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

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

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

worm → mutation → behavioral assay → infer role of neuron
Mapping behavior to neurons

classical method:

- worm
- mutation
- behavioral assay
- infer role of neuron

femtosecond laser dissection:

- worm
- dissect neurons
- behavioral assay
- infer role of neuron
Laboratory Setup

- microscope
- objective
- laser
- mercury lamp
- CCD camera
Surgery without incision
Surgery without incision
Background

Surgery without incision

Intensity equation

\[ I \equiv \frac{E}{A \tau} \]
Surgery without incision

Intensity equation:

\[ I \approx \frac{E}{A \tau} > I_{th} \]
Surgery without incision

Intensity equation

\[ I \approx \frac{E}{A \tau} > I_{th} \]
Surgery without incision

Intensity equation

\[ I \equiv \frac{E}{A \tau} > I_{th} \]
Surgery without incision

intensity equation

$$I \equiv \frac{E}{A \tau} > I_{th}$$
Dissection Results

Dissection precision

before

$t = 2 \text{ min}$

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
Confocal microscope image of neurons one day after surgery

14 nJ pulses
Confocal microscope image of AFD neurons two hours after surgery

3.2 nJ pulses
Dissection Results

Behavioral assay

$T > T_{cult}$
Dissection Results

1 cut control mock 2 cuts

cryophilic index

0.6
0.4
0.2
0

Behavioral assay

$T > T_{cult}$

active cryophilic drive above $T_{cult}$ switched off
Neurodegeneration in *C. elegans*
Application to Alzheimer’s and Parkinson’s Diseases

Image from Ennaceur Lab, University of Sunderland, UK
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