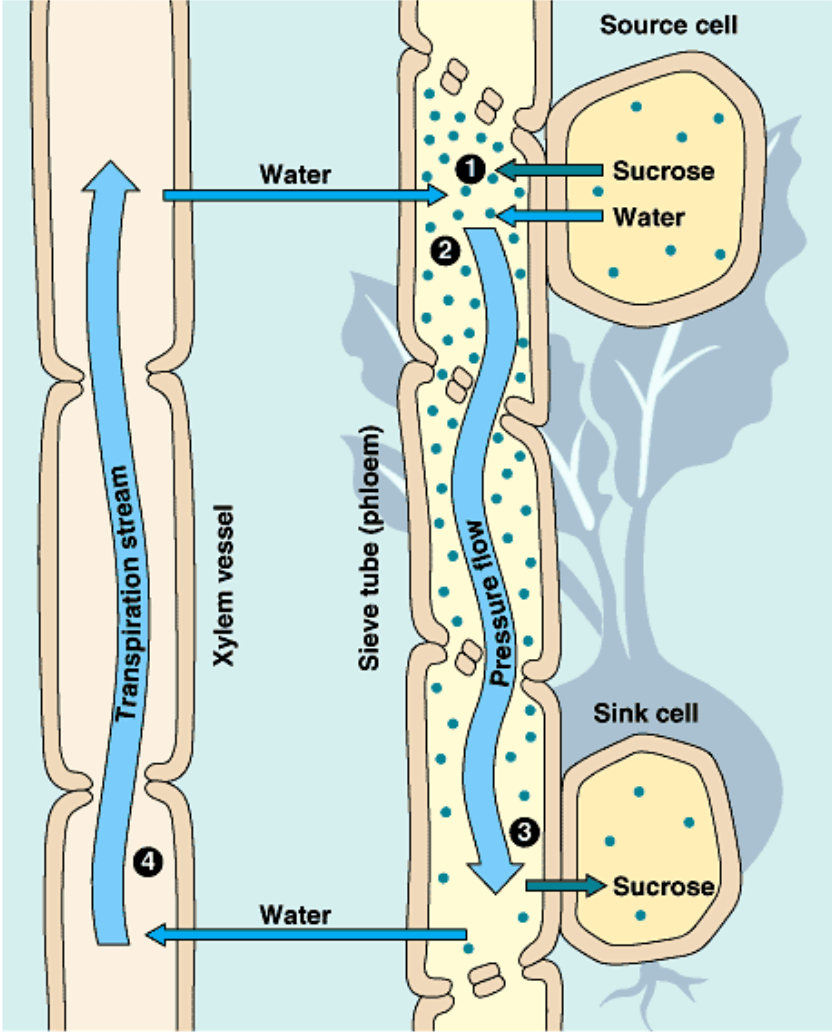
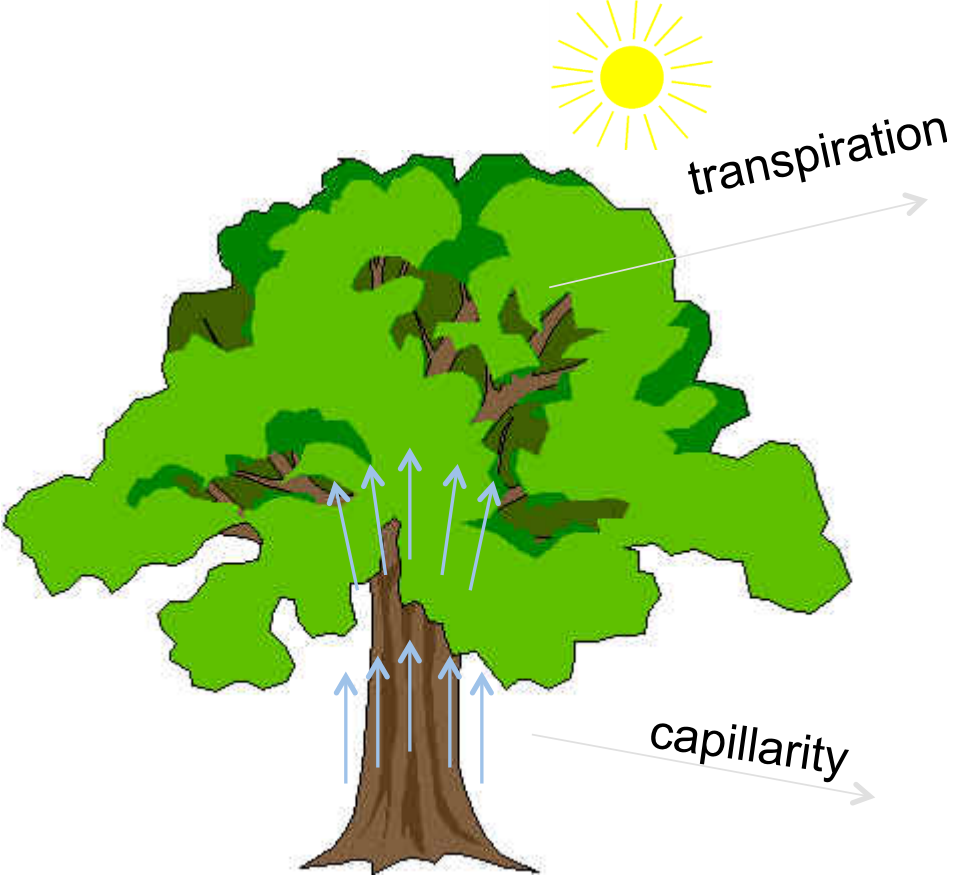


Applied Optics **22**, 1402 (1983)

Absorption

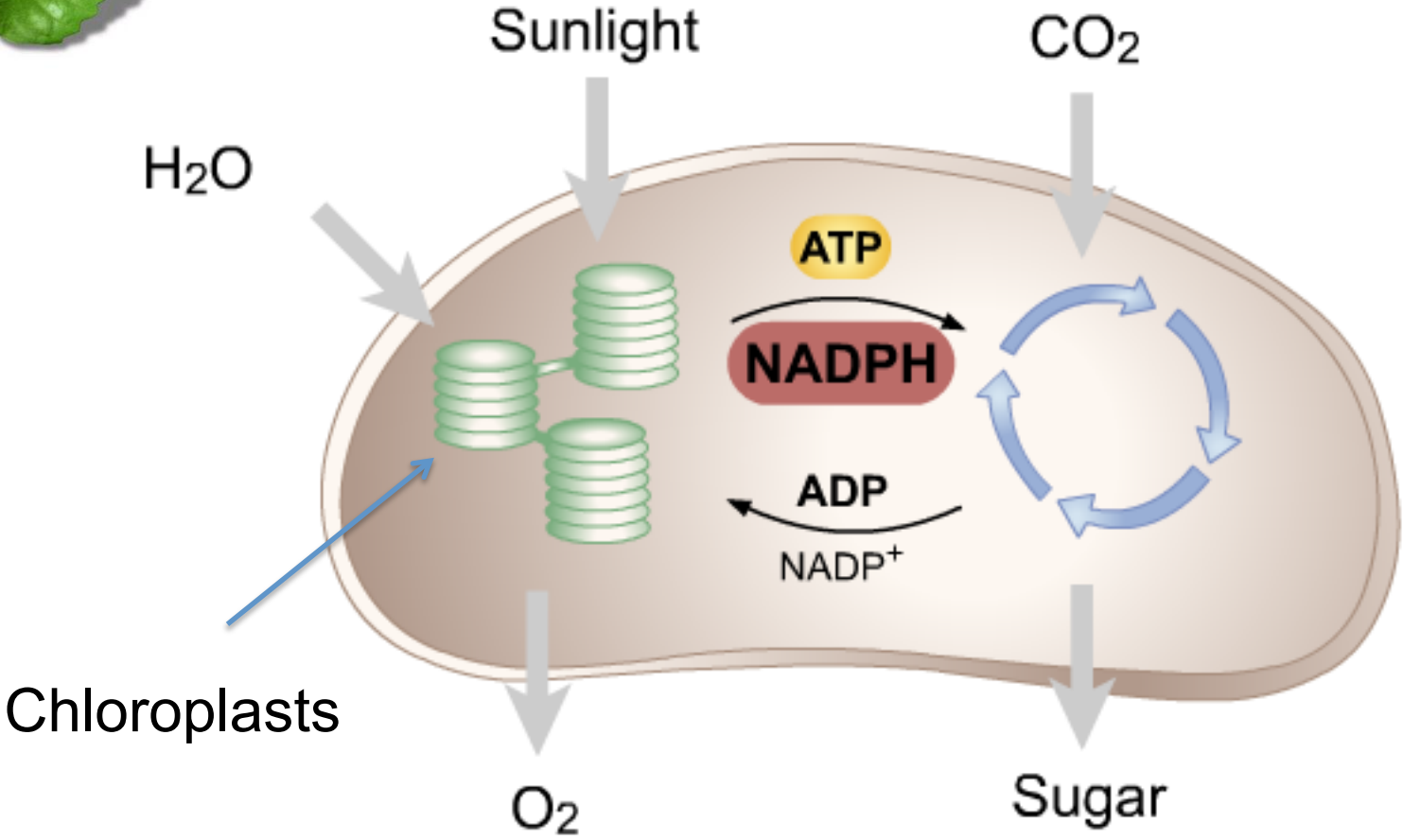


Fluidics of the Tree



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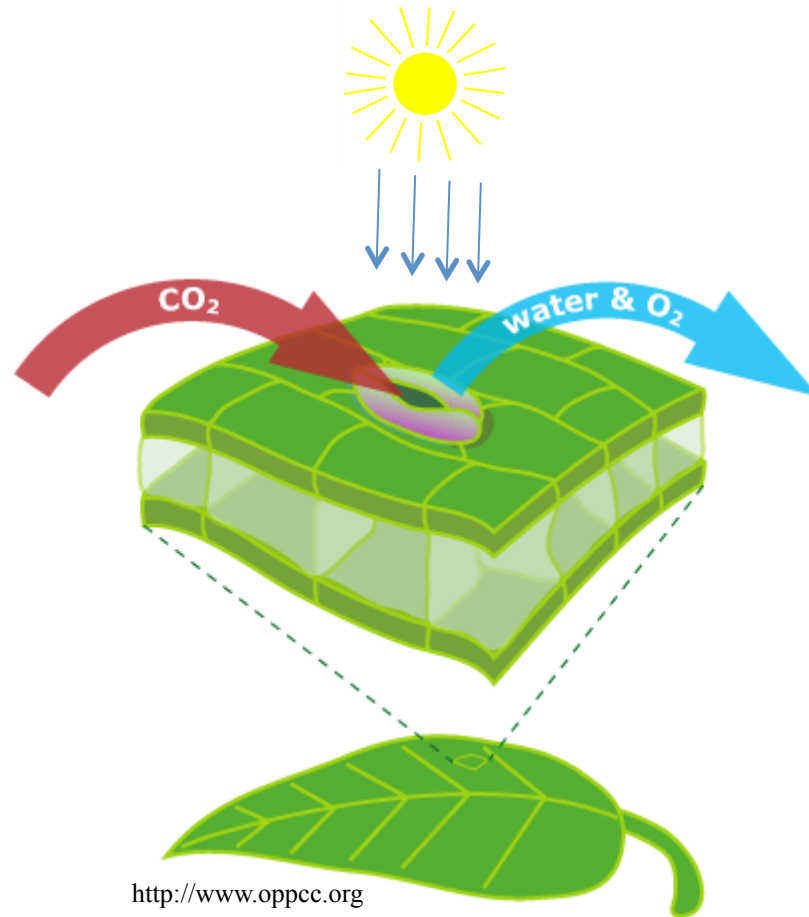
Photosynthesis



Optofluidics of Leaves

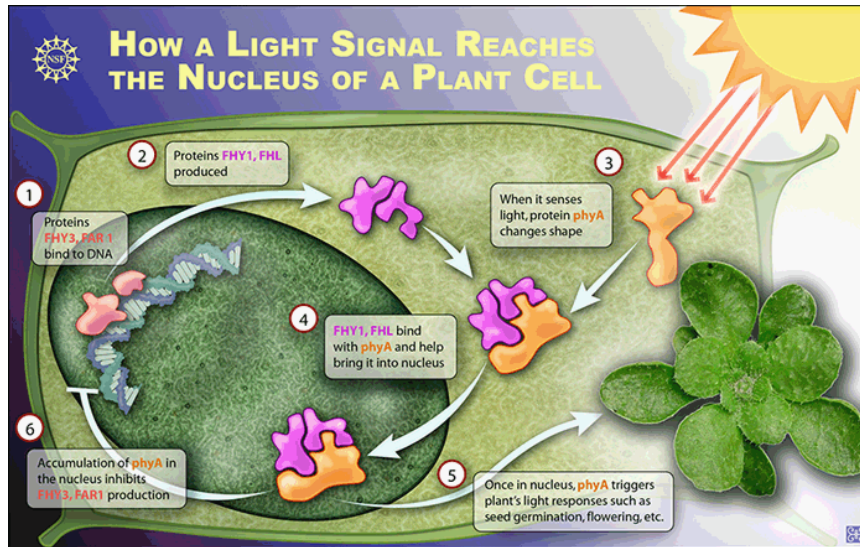


“Optofluidic” valve

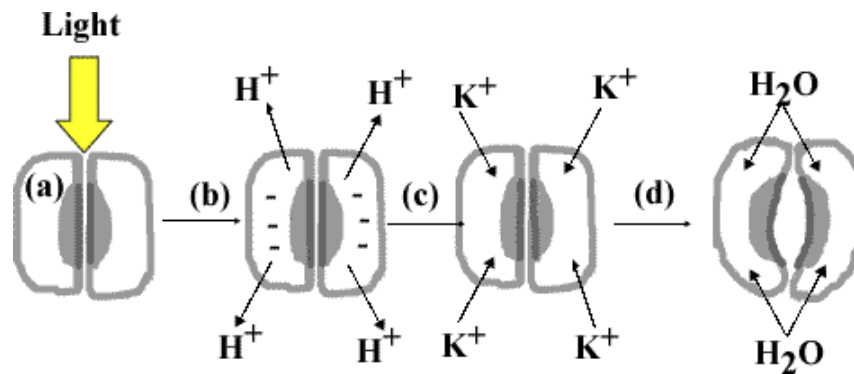


<http://www.opfcc.org>

Stomata



<http://bti.cornell.edu/index.php?page=NewsDetails&id=71>



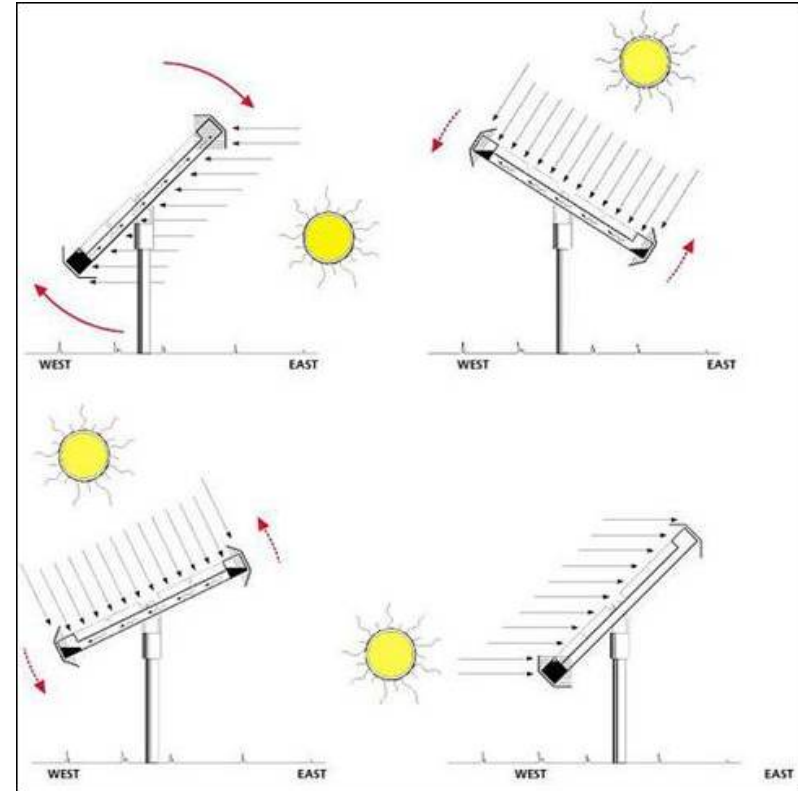
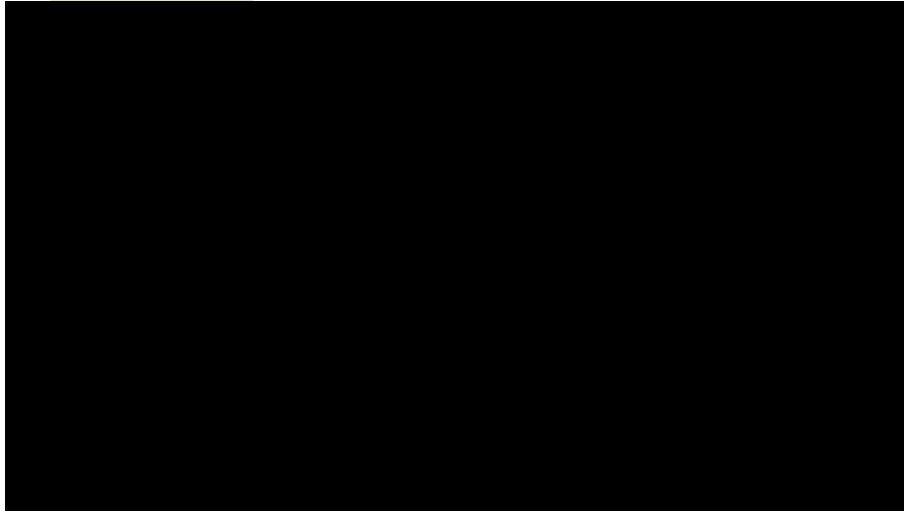
<http://click4biology.info>

Heliotropism: An optofluidic sun tracker



Optofluidic Solar Tracking Using Thermal Liquids

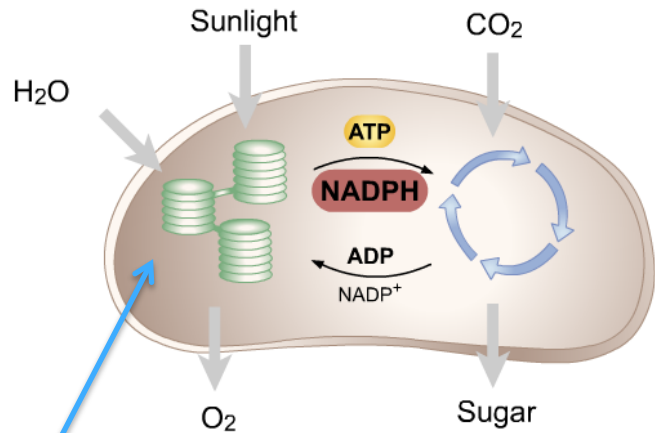
Zomewor



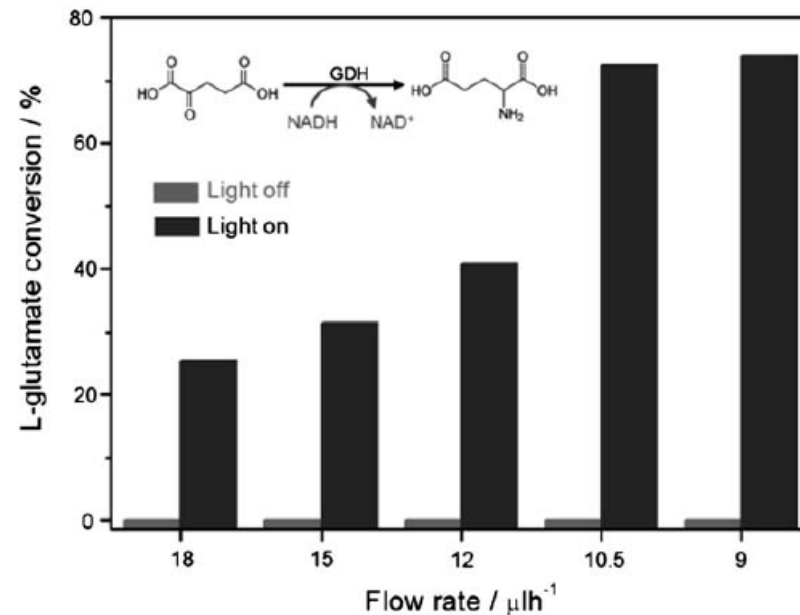
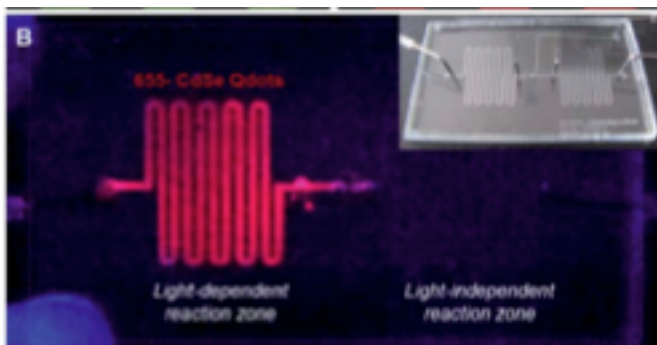
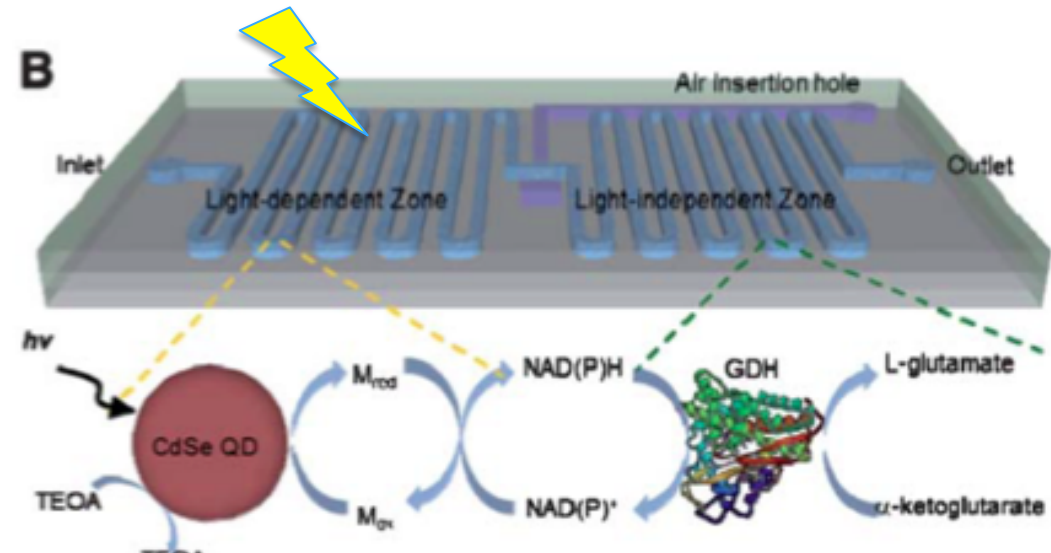
Artificial photosynthesis on a chip

Lee et.al, (Korea)

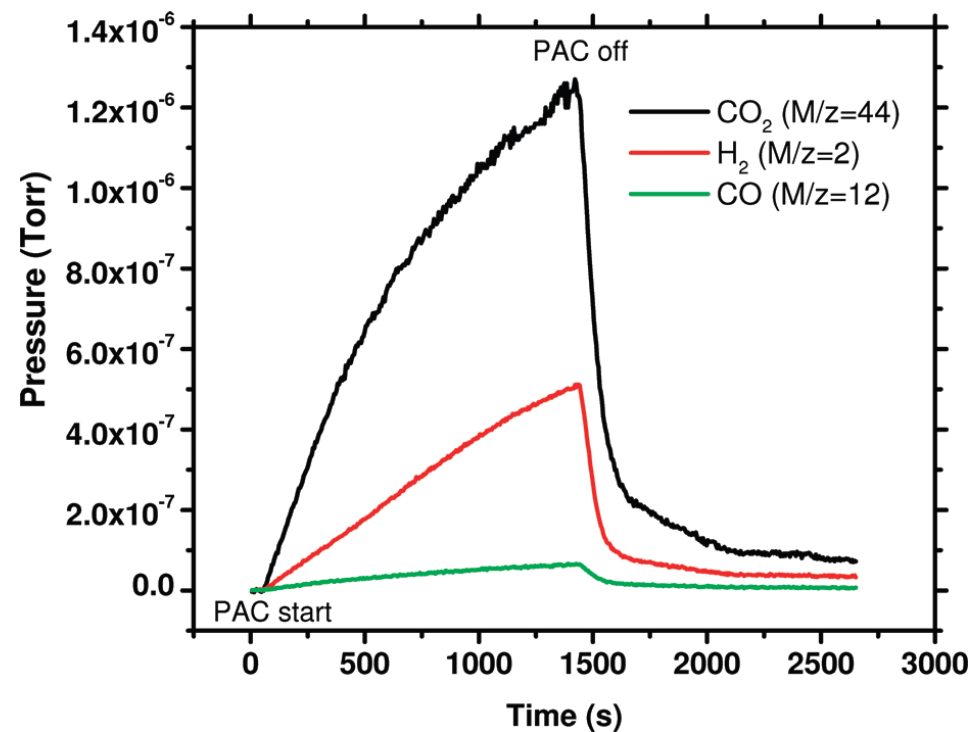
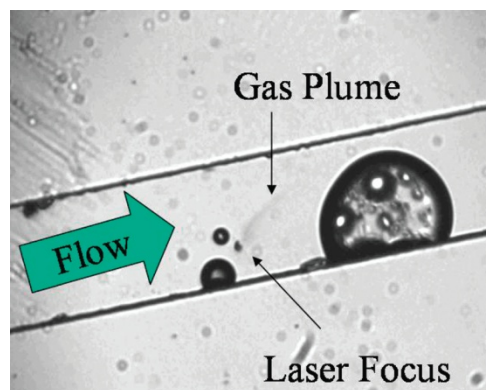
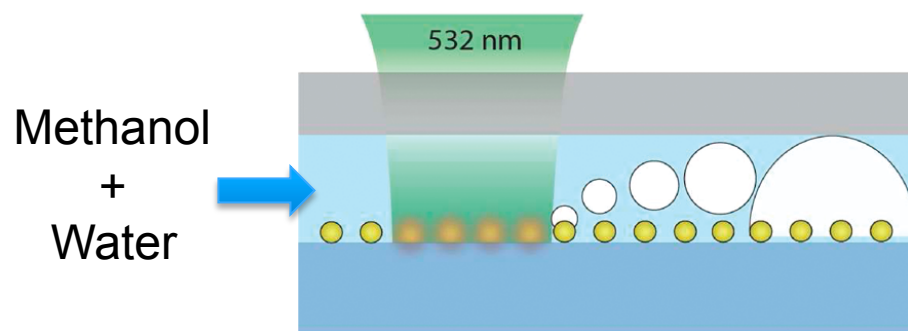
Lab Chip, 2011, 11, 2309–2311



Chloroplasts and Thylakoids

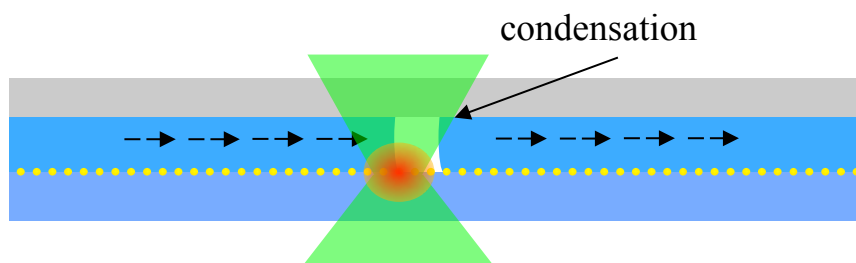
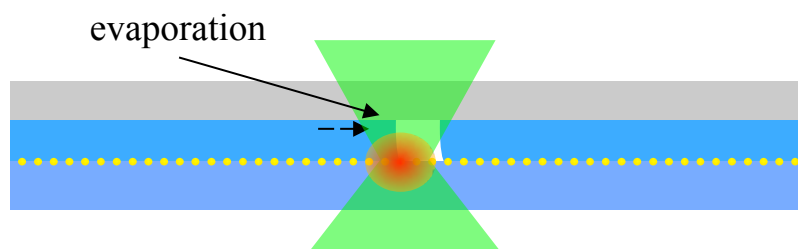
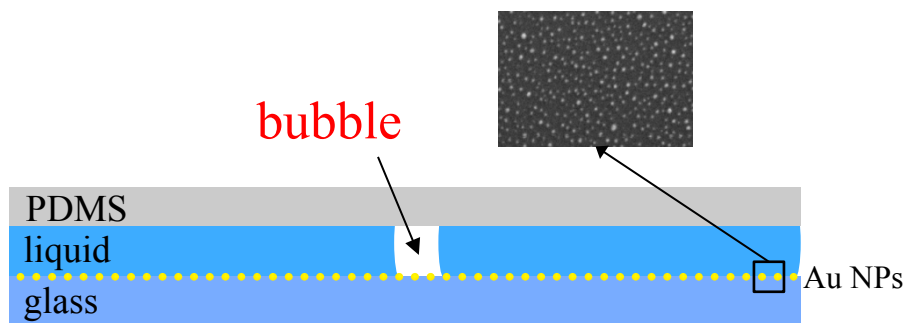


Heterogeneous catalytic steam reforming of ethanol with plasmon-heating activation



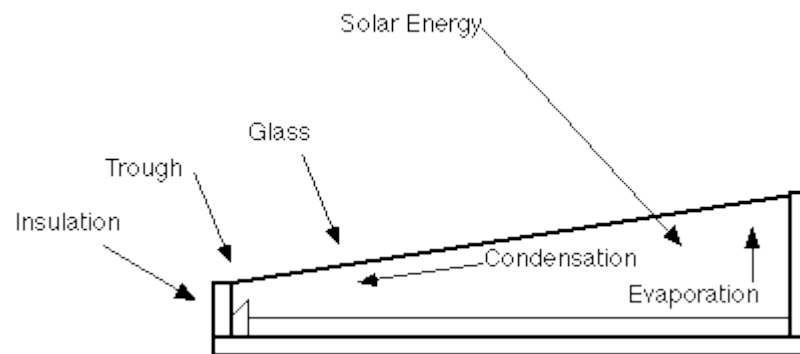
Heterogeneous catalysis mediated by plasmon heating, Adelman, Boyd, Goodwin, Psaltis, *Nano Lett.* 9, 4417–4423 (2009).

Plasmonic nano-carpets

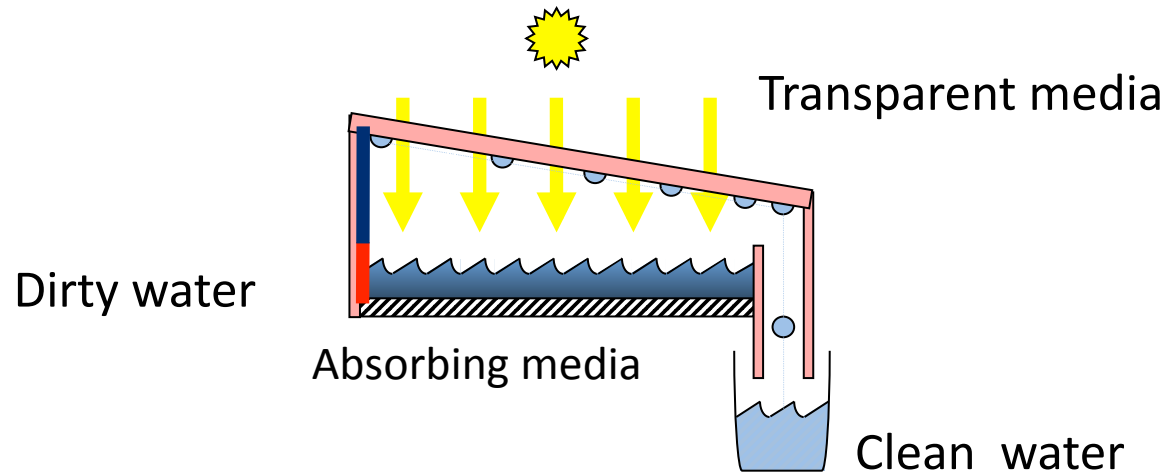


Solar water purification

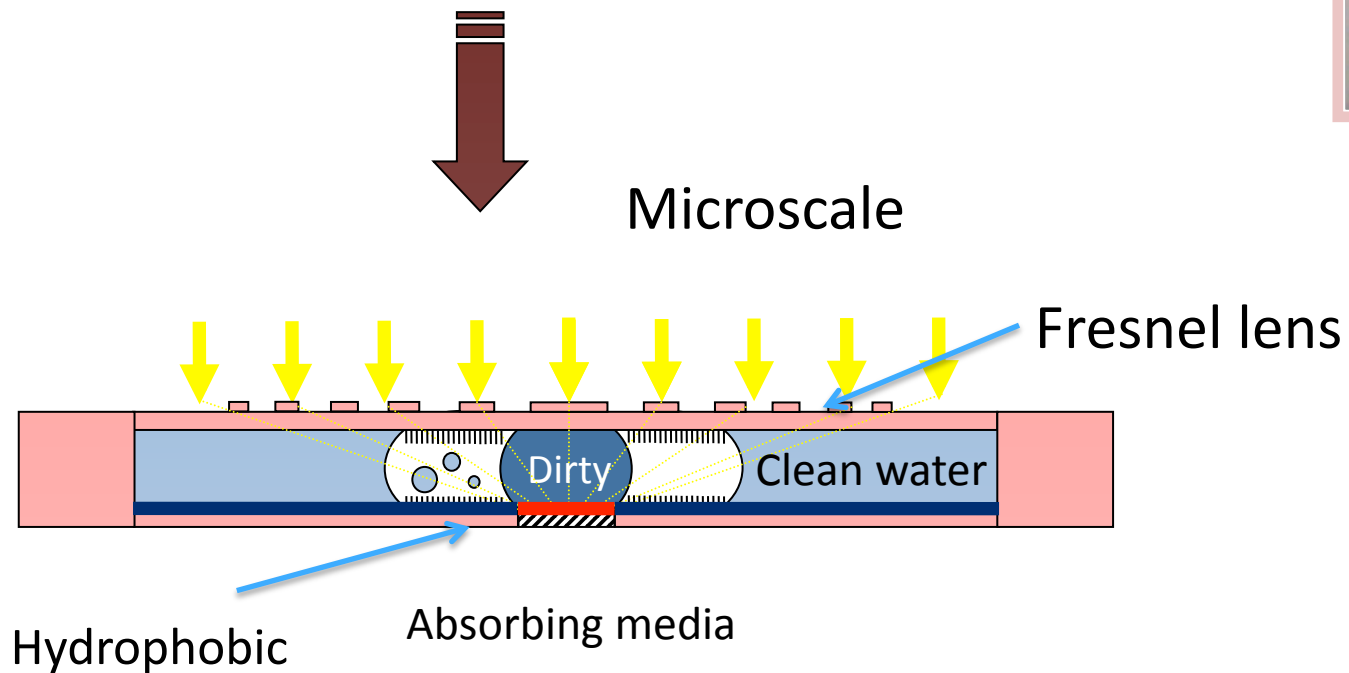
- Aquasol
 - 76 cm x 122 cm
 - 1.5 gallon (6 L) per day in summer, 3 L in winter
 - \$500



Optofluidic Implementation



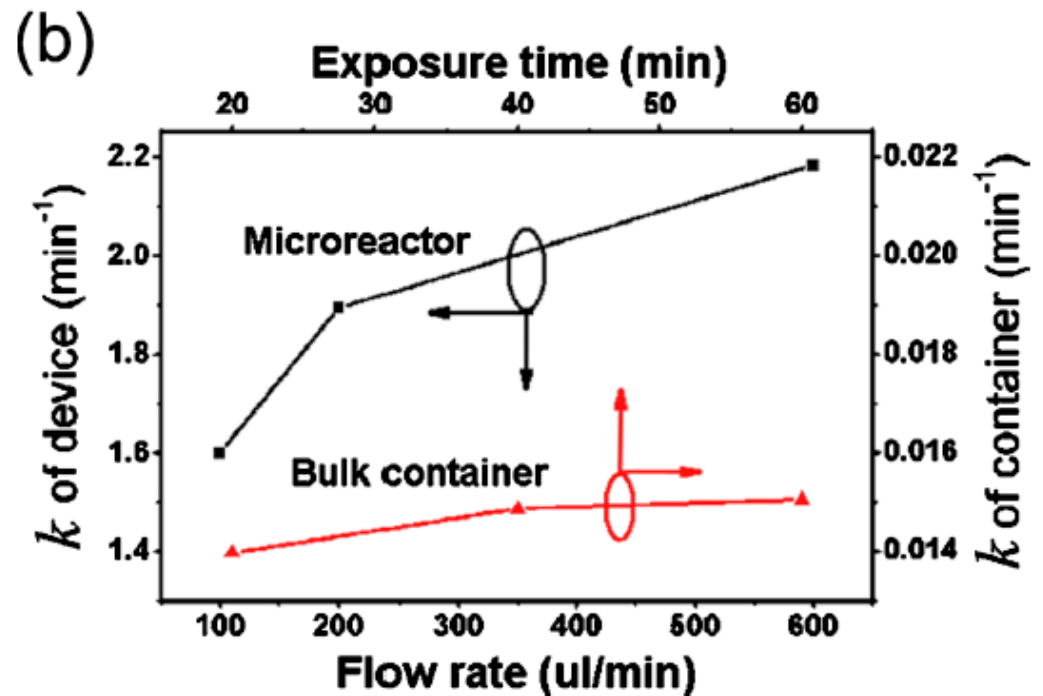
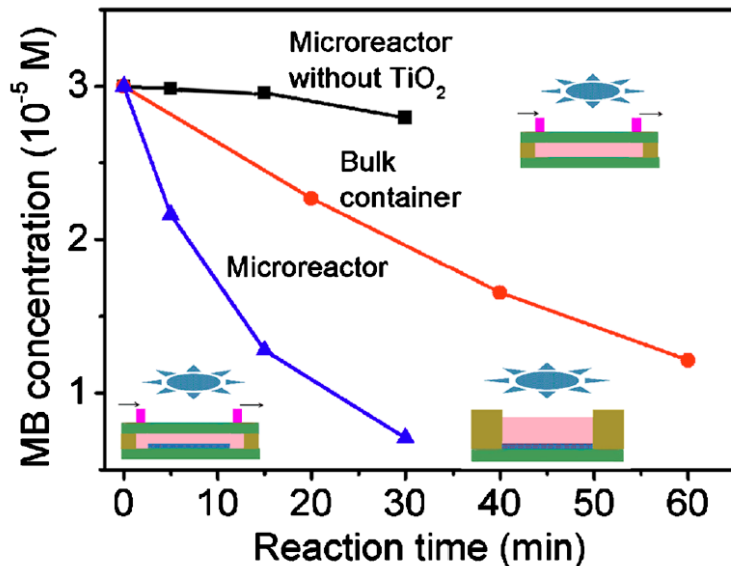
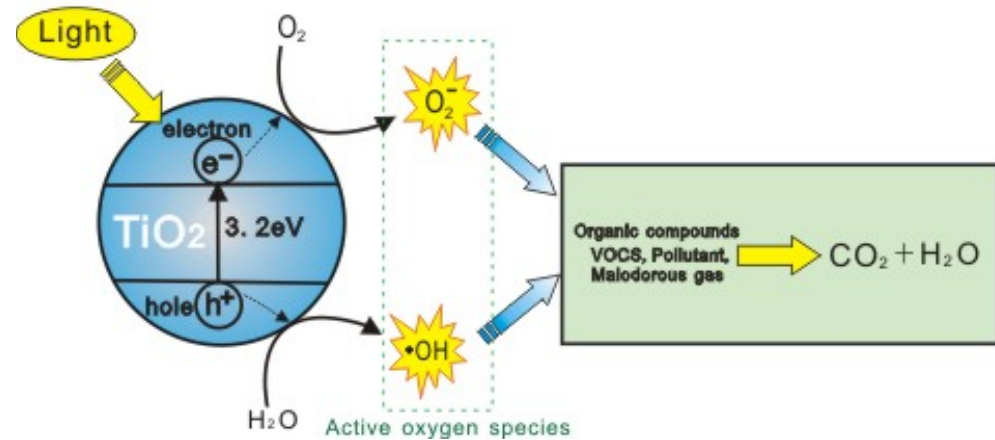
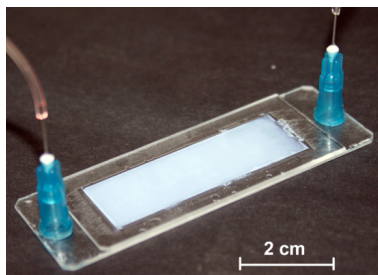
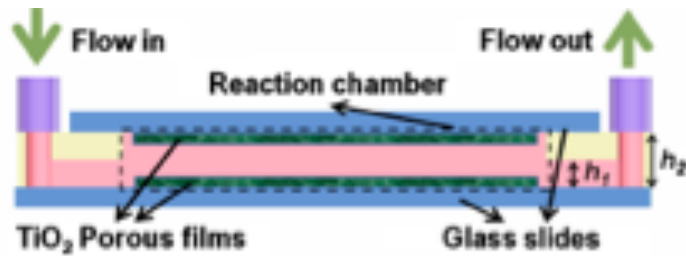
2 cm x 2 cm



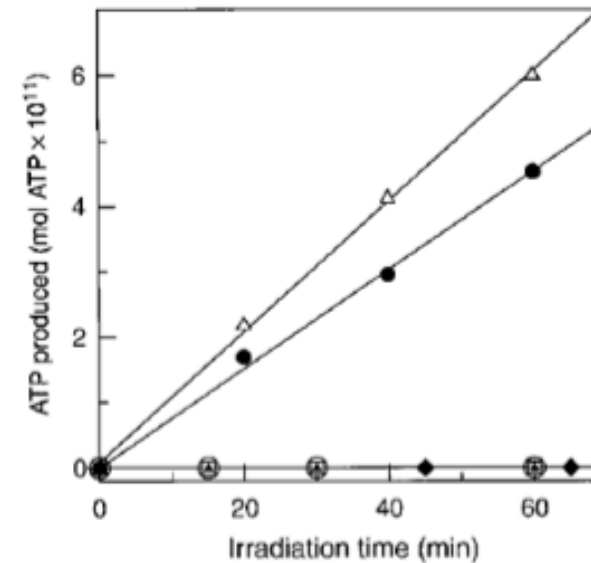
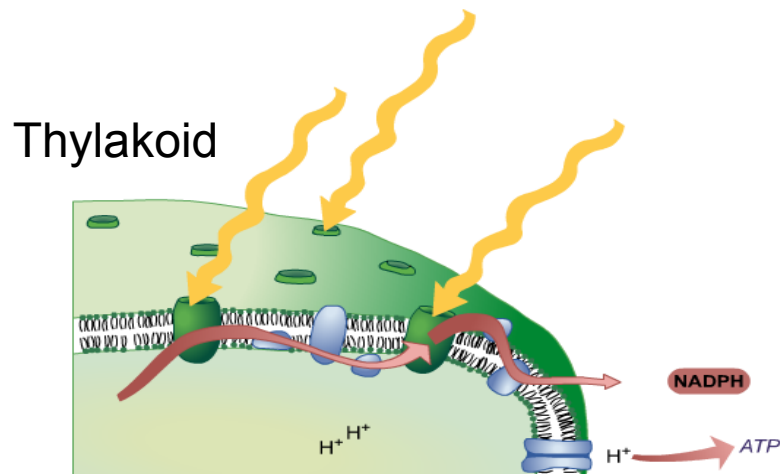
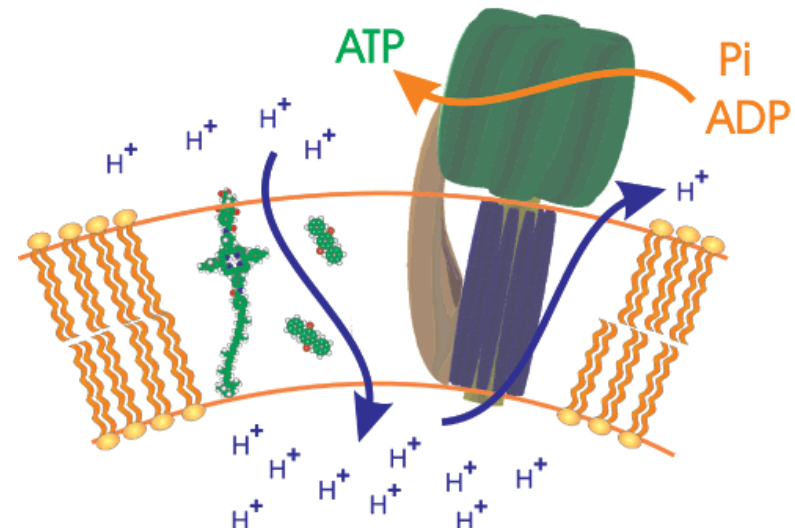
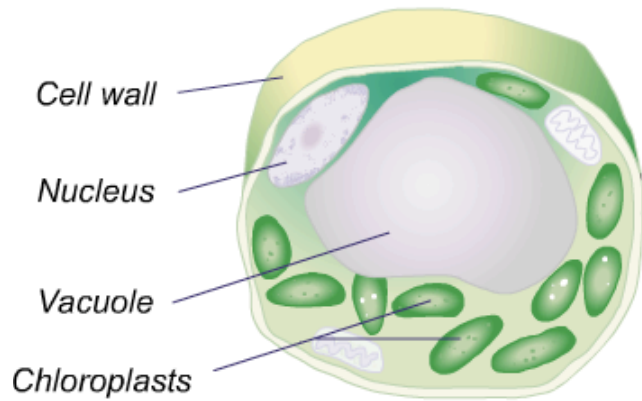
A close-up photograph of a metal mesh or screen. A dark, vertical strip runs down the center of the mesh. A blue rectangular box is overlaid on the mesh, containing the text "TURN ON THE SUNLIGHT" in white, uppercase letters. The mesh consists of a grid of small, circular openings. The background is a light, textured surface.

TURN ON THE SUNLIGHT

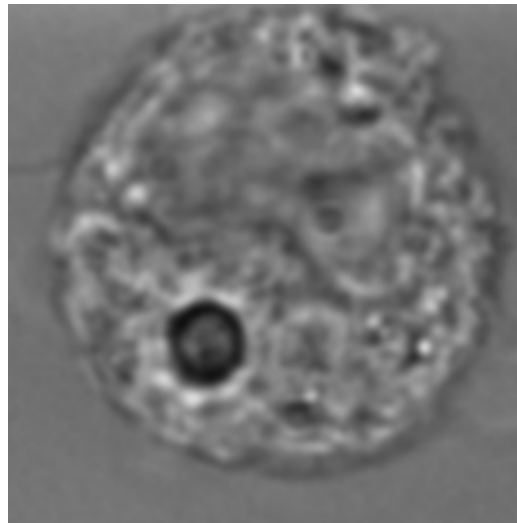
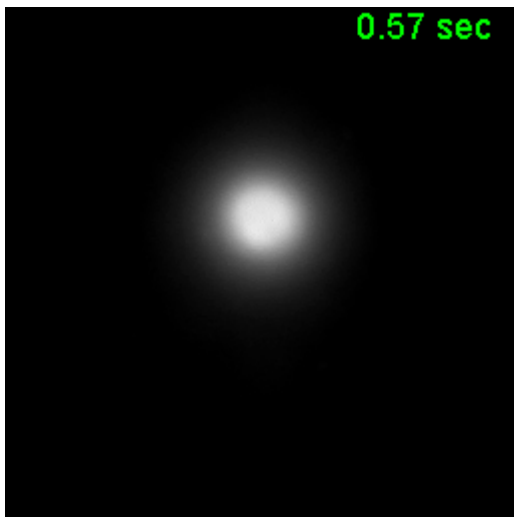
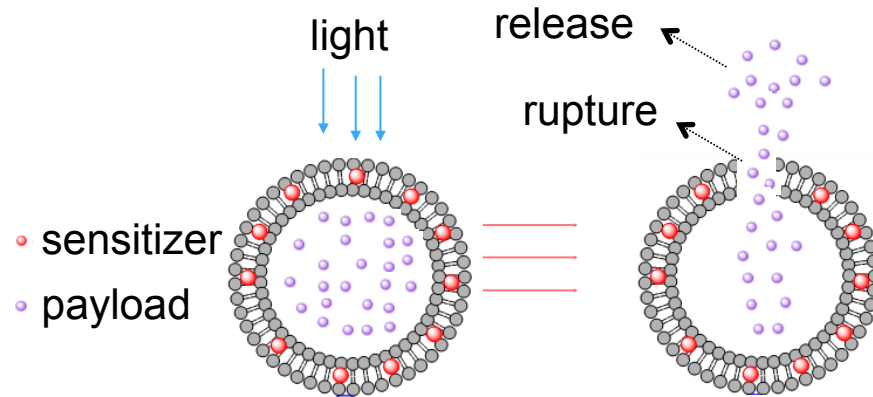
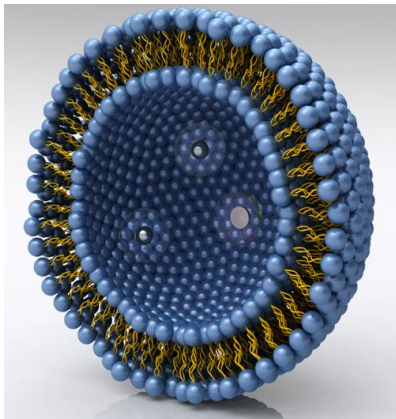
Optofluidic Planar Reactor for photocatalytic water treatment Using solar energy, Lei, et. al., Biomicrofluidics, 2010 (Taiwan)



Mimicking Photosynthetic Energy Transduction, Gust, Moore, and Moore, Acc. Chem. Res. 2001

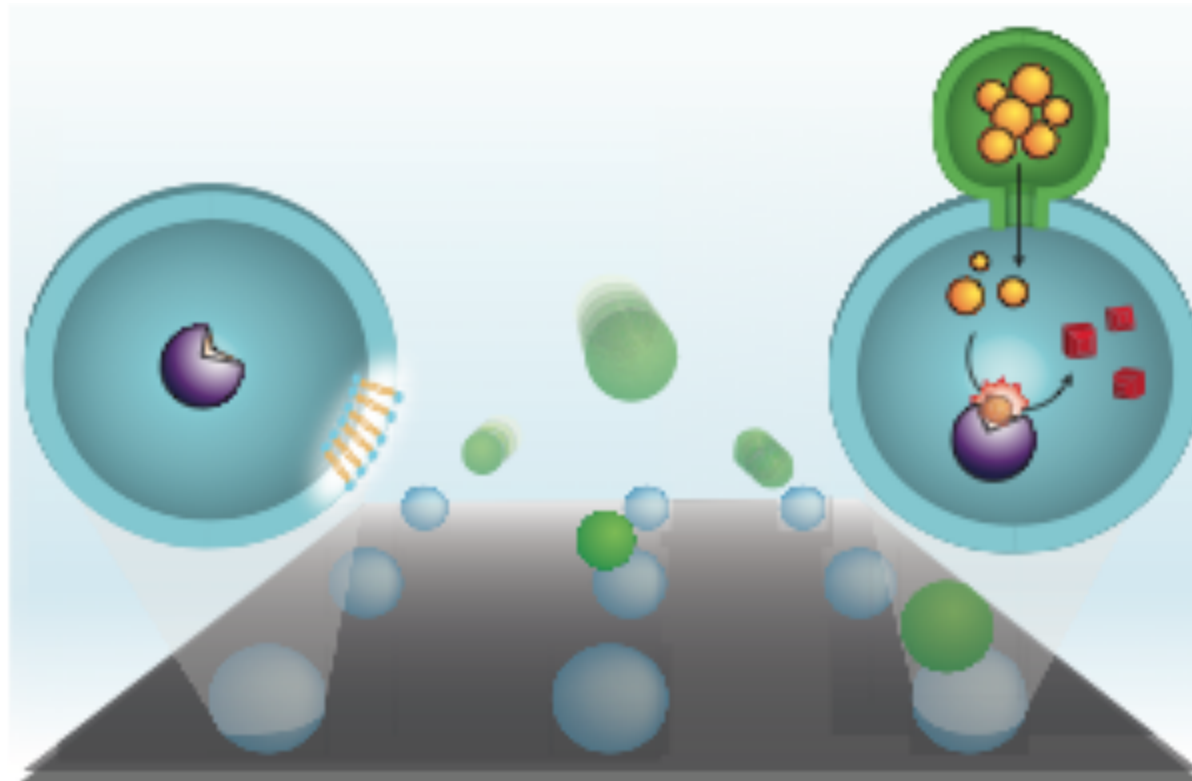


Optofluidic Vesicles (Polymersomes-PEG-PPS)



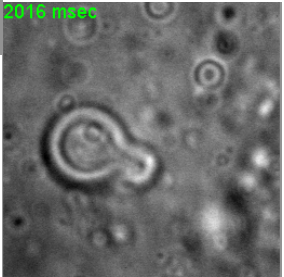
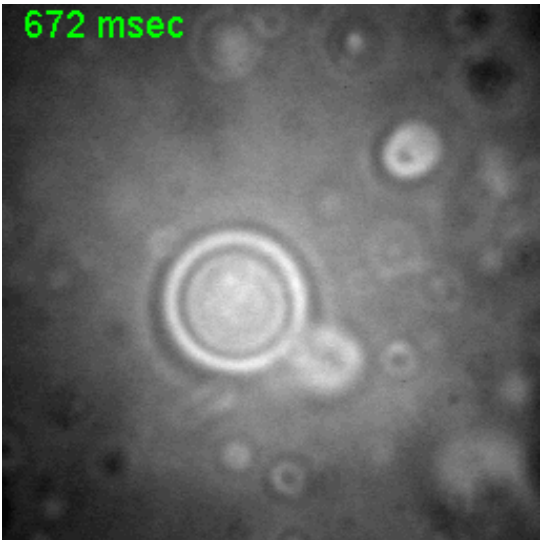
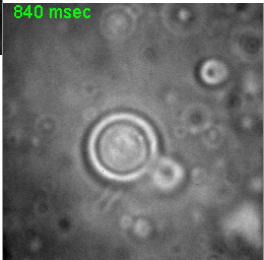
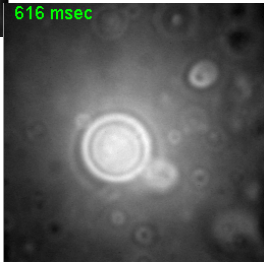
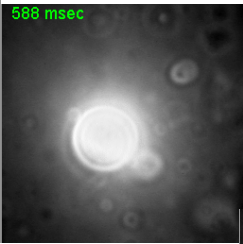
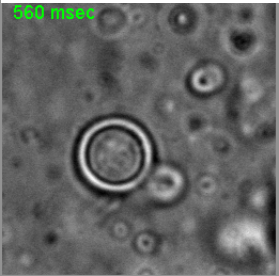
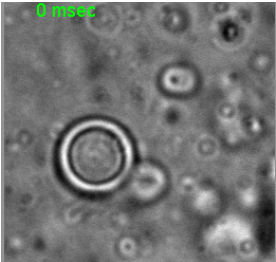
Optofluidic Intracellular delivery, Vasdekis, et. al. (submitted)

Vesicle Nanoreactors



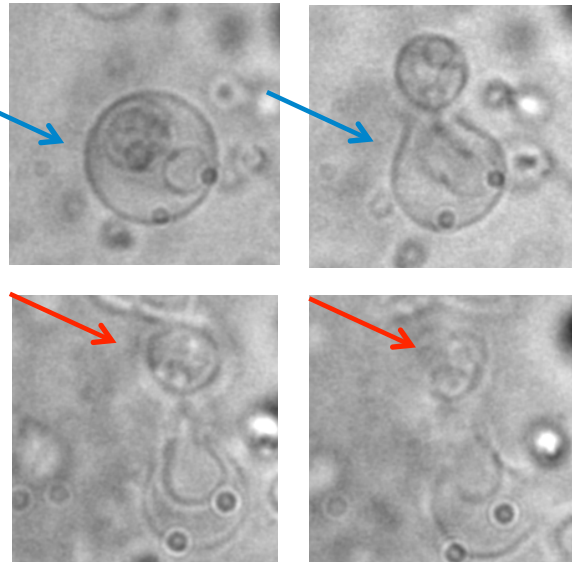
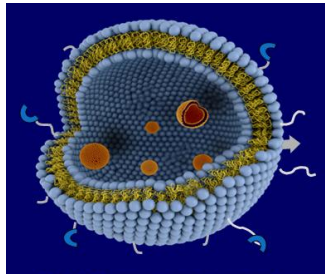
Christensen, et.al., Nature Nanotechnology, October 2011

Optically triggered Vesicle fusion

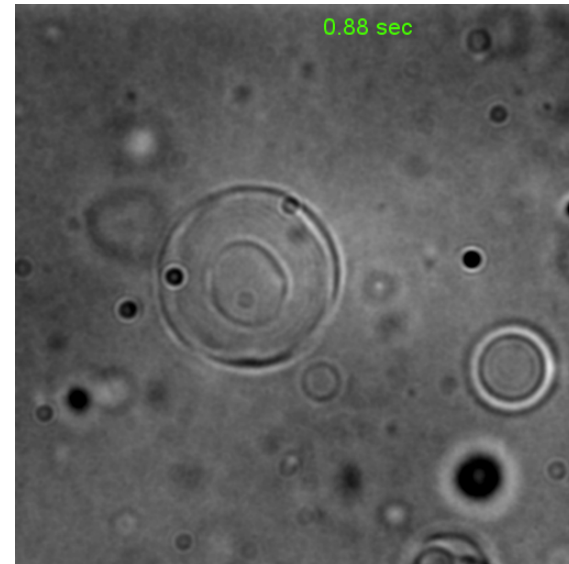


Vesicle chemical reactions

2 colors



Blue then red

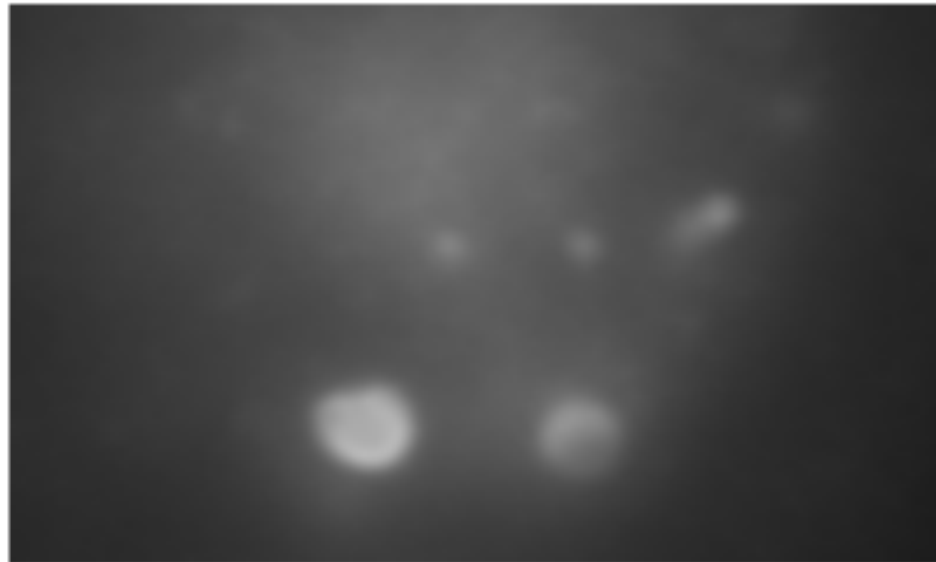


Red then blue

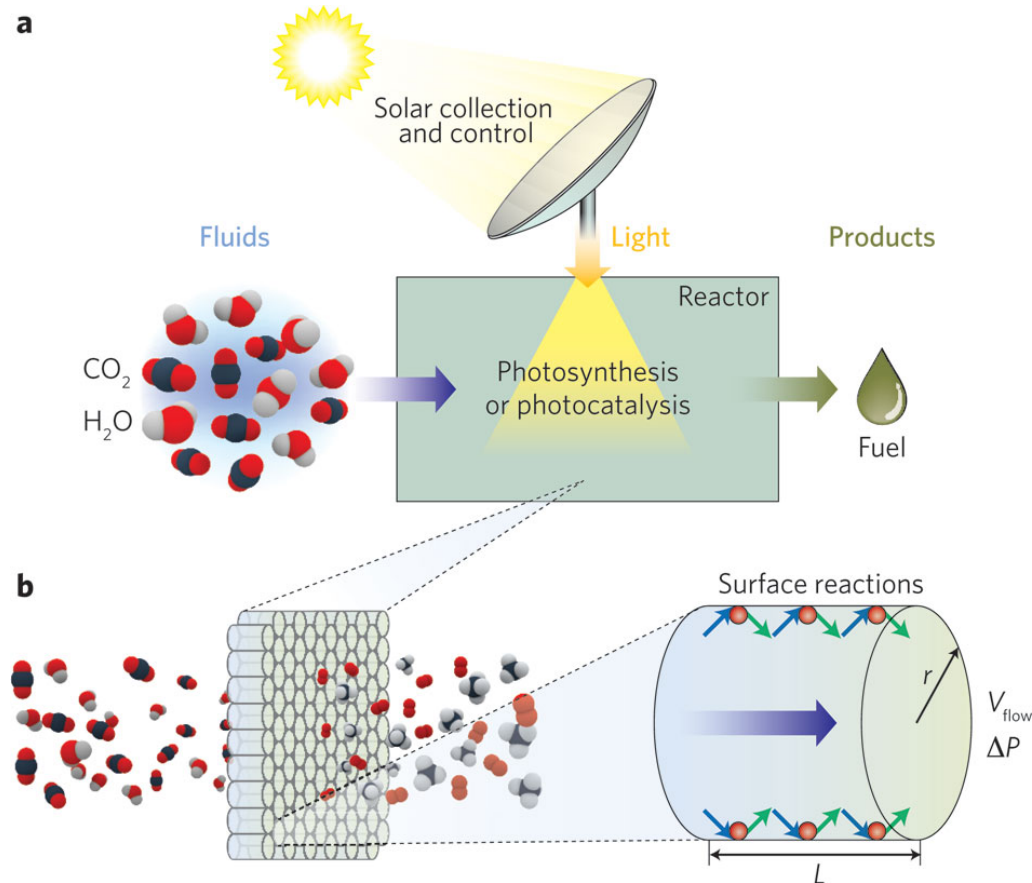
Quantum Dot Payload

CdSe/ZnO

0.00 sec



Final Comment



- (1) The velocity in a circular channel is $V_{\text{flow}} = \Delta P r^2 / (8 \mu L)$
- (2) The diffusion time for a reactant to be transported to the surface is $t = 2 \langle r \rangle^2 / D$

“Optofluidics for energy applications”, Erickson, Sinton, Psaltis
Nature Photonics 5, 583–590 (2011)