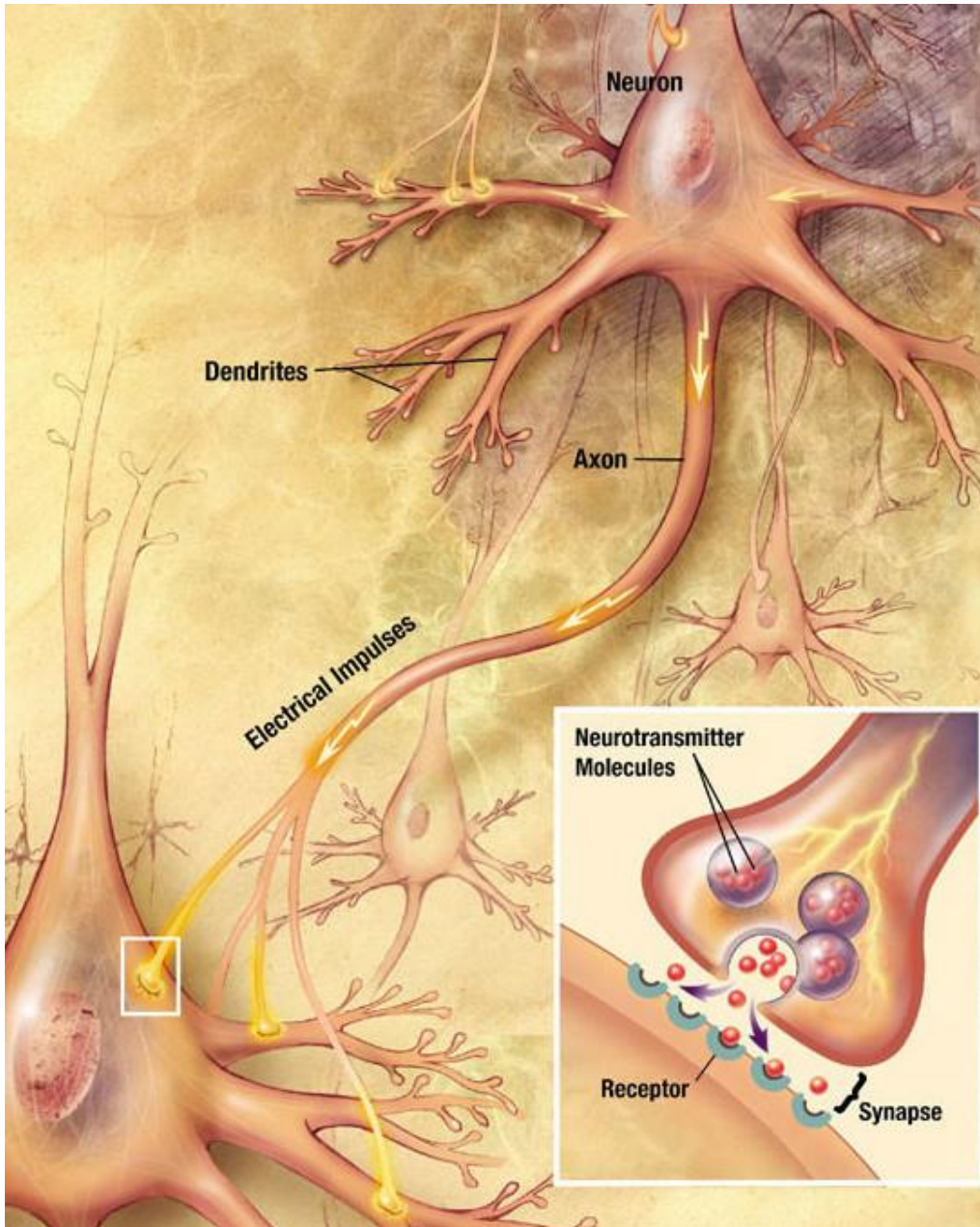


What happens
to the spike
(action
potential) when
it reaches the
end of an axon?

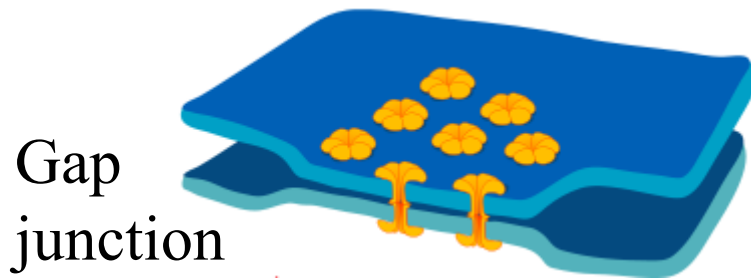
Enter...
the Synapse



What is a Synapse?

- ♦ A Synapse is a “connection” or junction between two neurons
 - **Electrical** synapses use *gap junctions*
 - **Chemical** synapses use *neurotransmitters*
customized (adjustable) amount of transmission: for memory/learning by changing number of receptors

Neuron A

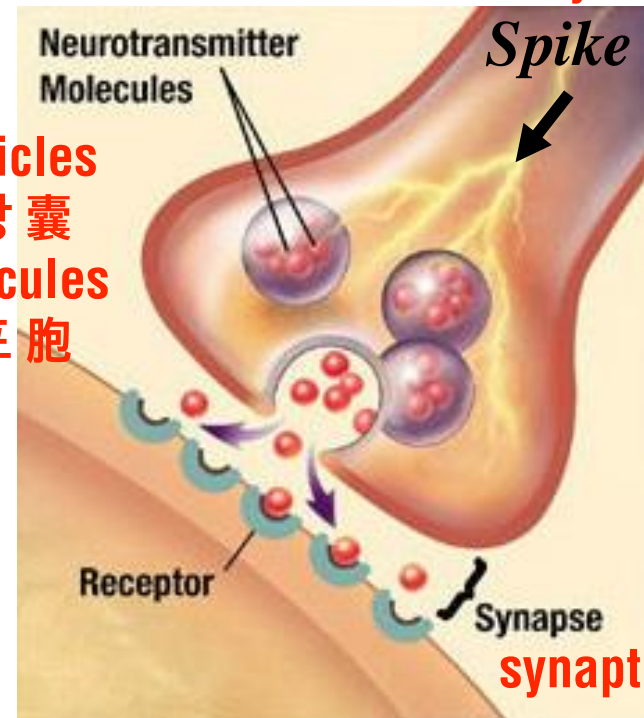


(essentially ionic channels)

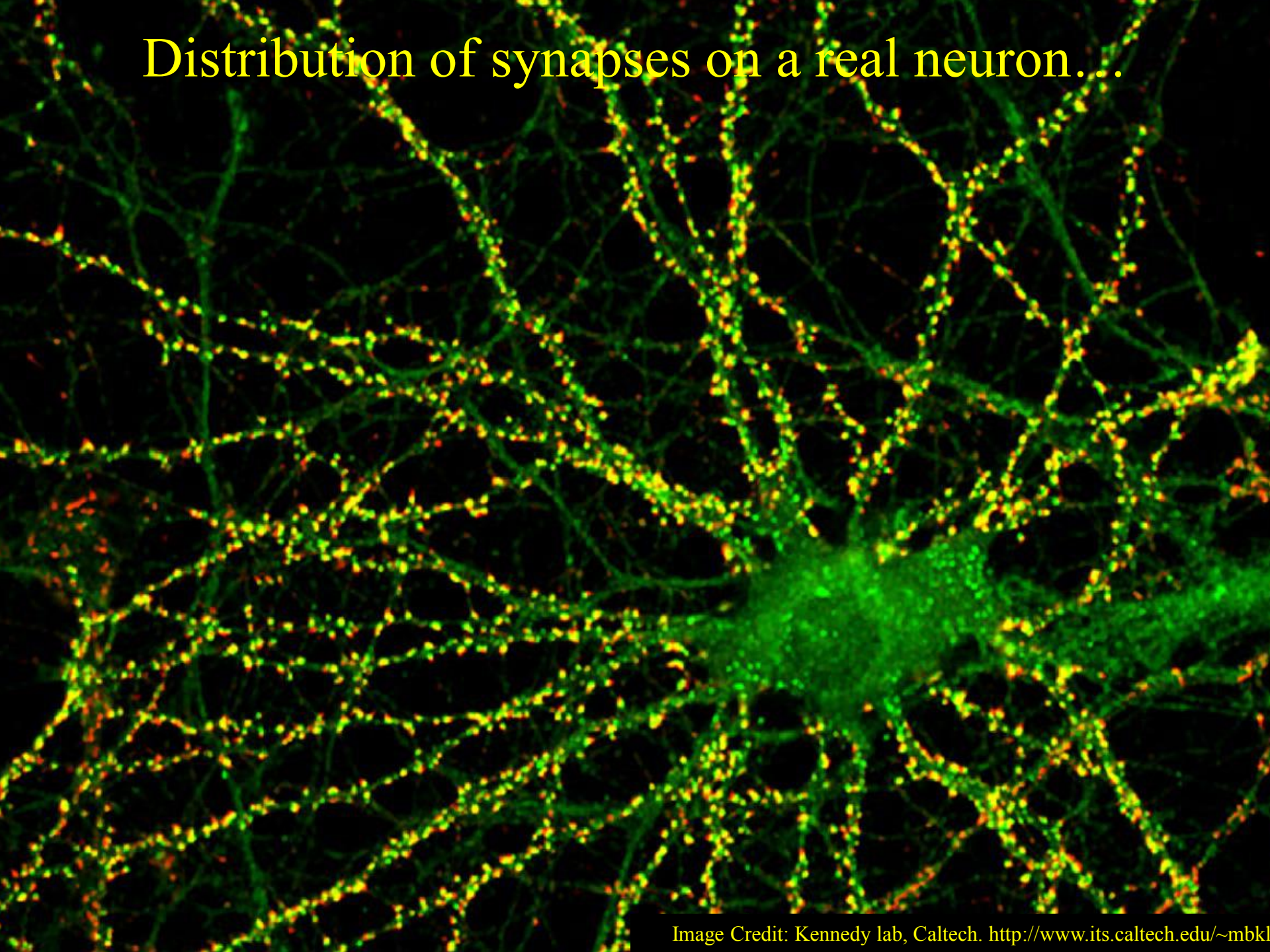
Neuron B

**smooth coordination: to synchronise;
to implement e.g. an escape reflex**

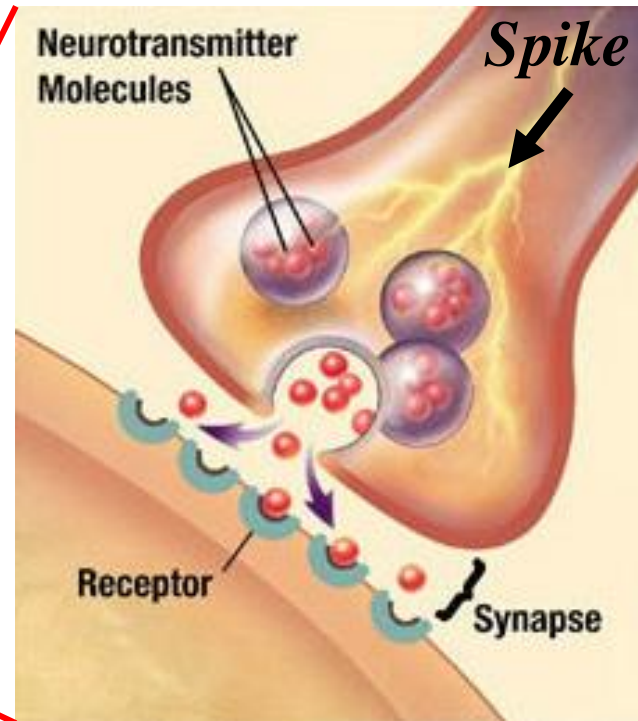
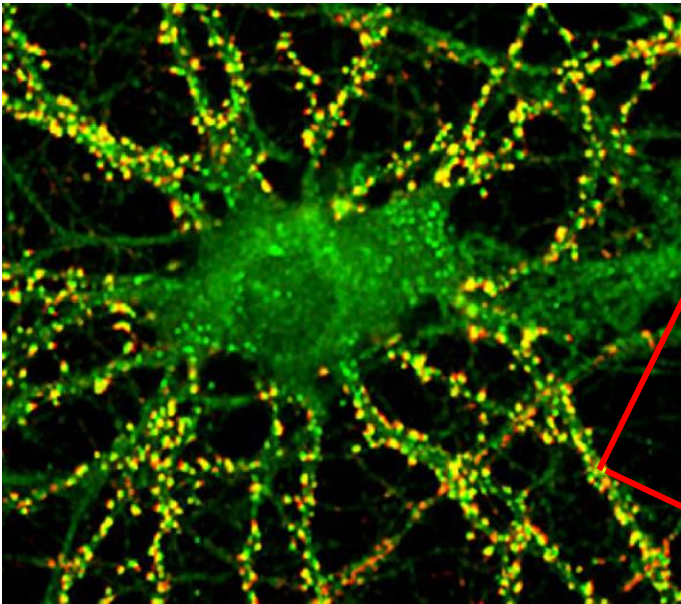
**vesicles
소낭 囊
reticules
소포 胞**



Distribution of synapses on a real neuron...

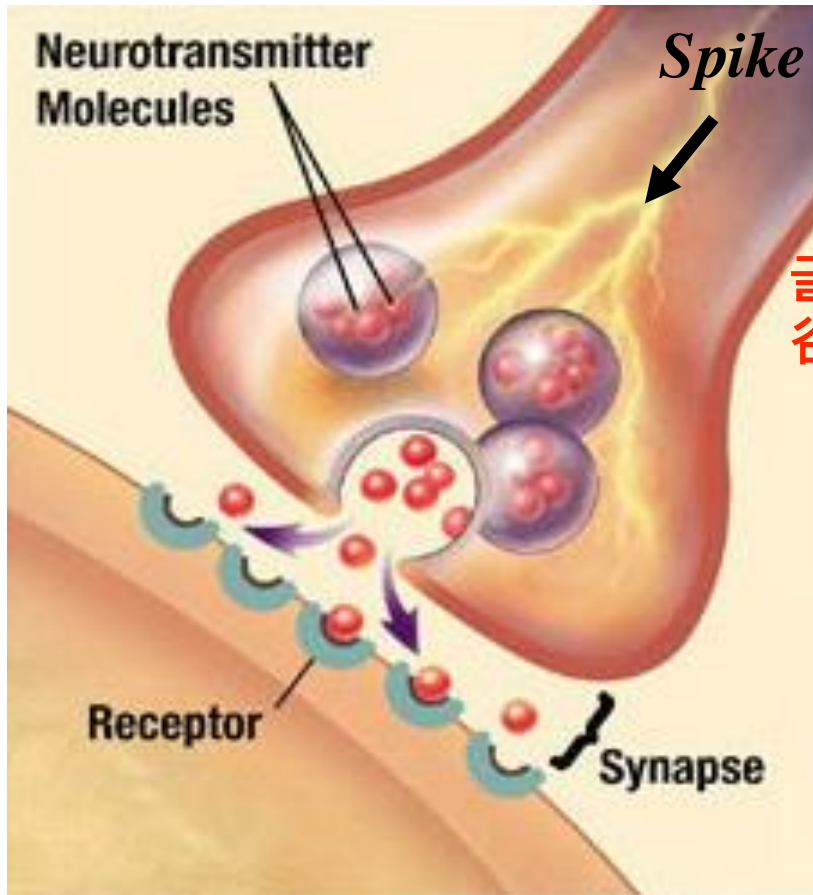


Synapses can be Excitatory or Inhibitory



Increase or decrease postsynaptic membrane potential

An **Excitatory** Synapse

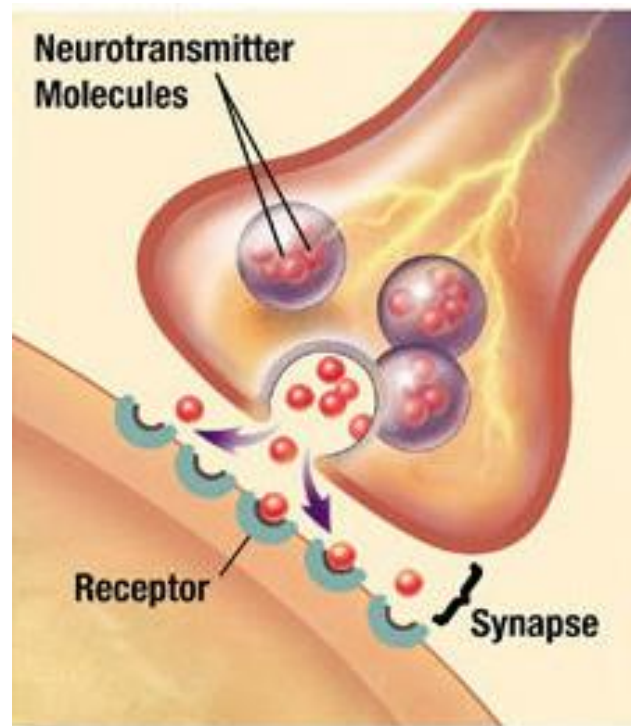


글루탐산
谷氨酸

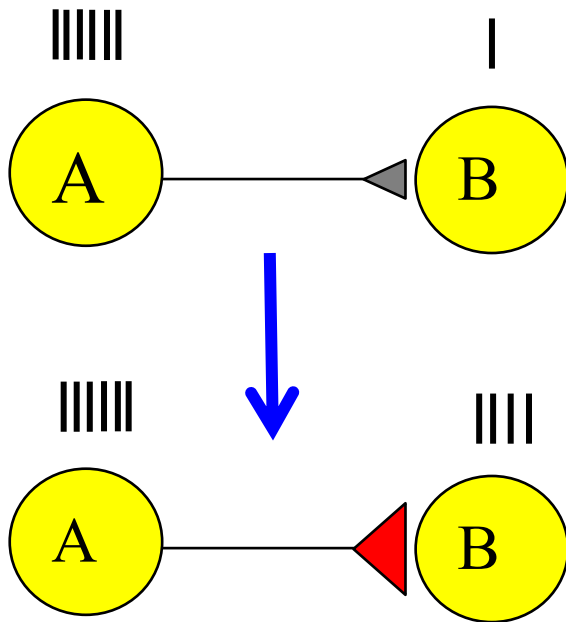
Input spike →
Neurotransmitter
release (e.g.,
Glutamate) →
Binds to ion channel
receptors →
Ion channels open →
Na⁺ influx →
Depolarization due to
EPSP (excitatory
postsynaptic potential)

The Synapse Doctrine

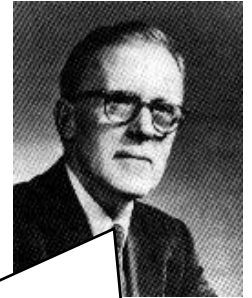
Synapses are the basis for **memory** and **learning**



How do Brains Learn? Synaptic Plasticity



Hebbian Plasticity



If neuron A repeatedly takes part in firing neuron B, then the synapse from A to B is strengthened

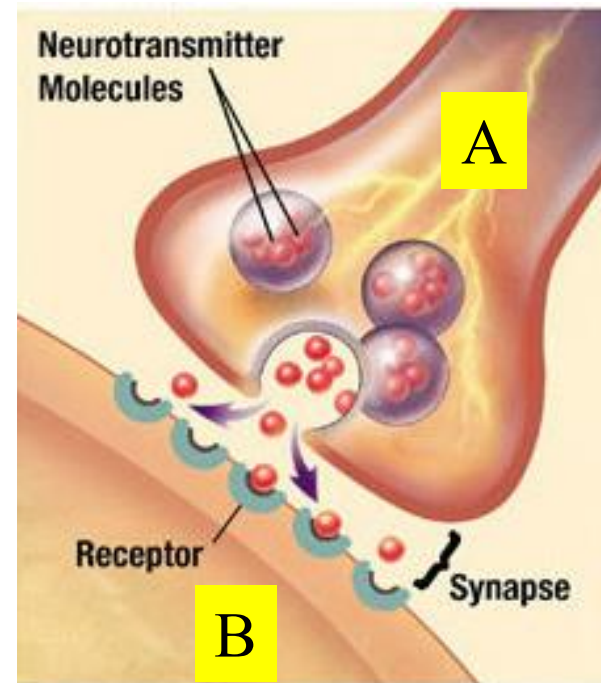
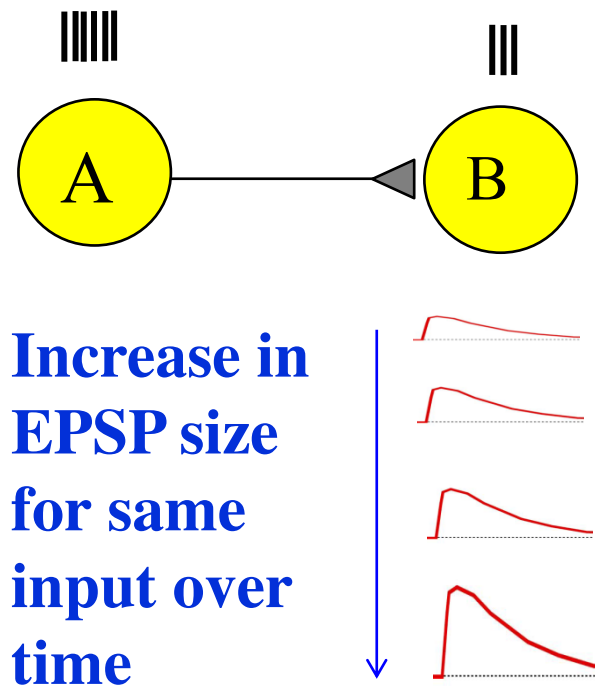


**“Neurons that
fire together
wire together!”**

observed most prominently in the hippocampus해마체 海馬體

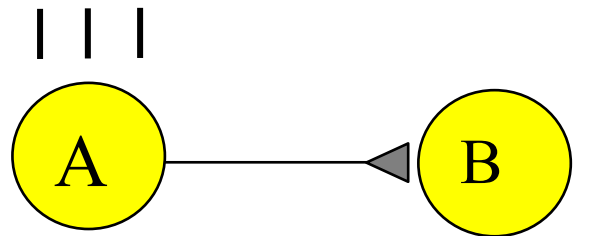
Long Term Potentiation (LTP)

LTP = Experimentally observed *increase* in synaptic strength that lasts for hours or days

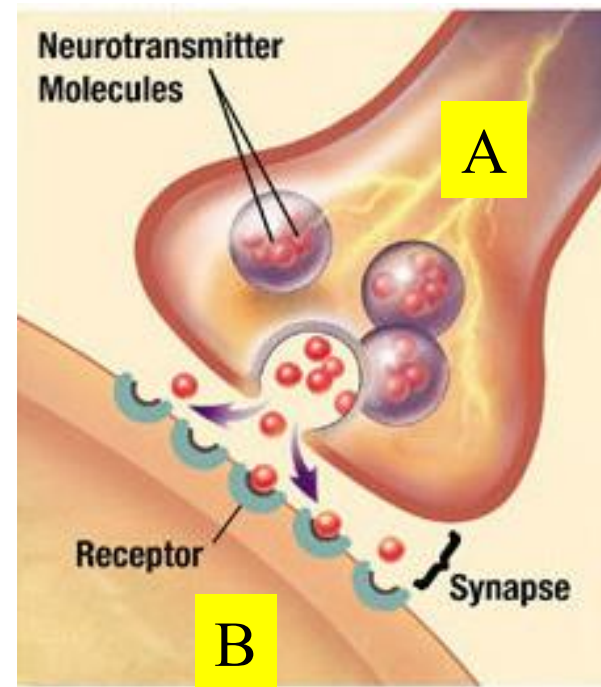
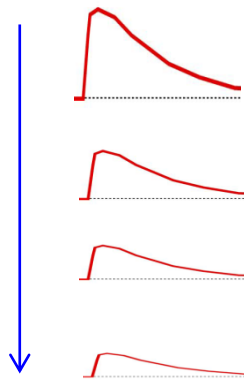


Long Term Depression (LTD)

LTD = Experimentally observed *decrease* in synaptic strength that lasts for hours or days



**Decrease in
EPSP size
for same
input over
time**



Synaptic Plasticity depends on Spike Timing!

LTP/LTD depends on relative timing of input and output spikes

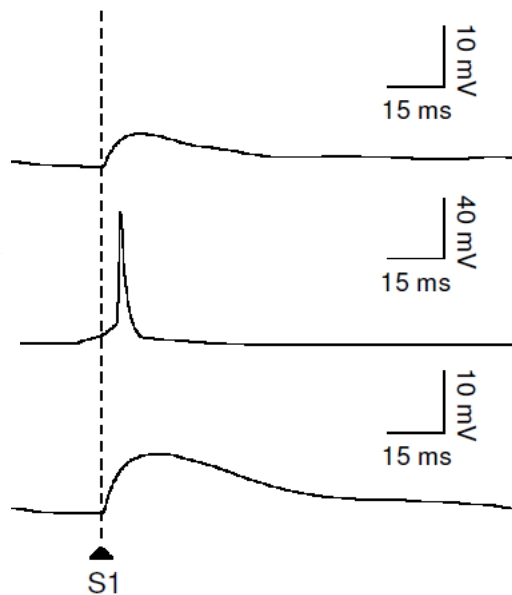
Input Spike before Output Spike

Input Spike after Output Spike

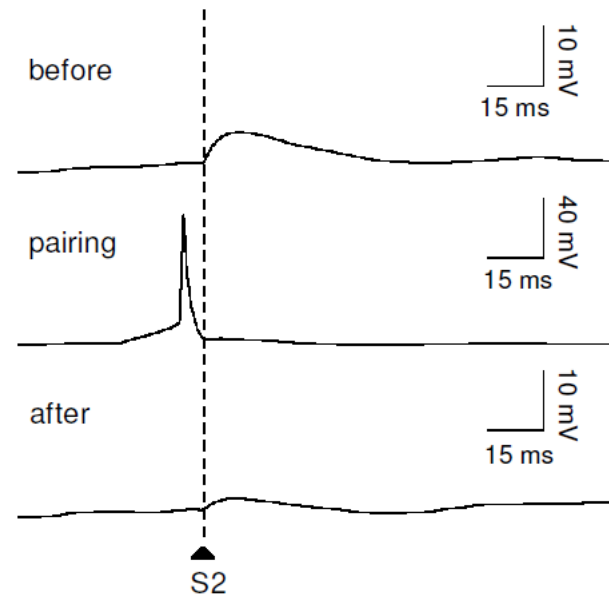
EPSP Before

Input-Output
Pairing

EPSP After

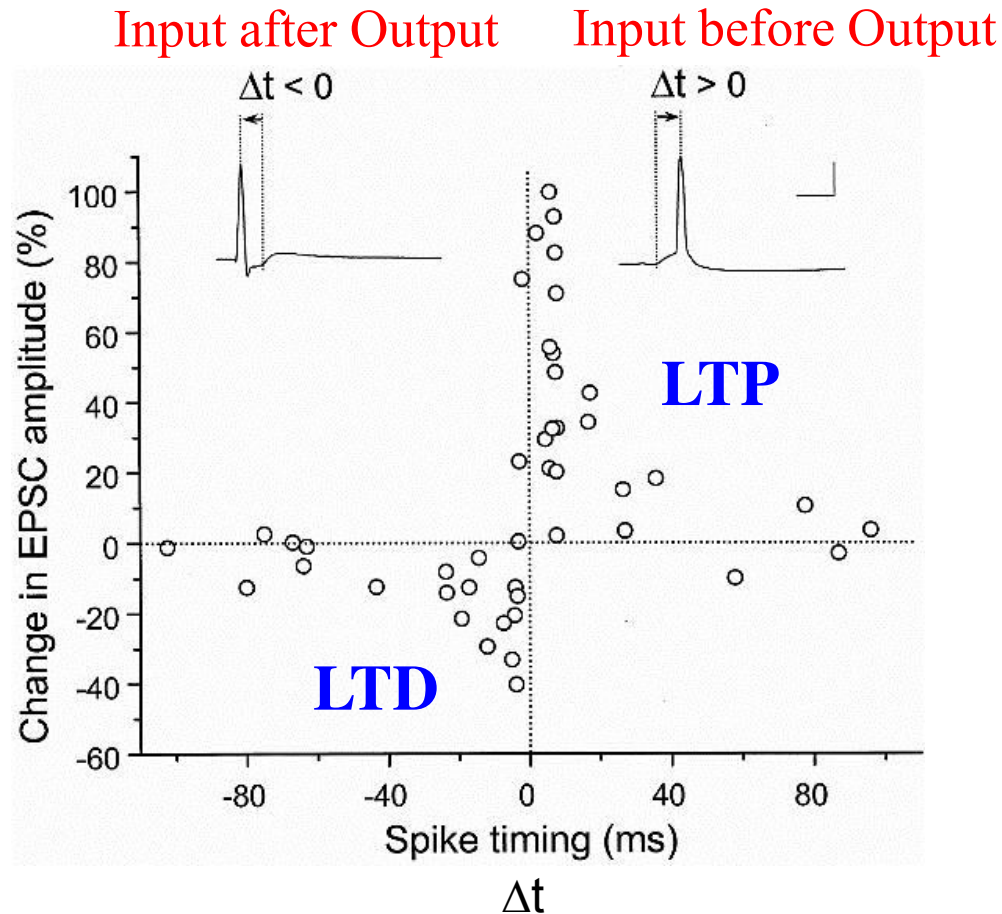


LTP



LTD

Spike-Timing Dependent Plasticity (STDP)



(Bi & Poo, 1998)

We seem to know a lot about channels,
neurons, and synapses...

What do we know about how networks of
neurons give rise to perception, behavior, and
consciousness?

Not as much

Next: Brain organization and information
processing in networks of neurons