9.01 Introduction to Neuroscience
Fall 2007

Working memory

- short-term memory +
- active manipulation of information

Wisconsin card sorting test

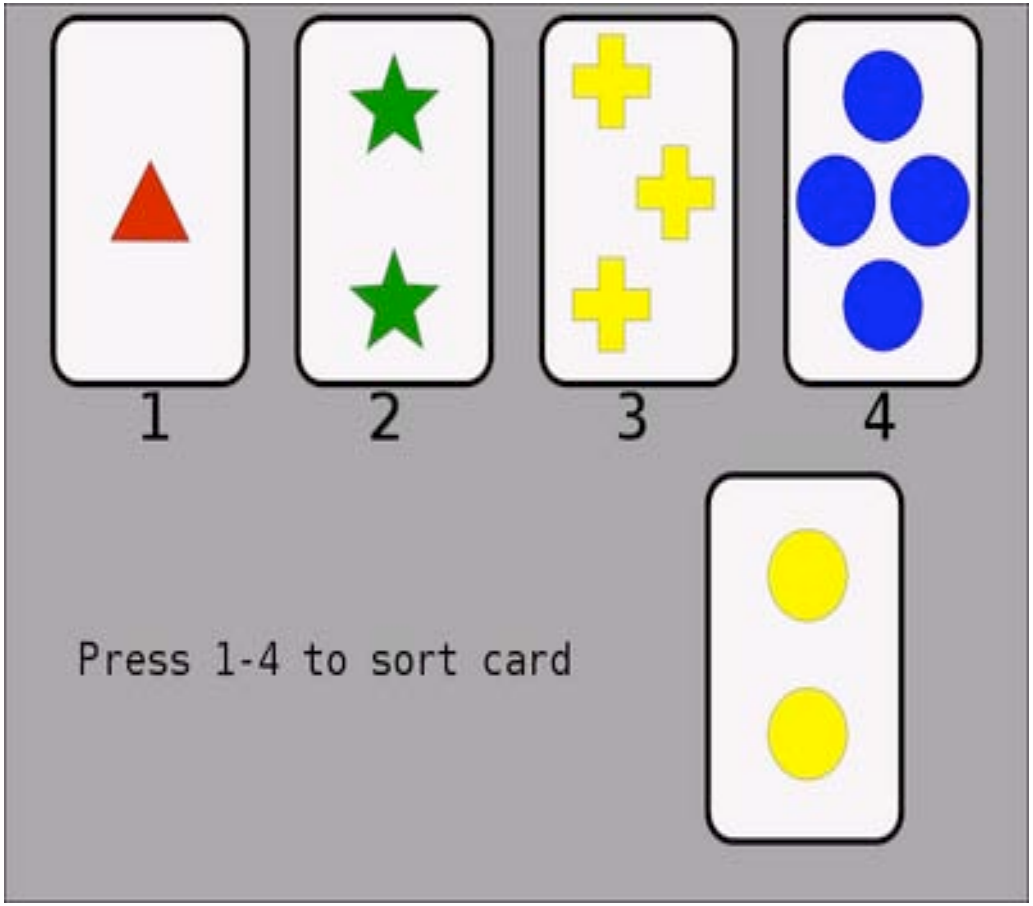

Image generated in PEBL: The Psychology Experiment Building Language (http://pebl.sourceforge.net/).

Errors of perseveration

- The task is switched
  - number, shape, or color.
- The switch is signaled only by feedback on whether choices are right or wrong.
- Lesions of prefrontal cortex
  - subjects have trouble switching.

Delayed-match-to-sample task

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Diagram of monkey performing delayed-match-to
-sample task, with a graph of results (spikes/second).

Persistent neural activity

- In many brain areas, a transient stimulus can cause a persistent change in neural activity.
- This is a neural correlate of short-term memory.

Radial arm maze

- Hippocampal lesion causes working memory deficit.
- Rats can't seem to remember which arms they have just visited.

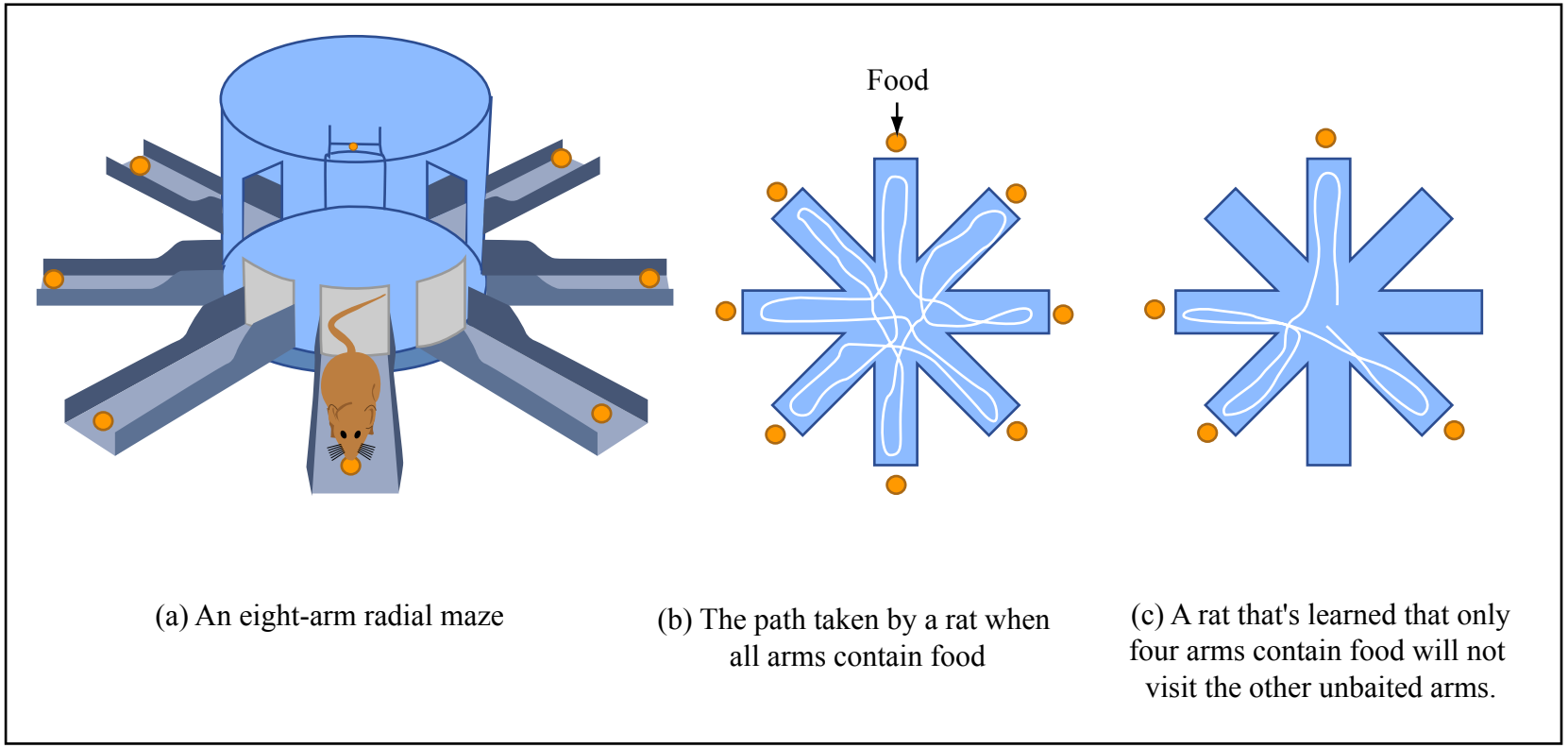

Figure by MIT OpenCourseWare. After Figure 24.15 in Bear, Mark F., Barry W. Connors, and Michael A. Paradiso. *Neuroscience: Exploring the Brain*. 3rd ed. Baltimore, MD: Lippincott Williams & Wilkins, 2007. Parts b and c adapted from Cohen and Eichenbaum, 1993.

Place cells

- Neural basis of cognitive maps?

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See Figure 24.17 in Bear, Mark F., Barry W. Connors, and Michael A. Paradiso. *Neuroscience: Exploring the Brain*. 3rd ed. Baltimore, MD: Lippincott Williams & Wilkins, 2007.

Nondeclarative memory

Classical (Pavlovian) conditioning

- U and C: unconditioned and conditioned
- S and R: stimulus and response
- before conditioning: US evokes UR
- conditioning: pairing of CS and US
- after conditioning: CS evokes CR

Timing requirements

- CS simultaneous with US
- CS preceding US by short interval
  - though there are exceptions

Instrumental (operant) conditioning

- make reward conditional on a particular behavior
- e.g. Thorndike's puzzle box

Aplysia californica

- California sea hare

Gill withdrawal reflex

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See Figure 25.4 in Bear, Mark F., Barry W. Connors, and Michael A. Paradiso. *Neuroscience: Exploring the Brain*. 3rd ed. Baltimore, MD: Lippincott Williams & Wilkins, 2007.

Habituation

- reflex: siphon touch causes gill withdrawal
- with repetition, the amplitude of the response decreases

Abdominal ganglion

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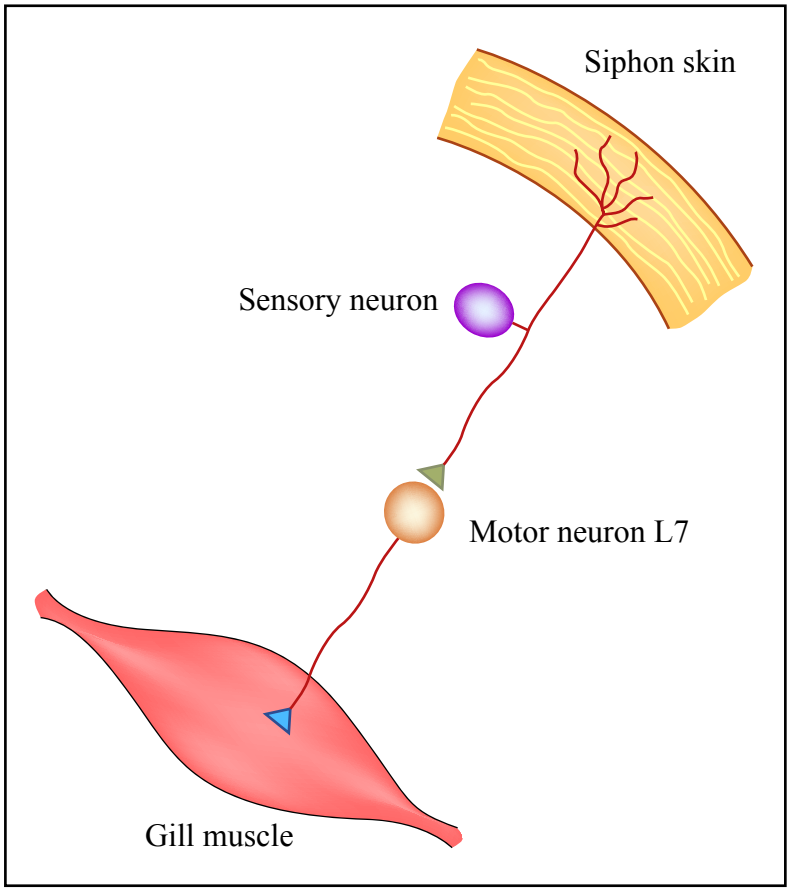
See Figure 25.5 in Bear, Mark F., Barry W. Connors,
and Michael A. Paradiso. *Neuroscience: Exploring the Brain*.
3rd ed. Baltimore, MD: Lippincott Williams & Wilkins, 2007.

Reflex arc

- What part of this neural circuit changes during habituation?



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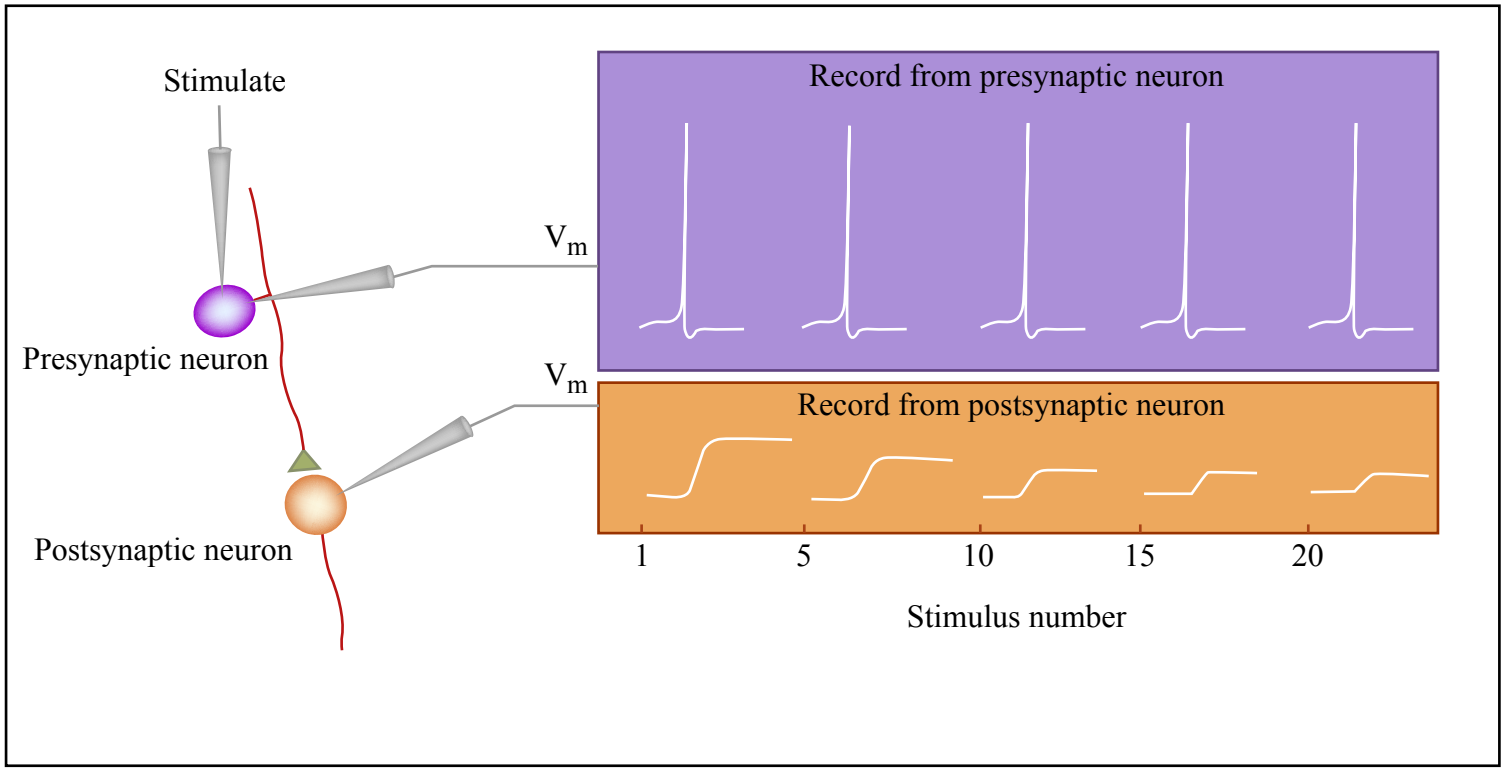
Decrease in efficacy of sensory to motor neuron transmission



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Sensitization

- Pairing siphon touch with an electrical shock makes the gill withdrawal larger.
- If this pairing is repeated, the effect is longer-lasting.
- The shock may follow the touch by up to 0.5 seconds.

Wiring diagram for sensitization

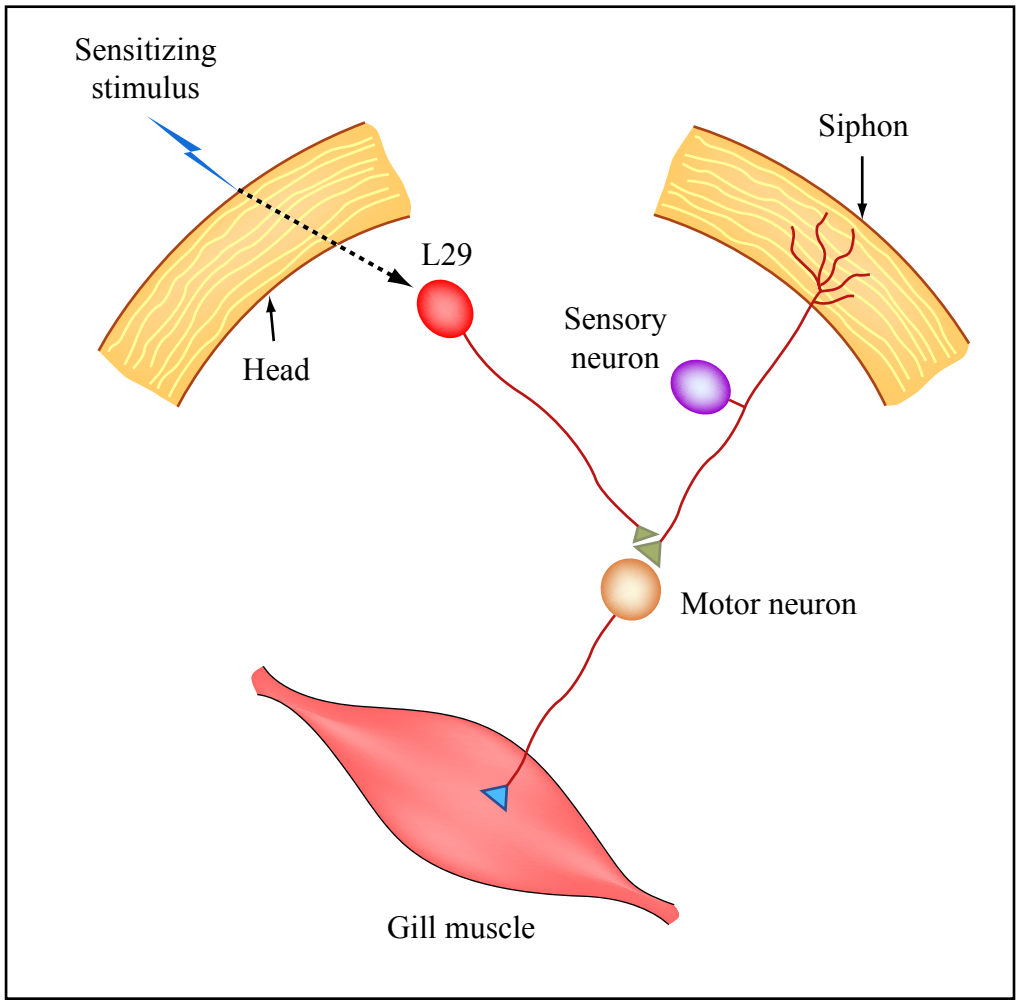


Figure by MIT OpenCourseWare. After Figure 25.8 in Bear, Mark F., Barry W. Connors, and Michael A. Paradiso. *Neuroscience: Exploring the Brain*. 3rd ed. Baltimore, MD: Lippincott Williams & Wilkins, 2007.

Serotonergic modulation

- shock causes L29 to release serotonin
- presynaptic serotonin receptors activate adenylyl cyclase
- cAMP is generated and activates PKA
- PKA phosphorylates potassium channels, reducing conductance
- the action potential becomes longer
- more calcium enters, so there is more release

Schaffer collateral LTP (in vitro)

Diagram and pair of graphs removed due to copyright restrictions.

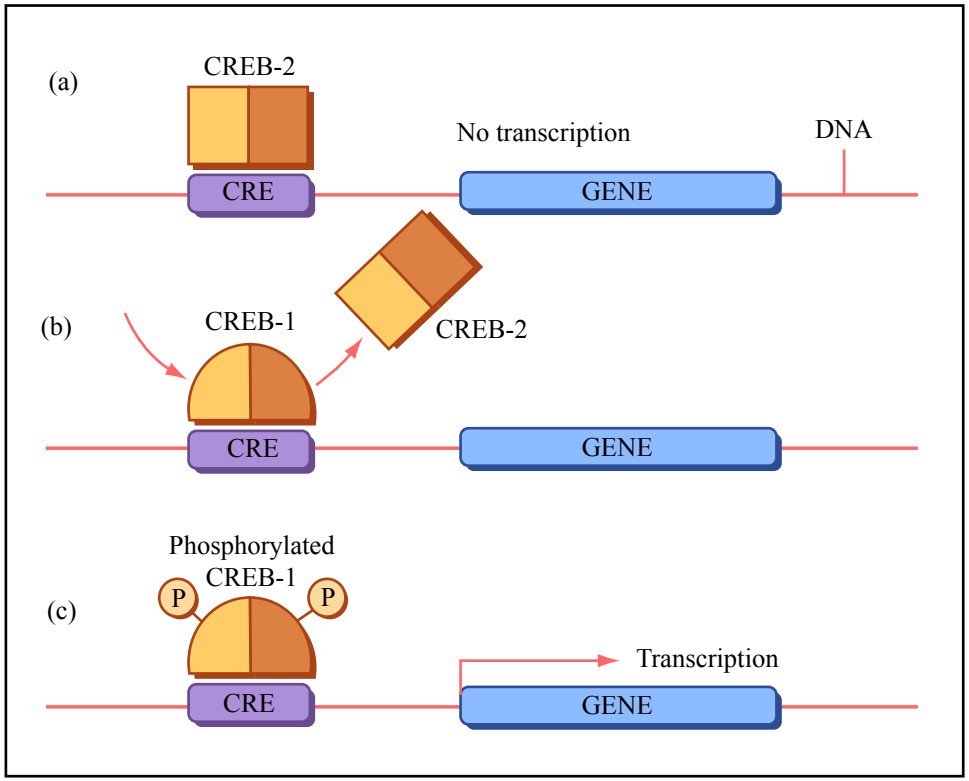
Molecular basis of memory

- Receptor phosphorylation
- Receptor insertion
- Protein synthesis

Protein synthesis

- Inhibitors of protein synthesis can prevent memory consolidation.

CREB



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In vivo imaging of dendritic spines

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Figure 1 in Trachtenberg, J. T. et al. "Long-term in Vivo Imaging of Experience-dependent Synaptic Plasticity in Adult Cortex." *Nature* 420 (2002): 788-794. doi:10.1038/nature01273.