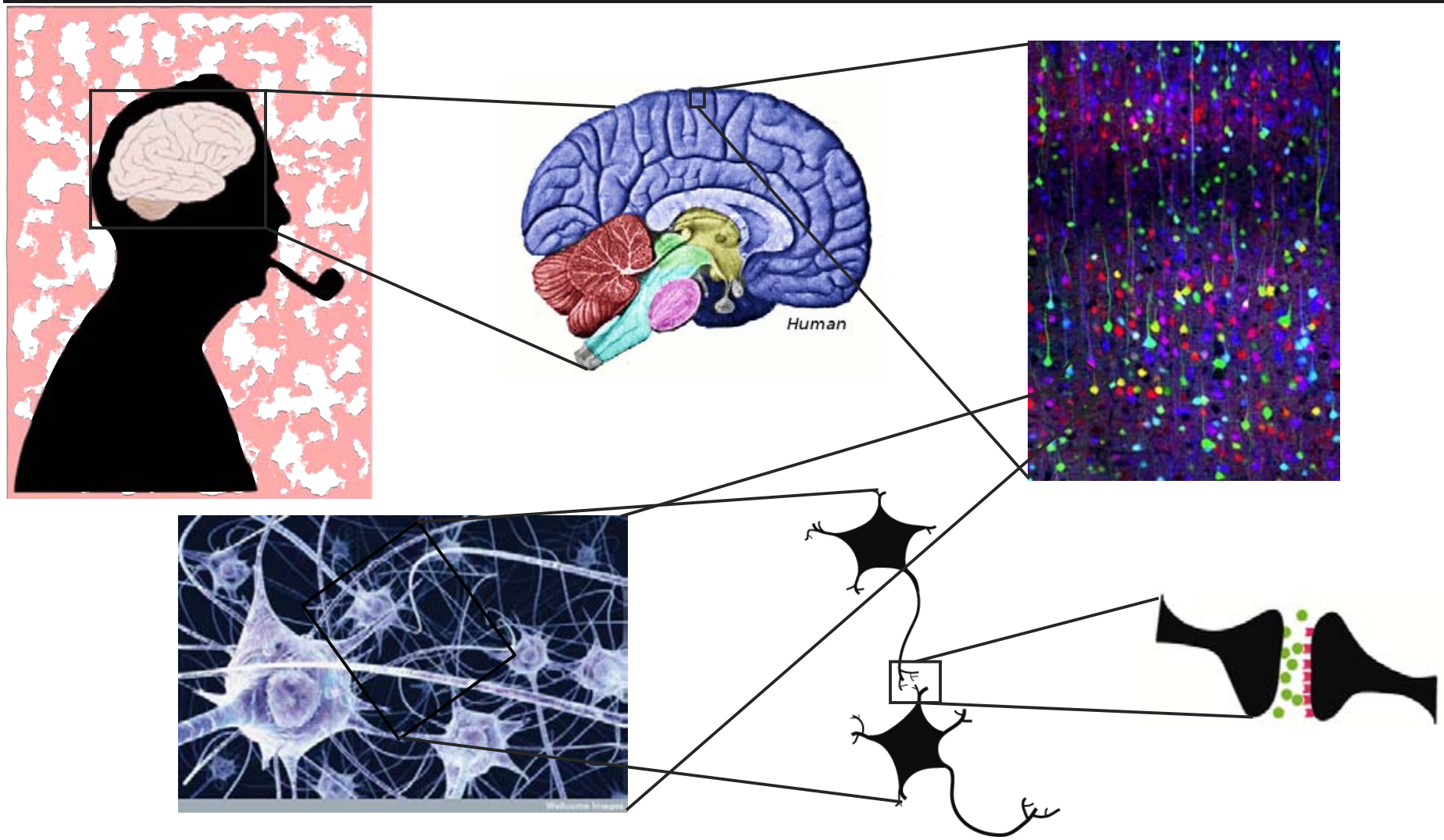
How do scientists study memory?

Alix Lacoste

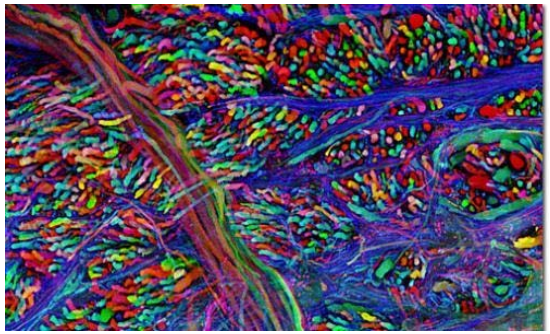
Different Levels of Memory



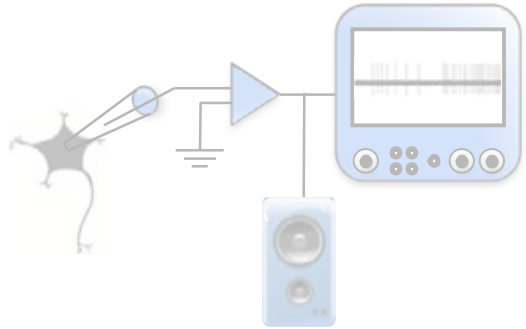
Images: Wikipedia commons, Nevit Dilmen, Tamily Weissman, Hljod Huskona and Allison Nishitani

HARVARD MEDICAL SCHOOL

Outline



- Studying physical connections

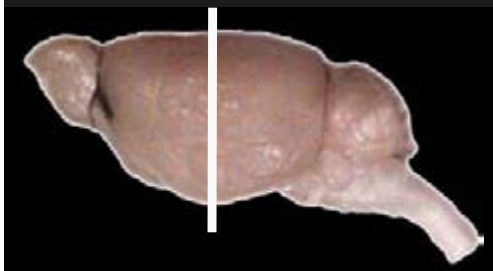


- Studying communication between neurons

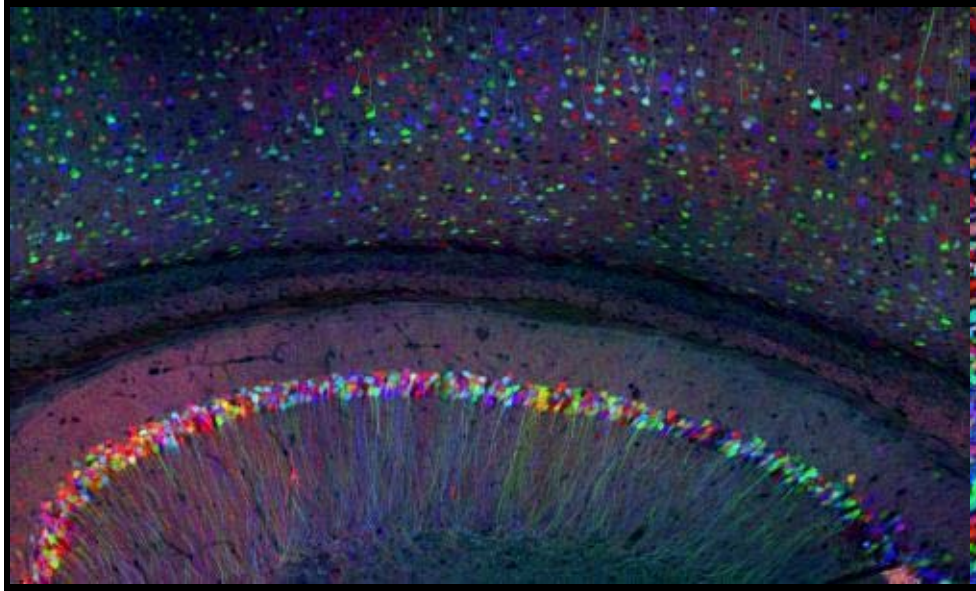
- Human studies

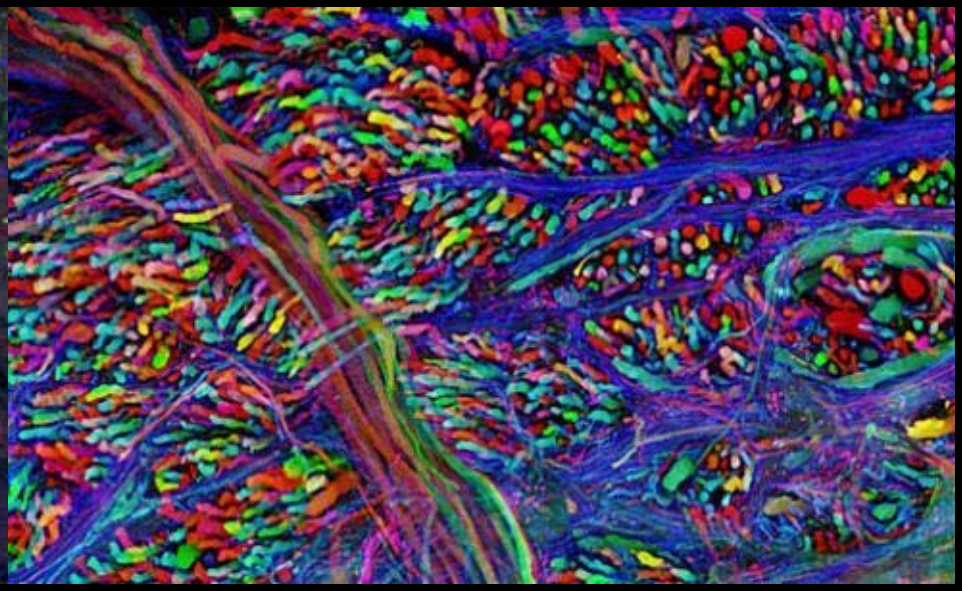
Images: Lichtman Lab, Nevit Dilmen

Imaging the Brain: Brainbow



Brainbow: each individual neuron is labeled with a different fluorescent color





Top: Cortex; Bottom: hippocampus

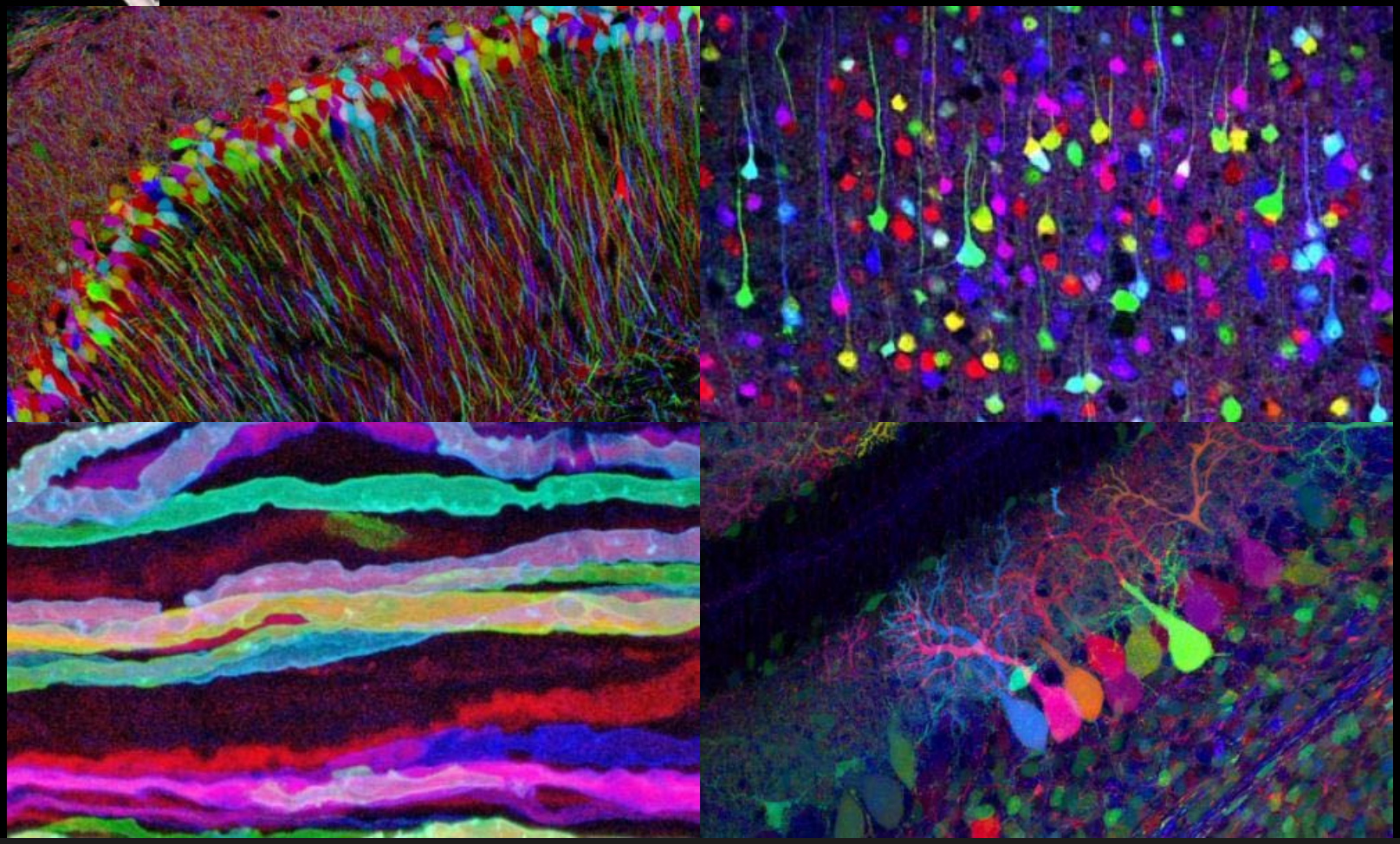
Brainstem

Images: Lichtman Lab, Harvard

HARVARD MEDICAL SCHOOL

Imaging the Brain: Brainbow

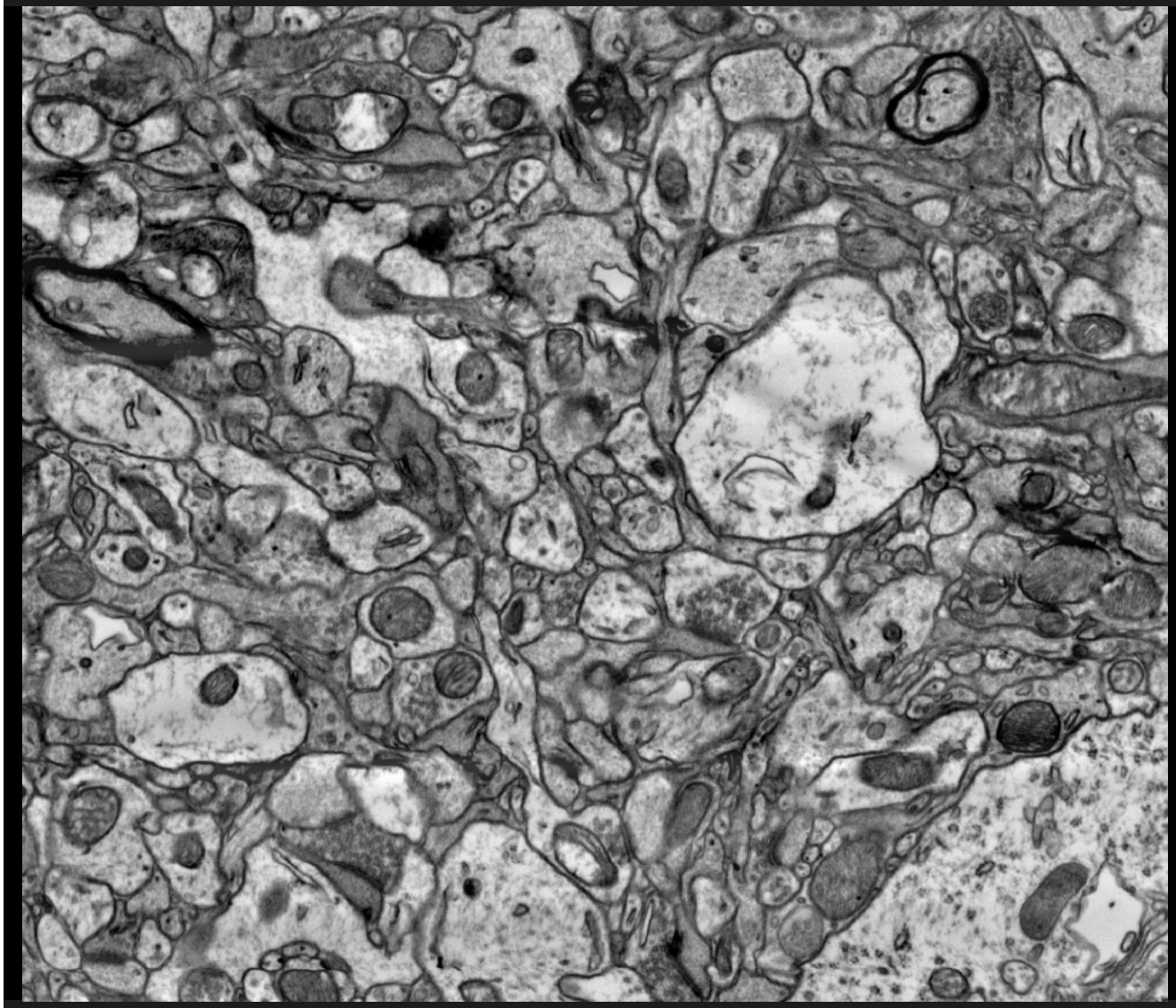
Brainbow

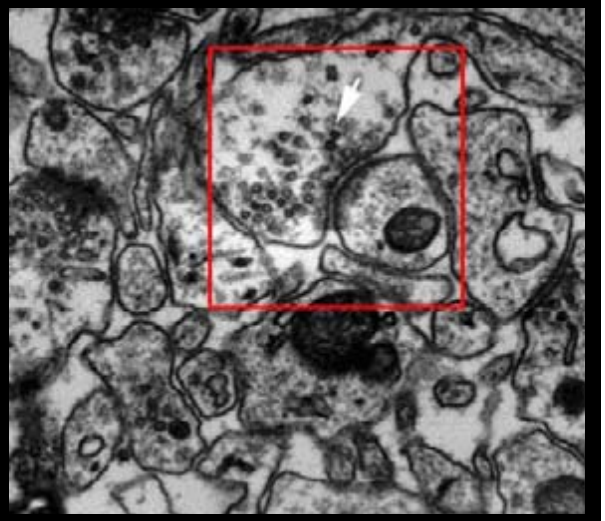


Images: Lichtman Lab, Harvard

HARVARD MEDICAL SCHOOL

Imaging the Brain: Electron Microscopy



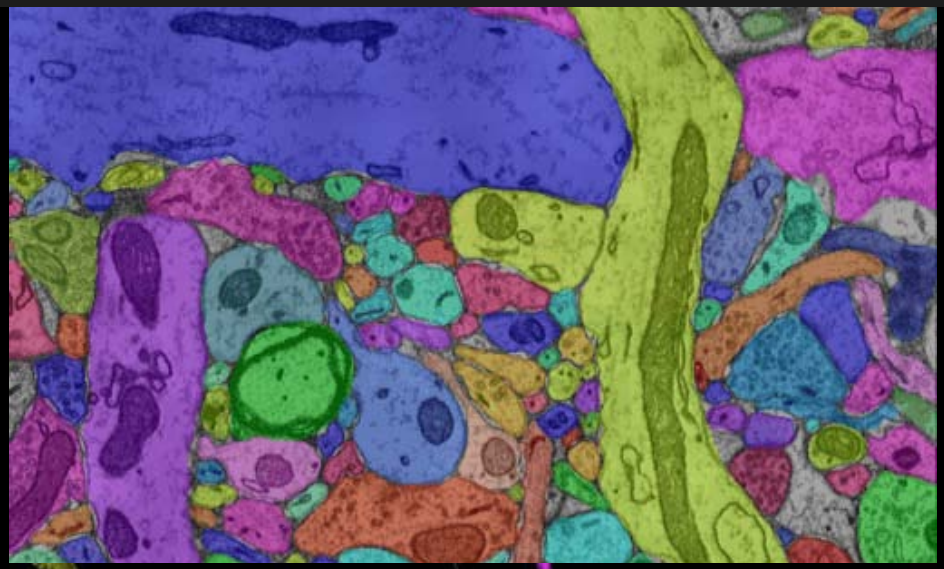


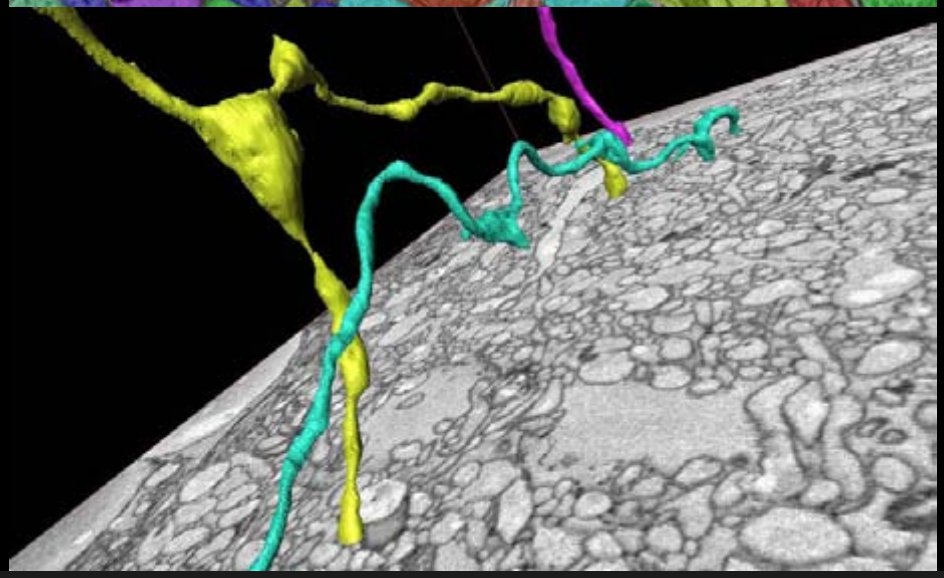
A Synapse!

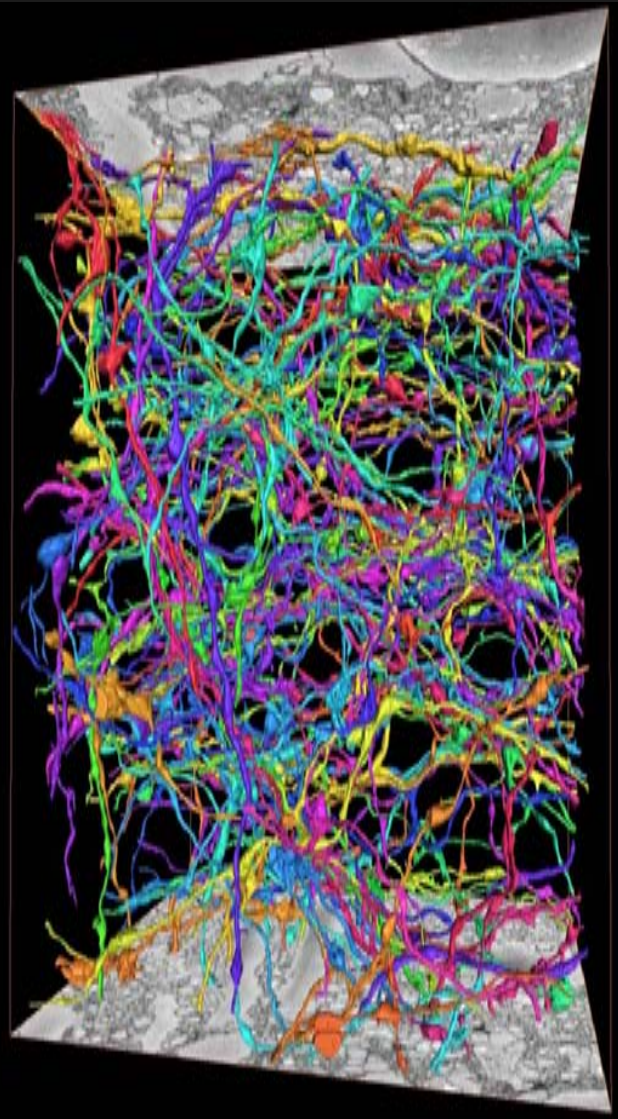
Images: D Berger, SS Seung, N.Kasthuri, K.Hayworth,& JW Lichtman
Wikimedia Commons; Allison Nishitani

HARVARD MEDICAL SCHOOL

Imaging the Brain: Electron Microscopy



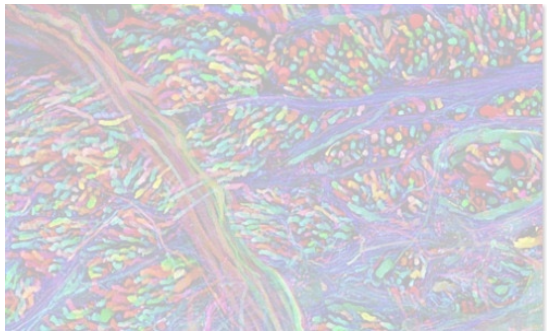




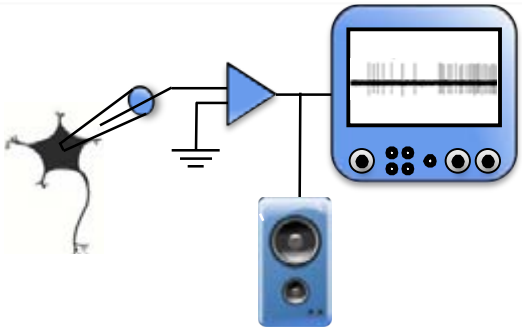
Images: D Berger, SS Seung, W Denk, N.Kasthuri, K.Hayworth,& JW Lichtman

HARVARD MEDICAL SCHOOL

Outline



- Studying physical connections

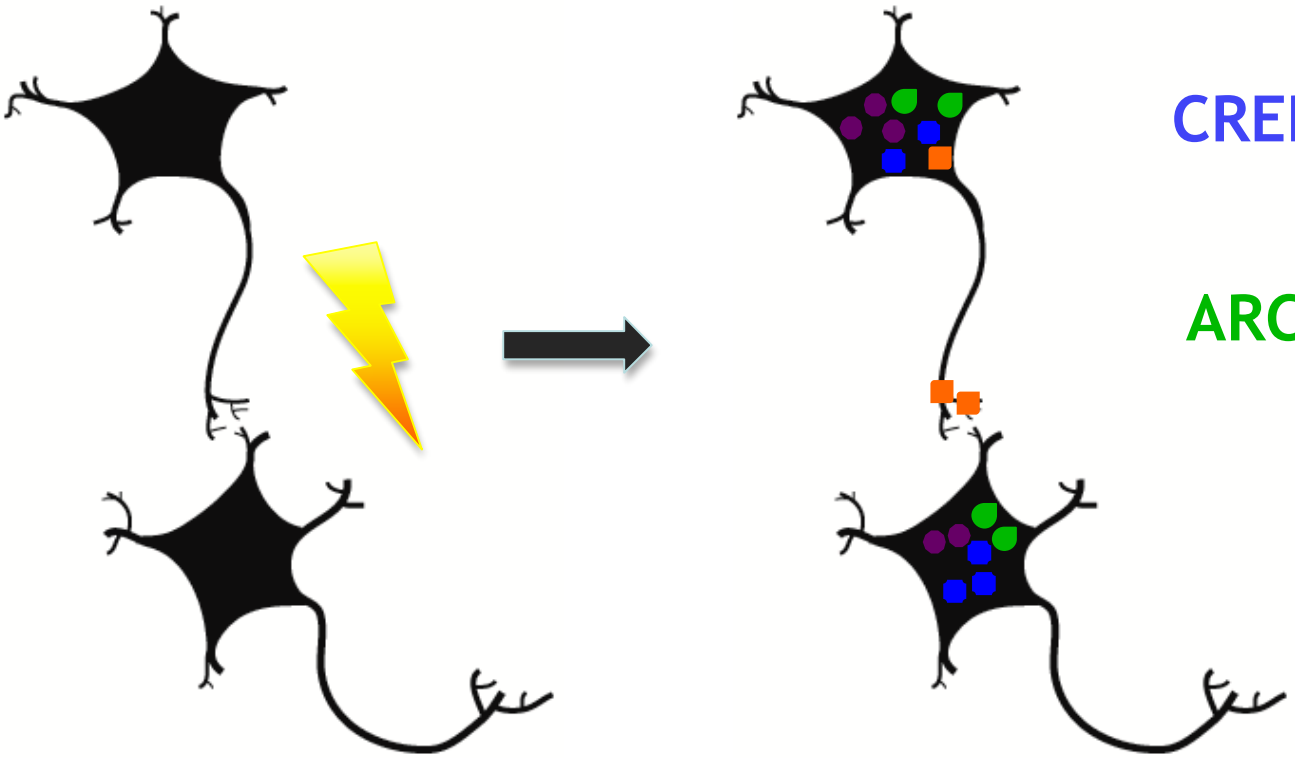


- Studying communication between neurons

- Human studies

Images: Lichtman Lab, Nevit Dilmen

Neurons Communicate Electrically

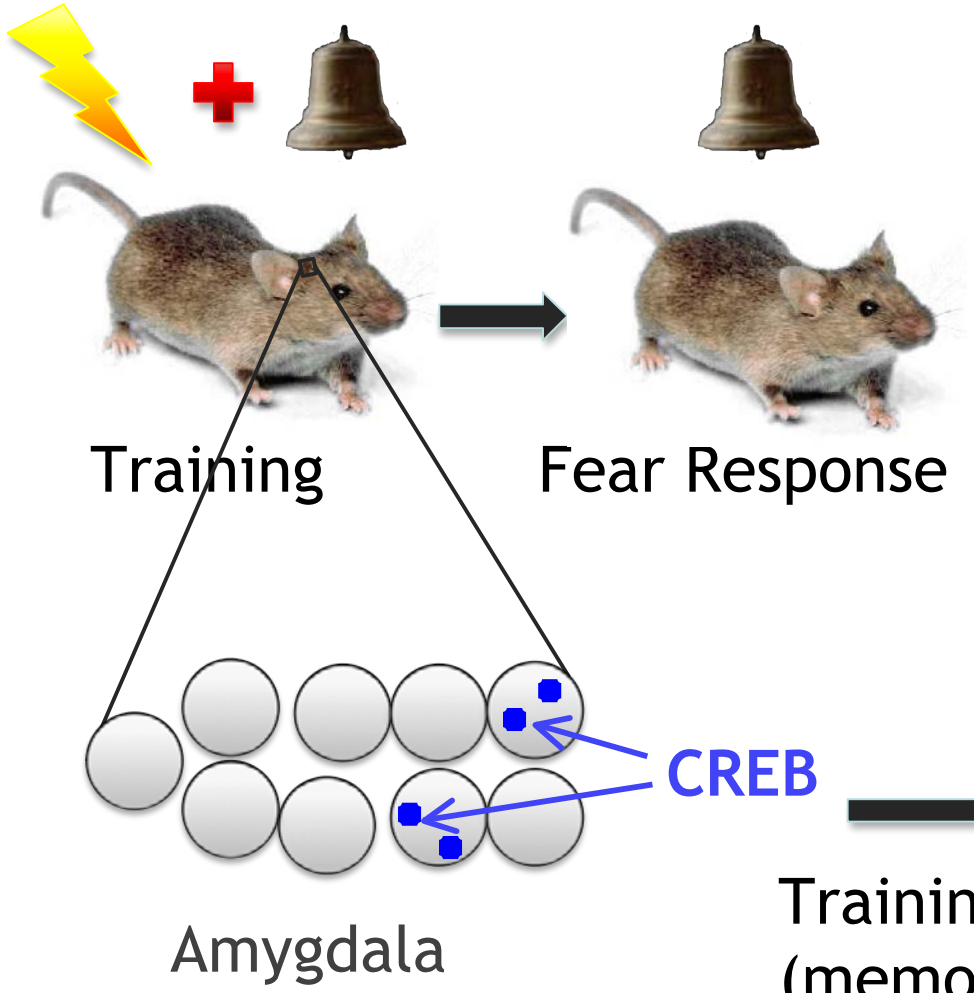


CREB ⇔ activity

ARC ⇔ memory

Images: Allison Nishitani

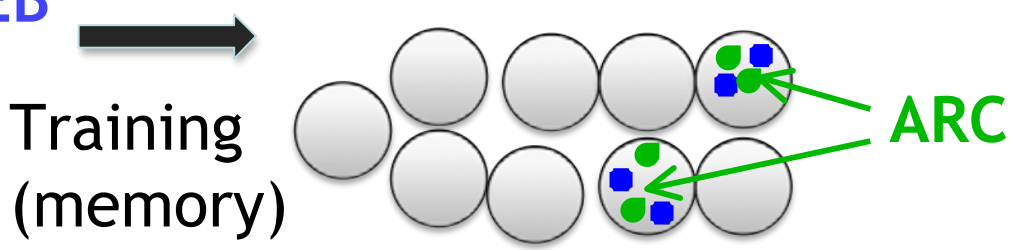
What neurons encode memory?



Can measure levels of proteins:

-CREB ⇔ neuronal activity
-High ARC ⇔ cell involved in the memory

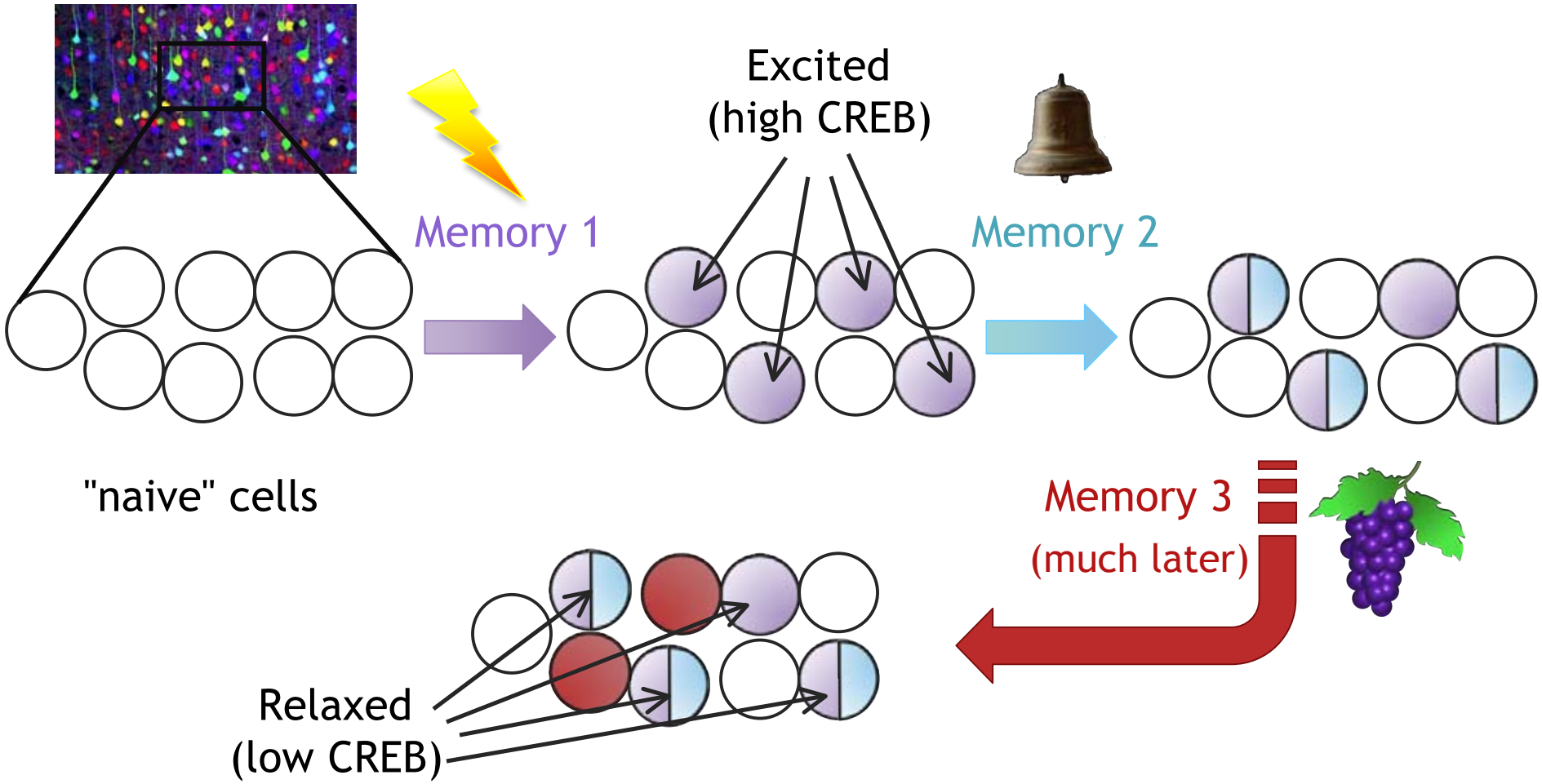
-Increase level of CREB in certain neurons
- Same neurons have higher levels of ARC → encode memory!



Images: Wikimedia Commons, Max Wahrhaftig
Credit: Han, J.H *et al.* Neuronal competition and selection during memory formation. *Science* (2007)

HARVARD MEDICAL SCHOOL

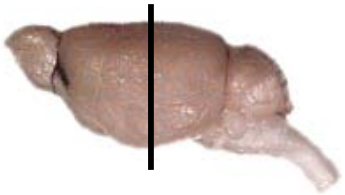
Memory Allocation in Neural Circuits



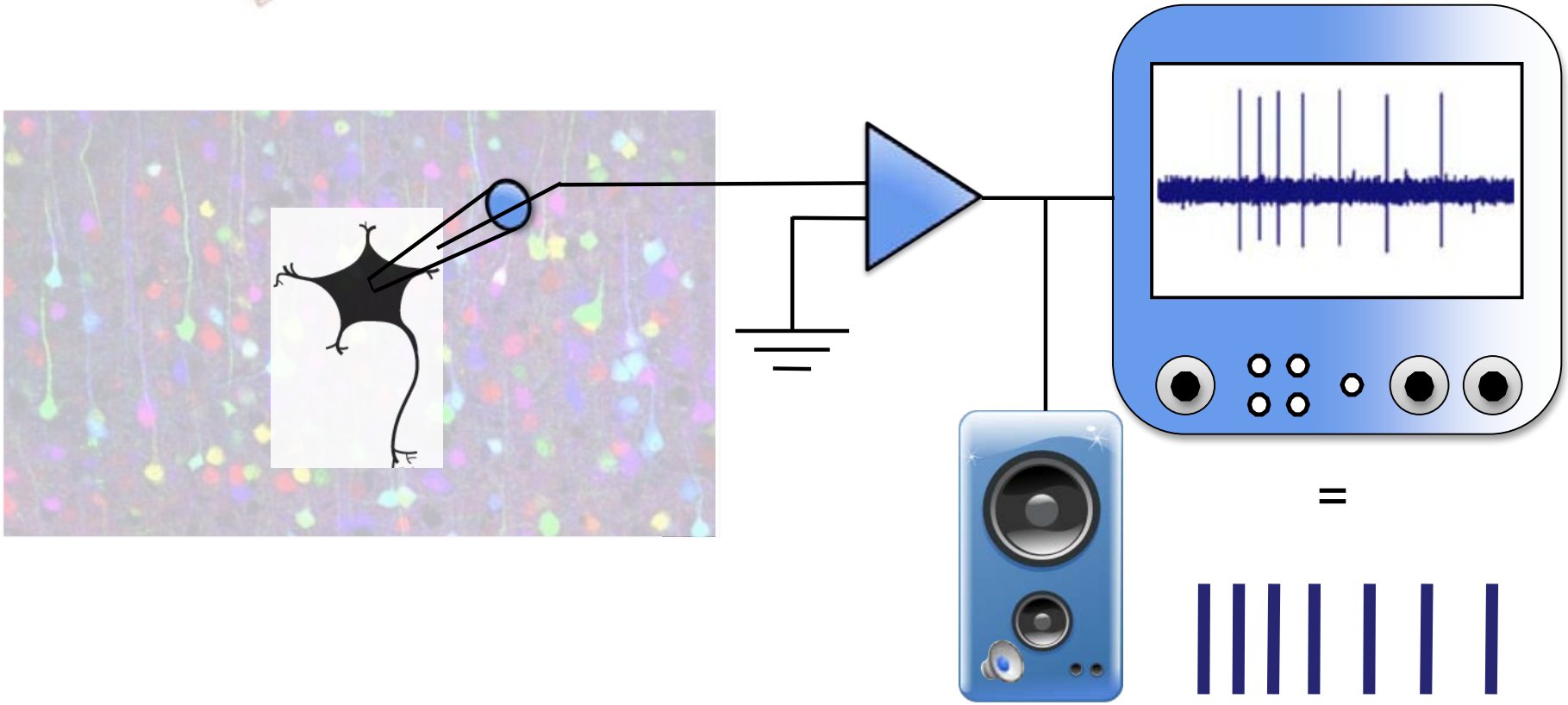
Silva, A.J. *et al.* Molecular and Cellular Approaches to Memory Allocation in Neural Circuits. *Science* (2009)

HARVARD MEDICAL SCHOOL

Neuroscientists Can “Listen” To Neurons!



A neuron’s activity is electrical by nature!



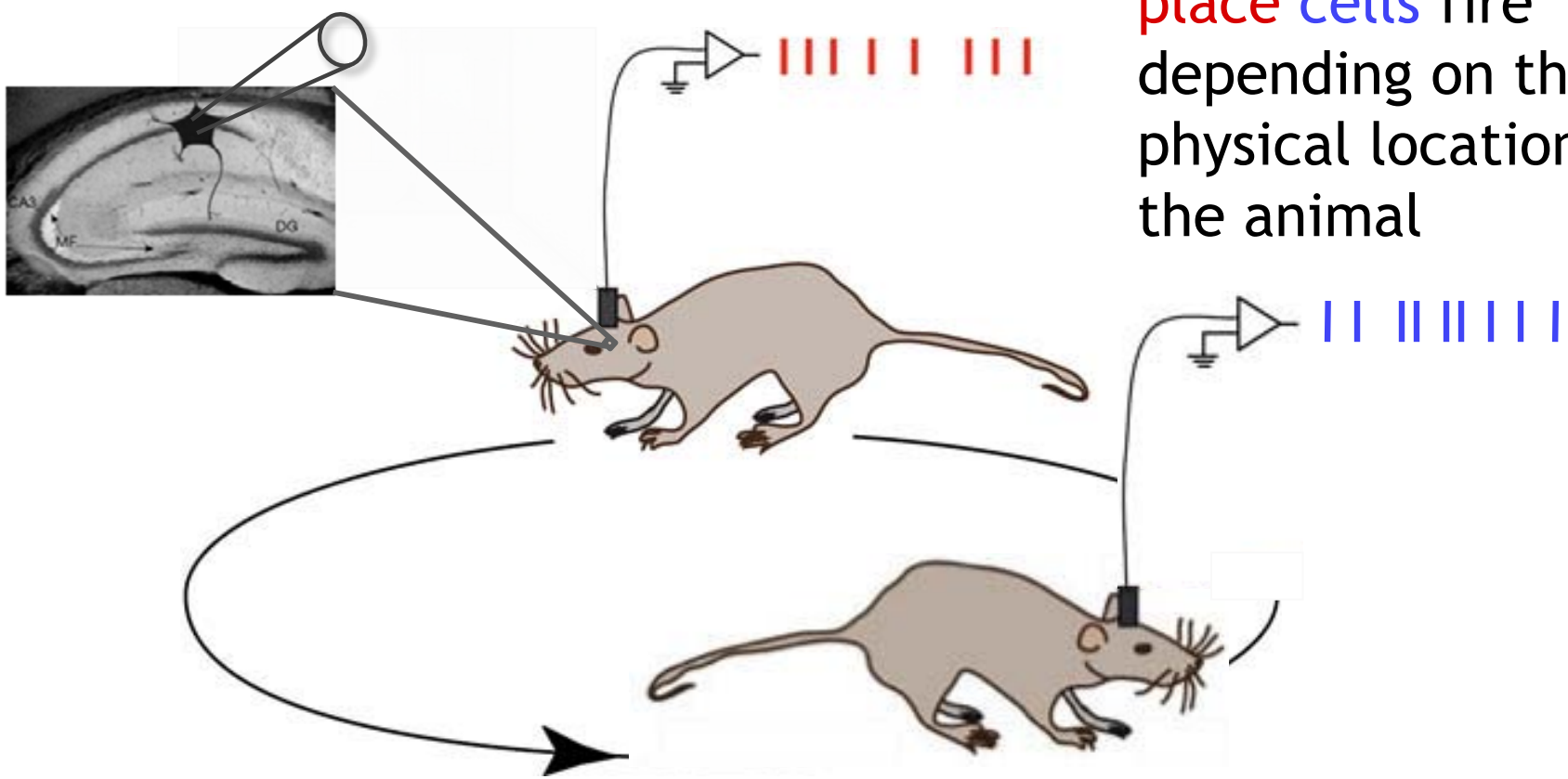
Images: Brainbow: Lichtman Lab; speaker: clipart.org;
mouse brain: http://jp.physoc.org/content/572/2/393/F3.expansion

HARVARD MEDICAL SCHOOL

Neuroscientists Can "Listen" To Neurons!

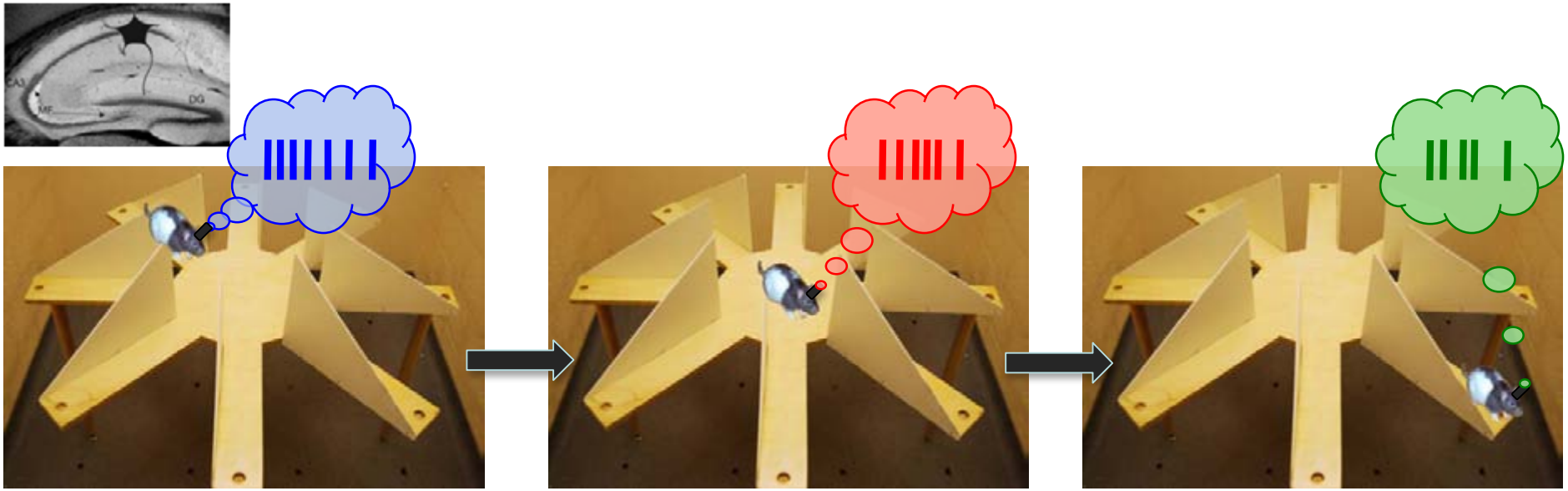
Scientists can monitor the activity of neurons in a freely behaving animal!

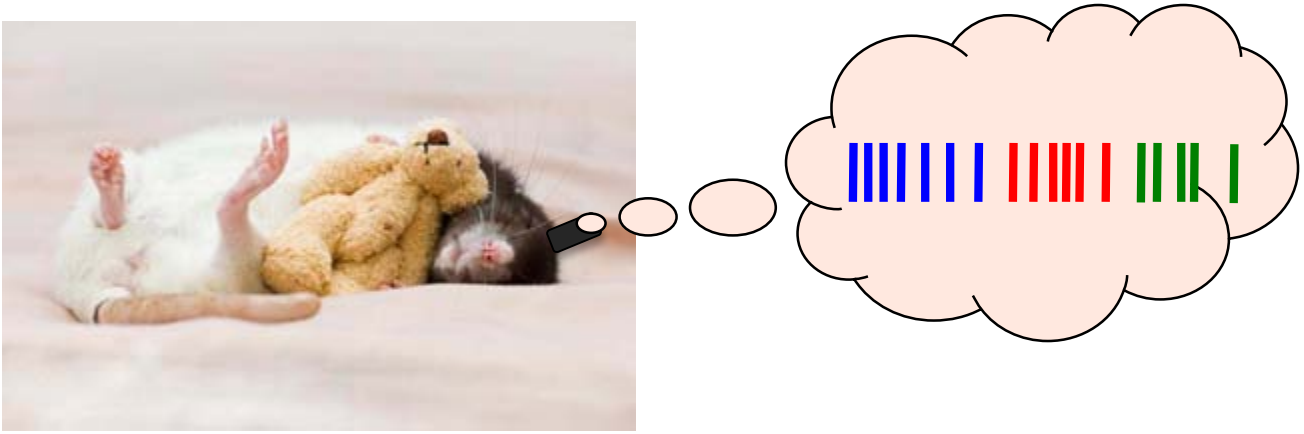
In the hippocampus, place cells fire depending on the physical location of the animal



Images: rat: www.hfsp.org; hippocampus: Wikimedia Commons

Memory Reactivation During Sleep



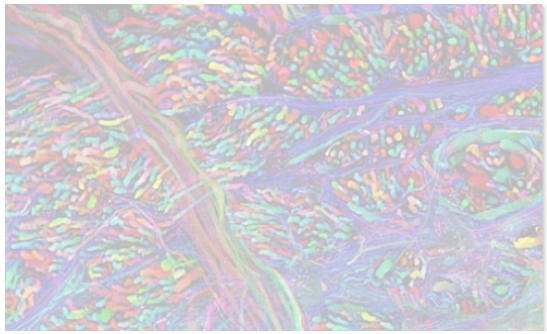


Reactivation occurs both in hippocampus and cortex

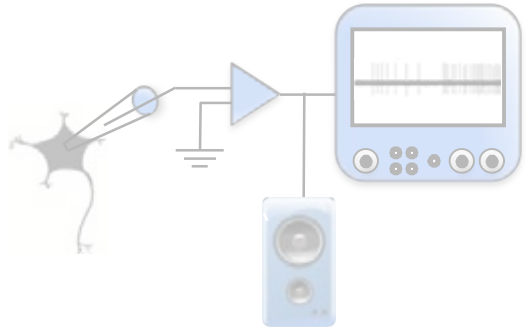
Wilson, M.A. and McNaughton, B.L. Reactivation of hippocampal ensemble memories during sleep. *Science* (1994)

HARVARD MEDICAL SCHOOL

Outline



- Studying connections



- Studying communication between neurons

- Human studies

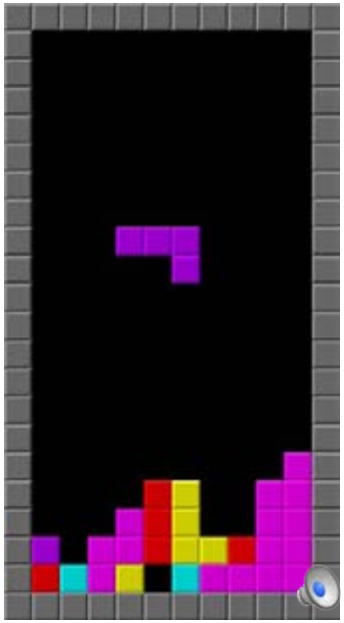
Images: Lichtman Lab, Nevit Dilmen

In Humans, Sleep is Crucial for Memory

Everyone knows that sleep can help people remember better

Have you ever played

TETRIS ?



Then you must be familiar with this picture… from your dreams!

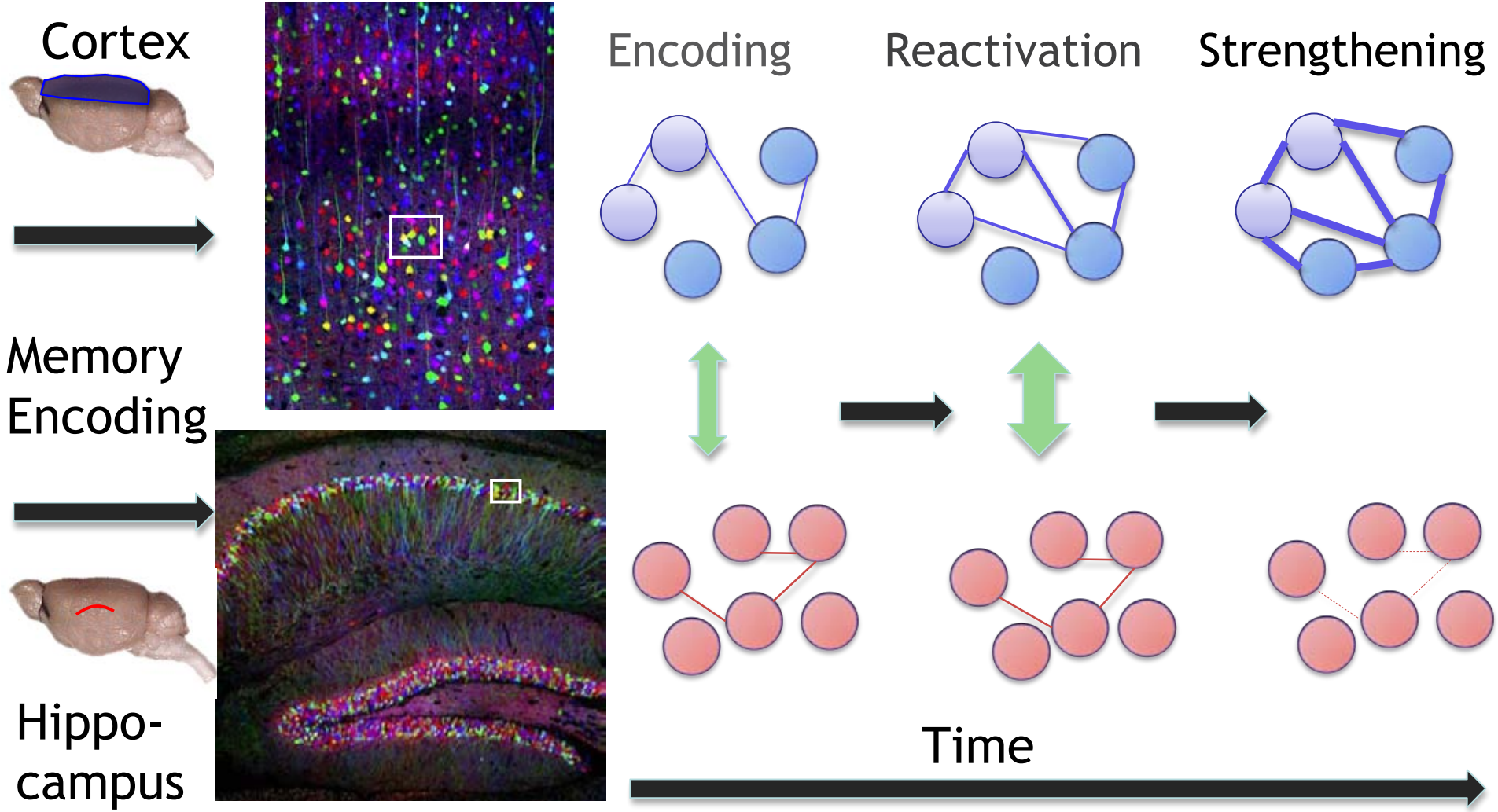
Replaying memories during sleep might help consolidate them

"Sleeping on it" is not just an old saying

Pictures: wikipedia commons, music: http://www.wrongway.org/?polltetris
Stickgold, R. *et al*. Replaying the game: hypnagogic images in normals and amnesics. Science (2000)

HARVARD MEDICAL SCHOOL

Memory Consolidation Model

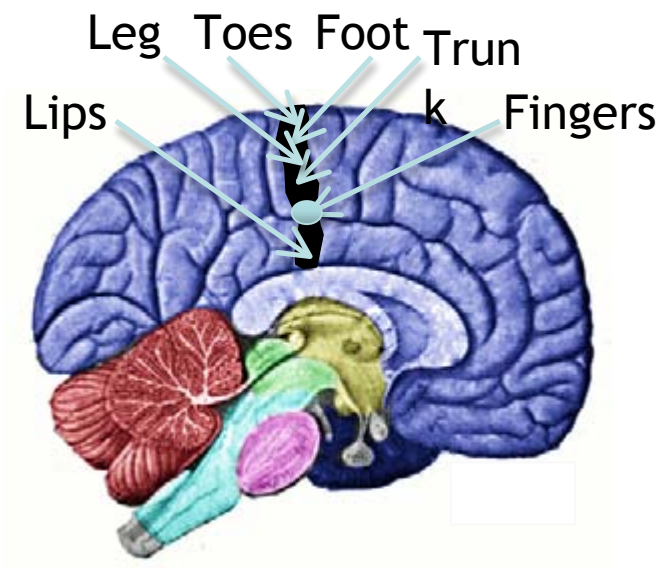


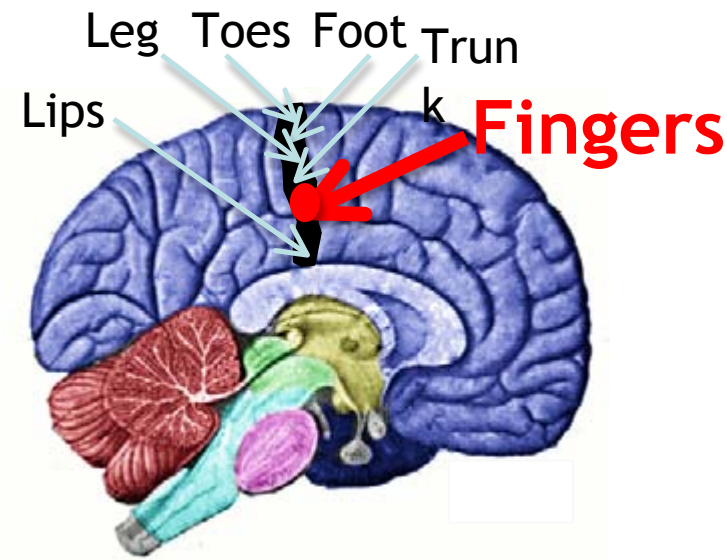
Images: Wikimedia Commons, Tamily Weissman, Lichtman Lab
Frankland PW and Bontempi B. The organization of recent and remote memories. *Nature Neuroscience* (2005)

HARVARD MEDICAL SCHOOL

Brain Area "Memory"

Training usually increases performance in the particular task





Training can increase the brain area devoted to the task!

Can this be applied to memory in general?

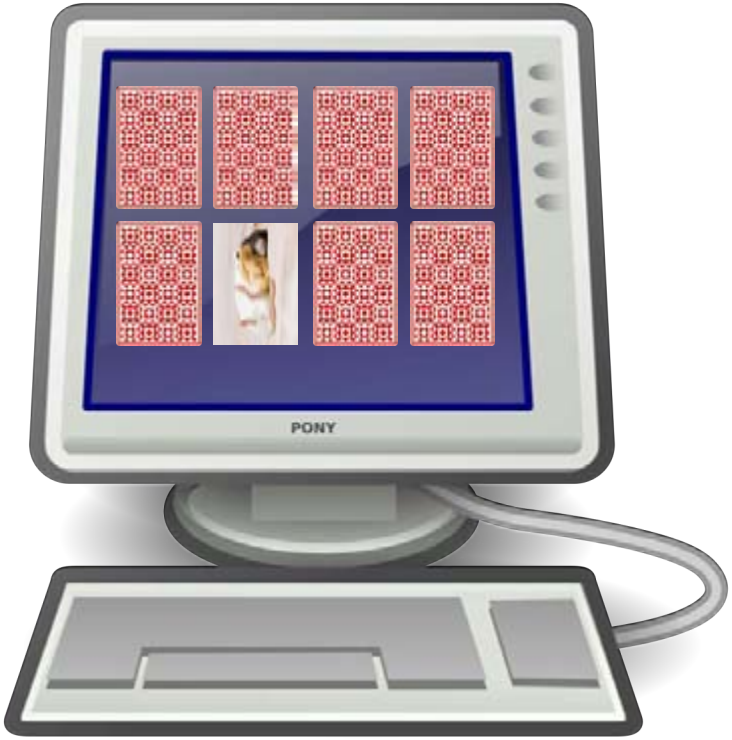
Images: Wikimedia Commons

Brain Training: Memory

Vol 465|10 June 2010|doi:10.1038/nature09042 nature

Putting brain training to the test

Adrian M. Owen[1], Adam Hampshire[1], Jessica A. Grahn[1], Robert Stenton[2], Said Dajani[2], Alistair S. Burns[3], Robert J. Howard[2] & Clive G. Ballard[2]



- 6-week online study of brain training, including some memory games
- After training, test on different tasks

Pictures: Nevit Dilmen
Owen, AM *et al*. Putting brain training to the test. *Nature* (2010)

HARVARD MEDICAL SCHOOL

Brain Training: Memory

Vol 465|10 June 2010|doi:10.1038/nature09042 nature

Putting brain training to the test

Adrian M. Owen[1], Adam Hampshire[1], Jessica A. Grahn[1], Robert Stenton[2], Said Dajani[2], Alistair S. Burns[3], Robert J. Howard[2] & Clive G. Ballard[2]

…1 5 6 8 9 2 3 3 5…

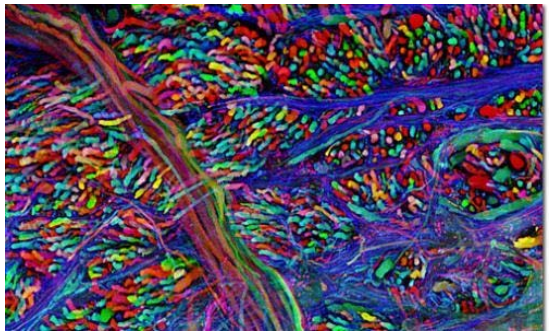
"The increase in the number of digits that could be remembered following training (…)was three-hundredths of a digit. (…)it would take almost four years of training to remember one extra digit."

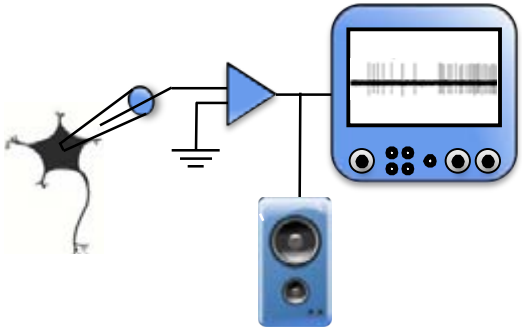
- 6-week online study of brain training, including some memory games
- After training, test on different tasks
- **Found no advantage of training on general memory!**

Pictures: Nevit Dilmen
Owen, AM *et al*. Putting brain training to the test. *Nature* (2010)

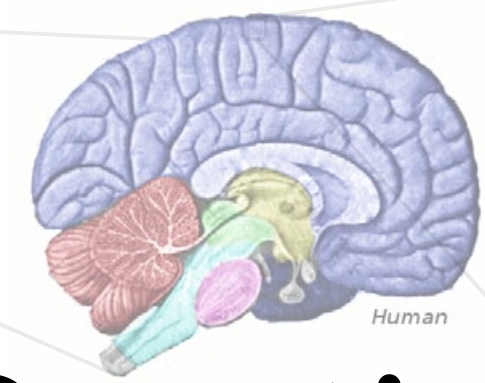
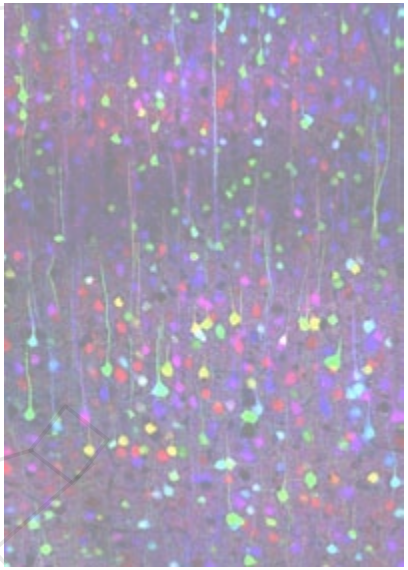
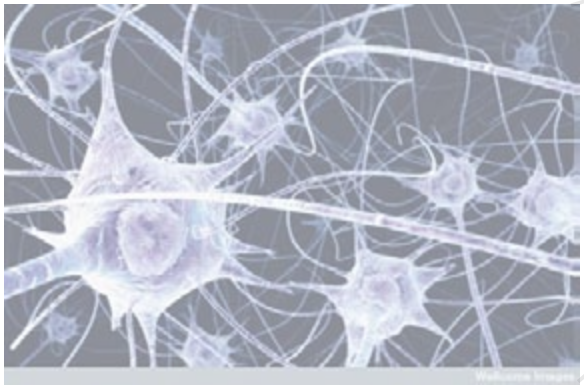
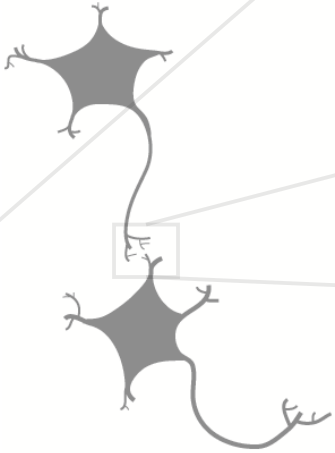
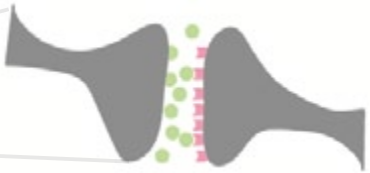
HARVARD MEDICAL SCHOOL

Summary





- New imaging techniques can show how the brain is connected
- Neuroscientists can eavesdrop on neural activity
- Reactivation of experiences during sleep strengthens neuronal connections
- Memory consolidation is thought to involve the hippocampus where short-term memories are stored, and the cortex, where long term memories are stored
- The brain is plastic but memory training does not seem to improve general memory abilities



Question?