

Optimal control with an electrophysiology experiment in the loop



University
of Exeter

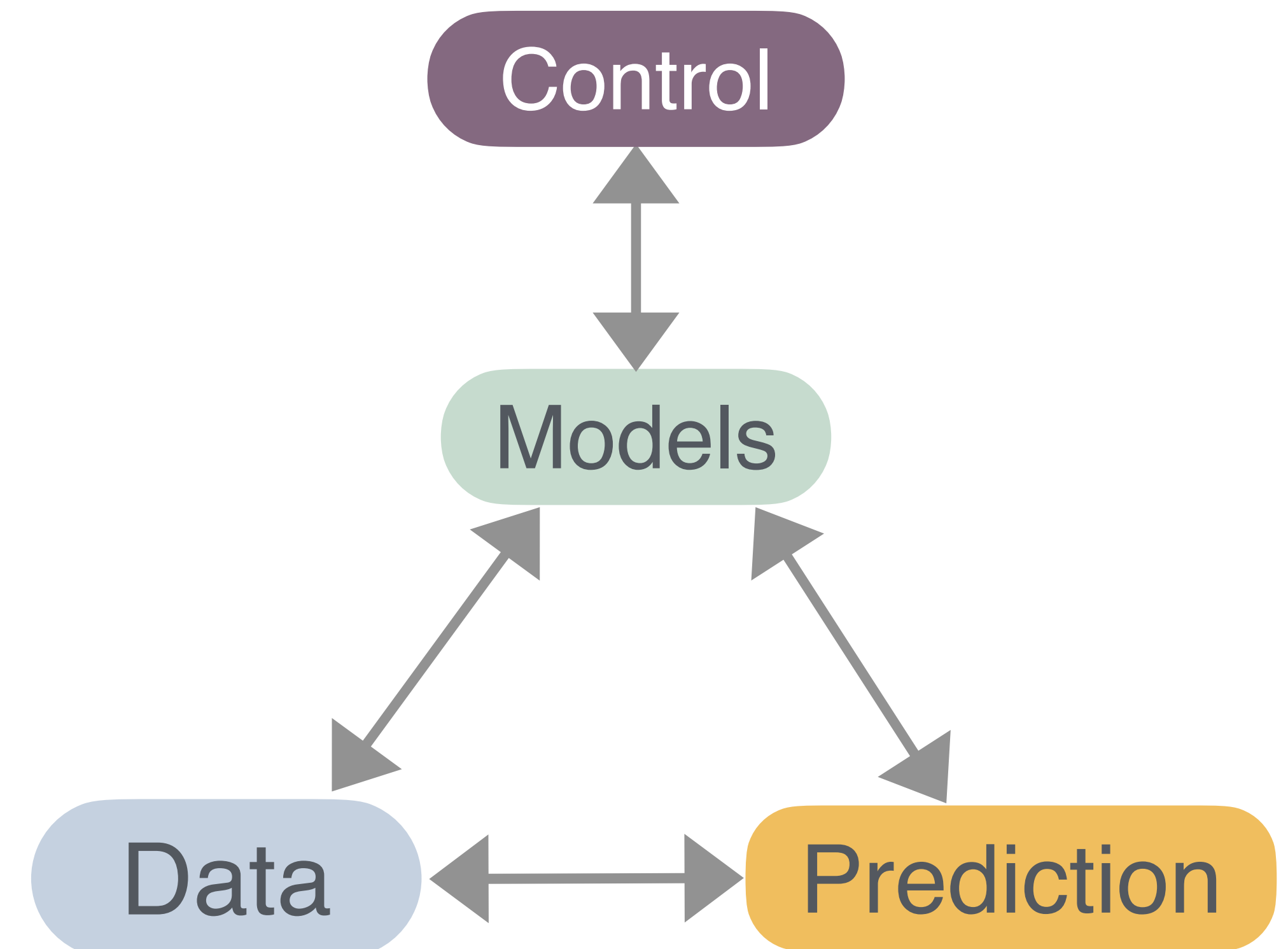
Melvyn Tyloo

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Department of Mathematics and Statistics

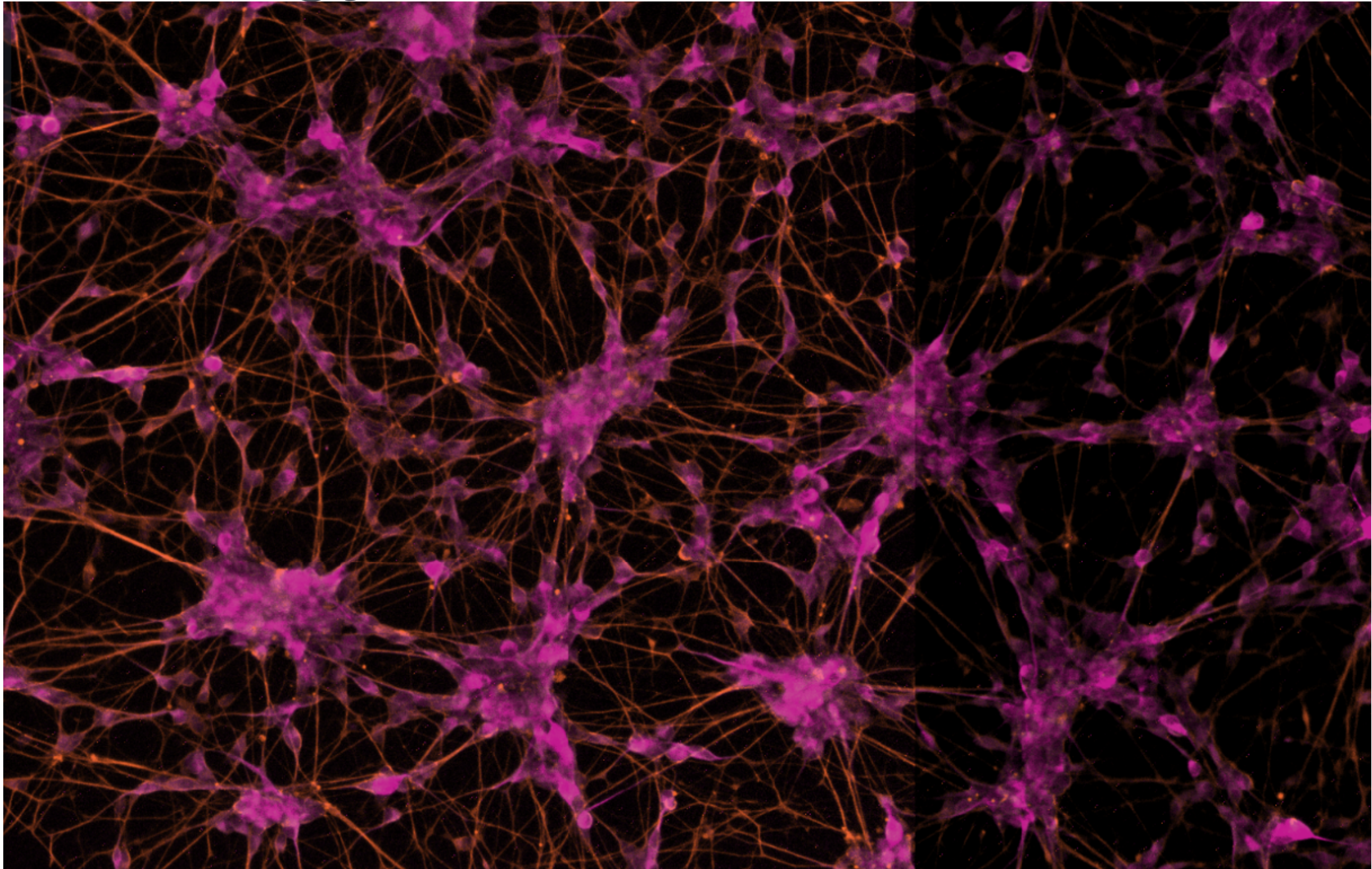
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arXiv:2603.00709, under review



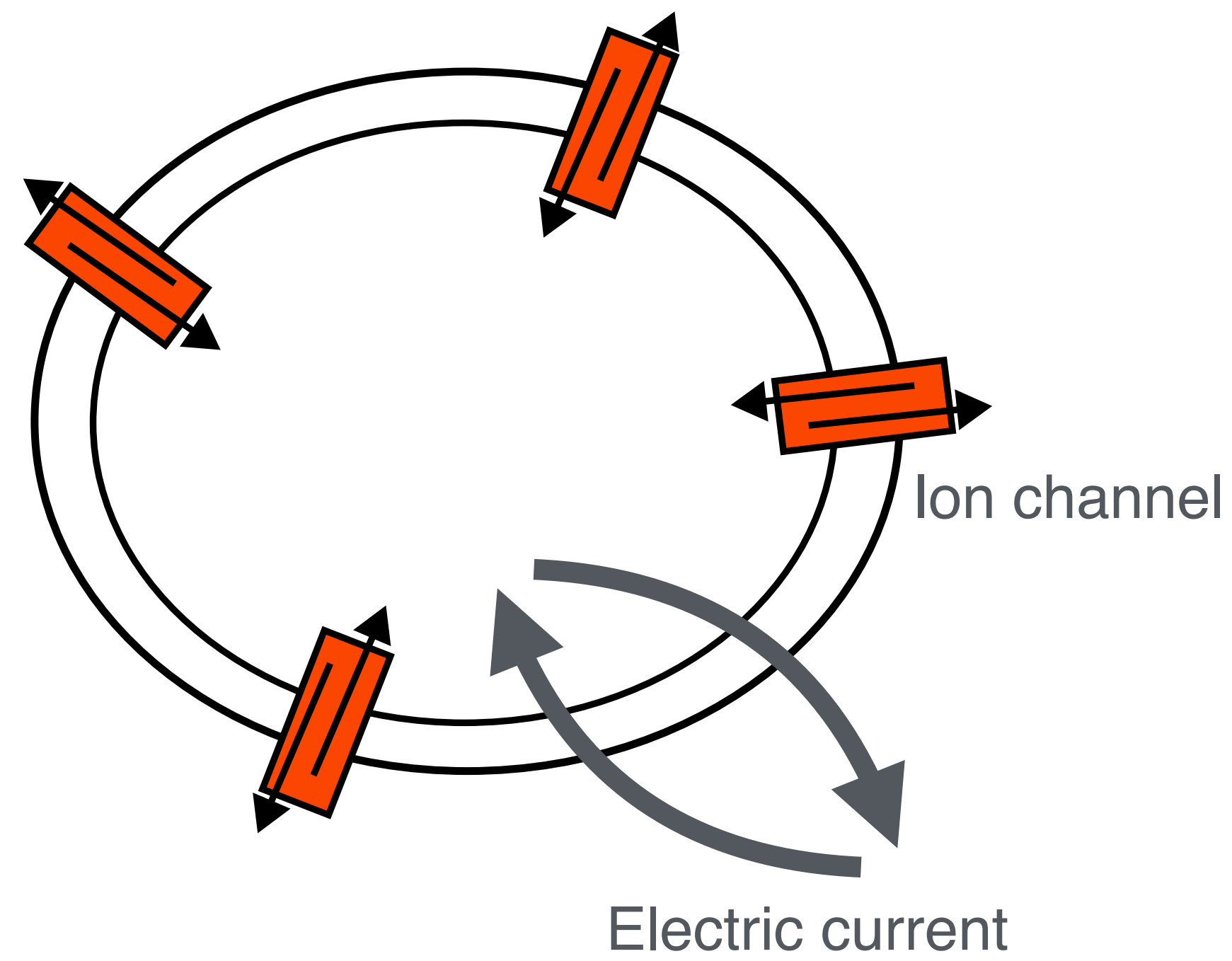
Actual biology

Imaging done by Pragati Thakur

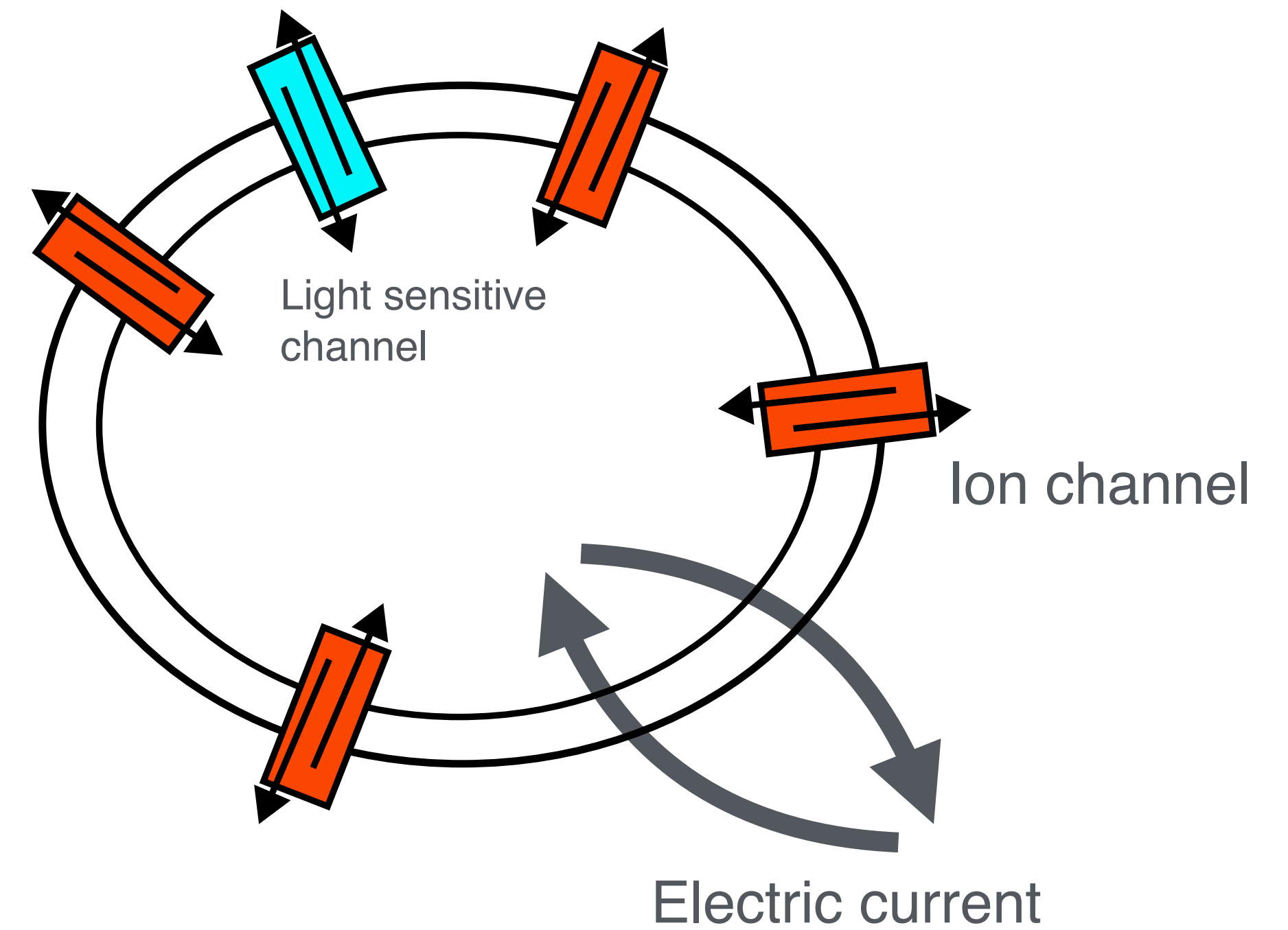


Biology by a physicist...

Neuron

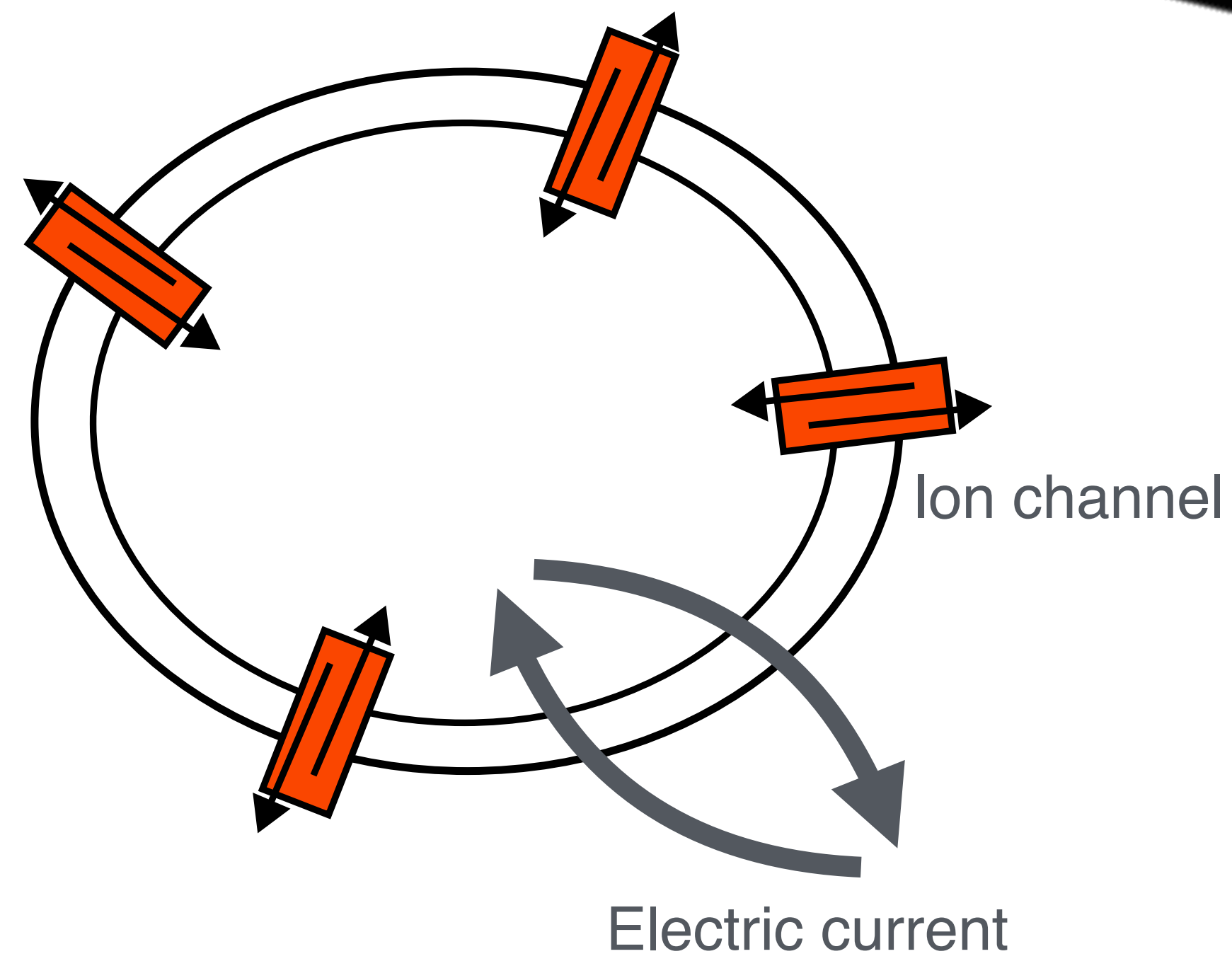


Neuron genetically modified

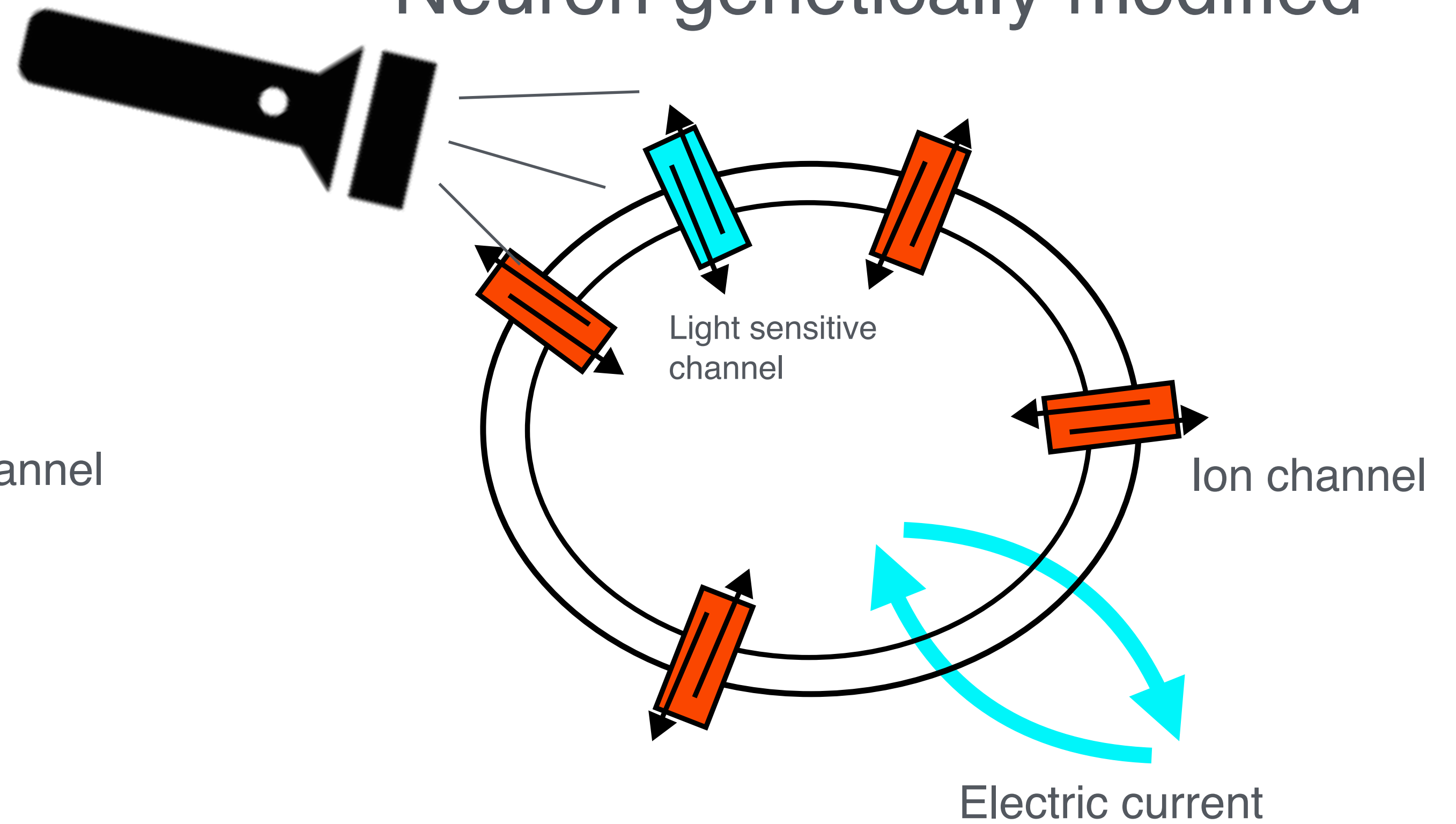


Biology by a physicist...

Neuron

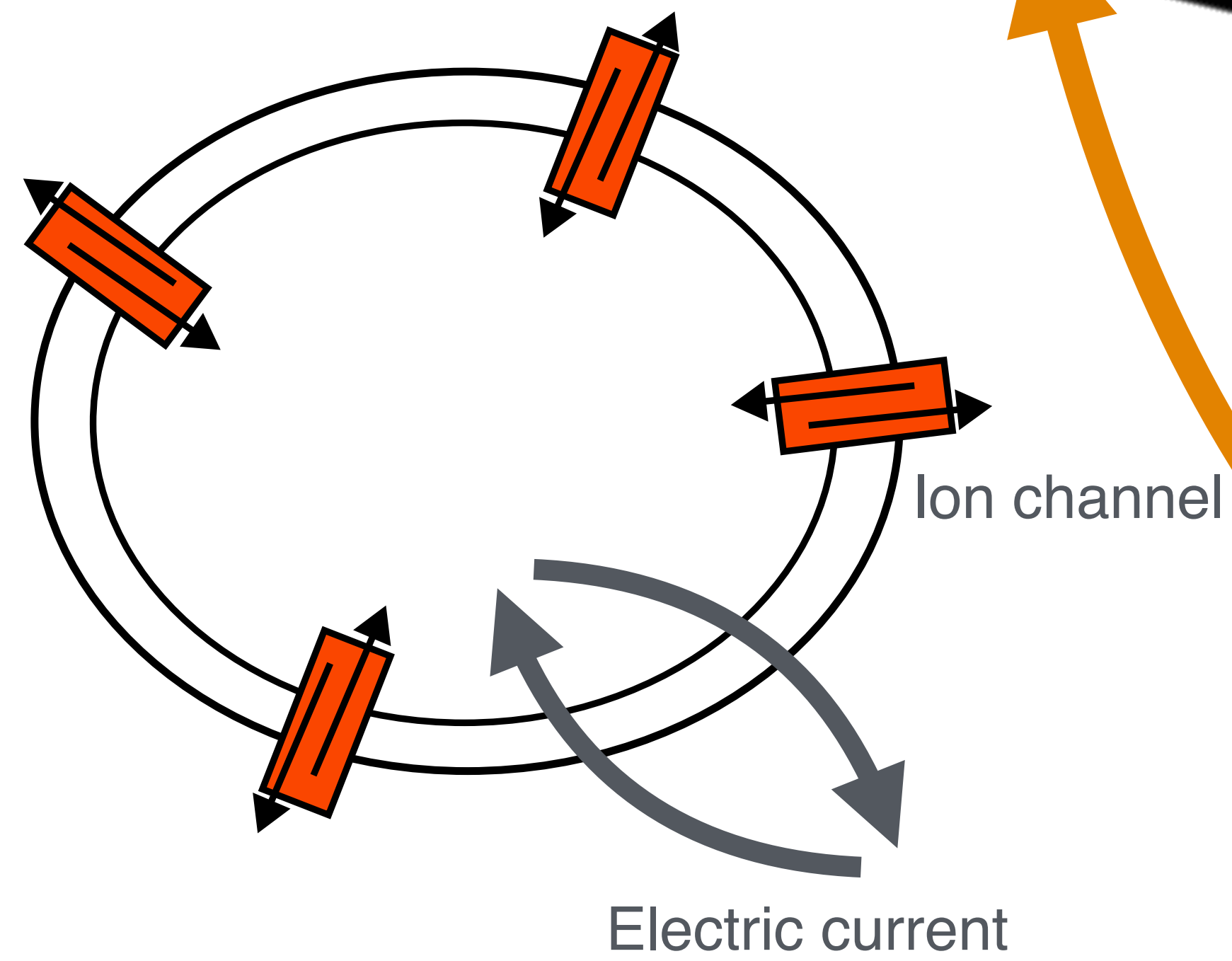


Neuron genetically modified



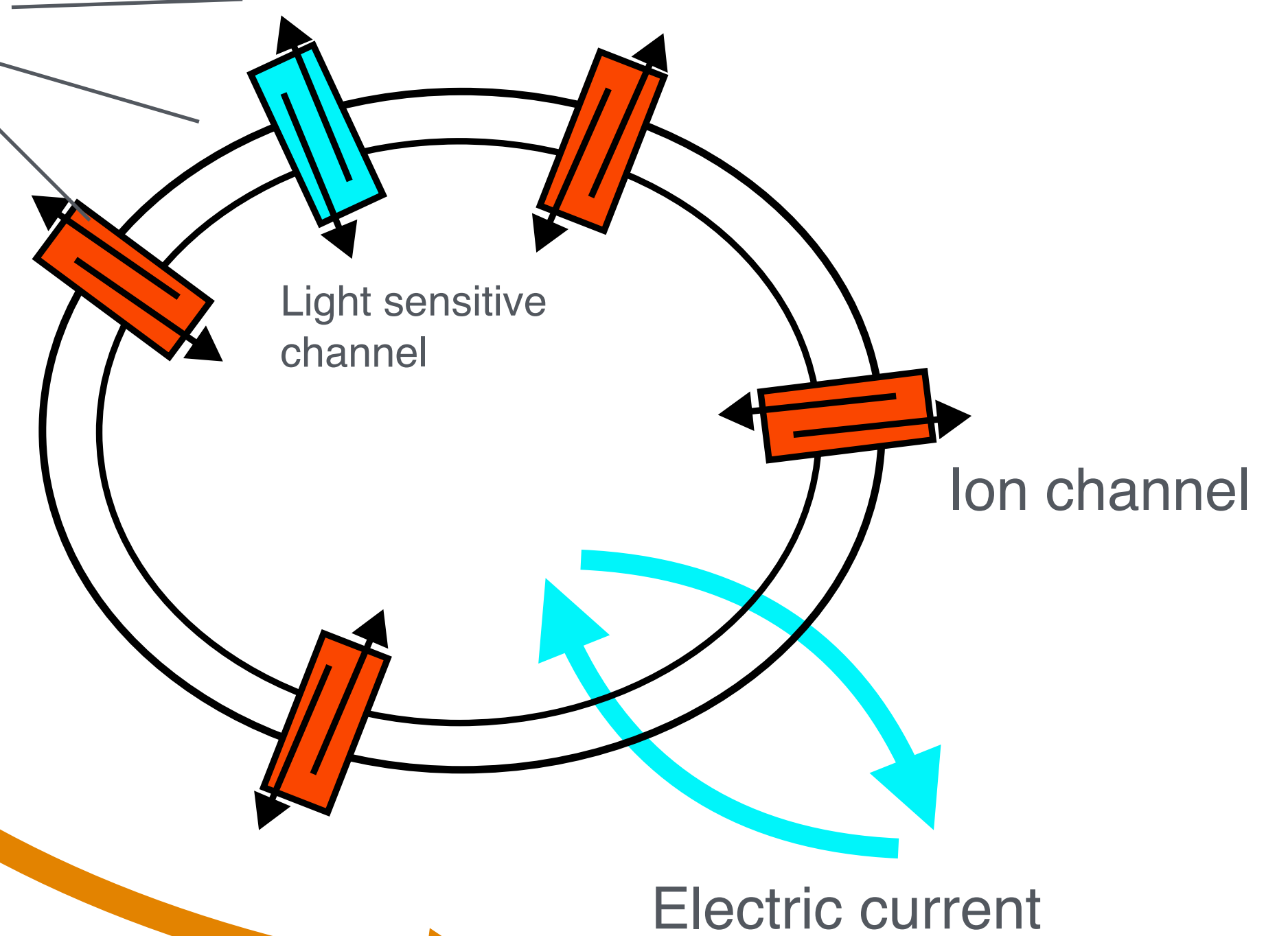
Biology by a physicist...

Neuron



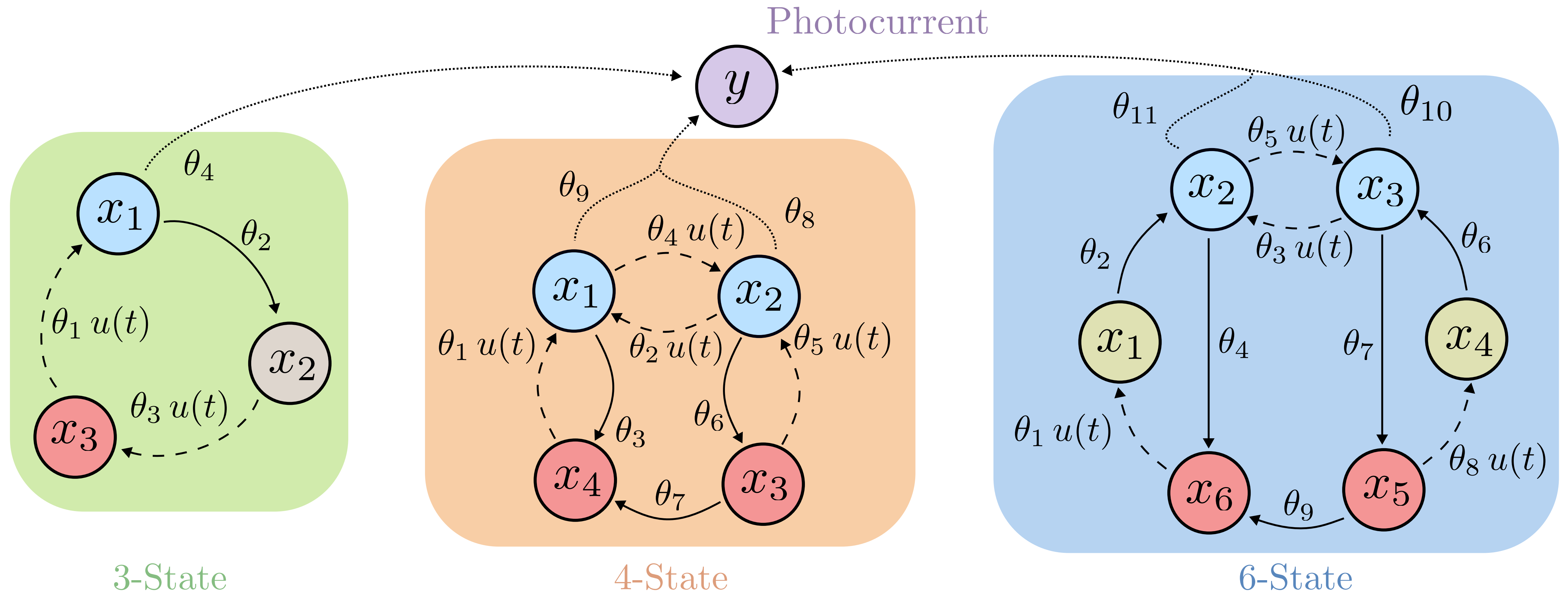
Control signal $u(t)$

Neuron genetically modified

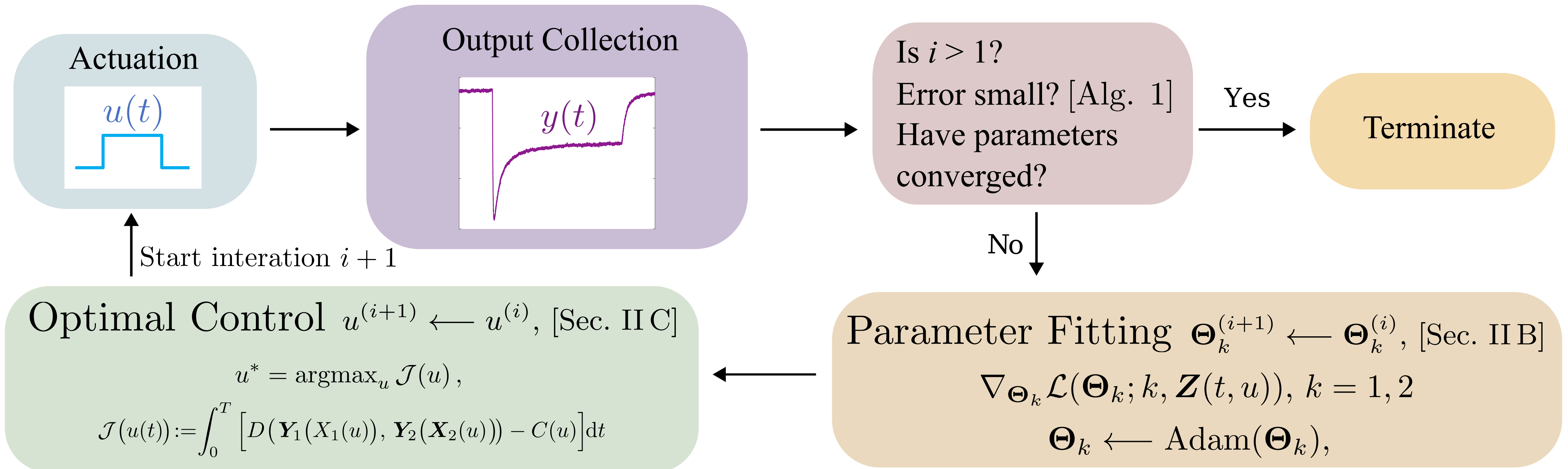


Output current $y(t)$

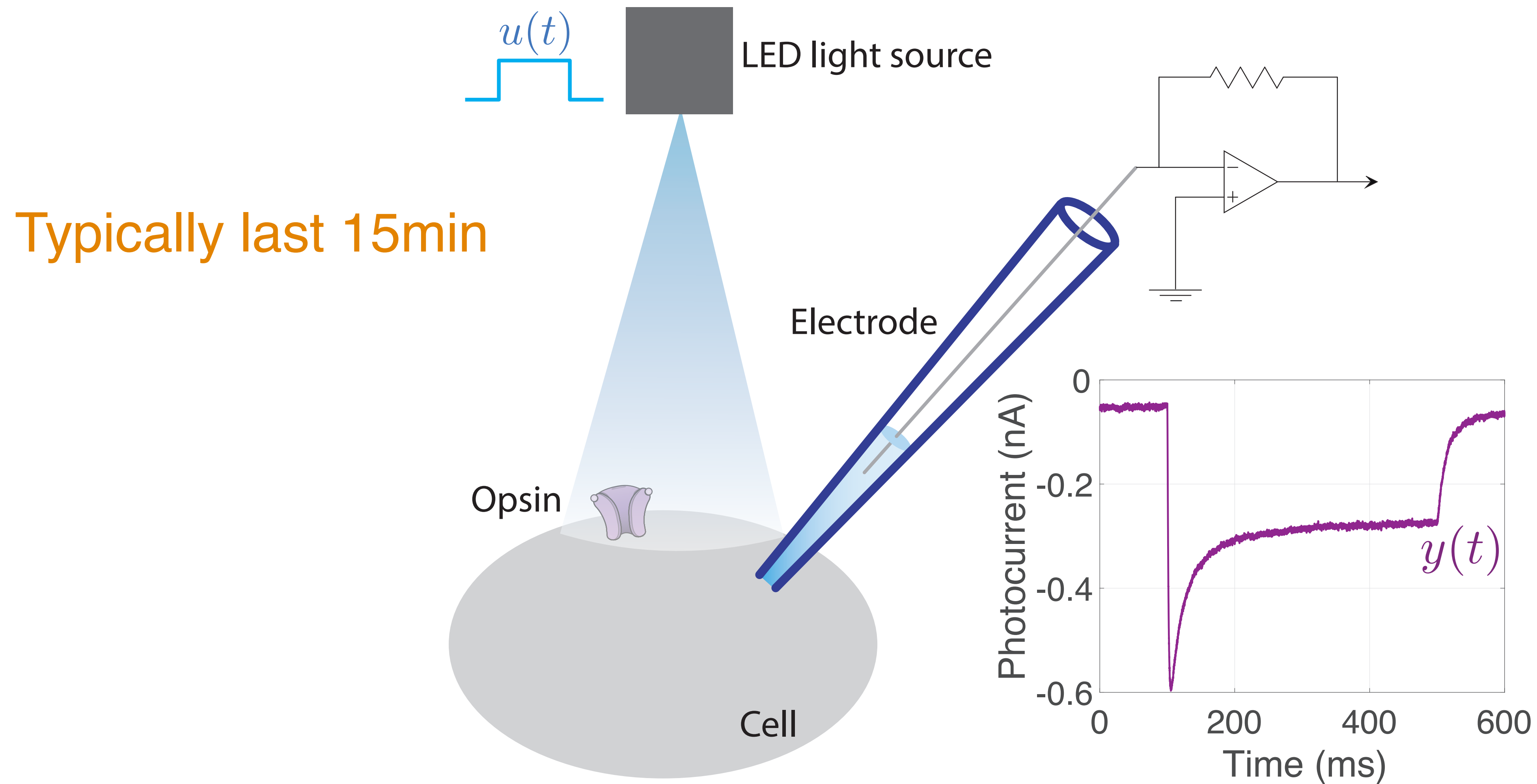
Light — current models



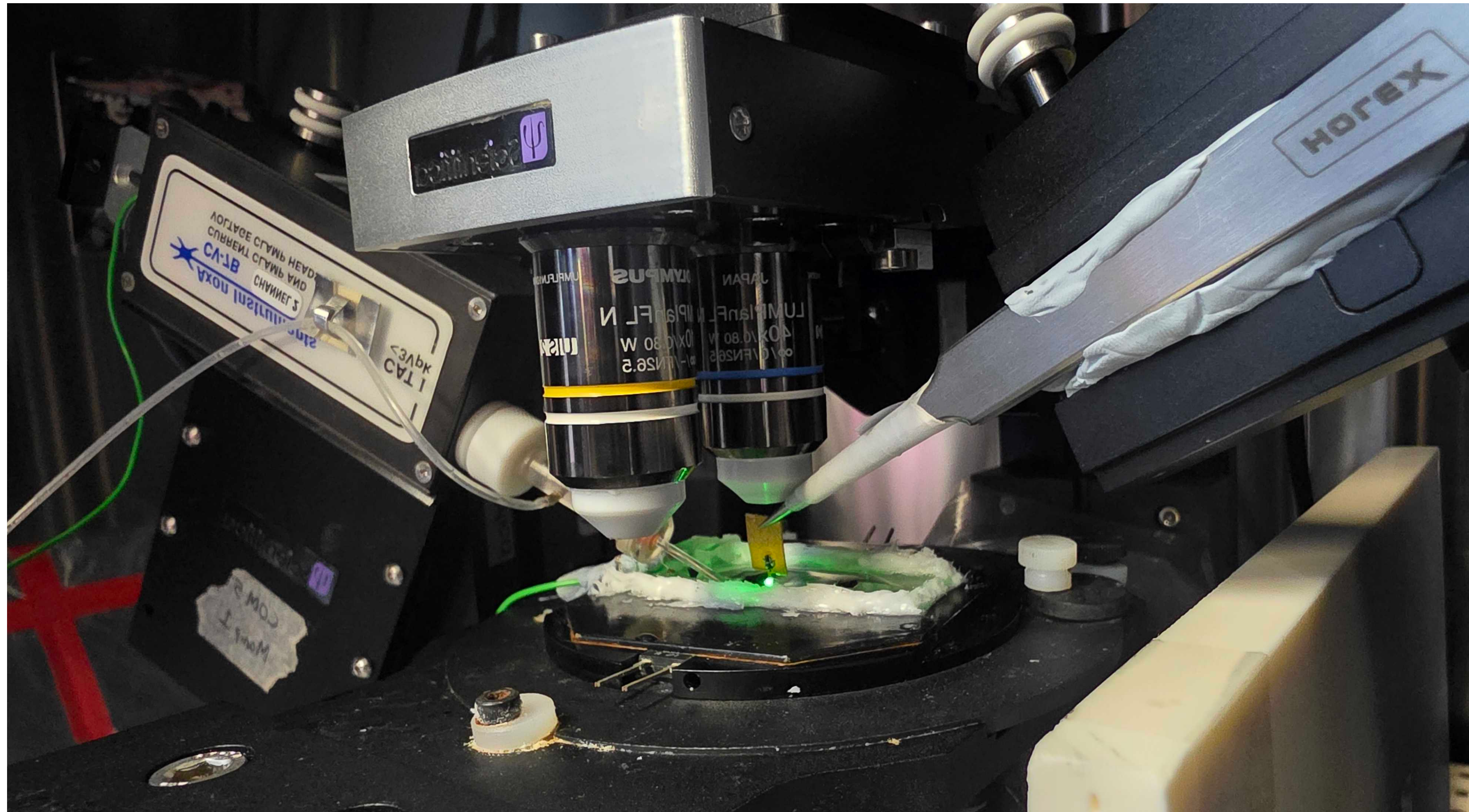
Method Workflow



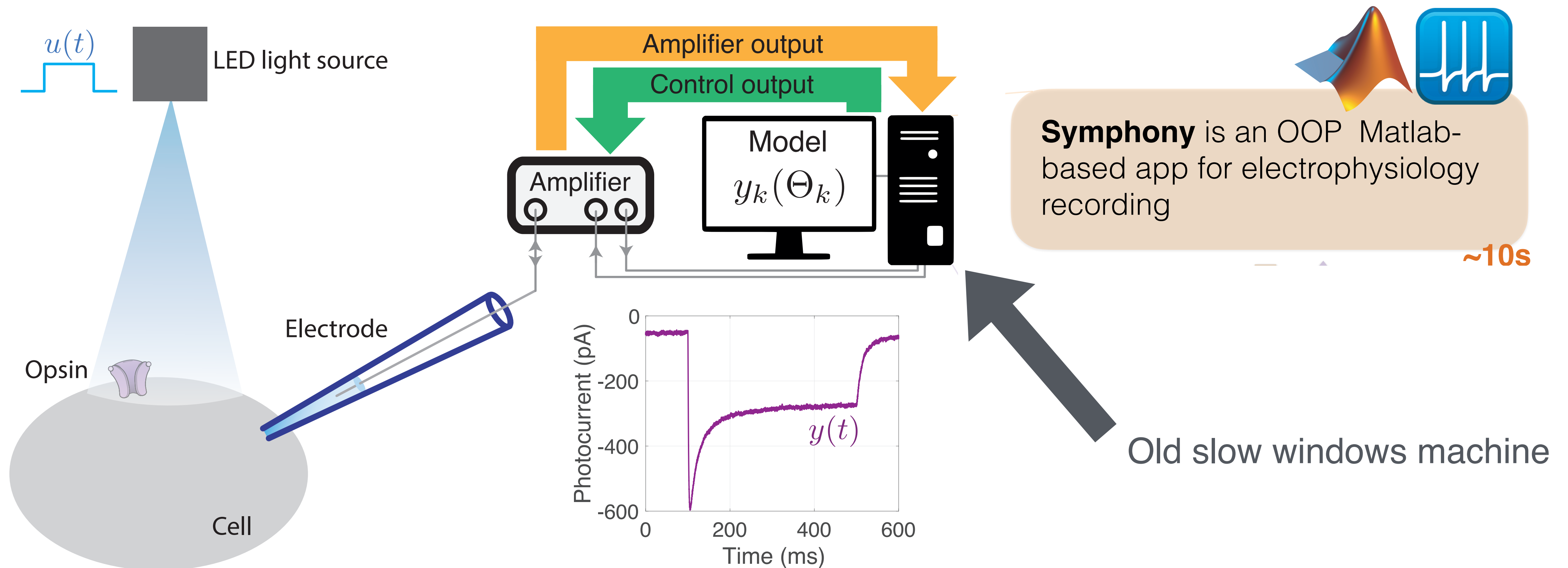
Electrophysiology experiment



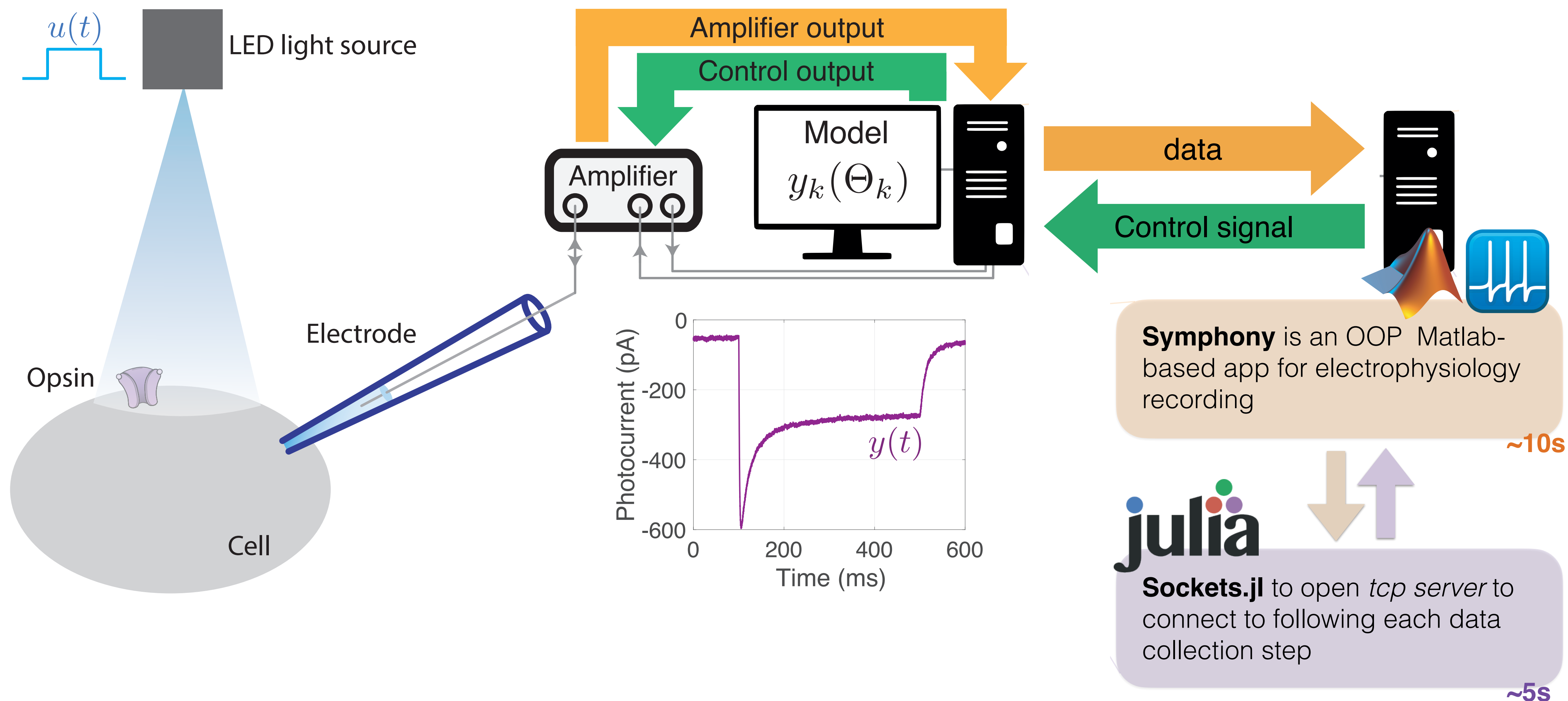
Actual Experiment



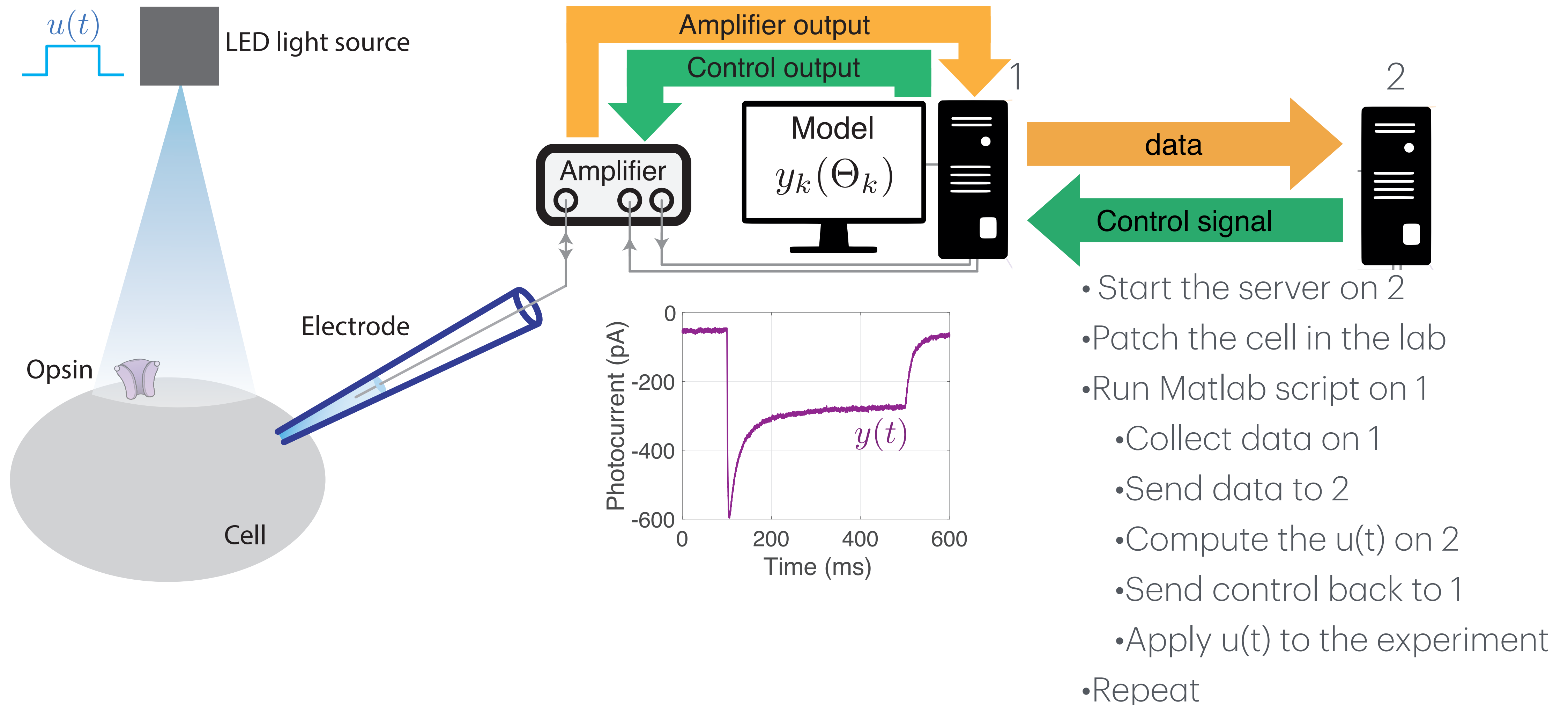
Computer — Experiment



Computer — Experiment



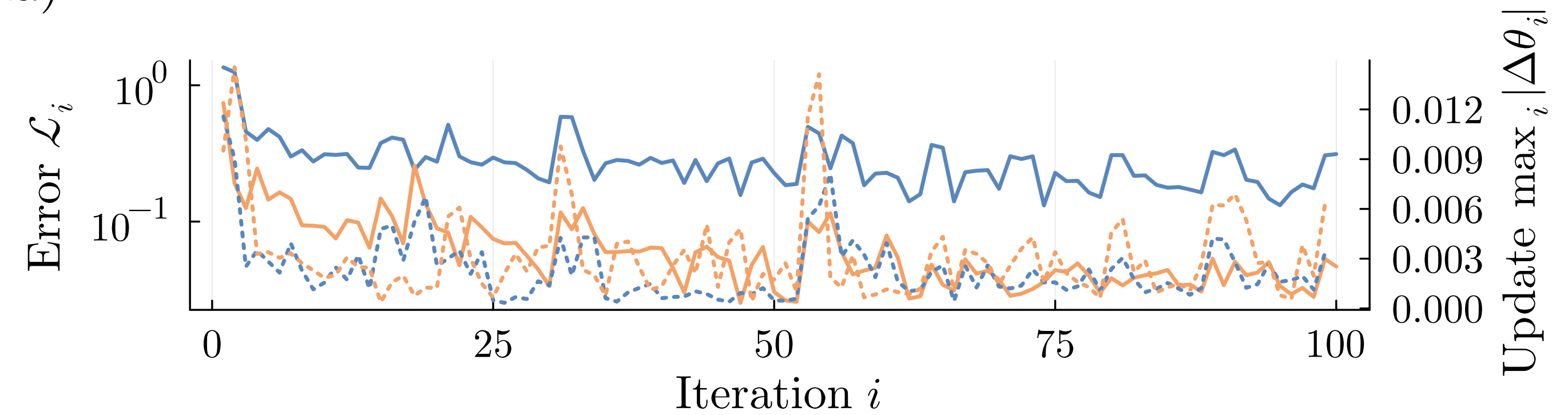
Computer — Experiment



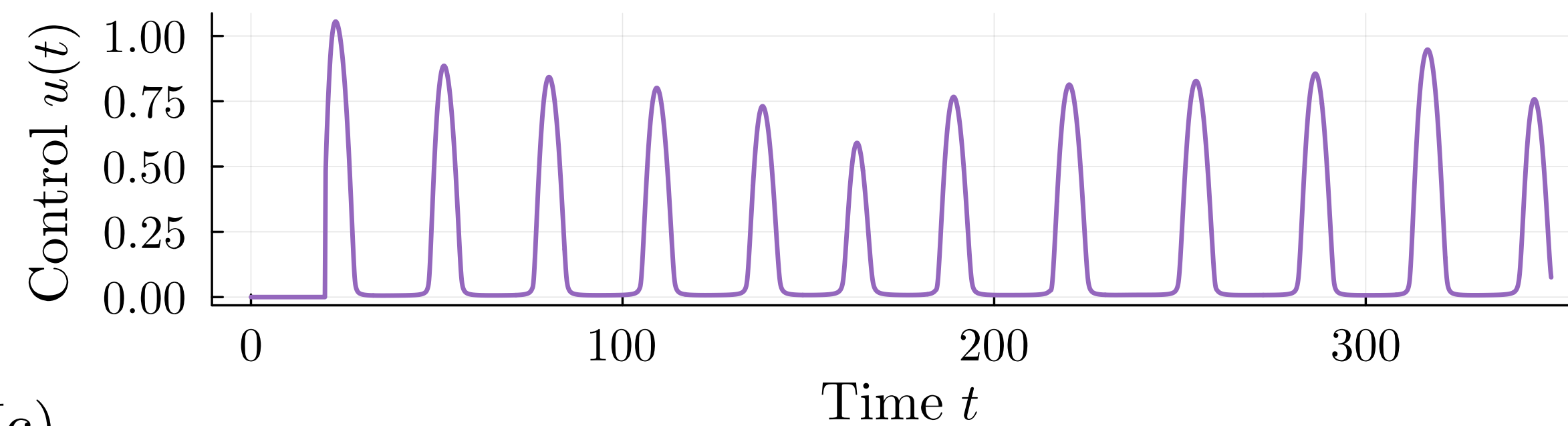
Experiment

Candidate models:
6-state vs. 4-state

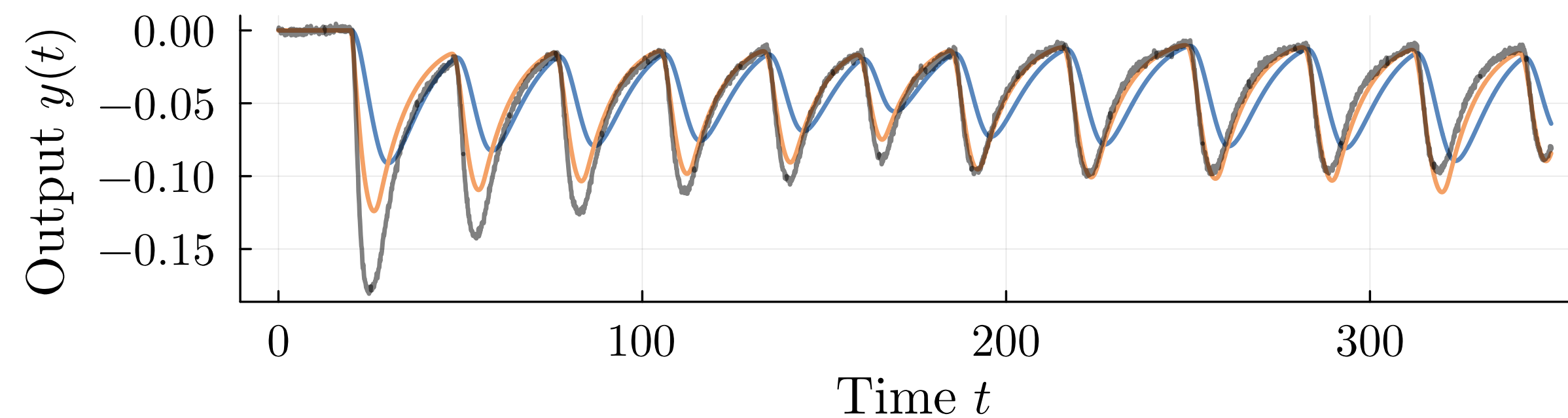
(Ia)



(Ib)



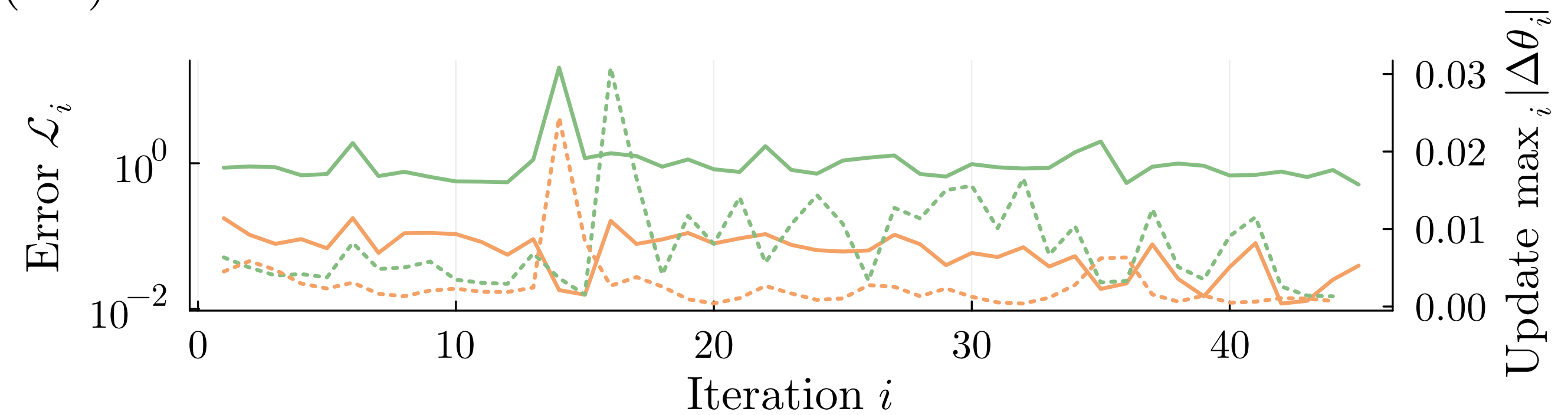
(Ic)



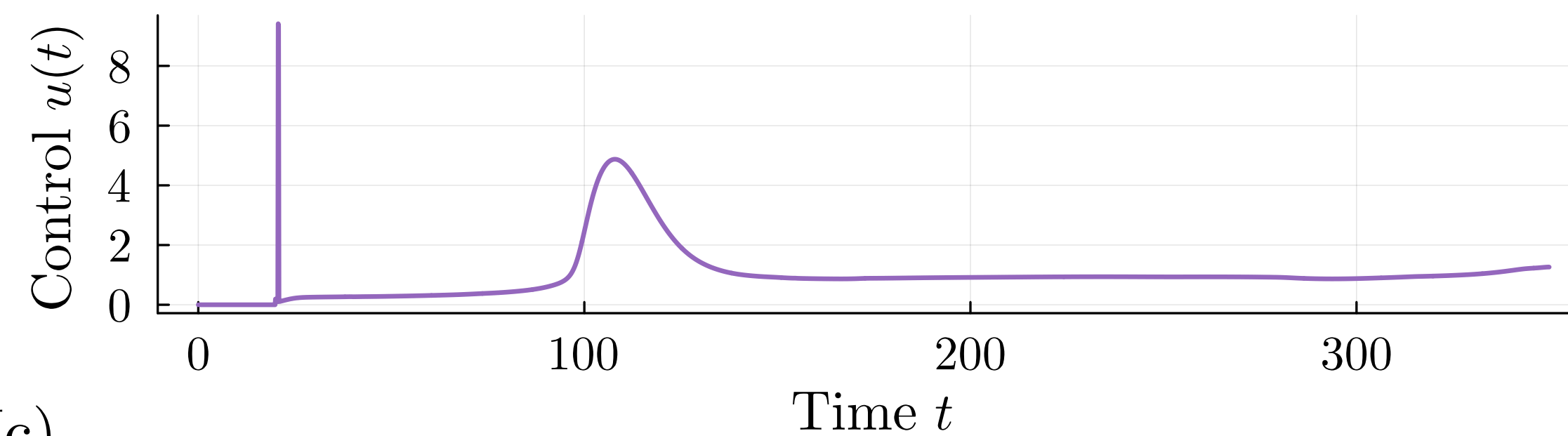
Experiment

Candidate models:
3-state vs. 4-state

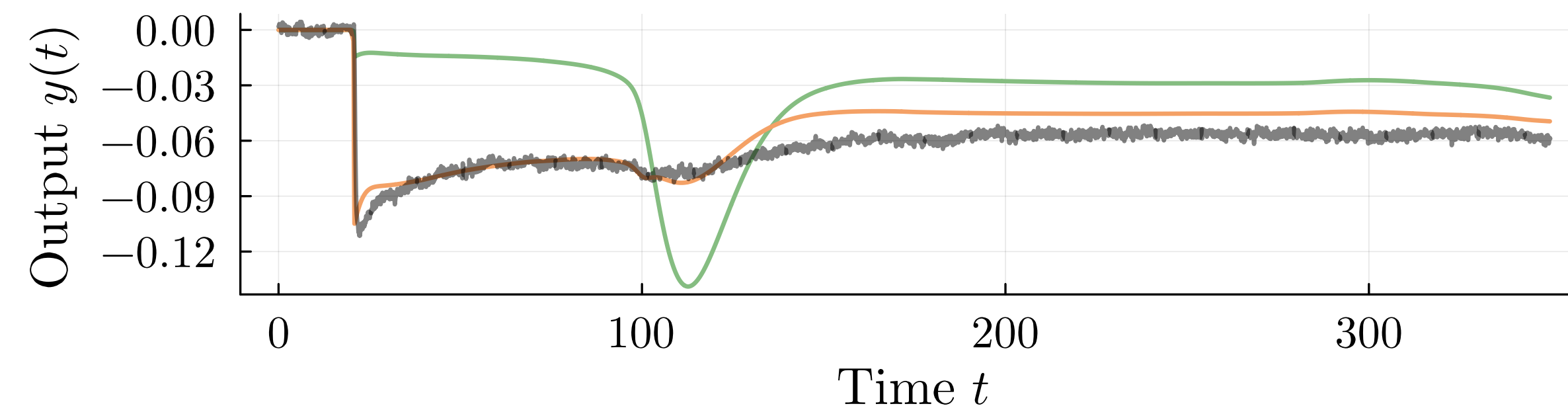
(IIa)



(IIb)



(IIc)



Conclusion

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- Closed-loop algorithm for model selection.
- Allowed to select the most accurate opsin model.
- Exploration of the phase space based on heuristics.

Currently looking for the next
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Future work

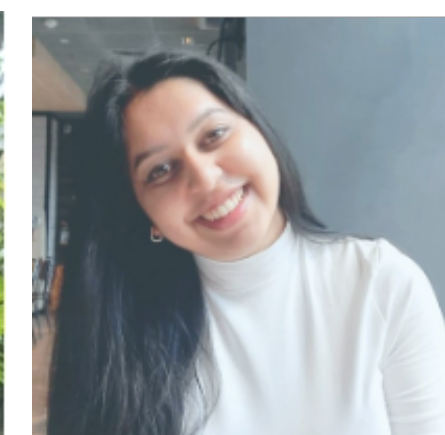
- Build digital twins.
- Leverage digital twin to optimize the control inputs.
- Apply to other systems.



Kyle Wedgwood



Akshita Jindal



Pragati Thakur



Laurent Pagnier

Preprint arXiv:2603.00709



Engineering and
Physical Sciences
Research Council



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