

C. ELEGANS OPTOGENETICS

A FRESHMAN LABORATORY EXPERIENCE

JUSTIN BOIS

BE 159, JAN 25, 2021



The Manchurian Candidate, United Artists, 1962

How optogenetics works

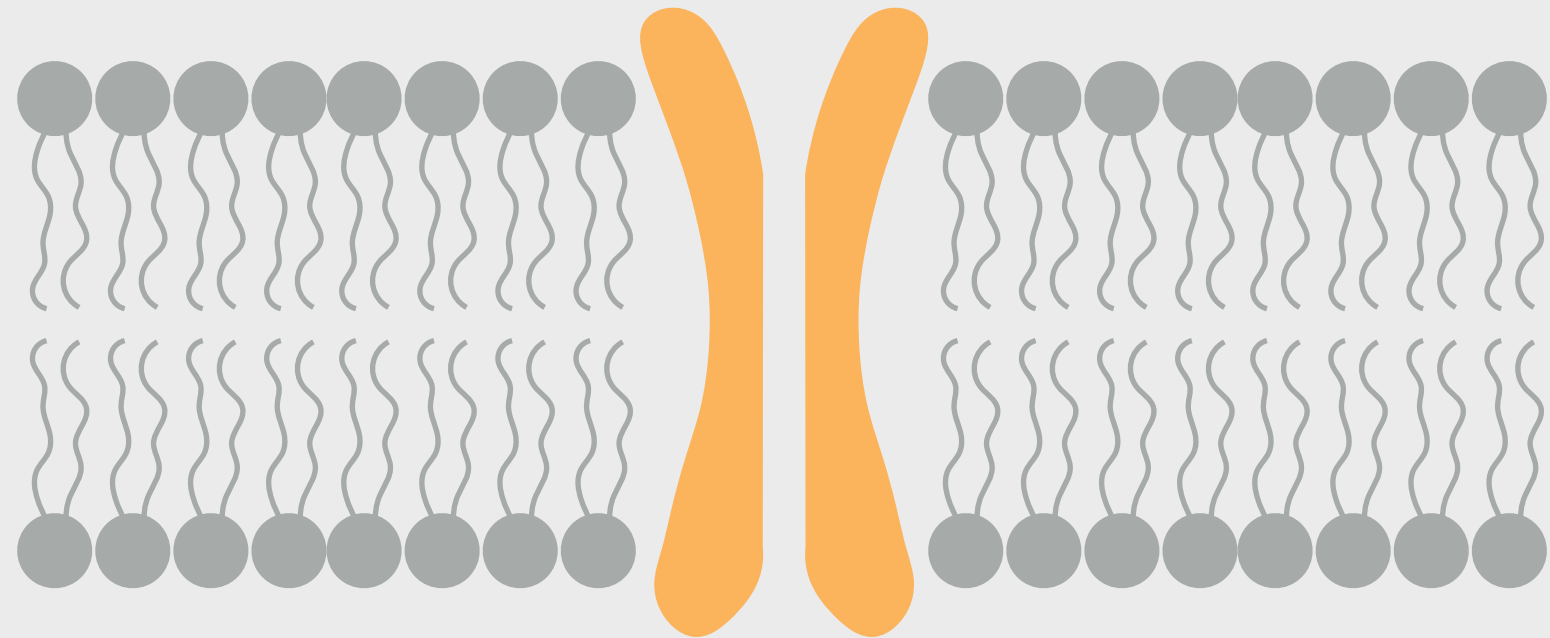
Our central research question
on neural networks

Statistical analysis

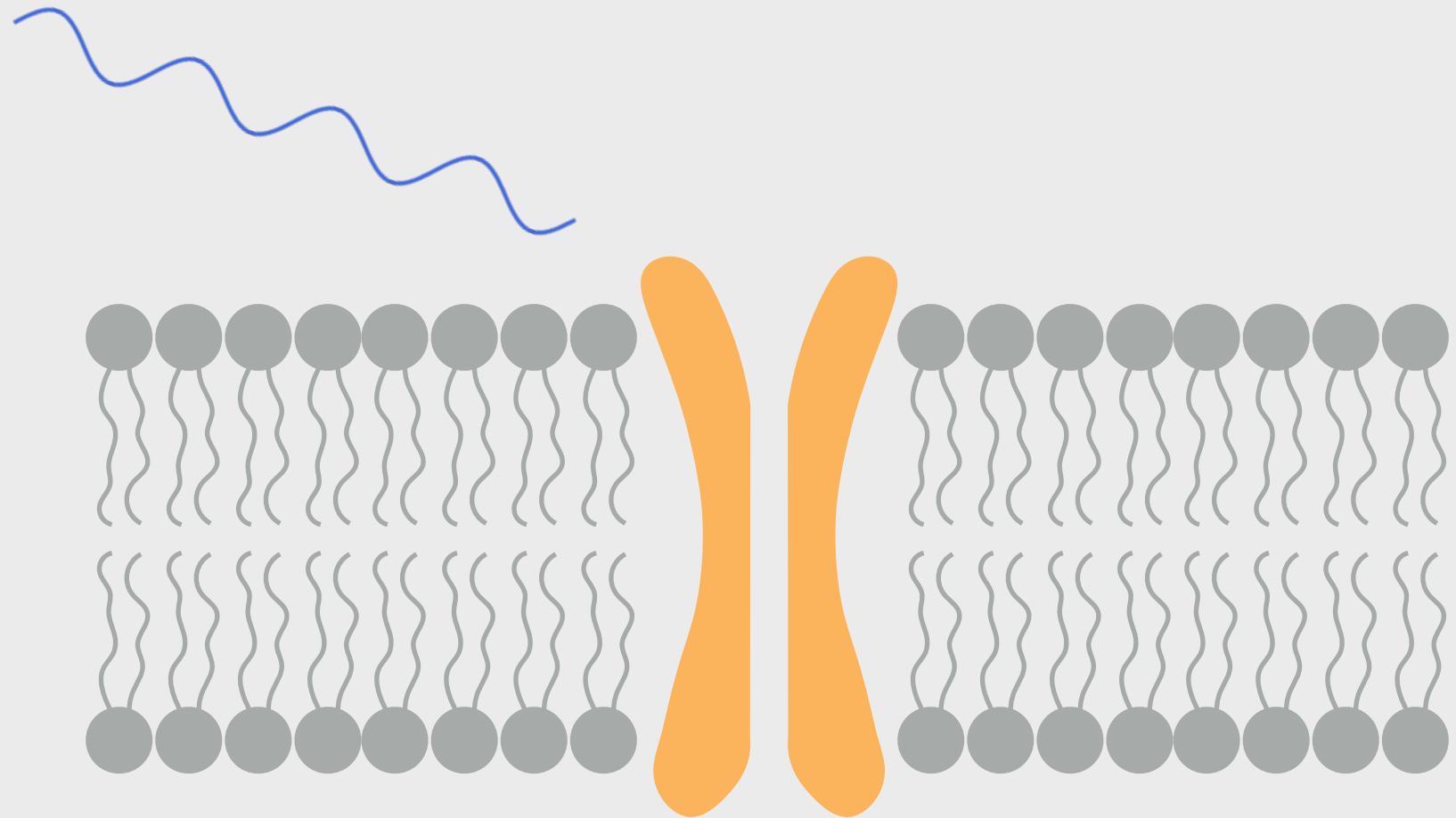
***Chlamydomonas* has an eyespot with Channelrhodopsin**



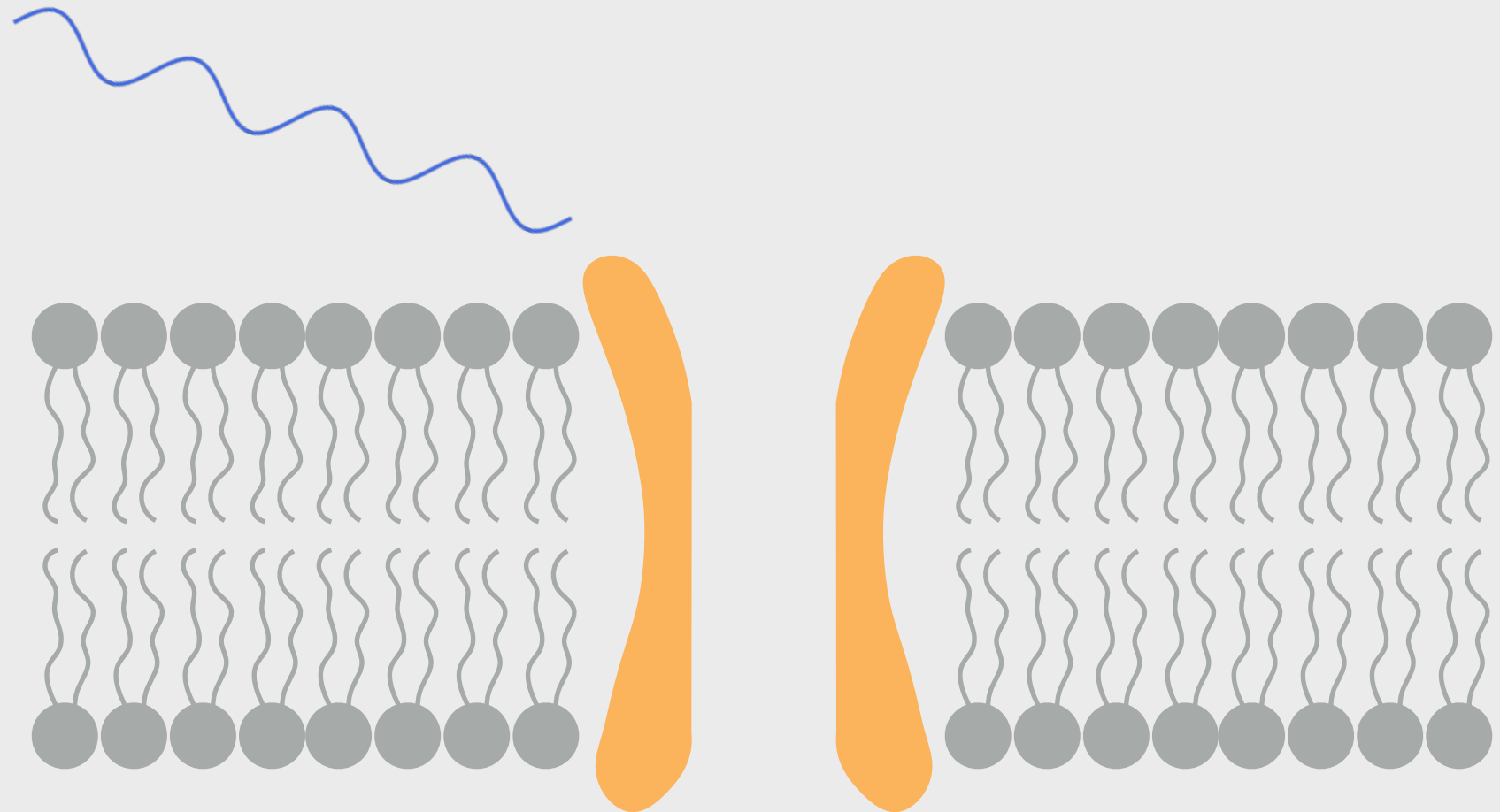
Channelrhodopsin is an optically-activated ion channel



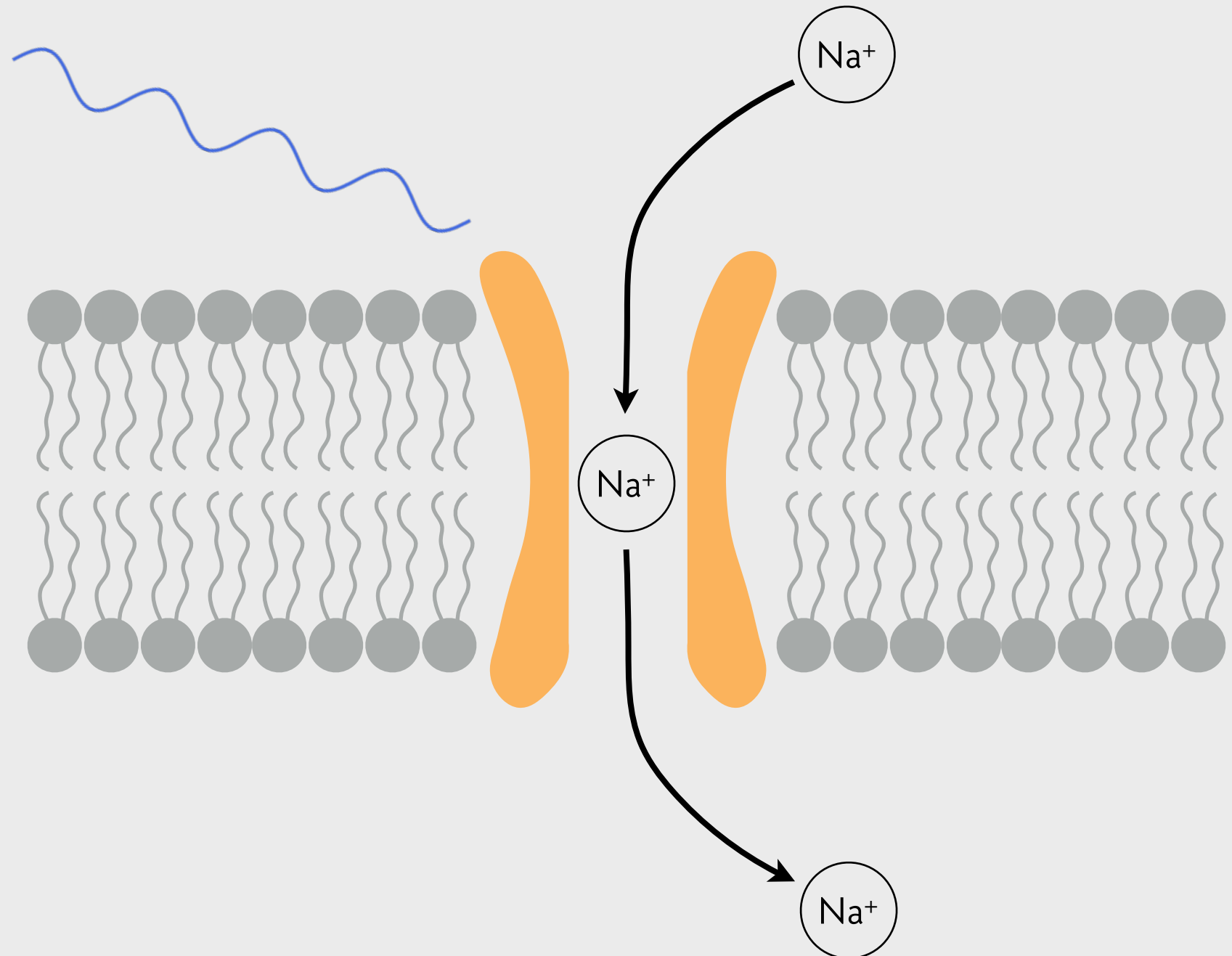
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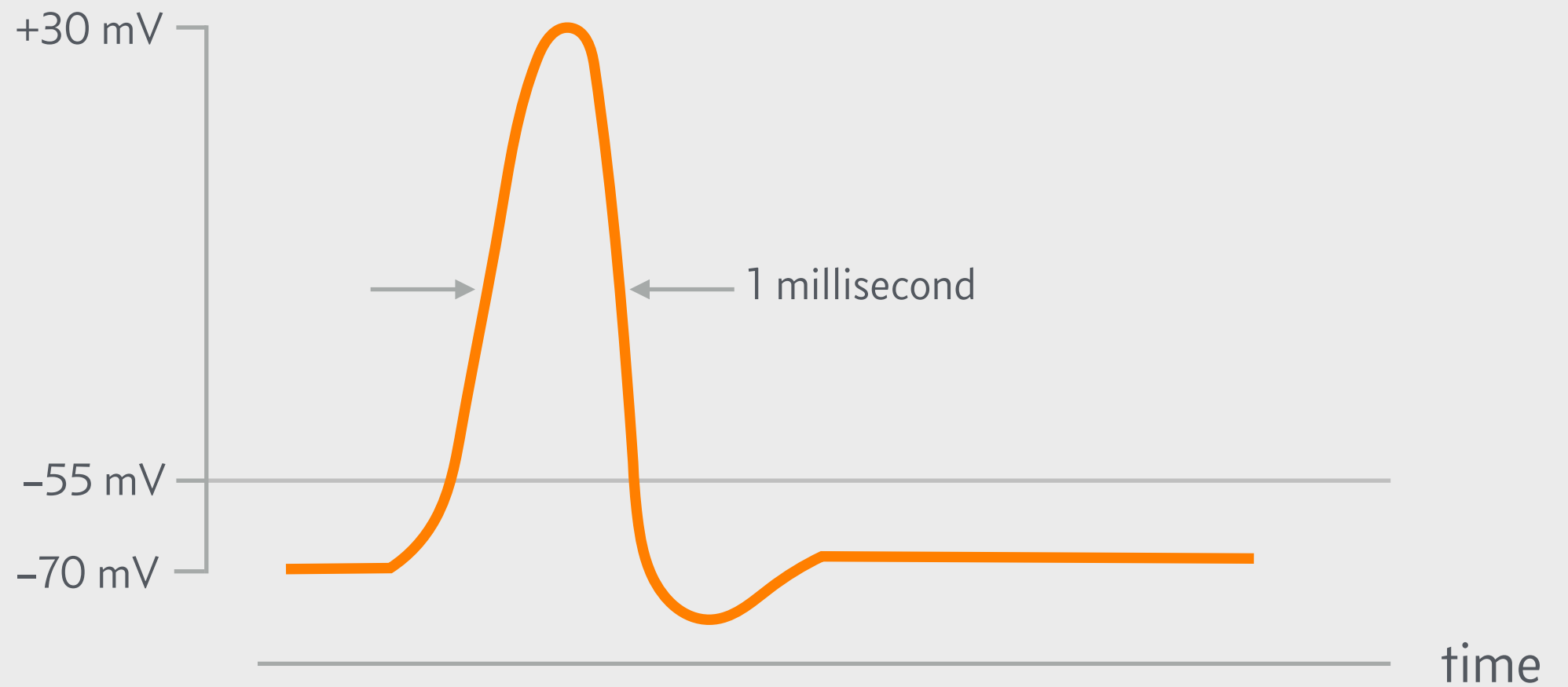


Channelrhodopsin is an optically-activated ion channel



Induced charge difference mimics an action potential

membrane potential



Optogenetics: put opsins in specific neurons



Karl Deisseroth

Optogenetics is used to control the thirst sensation



HOW DOES PROXIMITY OF THE CHANNELRHODOPSIN
TO MOTOR NEURONS AFFECT RESPONSE?

***C. elegans* is an ideal organism for optogenetics**



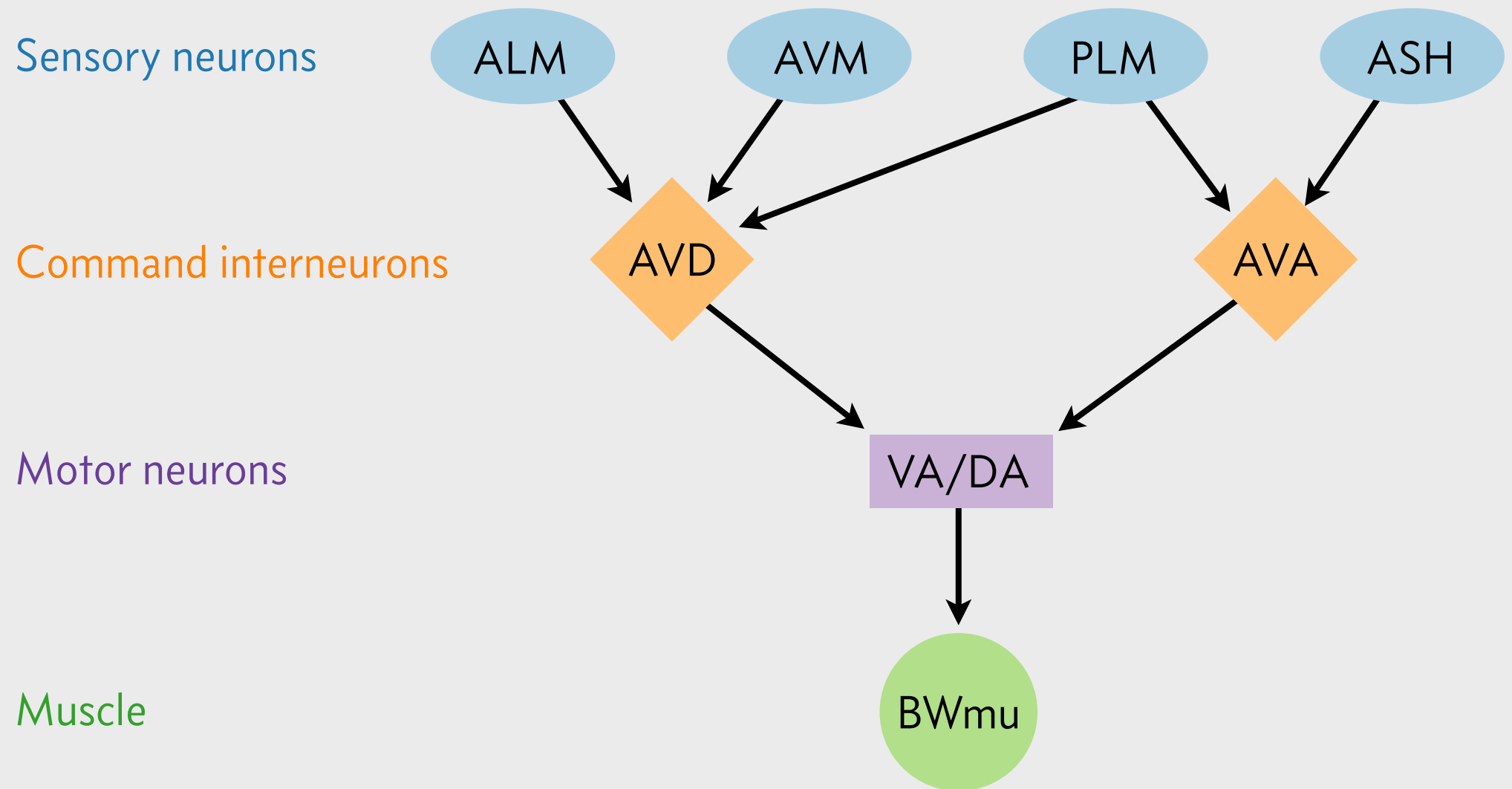
Complete set of genetic tools

Simple nervous system

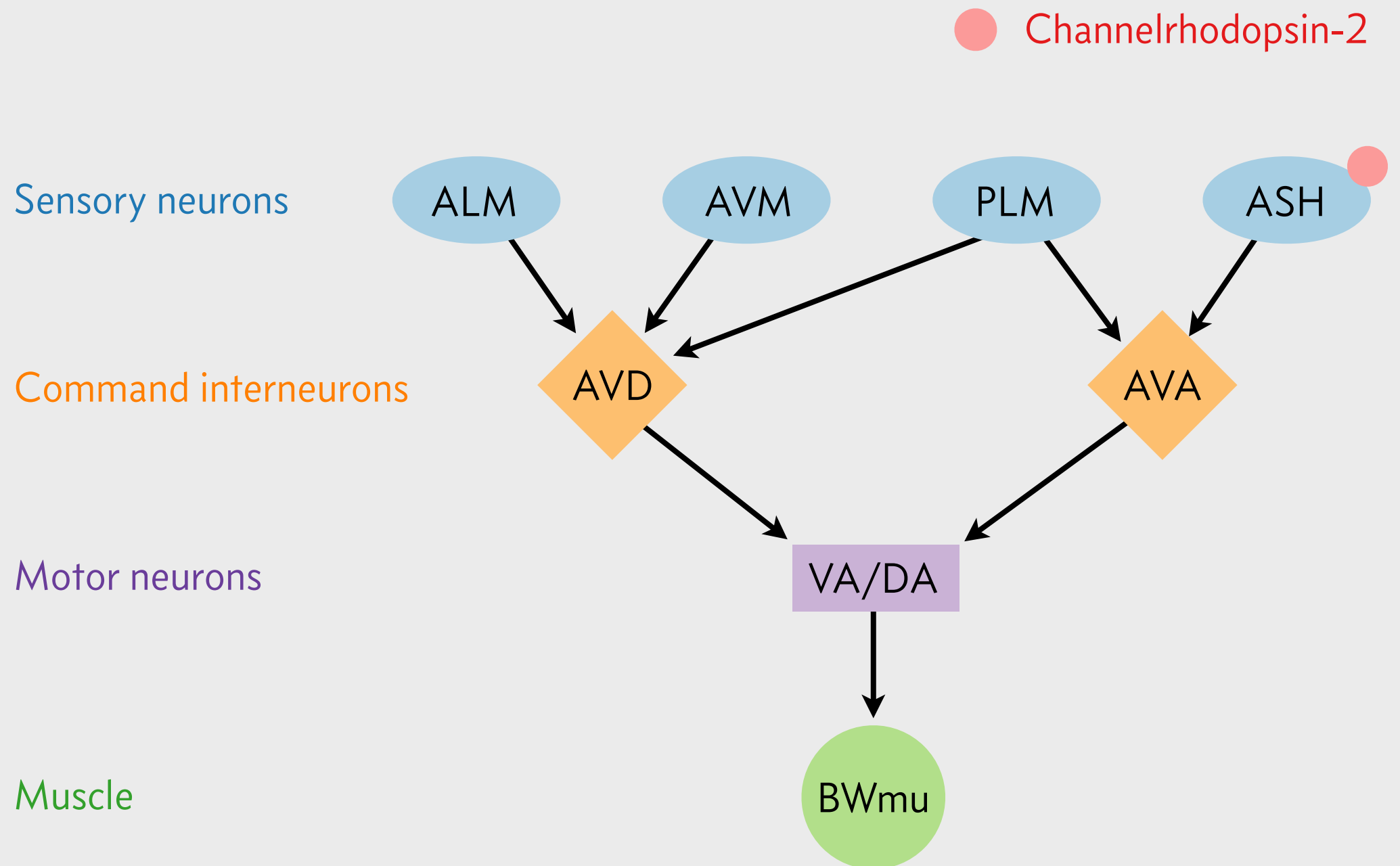
Have limited light sensing

Transparent!

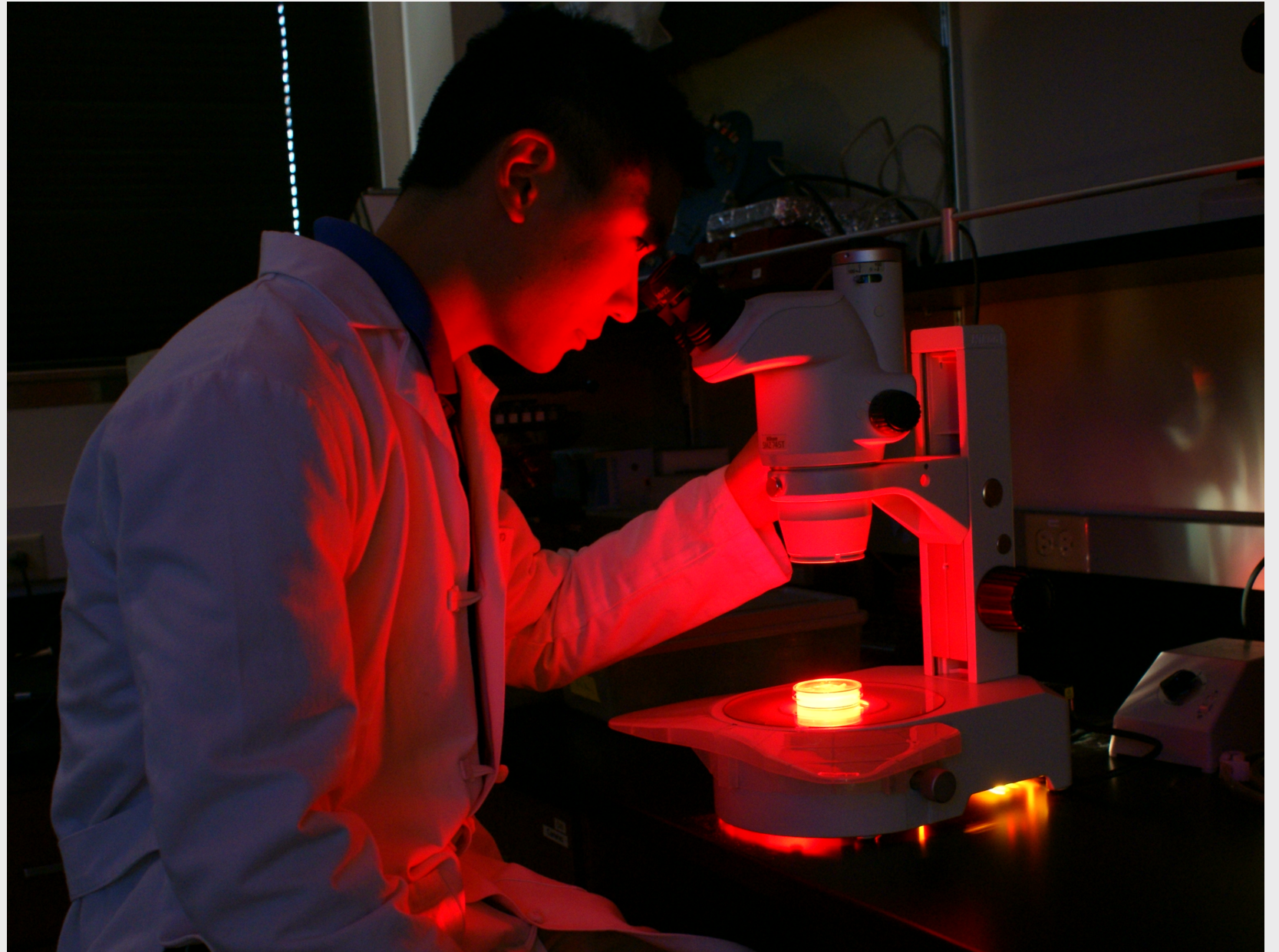
The *C. elegans* reversal circuit is well-mapped and simple



Channelrhodopsin can be expressed in specific neurons

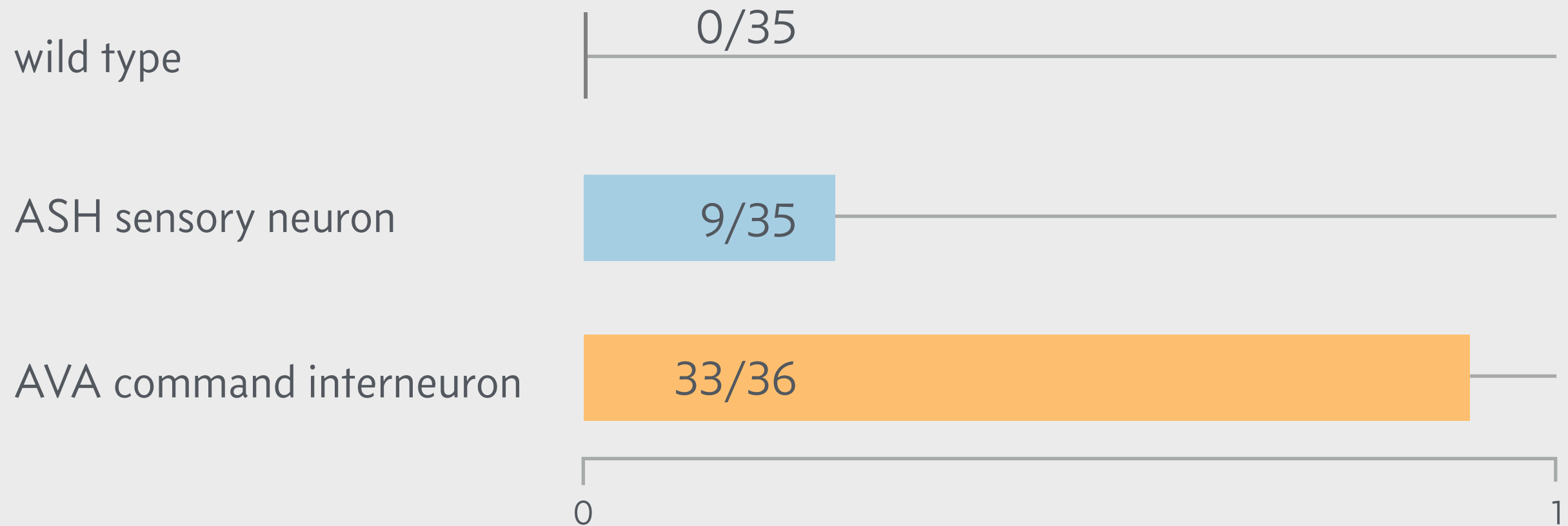


The experiment costs less than \$300



The command interneuron shows the strongest response

Fraction of reversals



We use Bayes's theorem to quantify reversal probability

$$P(A | B) = \frac{P(B | A) P(A)}{P(B)}$$

$A = p_{\text{rev}} =$ probability of reversal

$B = n, r = r$ reversals in n trials

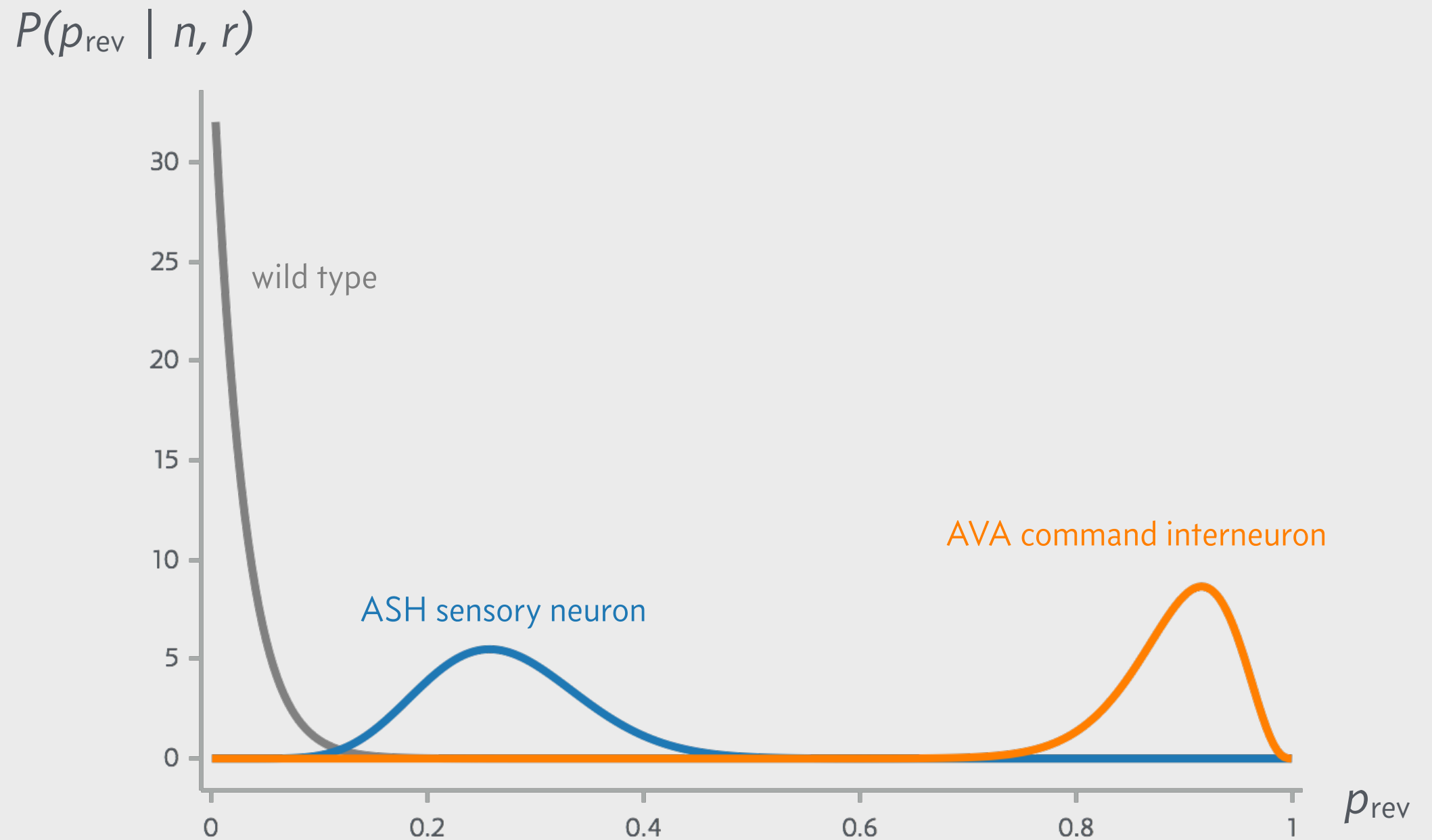
We use Bayes's theorem to quantify reversal probability

$$\begin{aligned} P(p_{\text{rev}} \mid n, r) &= \frac{P(n, r \mid p_{\text{rev}}) P(p_{\text{rev}})}{P(n, r)} \\ &= \frac{\text{Binomial}(r \mid n, p_{\text{rev}}) \times \text{Uniform}(0, 1)}{\text{Uniform}(0, n+1)} \end{aligned}$$

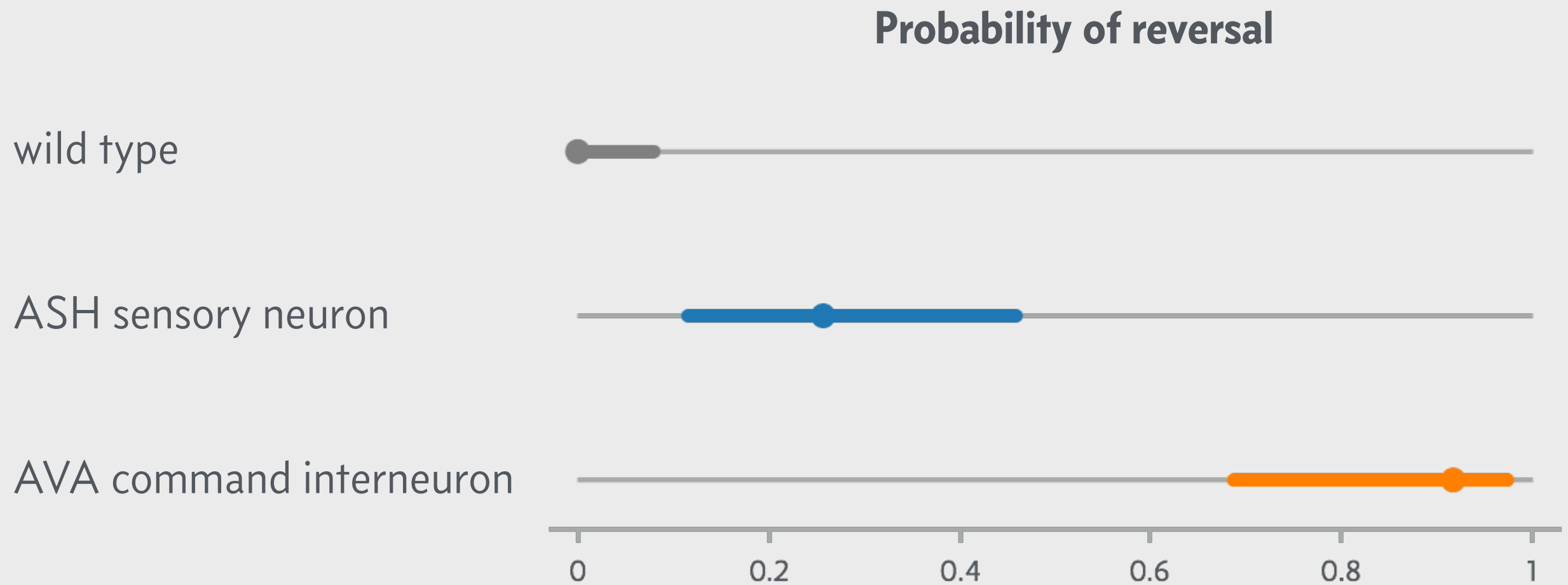
p_{rev} = probability of reversal

n, r = r reversals in n trials

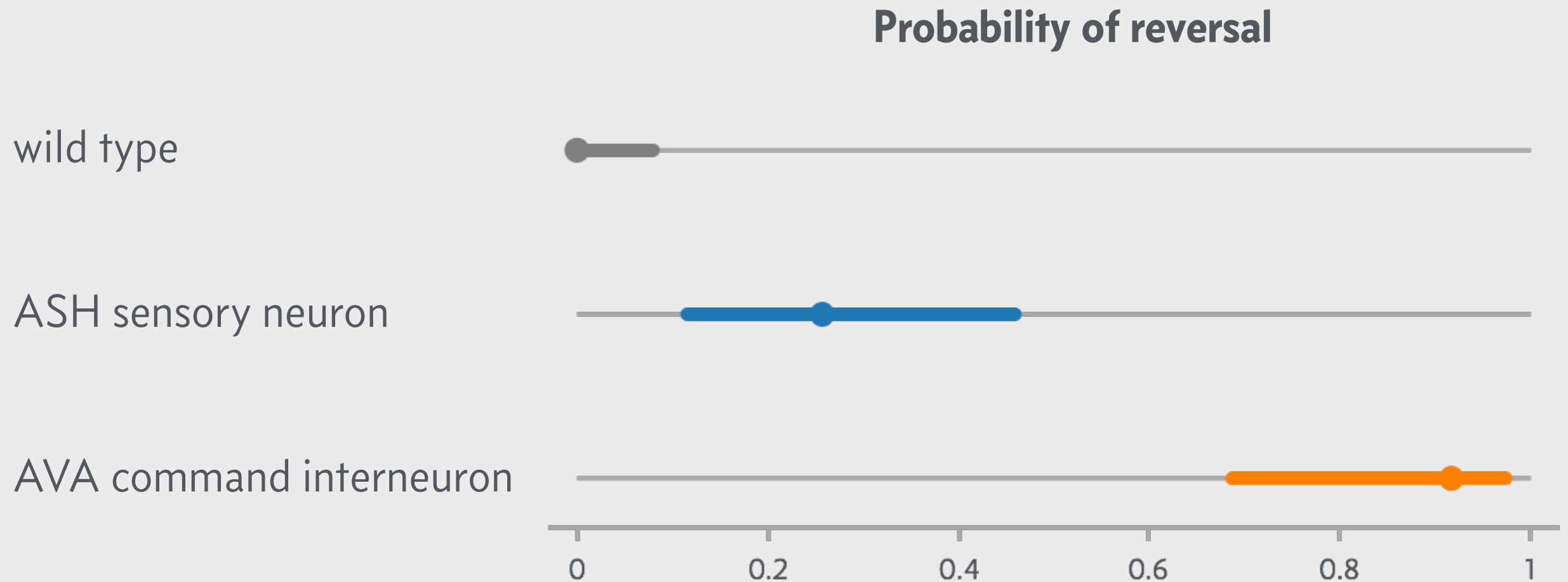
A Bayesian analysis give a complete description of reversal probability



95% confidence intervals reveal quantitative difference in reversal probability

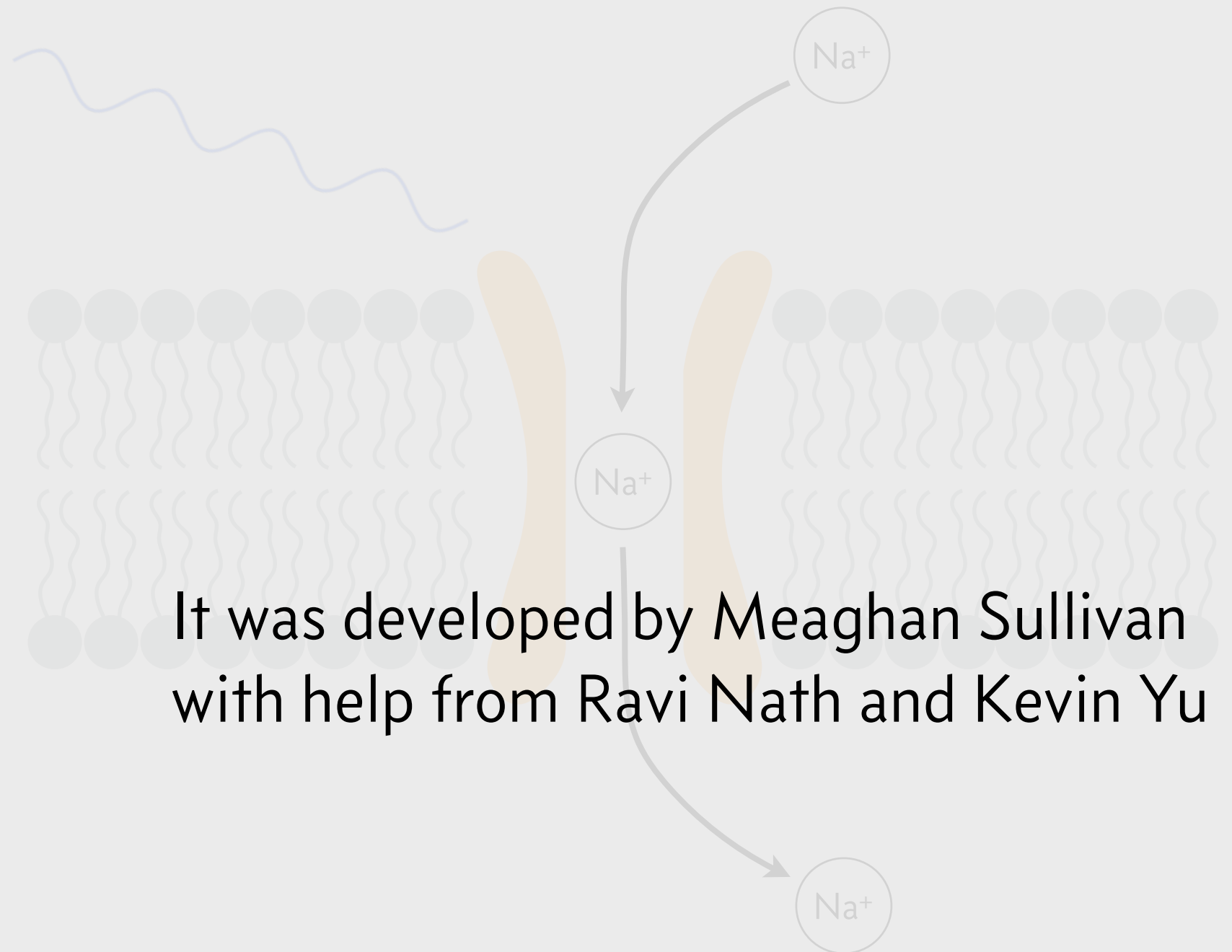


How does **proximity** of the Channelrhodopsin to motor neurons affect response?



Stimulation of the command interneuron is more than twice as likely to invoke a response.

This experiment was conducted
by the students of Bi 1x 2015



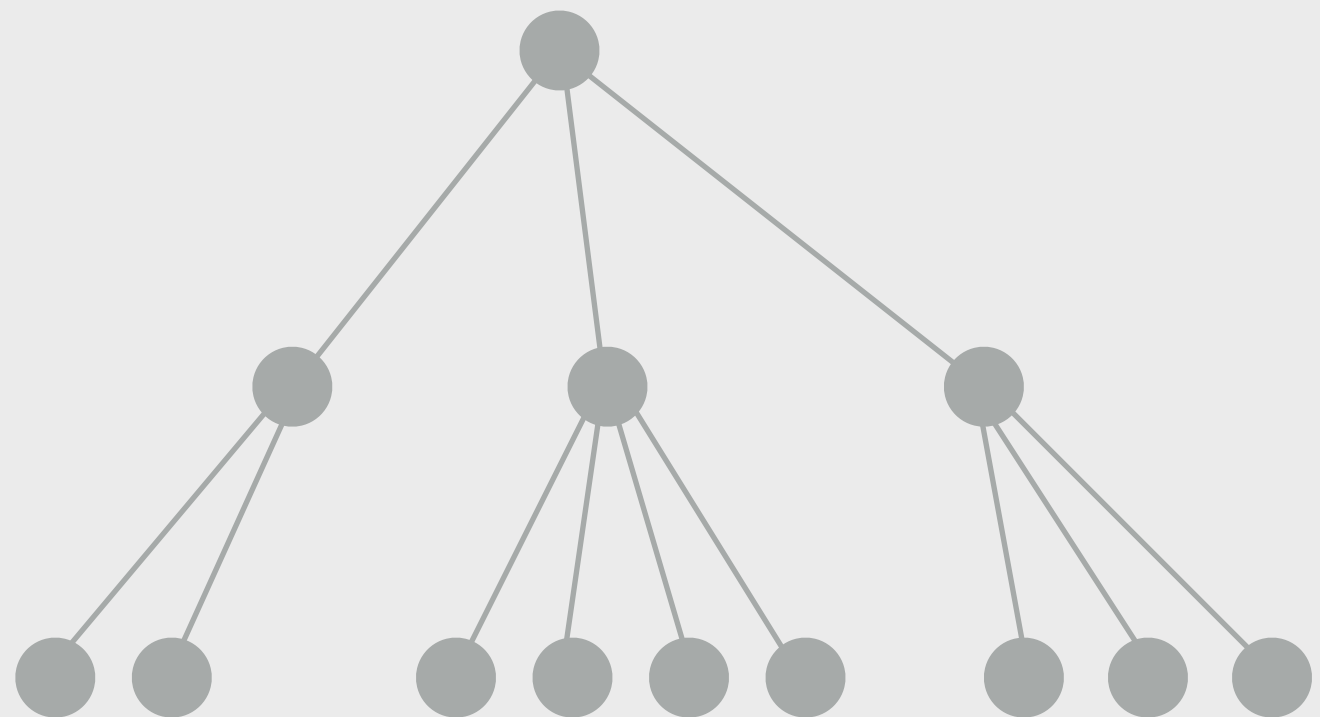
It was developed by Meaghan Sullivan
with help from Ravi Nath and Kevin Yu

The talk **content** has a top-down hierarchical structure

Main message

Main points

Subpoints



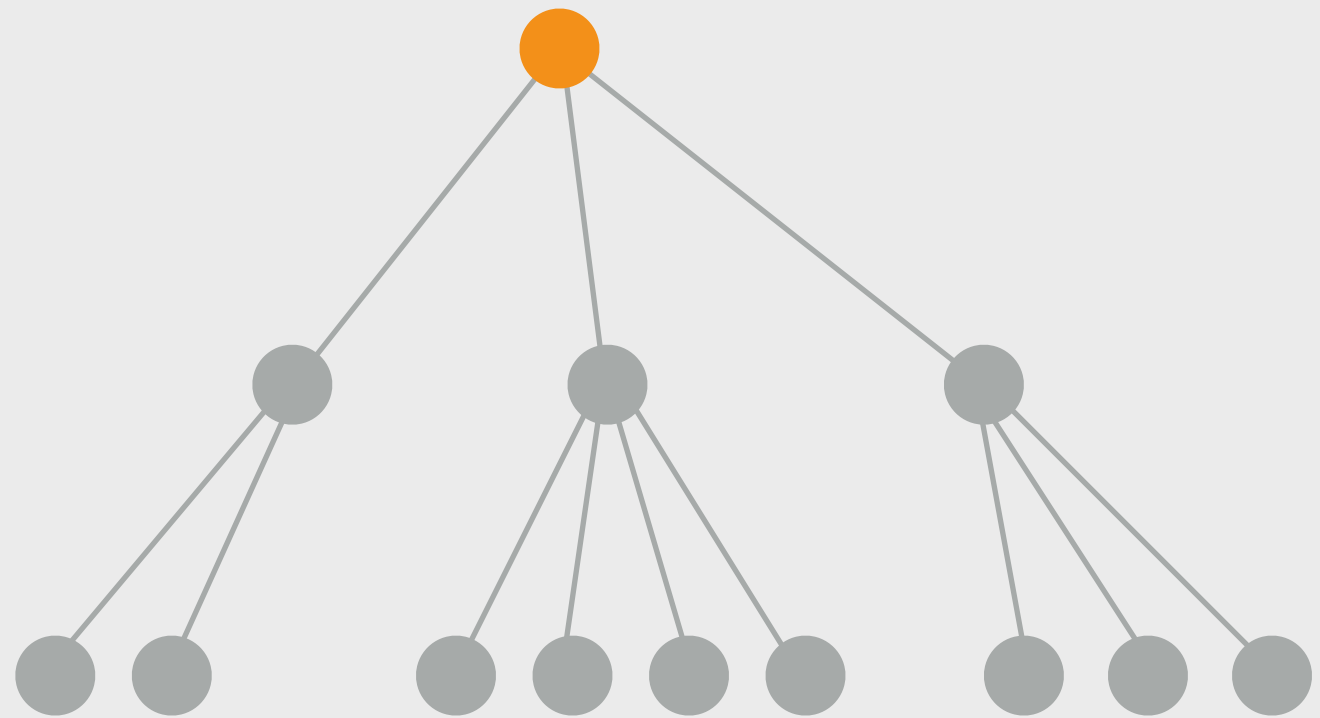
The talk **content** has a top-down hierarchical structure

A meaningful *C. elegans* optogenetics experiment was done cheaply in a freshman lab

Main message

Main points

Subpoints

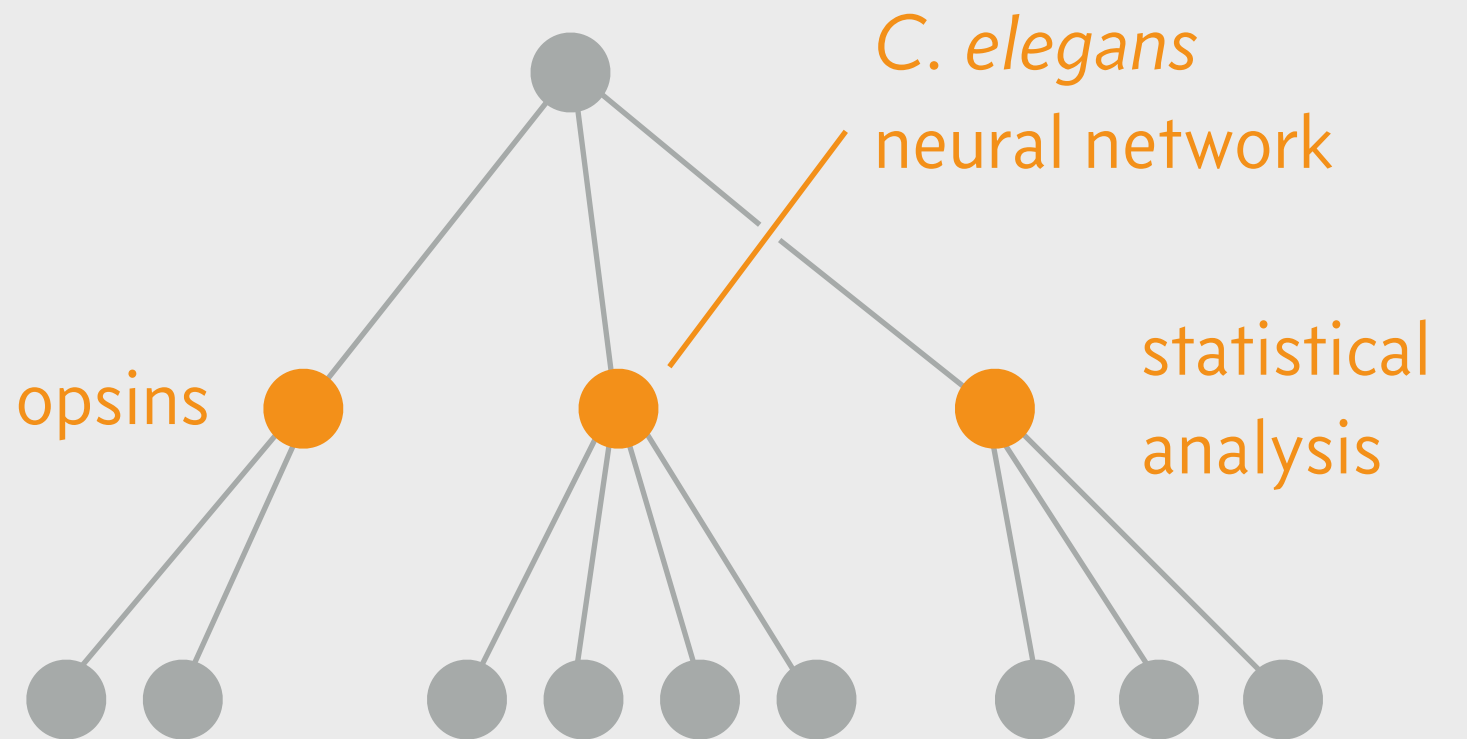


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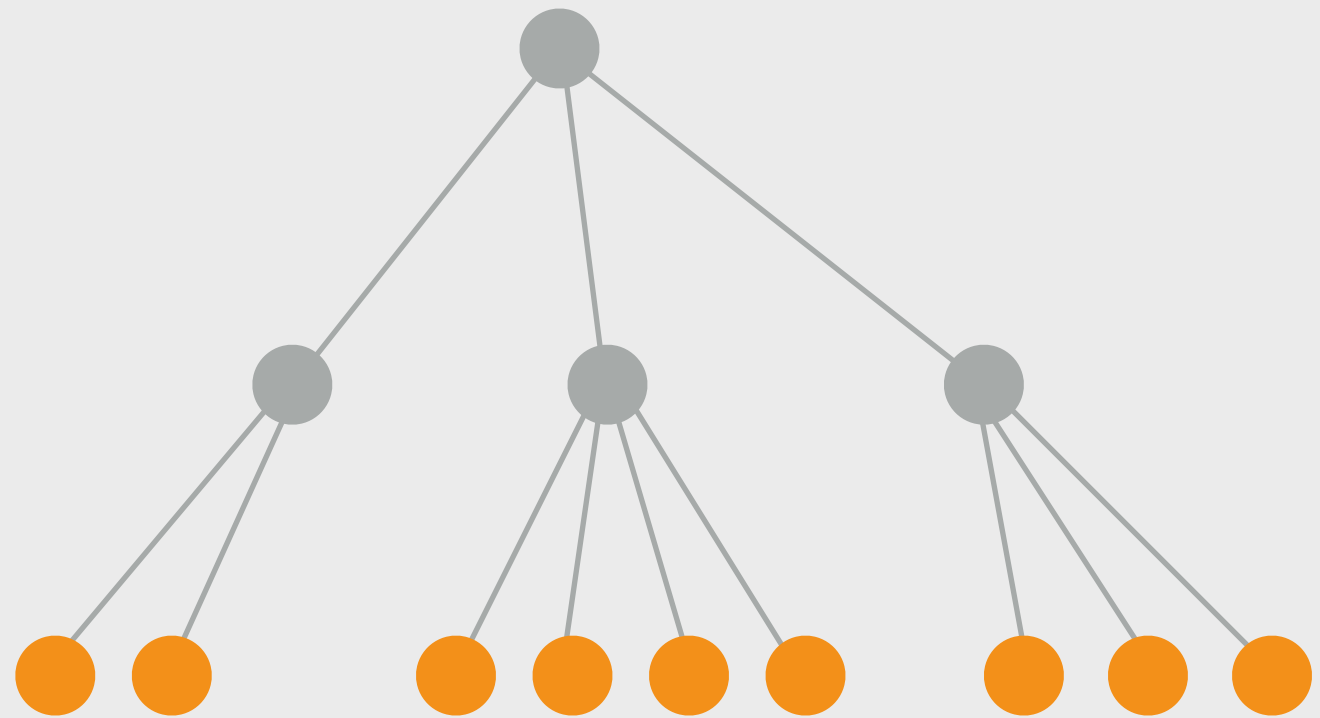


You should have one slide for each subpoint

Main message

Main points

Subpoints



The talk **structure** is linear

Introduction

Attention getter

Need

Task

Main message

Preview

Body

Main point 1



Main point 2



Main point 3



Closing

Review

Conclusion

Close

The talk **structure** is linear

Introduction

Attention getter

Need

Task

Main message

Preview

Body

Main point 1



Main point 2



Main point 3



Closing

Review

Conclusion

Close



The Manchurian Candidate, United Artists, 1962

Effective experimental design requires exquisite control.

In the past decade, optogenetics has enabled unprecedented control of neuronal systems.

In an effort to train our students in this powerful experimental technique, my TAs and I developed a module using optogenetics in *C. elegans* and implemented it in my freshman lab course at Caltech.

Do not waste words, especially at the beginning

Avoid niceties

Do not read anything from your title slide

Get attention, then focus

Tip: memorize the first few sentences

Introduction

Attention getter

Need

Task

Main message

Preview

Body

Main point 1



Main point 2



Main point 3



Closing

Review

Conclusion

Close

Need

In an effort to train our students in powerful experimental and statistical techniques,

Task

my TAs and I developed a module using optogenetics in *C. elegans*

Main message

and implemented it in my freshman lab course, Bi 1x.

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Main point 3



Closing

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Main point 2



Main point 3



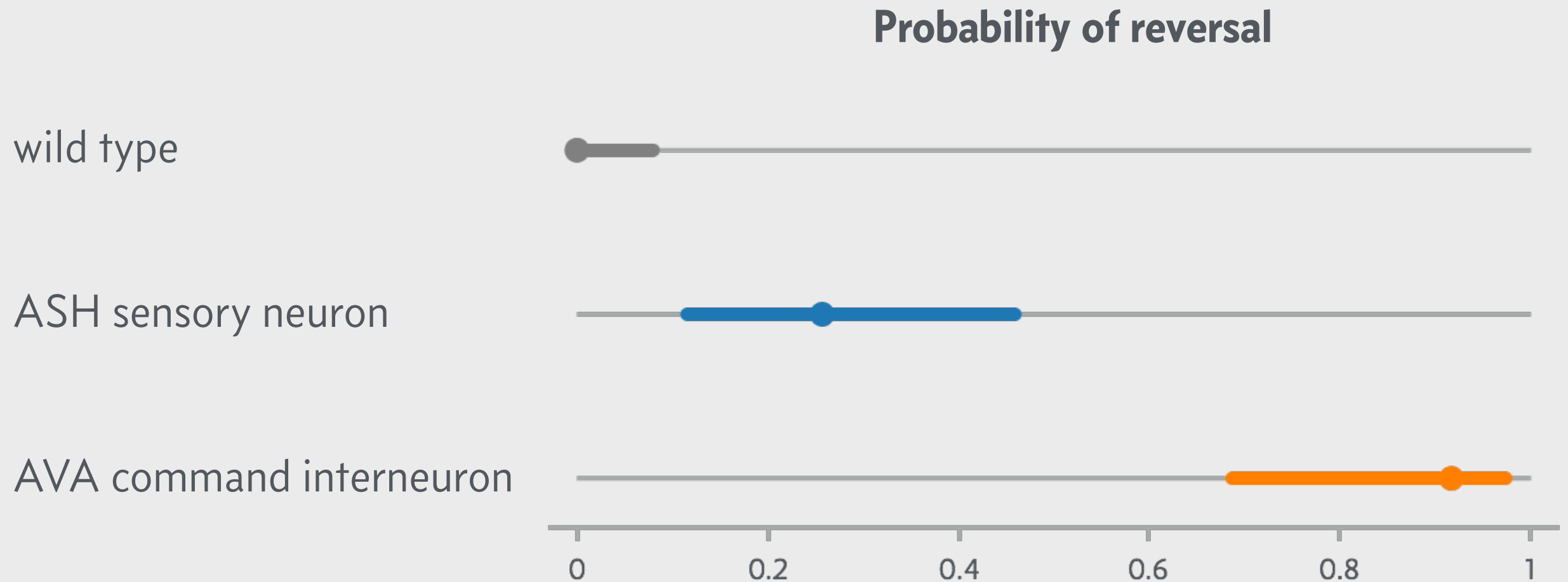
Closing

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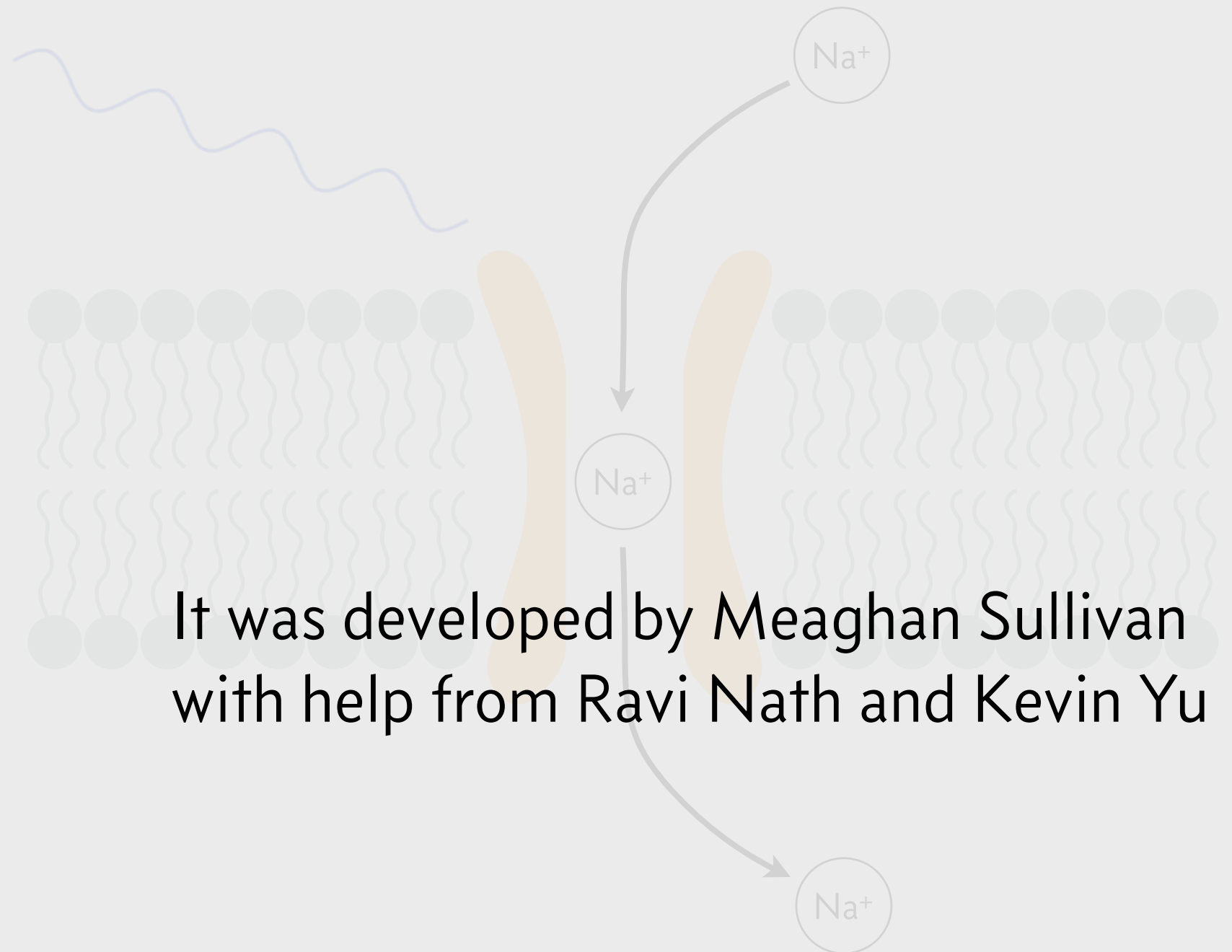
Close

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Answer questions directly and succinctly

Let person finish asking her question

Repeat long questions more concisely

Directly answer question with concise evidence, then move on

Constructively admit when you do not have a good answer

Always have your audience in mind

Speak about your work to the audience
not about yourself or your lab

Finish on time
or early; they'll thank you

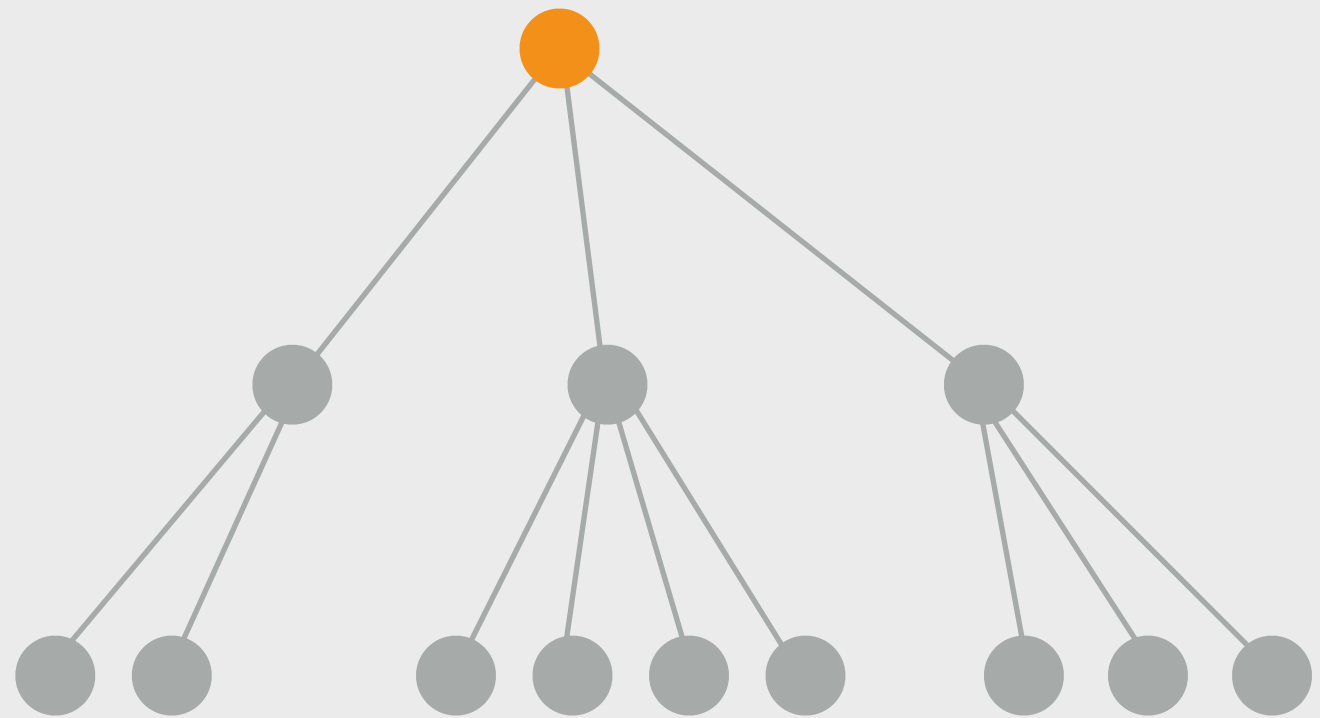
Develop audience-specific content
general audiences versus colleagues

Have **one** main message in your talk

Main message

Main points

Subpoints



Good delivery can make or break a talk

Stand firmly and do not move

Vary your tone and cadence for effect

Do not fiddle or make noise

Look your audience straight in the eyes

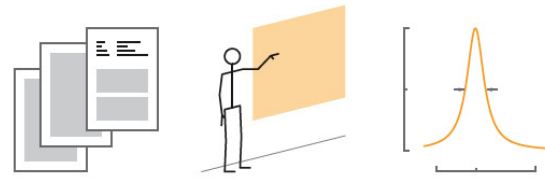
Do not use laser pointers.

Jean-luc Doumont's work is an unparalleled resource

Trees, maps, and theorems

Effective communication for rational minds

Jean-luc Doumont



It usually takes me more than three weeks
to prepare a good impromptu speech.

—Mark Twain

