THE UNIVERSITY OF QUEENSLAND
AUSTRALIA

QUEENSLAND BRAIN INSTITUTE

Feedback
Education and Neuroscience

Pankaj Sah

Science of Learning

Learning

The process of acquiring a skill or knowledge that leads to a change in behaviour

Memory

The ability to retain and recover information from a previous experience

Education

Learning during which Skills/Knowledge/Ideas transferred from a teacher to student(s)
Memory formation is an essential part of Education

Information/ skills

Testing / Recall

learning

memory

Storage

3 x 6 = 15

4 x 5 = 21

The feedback loop

Teaching

Testing

Feedback

What kind of feedback?

Four general types recognised

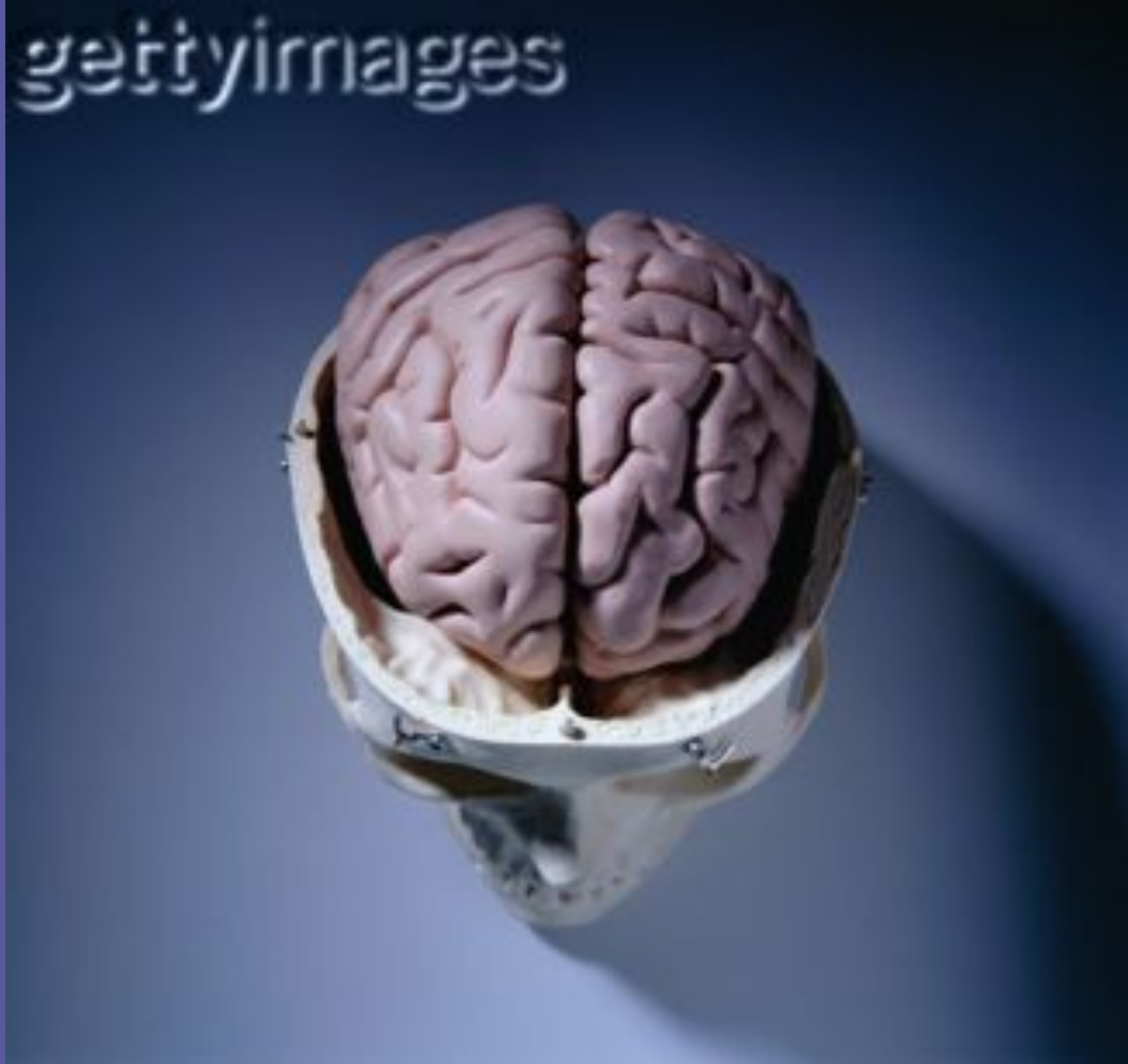
about the task

processing the task

self regulation

person

? What is the best way and how to decide
? Why does it work?


gettyimages

Theories of mental function

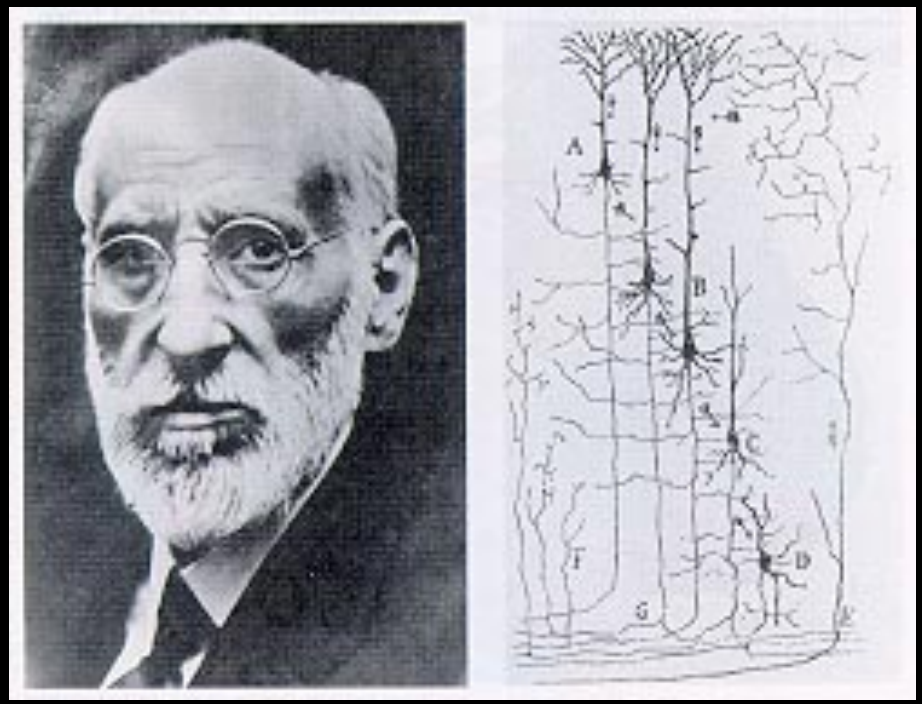
Rene Descartes - 1596-1650 the original dualist

1632, It is a problem of the mind, not the brain - a physical object

Mental function results from Neural Activity

Neuron Hypothesis 1906

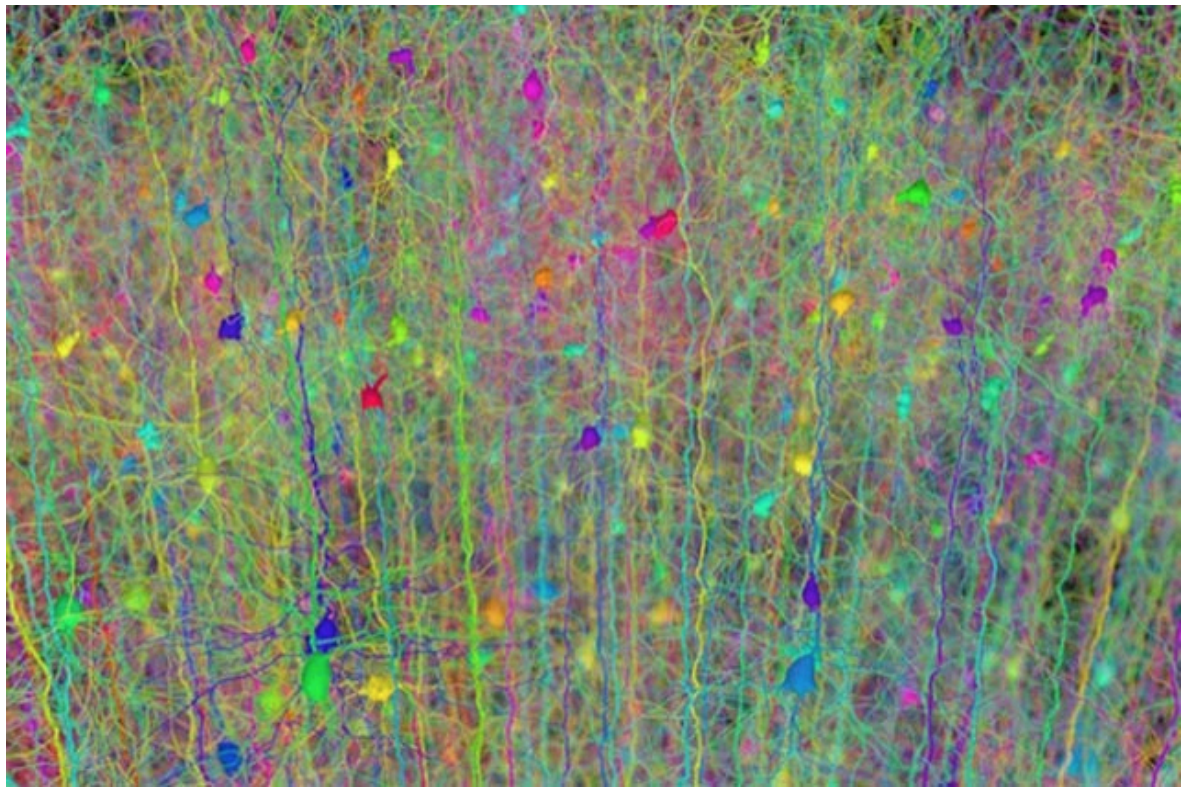
Camillo Golgi
1843-1926

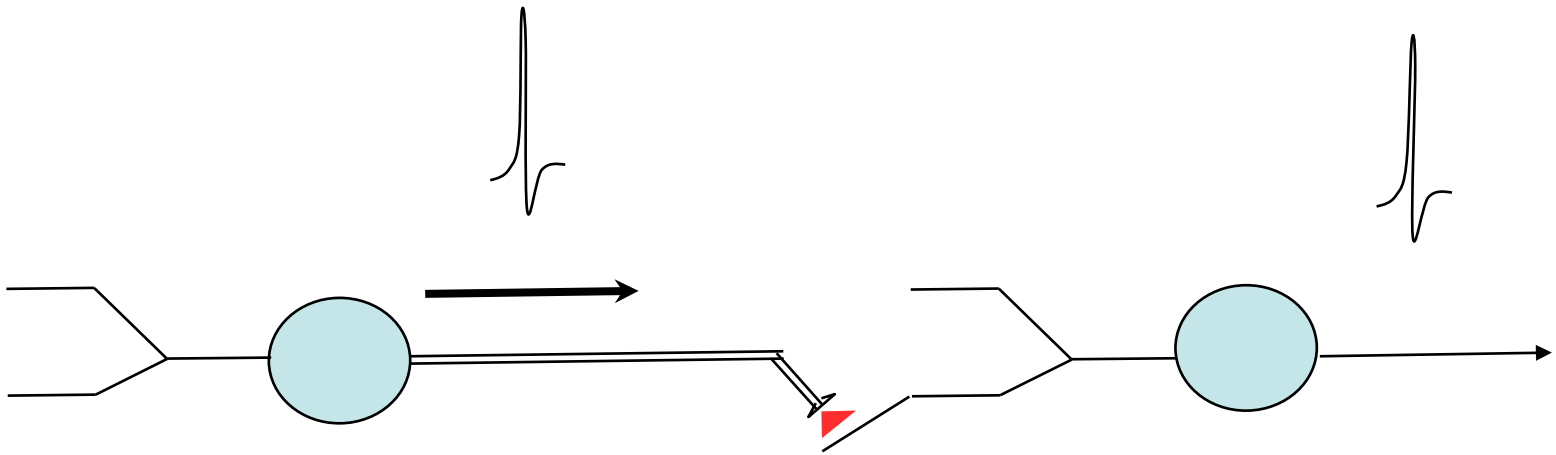


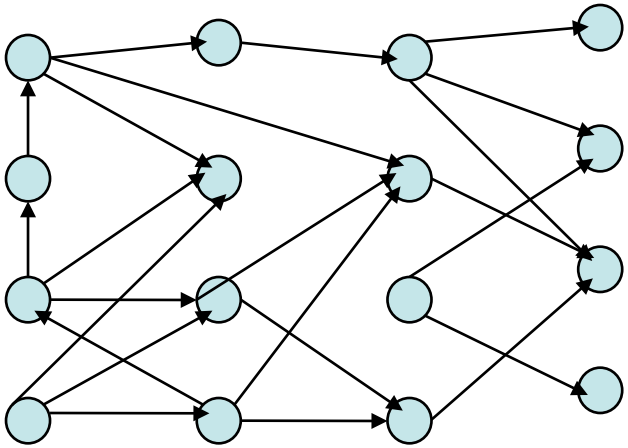
Santiago Ramon y Cajal
1852-1934

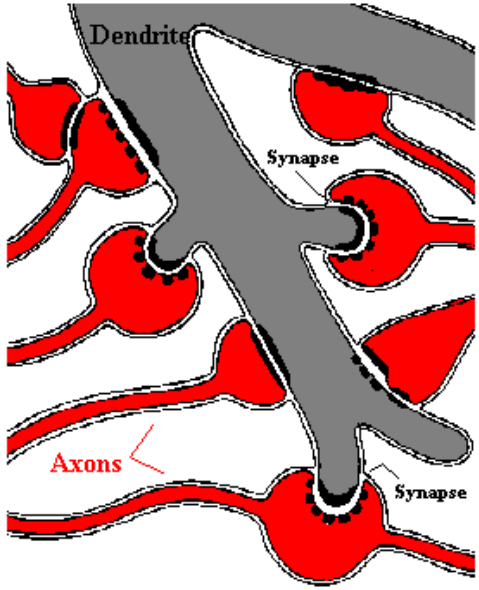
About 10^{12} neurons - 1000 billion

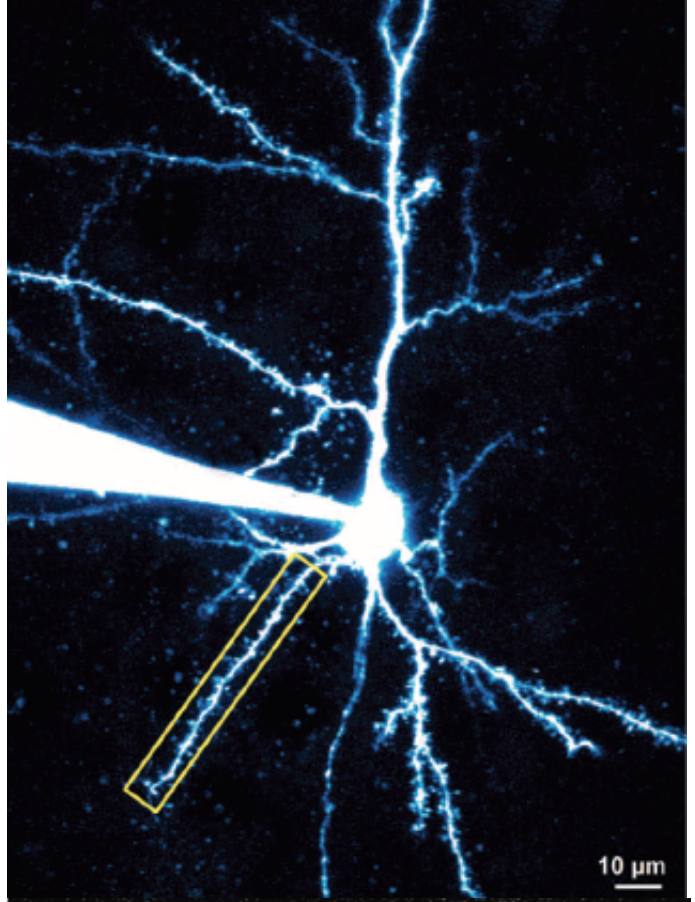
Connected in networks - an electrochemical machine







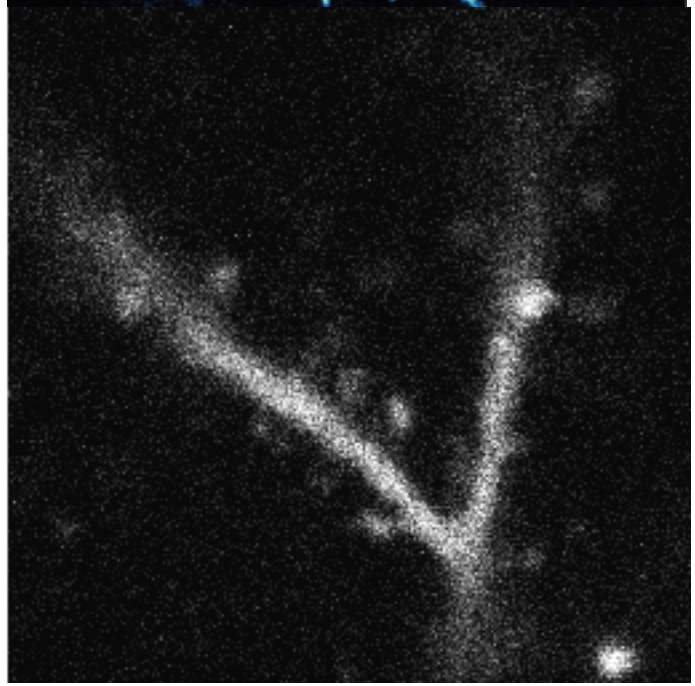




About 10^{12} neurons in human brain

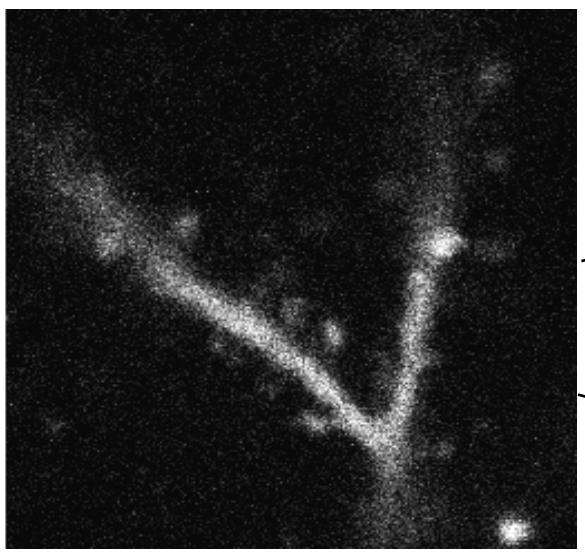
Connections are synapses

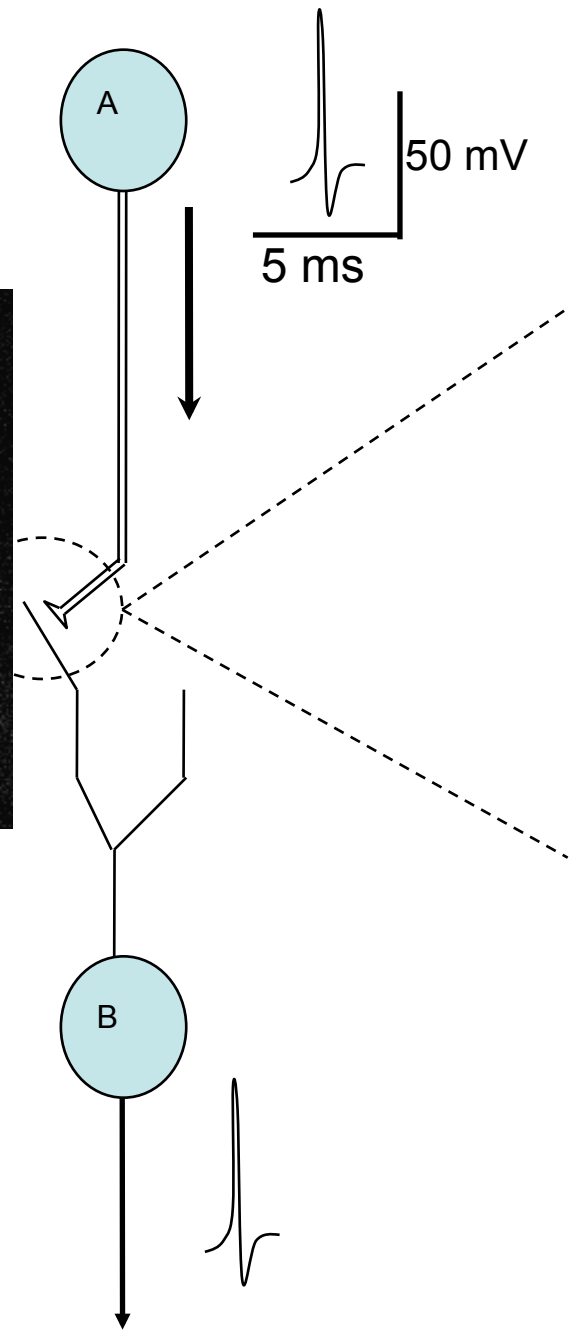
Each cell has up to 10,000 connections



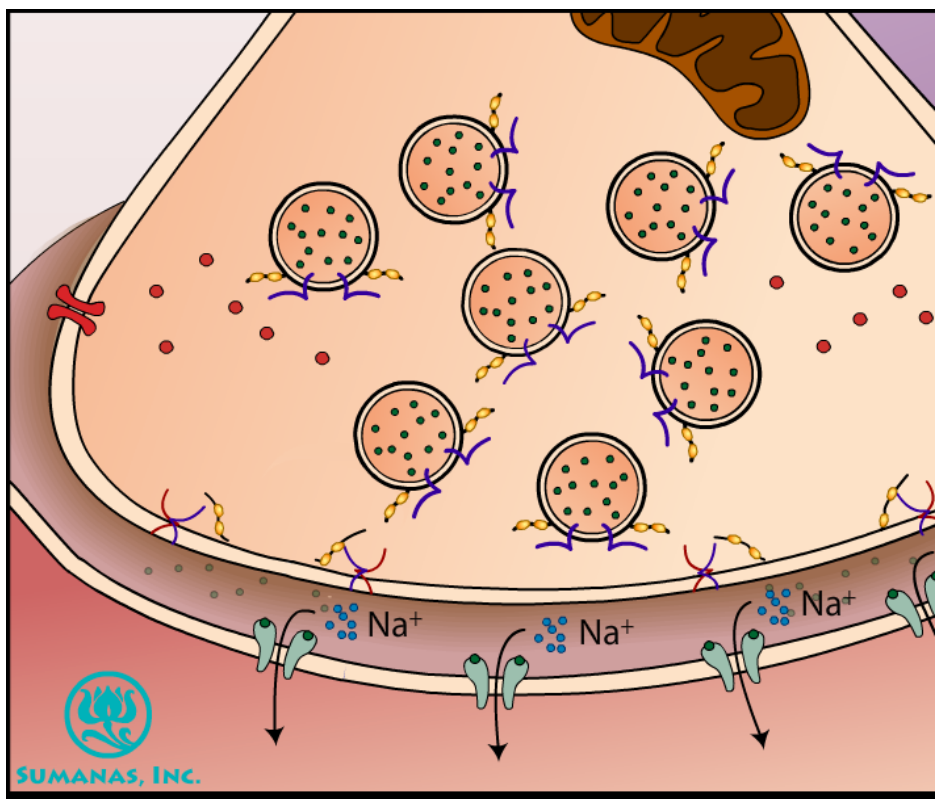
Total number of connections is immense!

Neural circuits are electrochemical machines





Presynaptic



Cellular theories of learning and memory formation

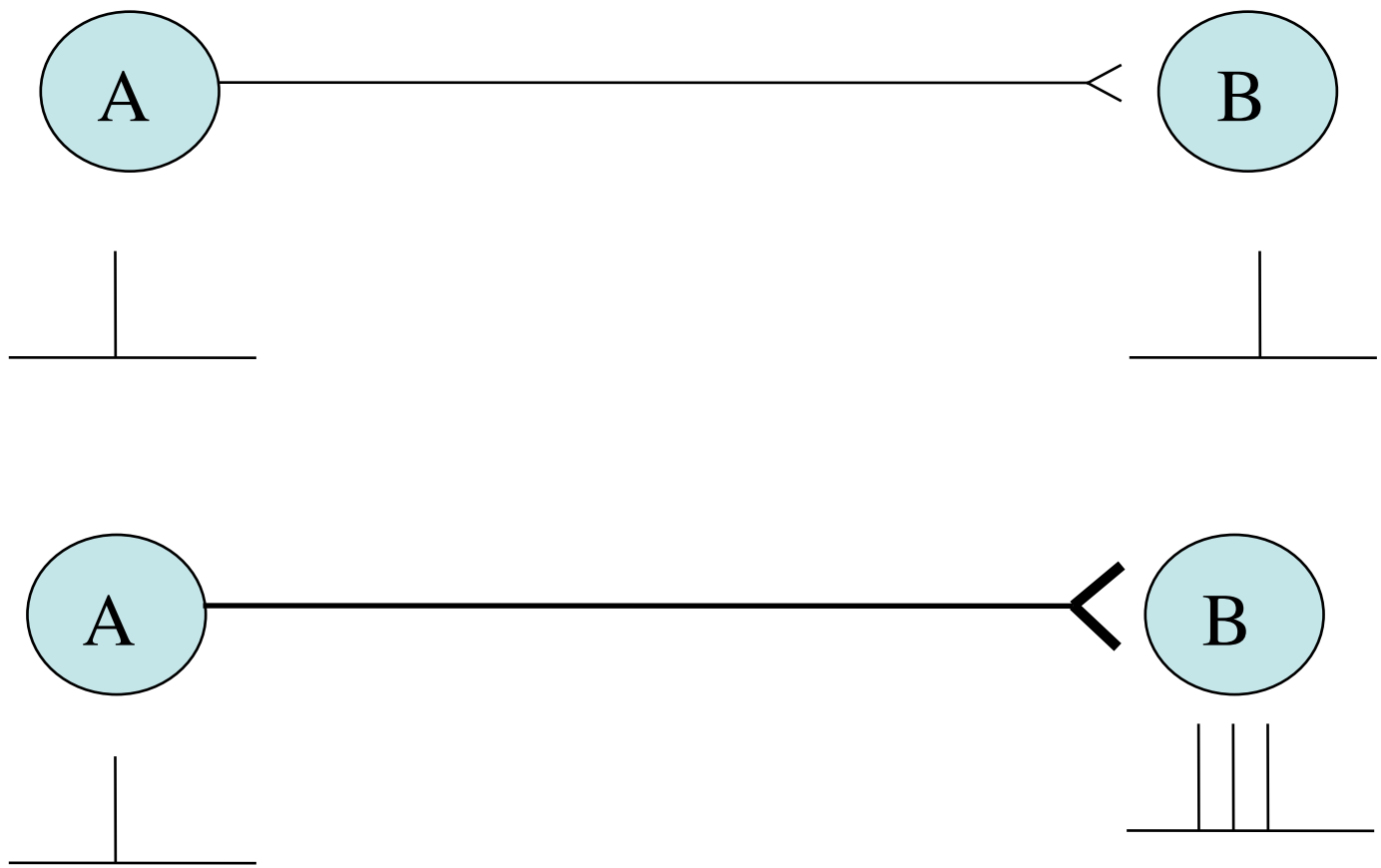
Cajal 1906 - Changes in connection strength

Donald Hebb (1949) "The organisation of behaviour"

Let us assume that the persistence or repetition of a reverberatory activity (or "trace") tends to induce lasting cellular changes that add to its stability. . . . When an axon of cell A is near enough to excite a cell B and repeatedly or persistently takes part in firing it, some growth process or metabolic change takes place in one or both cells such that A's efficiency, as one of the cells firing B, is increased.

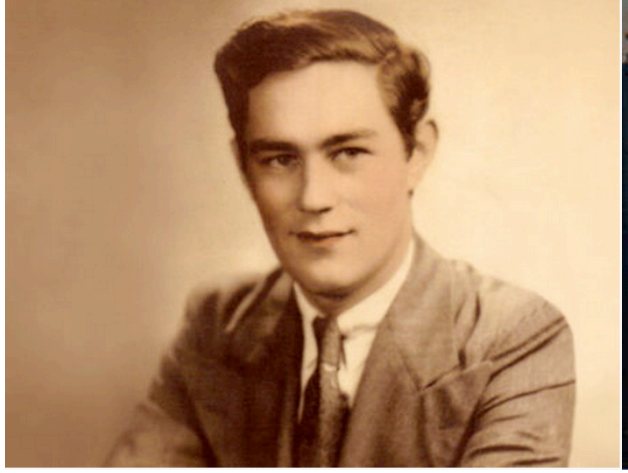
Hebbian Synapse

Hebbian Synapses



Cells that fire together wire together

The case of H.M.



Henry Molaison 1953

Age 60, 1986
Died 2008 age 82

At age 9 H.M. was knocked down while riding a bicycle

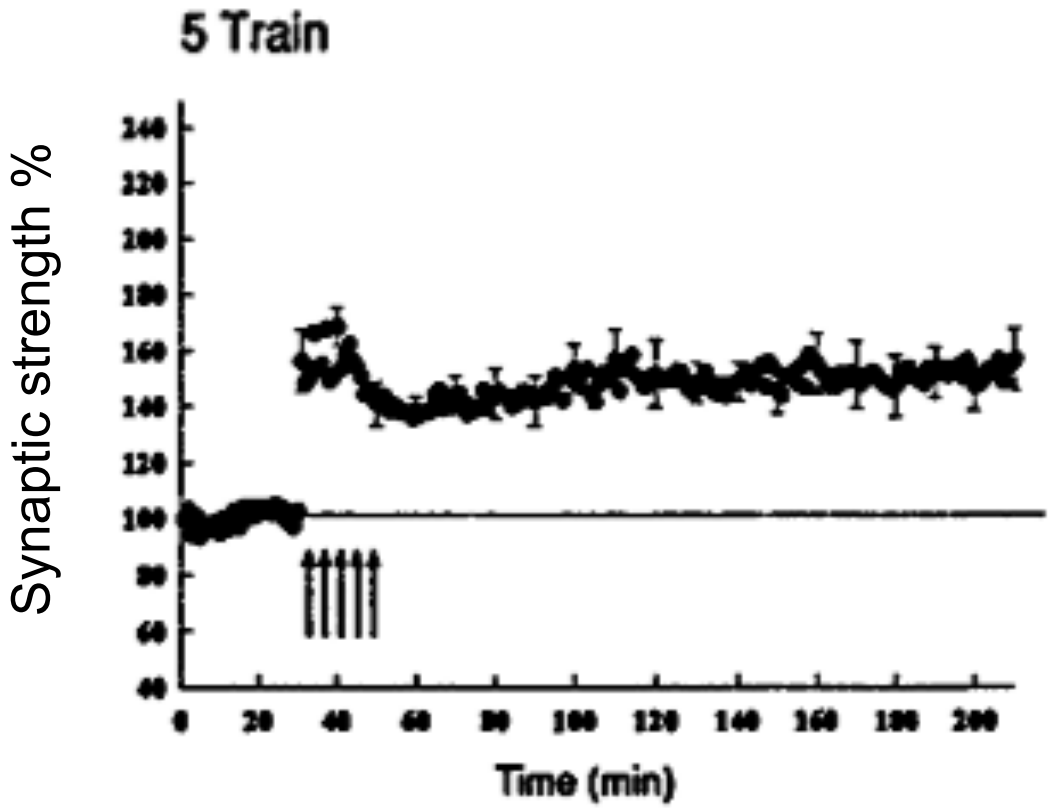
Sustained brain injury that led to severe epilepsy

1953 (age 26) - operated on and inner surface of temporal lobe removed including the hippocampus

After surgery relieved seizures but left with severe memory loss

Unable to form new memories though retained past memories

Tim Bliss and Terje Lomo describe synaptic plasticity in the hippocampus - 1973



This is long -term potentiation (LTP)

Acquired rapidly

Long lasting

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Brain Function ⟷ Activity

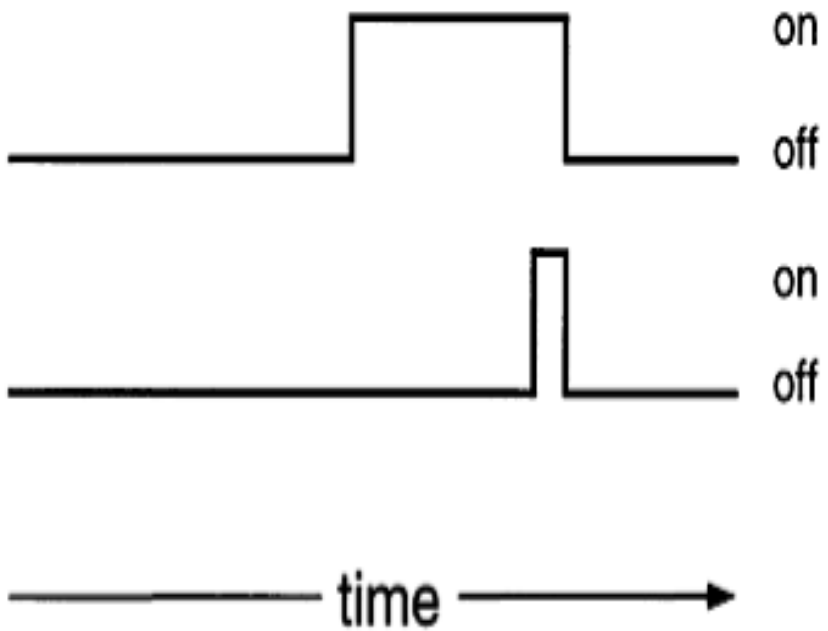
Circuits

Behaviour

Fear conditioning

CONDITIONED STIMULUS (CS)
(tone or light)

UNCONDITIONED STIMULUS (US)
(footshock)



Before conditioning

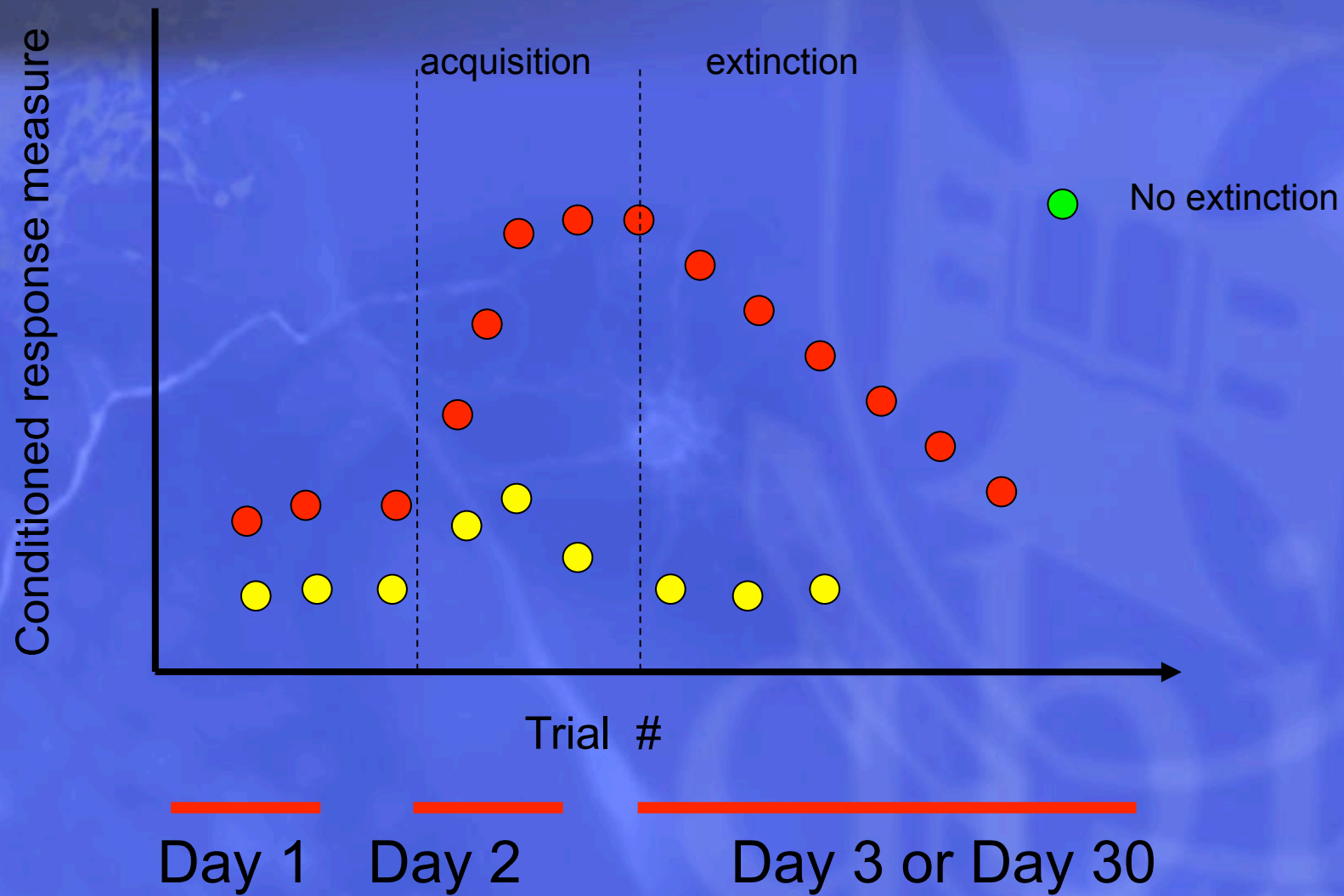
CS → no response

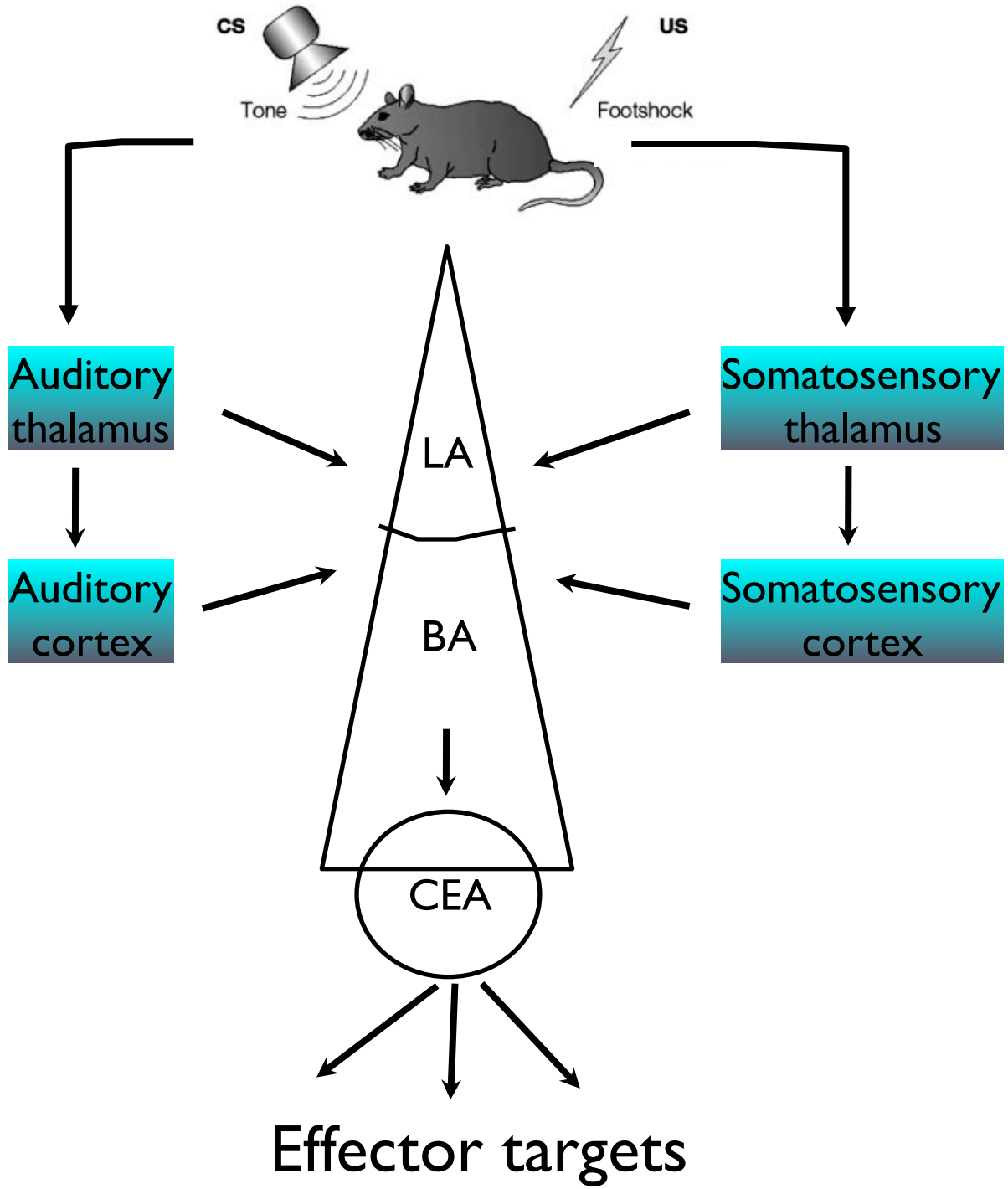
After conditioning

CS → Defense behavior - freezing

CS → Autonomic changes HR/BP
defecation

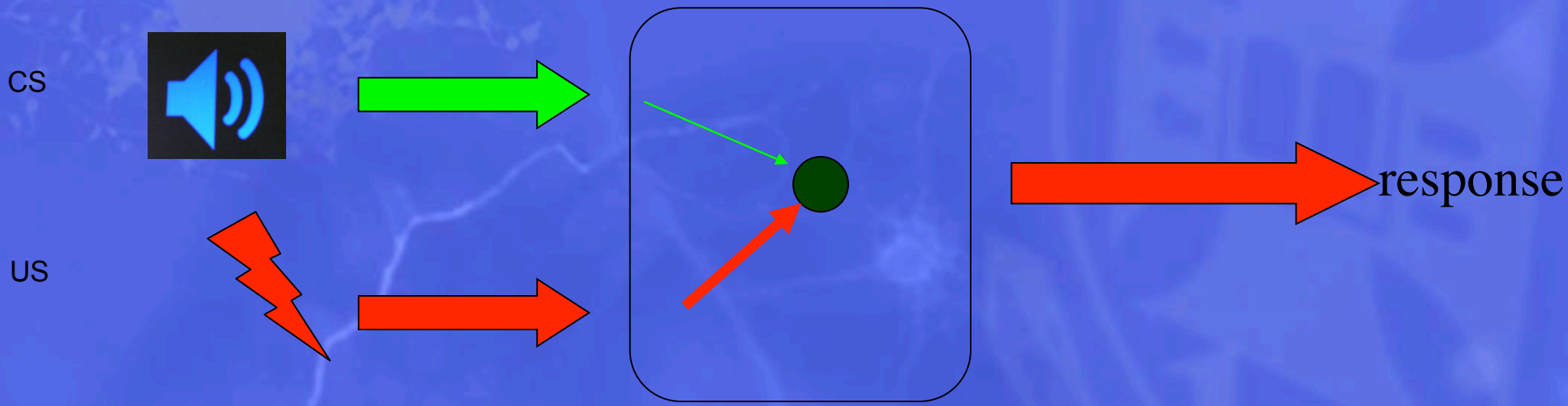
CS → Hypothalamic/pituitary




CS
US
Tone
Footshock
Auditory thalamus
Somatosensory thalamus
LA
Auditory cortex
BA
Somatosensory cortex
CEA
Effector targets

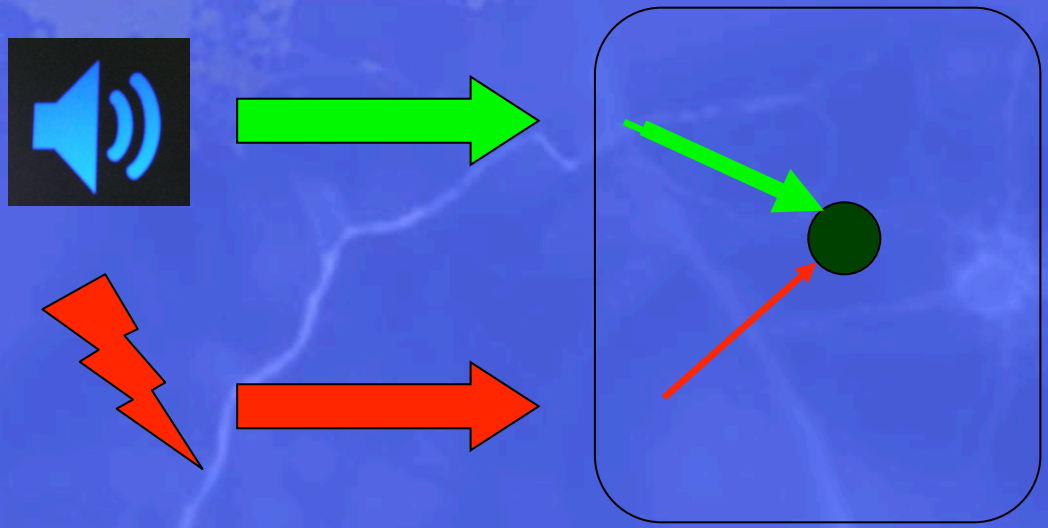
stimulus

amygdala



stimulus

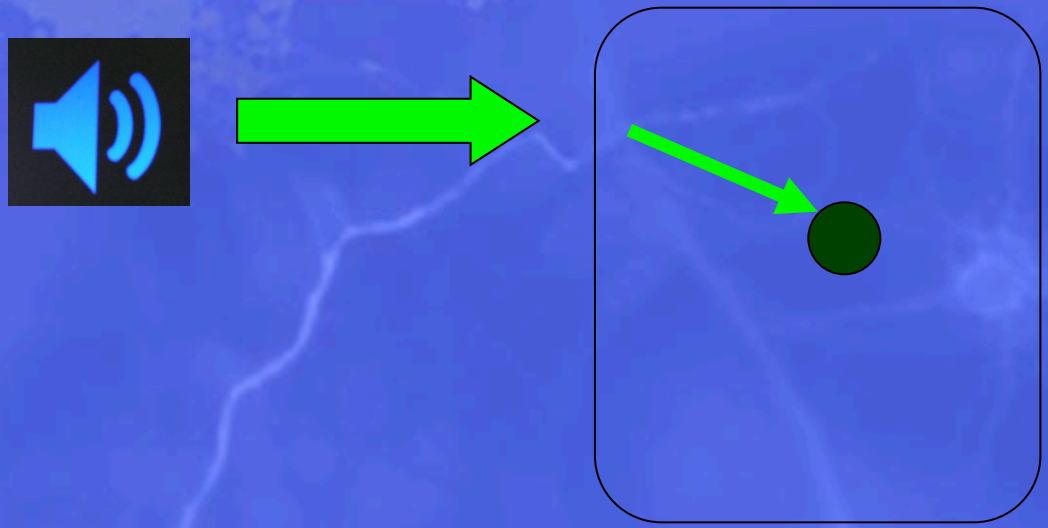
amygdala



response

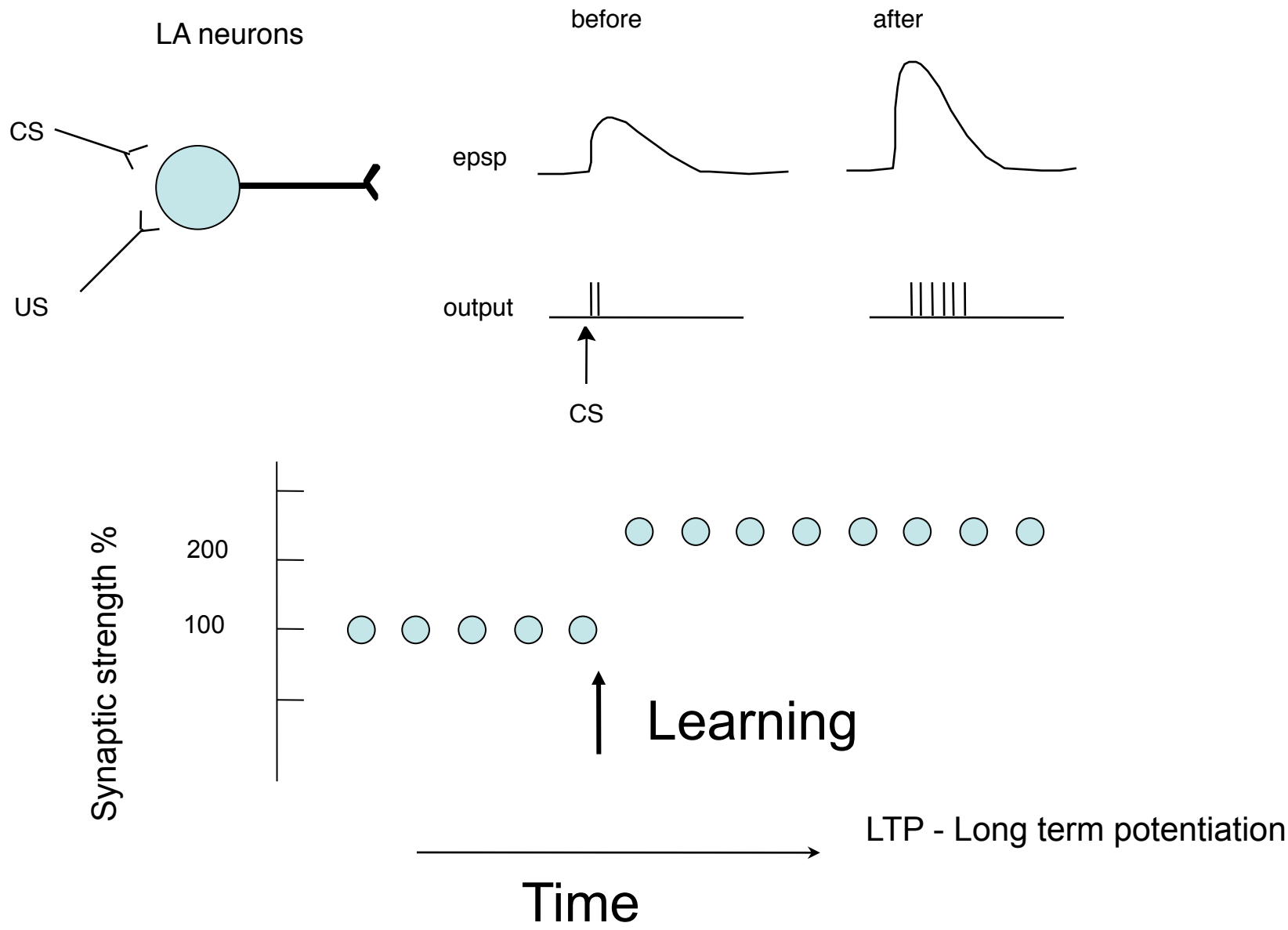
stimulus

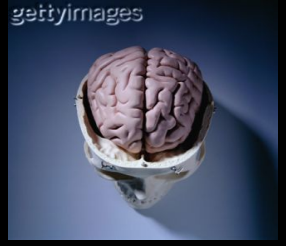
amygdala



response

Cellular model for fear conditioning: Hebbian plasticity in the amygdala





Learning / Memory

Education

Brain

+

+

Systems

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Networks

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Pedagogy

Science of Learning

Neurons

+++

Biological understanding of learning

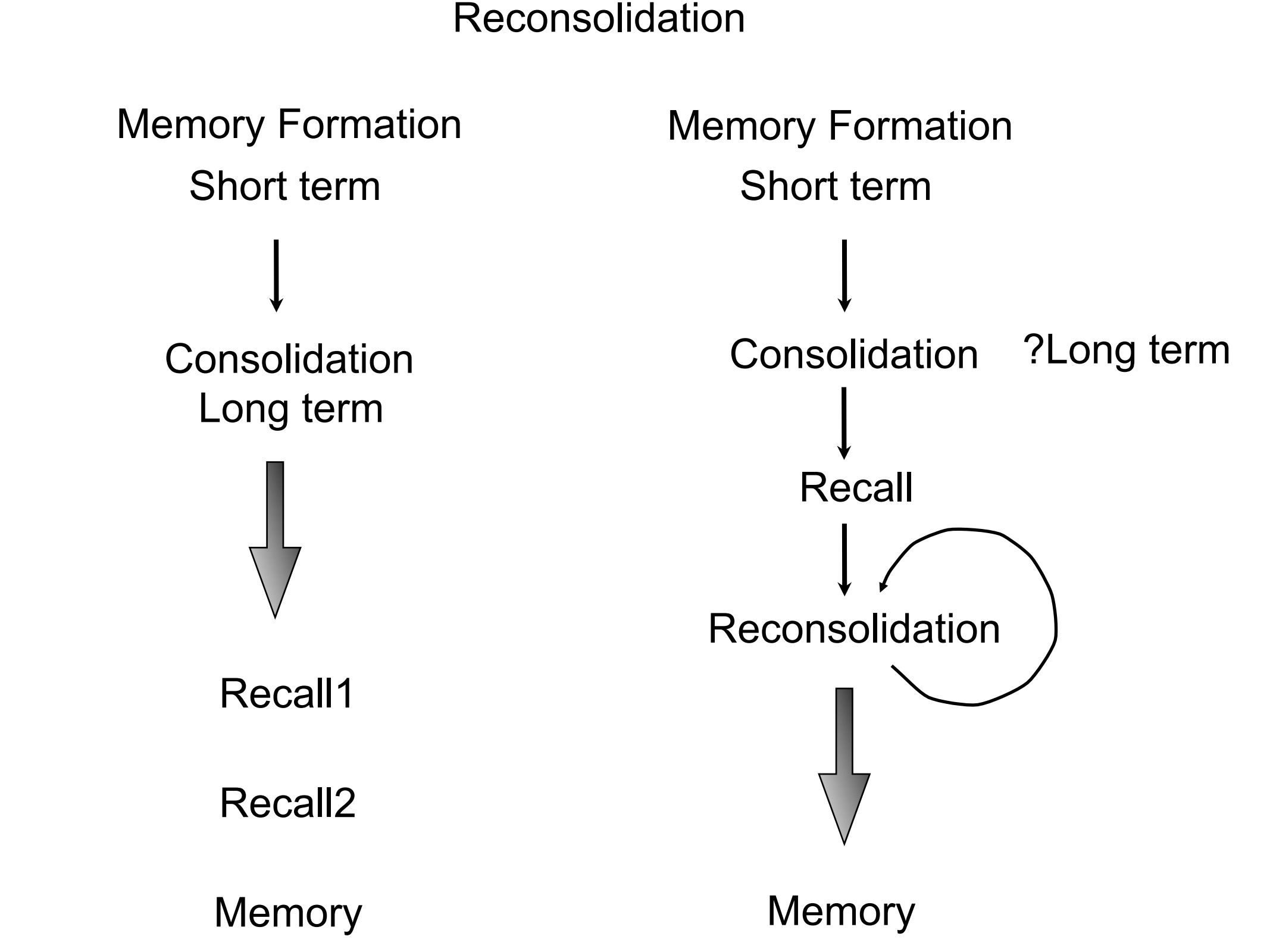
Synapses

++++

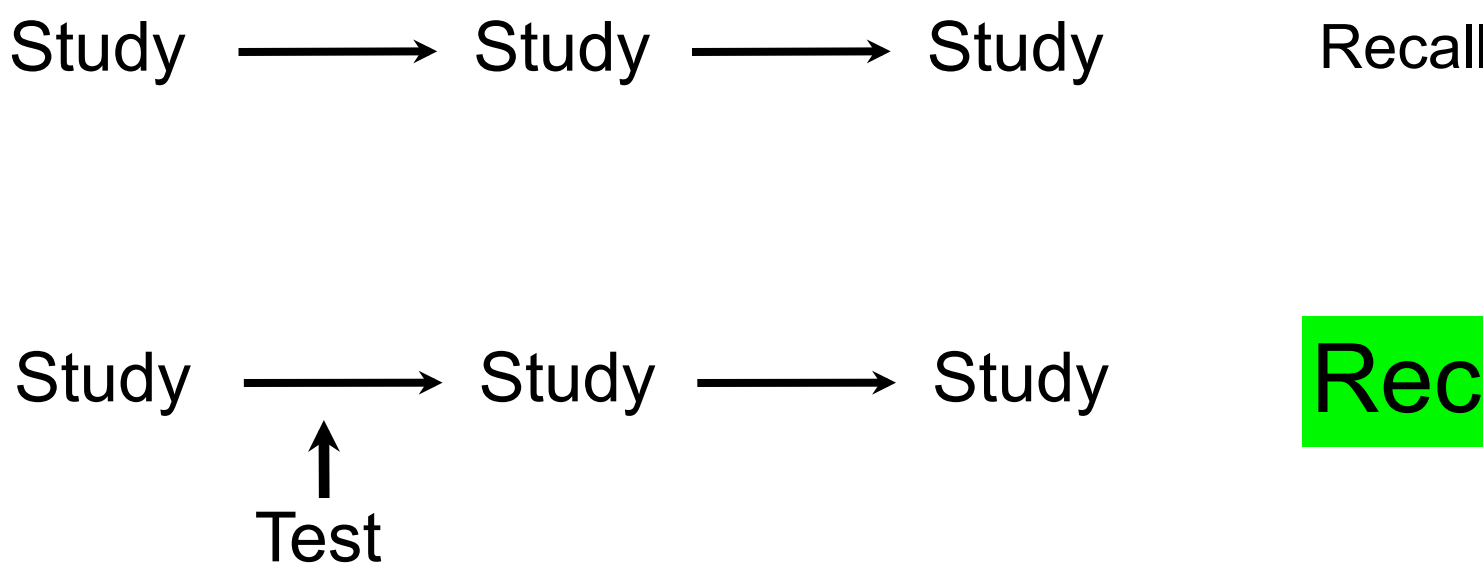
Molecules

+++++

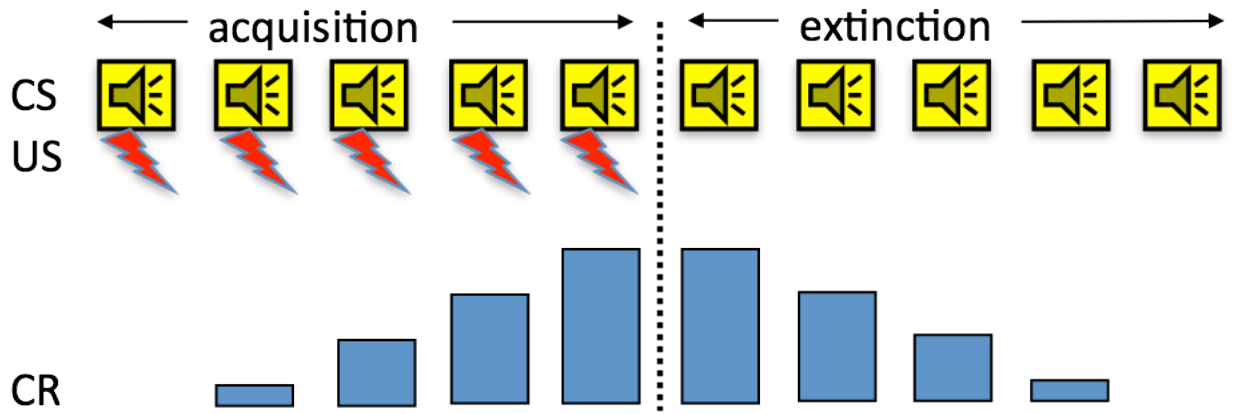
Neuroscience


Reconsolidation
Memory Formation
Short term
Consolidation
Long term
Recall1
Recall2
Memory
Memory Formation
Short term
Consolidation
?Long term
Recall
Reconsolidation
Memory

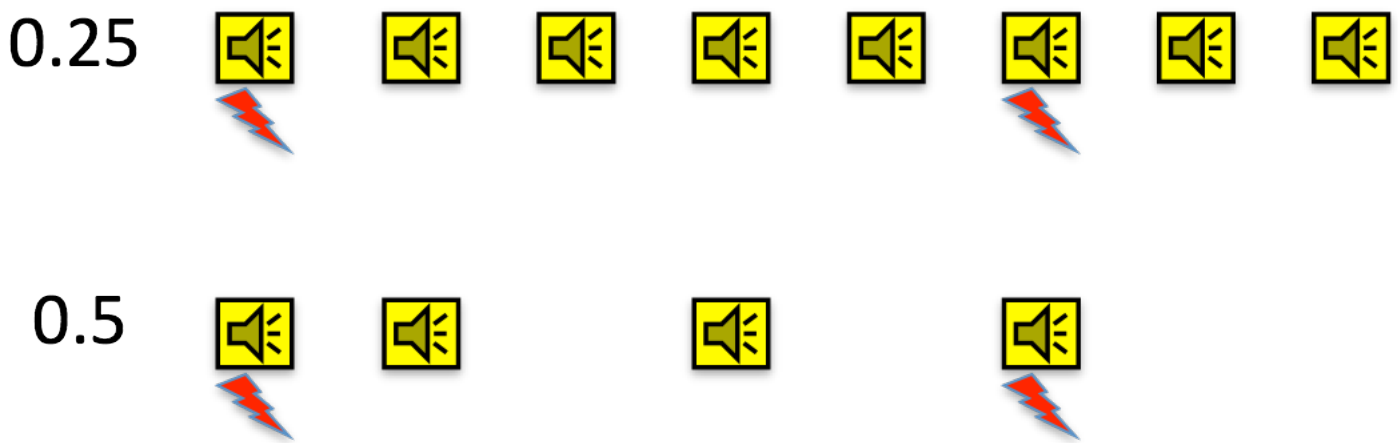
The “testing effect”



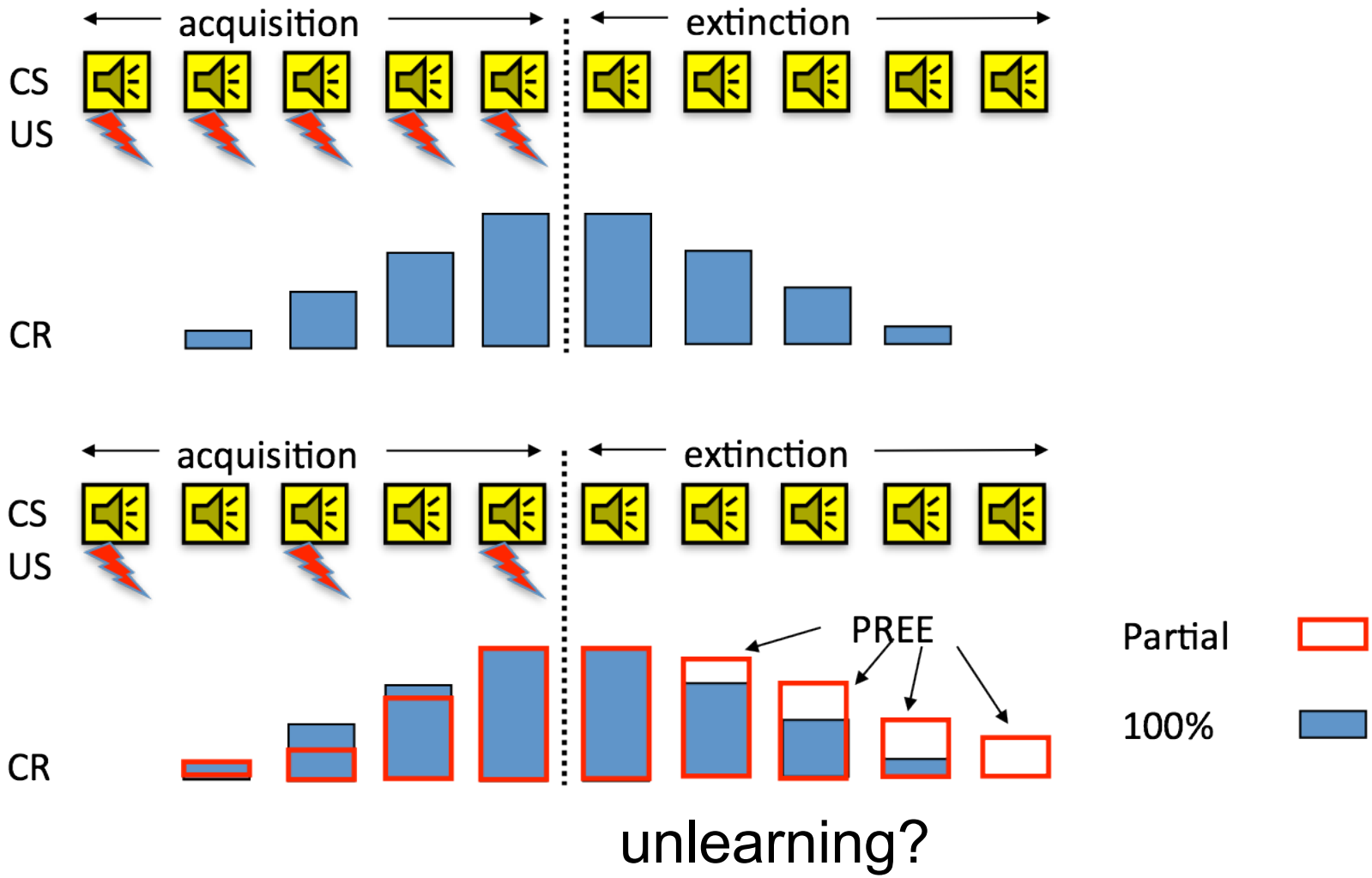
CS conditioned stimulus
US unconditioned stimulus
CR conditioned response



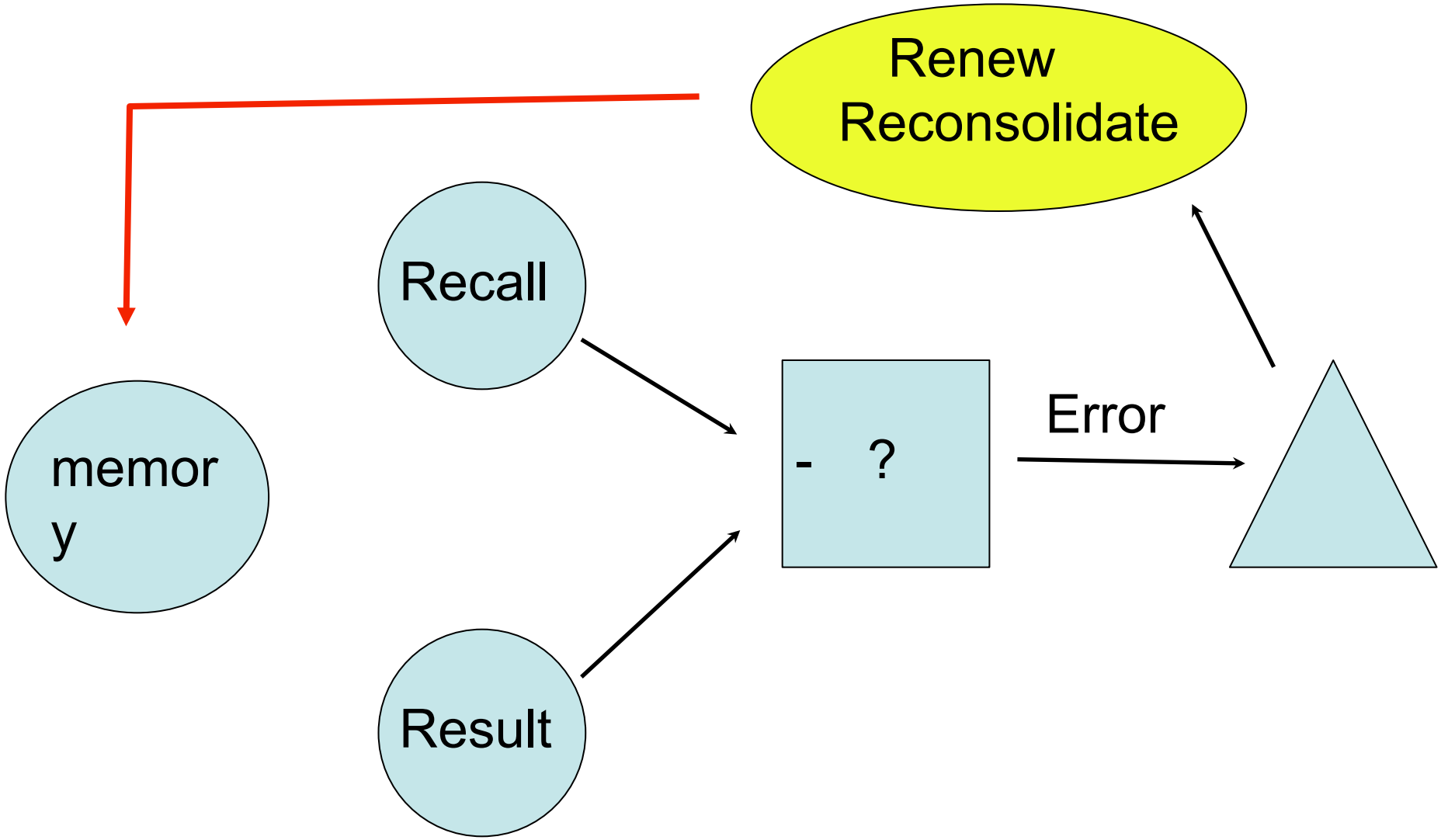
Partial reinforcement



CS conditioned stimulus
US unconditioned stimulus
CR conditioned response



unlearning?


Renew
Reconsolidate
Recall
memor
y
-
?
Error
Result