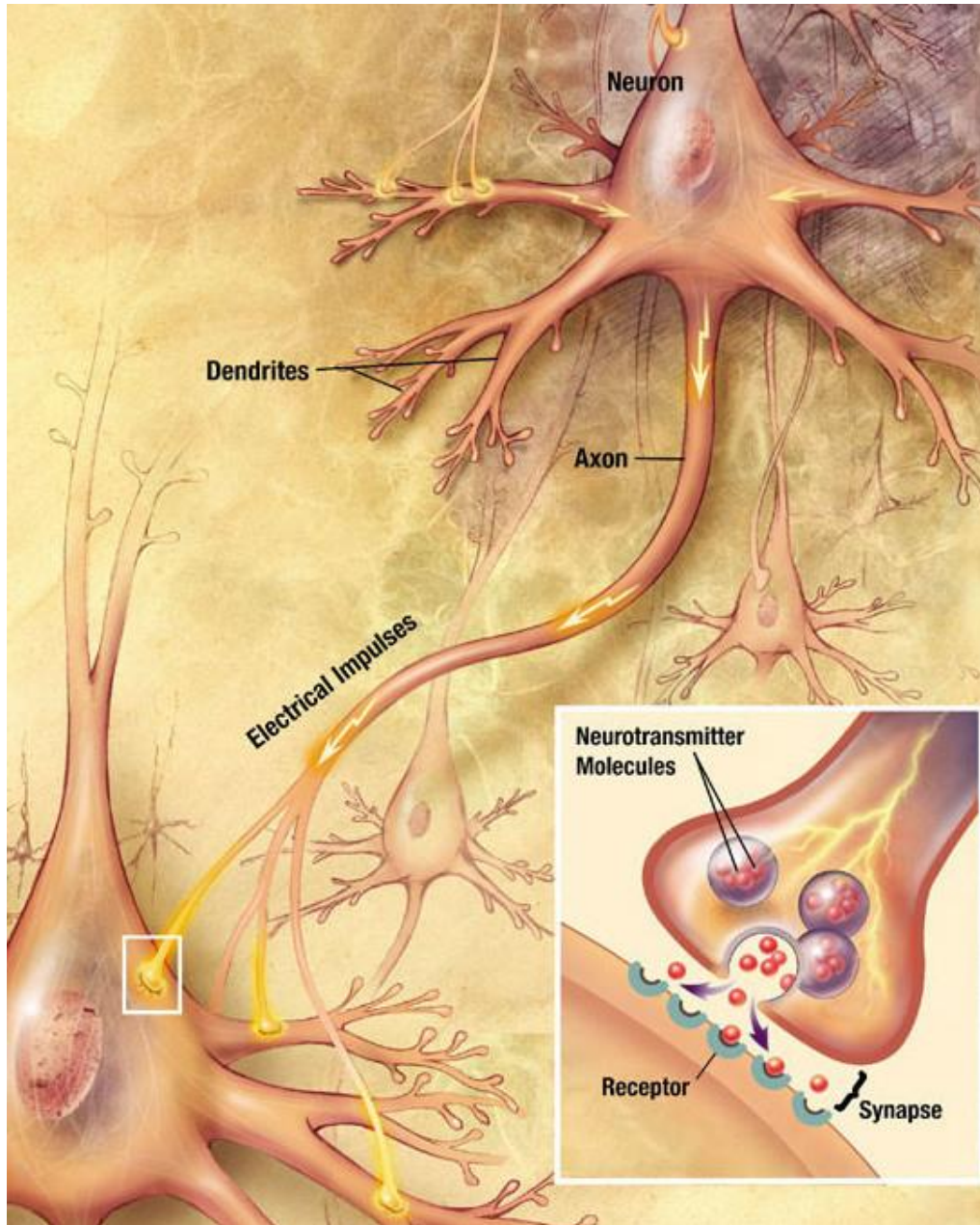


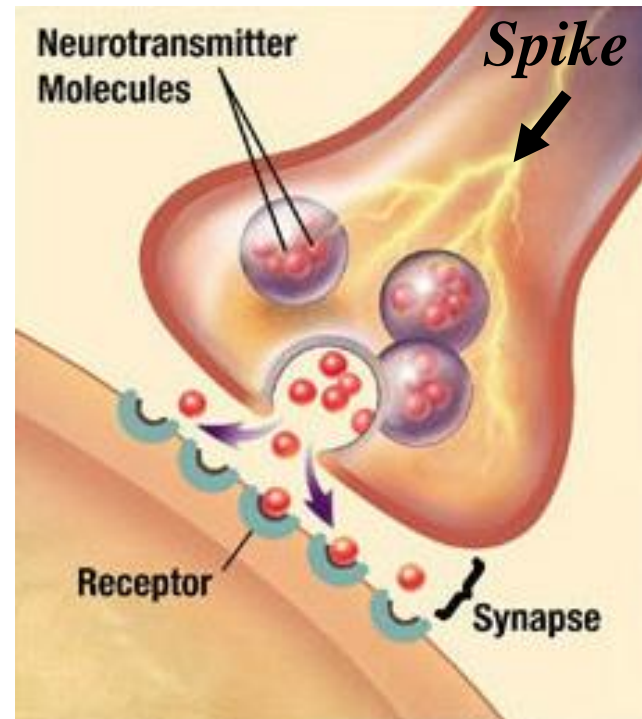
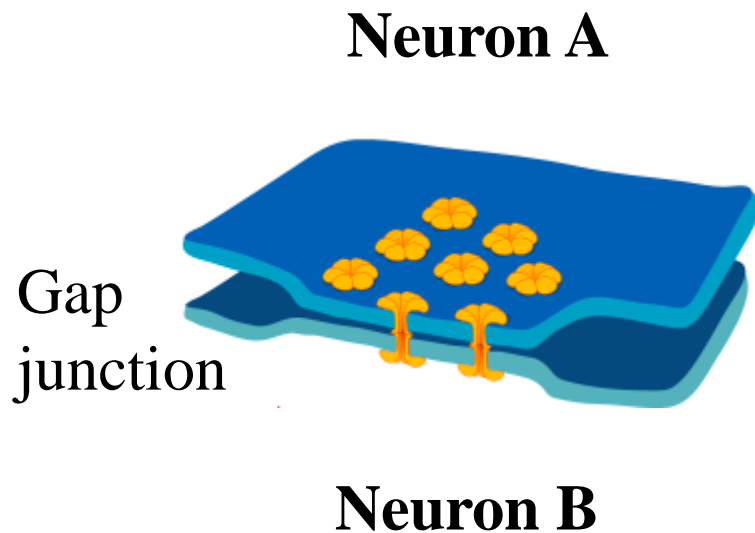
What happens
to the spike
(action
potential) when
it reaches the
end of an axon?

Enter...
the Synapse

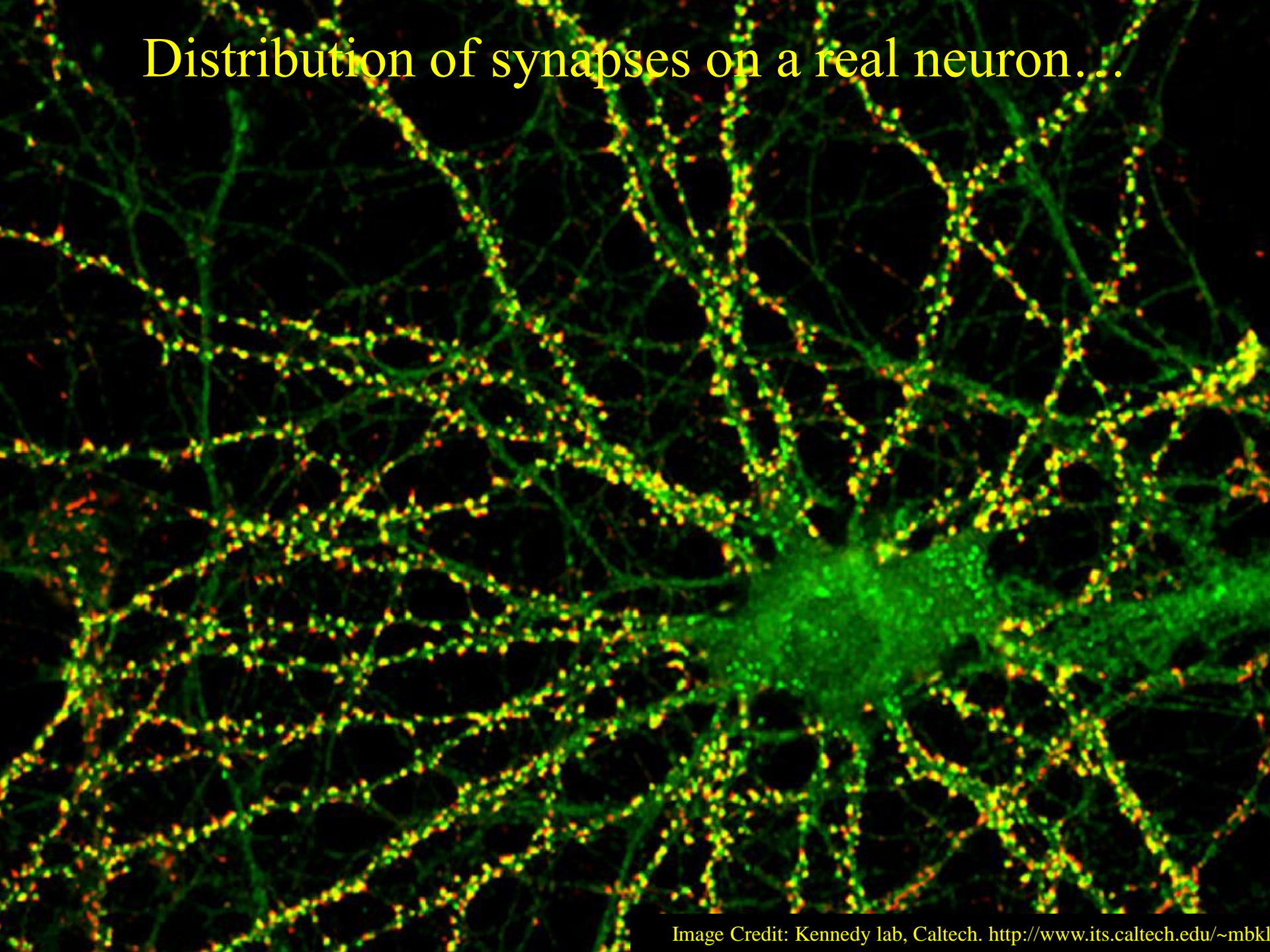


What is a Synapse?

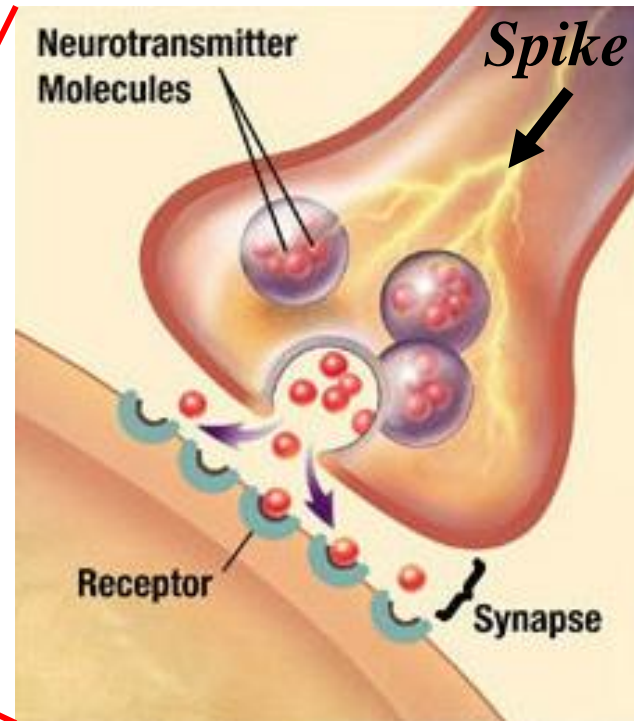
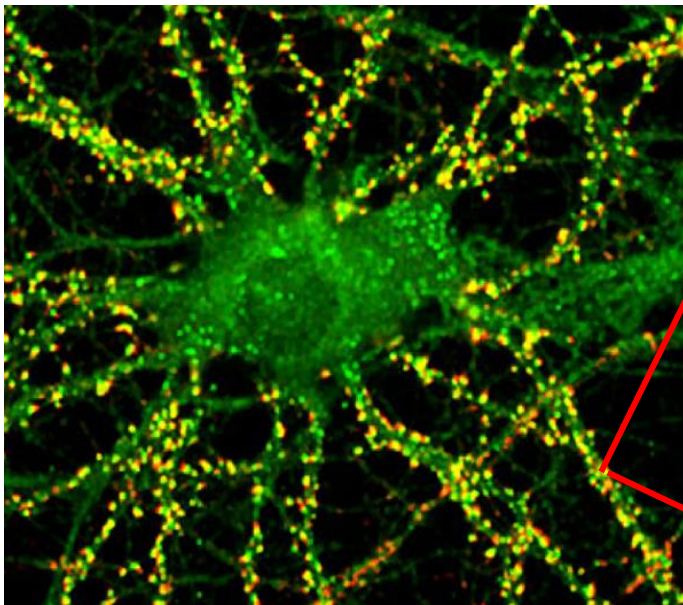
- ♦ A Synapse is a “connection” or junction between two neurons
 - ➞ **Electrical** synapses use *gap junctions*
 - ➞ **Chemical** synapses use *neurotransmitters*



Distribution of synapses on a real neuron...

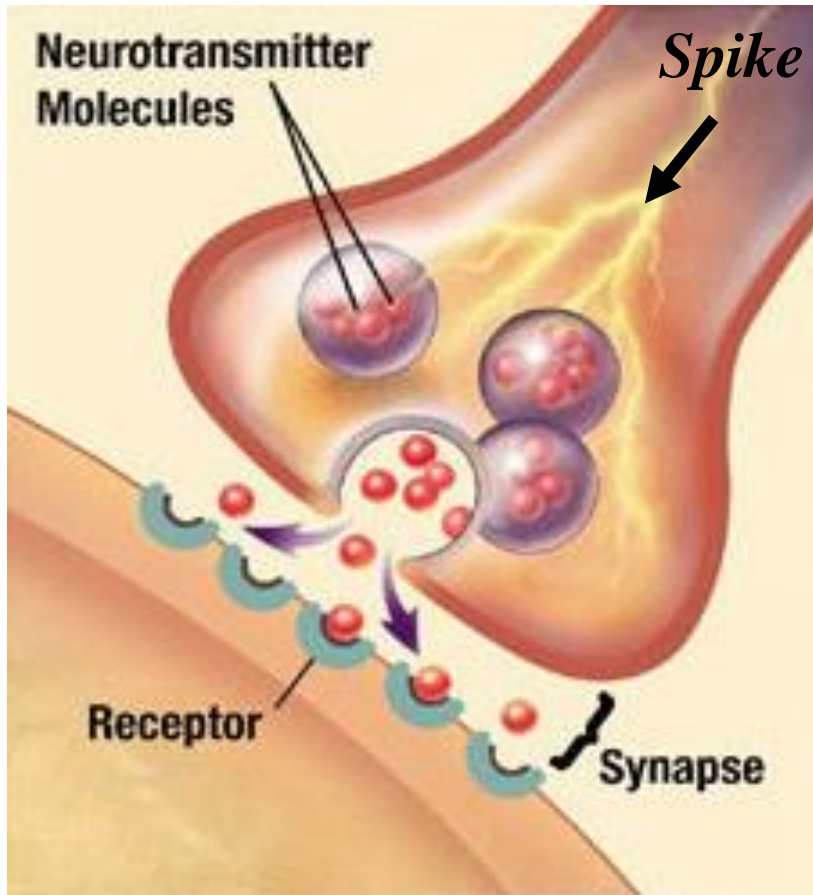


Synapses can be Excitatory or Inhibitory



Increase or decrease postsynaptic membrane potential

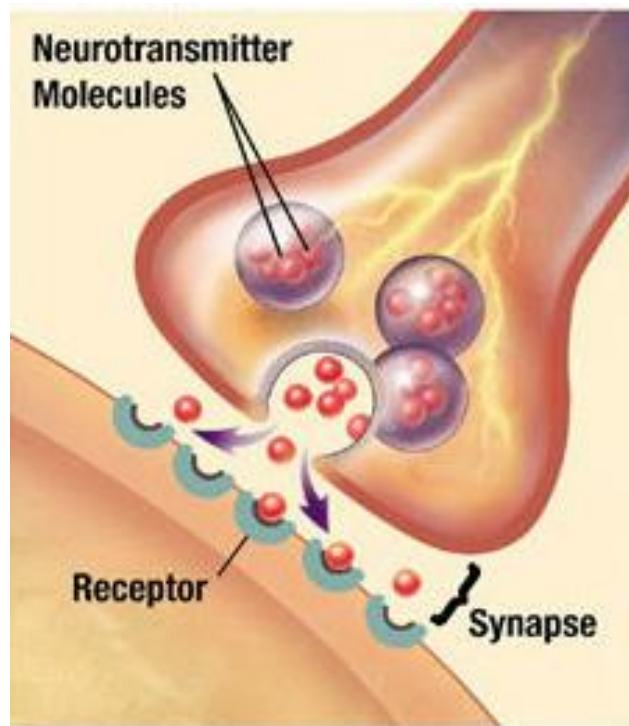
An **Excitatory** Synapse



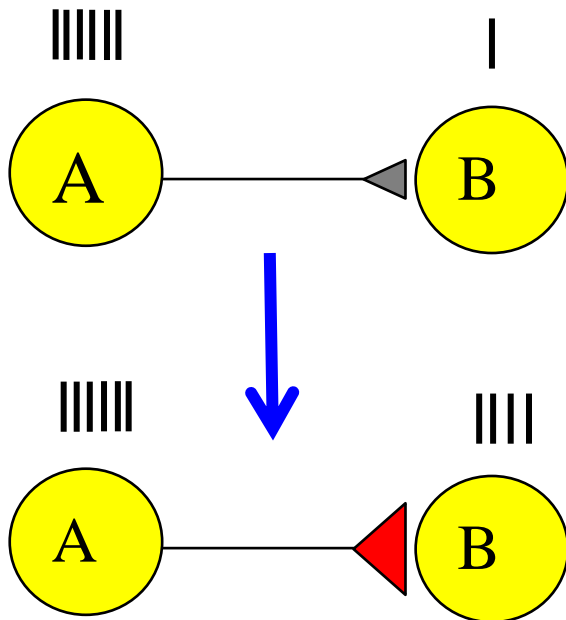
Input spike →
Neurotransmitter
release (e.g.,
Glutamate) →
Binds to ion channel
receptors →
Ion channels open →
Na⁺ influx →
**Depolarization due to
EPSP (excitatory
postsynaptic potential)**

The Synapse Doctrine

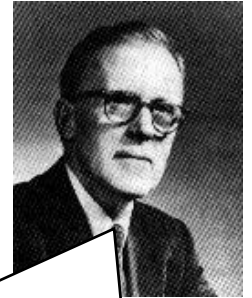
Synapses are the basis for **memory** and **learning**



How do Brains Learn? Synaptic Plasticity



Hebbian Plasticity



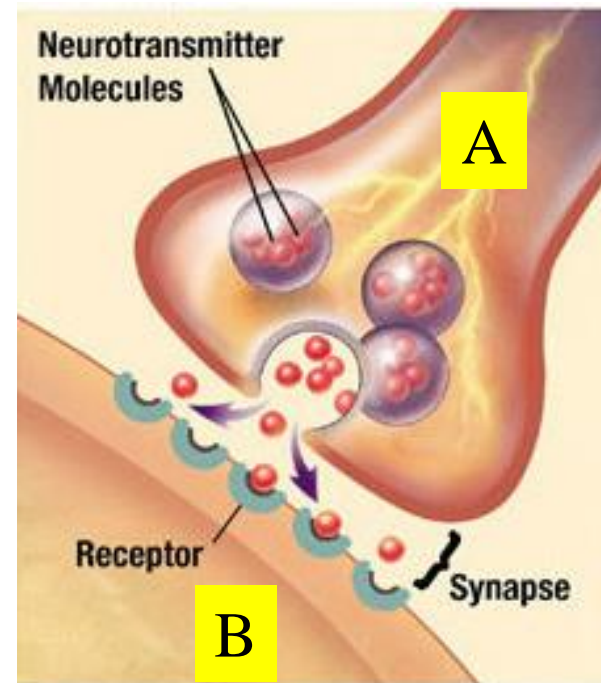
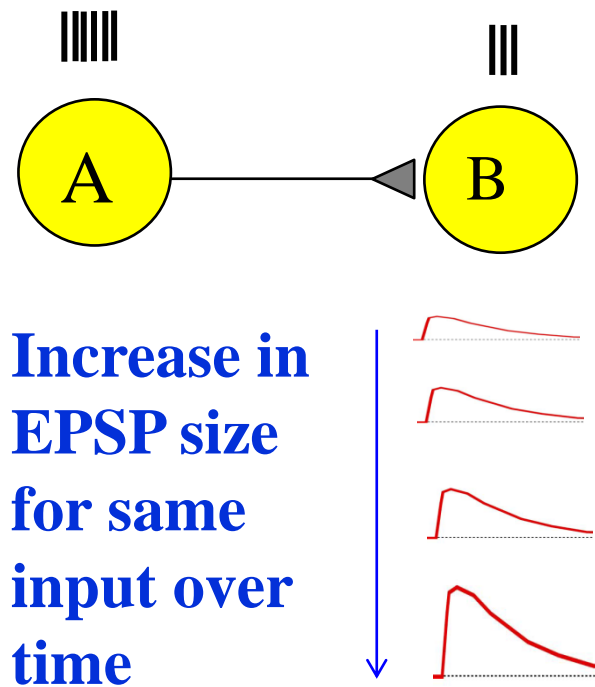
If neuron A repeatedly takes part in firing neuron B, then the synapse from A to B is strengthened



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

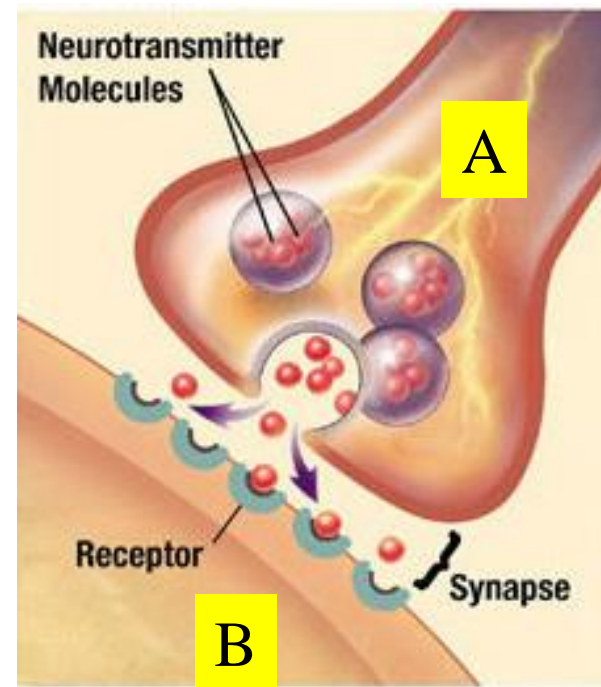
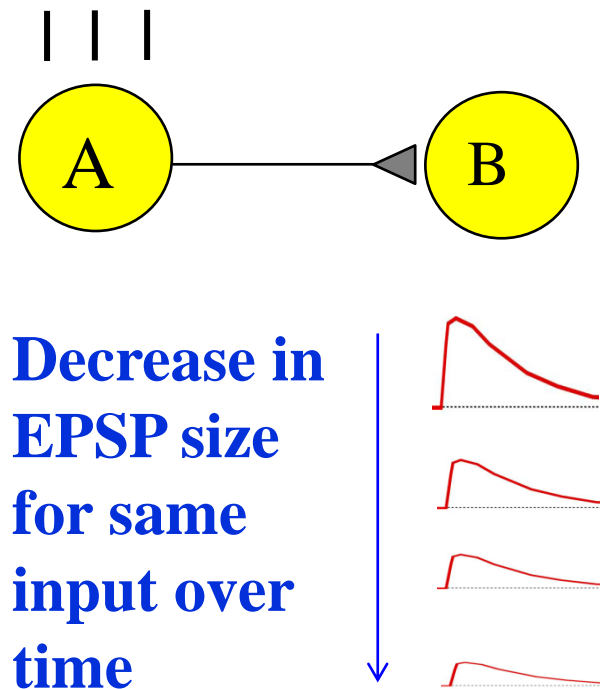
Long Term Potentiation (LTP)

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



Synaptic Plasticity depends on Spike Timing!

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

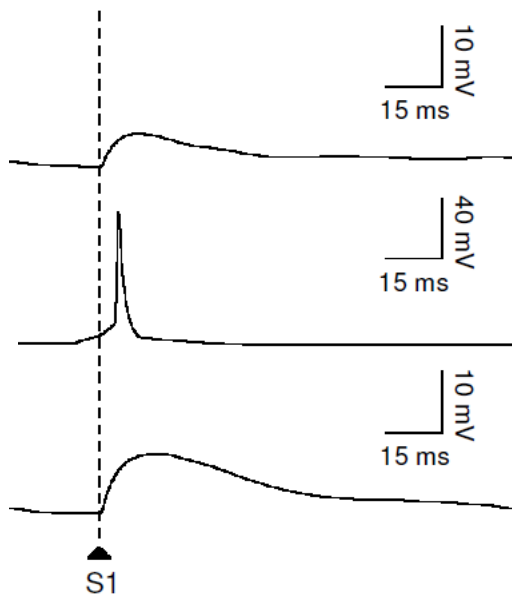
Input Spike before Output Spike

Input Spike after Output Spike

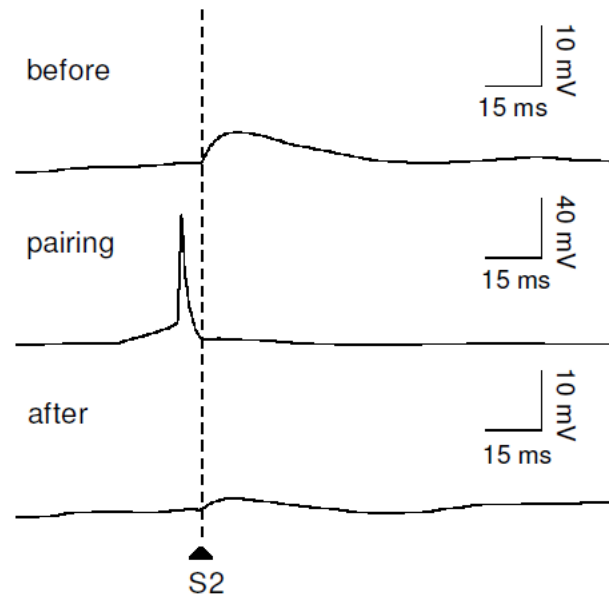
EPSP Before

Input-Output
Pairing

EPSP After

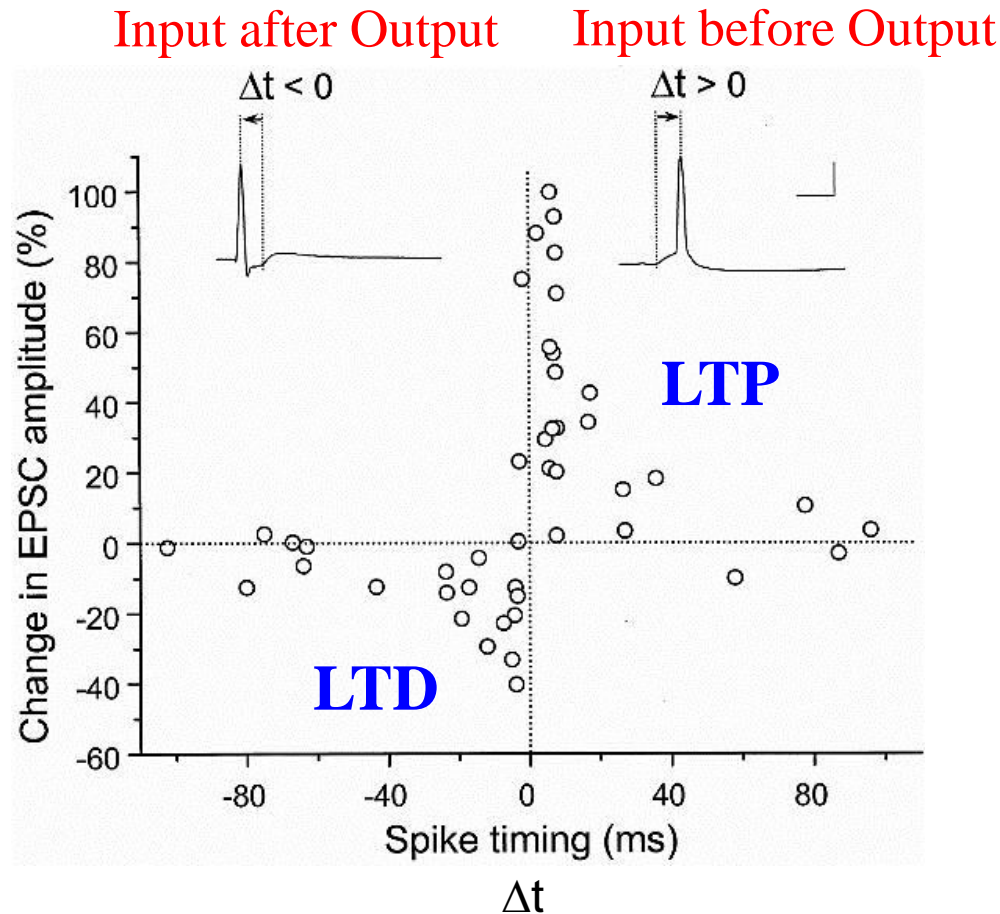


LTP



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