Photodisruption in biological tissues and single cells using femtosecond laser pulses

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CLEO, Baltimore, MD
May 10, 2001

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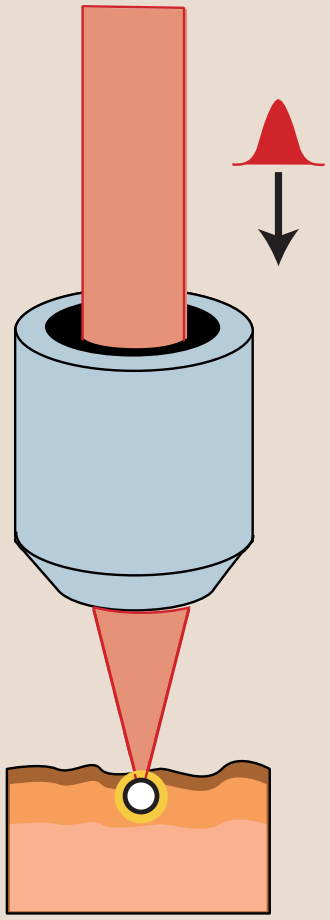
Department of Physics

Introduction



Photodisruption: removal of tissue by ablation or vaporization

focus ultrashort pulse on tissue

high laser intensity at focus

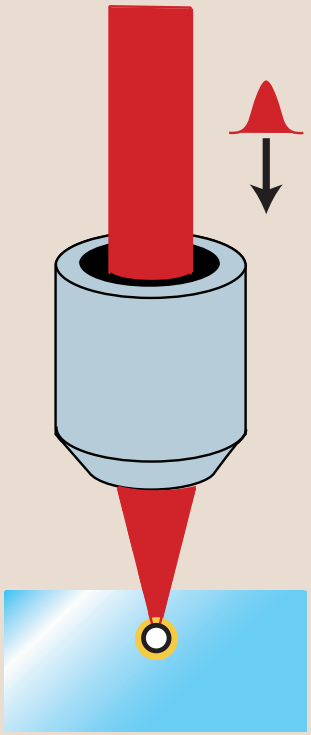
ionization by nonlinear mechanisms (MPI, tunneling, avalanche)

microscopic structural change

Outline

- Photodisruption dynamics
- Results and discussion
  - Turbid tissue photodisruption
  - Sub-cellular micromachining
- Summary
- Works in progress

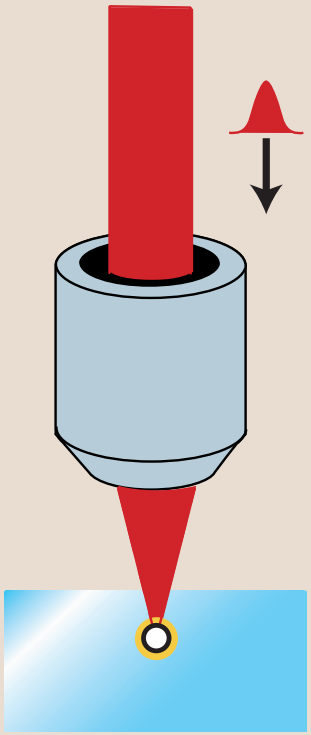
Dynamics



Dynamics

Nonlinear
Absorption

Plasma formation



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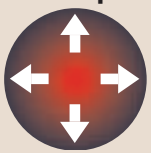

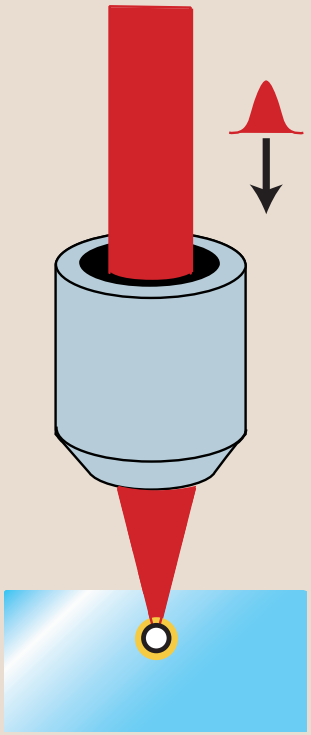

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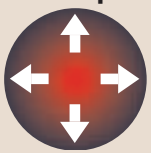
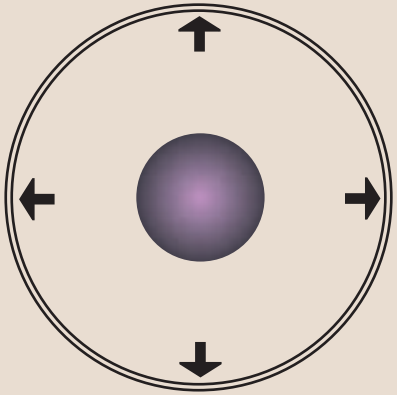
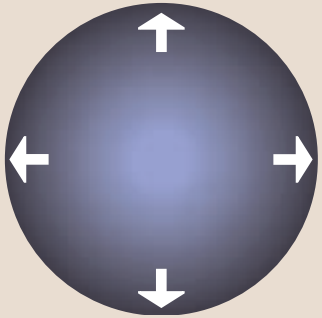
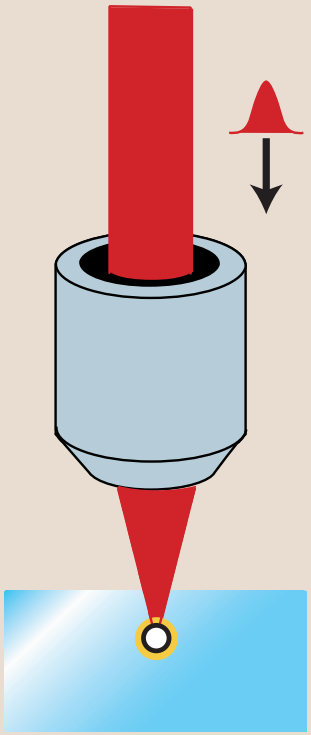


Mechanical effects







Dynamics

Nonlinear
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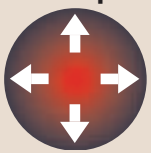
Plasma formation

Plasma expansion



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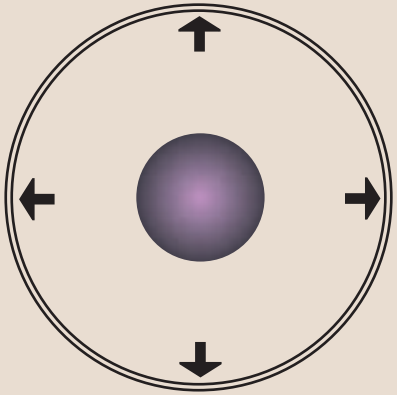
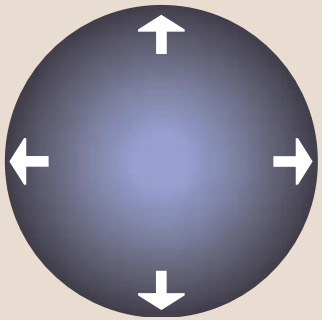
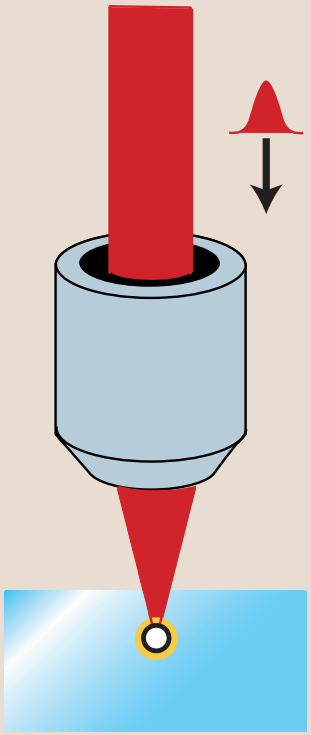
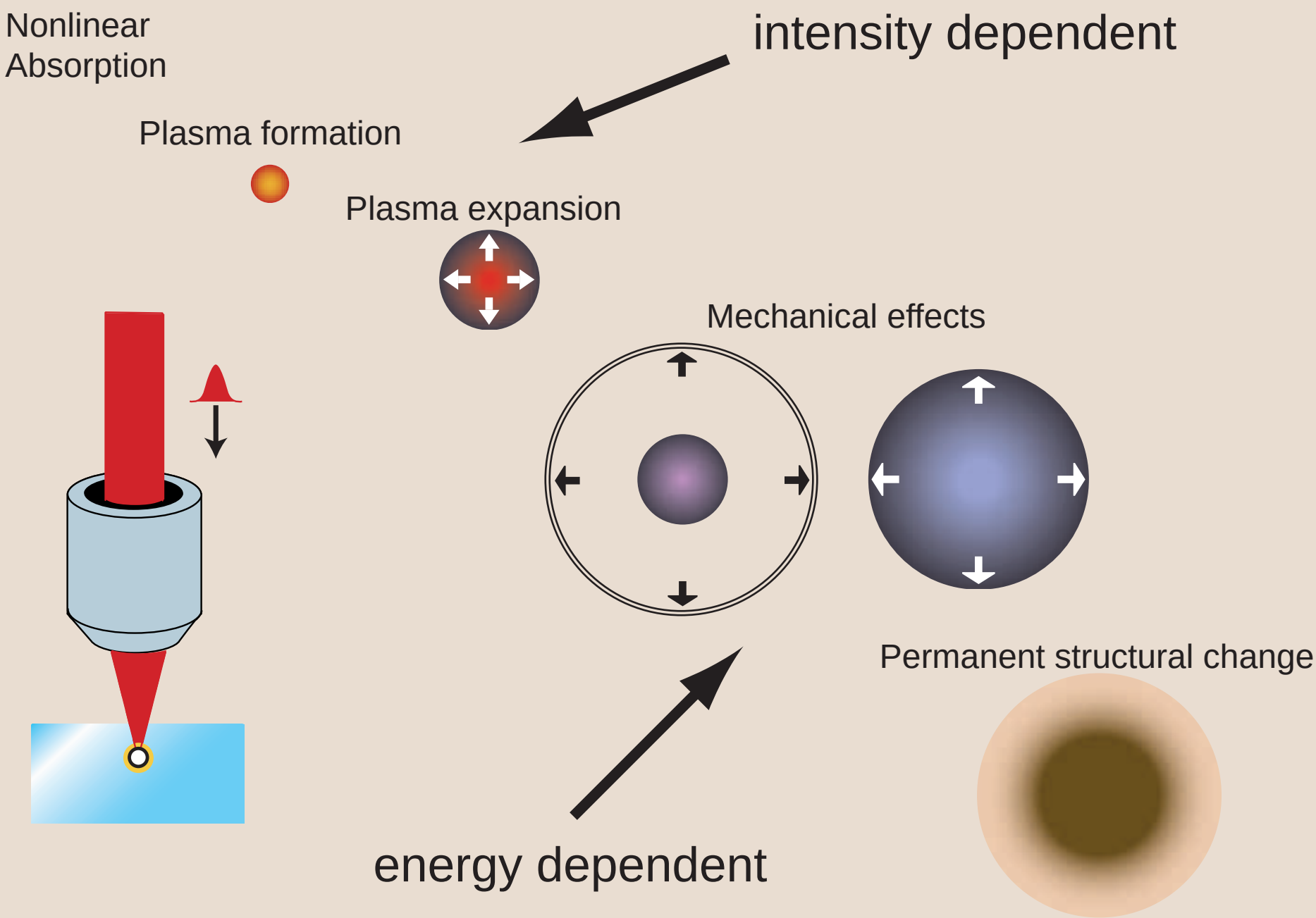




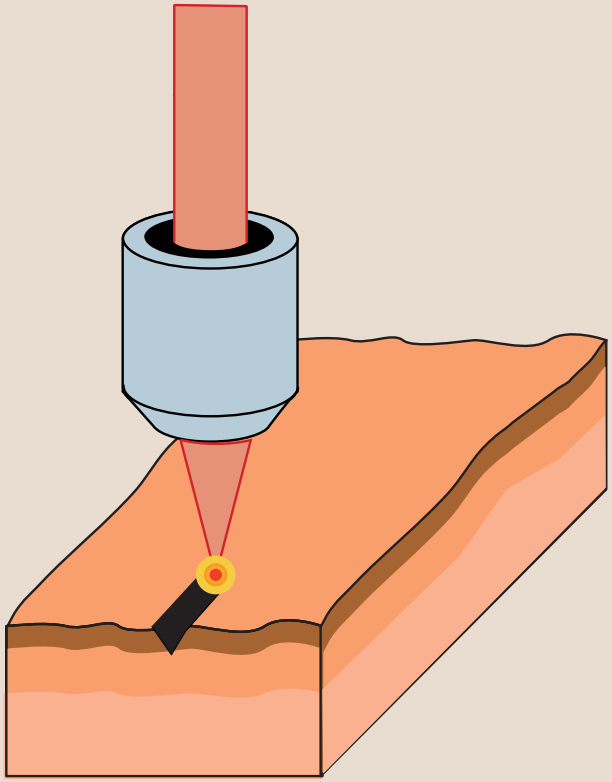


Permanent structural change

Dynamics


Nonlinear
Absorption
intensity dependent
Plasma formation
Plasma expansion
Mechanical effects
Permanent structural change
energy dependent

Precise incision



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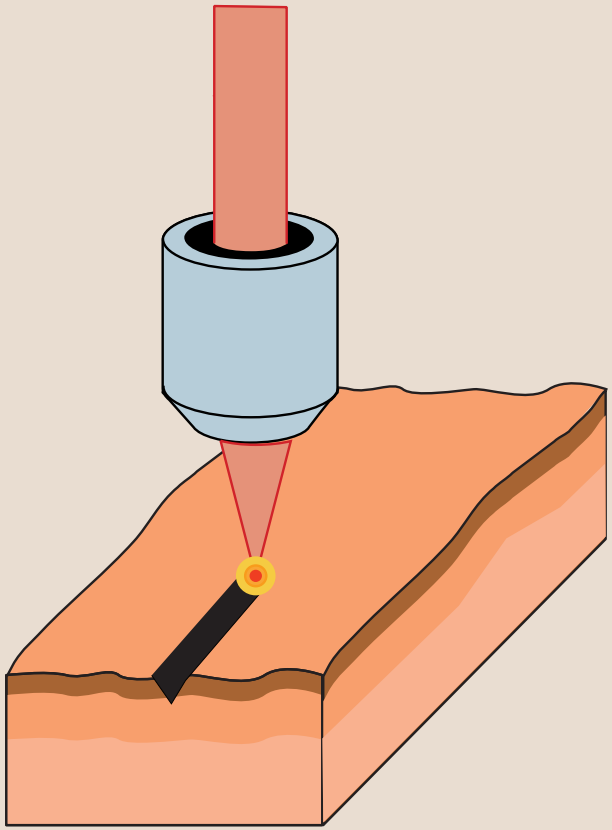

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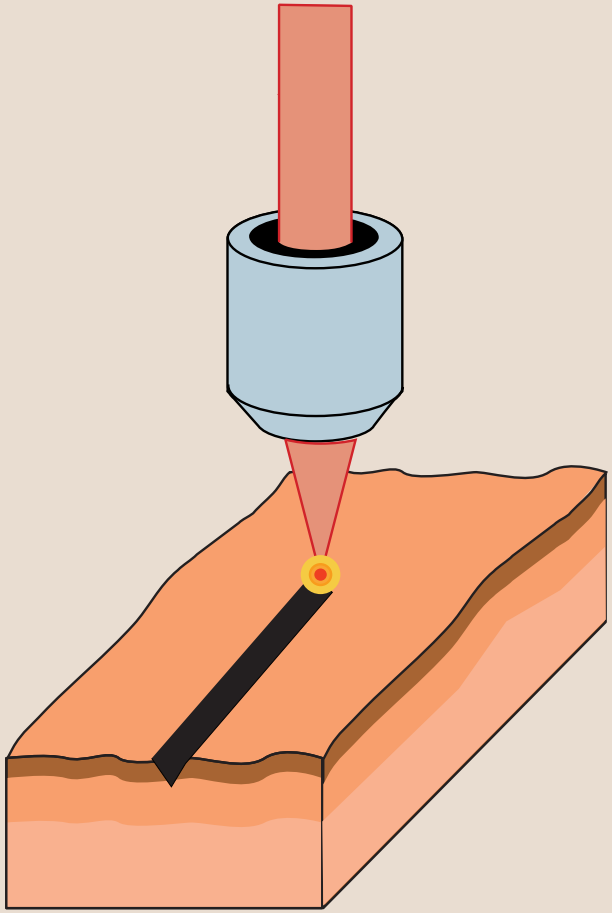
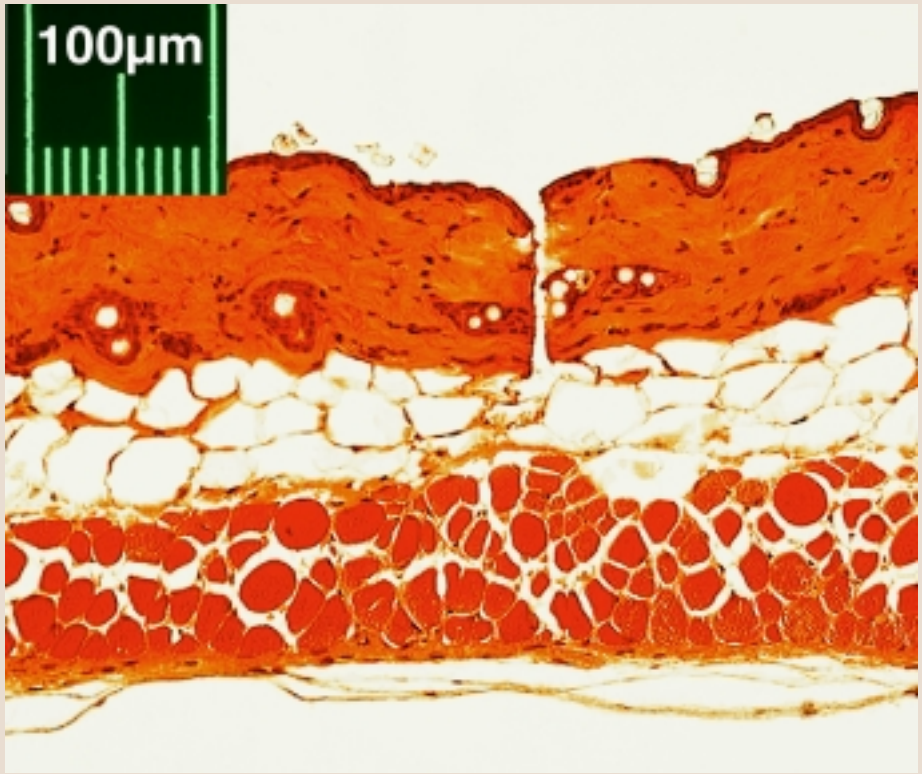
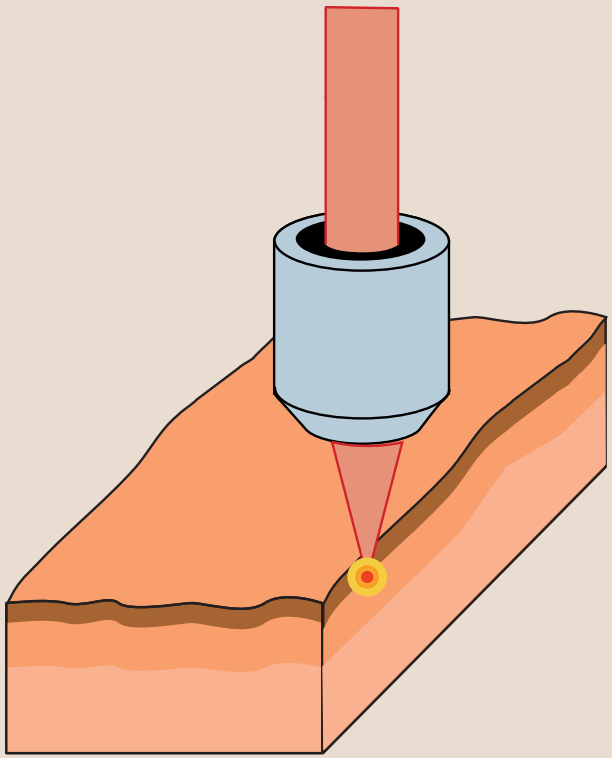


100fs, 20μJ



3 passes
at 0, 100μm, and 200μm deep

Subsurface microstructure



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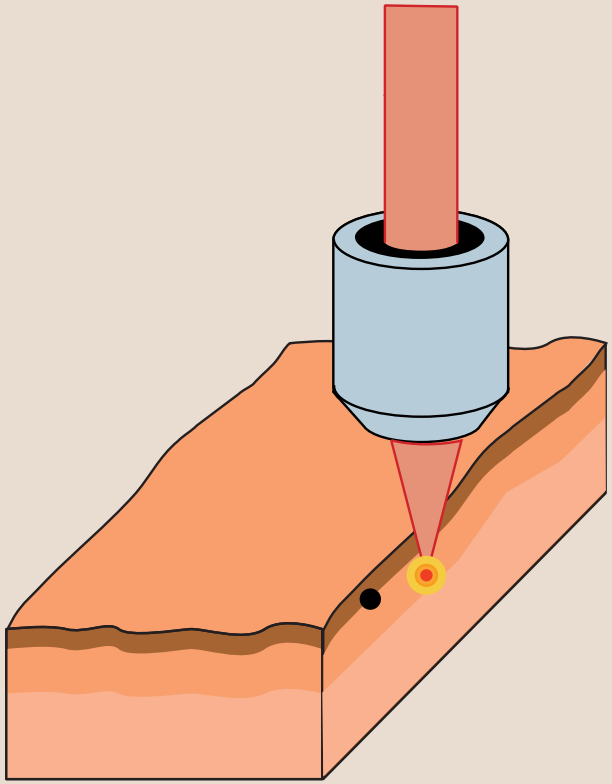
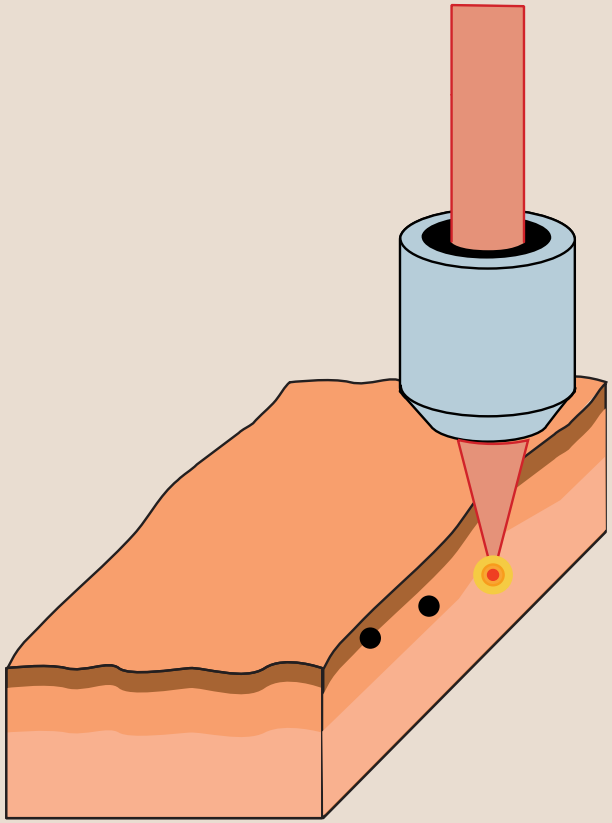
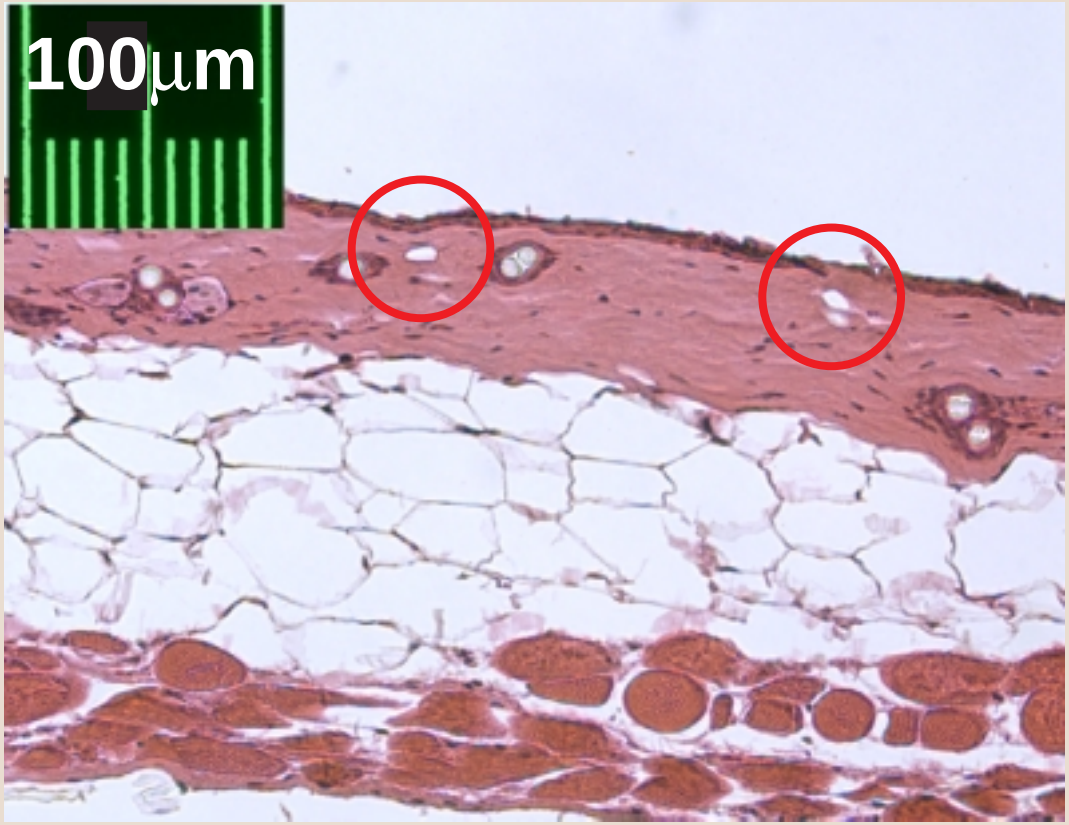


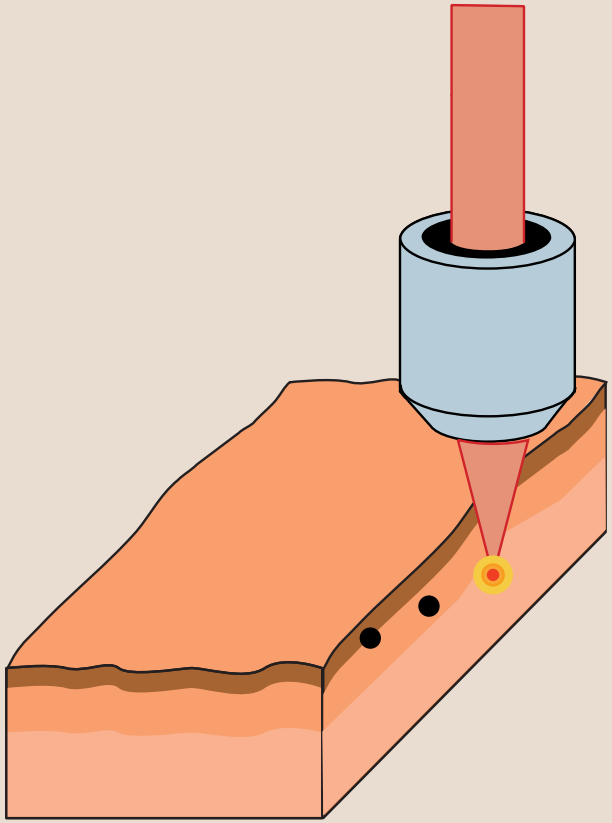
Subsurface microstructure

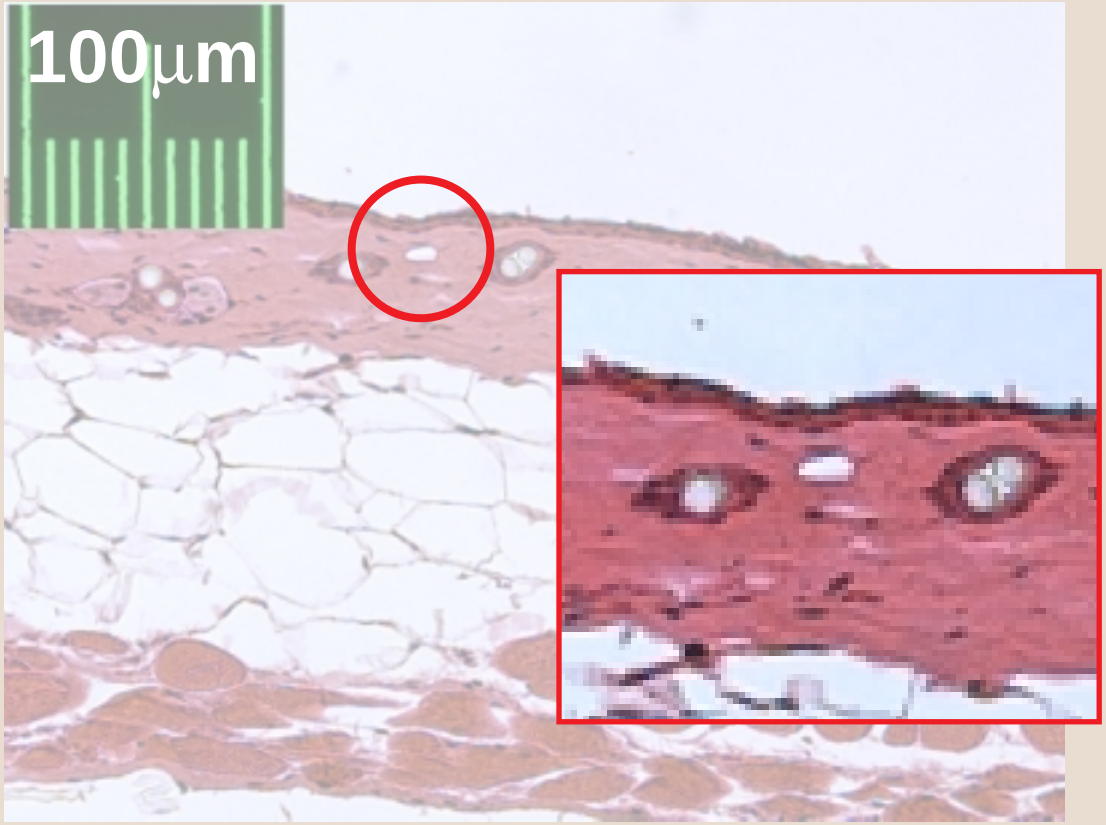




100fs, 20μJ, single pulse

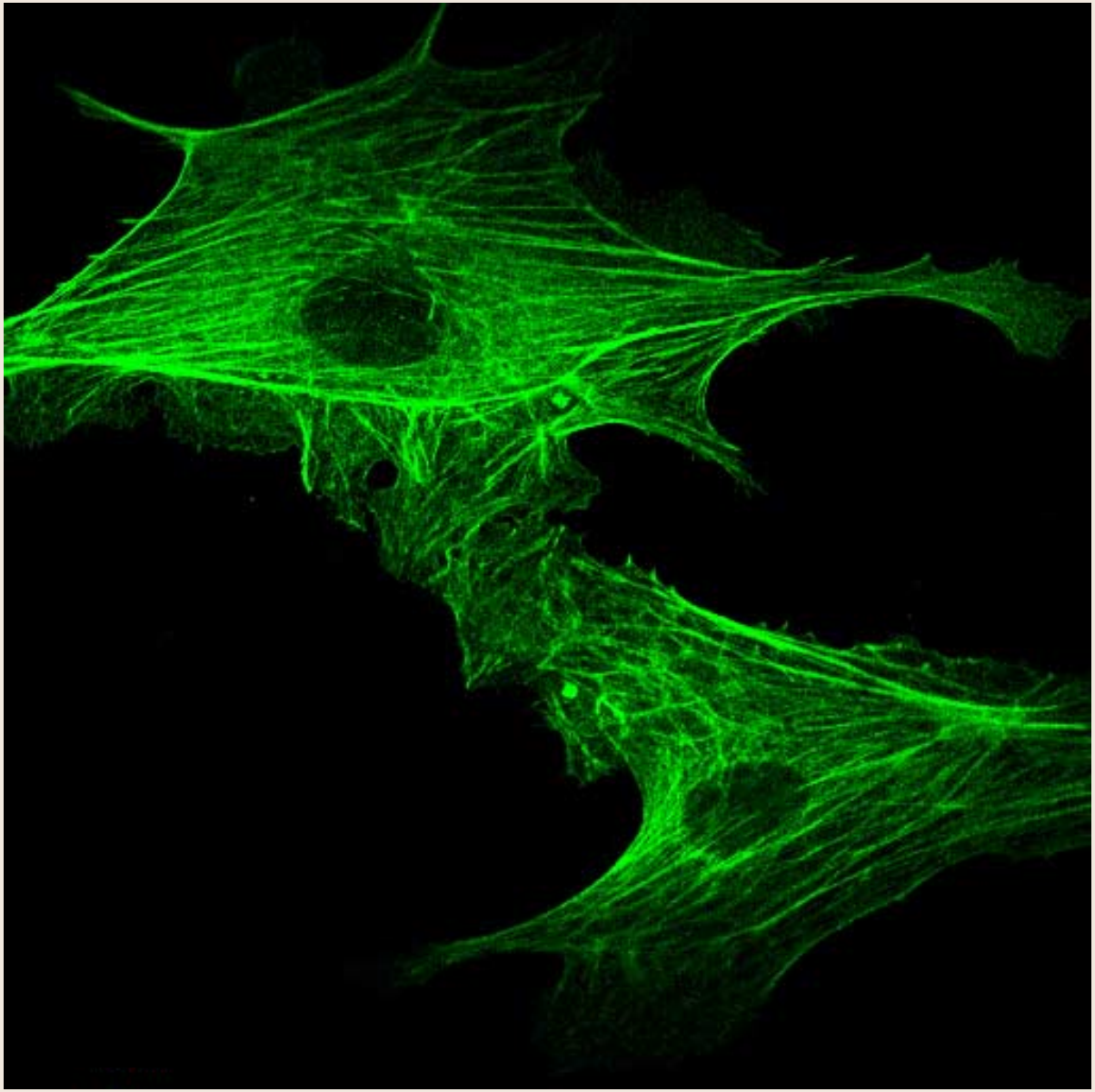
Subsurface microstructure





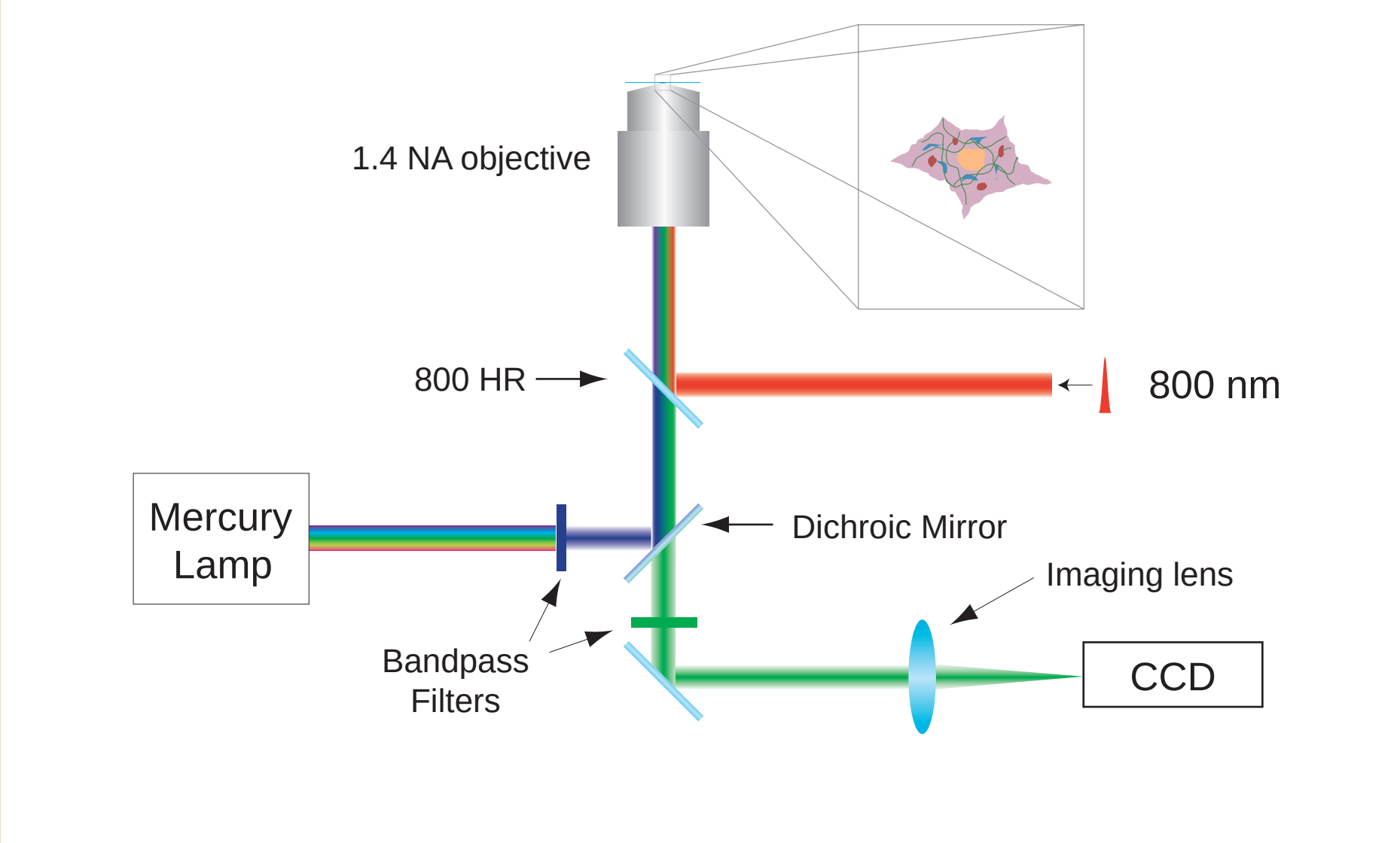
100fs, 20μJ, single pulse

Single cell

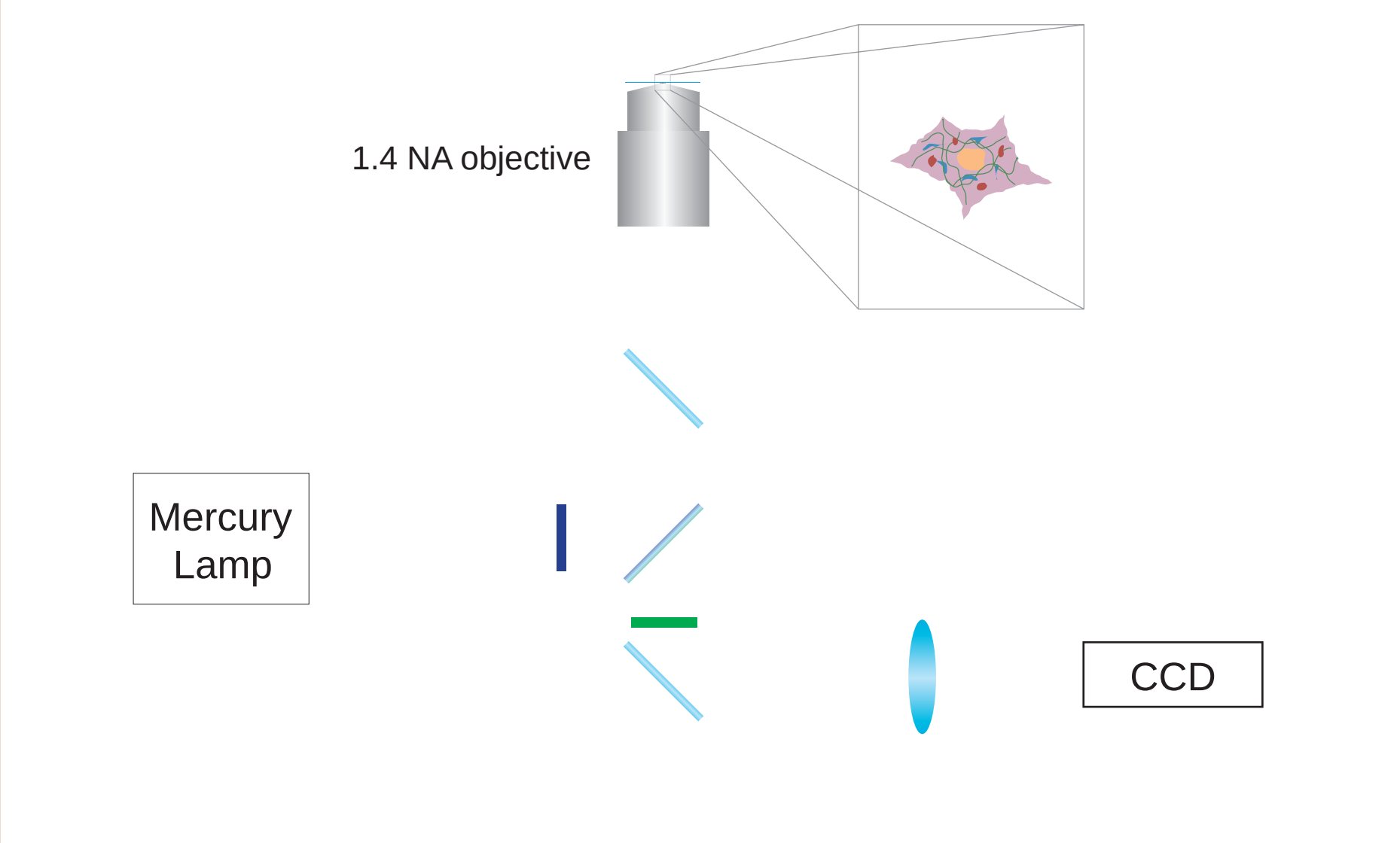


Sub-cellular Photodisruption

Microscope


1.4 NA objective
800 HR
800 nm
Mercury Lamp
Dichroic Mirror
Imaging lens
Bandpass Filters
CCD

Microscope



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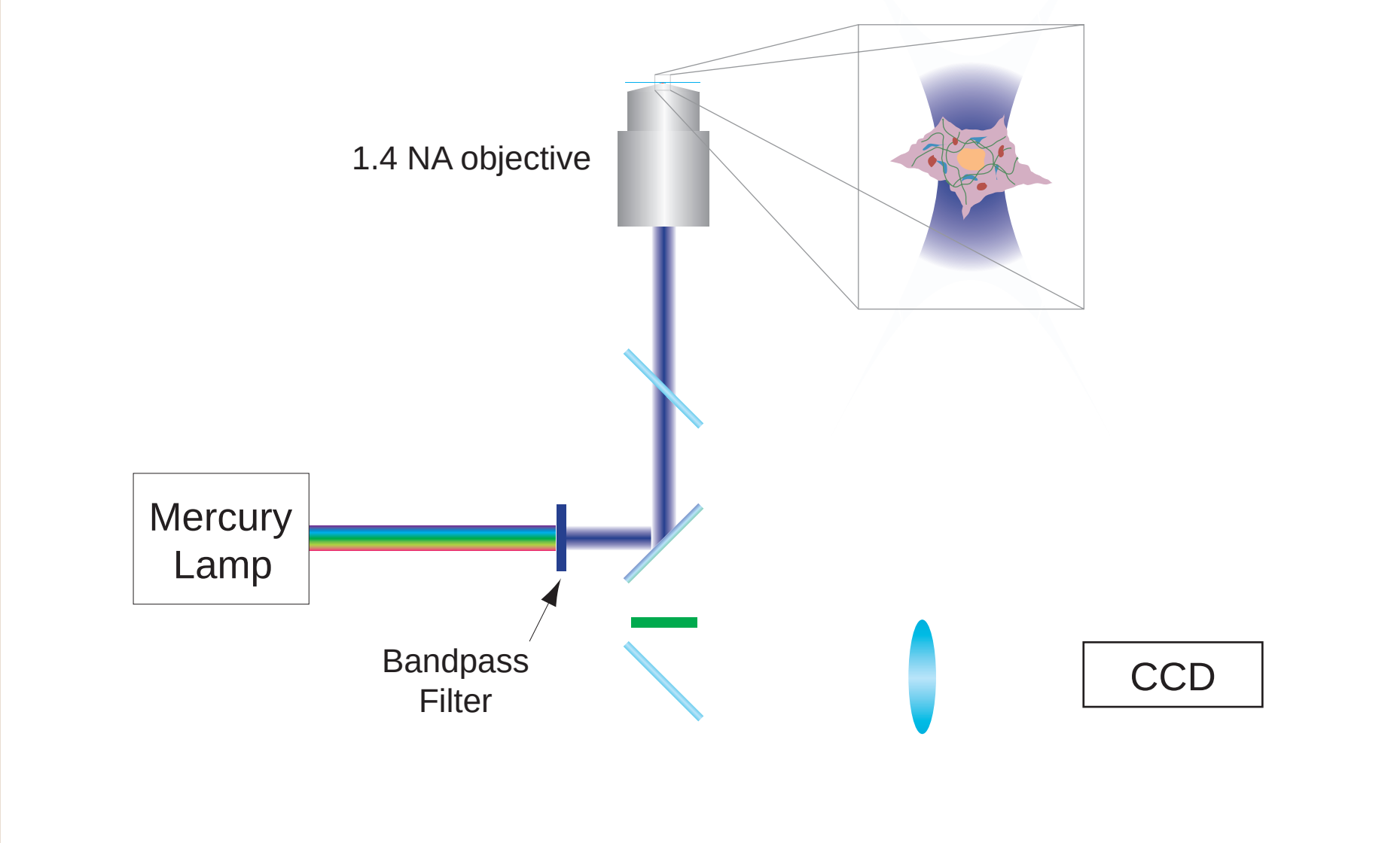

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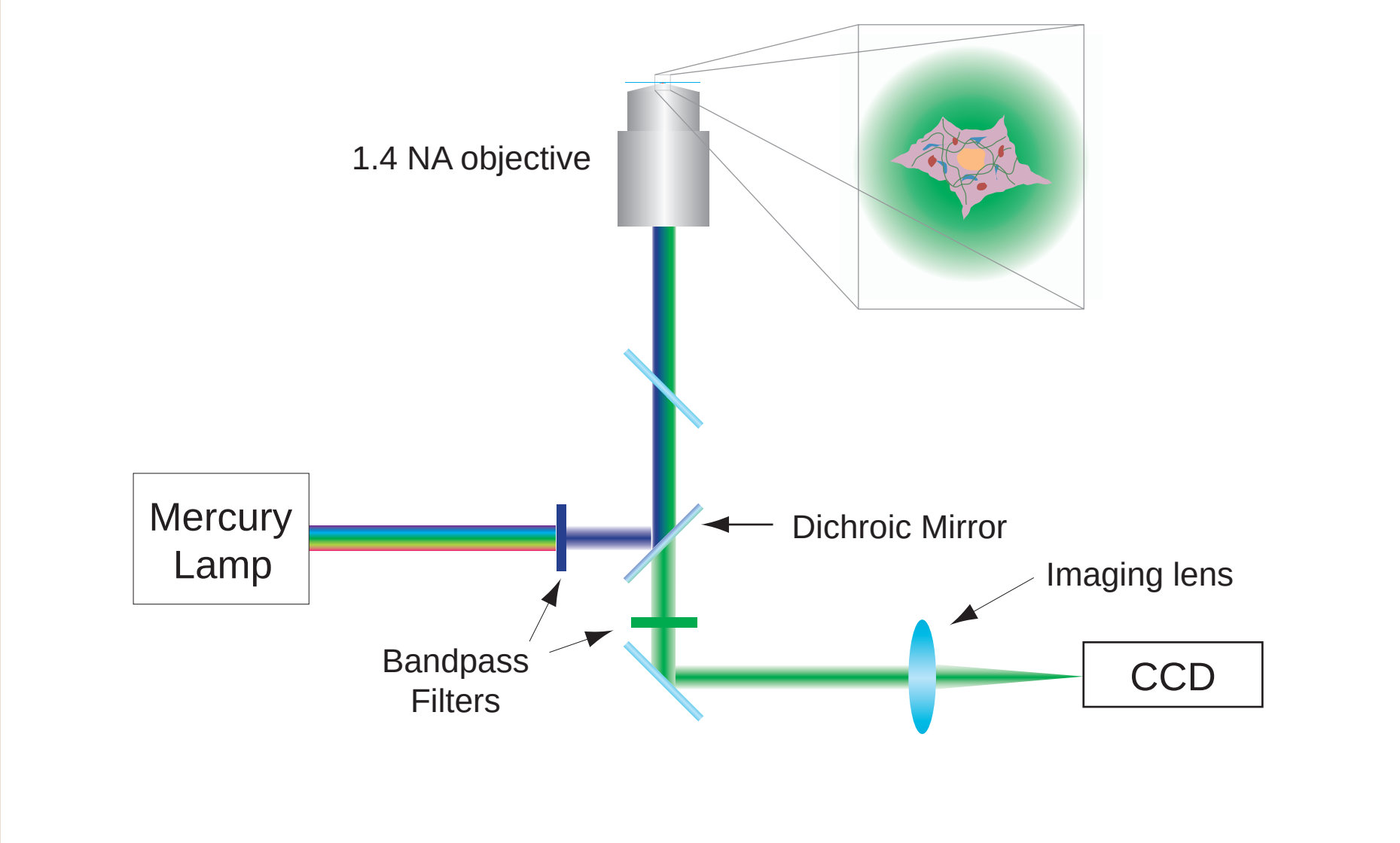
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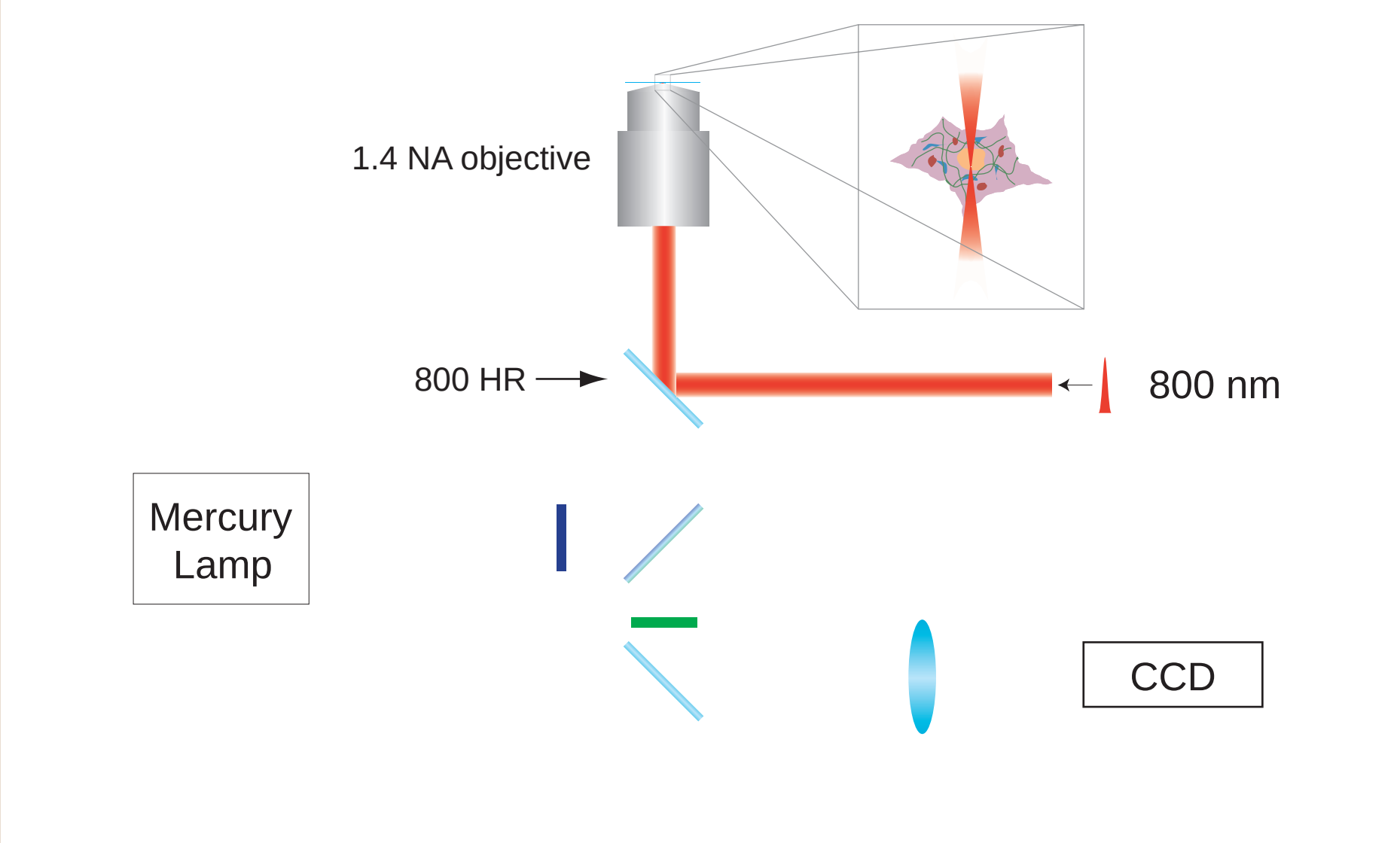

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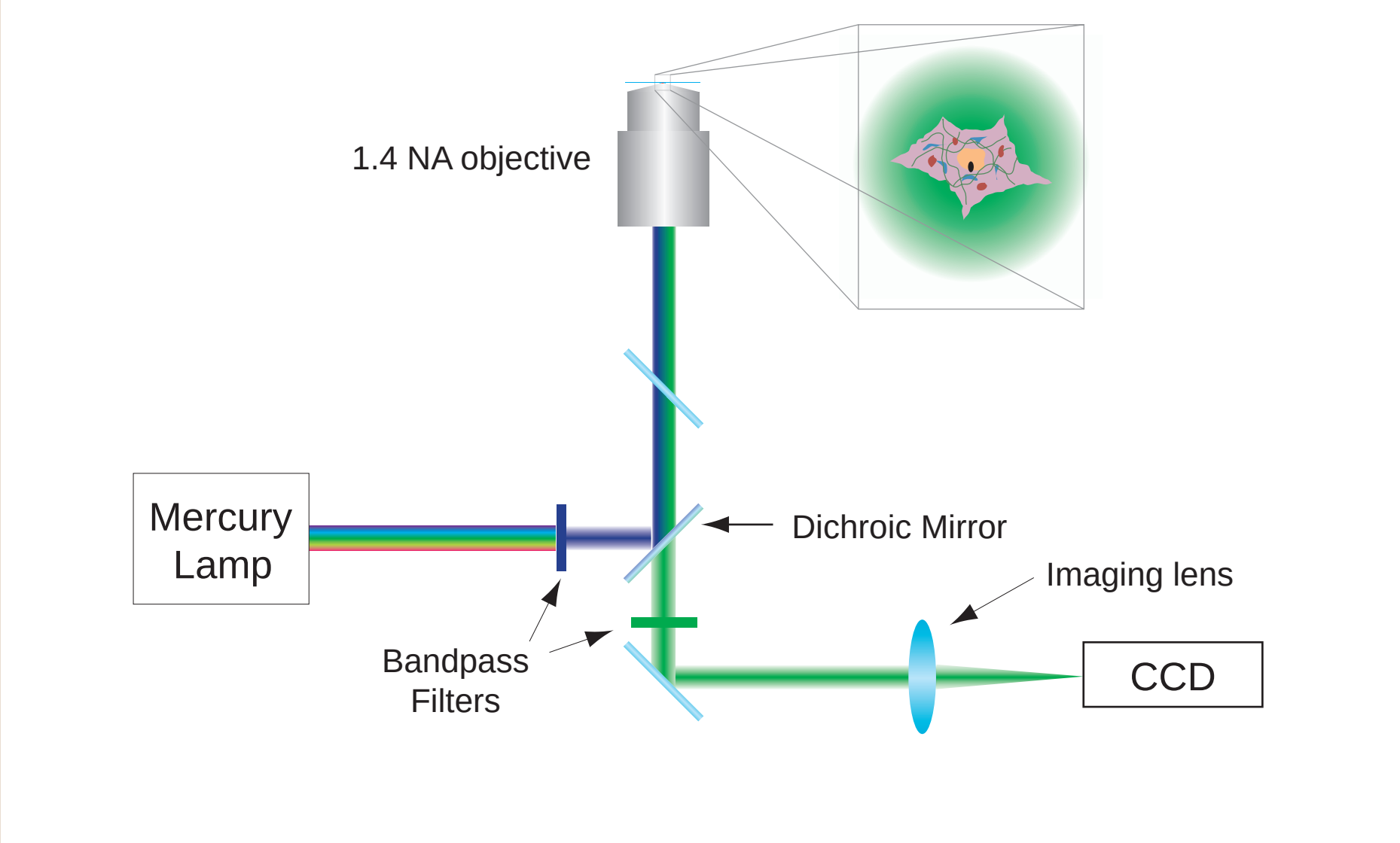
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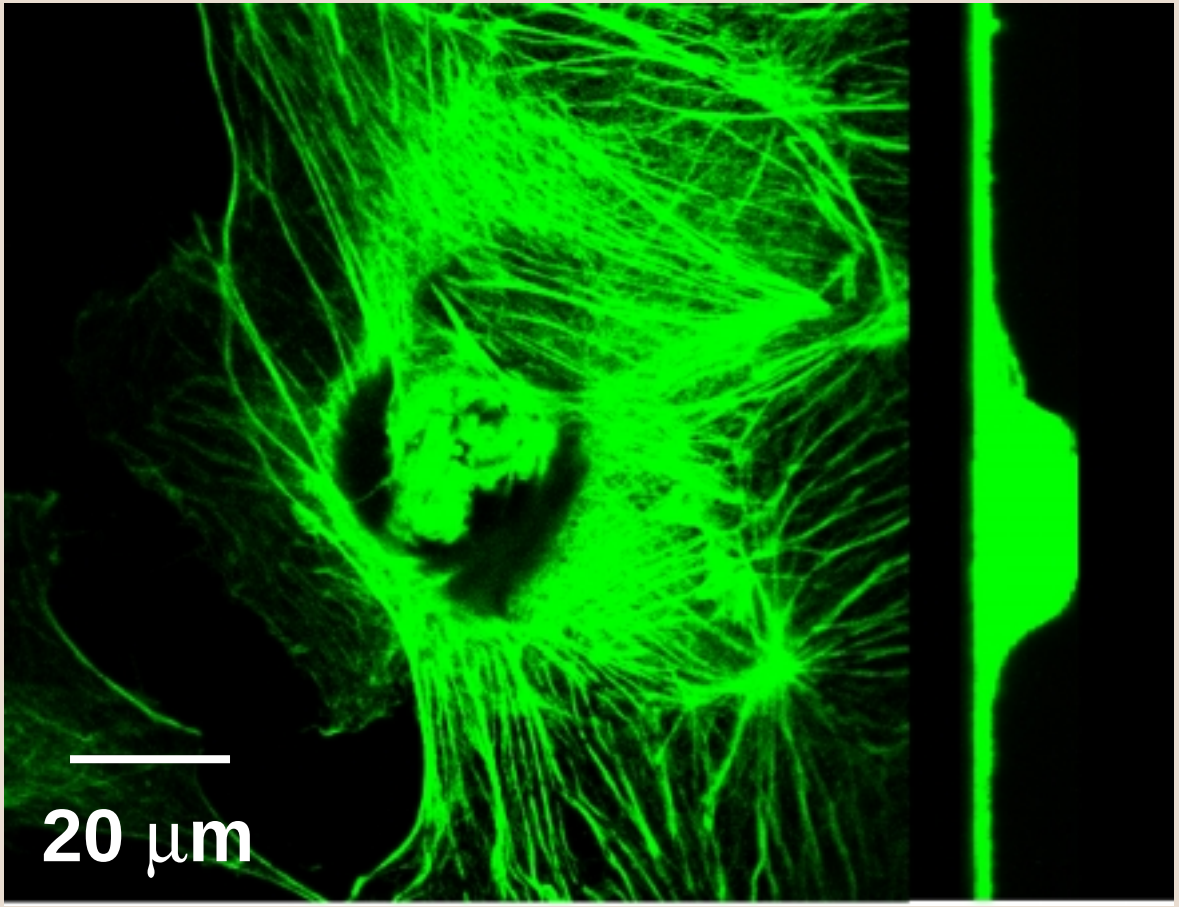
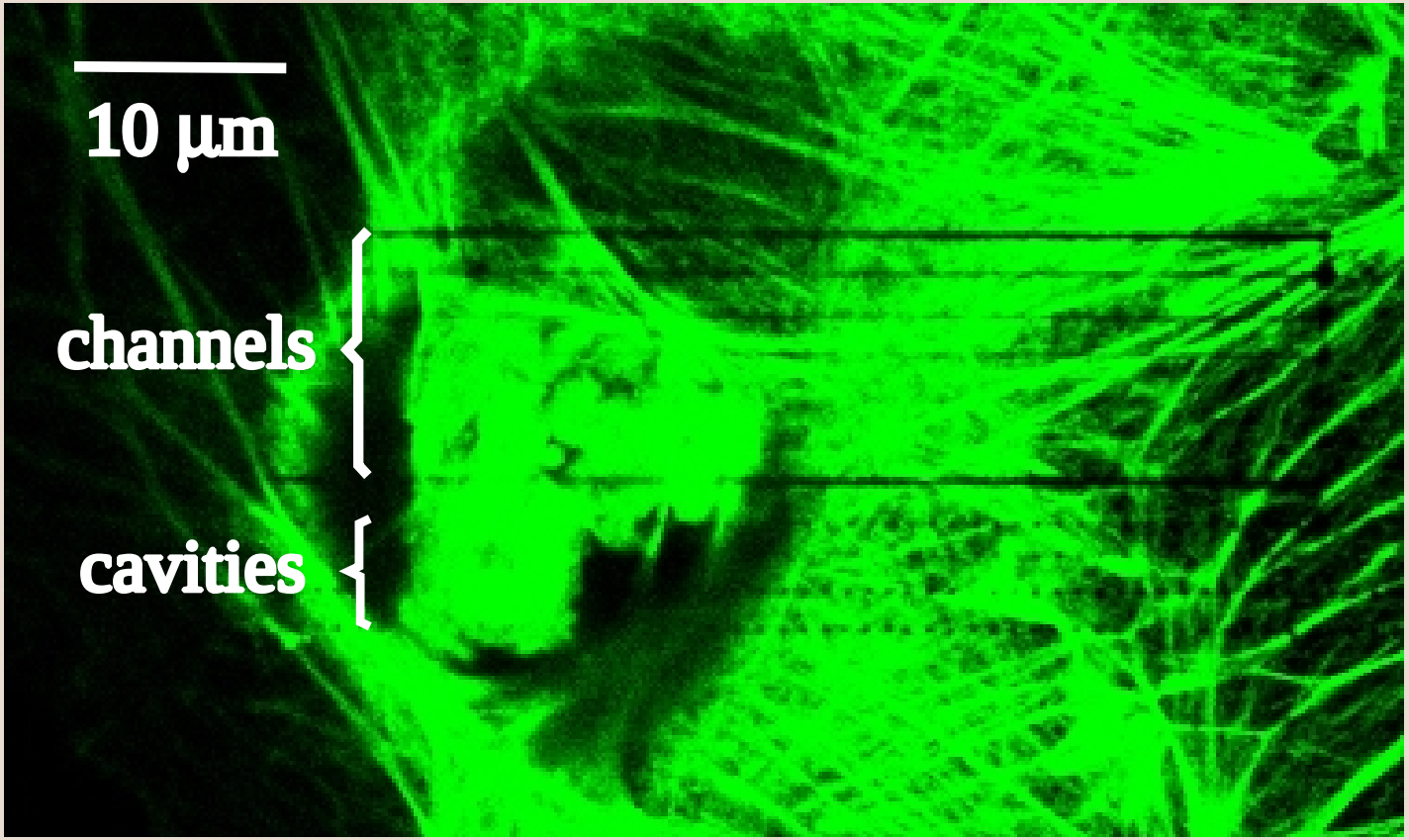
Single cell

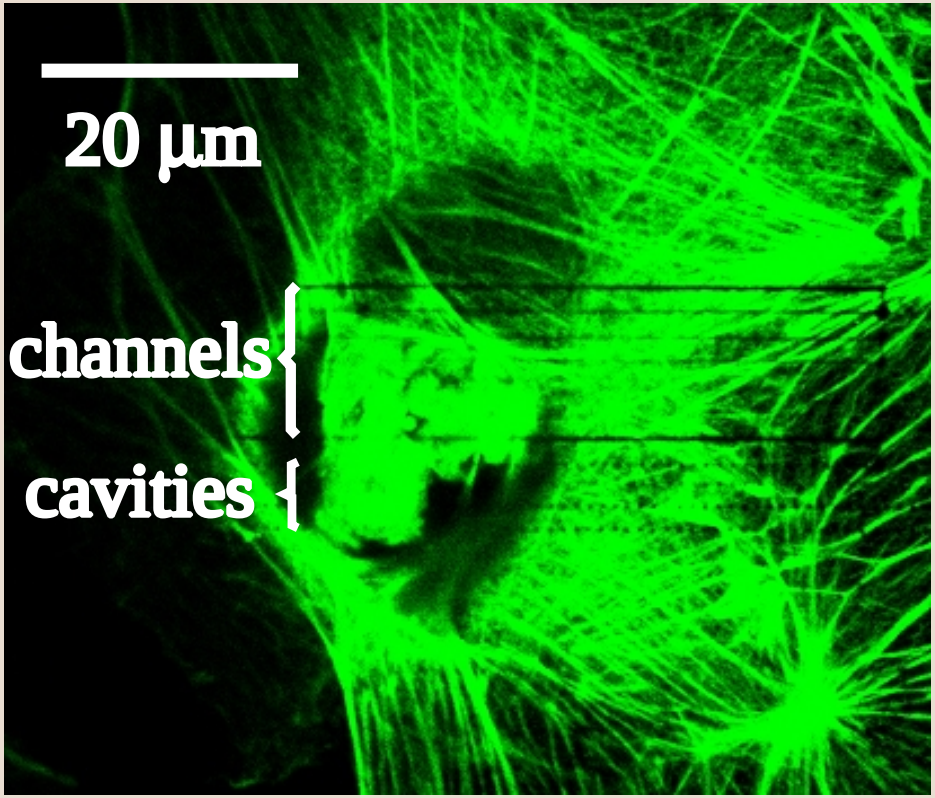


top view

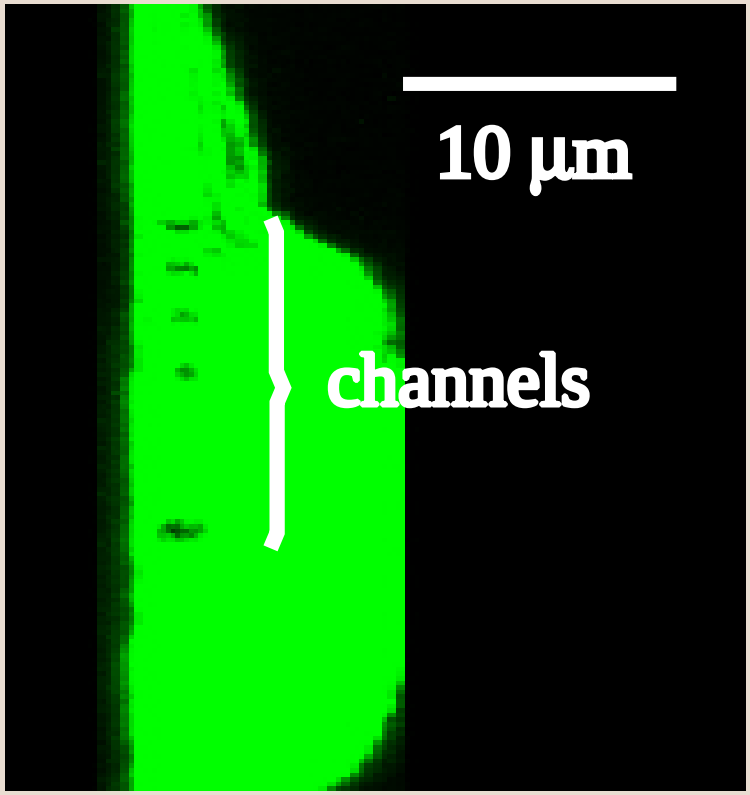


Single cell

top view

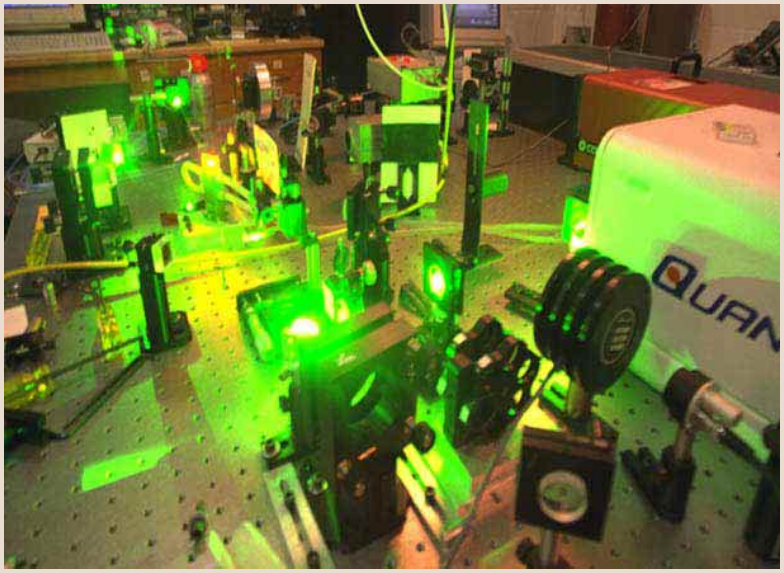


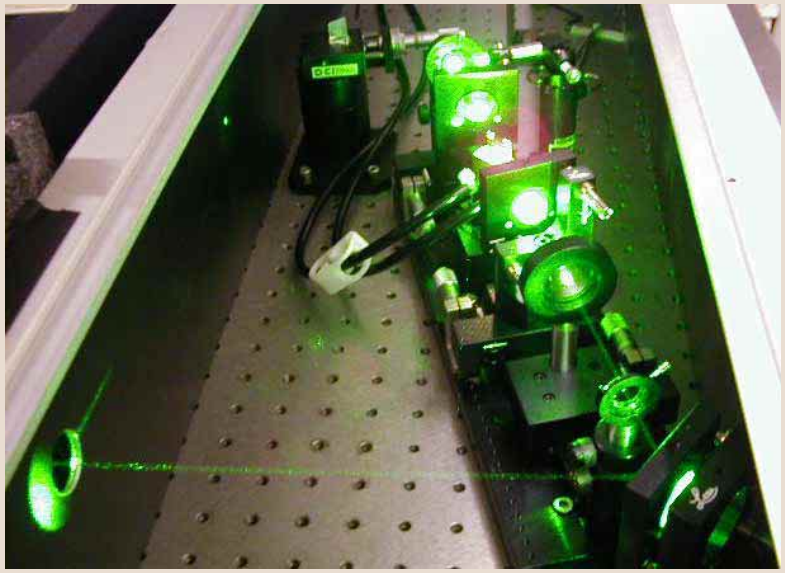
side view



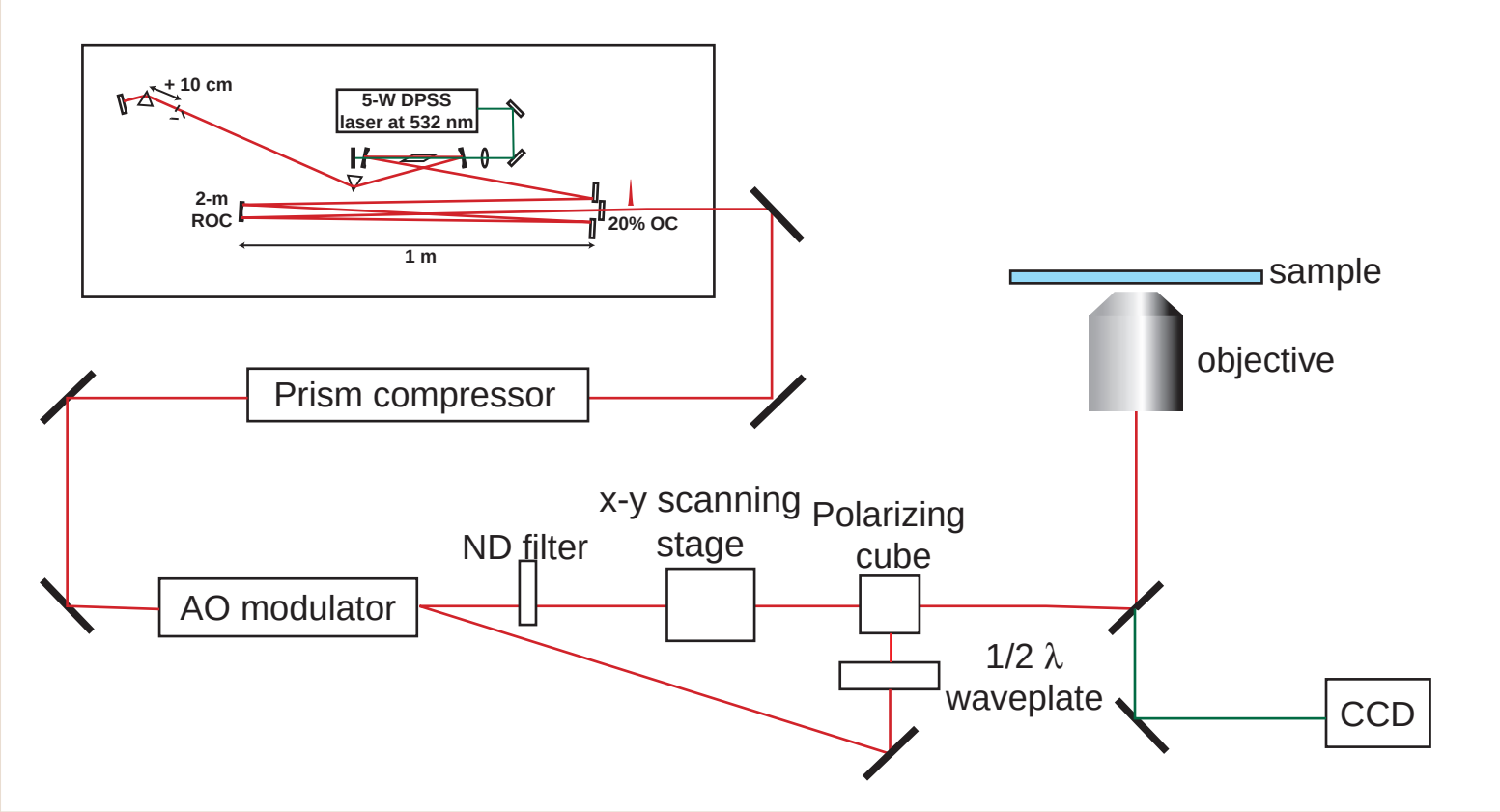
why nanojoules?

non-amplified micromachining





Single cell

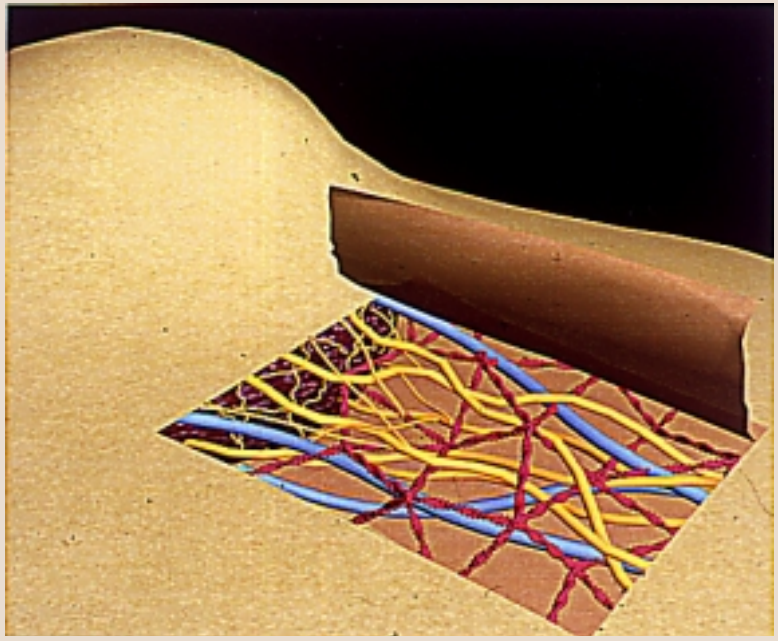

+ 10 cm
5-W DPSS
laser at 532 nm
2-m
ROC
20% OC
1 m
sample
objective
Prism compressor
x-y scanning
stage
Polarizing
cube
ND filter
AO modulator
1/2 λ
waveplate
CCD

Summary

- precise μm-wide incision and subsurface cavity formation in animal skin tissue

- photodisruption in cells with sub-cellular precision using fs laser pulses with only a few nJ of energy

Work in progress



structural integrity of the cytoskeletal network

⇩

mechanical signal transduction in a cell

⇩

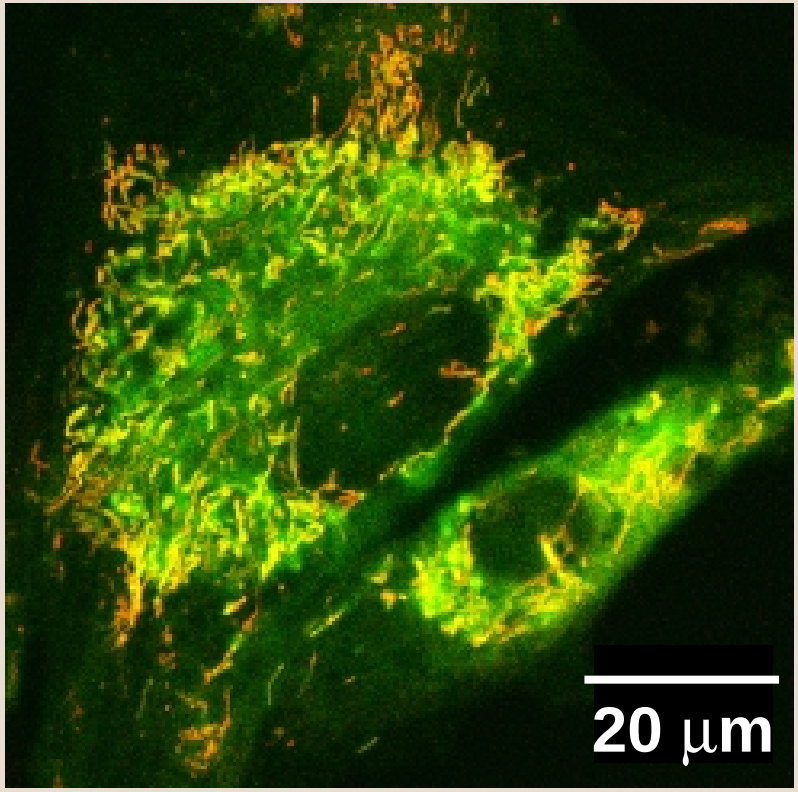
biochemistry

⇩

cell functions such as growth and movement

N. Wang, J. P. Butler, and D. E. Ingber, **Science** *1993 Vol. 260*

Work in progress



Mitochondrial network in a BCE cell

distribution

colocalization with certain cytoskeletal components

diffusion dynamics

How is mitochondrial behavior coordinated with other central events in cell proliferation and development?

Acknowledgements

Prof. Douglas Melton

National Science Foundation

For a copy of this talk and additional information, please see:

http://mazur-www.harvard.edu