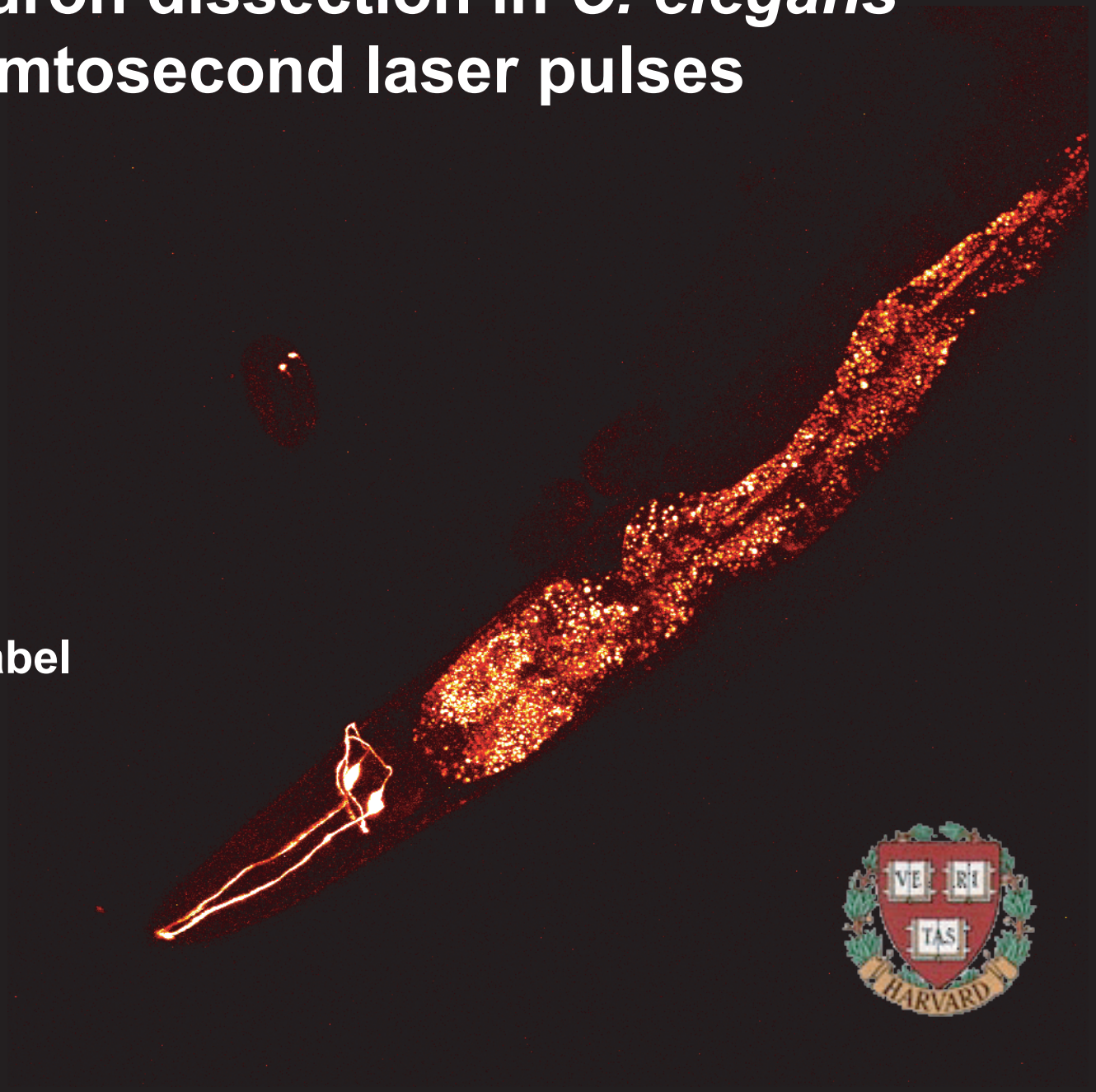
Single neuron dissection in *C. elegans* by femtosecond laser pulses



Samuel Chung
Eric Mazur

Damon Clark, Chris Gabel
Aravinthan Samuel

Photonics West
21 January 2006

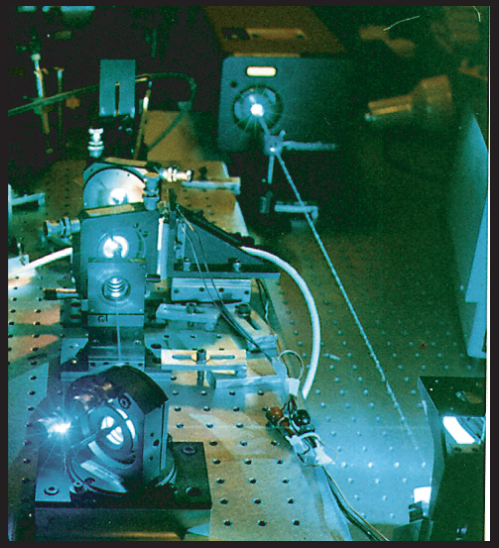
Introduction

Samuel Group

C. elegans neurobiology

Mazur Group

Femtosecond laser physics



Worm image from J. Berger and R. Sommer, Max-Planck Institute for Developmental Biology

Introduction

Samuel Group

C. elegans neurobiology

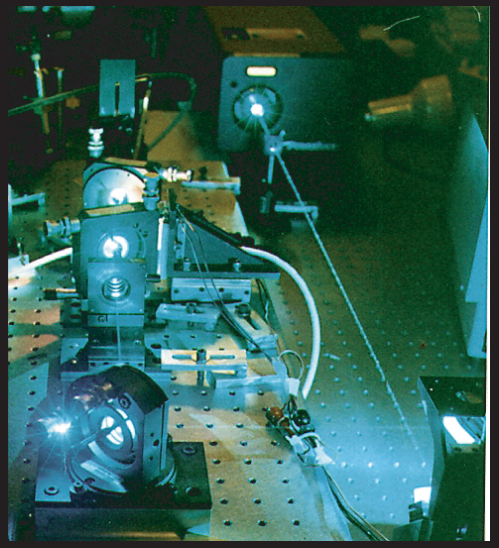
neural basis of behavior

regeneration

degeneration

Mazur Group

Femtosecond laser physics



Worm image from J. Berger and R. Sommer, Max-Planck Institute for Developmental Biology

Background

"Model" organism

- simple animal
- similarities to higher organisms

Worm image from David Gems, University College London

Background

"Model" organism
- simple animal
- similarities to higher organisms

Nervous system
- composed of 302 neurons
- invariant wiring diagram
- encodes the worm's standard behavior

Worm image from David Gems, University College London

Background

"Model" organism
- simple animal
- similarities to higher organisms

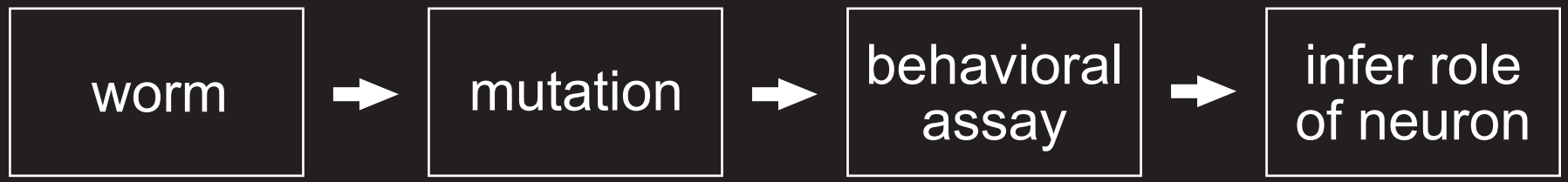
- transparent in visible
- transparent in near infrared

Nervous system
- composed of 302 neurons
- invariant wiring diagram
- encodes the worm's standard behavior

Worm image from David Gems, University College London

Mapping behavior to neurons

conventional method:



Mapping behavior to neurons

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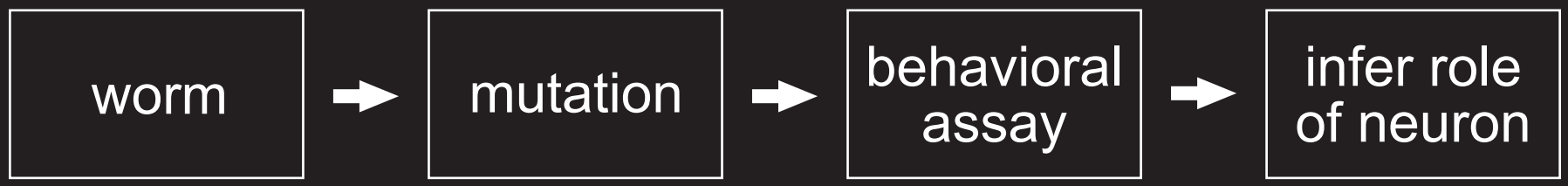
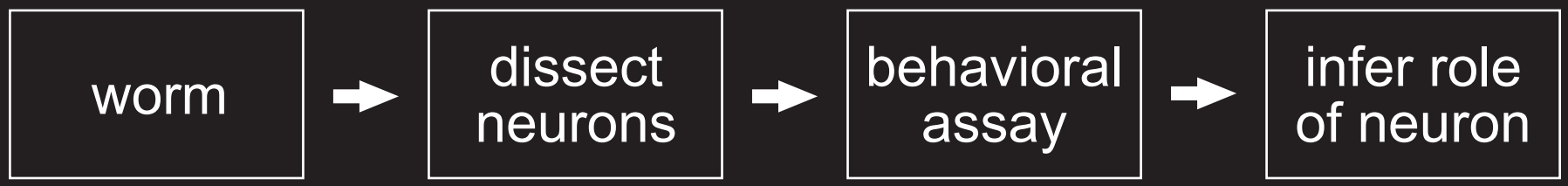
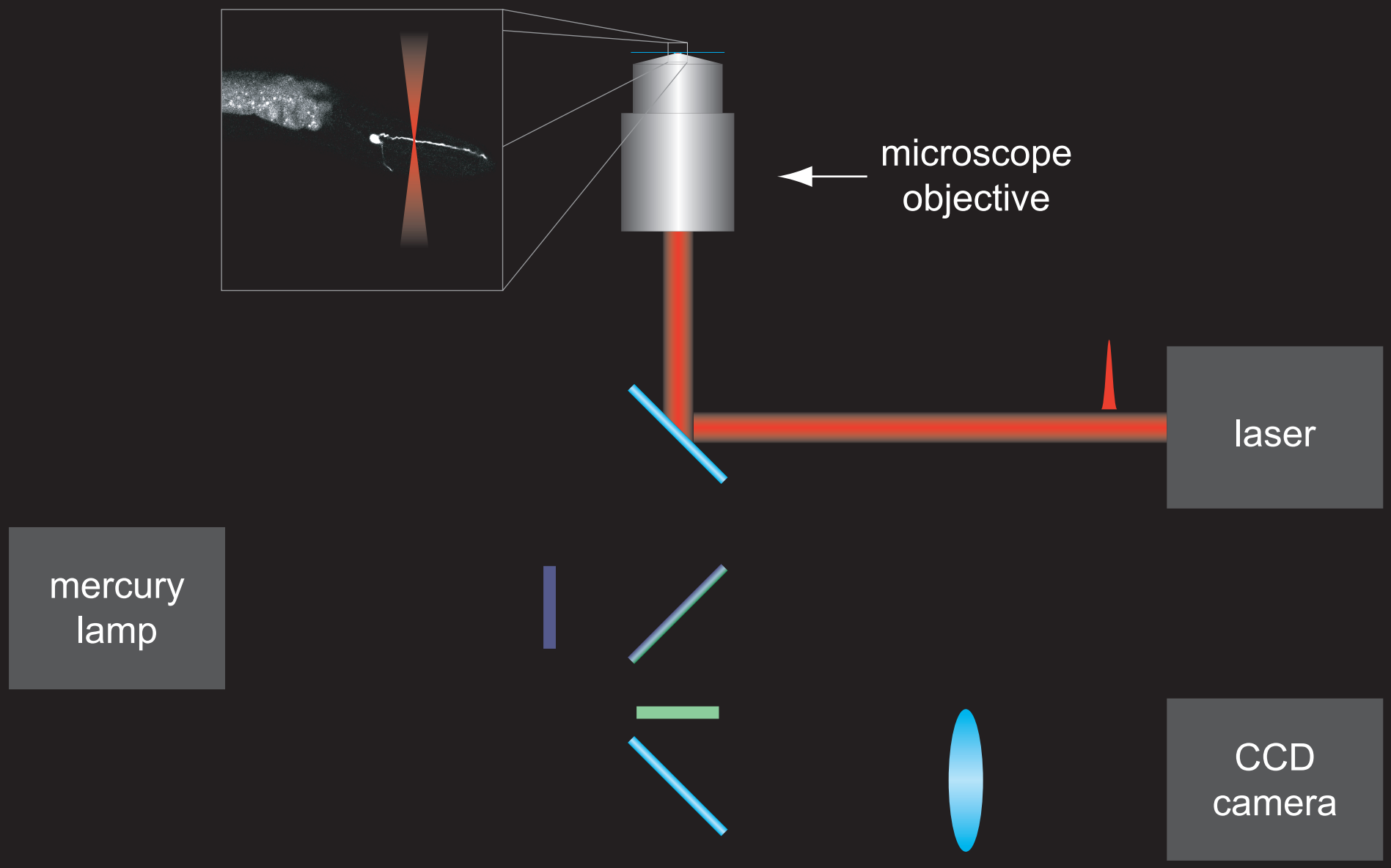


femtosecond laser dissection:



Laboratory Setup

Laboratory Setup



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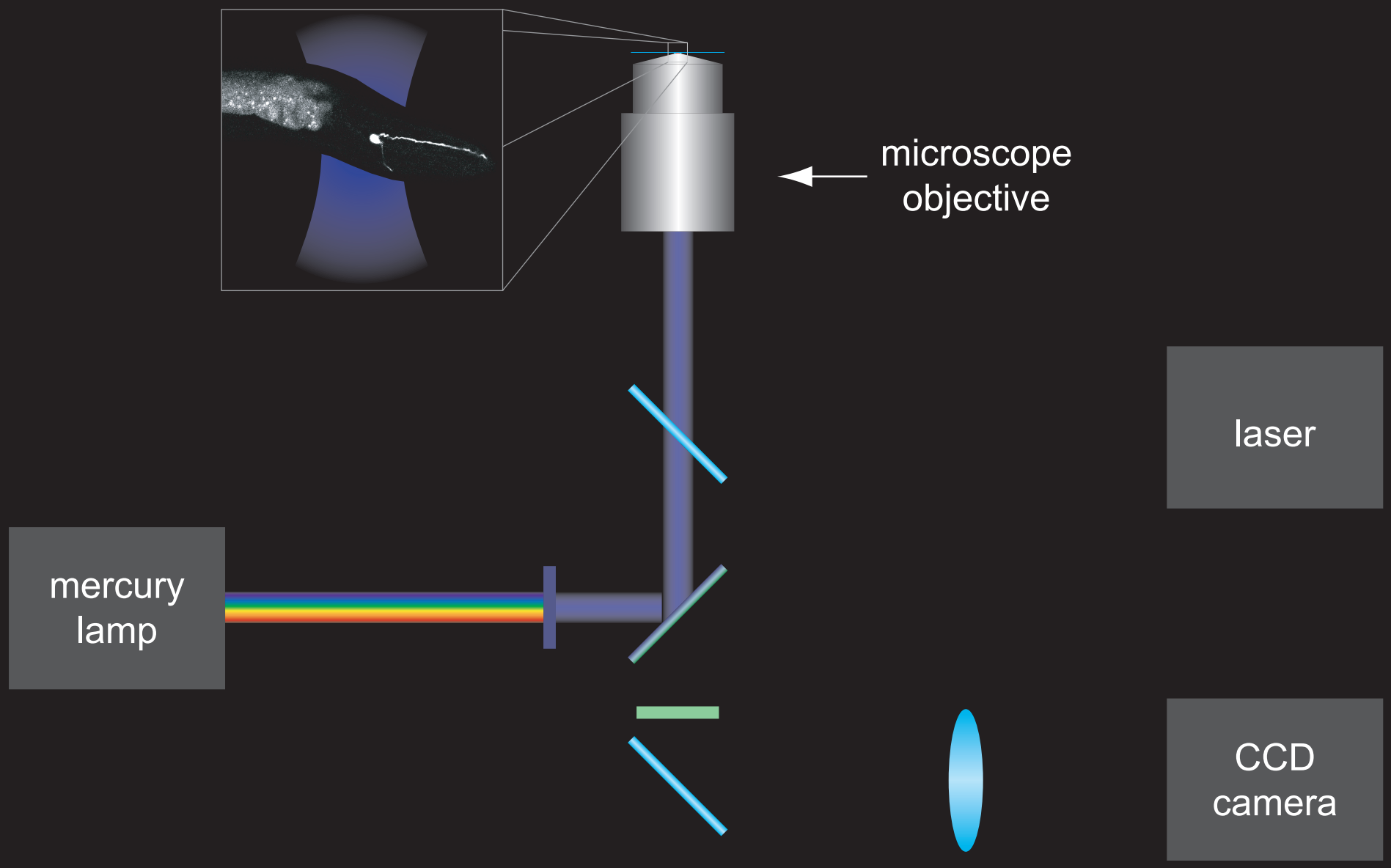

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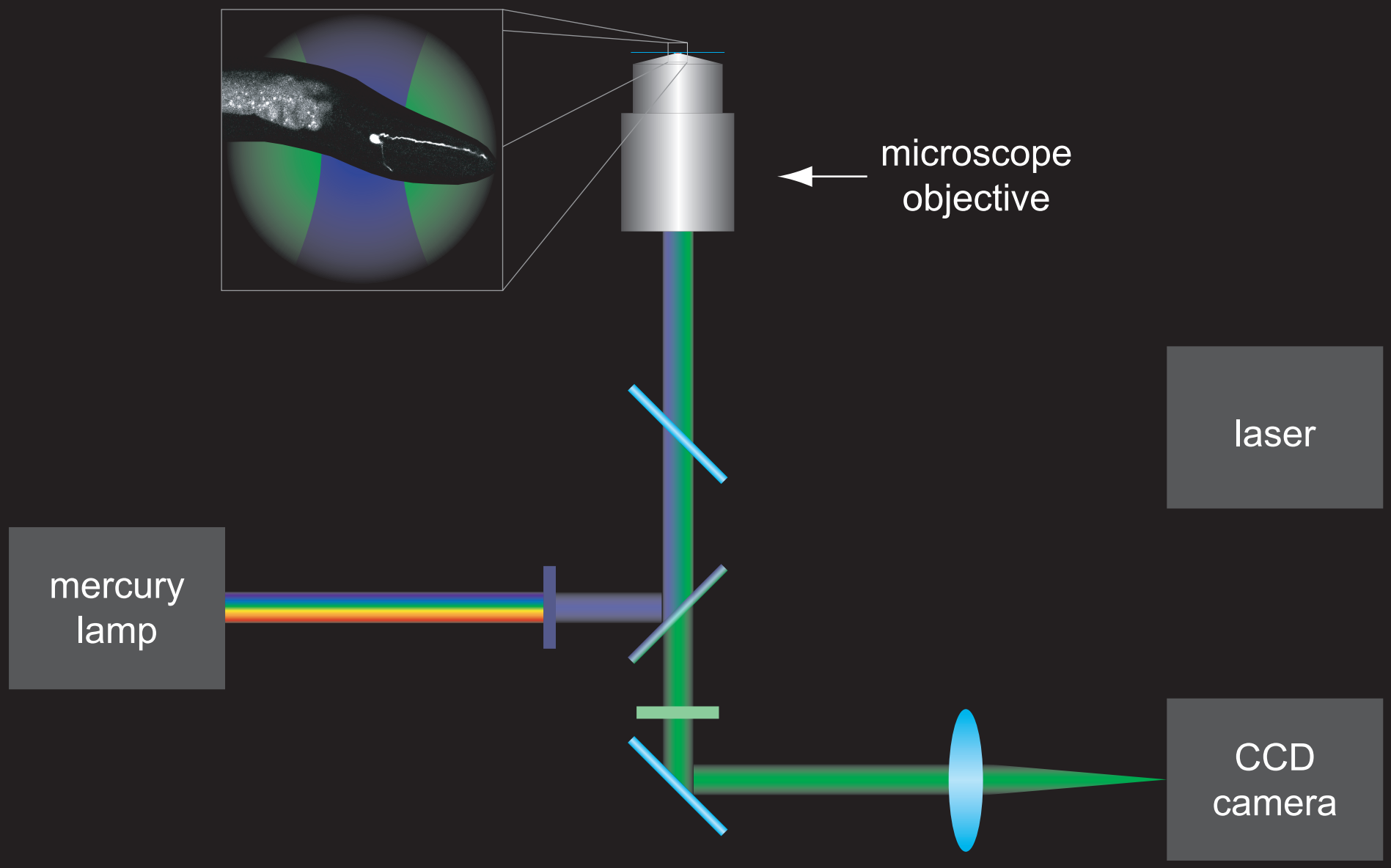

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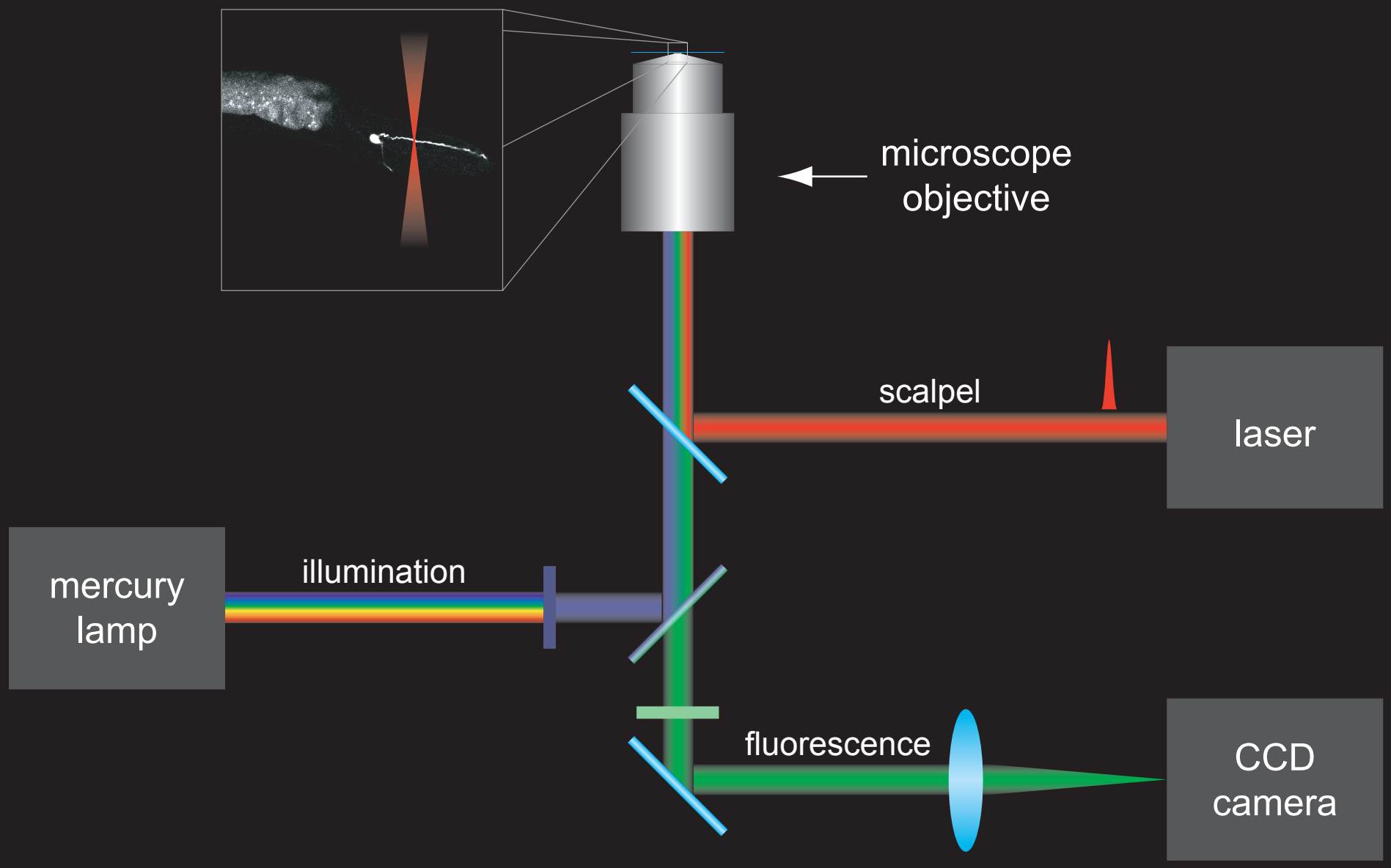
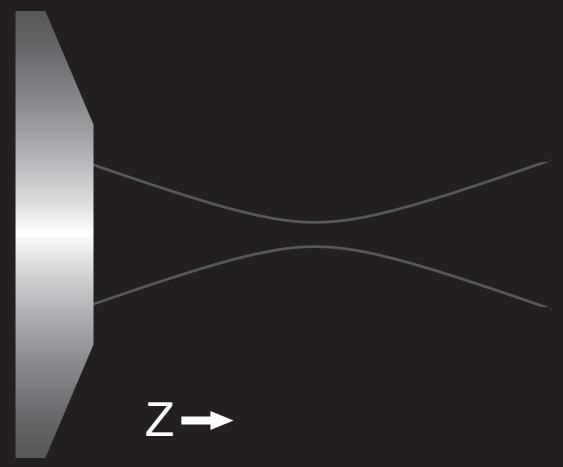


Background

Surgery without incision



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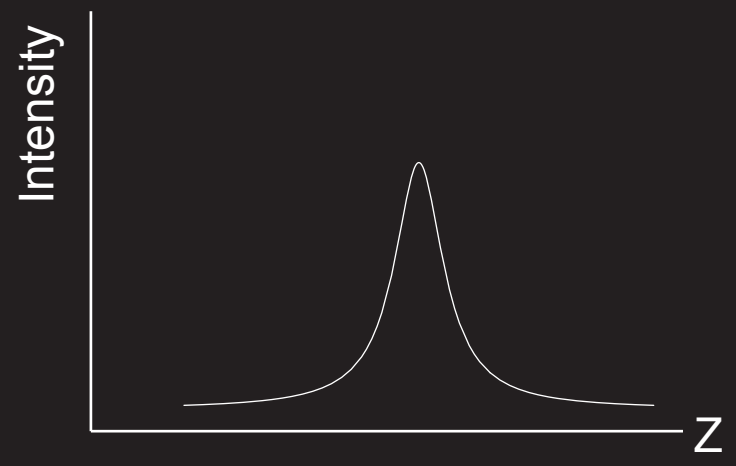

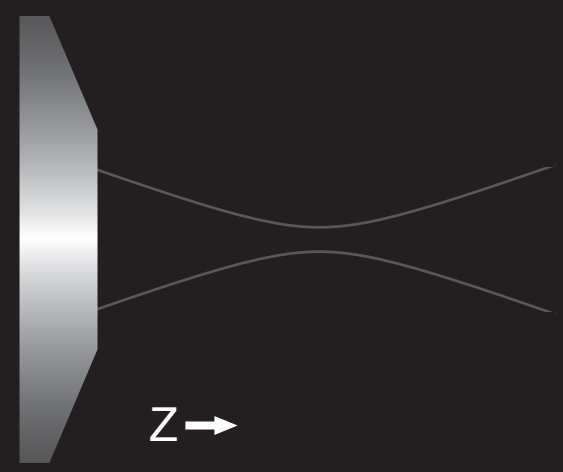

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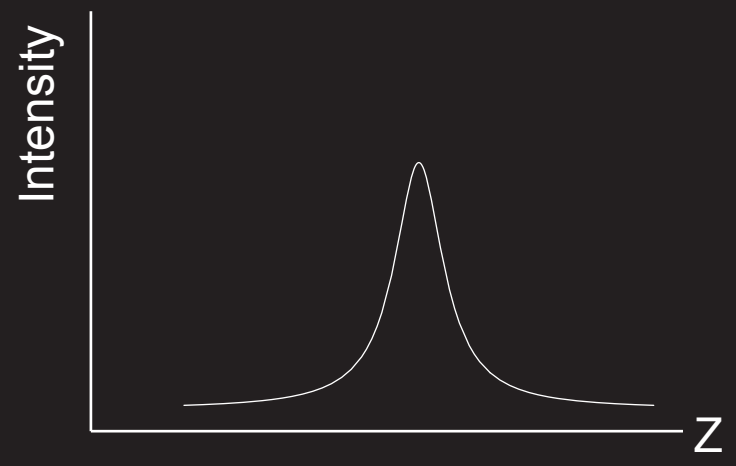
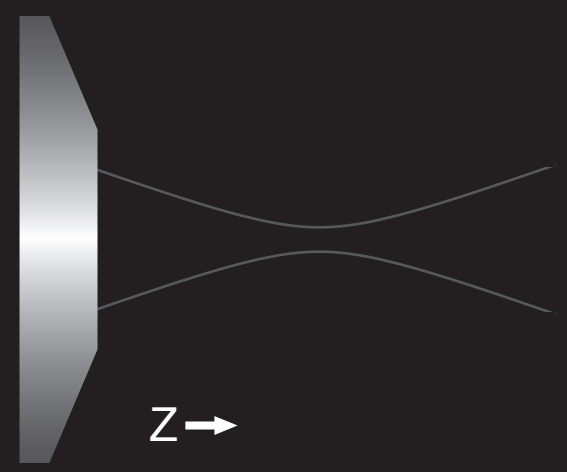


intensity equation

$$I \cong \frac{E}{A\tau}$$



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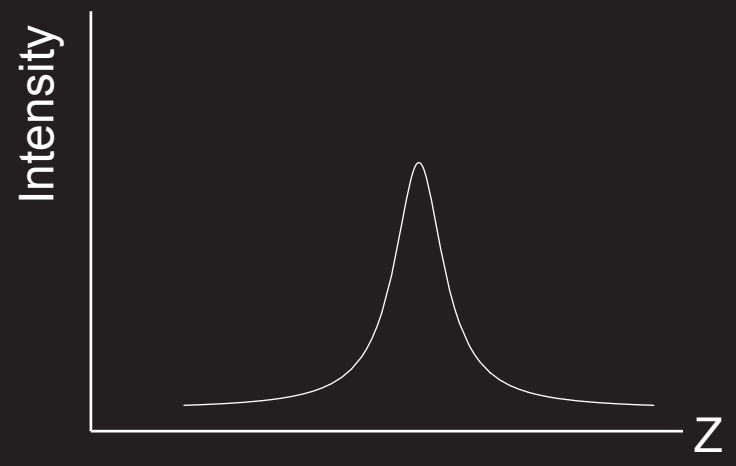

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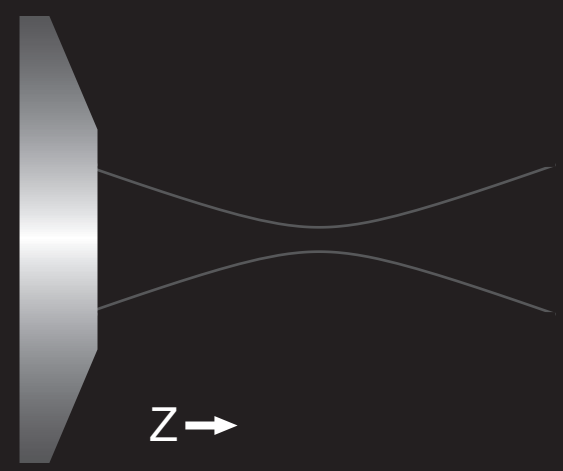

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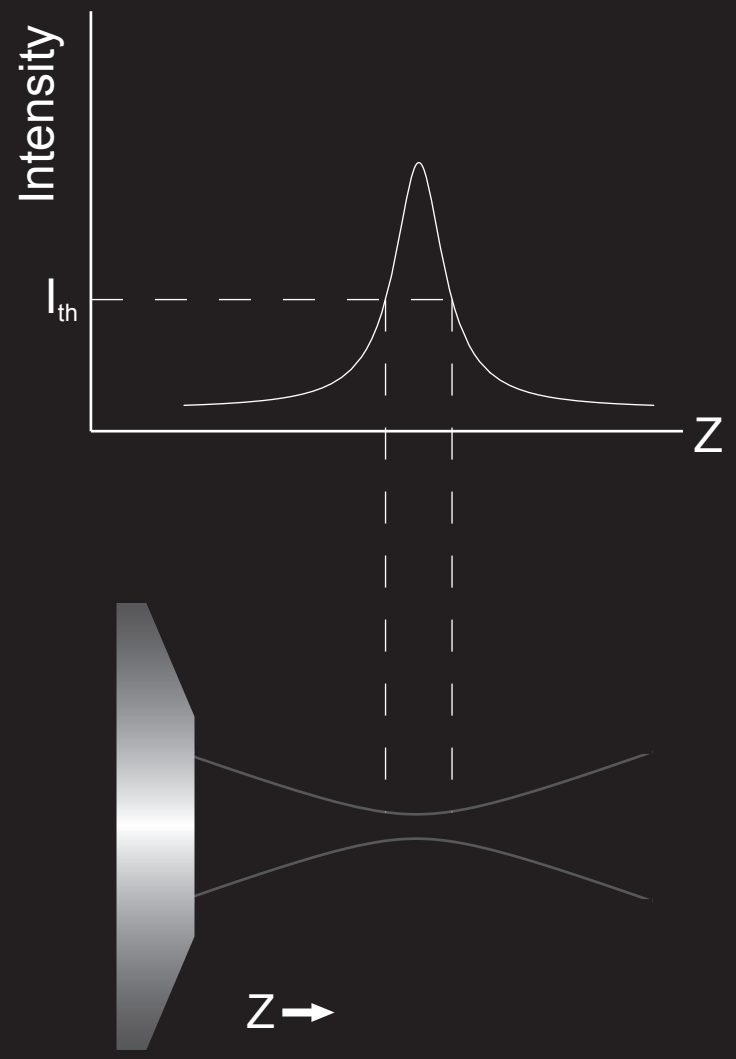

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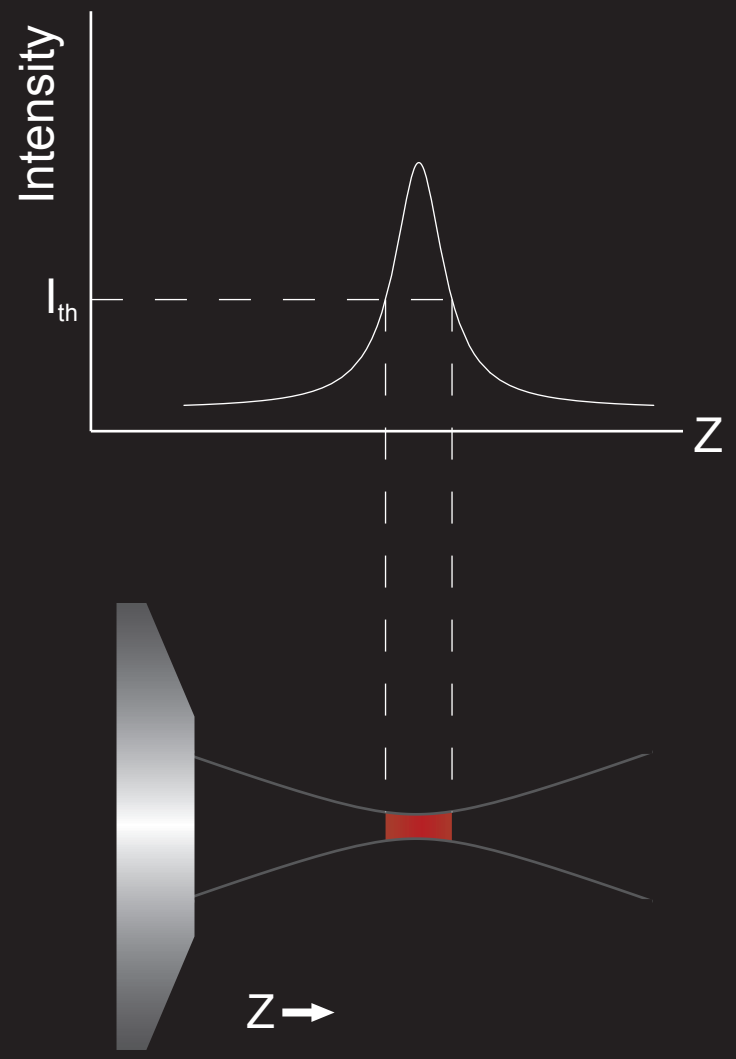

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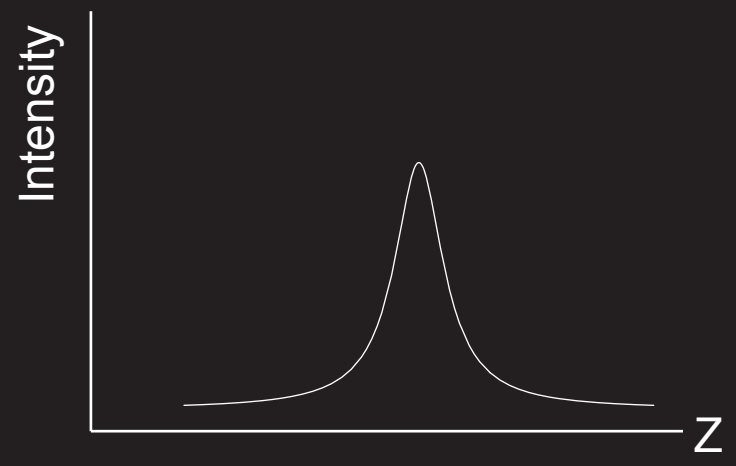

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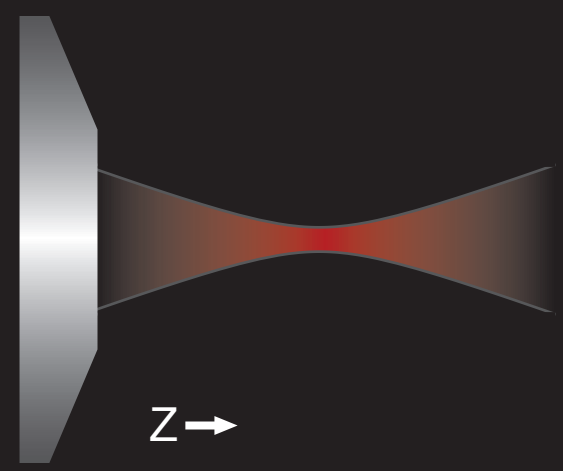
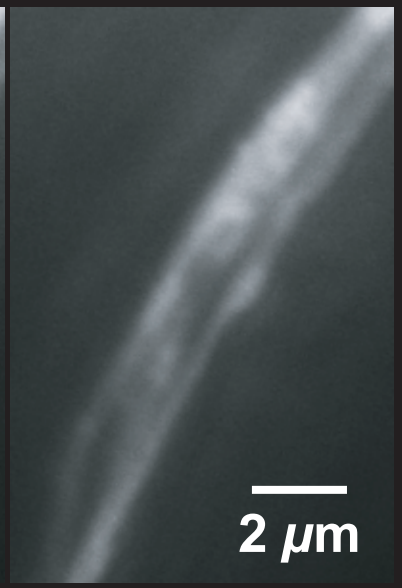


Dissection Results

Dissection precision

before

t = 2 min

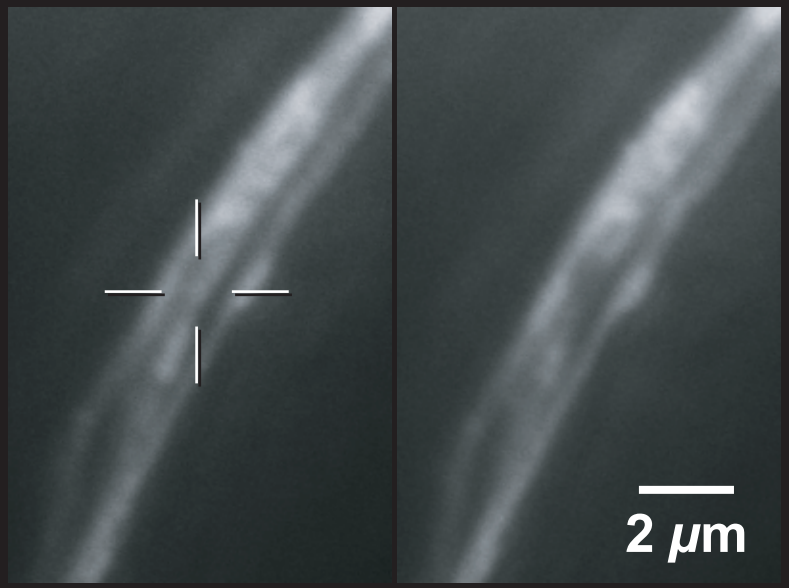


3.2 nJ pulses

Dissection Results

Dissection precision

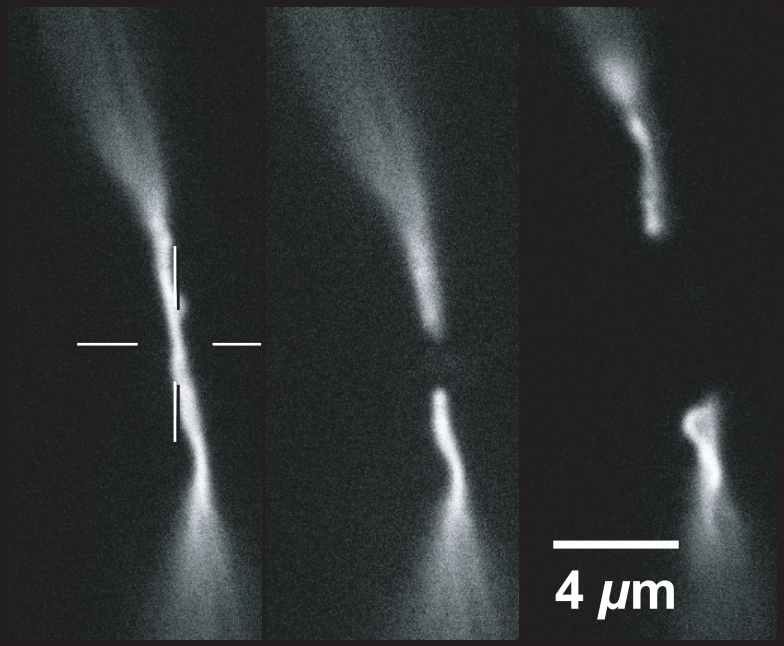
before | t = 2 min



3.2 nJ pulses

Post-surgery dynamics

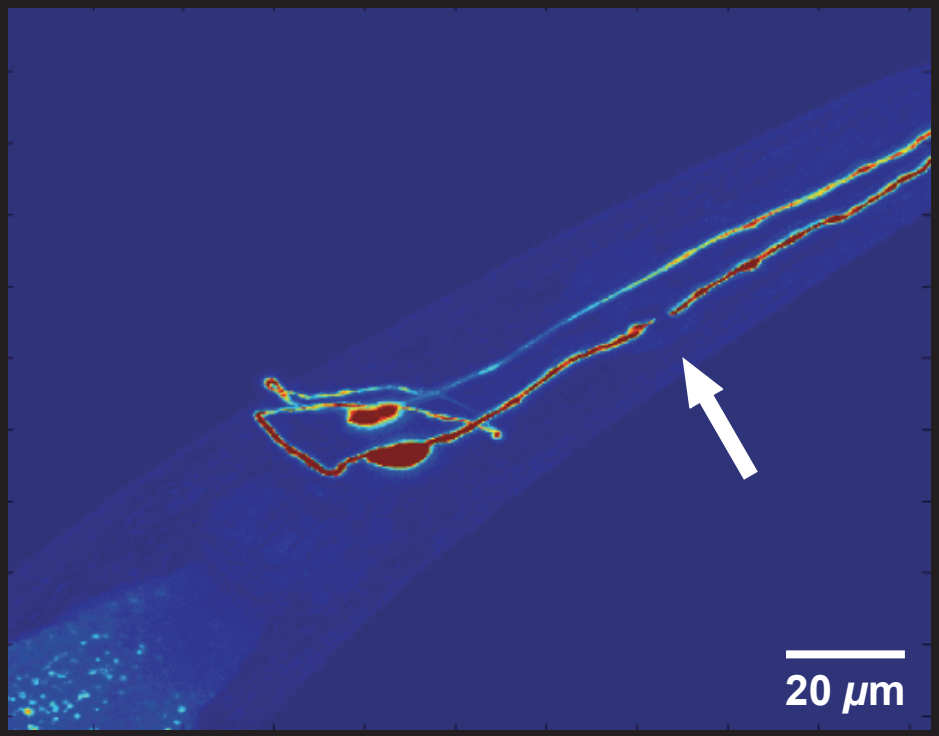
before | t = 30 s | t = 3 min



5.6 nJ pulses

Dissection Results

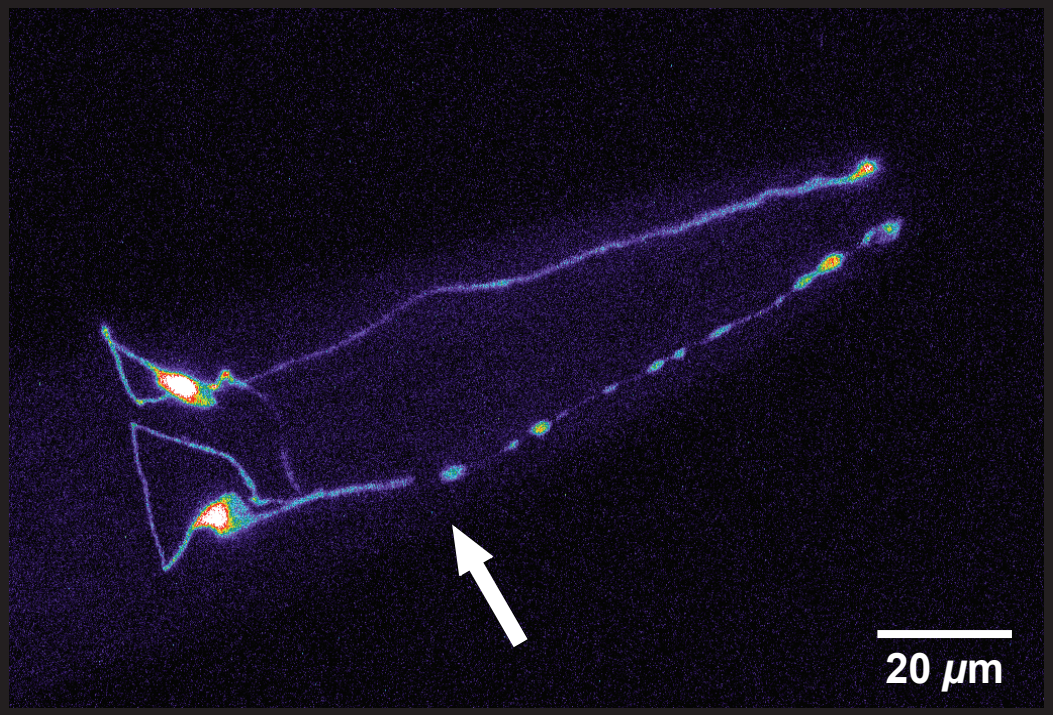
Confocal microscope image of neurons
one day after surgery



14 nJ pulses

Dissection Results

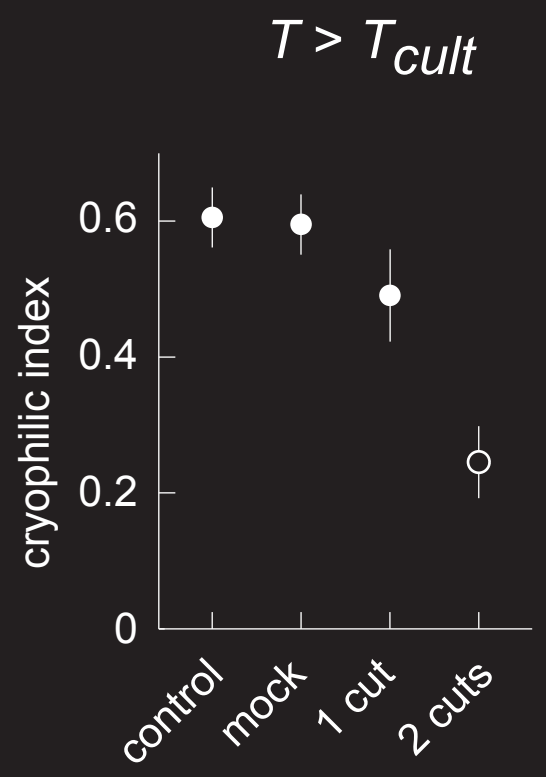
Confocal microscope image of AFD neurons
two hours after surgery



3.2 nJ pulses

Dissection Results

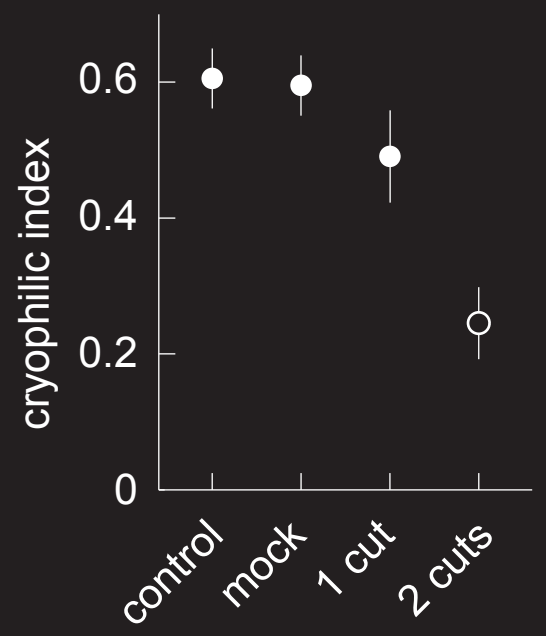
Behavioral assay



Dissection Results

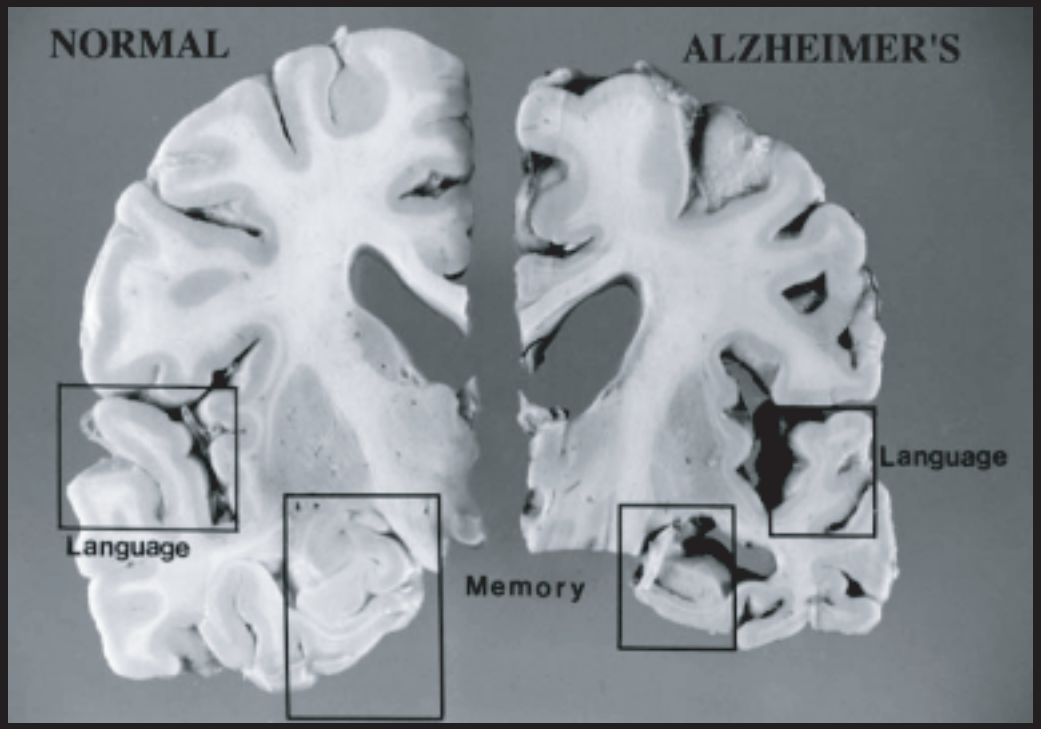
Behavioral assay

$T > T_{cult}$



active
cryophilic drive
above T_{cult}
switched off

Future Work



Neurodegeneration in *C. elegans*

Application to Alzheimer's and Parkinson's Diseases

Image from Ennaceur Lab, University of Sunderland, UK

Acknowledgements

National Science Foundation
DMR-0213805