

The Ever-Changing Brain

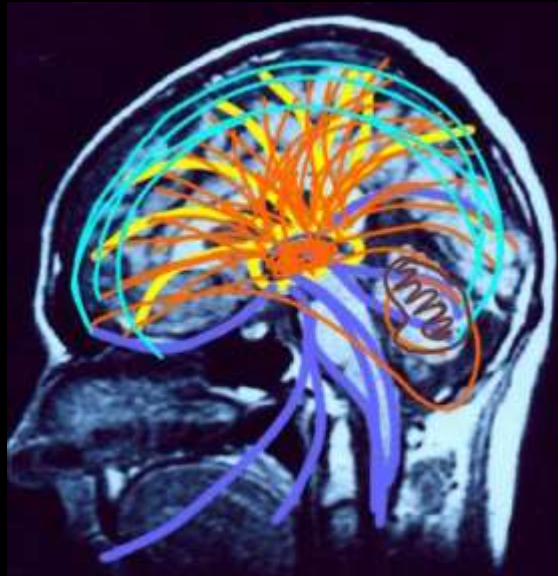
Dr. Julie Haas
Biological Sciences

Outline

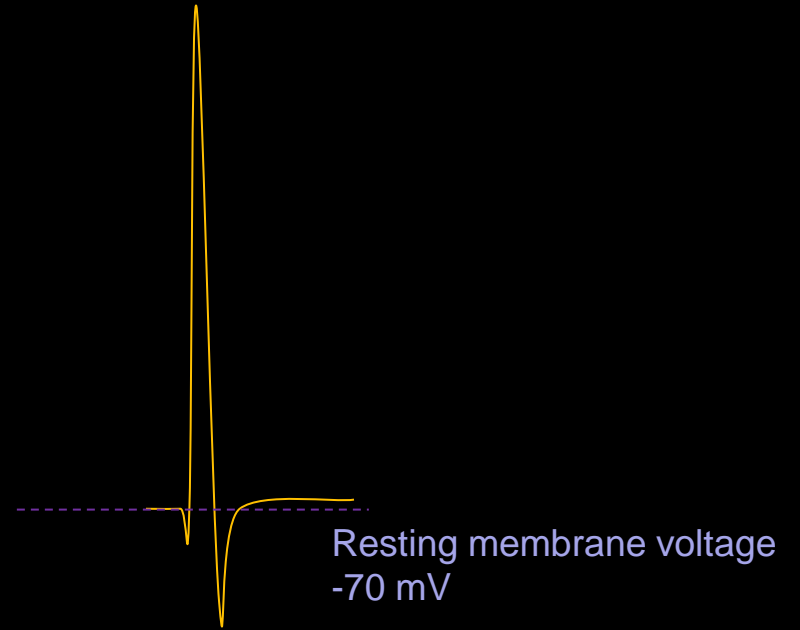
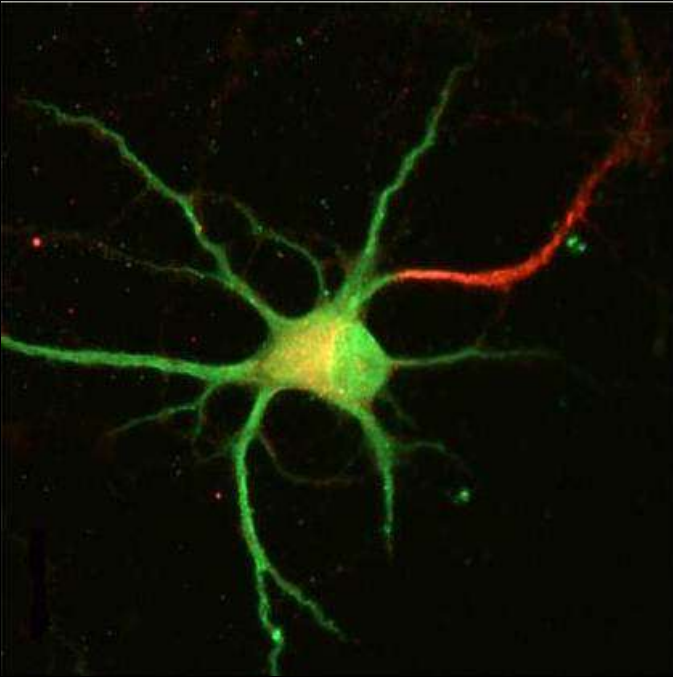
- 1) Synapses: excitatory, inhibitory, and gap-junctional
- 2) Synaptic plasticity, and Hebb's postulate
- 3) Sensory maps and plasticity
- 4) Brain plasticity

Synapses

- The human brain has ~10 billion neurons.
- Each neuron receives ~10,000 inputs from other neurons at specialized contacts known as synapses.
- The brain is organized into areas – and pathways.



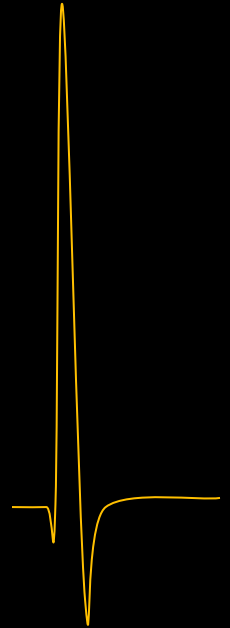
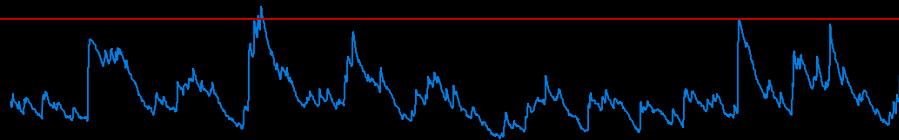
Gary Osborn, "The Gate of God"



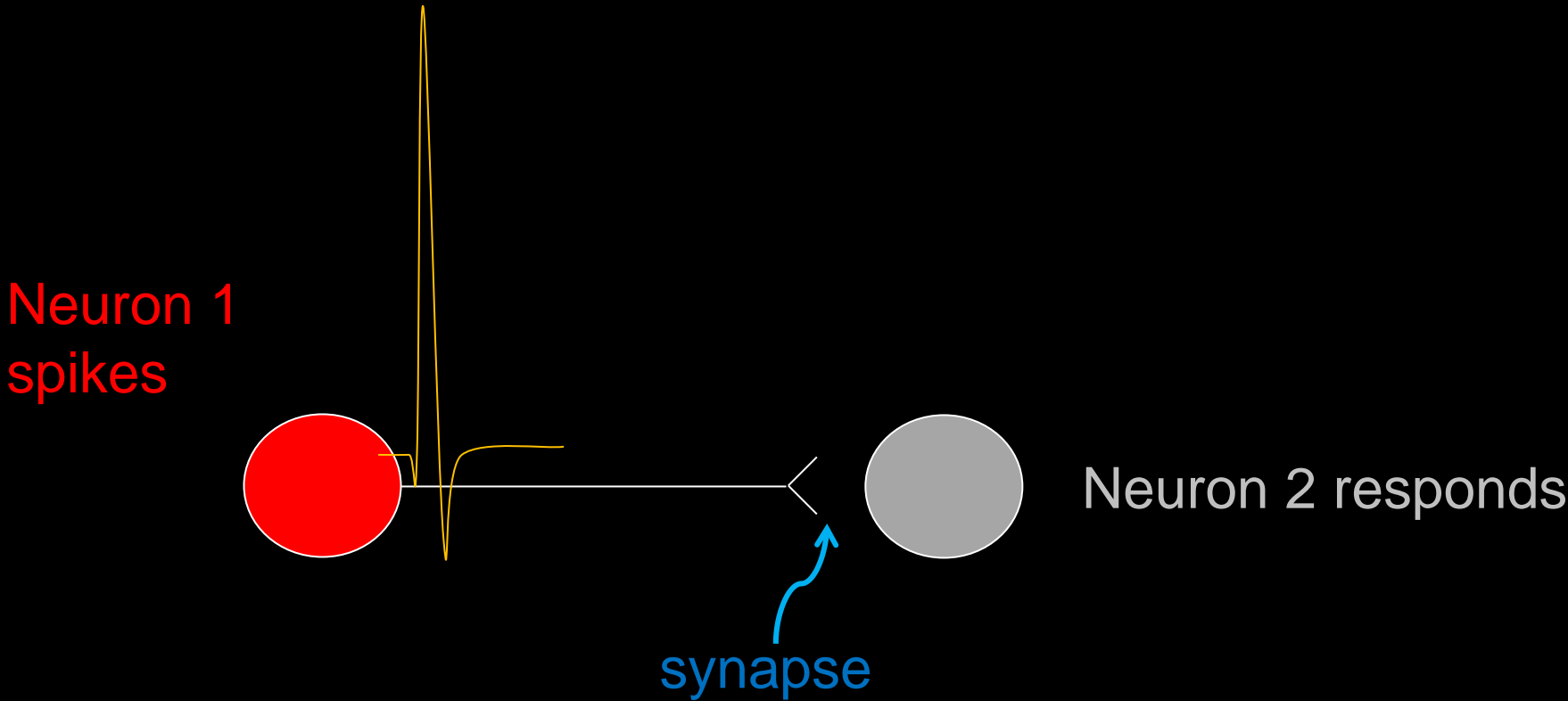
Do the synaptic responses in neuron 2 make it spike?

Spike threshold voltage
-40 mV

Resting membrane voltage
-70 mV



Neurons communicate with spikes at synapses:



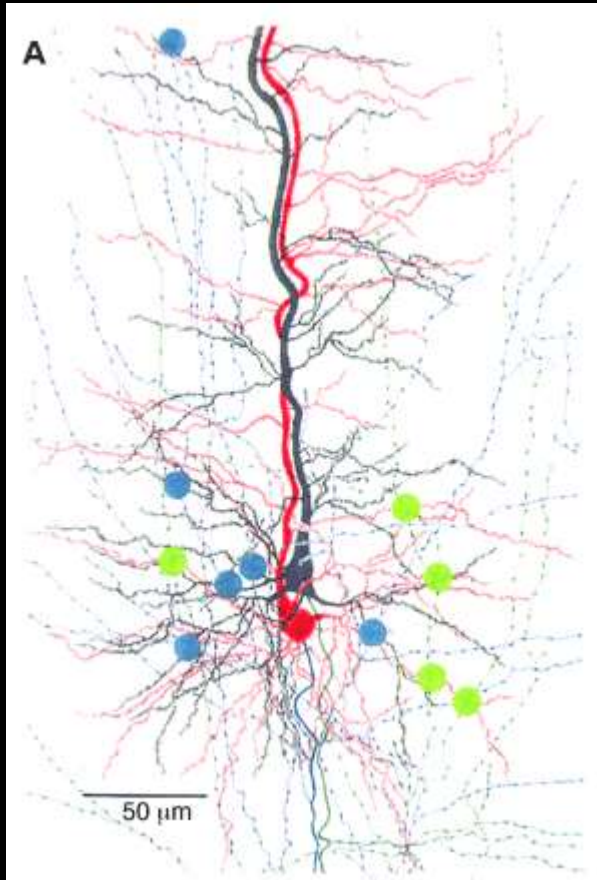
What is a synapse?



Sir Charles Sherrington

Derived from the Greek word meaning “to clasp”, a synapse is considered *any specialized relation between two neurons in which one affects another.*





Neuron 1
Neuron 2

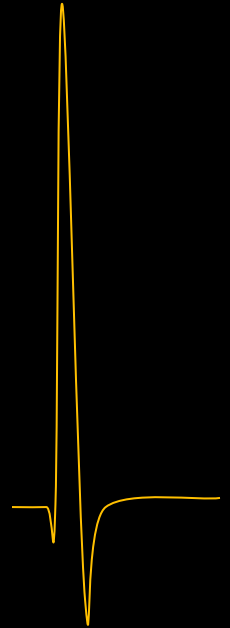
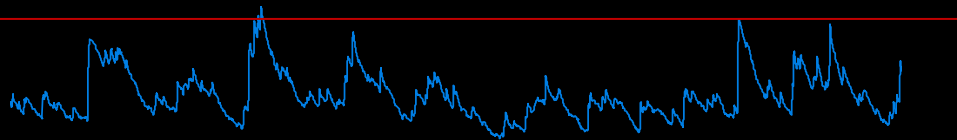
Synapses from neuron 1 to neuron 2
Synapses from neuron 2 to neuron 1

Markram et al. (1997)

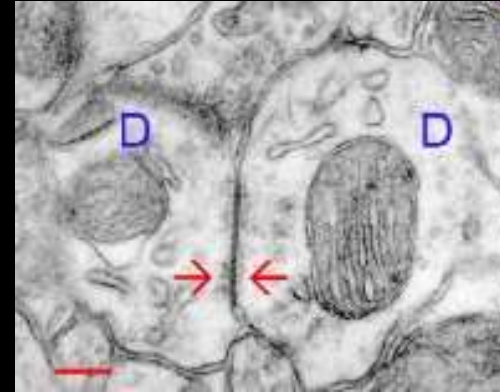
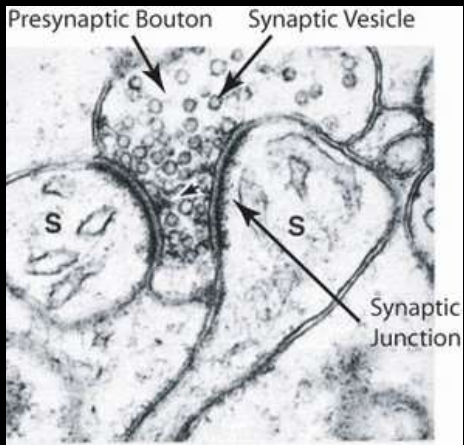
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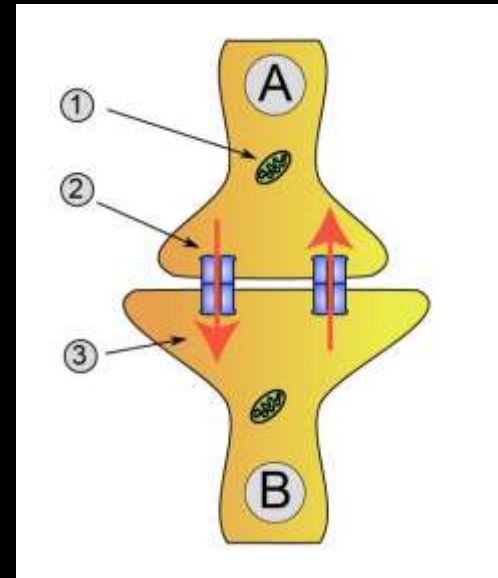
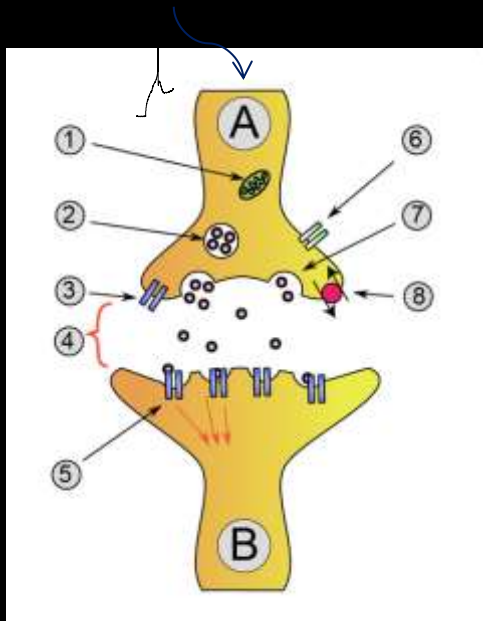


*collected from all over the neuron's dendrites



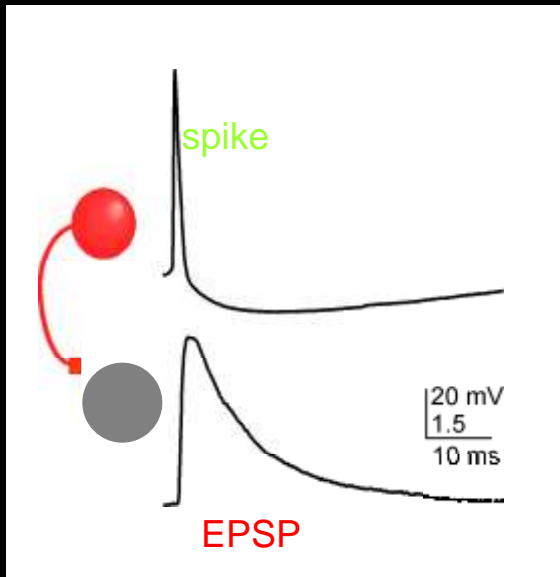
Synapses use neurotransmitter

.... or not!

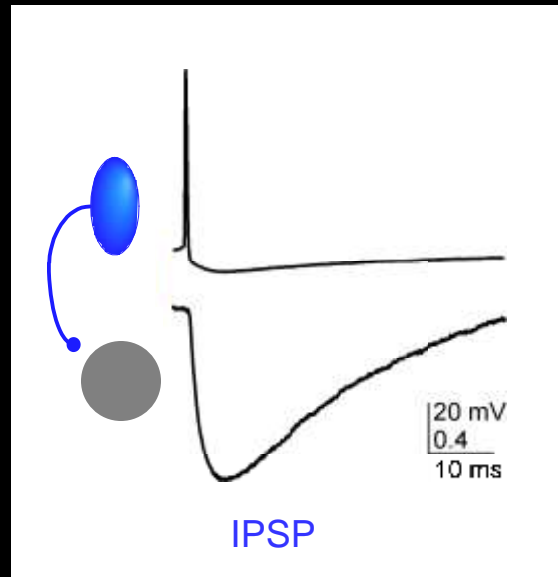


Synaptic Transmission

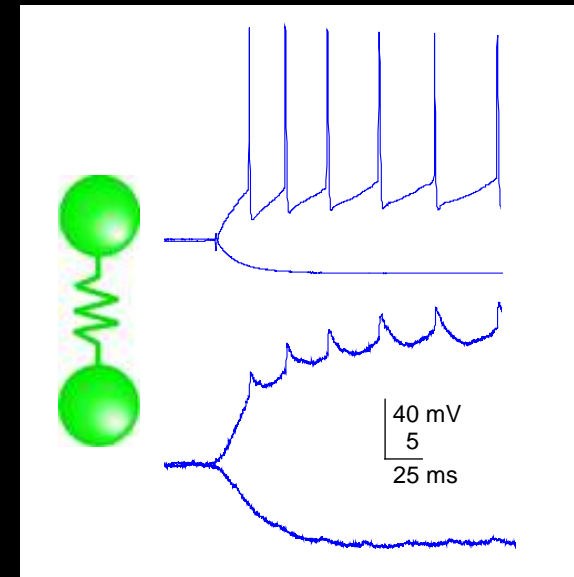
Excitatory



Inhibitory



Electrical



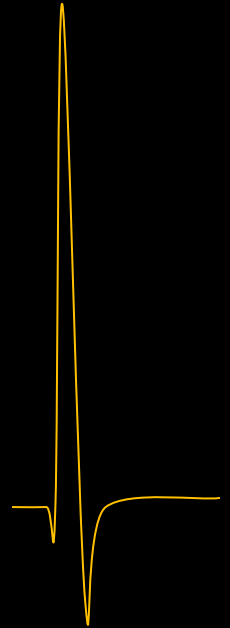
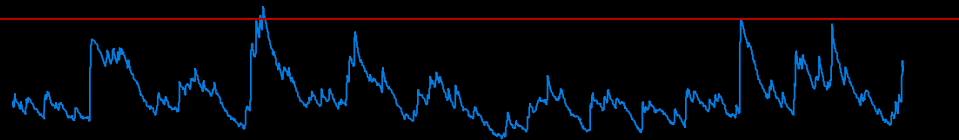
- Directional, with pre- and post-synaptic sides
- Stereotyped timecourses
- Metabolically expensive

- Bidirectional flow
- Sign-preserving response

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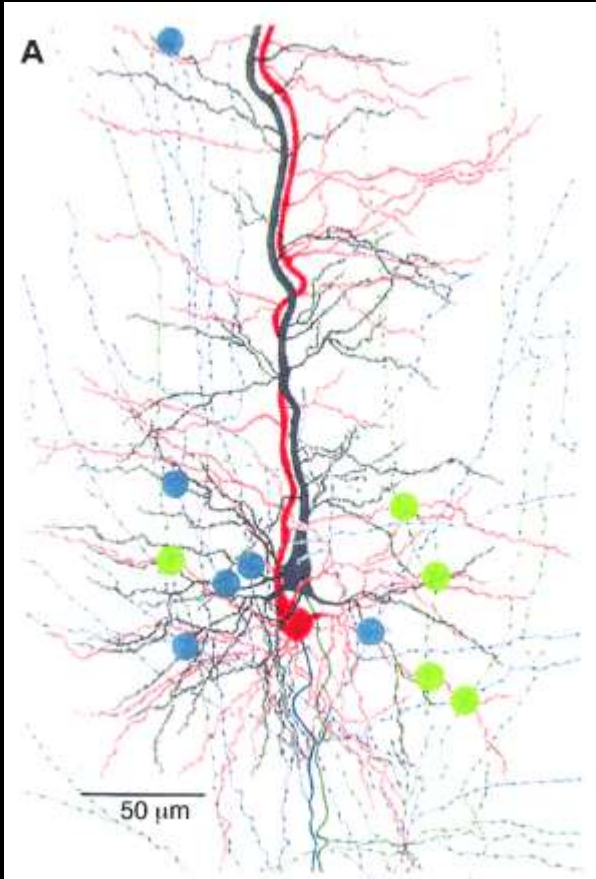
*a combination of excitatory, inhibitory and gap-junctional synaptic inputs

Outline

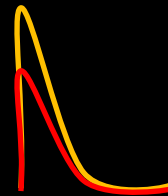
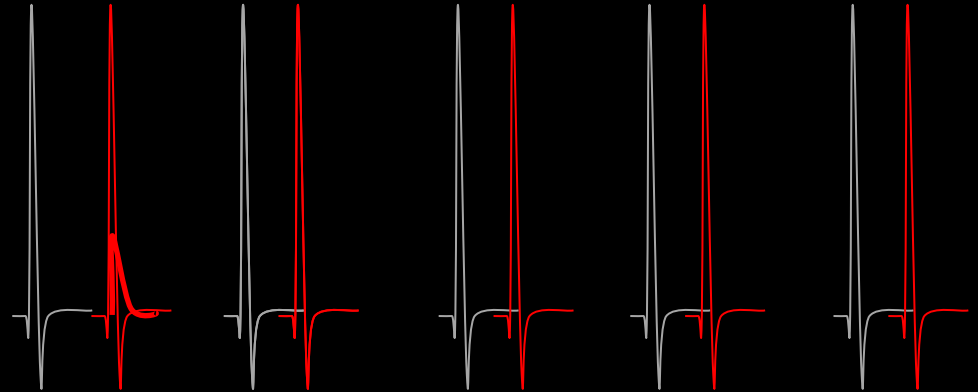
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*Let us assume that the persistence or repetition of a reverberatory activity (or "trace") tends to induce lasting cellular changes that add to its stability...
When an axon of cell A is near enough to excite a cell B and repeatedly or persistently 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.*

Donald Hebb, 1949

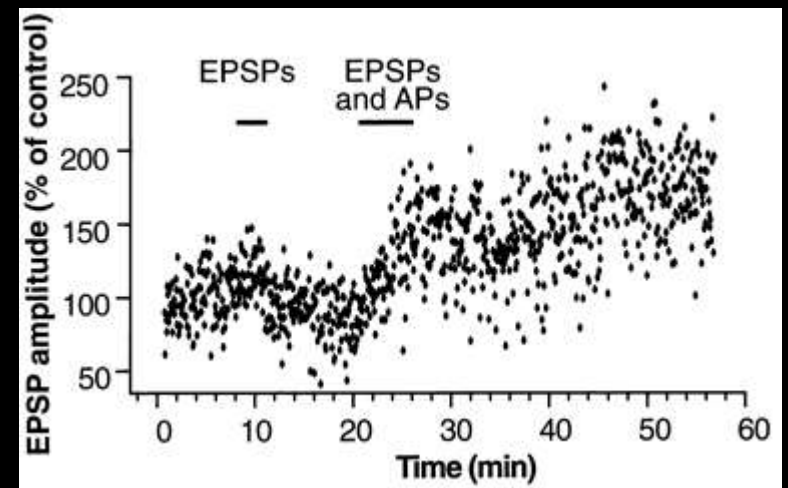


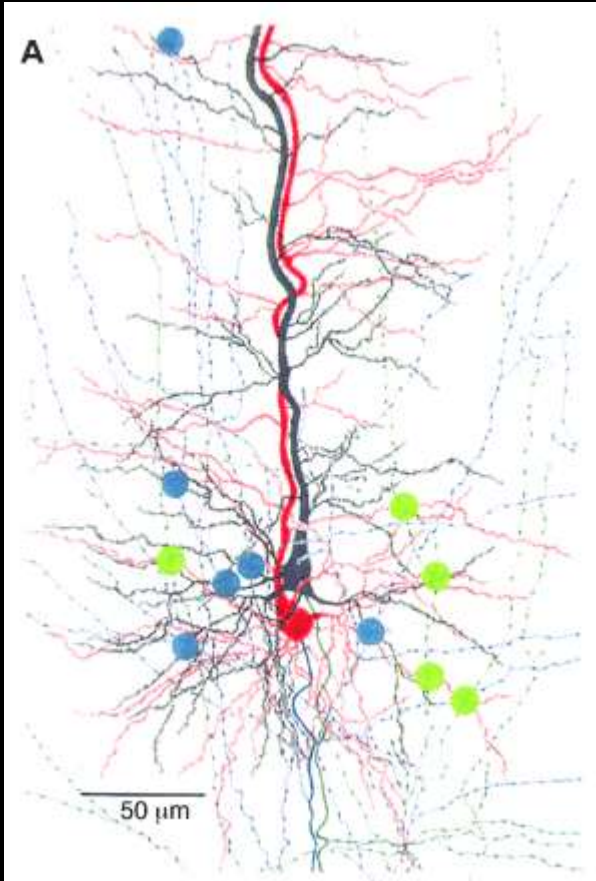
Markram et al. (1997)



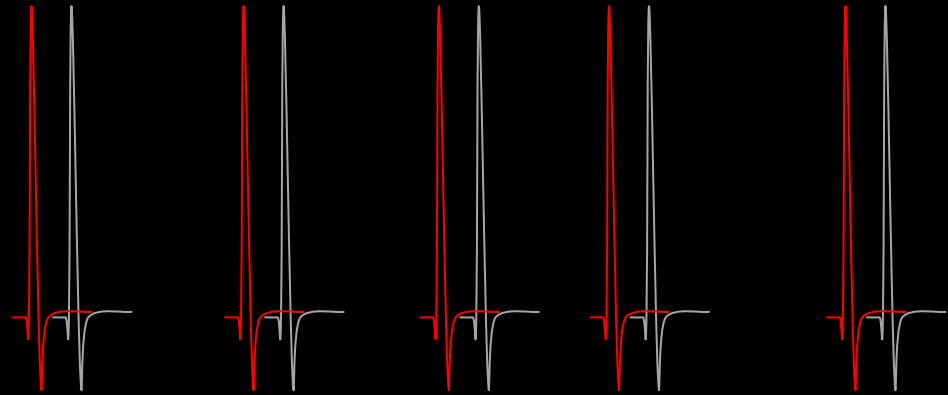
firing together

... and wiring together,
strengthening connections

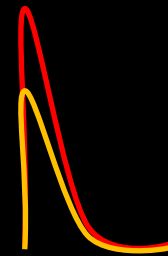




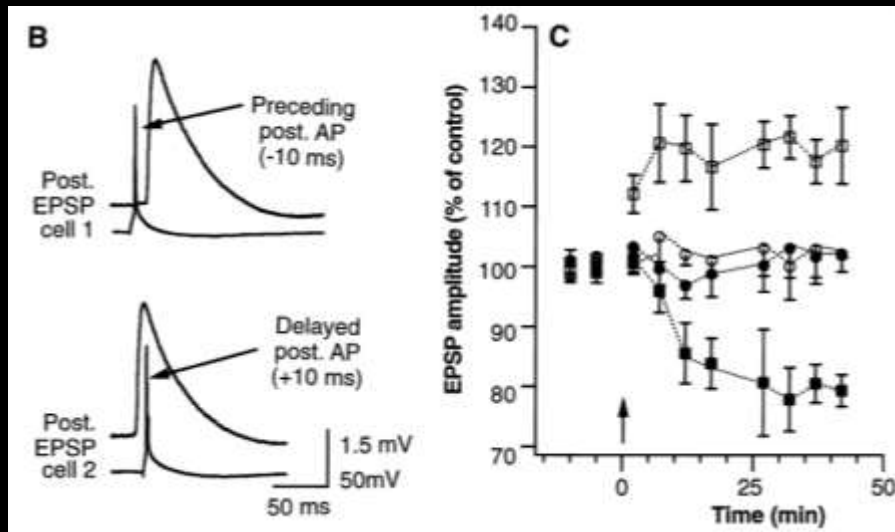
Markram et al. (1997)



for the opposite spiking order



the synaptic connection gets weaker



← stronger

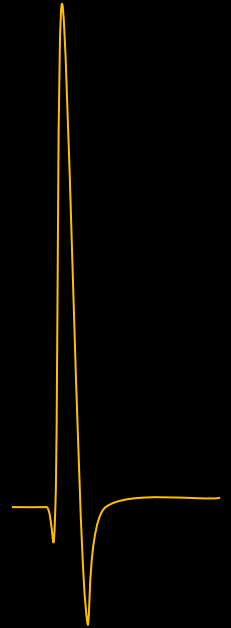
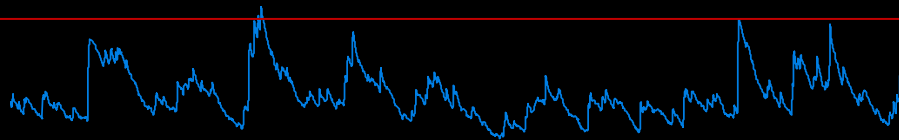
← weaker

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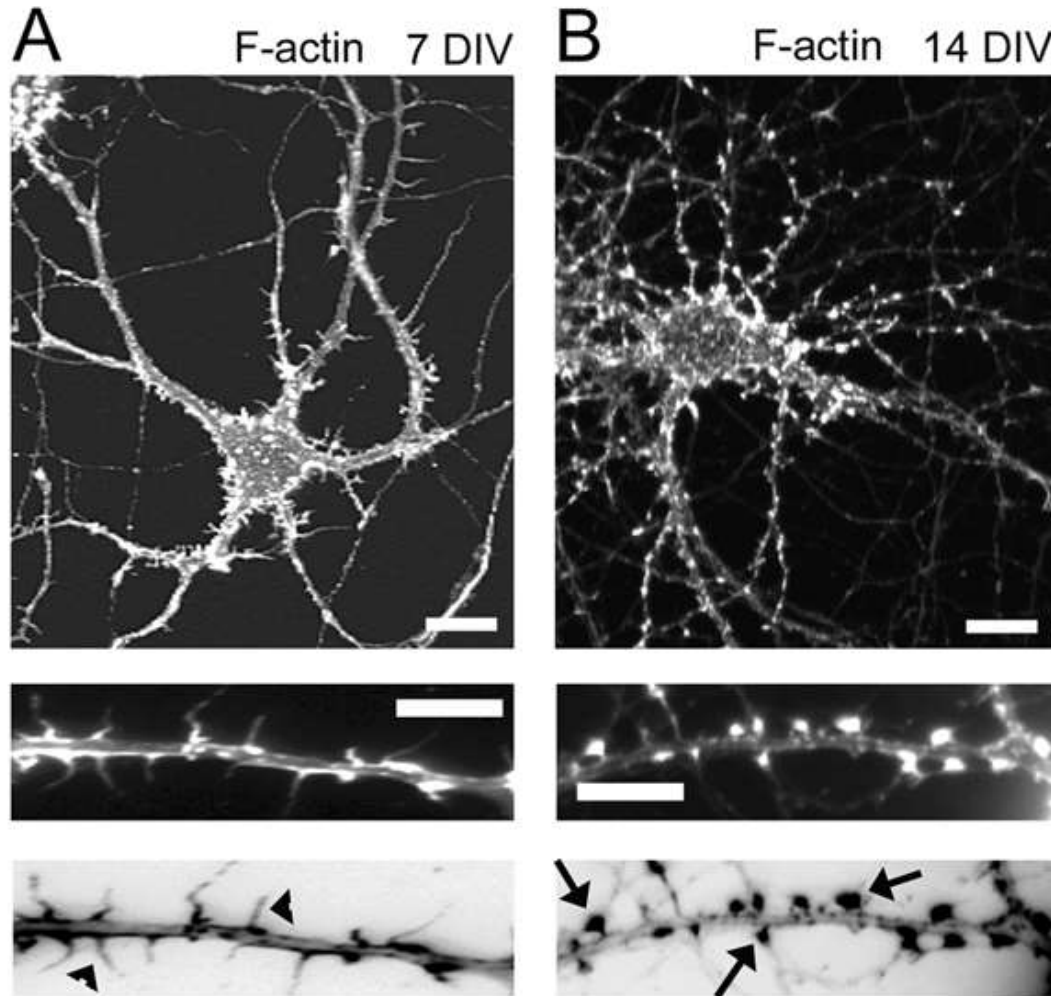


How about now?
How about now?
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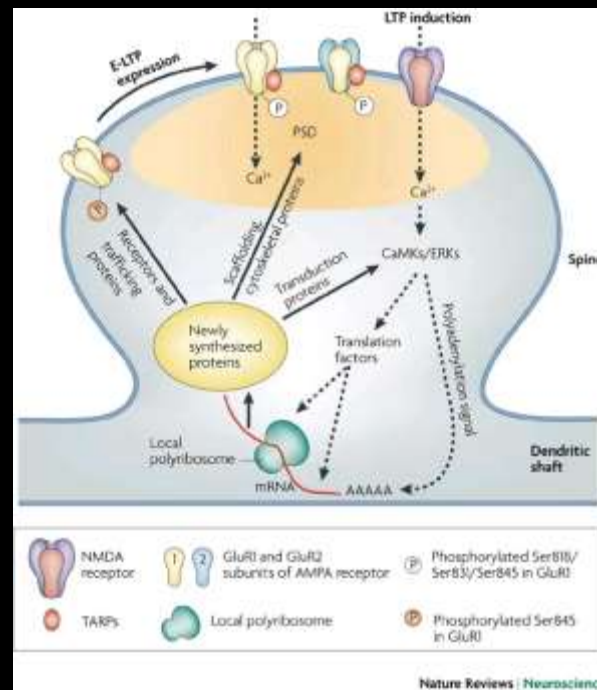
Plasticity is everywhere!

- at excitatory synapses
- at inhibitory synapses
- at gap junctional synapses
- long-term depression, long-term potentiation
- short-term depression, short-term potentiation
- Metaplasticity – changes in how plasticity is expressed.
- Structural plasticity: growth and pruning of synaptic structures
-the list goes on!

Structural plasticity



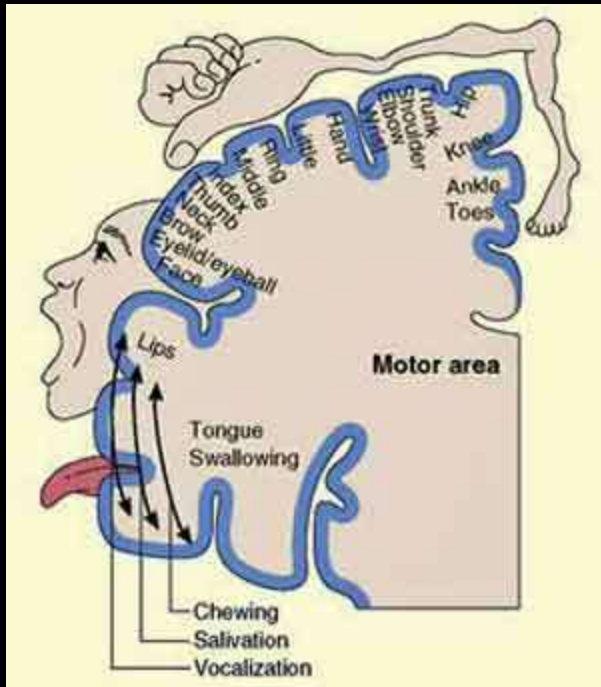
Plasticity is complex



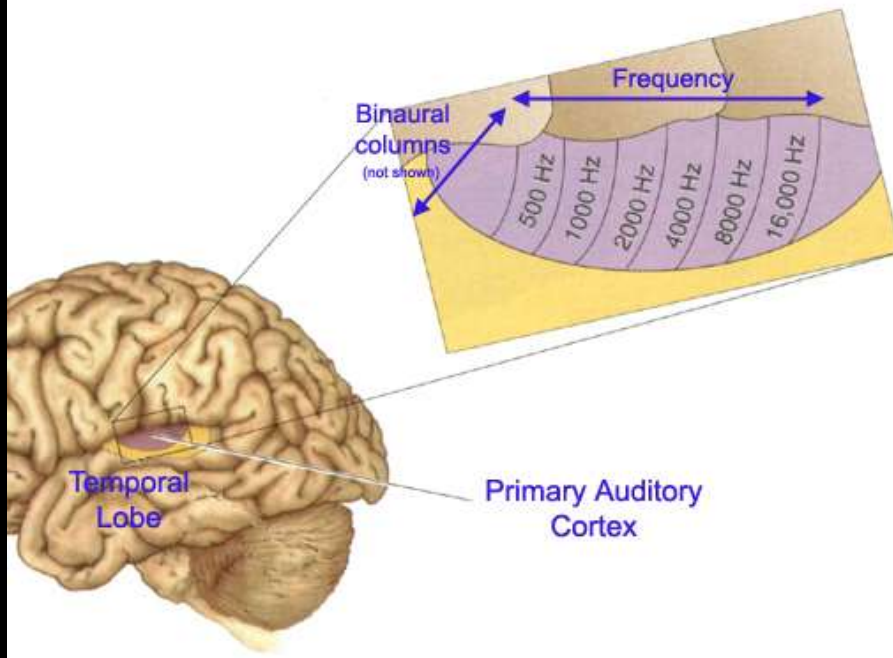
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The somatosensory homonculus:



Tonotopic Map Has Columnar Organization

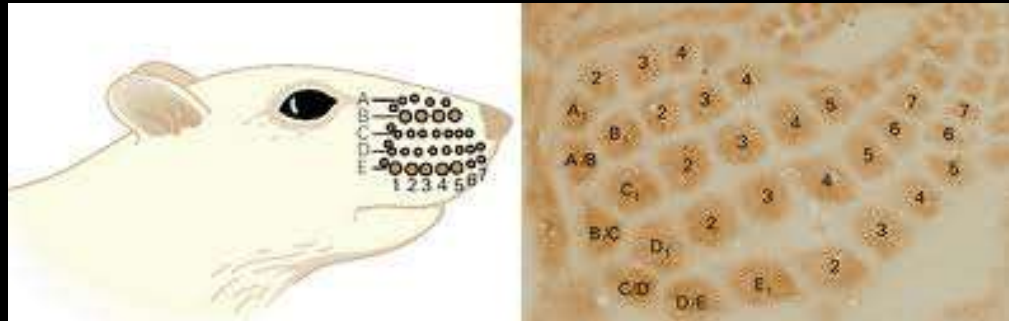


Auditory tonotopic maps

?

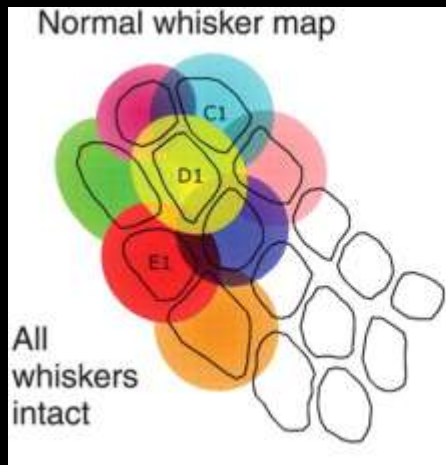
Olfactory map

Rats and the barrel cortex – a type of sensory map



www.neurobiology.info

Sensory map can be changed by experience: Map plasticity



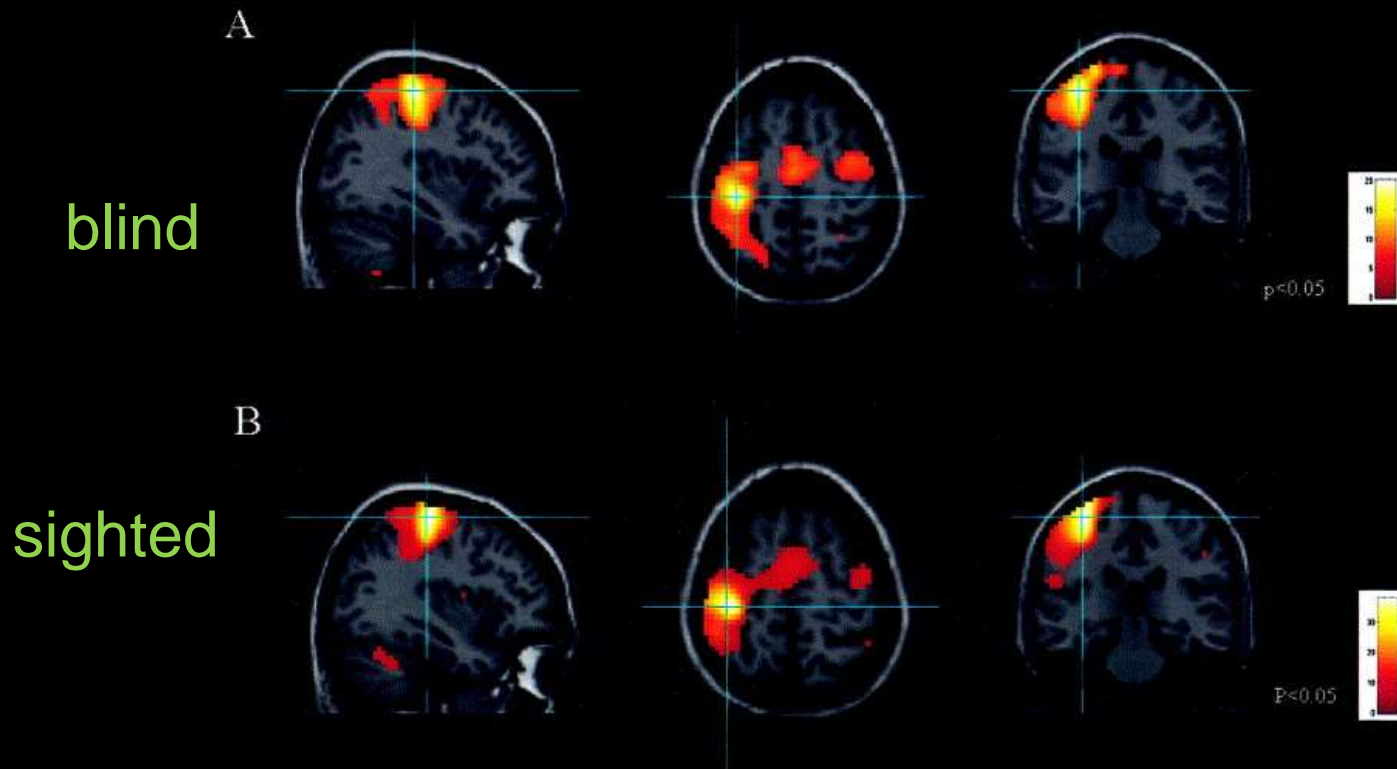


Cochlear implants: a form of map plasticity?

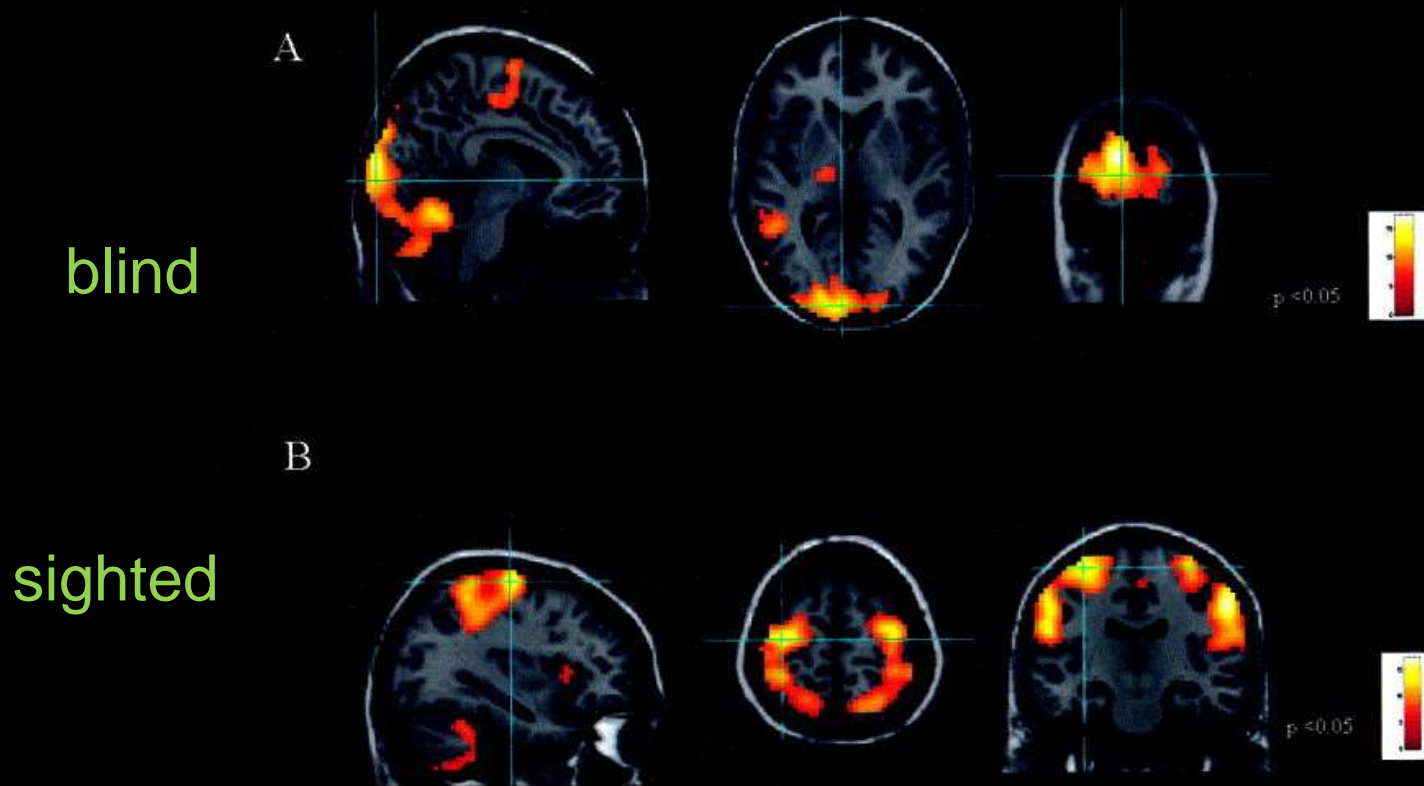
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Brain Plasticity: A finger tapping task



Braille – a language task



Brain Plasticity:

Lumosity.com

