# Neuroscience approaches, ethics, and sustainability

Prof. Pavan Ramdya

Reading: *None*

BIO-311

Image credit: https://greatergood.berkeley.edu/article/item/feeling_lost_here_are_four_steps_to_finding_your_path

# The Goals of Modern Neuroscience

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# ‘Model organisms’ in neuroscience

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# ‘Model organisms’ in neuroscience

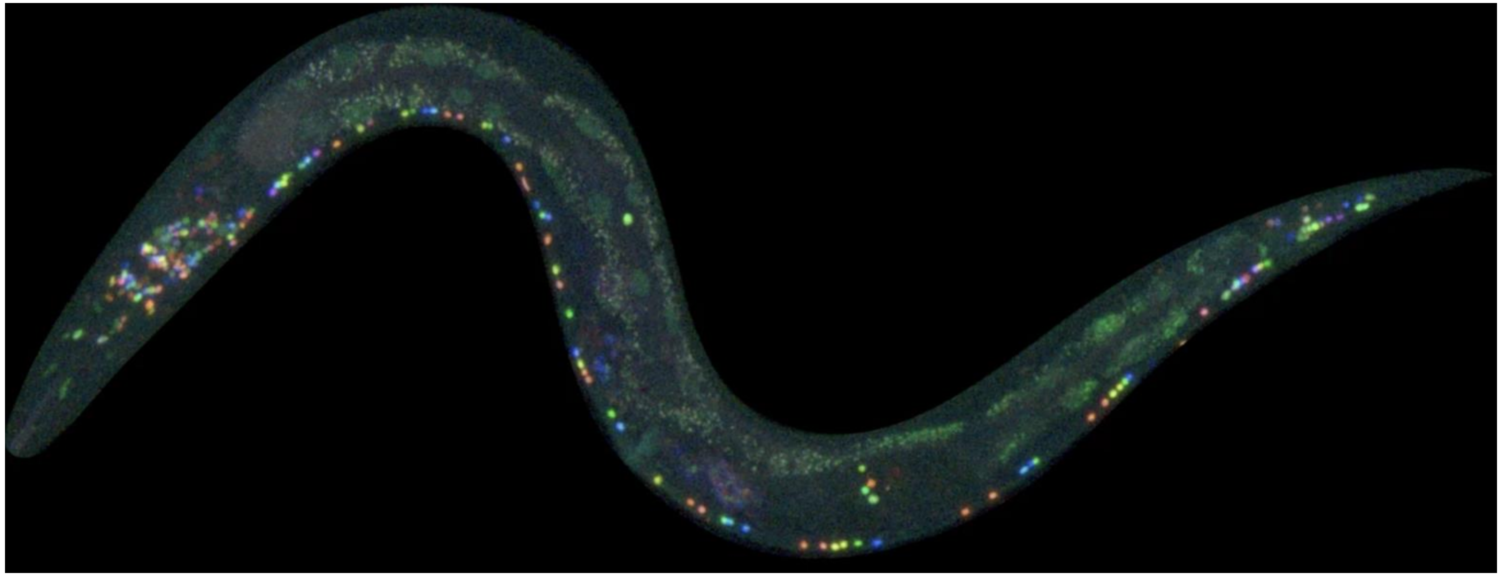
**What** is a “model organism”?

**What** typically makes model organisms advantageous for experiments?

**How** can we decide which model organisms are worth using *for a particular goal*?

# ‘Model organisms’ in neuroscience

**Worms**
**(*C. elegans*)**



302 neurons

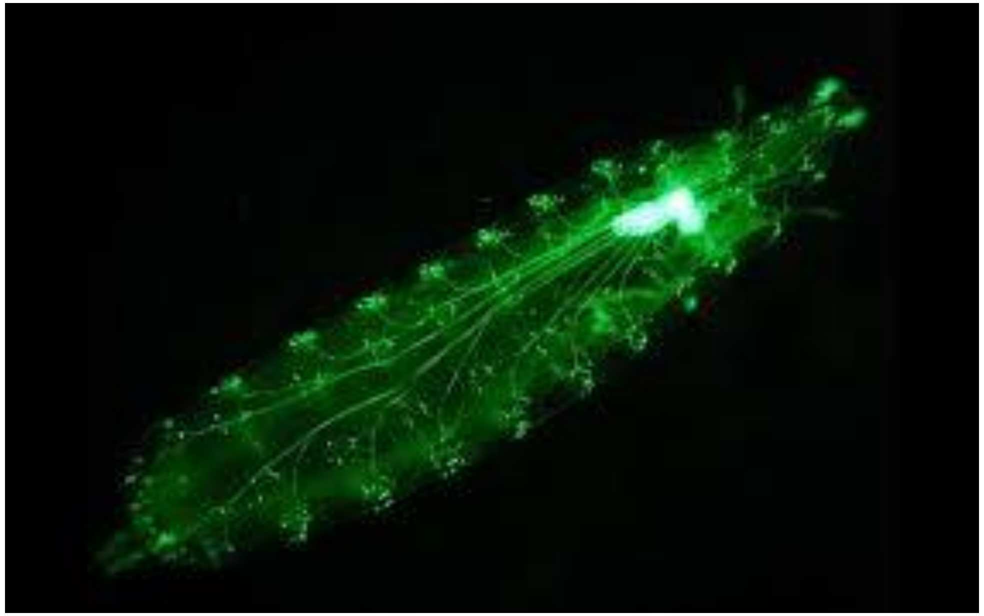
Complete connectome

Transgenic animals

# ‘Model organisms’ in neuroscience

Worms
(*C. elegans*)

**Fly larvae**
**(*D. melanogaster*)**



~15,000 neurons

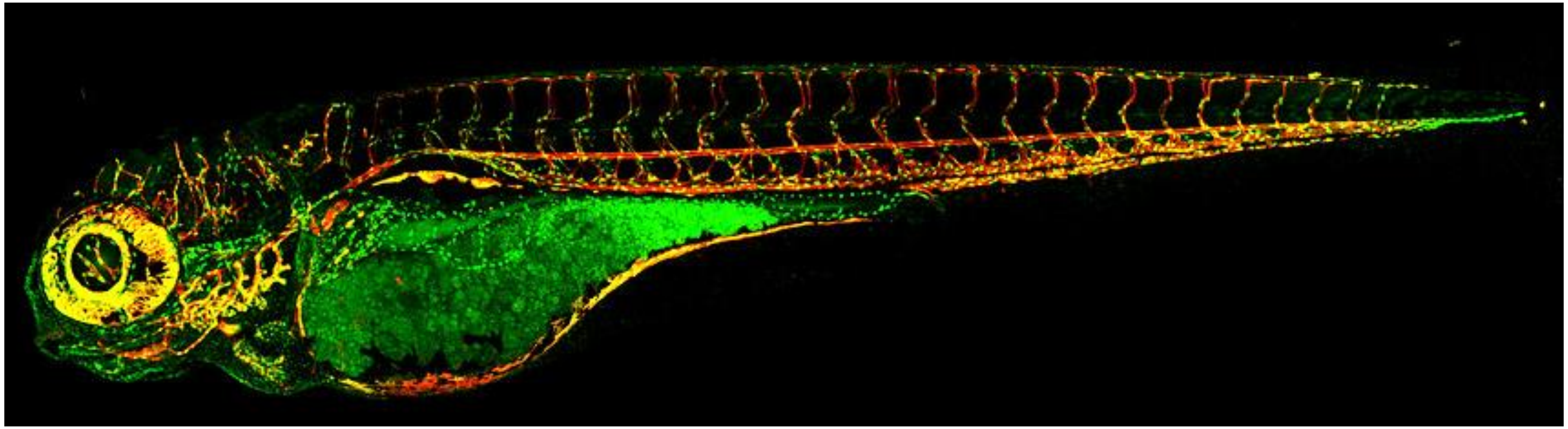
Complete connectome

Transgenic animals

# ‘Model organisms’ in neuroscience

Worms
(*C. elegans*)
Fly larvae
(*D. melanogaster*)

**Zebrafish larvae**
**(*D. rerio*)**



~100,000 neurons

Partial connectome

Some transgenic animals

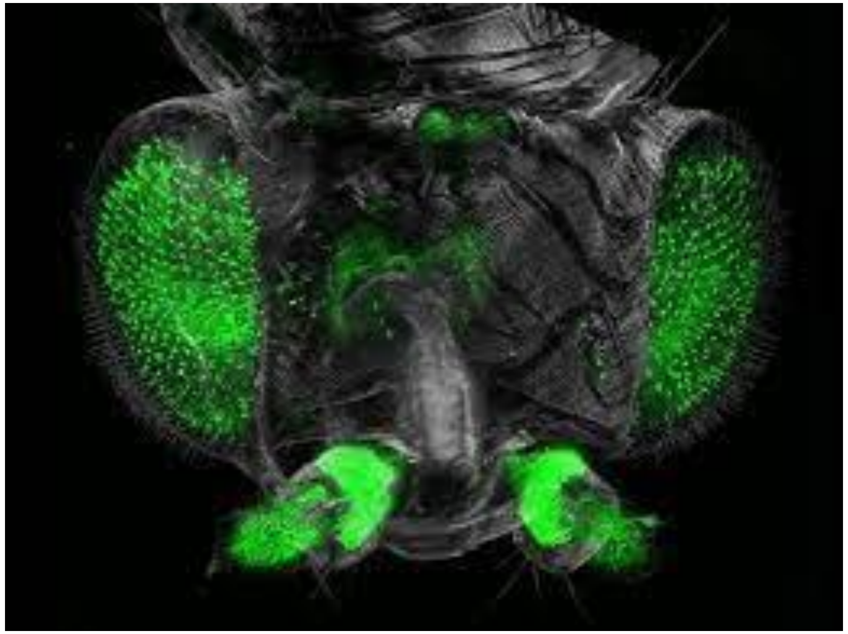
# ‘Model organisms’ in neuroscience

Worms
(*C. elegans*)

Fly larvae
(*D. melanogaster*)

Zebrafish larvae
(*D. rerio*)

**Fly adults**
**(*D. melanogaster*)**



~150,000 neurons

Complete connectome

Many transgenic animals

# ‘Model organisms’ in neuroscience

Worms
(*C. elegans*)
Fly larvae
(*D. melanogaster*)

Zebrafish larvae
(*D. rerio*)

Fly adults
(*D. melanogaster*)

**Mice**
**(*M. musculus*)**

~100,000,000 neurons

Small regions have connectome

Transgenic animals

# ‘Model organisms’ in neuroscience

Worms
(*C. elegans*)
Fly larvae
(*D. melanogaster*)

Zebrafish larvae
(*D. rerio*)

Fly adults
(*D. melanogaster*)
Mice
(*M. musculus*)

**Nonhuman primates (macaque)**

~1,500,000,000 neurons

No connectome

Rare transgenics

# ‘Model organisms’ in neuroscience

Worms
(*C. elegans*)

Fly larvae
(*D. melanogaster*)

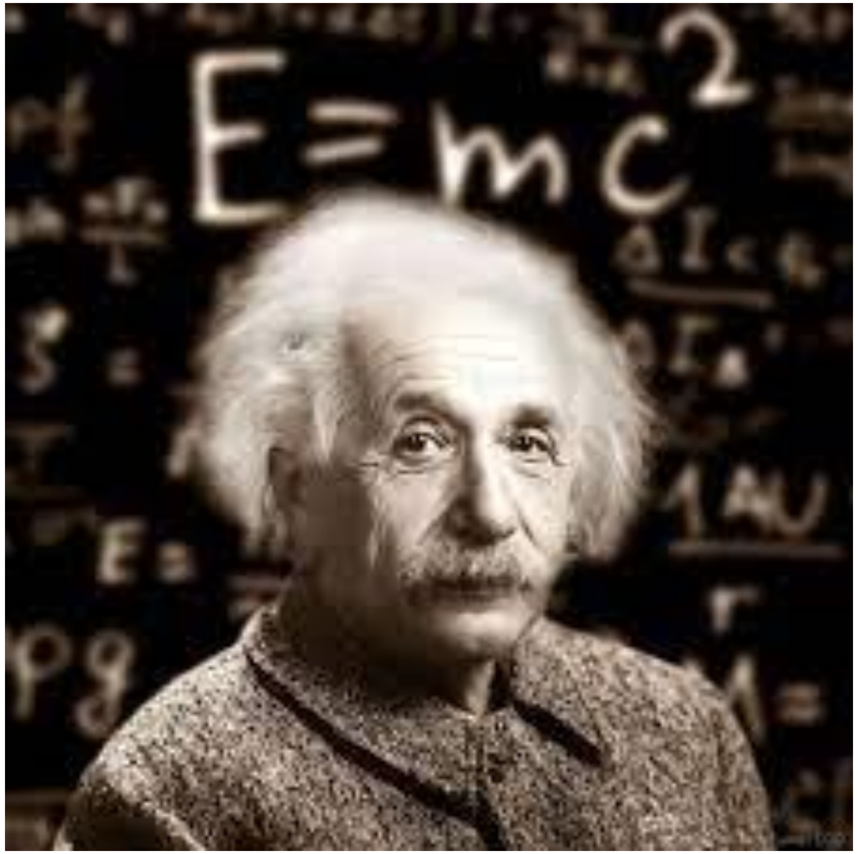
Zebrafish larvae
(*D. rerio*)

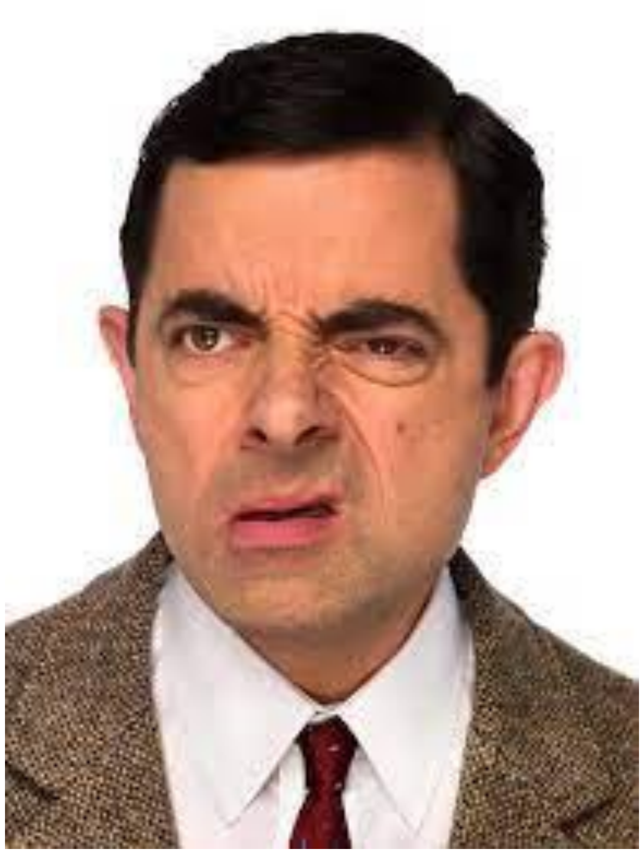
Fly adults
(*D. melanogaster*)

Mice
(*M. musculus*)

Nonhuman primates (macaque)

**Humans**



~100,000,000,000 neurons

No connectome

No transgenics yet

# Choosing a ‘model organism’ to study in neuroscience

| | | | |
|---|---|---|---|
| Worms<br>(*C. elegans*) | | | |
| Fly larvae<br>(*D. melanogaster*) | | | |
| Zebrafish larvae<br>(*D. rerio*) | | | |
| Fly adults<br>(*D. melanogaster*) | | | |
| Mice<br>(*M. musculus*) | | | |
| Macaque monkey | | | |
| Humans | | | |

# Choosing a ‘model organism’ to study in neuroscience

| | **Similarity to humans** (vertebrates/mammals) | | |
|---|---|---|---|
| Worms (*C. elegans*) | Some genes/cells | | |
| Fly larvae (*D. melanogaster*) | More genes/cell types | | |
| Zebrafish larvae (*D. rerio*) | Vertebrates | | |
| Fly adults (*D. melanogaster*) | More genes/cell types some behaviors | | |
| Mice (*M. musculus*) | Many genes/cell types many behaviors | | |
| Macaque monkey | Most genes/cell types most behaviors | | |
| Humans | Same | | |

# Choosing a ‘model organism’ to study in neuroscience

| | **Similarity to humans** (vertebrates/mammals) | **Behavior complexity** (‘expressivity’) | |
|---|---|---|---|
| Worms (*C. elegans*) | Some genes/cells | Simple - crawling | |
| Fly larvae (*D. melanogaster*) | More genes/cell types | Simple - crawling | |
| Zebrafish larvae (*D. rerio*) | Vertebrates | Simple - swimming | |
| Fly adults (*D. melanogaster*) | More genes/cell types some behaviors | Complex: walk, fly, fight, mate | |
| Mice (*M. musculus*) | Many genes/cell types many behaviors | Complex: walk, fight, mate, care for young | |
| Macaque monkey | Most genes/cell types most behaviors | Very complex: Include language | |
| Humans | Same | Very complex: include planning | |

# Choosing a ‘model organism’ to study in neuroscience

| | **Similarity to humans** (vertebrates/mammals) | **Behavior complexity** (‘expressivity’) | **Tractability** (ease of understanding) |
|---|---|---|---|
| Worms (*C. elegans*) | Some genes/cells | Simple - crawling | Very high: transgenics, connectome |
| Fly larvae (*D. melanogaster*) | More genes/cell types | Simple - crawling | Very high: transgenics, connectome |
| Zebrafish larvae (*D. rerio*) | Vertebrates | Simple - swimming | High: transgenics, soon connectome |
| Fly adults (*D. melanogaster*) | More genes/cell types some behaviors | Complex: walk, fly, fight, mate | High: transgenics, connectome |
| Mice (*M. musculus*) | Many genes/cell types many behaviors | Complex: walk, fight, mate, care for young | Medium: transgenics, cells not ID across animals |
| Macaque monkey | Most genes/cell types most behaviors | Very complex: Include language | Low |
| Humans | Same | Very complex: include planning | Lowest |

# Which model(s) would you use for different applications (and why)?

**Fundamental understanding**
(of the human or animal brain)

**Medicine**
(healing or prevention for healthy *human* brains)

**"NeuroAI"**
(building biologically-inspired artificial/robotic systems)

**Bioengineering**
(improving human capabilities)

# Ethics: which experiments concern you (and why)?

**What** are "ethical considerations”?

**What** is the compromise between ethics and science?

**How** can we decide which experiments are worth doing?

# Sustainability: how can we make neuroscience sustainable?

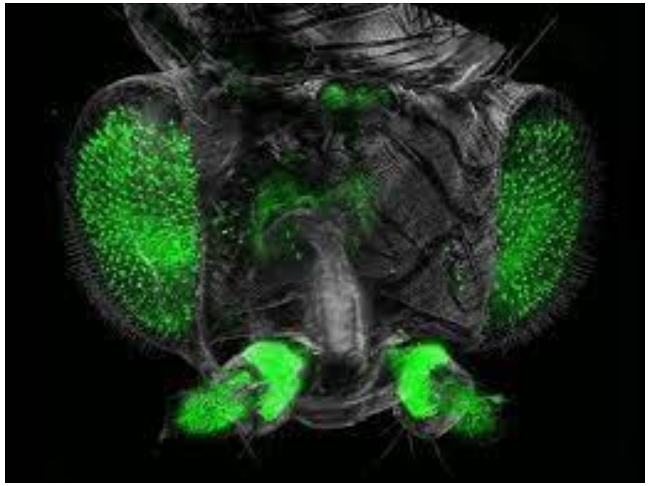
**What** is "sustainability” in the context of neuroscience?

**Why** should we be more sustainable in neuroscience?

**How** can we become more sustainable in neuroscience?

# My choice: use the **adult fly** to **understand brains** and **develop NeuroAI**

**Fundamental understanding**
(of the human or animal brain)



**Medicine**
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<u>Summary</u>: Neuroscience approaches, ethics, sustainability: Important concepts and keywords

- What are the four most prominent goals of neuroscience?
- What is a model organism and what are examples of model organisms?
- Name the 6 model organisms (humans excluded) that are most commonly used in neuroscience
- How do these 6 model organisms compare with one another in terms of (i) ’modeling’ human brains, (ii) generating interesting, complex behaviors, (iii) being easy to study?
- What are some ethical concerns in neuroscience and why do we still perform these experiments anyway?

# In-depth feedback

The evaluations are accessible via the moodle. To access them, students have to:

•Log onto moodle and stay on the **moodle home page (dashboard, <u>not</u> the course page)**.

•Click on the arrow to the top right of the screen which will reveal a block that contains the entitled "In-depth evaluation" tile (please note: all evaluations will be together in the evaluation tile on the moodle home page, and not separate in each course moodle page).

•Students can then select your course and complete the feedback.

Students will also be able to access the course evaluations via the **EPFL Campus App**. We hope this will make the surveys more accessible and so help you to increase the response rate.
Teachers can access evaluations in the same location on the moodle home page. You will be able to:

•Access the response rate while the evaluation is open (Moodle - nouveau plugin).

•Access the report from <u>11 February 2025</u>.