如何用光控制你的大腦

The Development and Application of Optogenetics in Neuroscience

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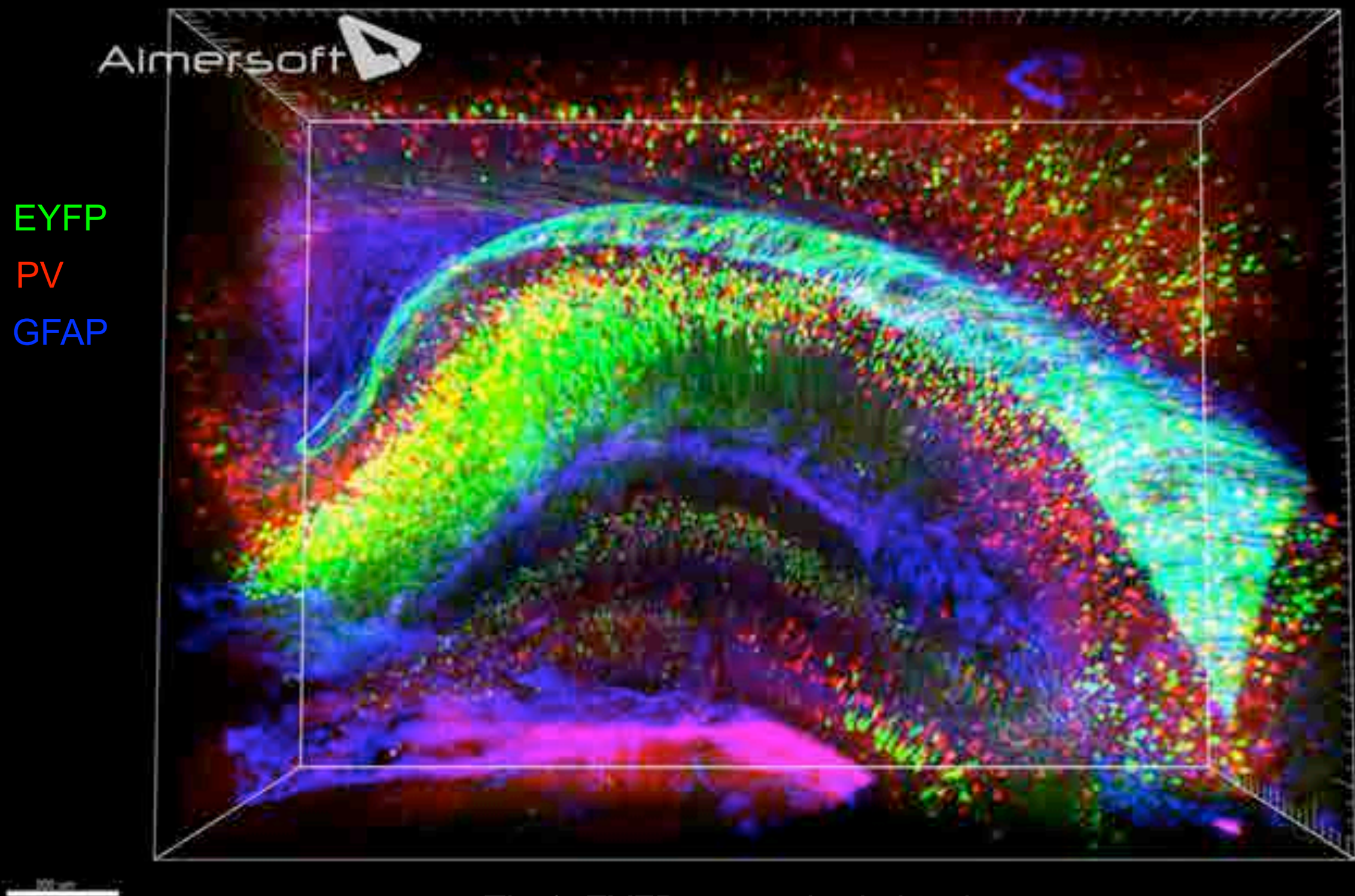
Institute of Neuroscience, NYMU

Speaker: Tsan-Ting Hsu, PhD student

The complexity of the brain

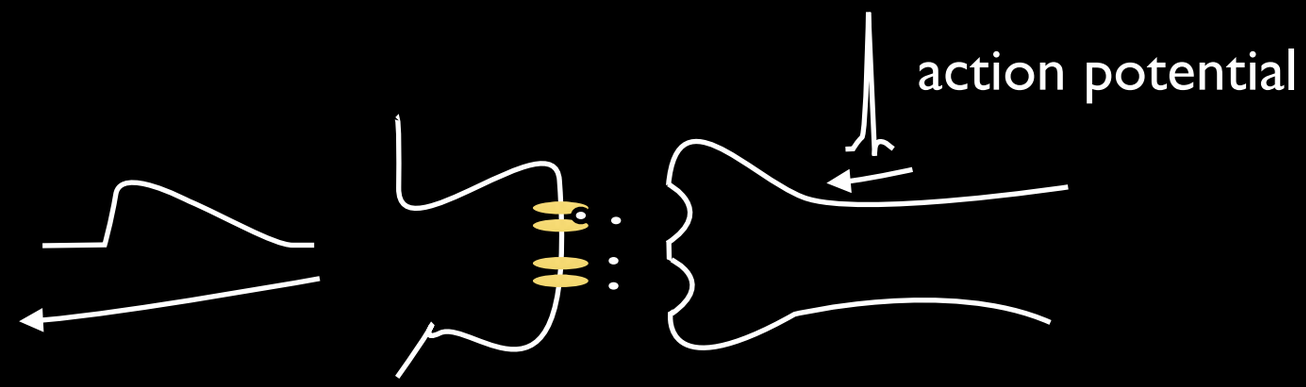
The complexity of the brain



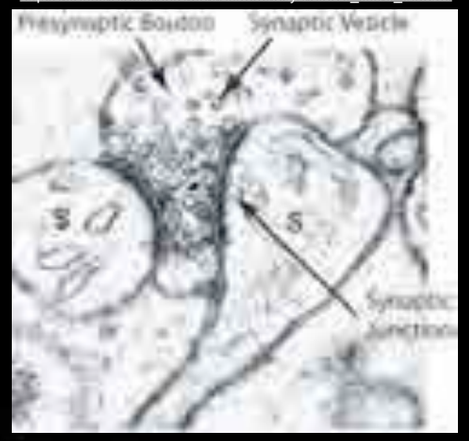
Thy1–EYFP mouse brain block

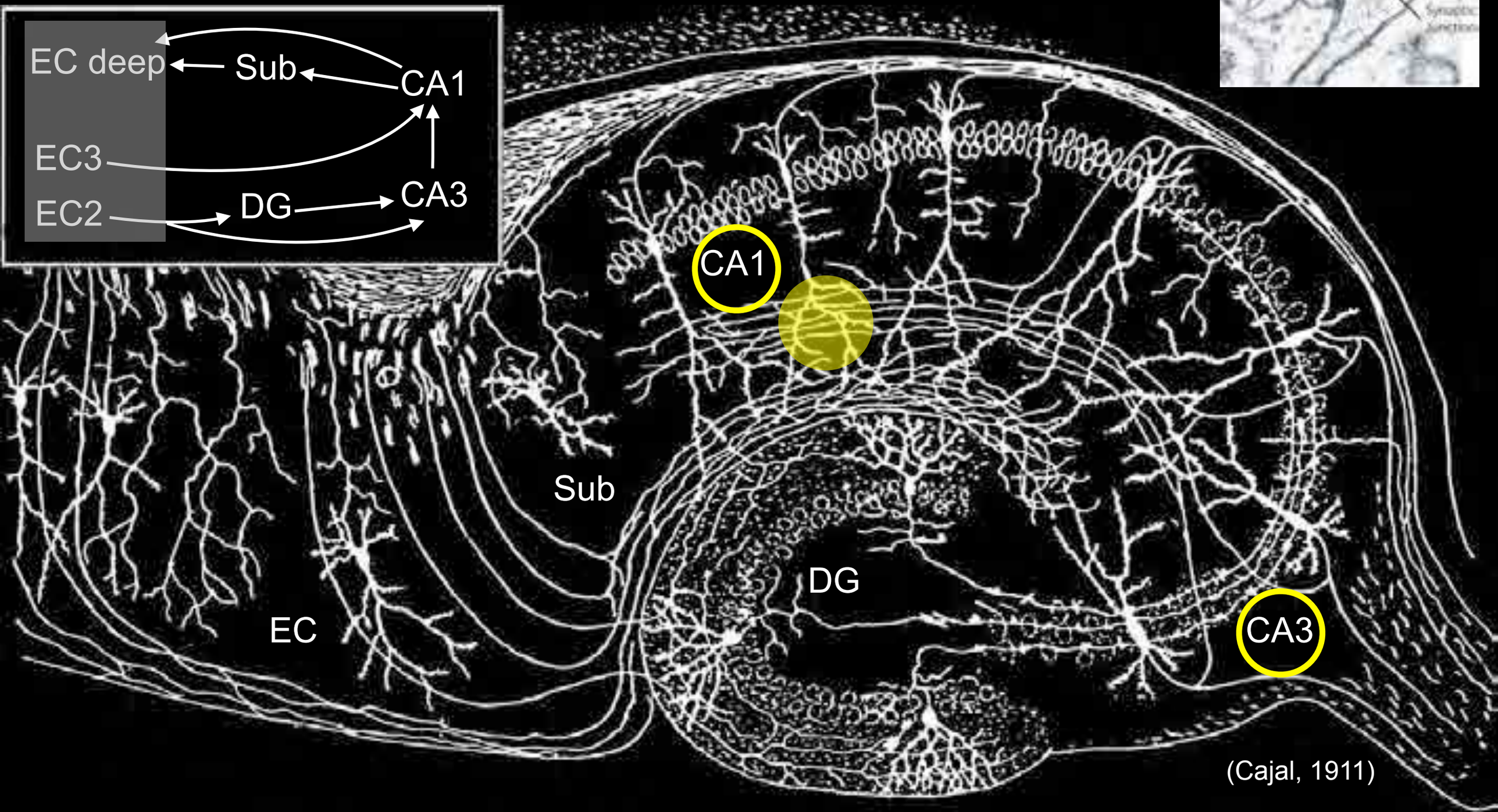
(Chung et al., 2013)

Hippocampal circuit



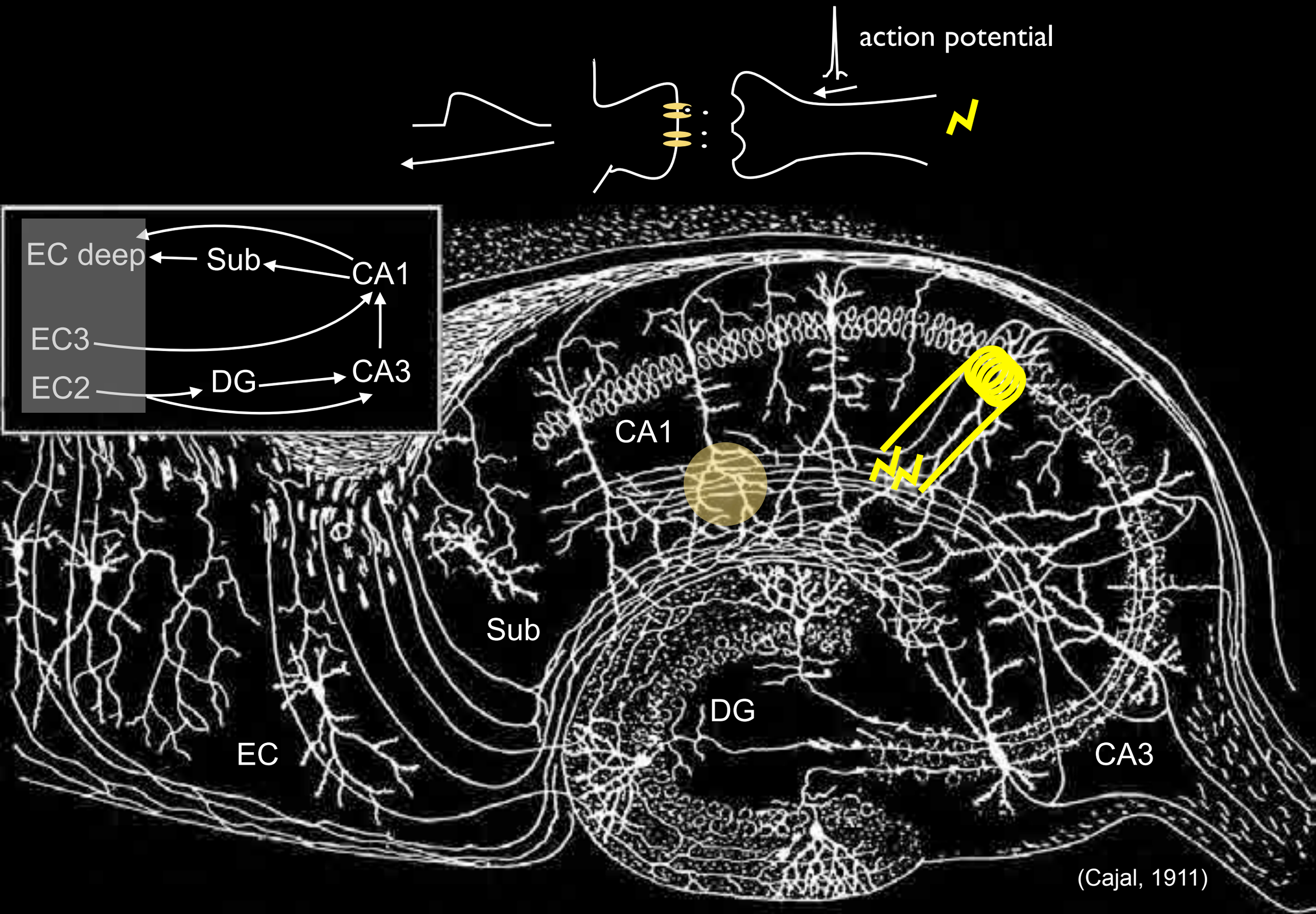
http://dsresearch.stanford.edu/community/archive_issue_03.html





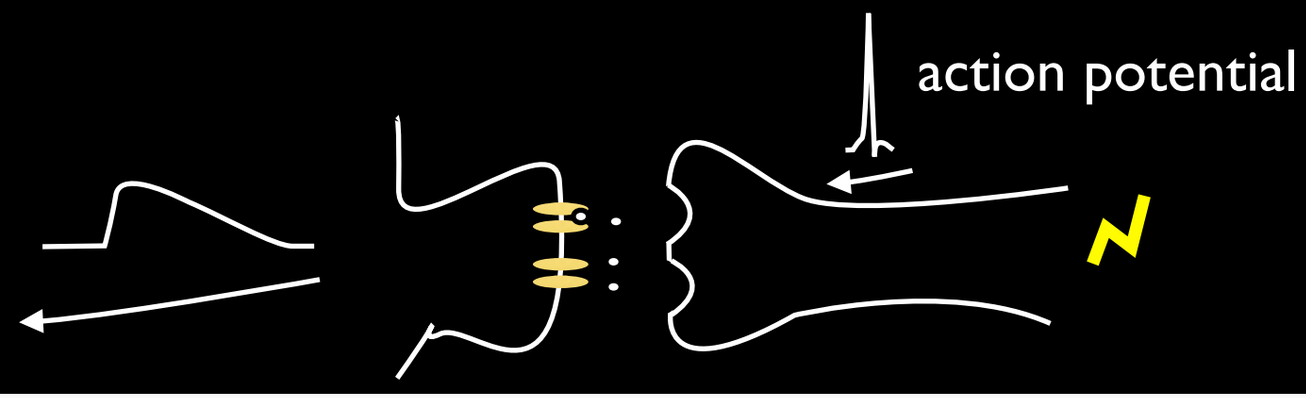
(Cajal, 1911)

Hippocampal circuit



(Cajal, 1911)

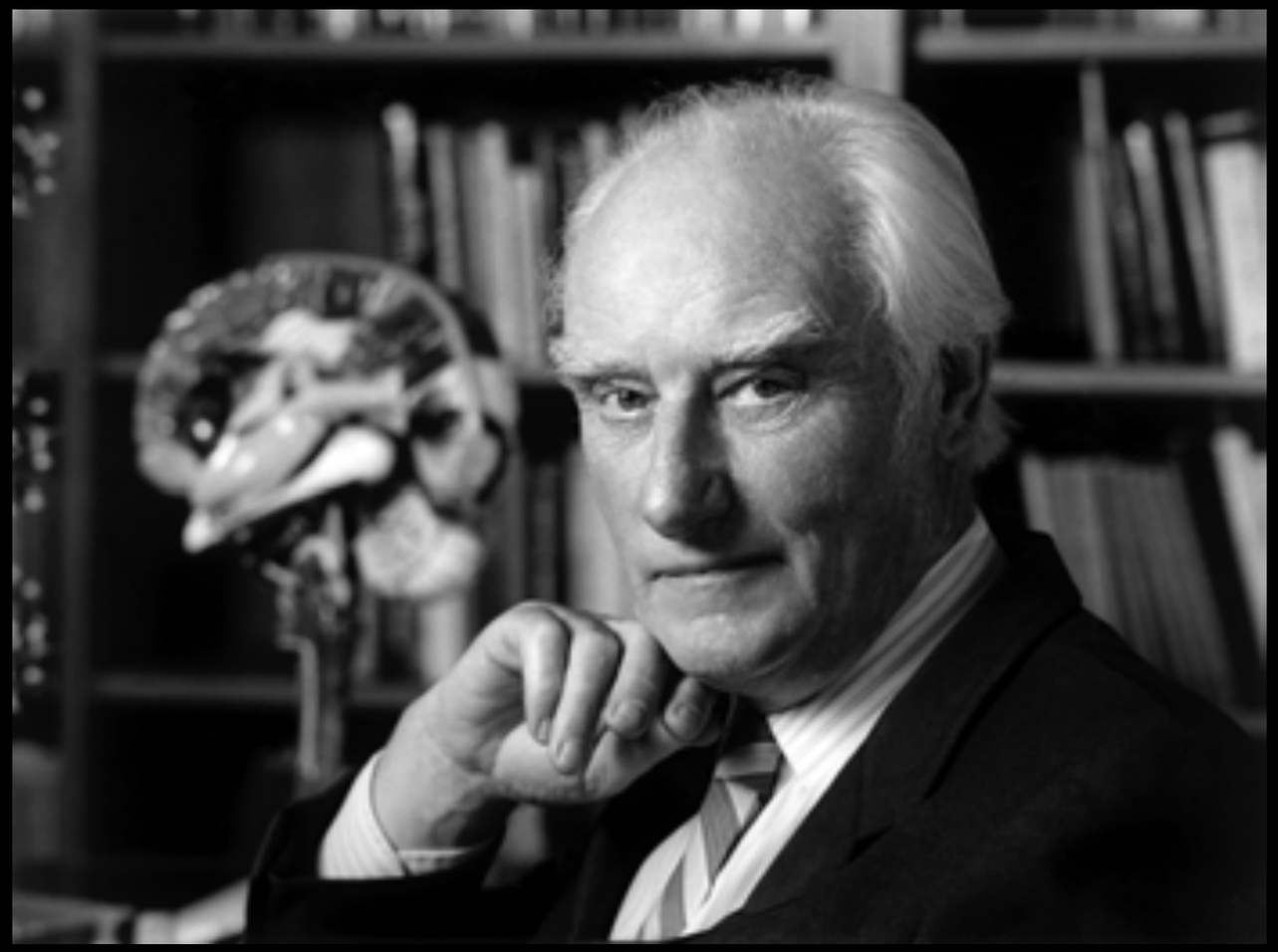
Hippocampal circuit



(Klausberger and Somogyi, 2008)

Glutamatergic inputs:
Thalamus
Entorhinal cortex
Amygdala
Stratum lacunosum moleculare
Stratum radiatum
CA3
Stratum pyramidale
Stratum oriens
Pyramidal cells
CB-
CB+
CB-
Dentate gyrus
Subiculum, retrosplenial cortex
CA3 dentate gyrus
?
Subiculum
?
CA3 dentate gyrus
Subiculum
Septum

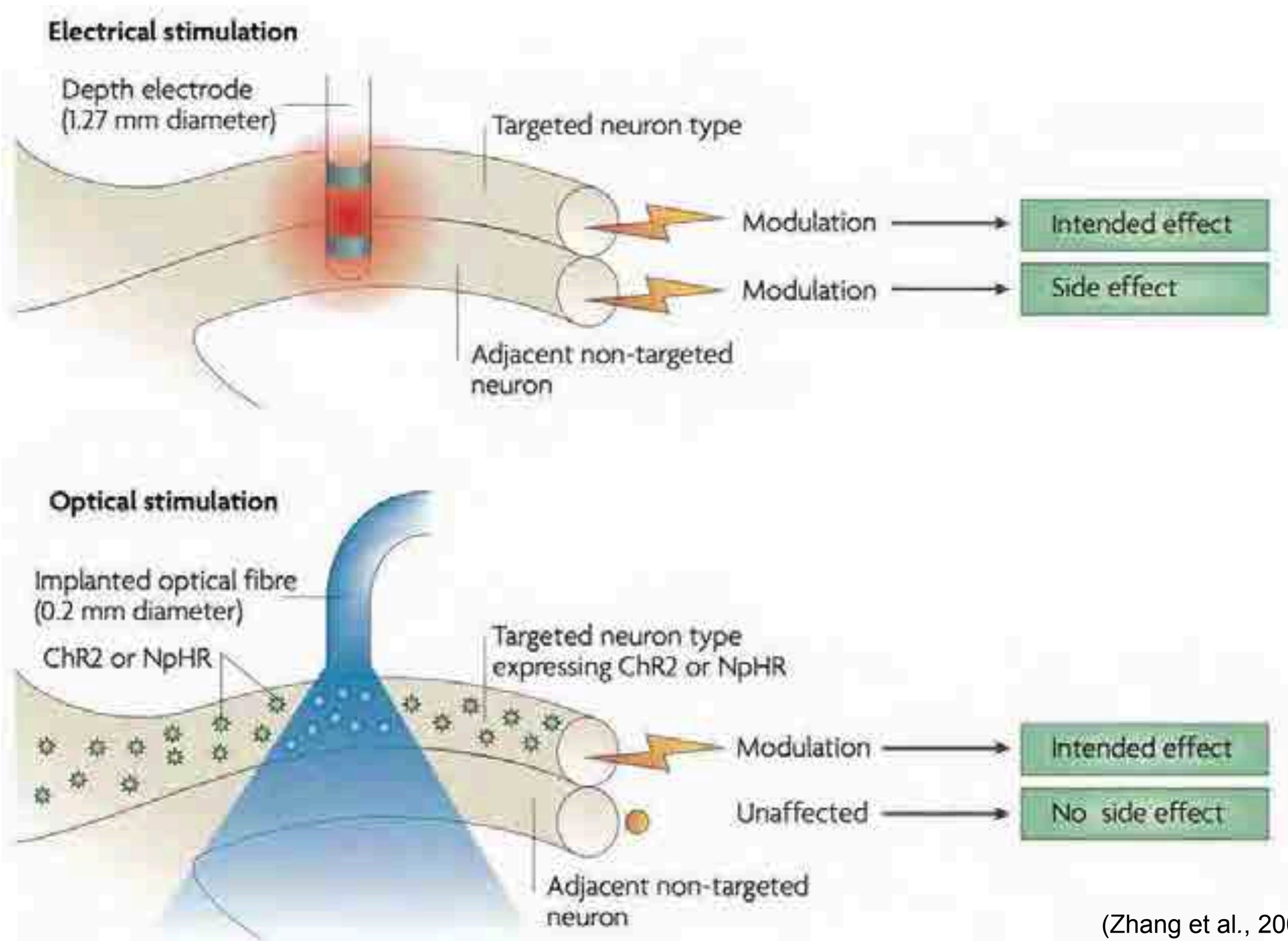
side effect



The major challenge facing neuroscience was the need to control one type of cell in the brain while leaving others unaltered.

Nobel laureate Francis Crick (1979)

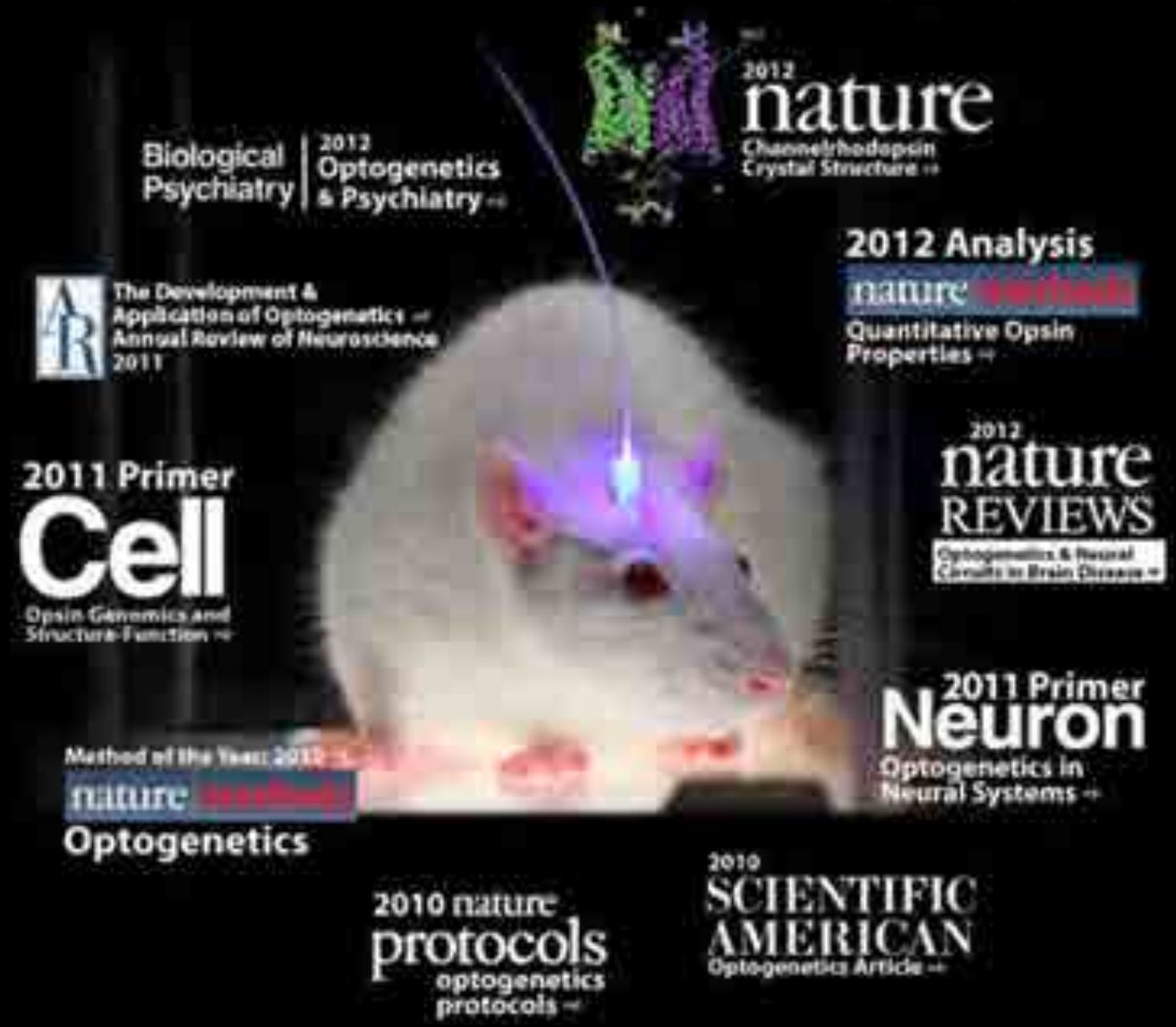
Controlling the brain with light



(Zhang et al., 2007)

Controlling the brain with light

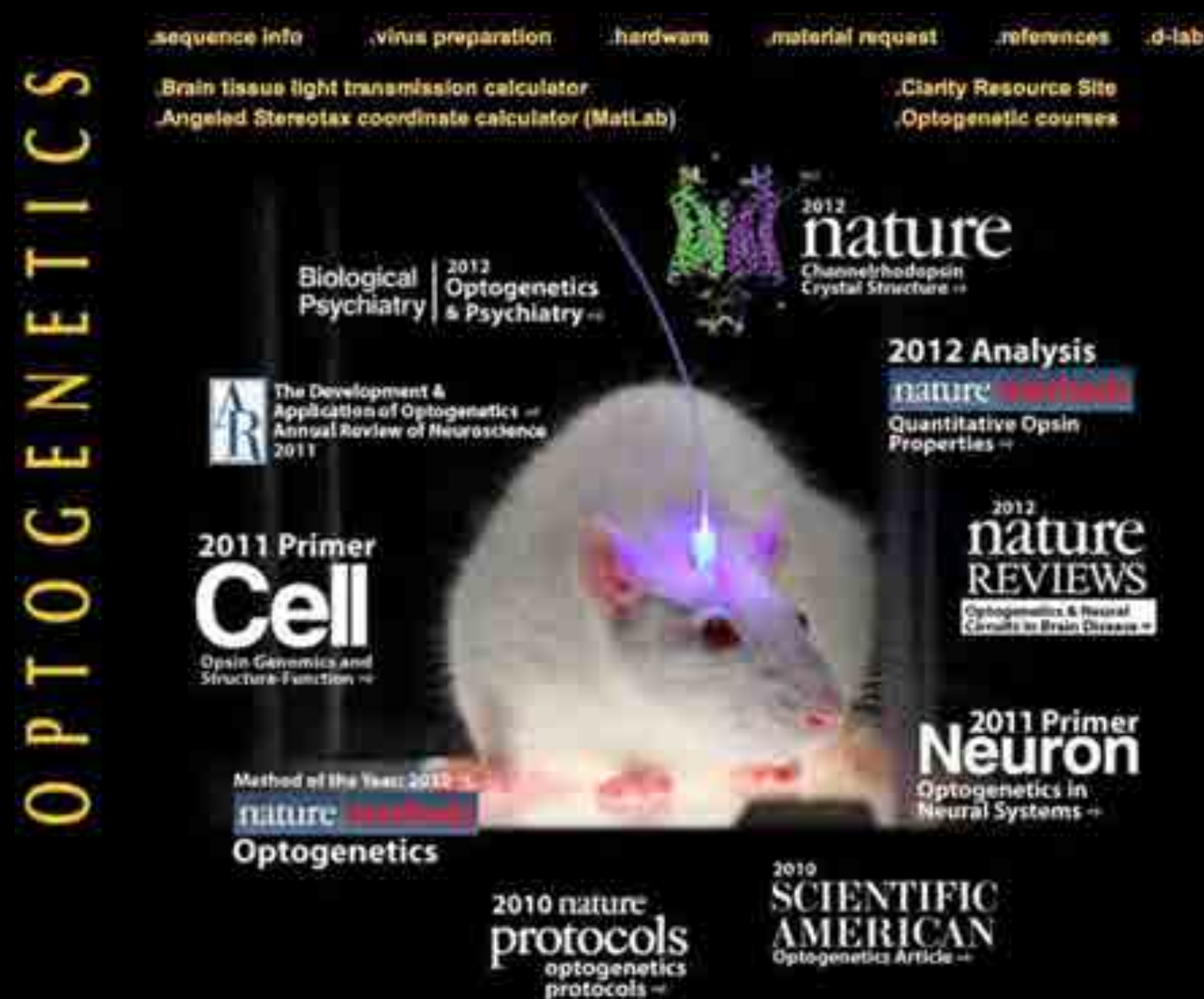
Karl Deisseroth Edward S Boyden Feng Zhang



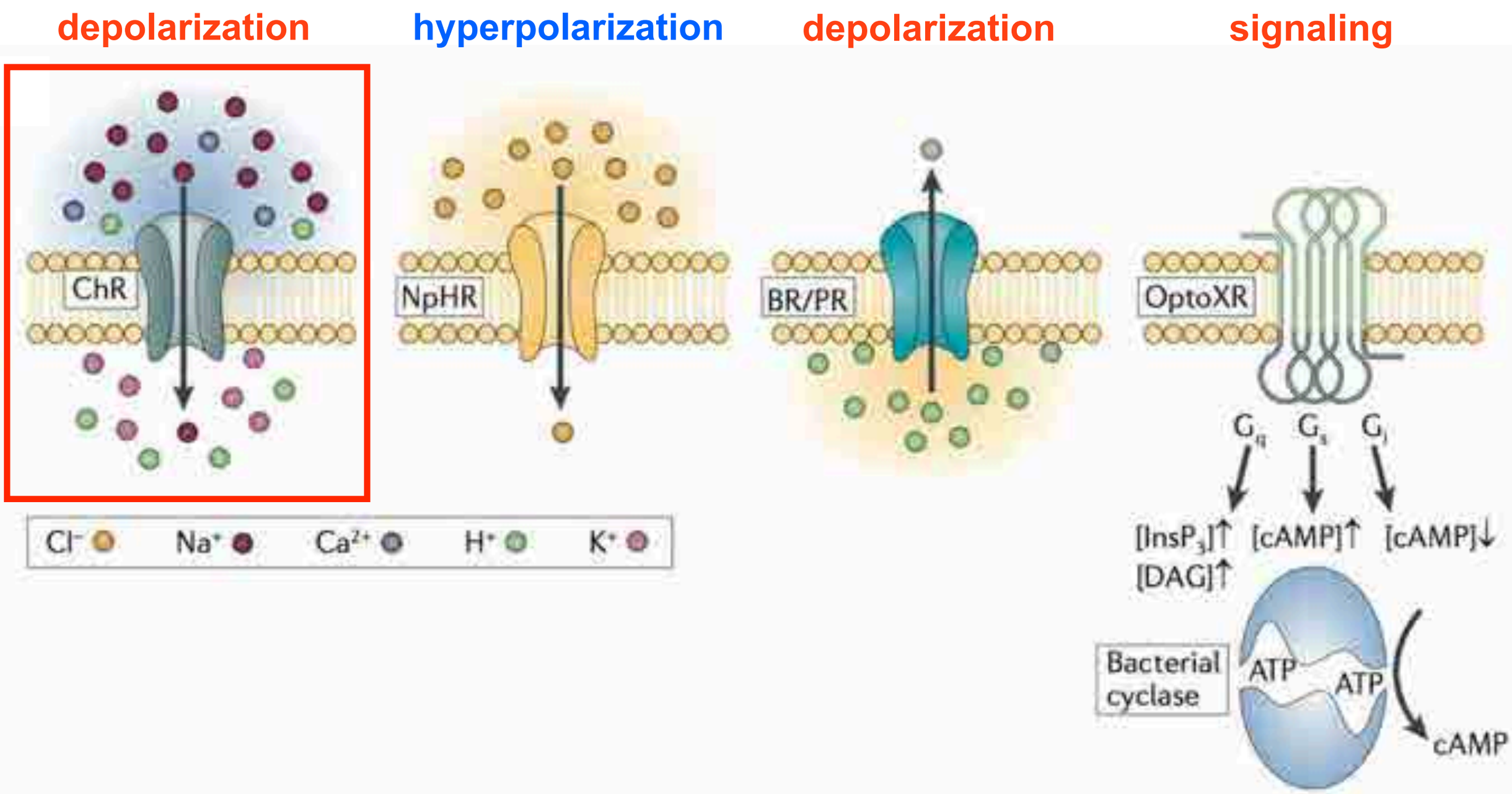
Controlling the brain with light

Optogenetics Resource Center

http://www.stanford.edu/group/dlab/optogenetics/



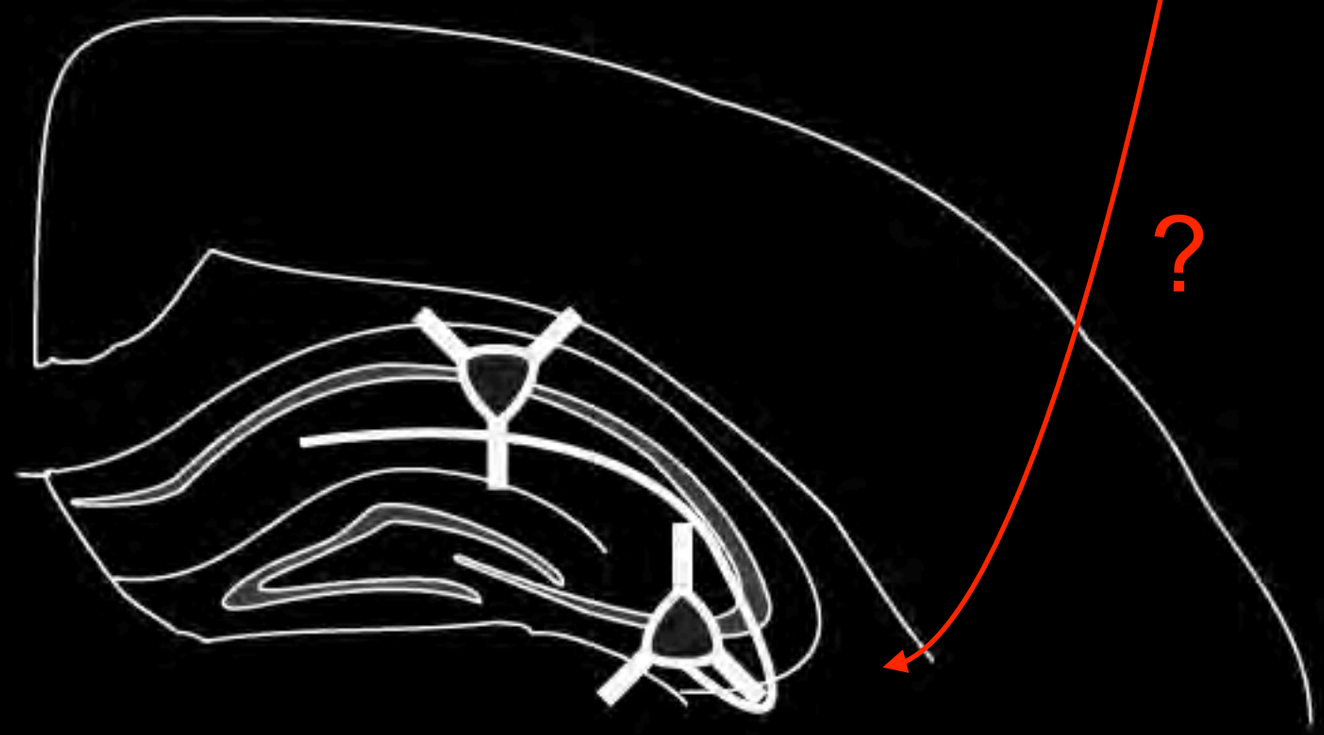
Optogenetic Tool Family



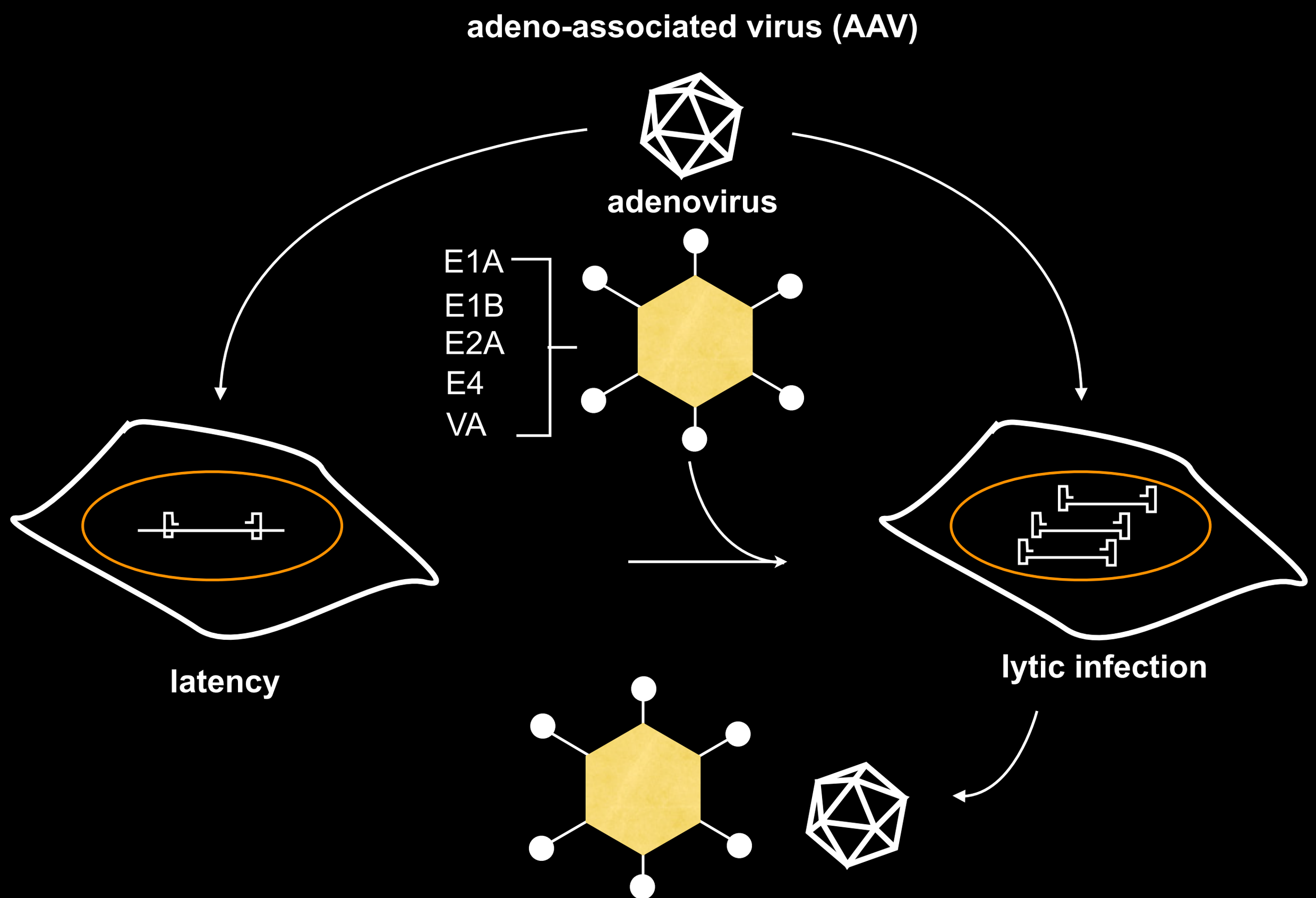
(Tye and Deisseroth., 2012)

Channelrhodopsin-2 (ChR2) expression on specific neural populations

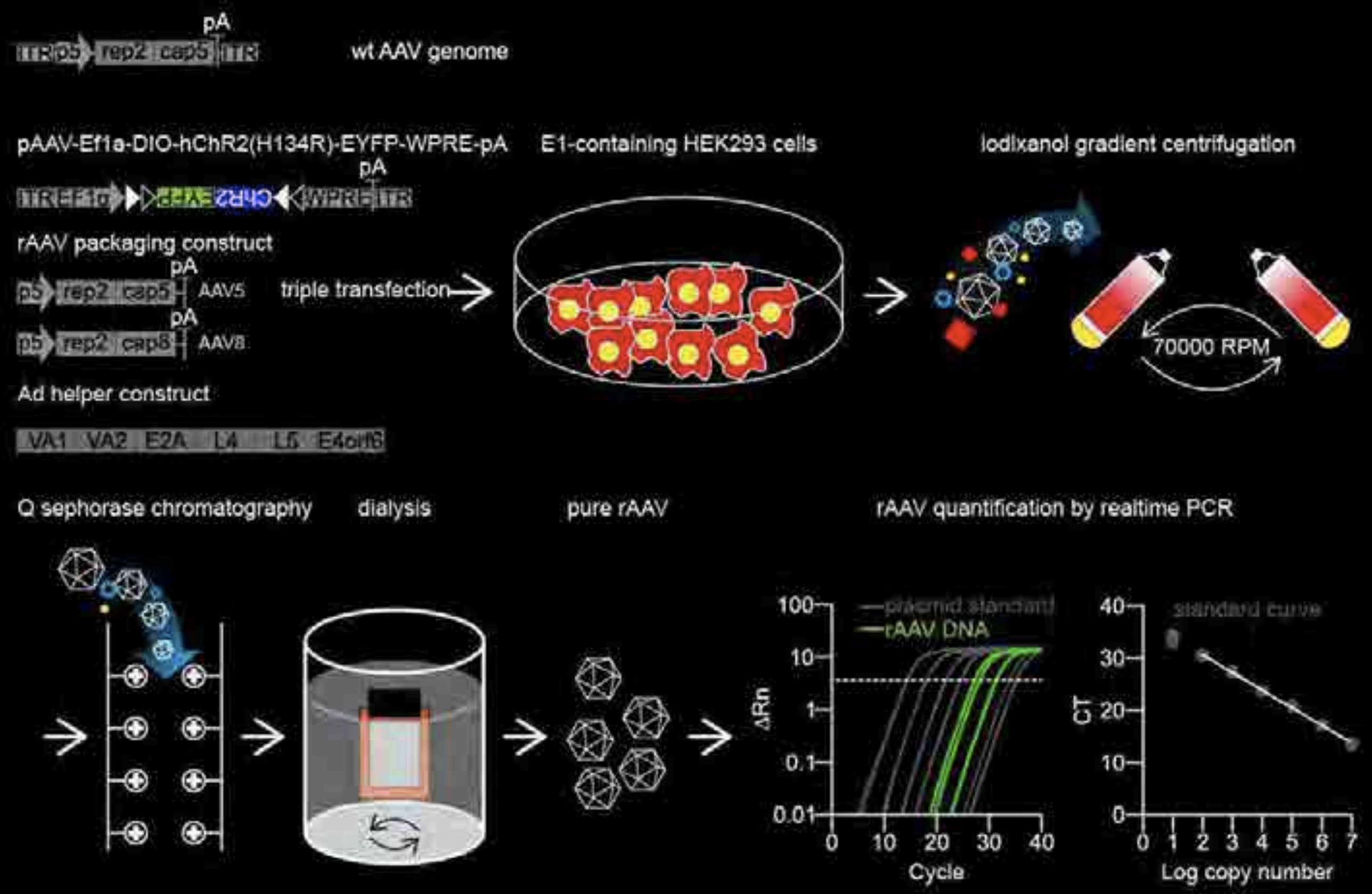
Chlamydomonas reinhardtii



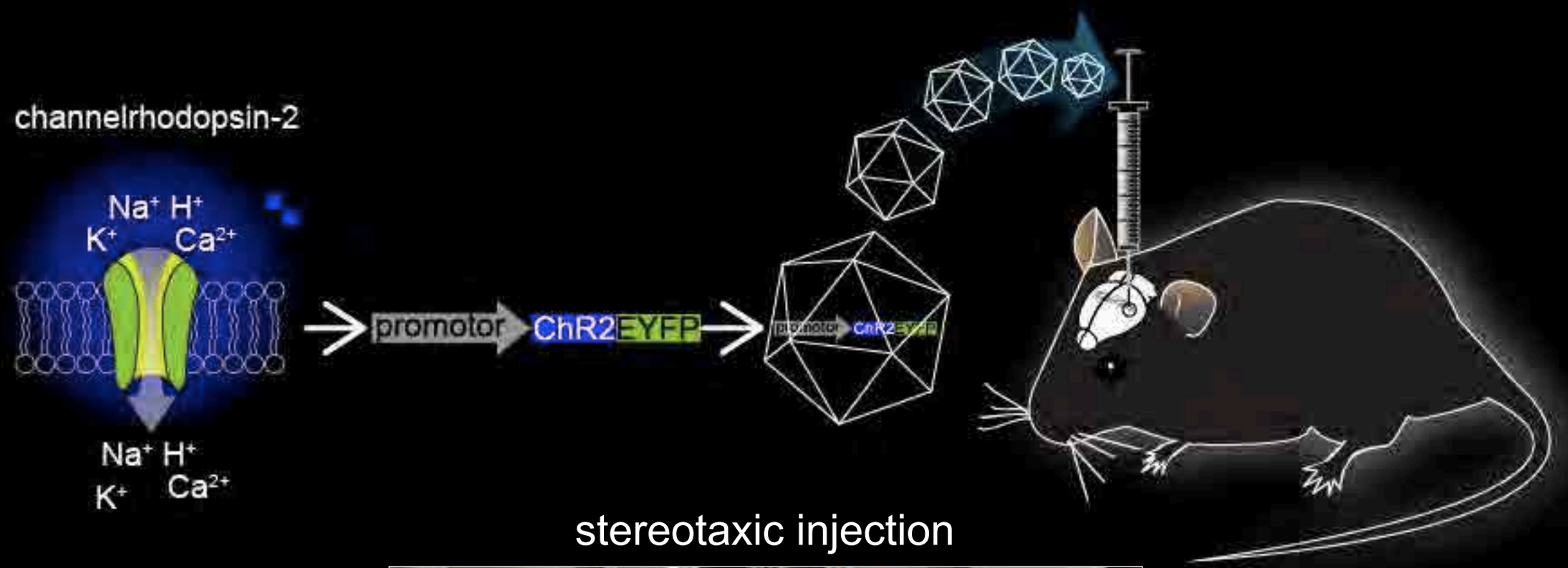
Channelrhodopsin-2 (ChR2) expression on specific neural populations



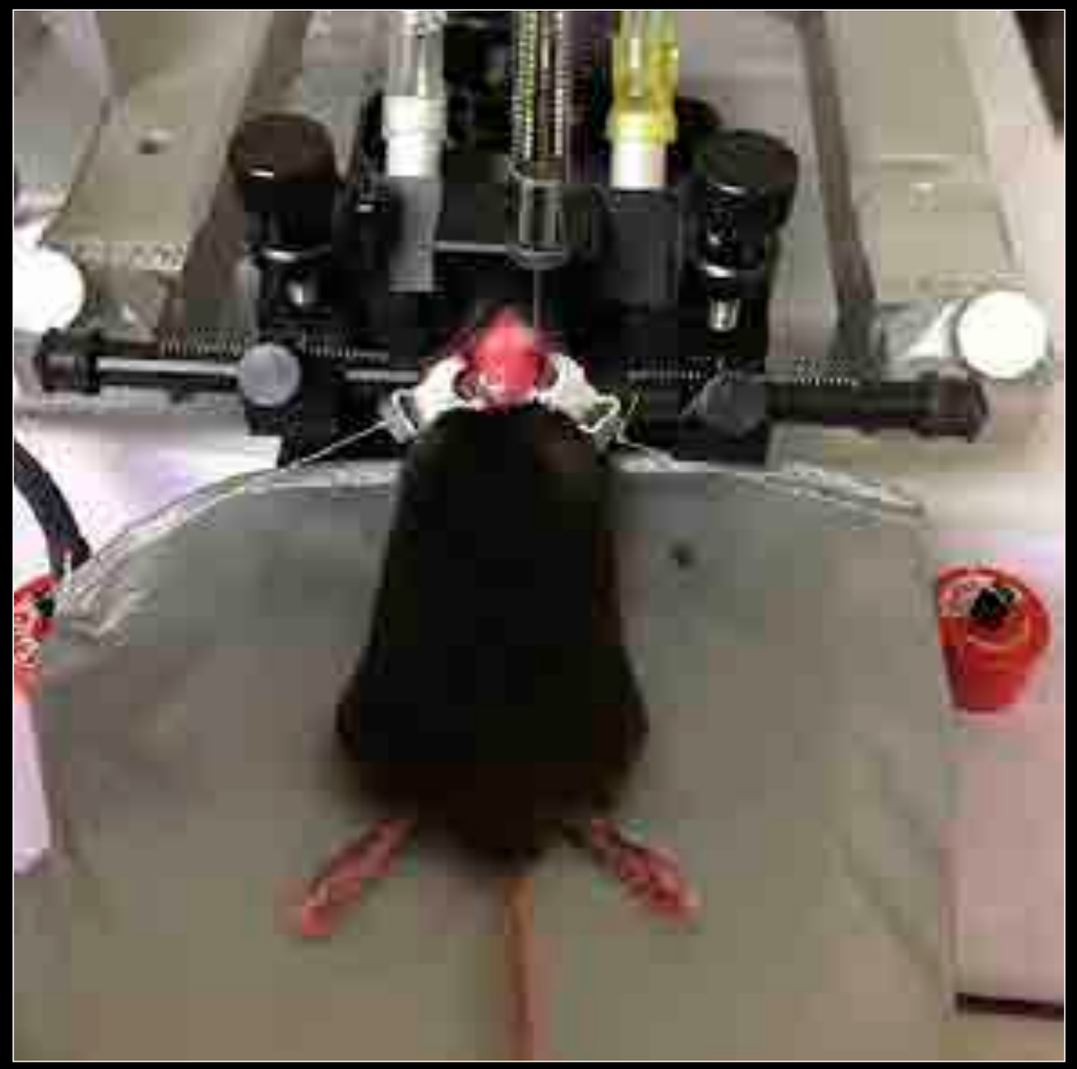
Channelrhodopsin-2 (ChR2) expression on specific neural populations



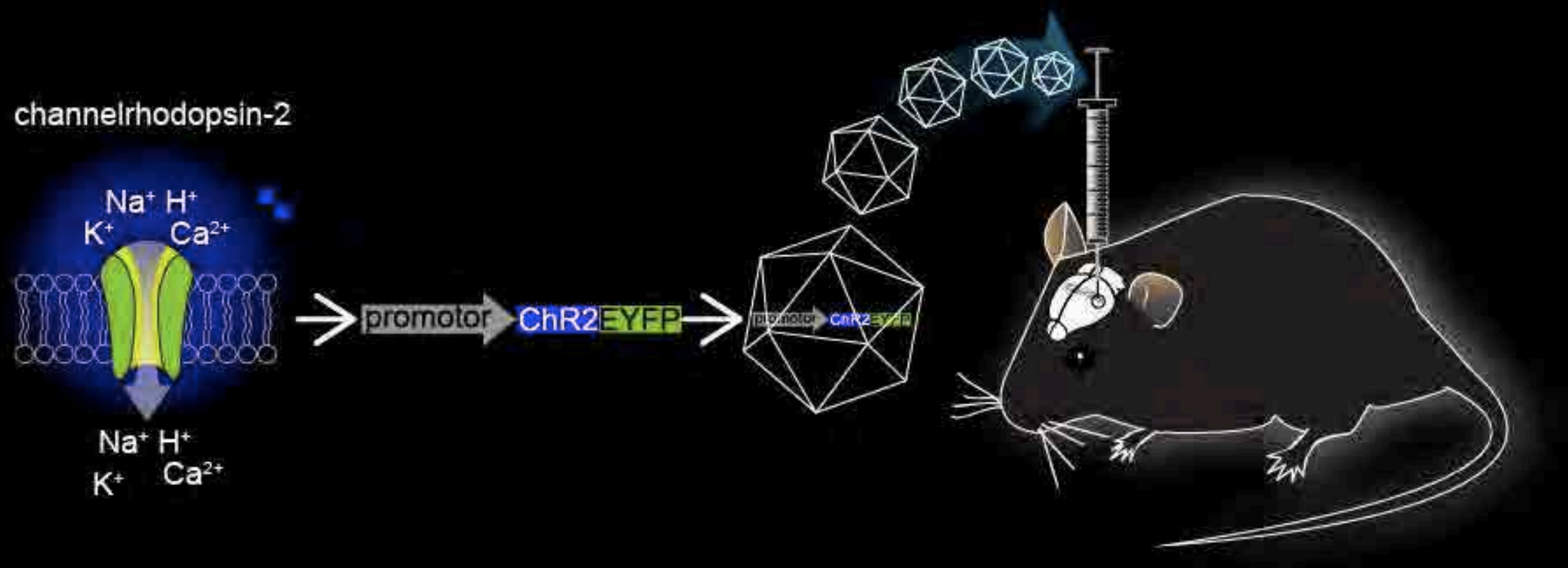
Channelrhodopsin-2 (ChR2) expression on specific neural populations

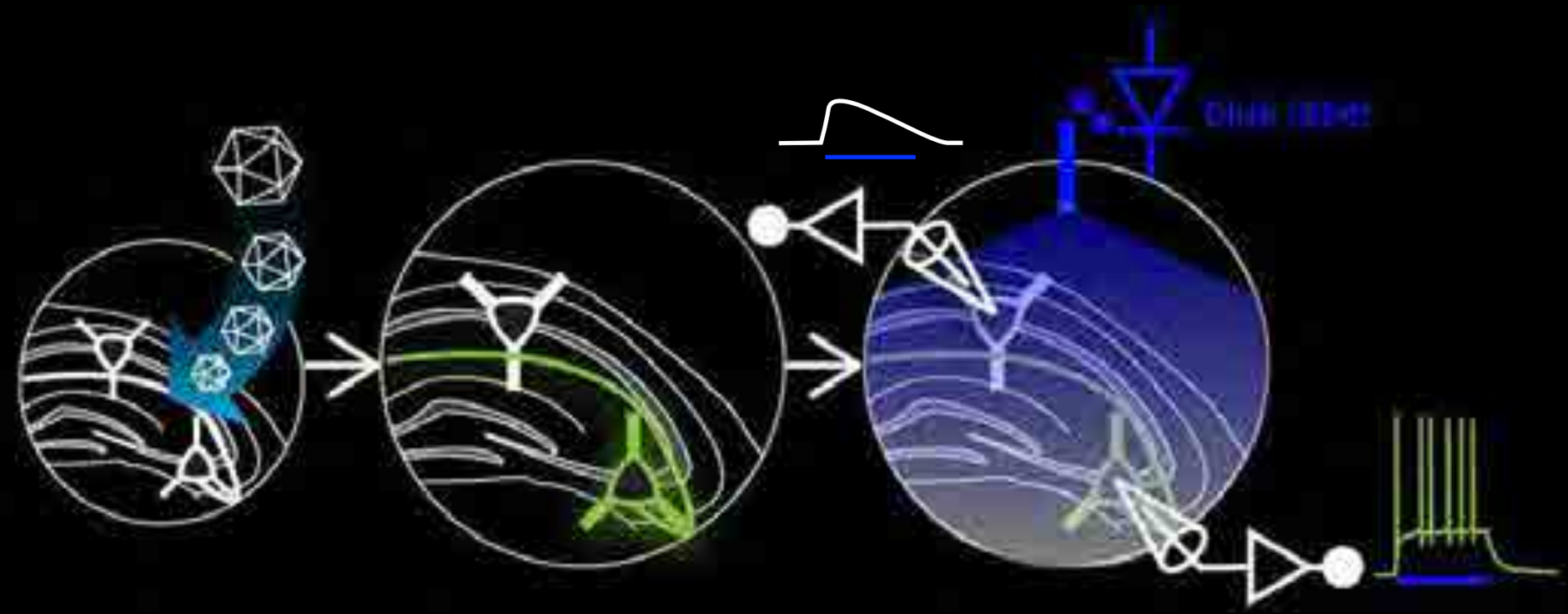


stereotaxic injection



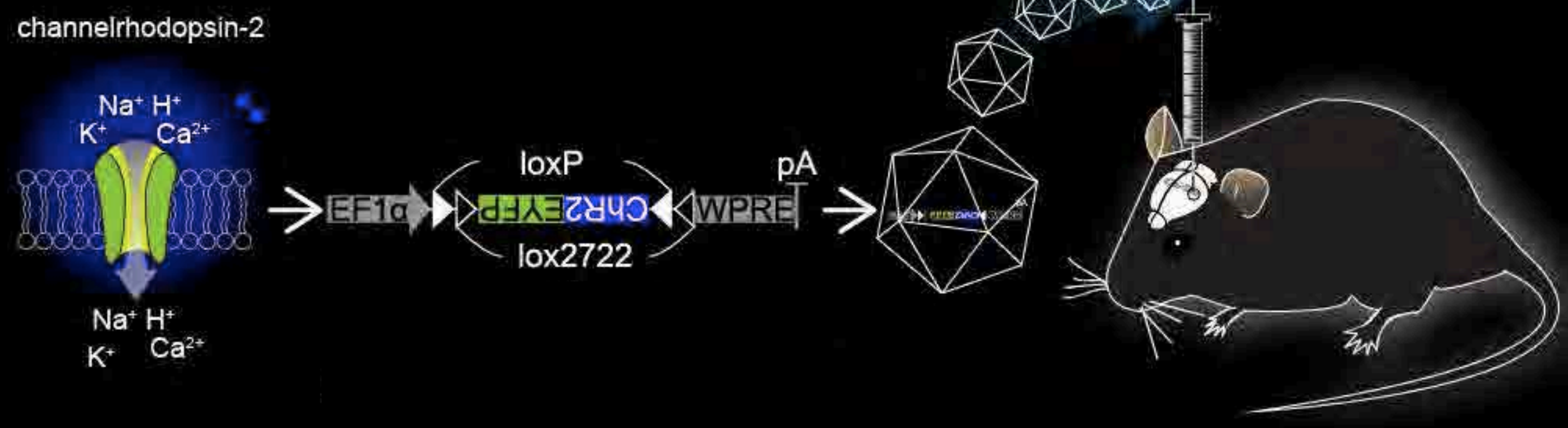
Channelrhodopsin-2 (ChR2) expression on specific neural populations



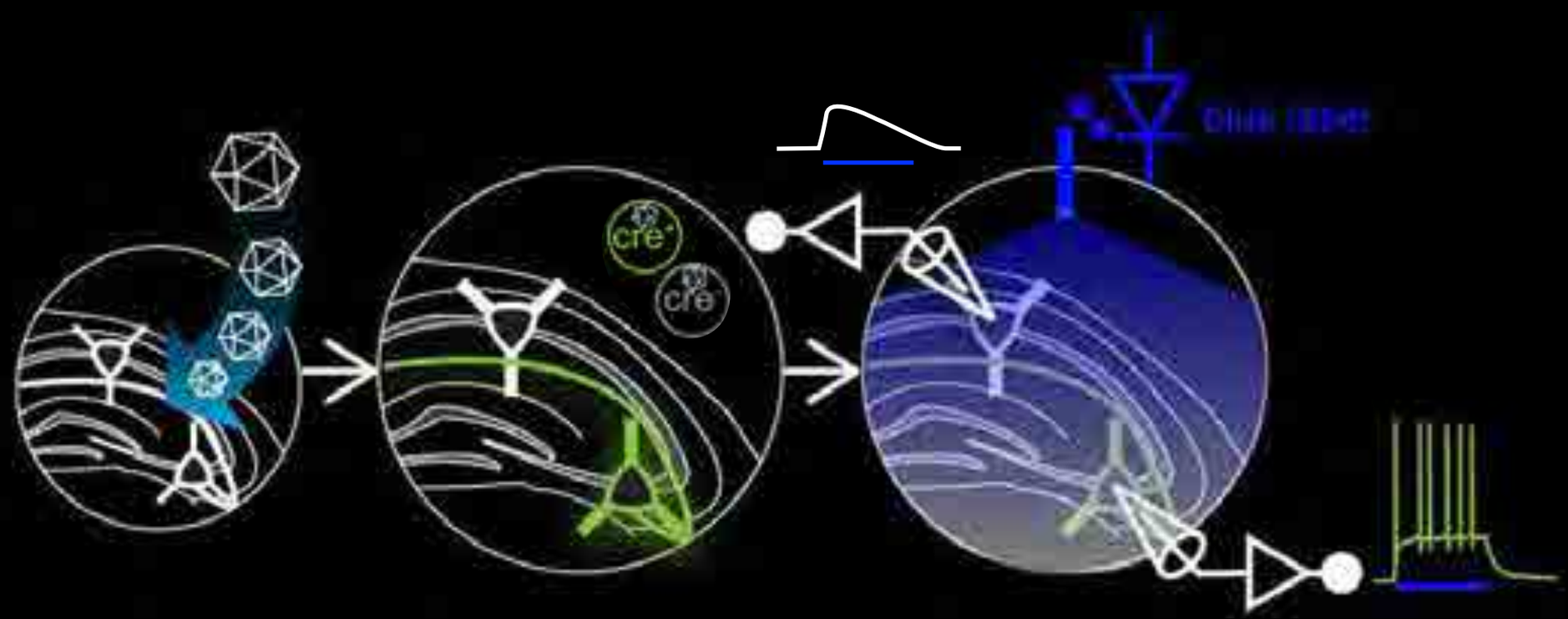


ex vivo slice recording

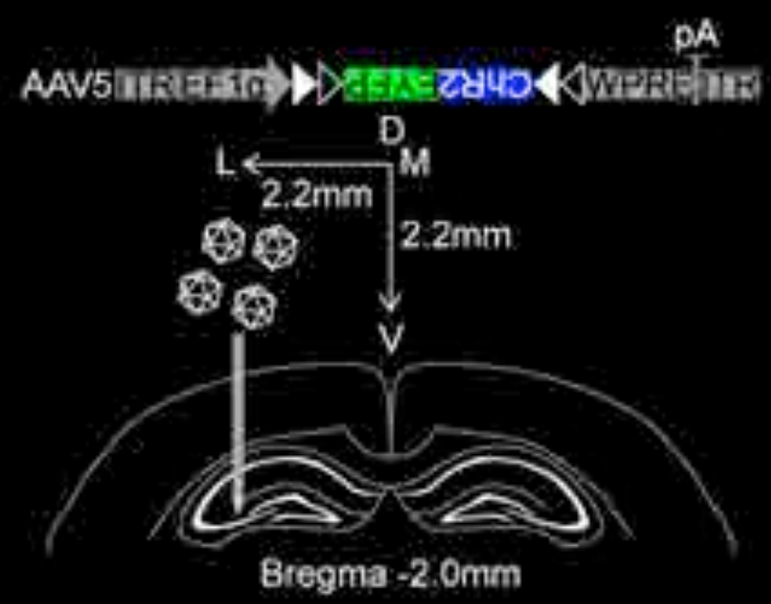
Channelrhodopsin-2 (ChR2) expression on specific neural populations

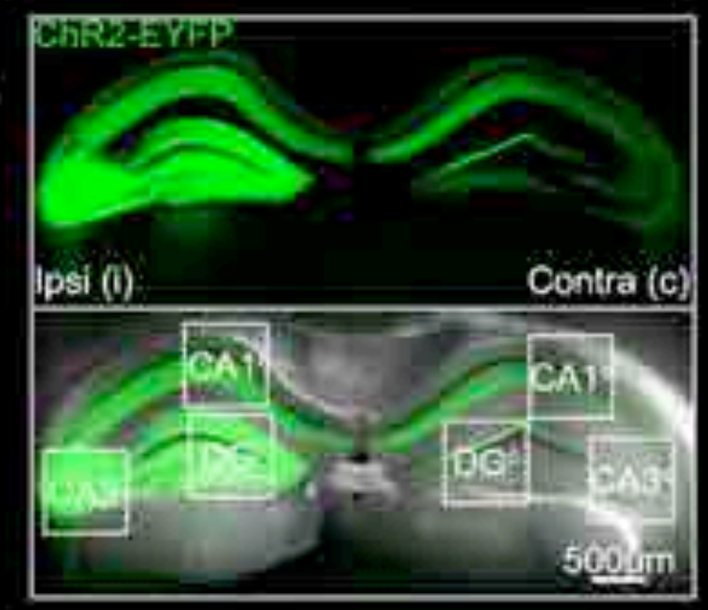


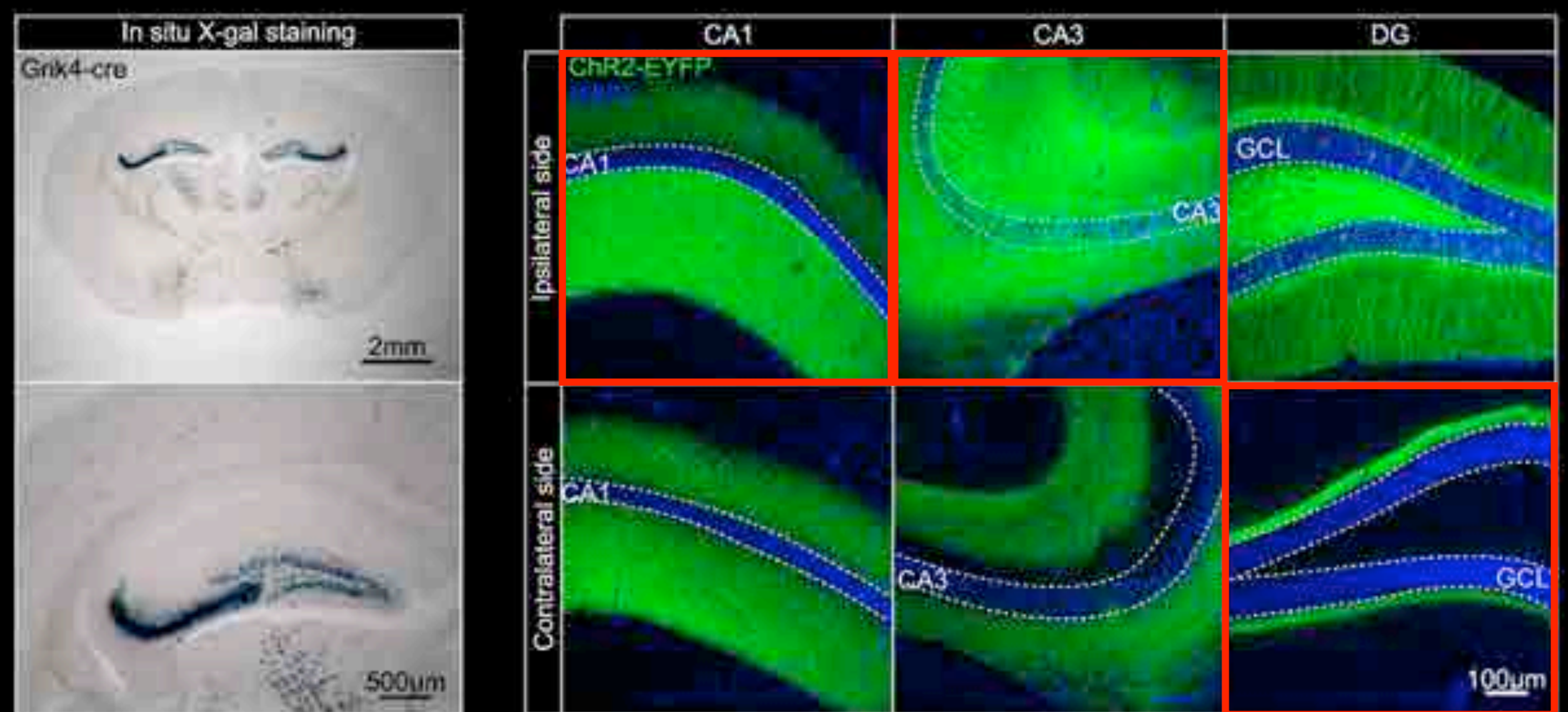
Cre driver mice

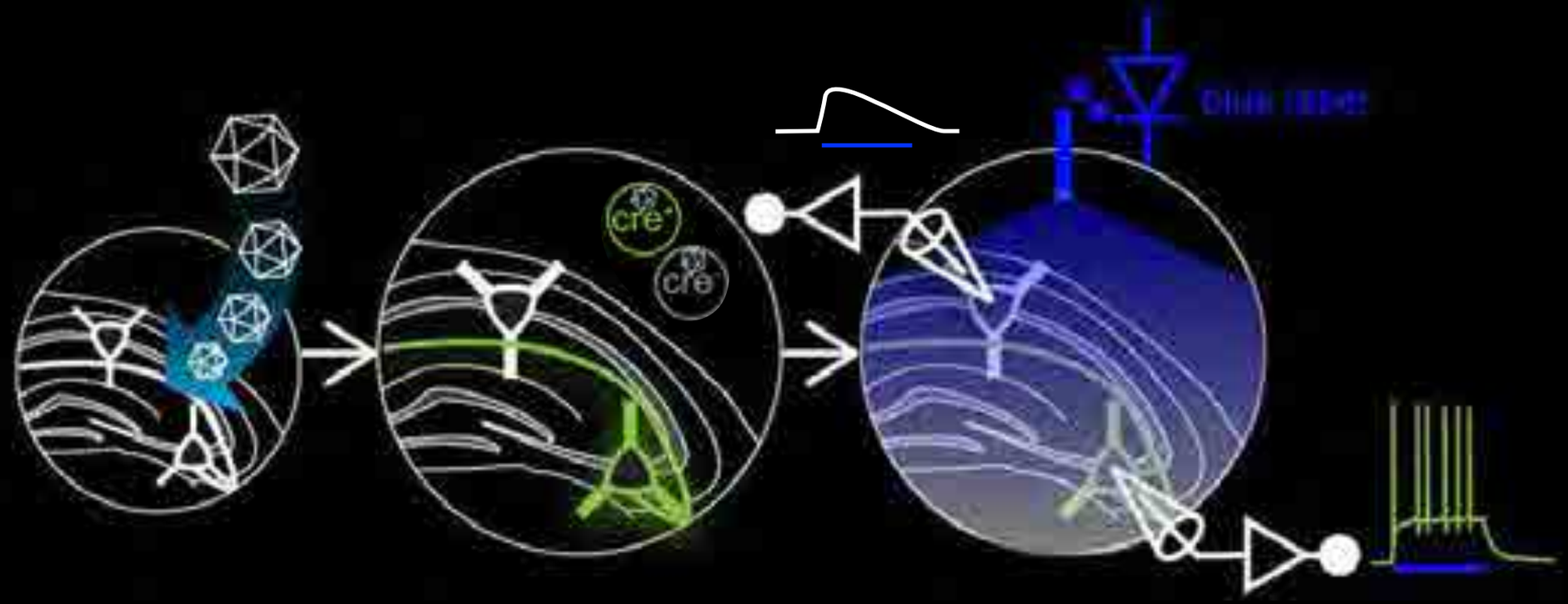


ChR2 expression on CA3, GC, Mossy cell afferents

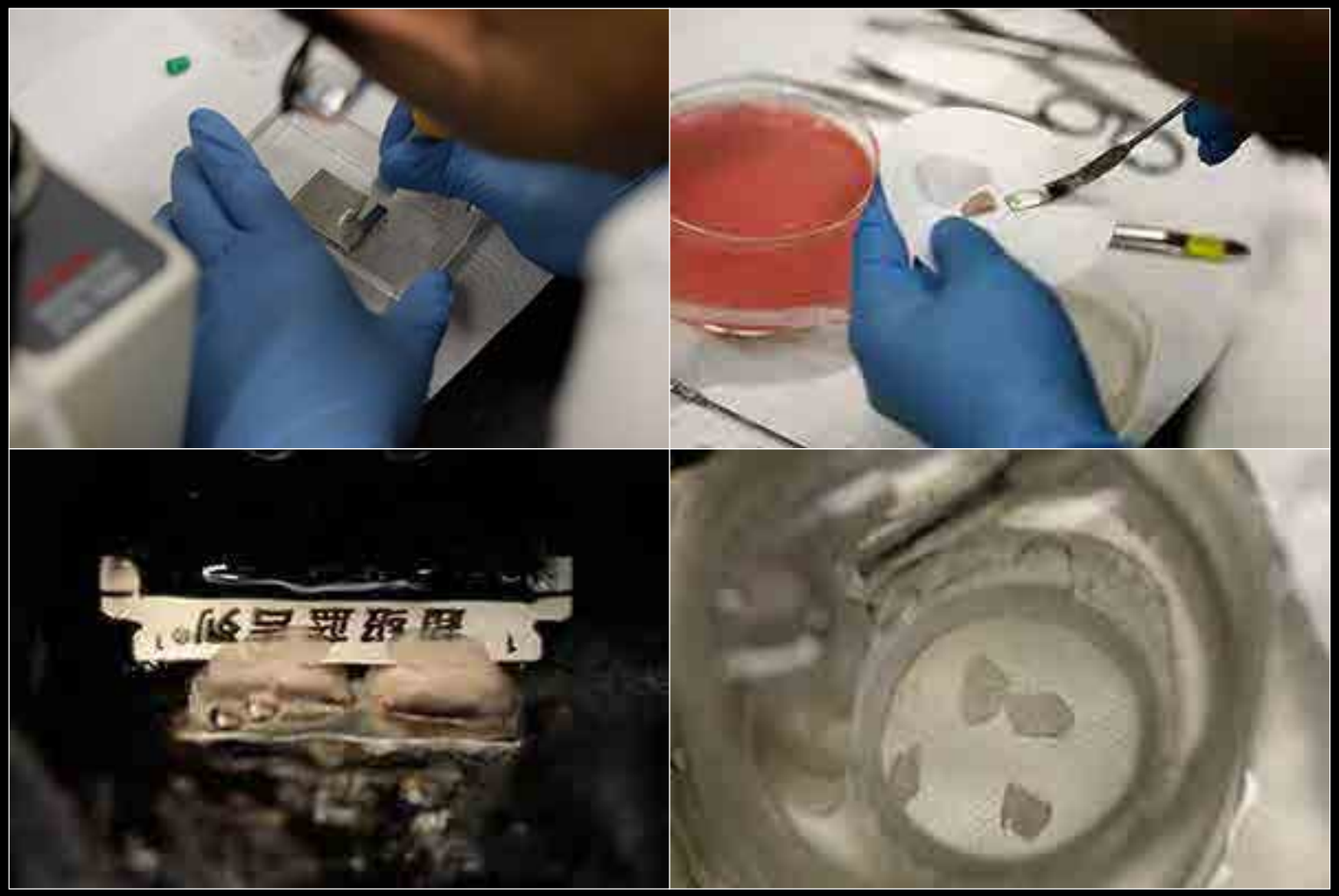


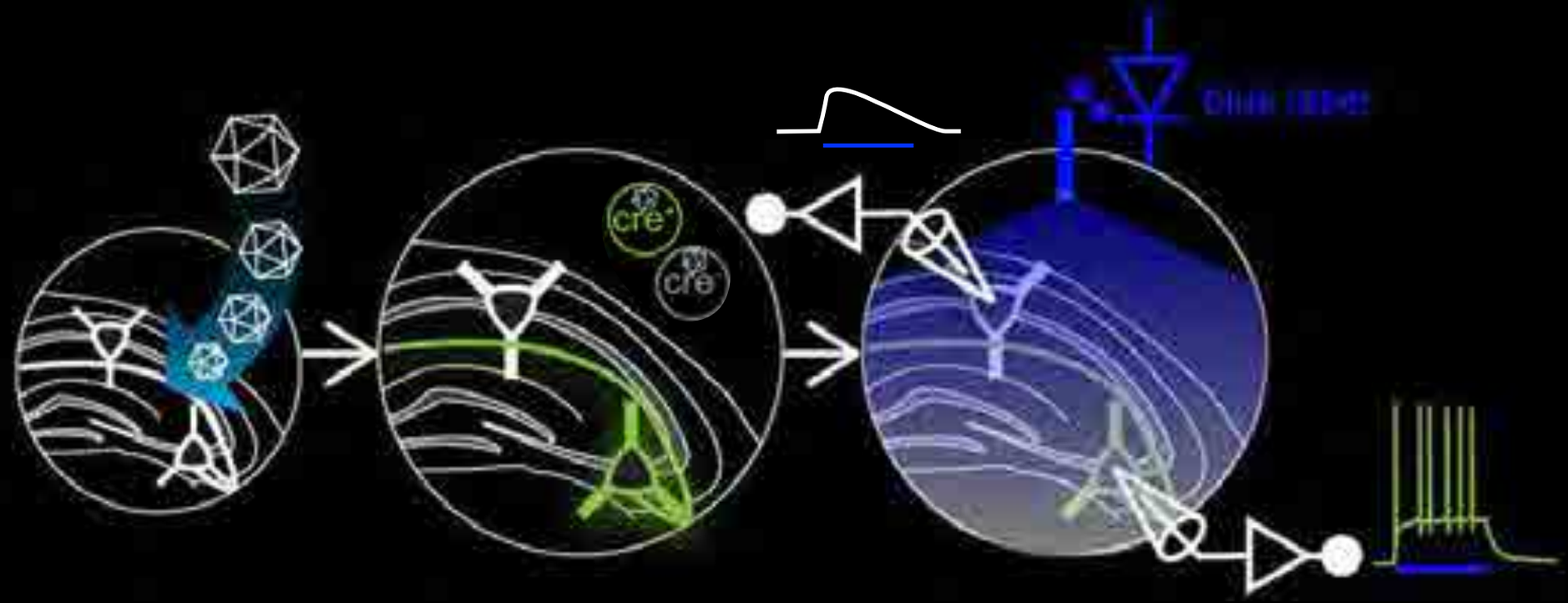


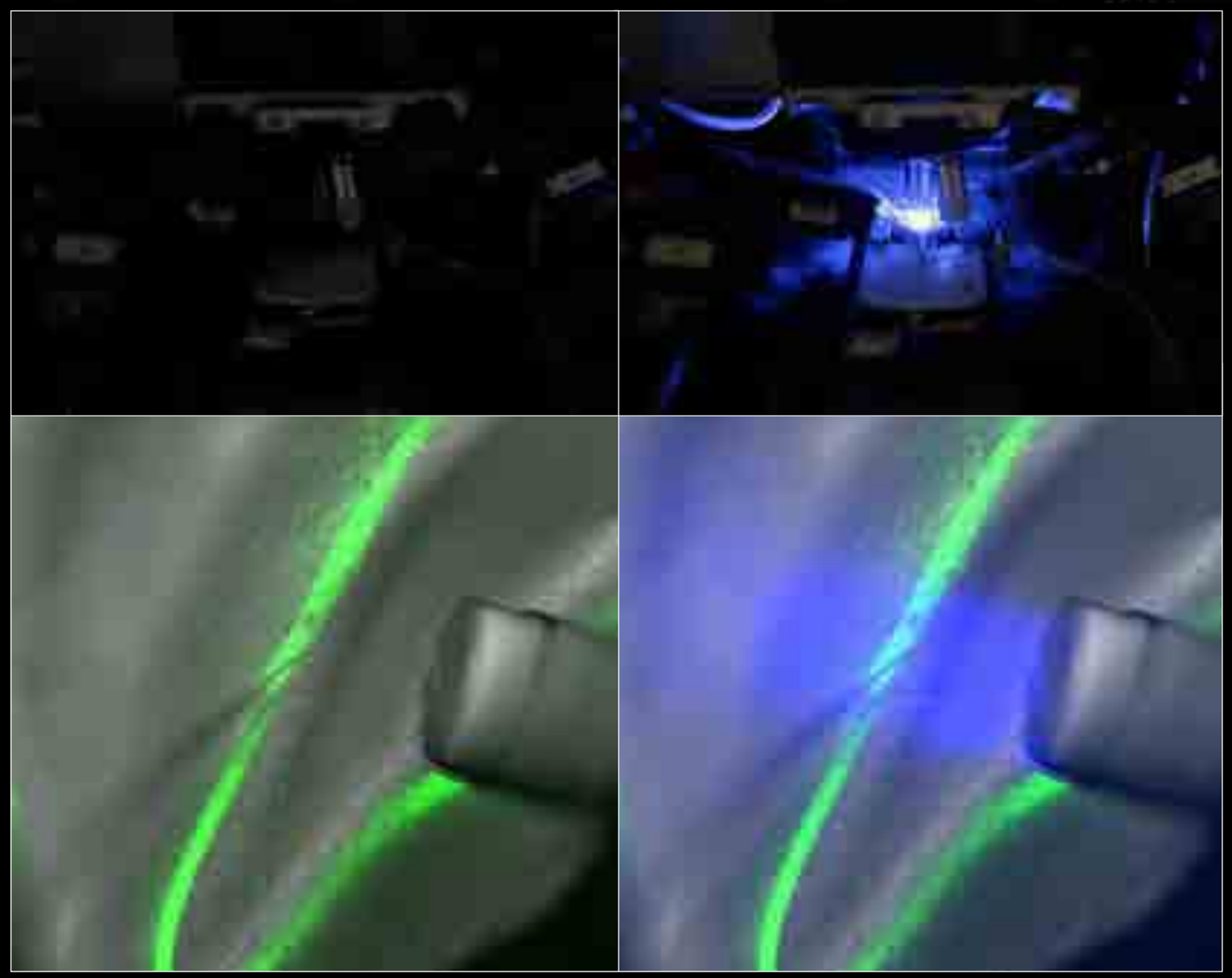




acute brain slice preparation







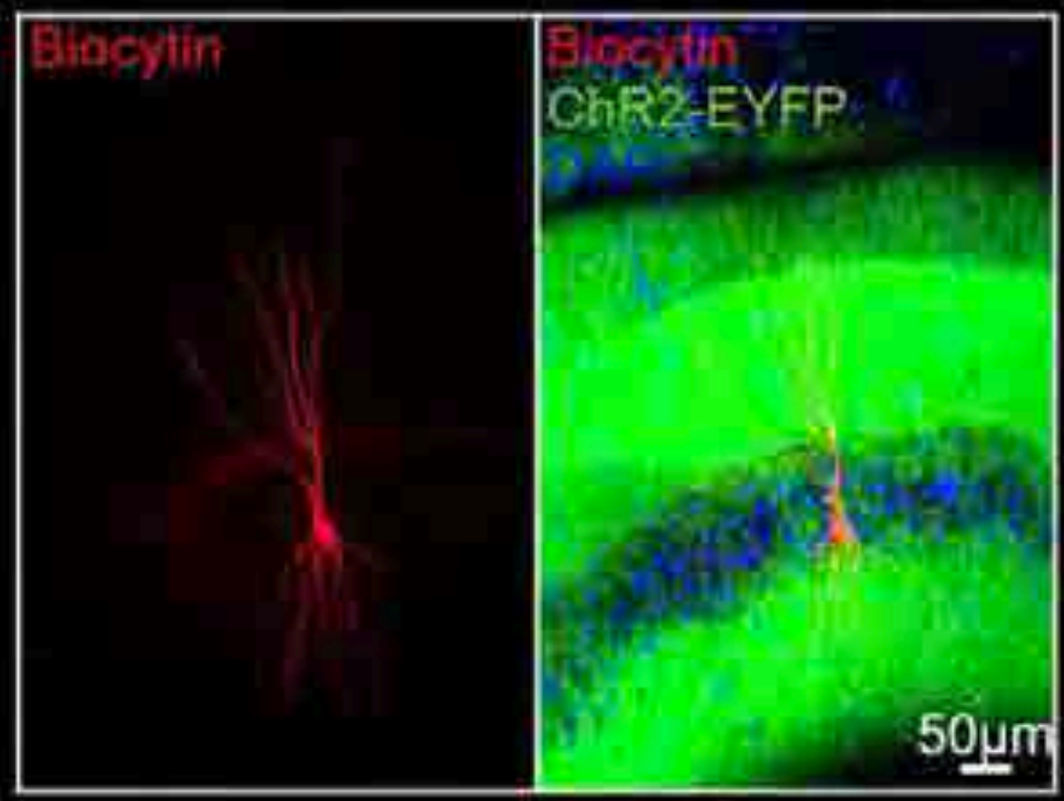
optic fiber

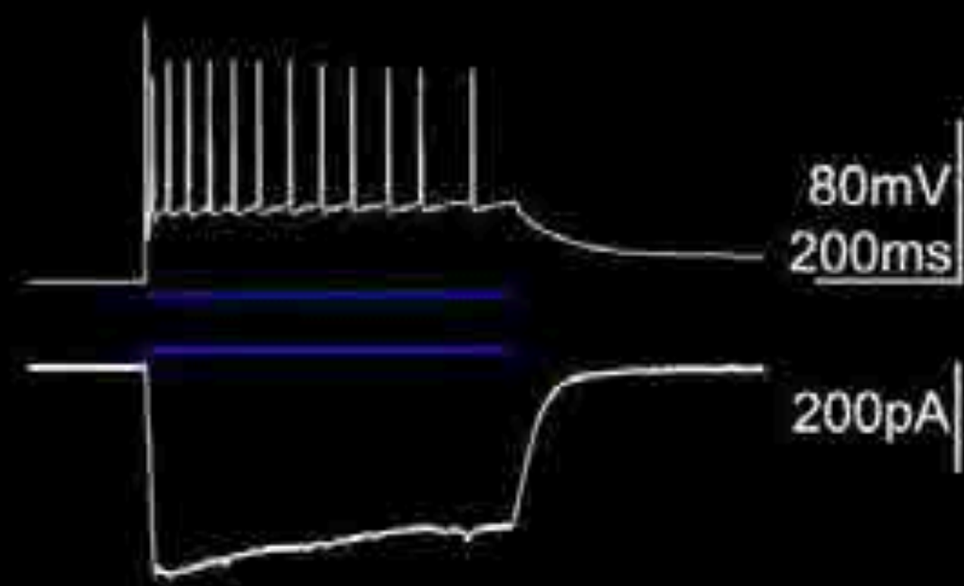
biocytin loading

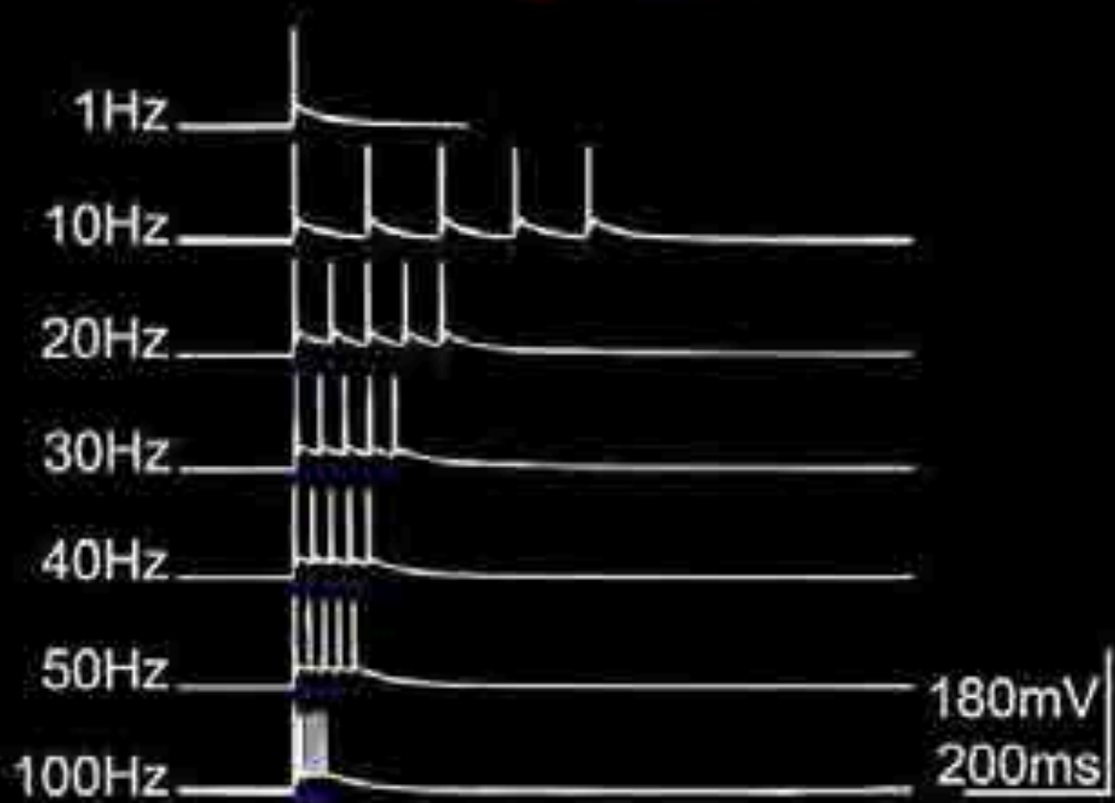
recording

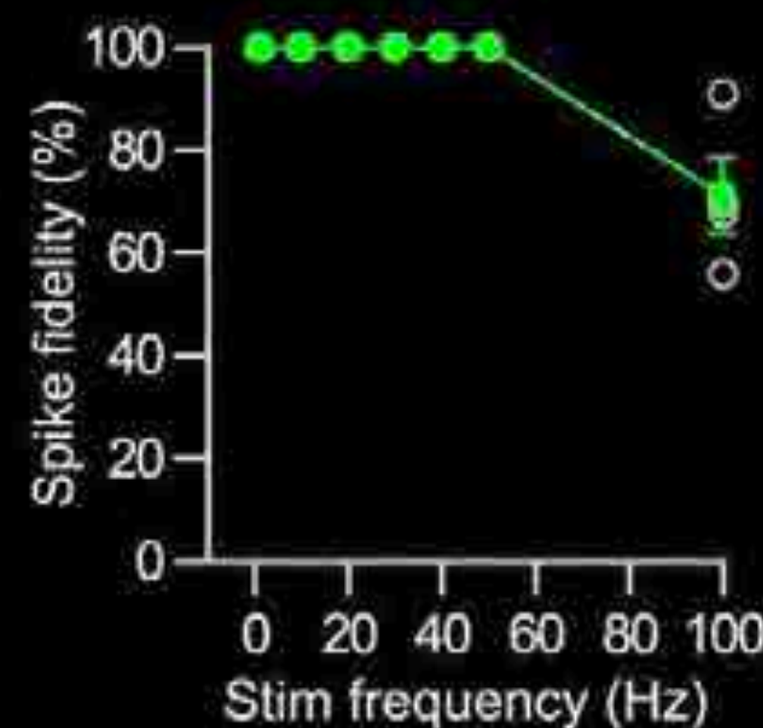
ChR2 expression on CA3, GC, Mossy cell afferents

ChR2-EYFP expressing CA3 neuron



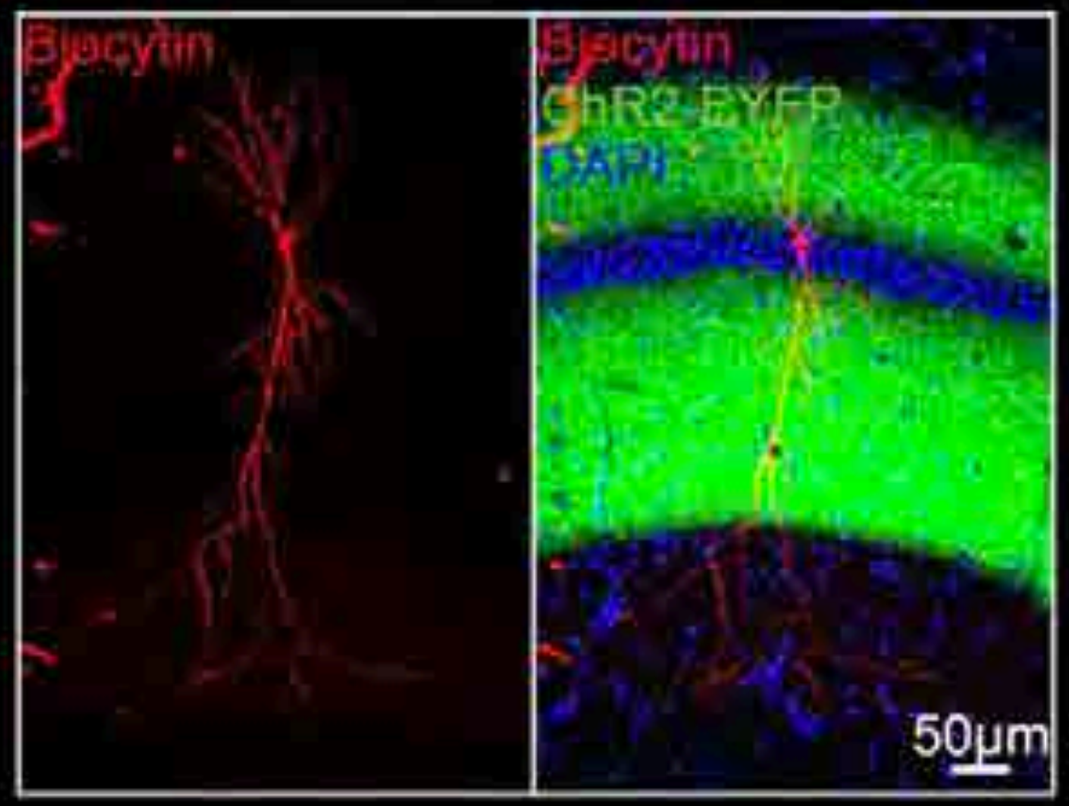


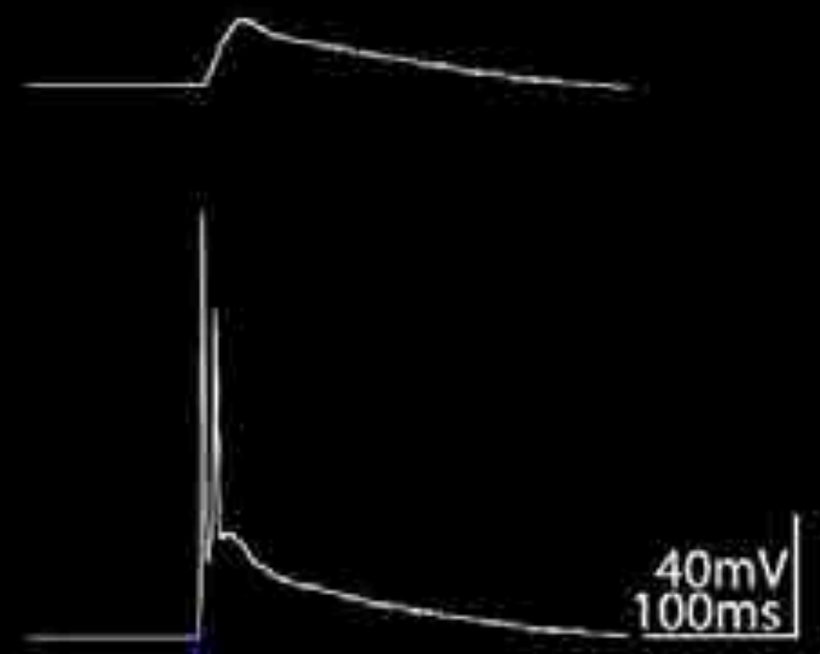




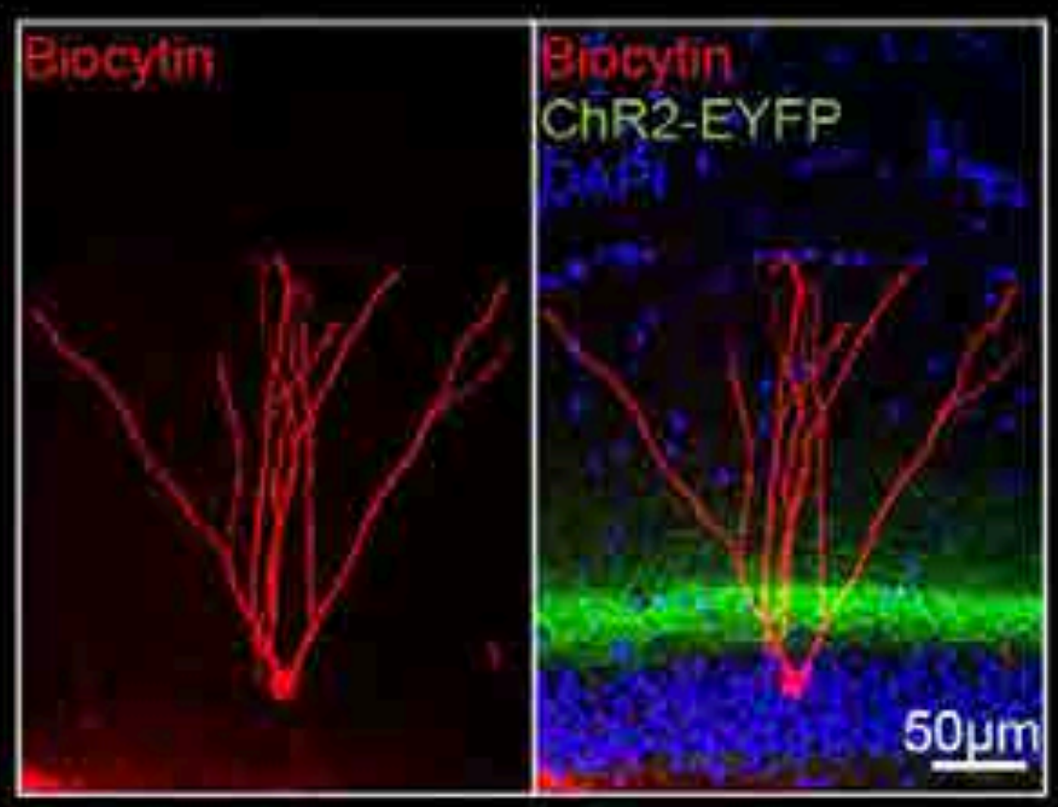
Optical stimulation of ChR2-EYFP expressing afferents

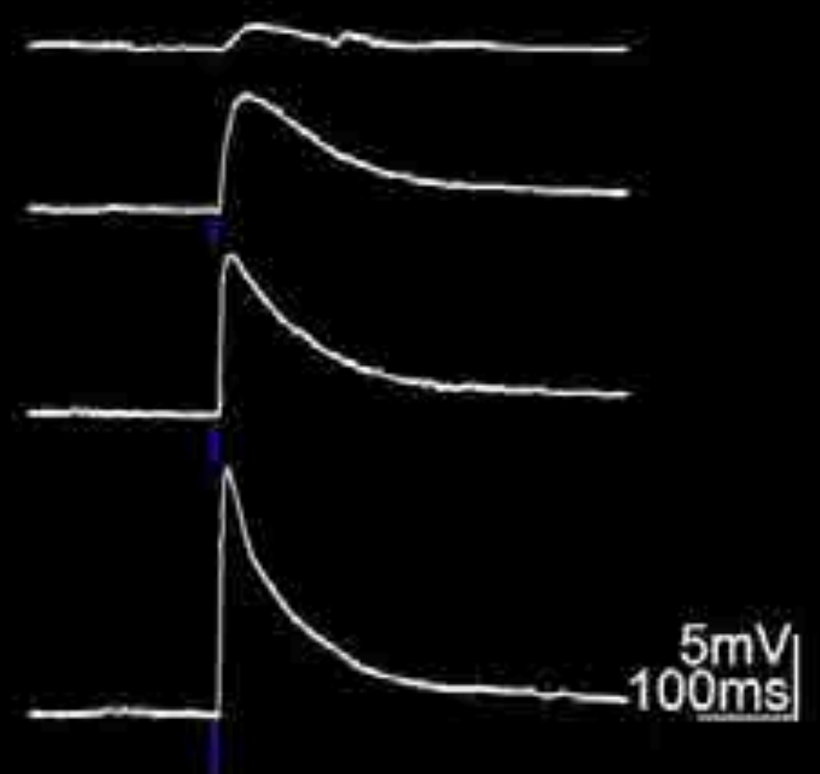
CA3-CA1 synapse

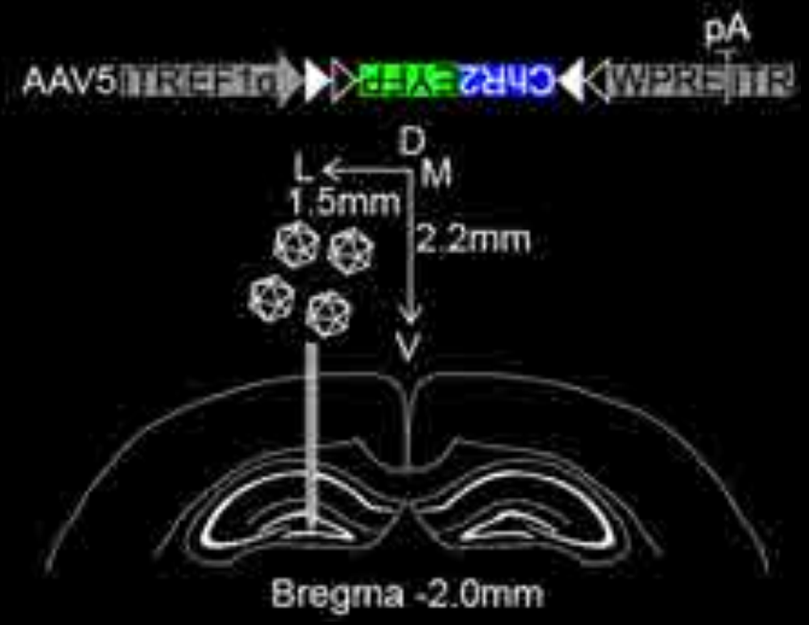




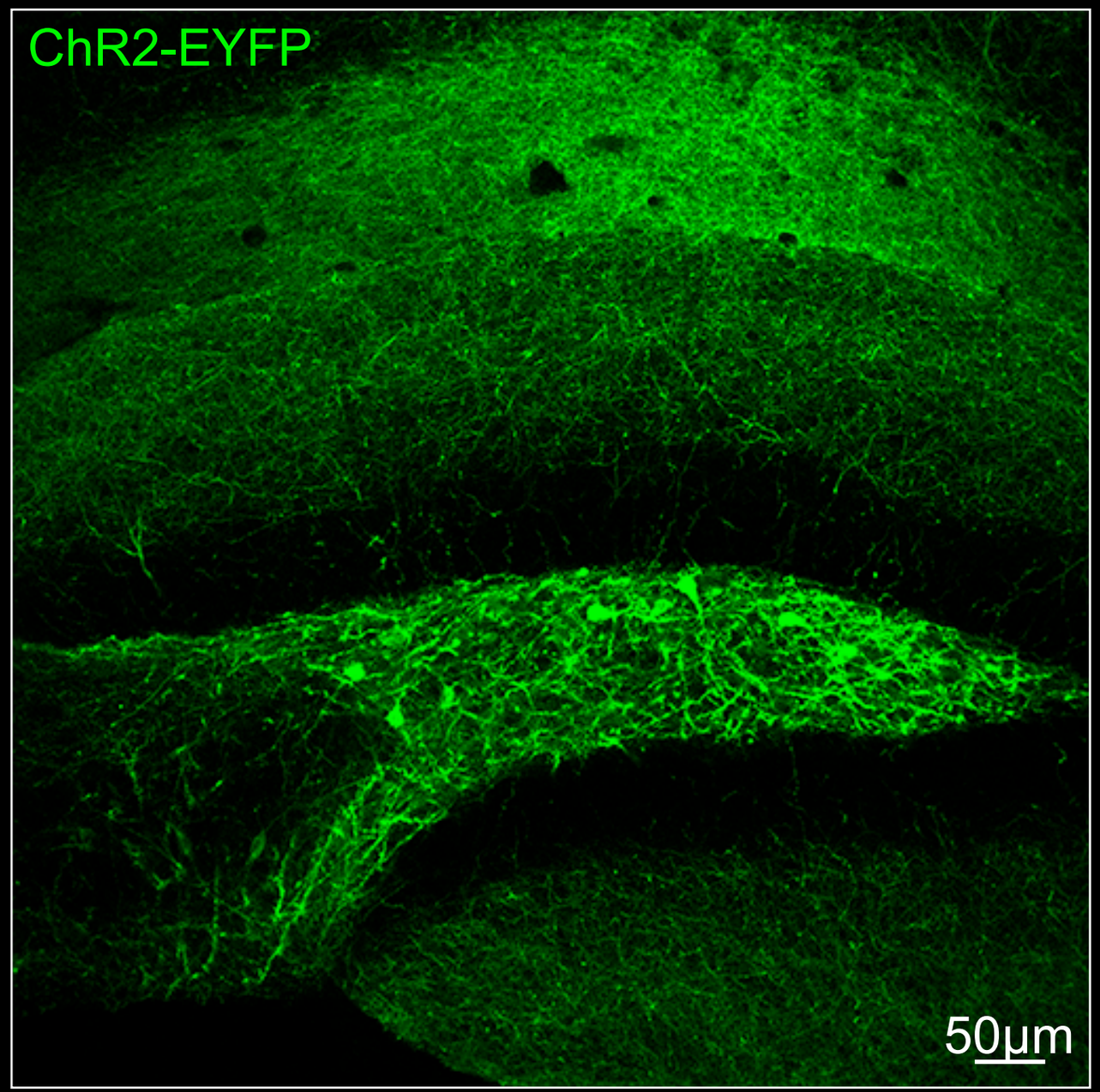
MC-GC synapse

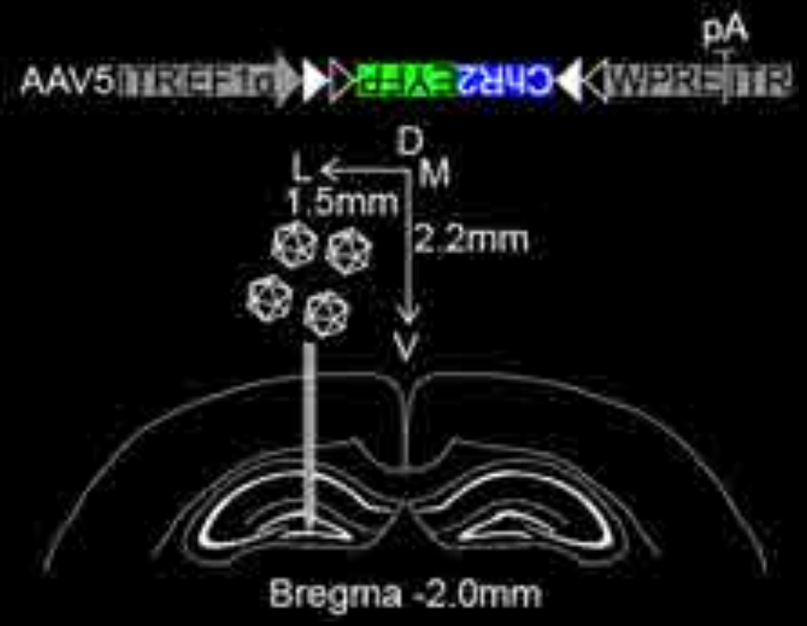




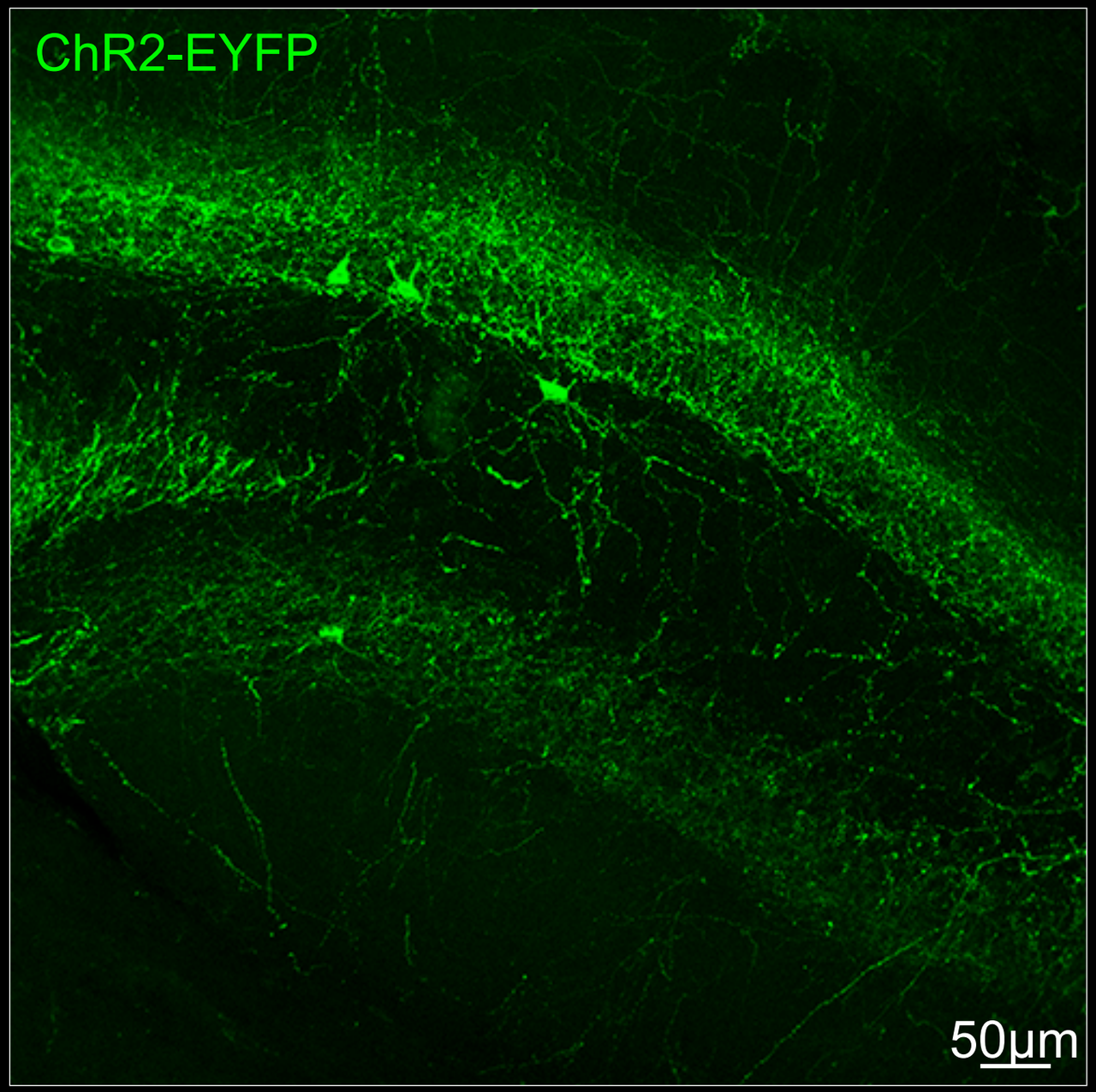


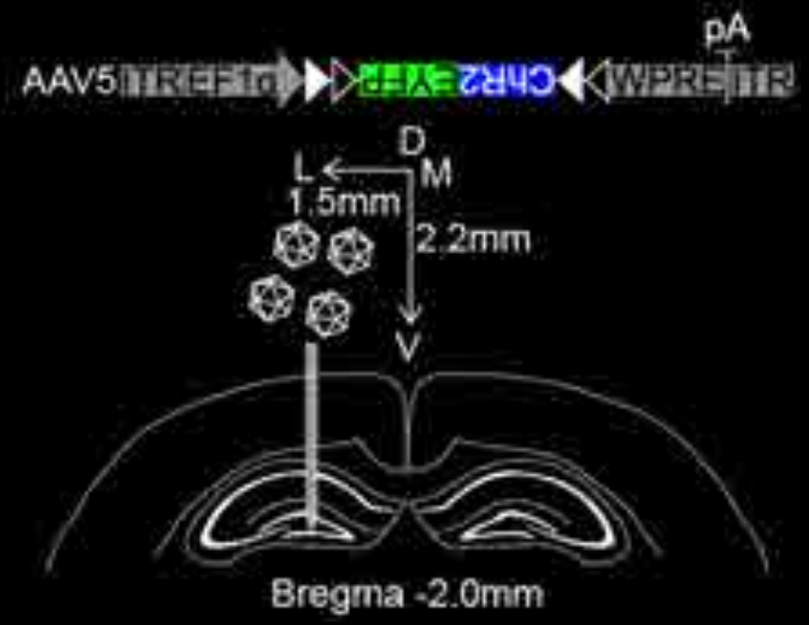
somatostatin-Cre mice



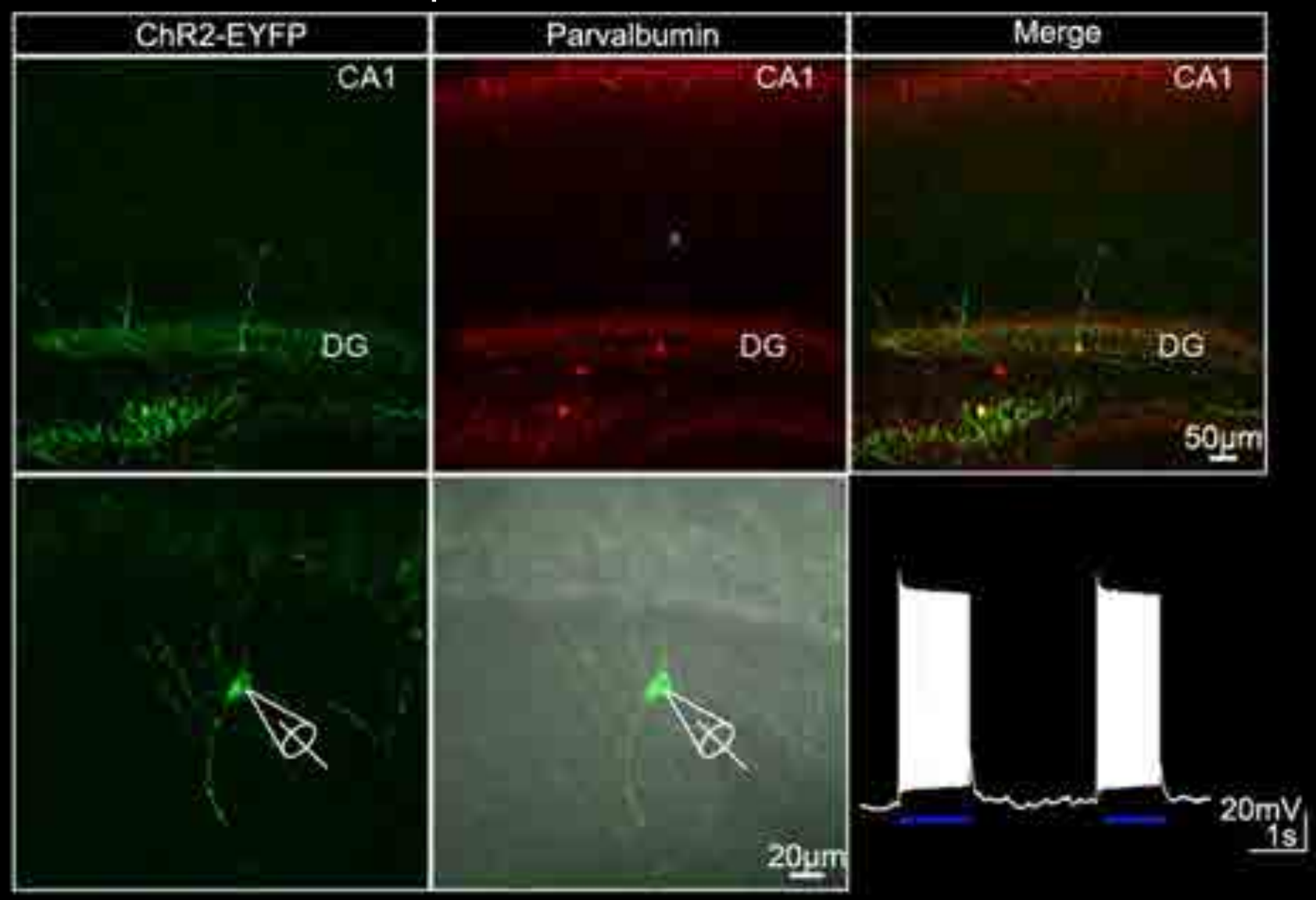


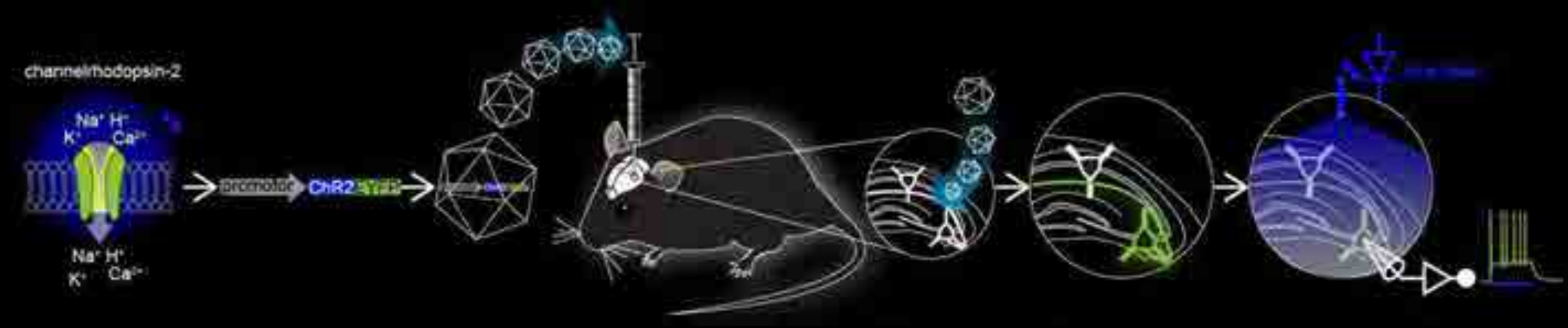
pavalbumin-Cre mice

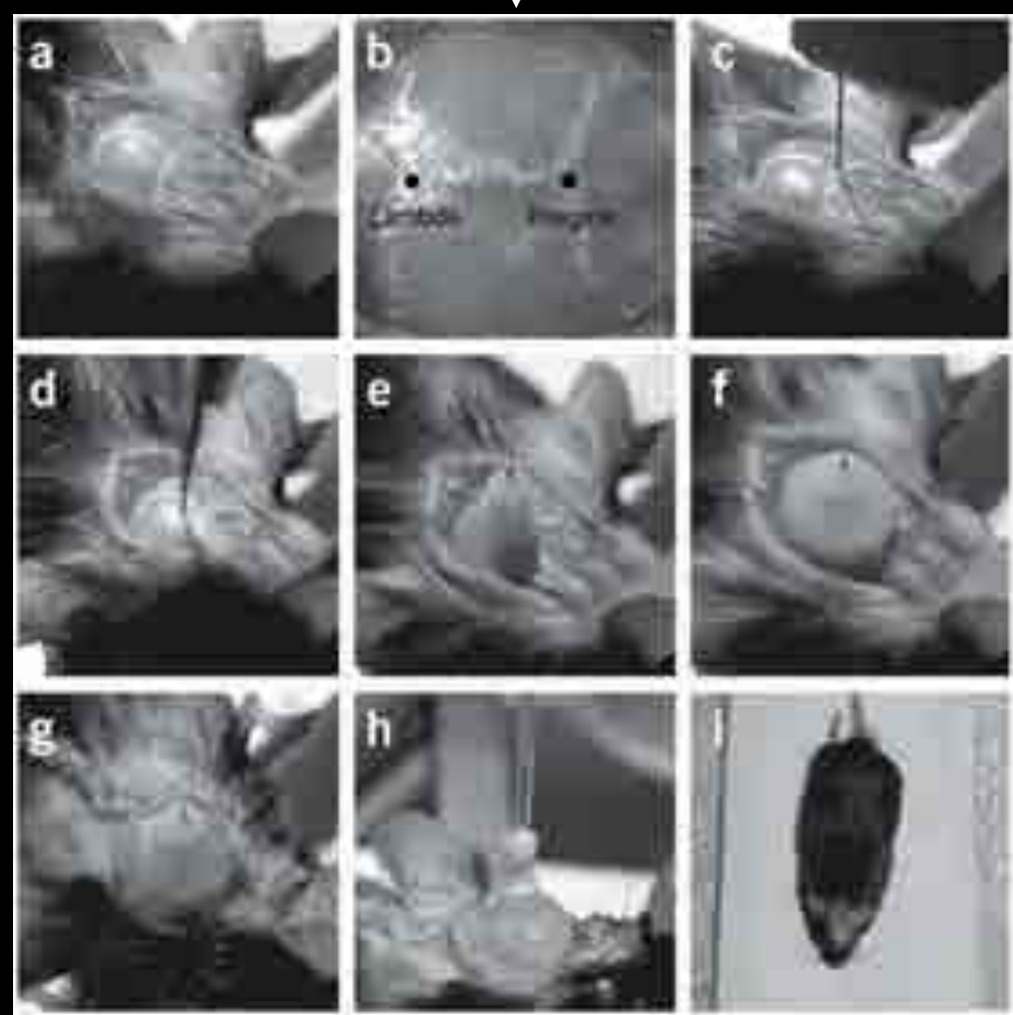


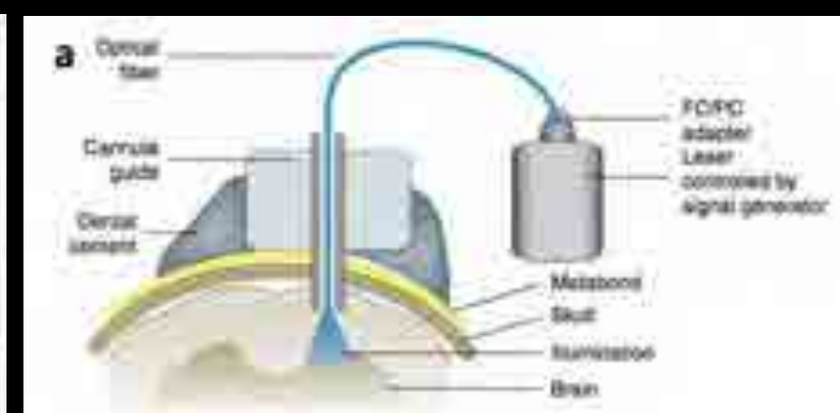


pavalbumin-Cre mice









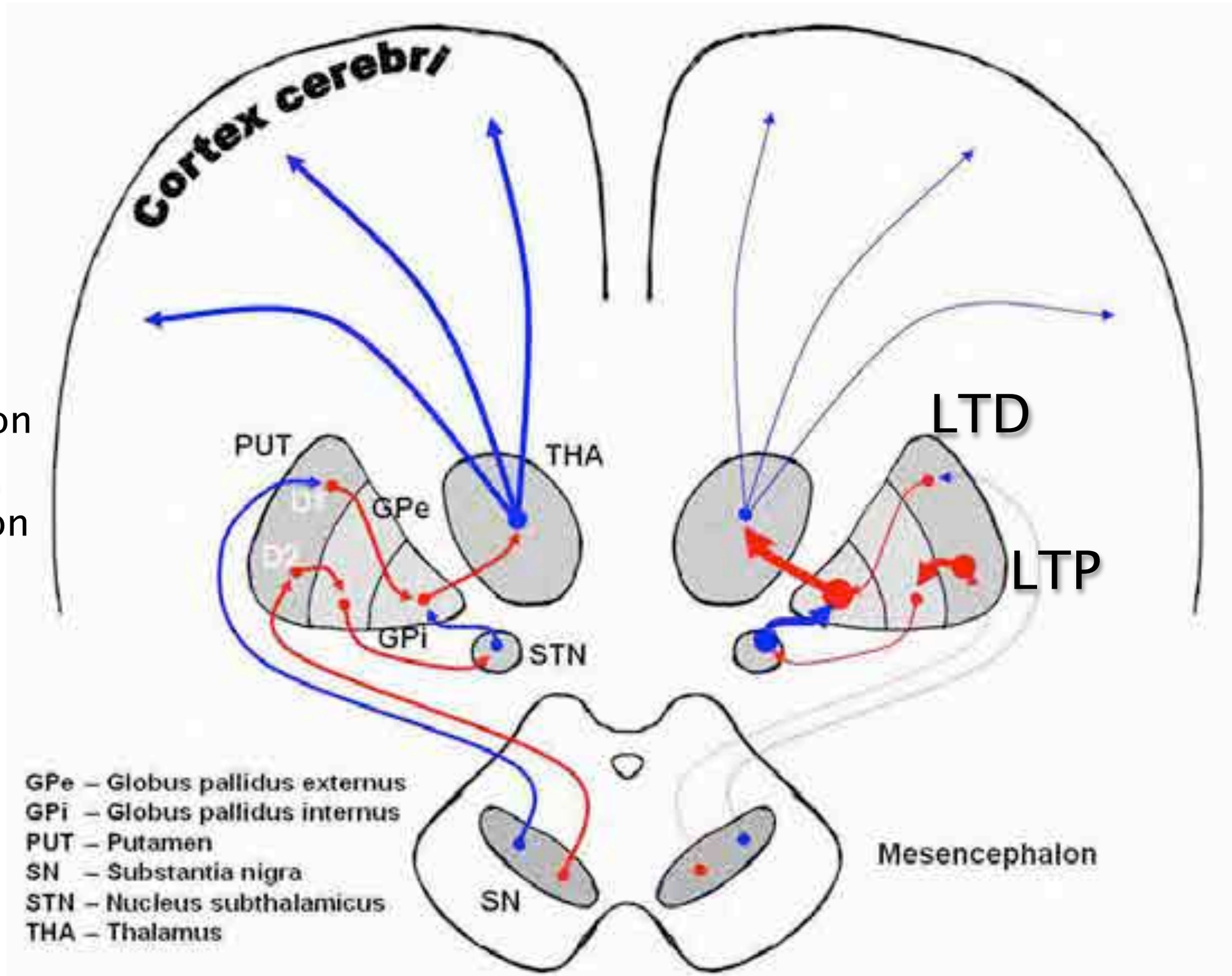
(Zhang et al., 2010)

***In vivo* optogenetics**

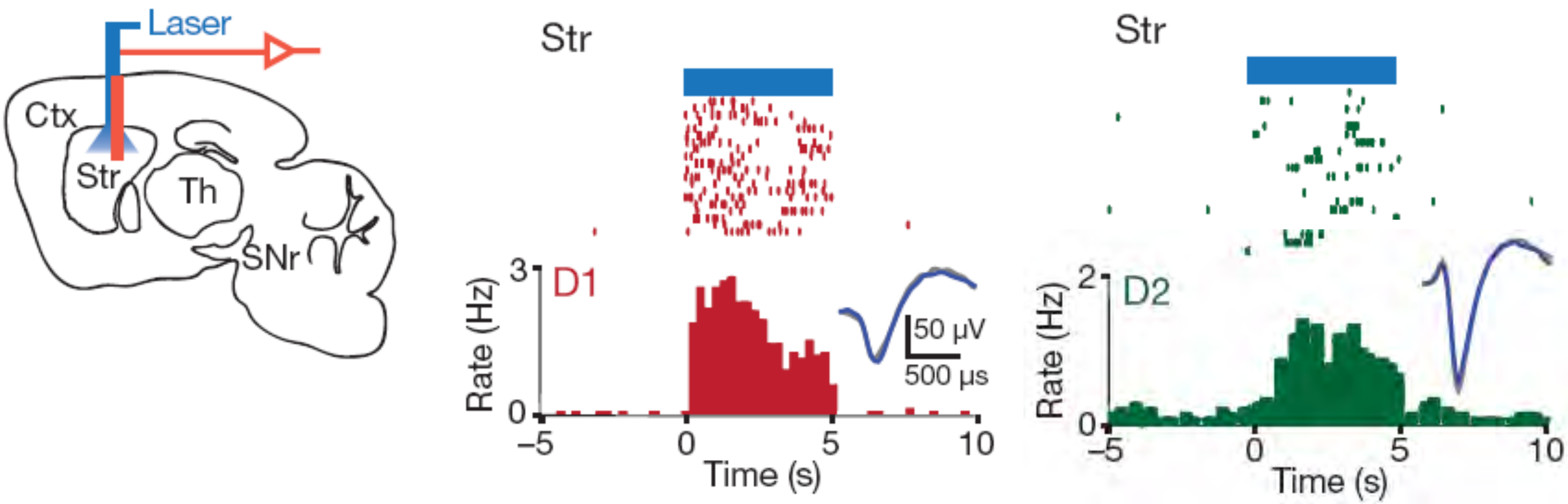
Direct and indirect-loop

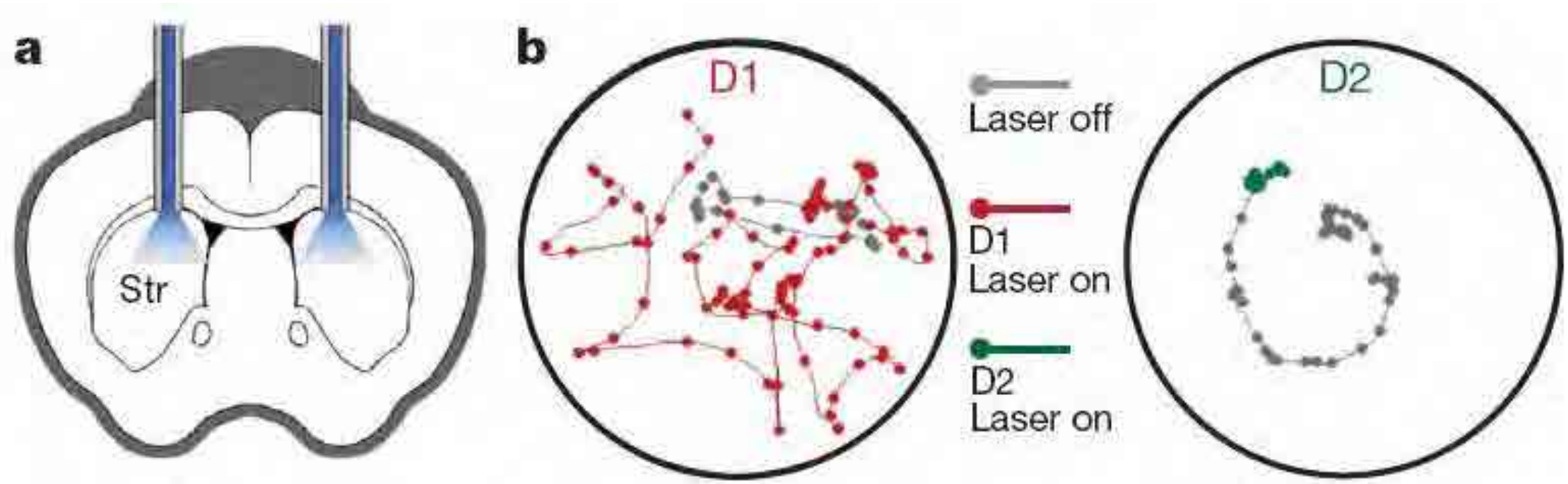
Excitation

Inhibition



Optogenetics re-visits the theory





(Kravitz et al., 2010)

Bilateral stimulation of indirect pathway

Movie S2:
Bilateral illumination of indirect pathway

Kreitzer lab, 2010

(Kravitz et al., 2010)

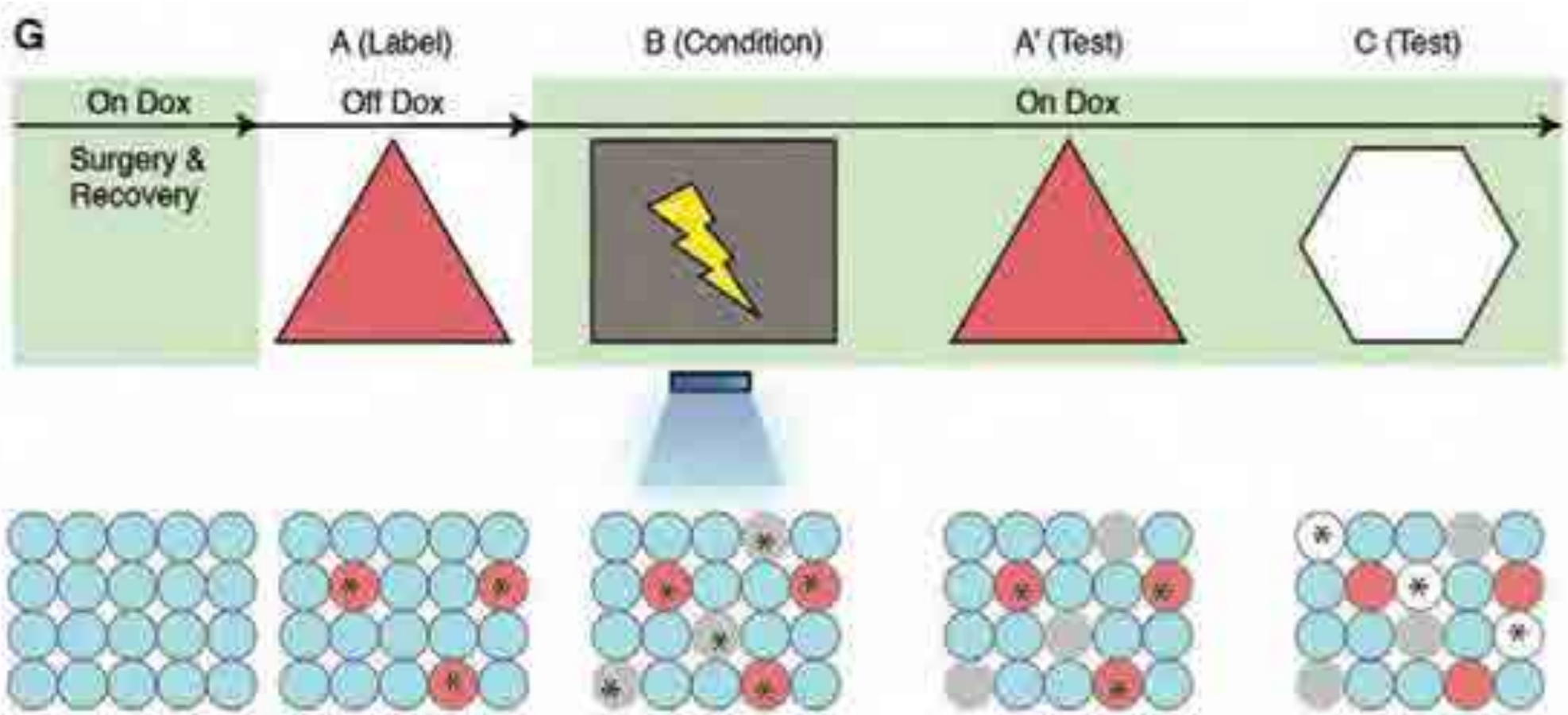
Contextual fear memory

Contextual fear memory

Optogenetics

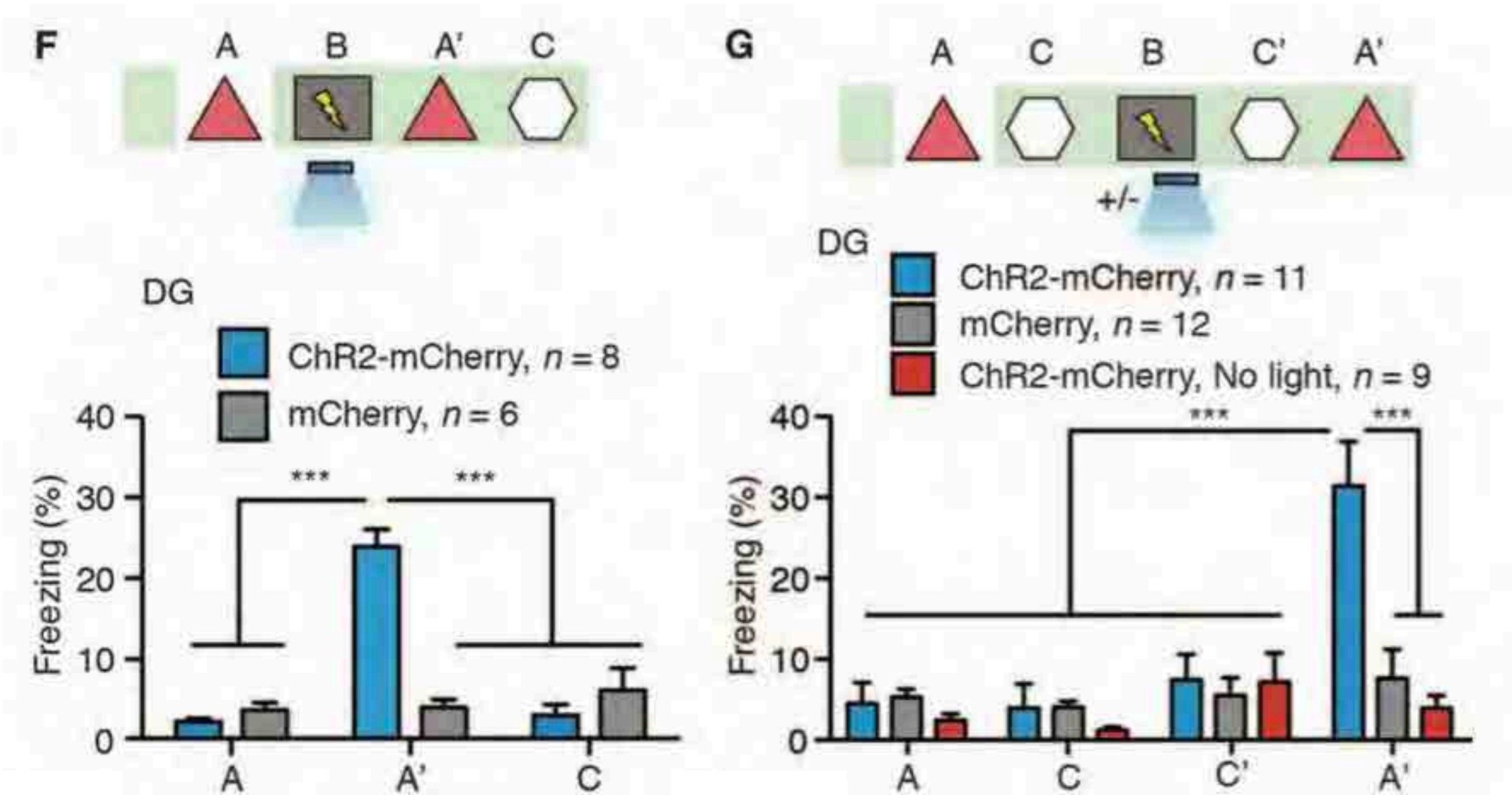
http://www.impawards.com/2010/inception_ver14_xlg.html

Creating a false memory in the hippocampus



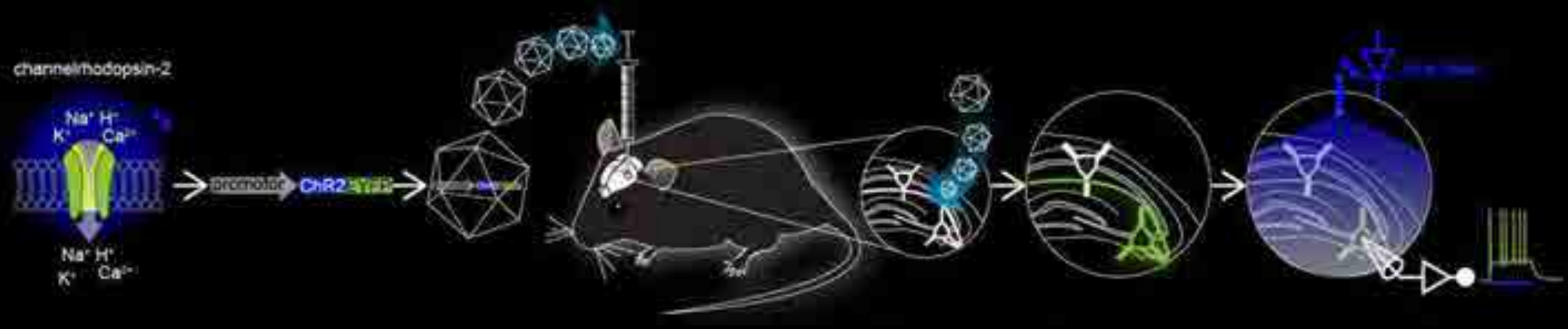
(Ramirez et al., 2013)

Creating a false memory in the hippocampus



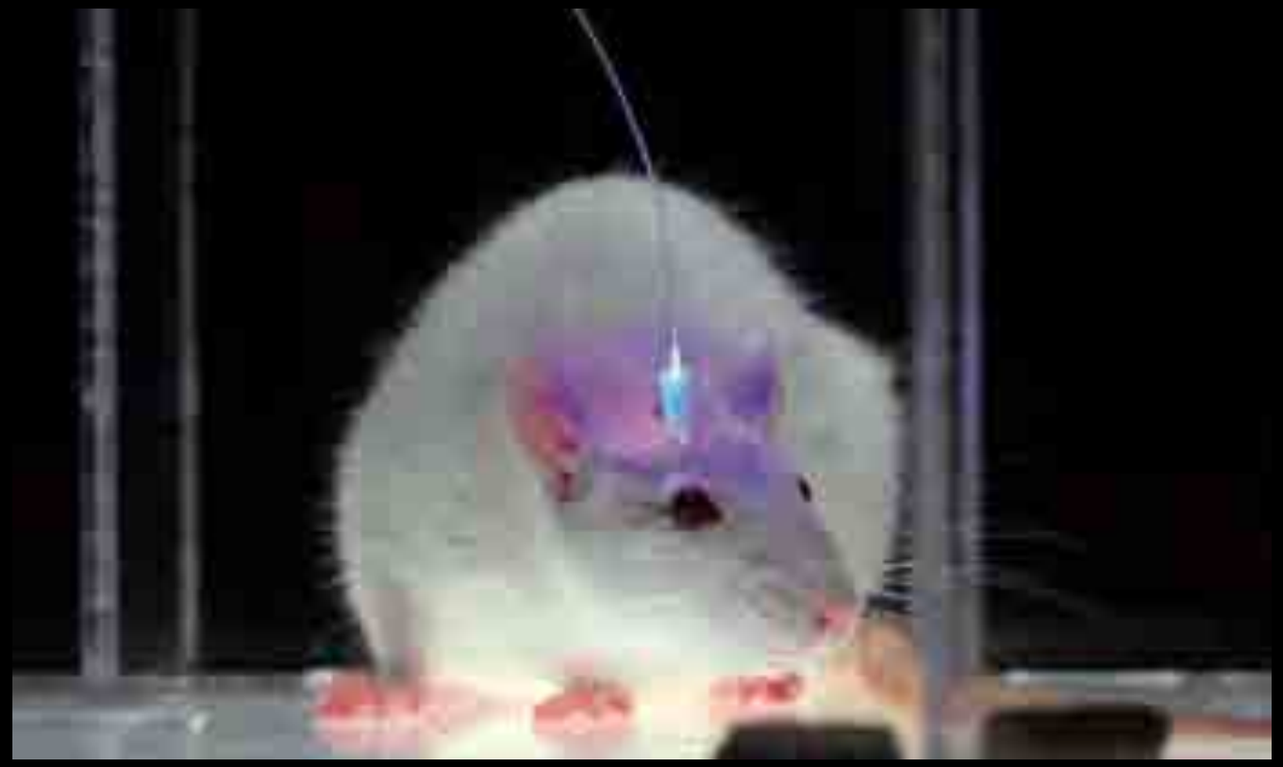
(Ramirez et al., 2013)

Summary



virus generation stereotaxic generation Optogenetics in brain slices

in vivo optogenetics



http://www.stanford.edu/group/dlab/optogenetics/

Thanks for your attention