

# Manipulating neurons with light

## Spotlight on opsins

Emerson Harkin

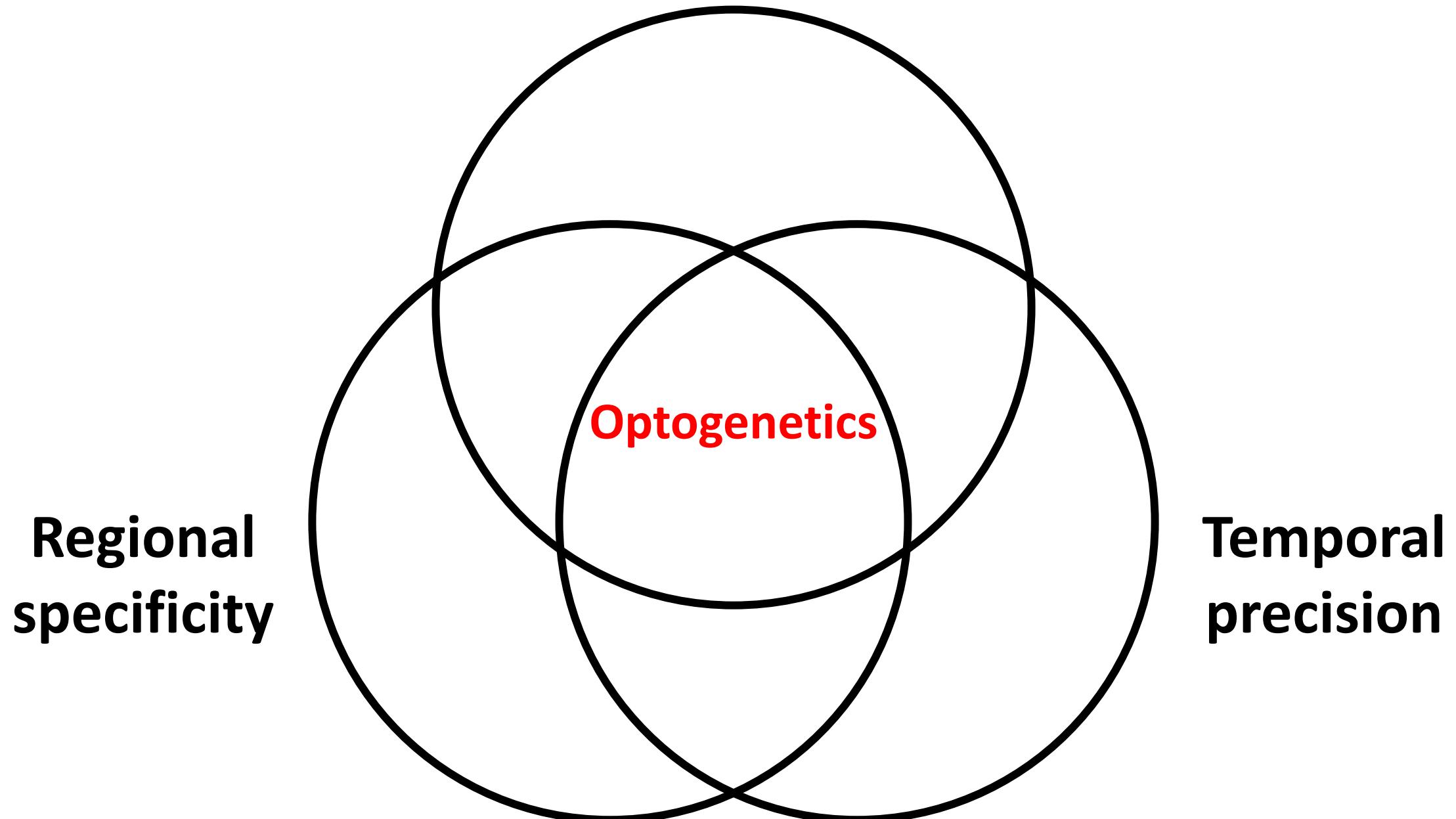
Supervised by Jean-Claude Béïque

# Introduction

# Canonical model of neuroscience

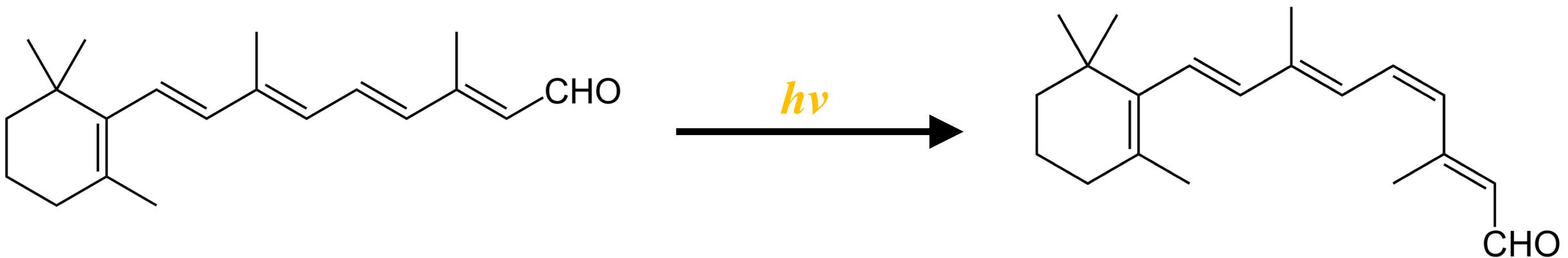


# Cell-type specificity

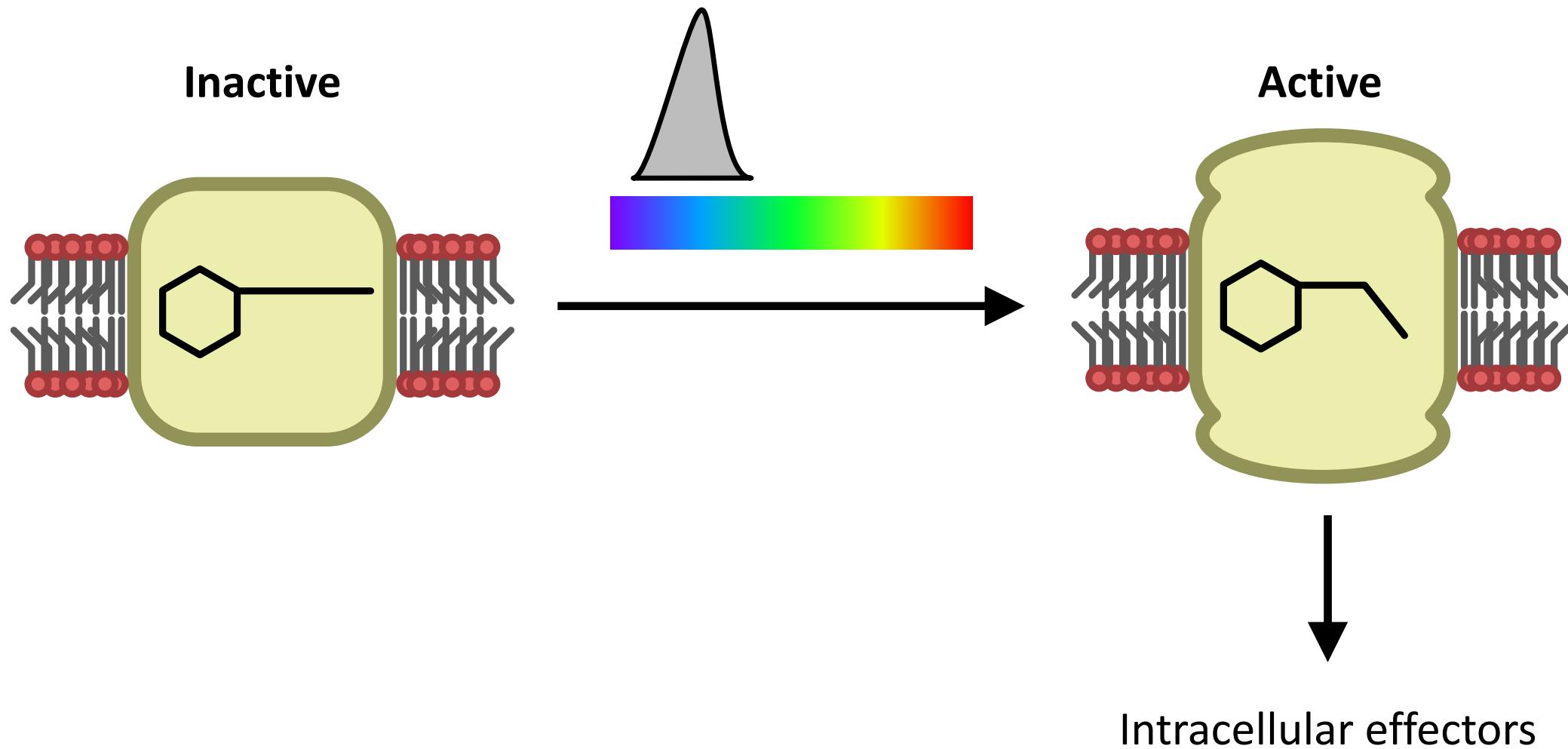


# Fundamentals of optogenetics

# Retinal mediates light sensitivity

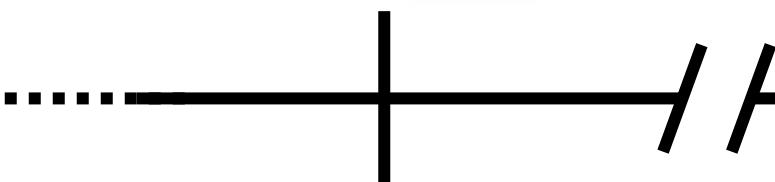
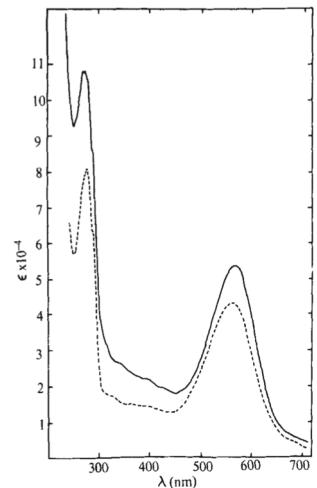


# Opsins are photoreceptors



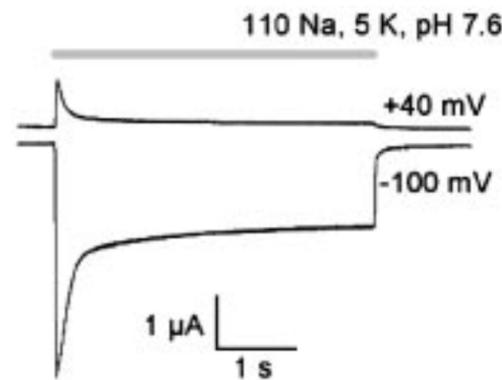
# Development of optogenetics

Discovery of  
bacteriorhodopsin

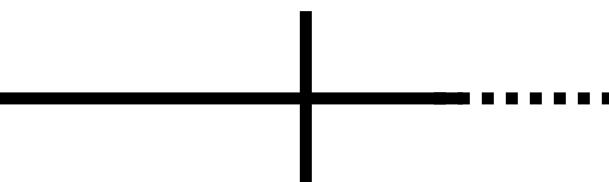
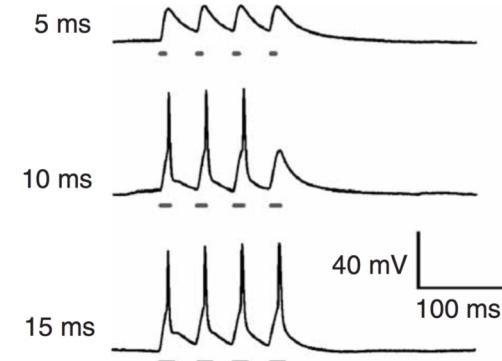


**Stoeckenius**  
**1971**

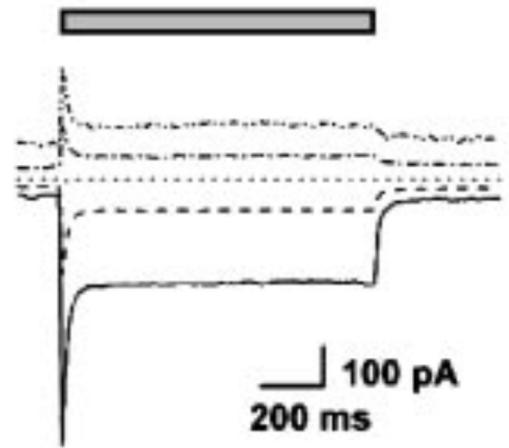
Chlamyopsin-4 is  
a cation channel



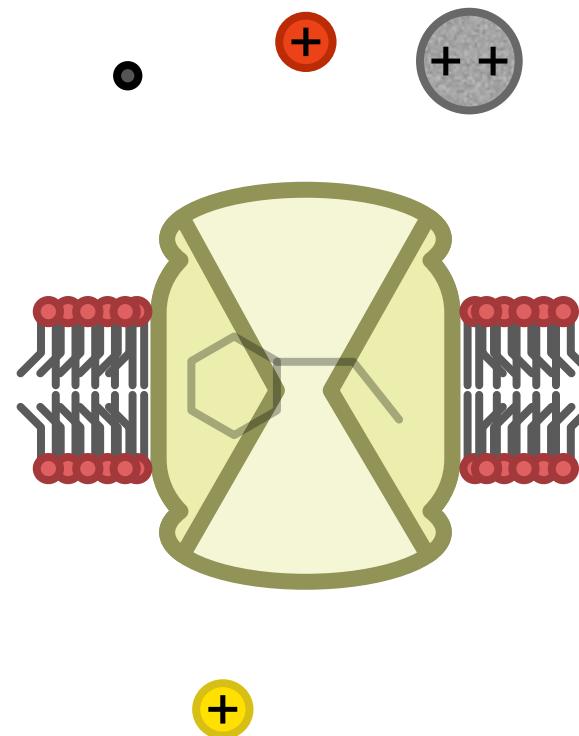
Channelrhodopsin-2  
first used in neurons



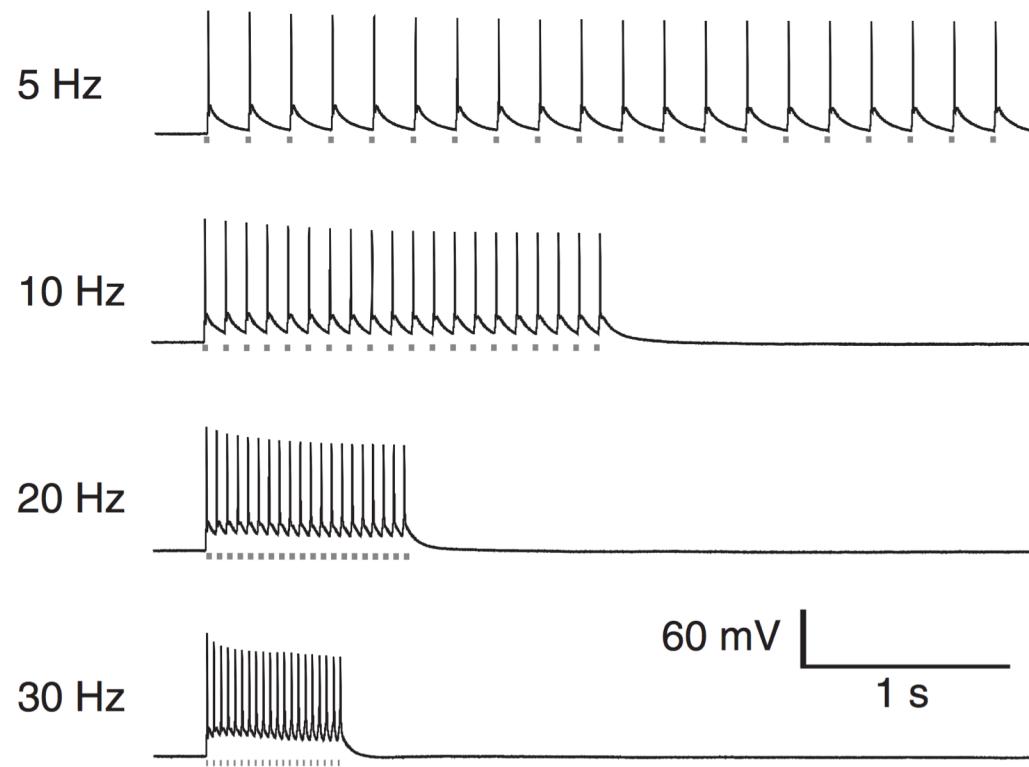
**Boyden & Deisseroth**  
**2005**



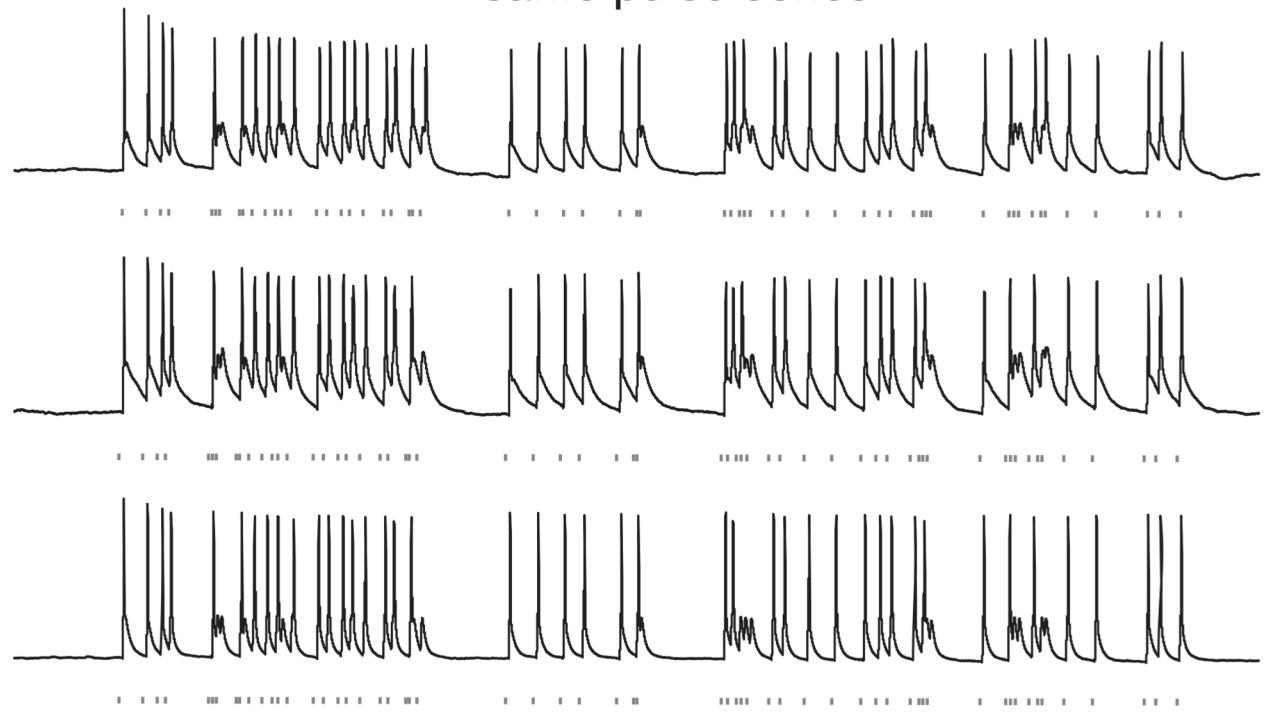
	$P_x/P_{Na}$
$H^+$	$\sim 10^6$
Guanidinium $^+$	$13 \pm 5$
$CH_3NH_3^+$	$6 \pm 2$
$(CH_3)_2NH_2^+$	$4 \pm 2$
$Li^+$	$2 \pm 0.5$
$Na^+$	1
$K^+$	$0.5 \pm 0.3$
TMA $^+$	$\leq 0.06$



# Precise control of spiking with ChR2

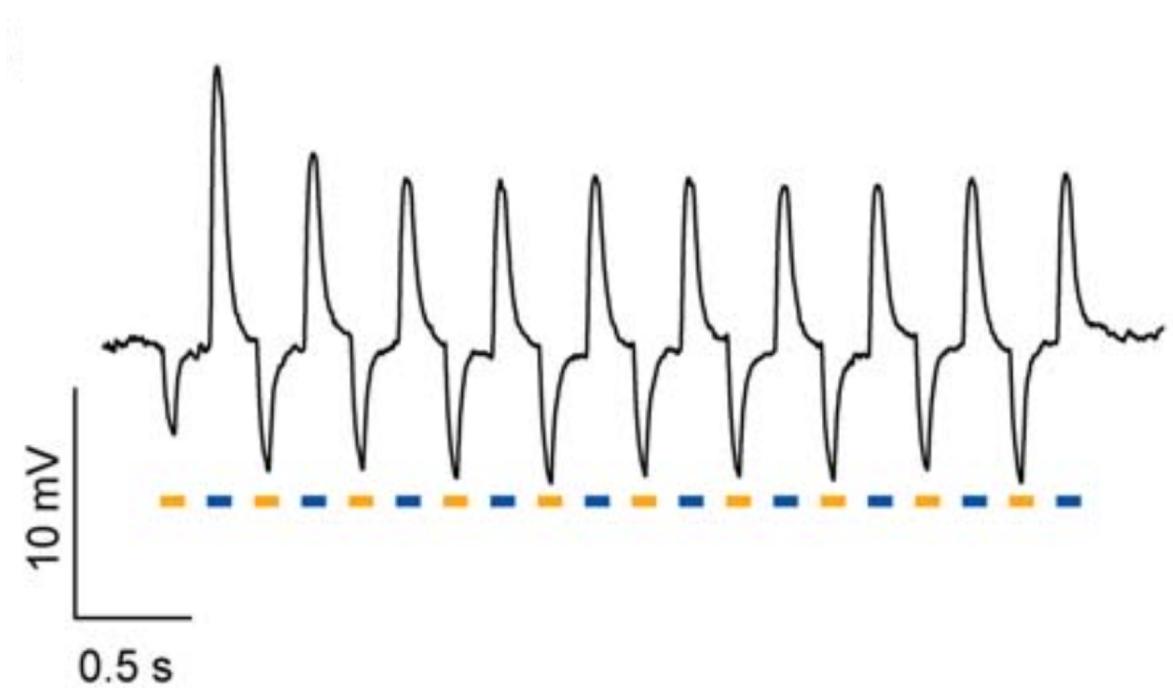
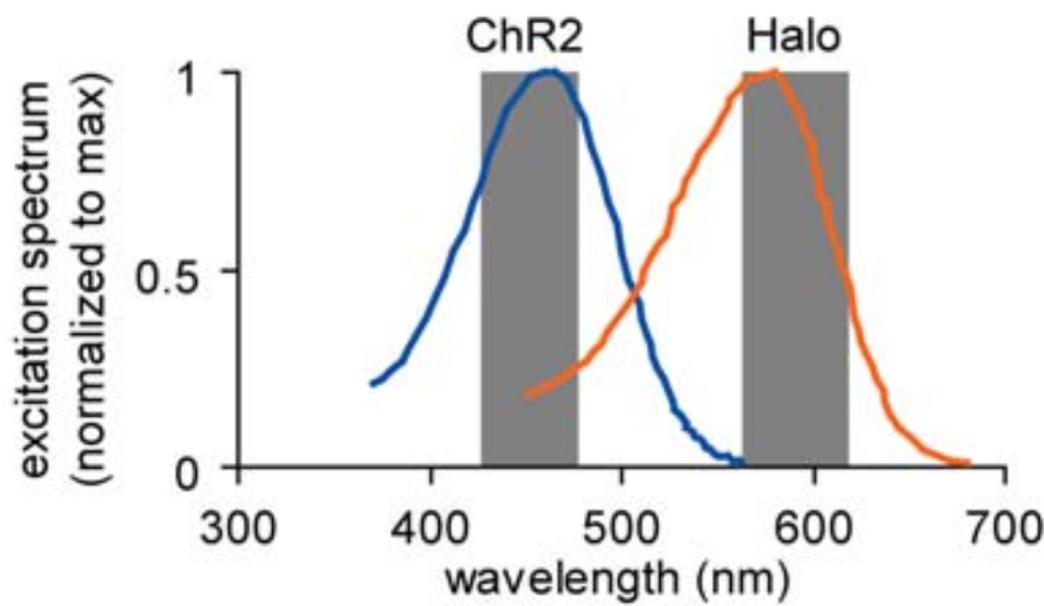


Three different neurons:  
same pulse series



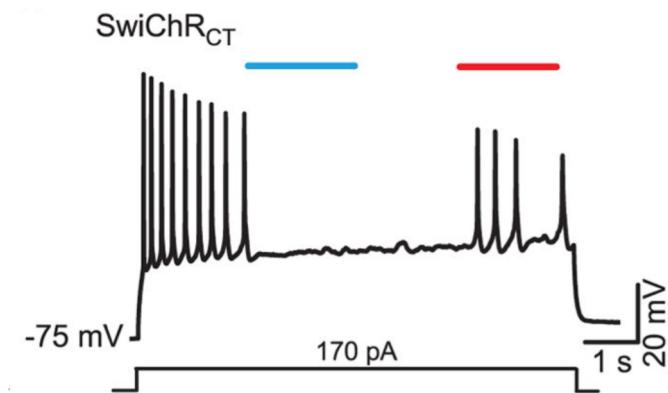
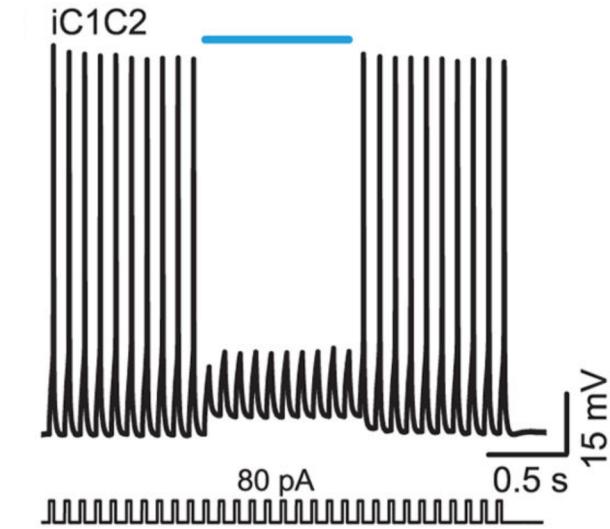
# A modern optogeneticist's toolbox

# Bidirectional control using halorhodopsin

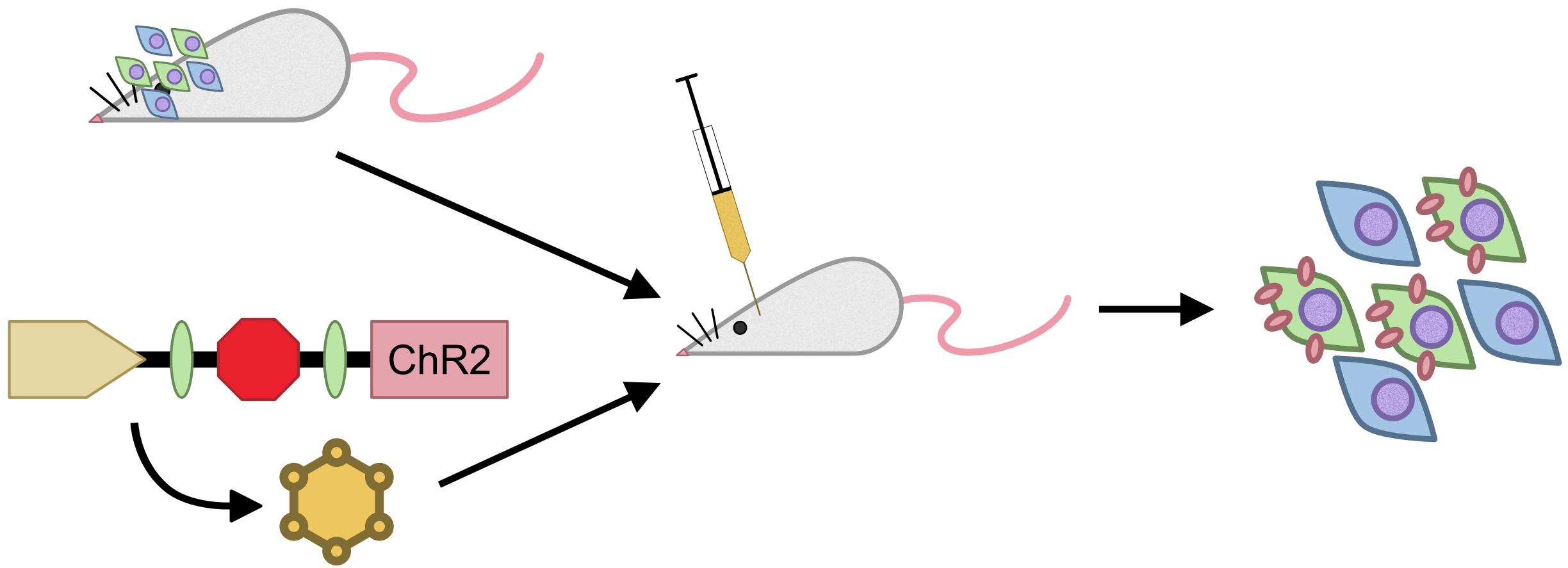


# Flavours of channel opsins

- Red-shifted opsins
  - bReaChES
- Faster kinetics
  - ChETA
- Inhibitory channel
  - iC1C2
- Slower kinetics
  - SwiChR

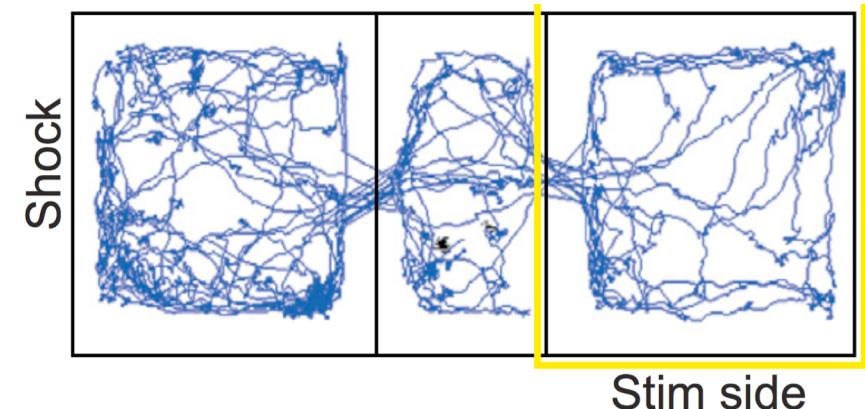
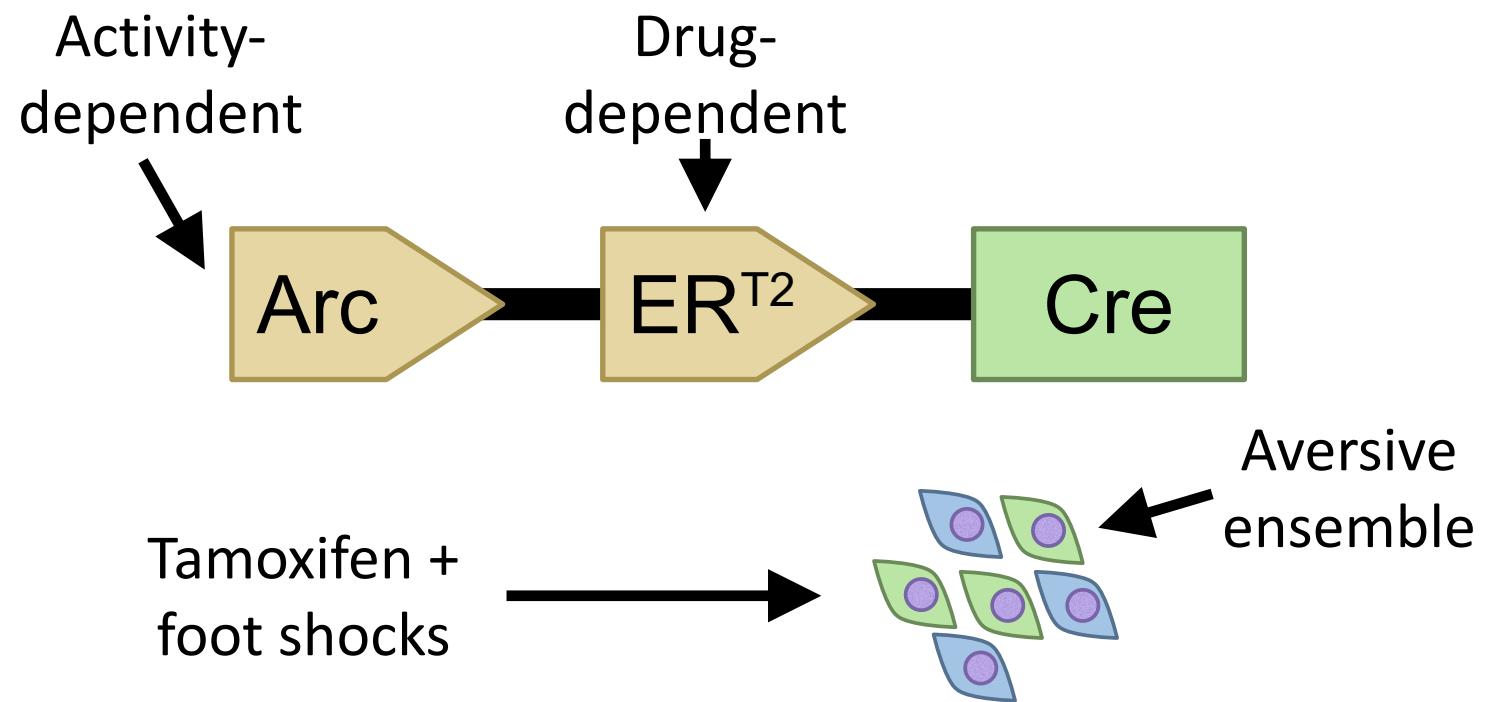


# Complex designs using conditional expression



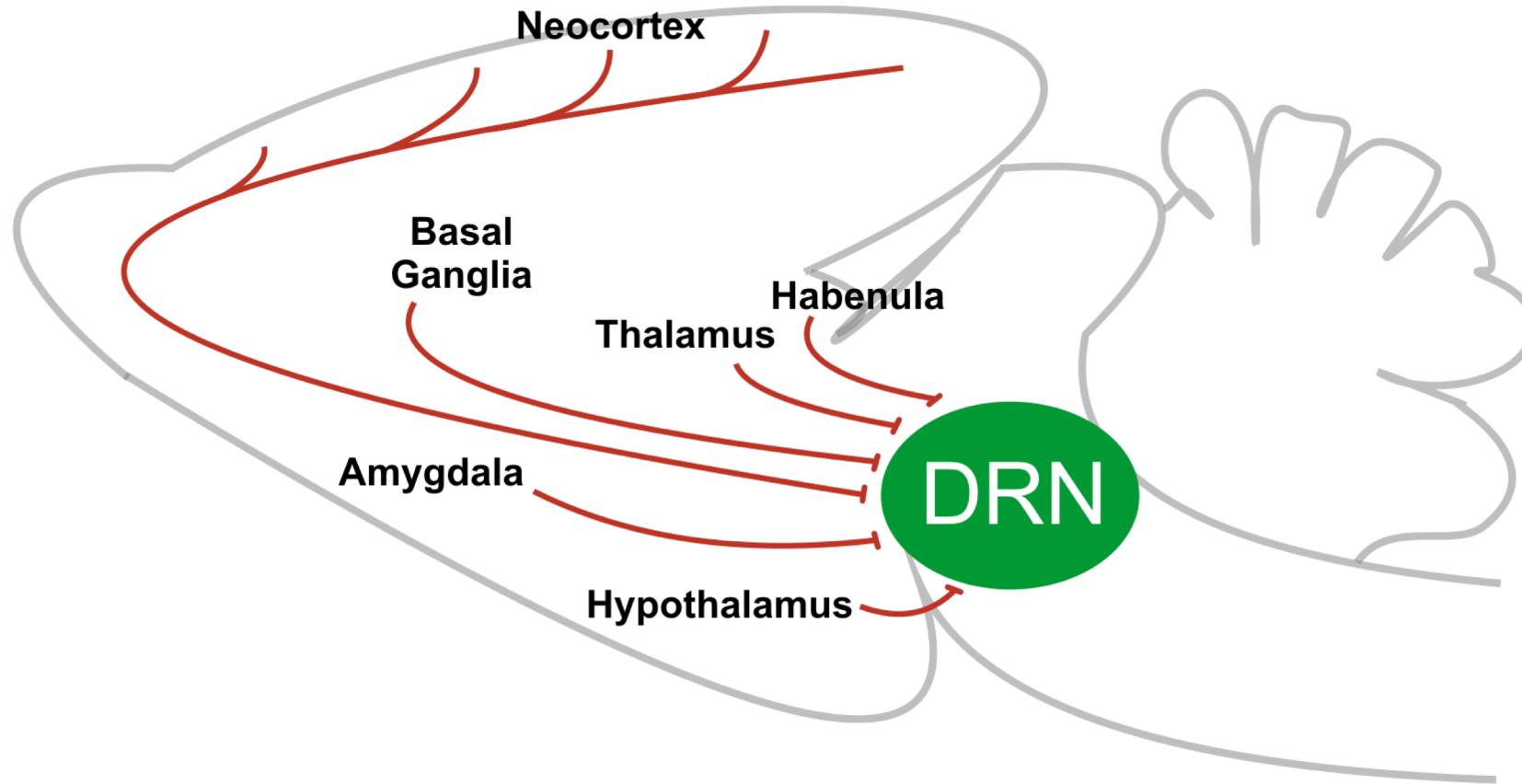
# Application

- Activity-dependent expression
  - Manipulate populations activated by reward or punishment

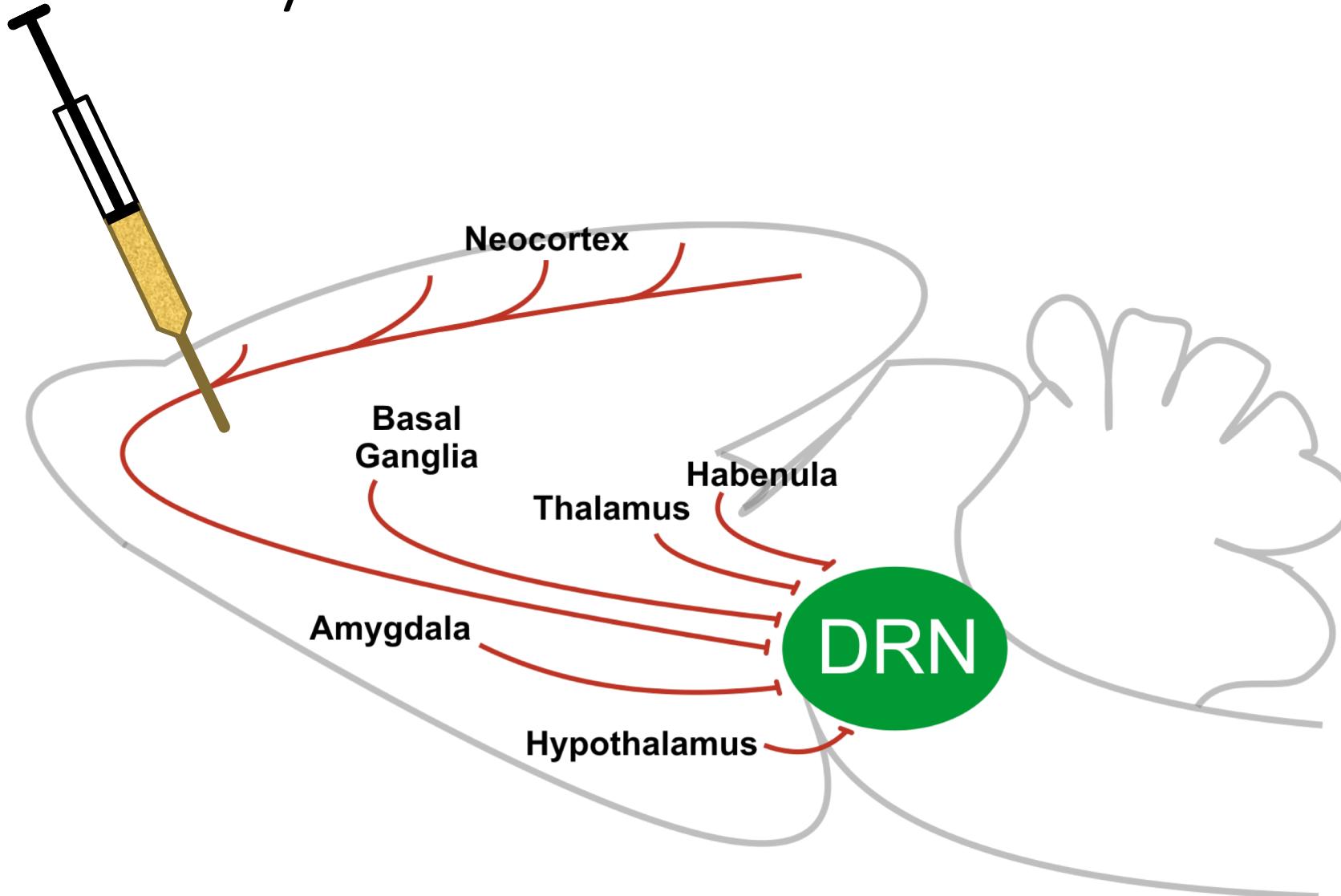


Case-study: dissecting inputs to  
the serotonin system

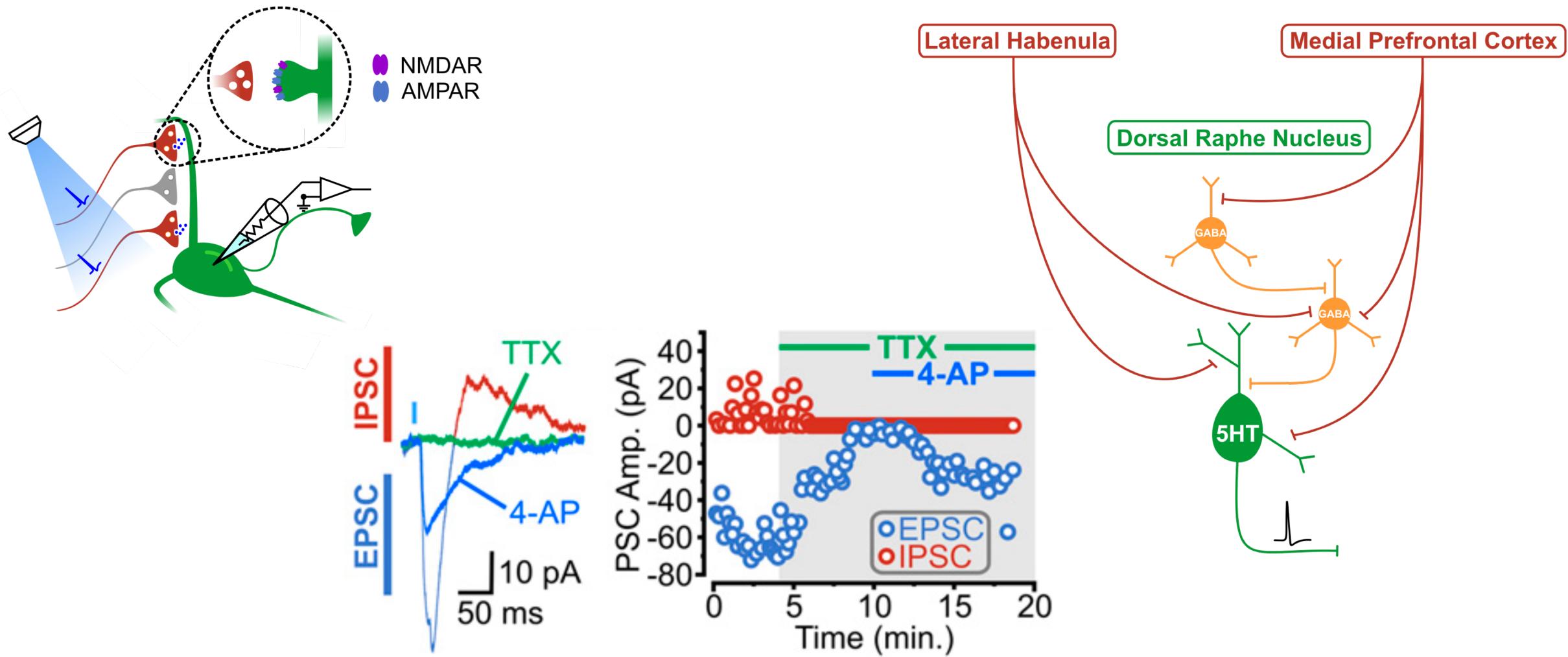
# Application: understanding inputs to the serotonin system



# Application: understanding inputs to the serotonin system



# Focus on mPFC input



Take-home message

# Acknowledgements

Supervised by Jean-Claude Béïque

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- Sean Geddes



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