

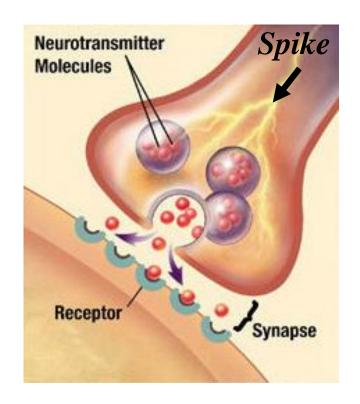
What happens
to the spike
(action
potential) when
it reaches the
end of an axon?

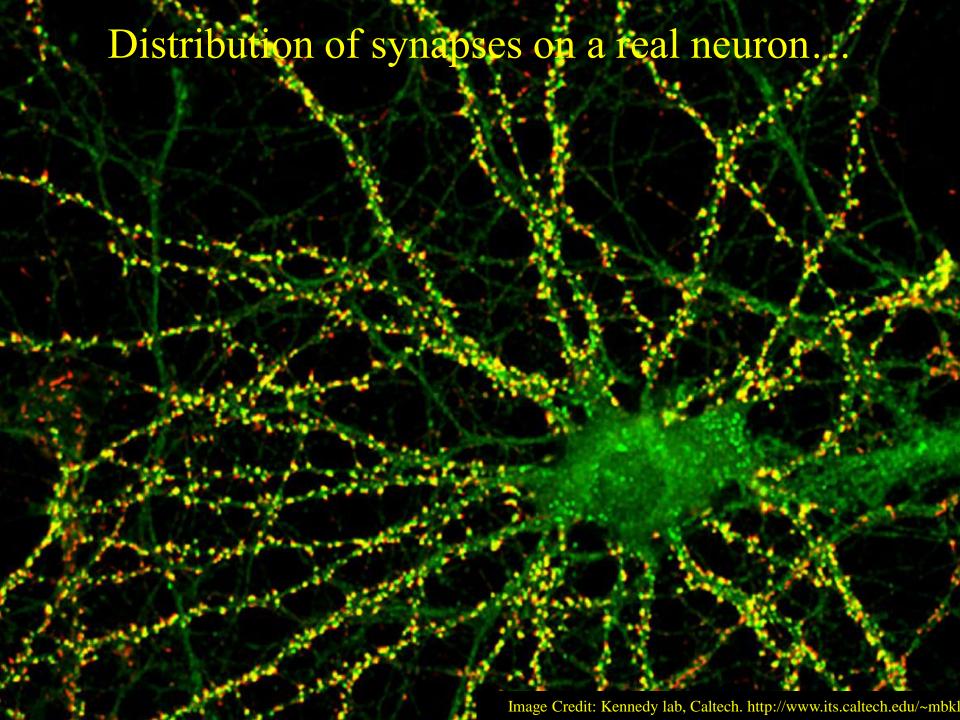
Enter...
the Synapse

What is a Synapse?

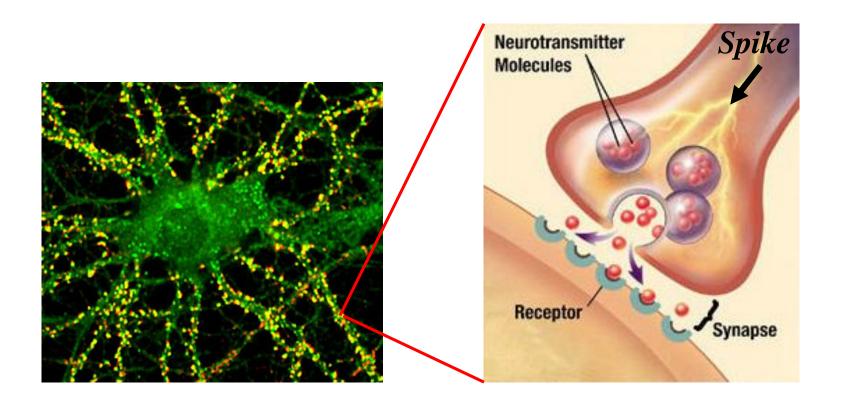
- → A **Synapse** is a "connection" or junction between two neurons
 - ⇒ Electrical synapses use gap junctions
 - Chemical synapses use neurotransmitters

Sap junction Neuron B



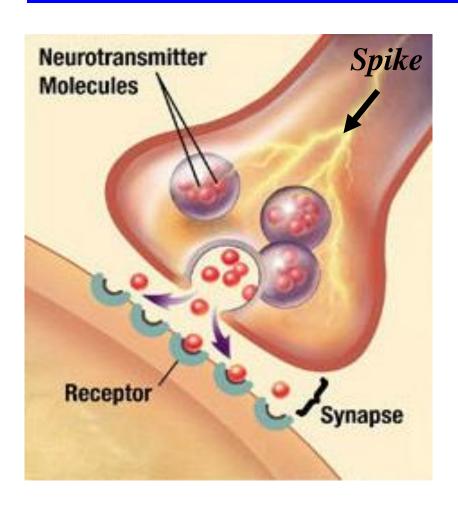


Synapses can be **Excitatory** or **Inhibitory**



Increase or decrease postsynaptic membrane potential

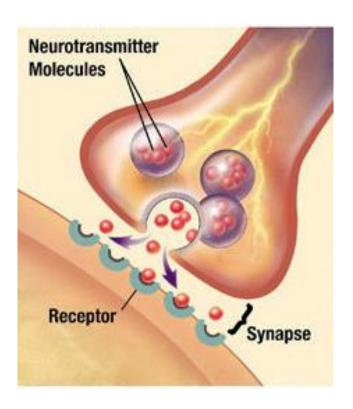
An Excitatory Synapse



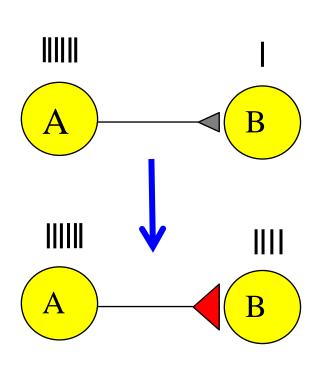
Input spike \rightarrow Neurotransmitter release (e.g., Glutamate) \rightarrow Binds to ion channel receptors \rightarrow Ion channels open \rightarrow Na+ influx \rightarrow Depolarization due to **EPSP** (excitatory postsynaptic potential)

The Synapse Doctrine

Synapses are the basis for memory and learning



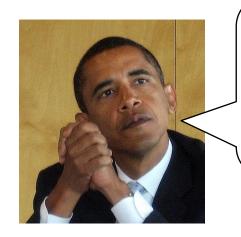
How do Brains Learn? Synaptic Plasticity



Hebbian Plasticity



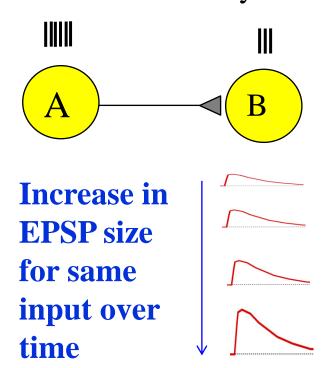
If neuron A repeatedly takes part in firing neuron B, then the synapse from A to B is strengthened

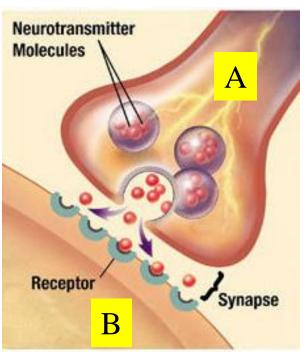


"Neurons that fire together wire together!"

Long Term Potentiation (LTP)

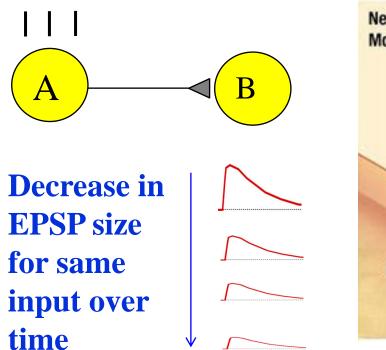
LTP = Experimentally observed *increase* in synaptic strength that lasts for hours or days

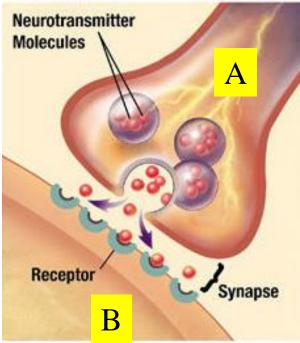




Long Term Depression (LTD)

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





Synaptic Plasticity depends on Spike Timing!

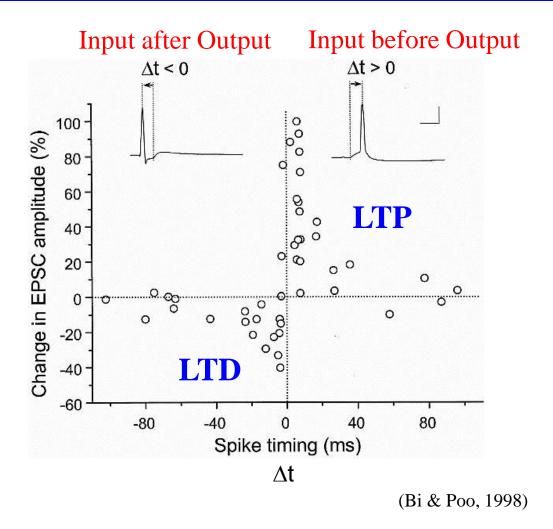
LTP/LTD depends on relative timing of input and output spikes

Input Spike after Output Spike

EPSP Before before 15 ms 40 m√ **Input-Output** pairing 15 ms **Pairing** after **EPSP** After 15 ms LTP

Input Spike before Output Spike

Spike-Timing Dependent Plasticity (STDP)



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