BioE332 Lecture 2

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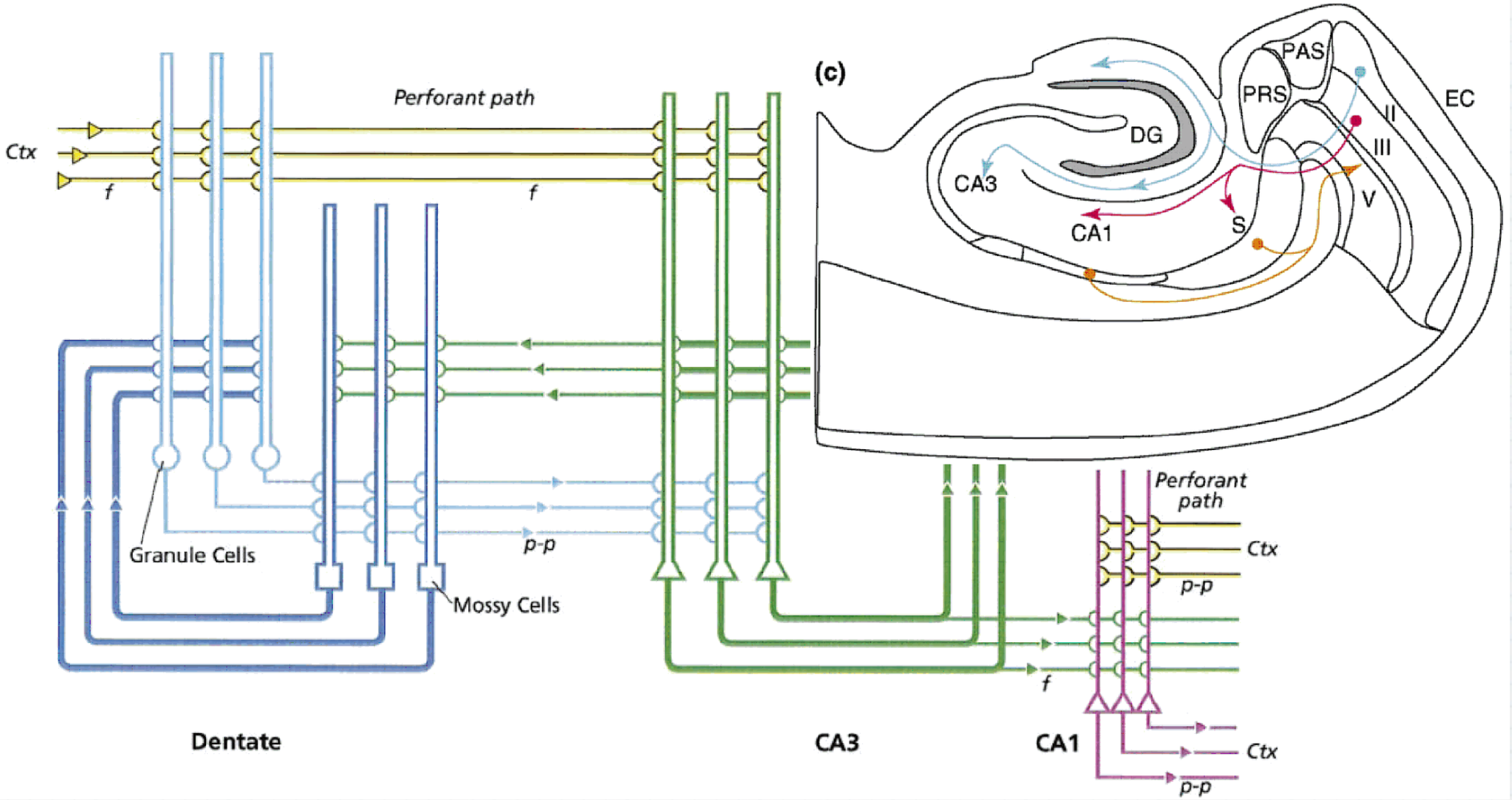
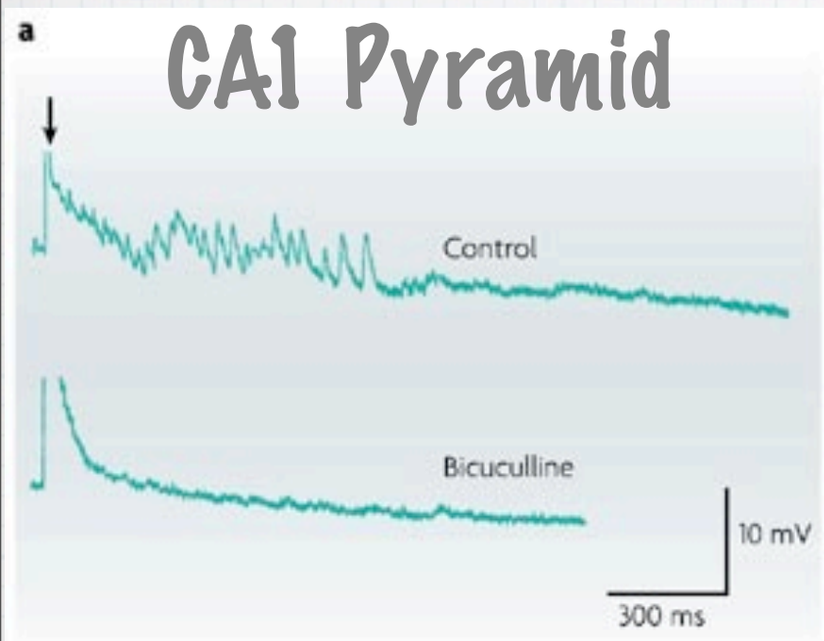
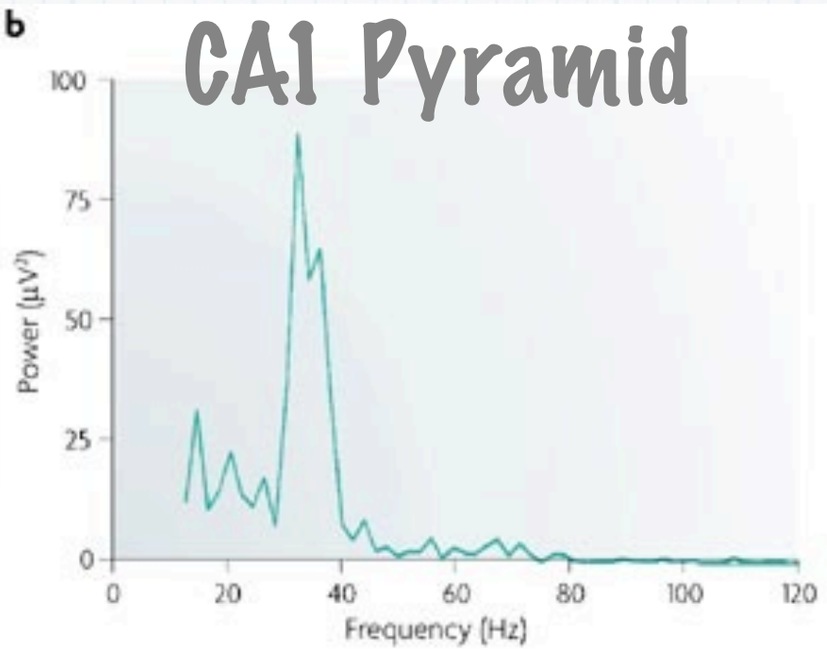
The hippocampal circuit

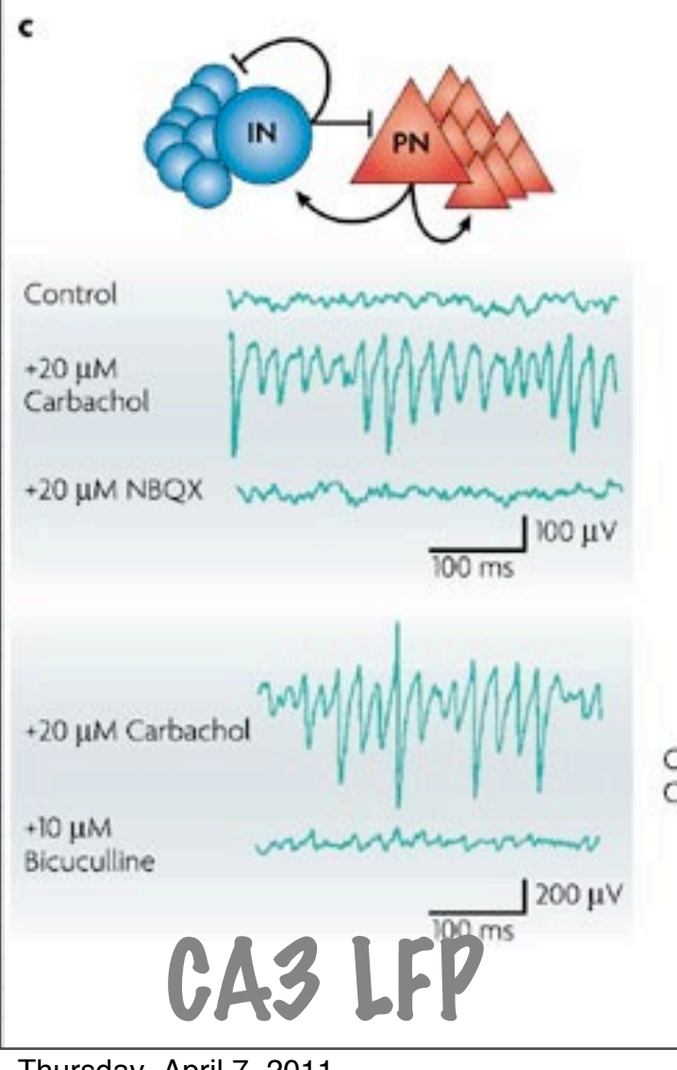


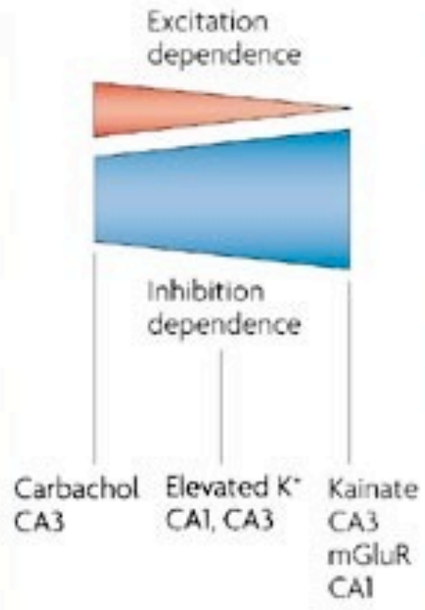
Trisynaptic circuit through dentate gyrus, CA3, and CA1 originates and terminates in entorhinal cortex (insert , rat brain). p-p, point-to-point; f, fanning; Sl,subiculum; PAS/PRS, pre/parasubiculum [Lisman99,Moser06].

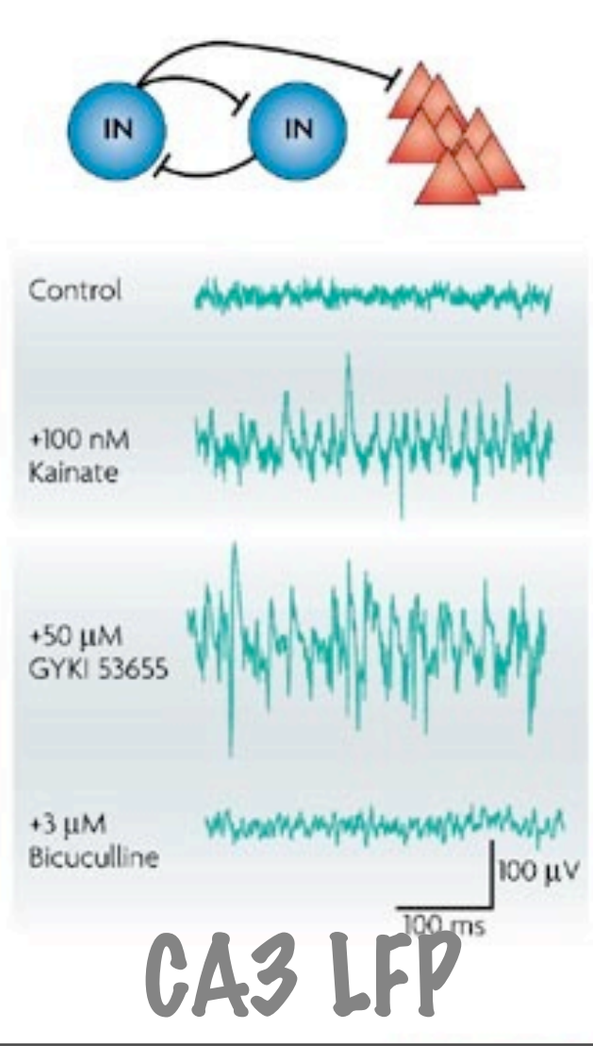
Gamma oscillations in vitro











Jonas 07

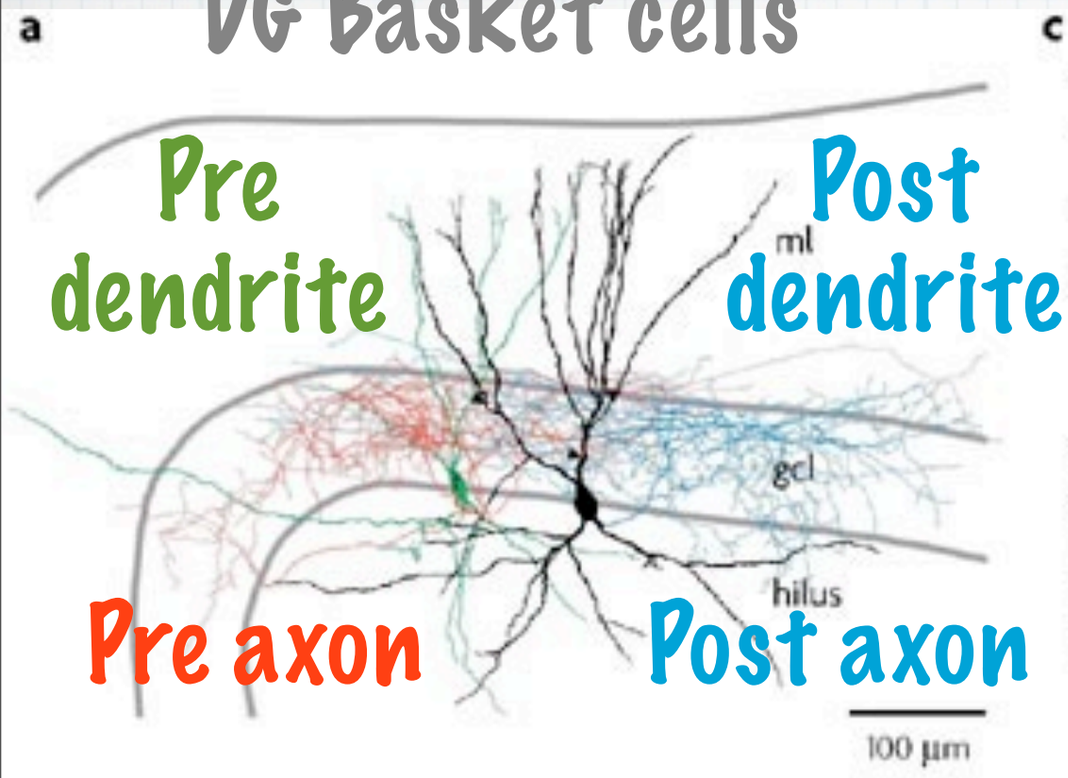
a. Blocking GABAa receptors eliminates mGluR-agonist induced oscillations.
b. Oscillations occur at 30-40Hz.
c. Left: Blocking AMPA or GABAa receptors eliminates mAChR-agonist induced oscillations.
Right: Blocking GABAa receptors eliminates kainate-induced oscillations but blocking AMPA receptors does not.

Models of Gamma Synchrony

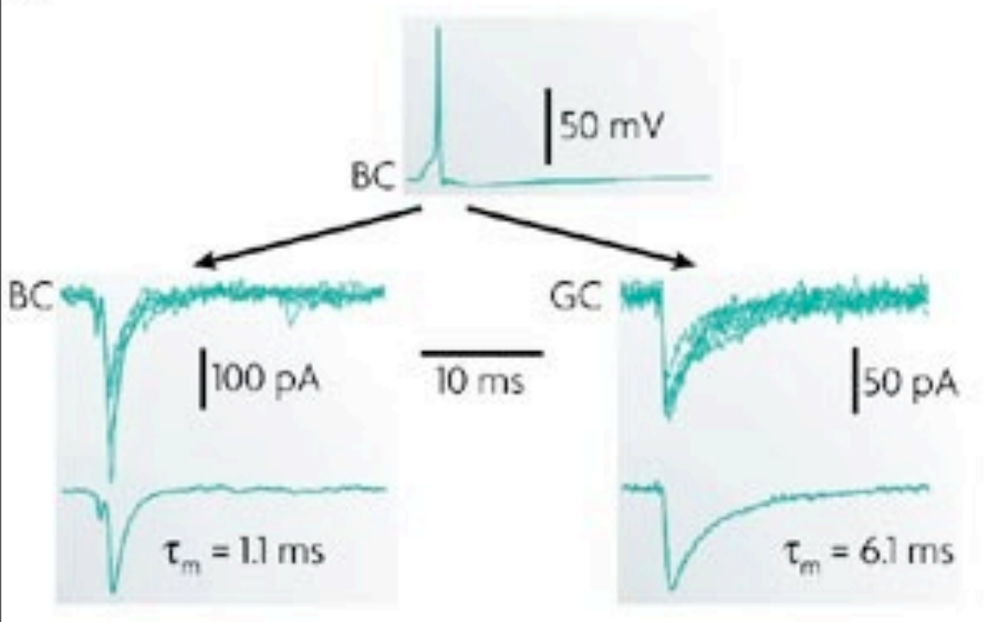
* Wang and Buzsaki (1996) used:
  * Hyperpolarizing inhibition
  * With slow decay constant and weak strength
  * Synchrony was fragile
* Jonas et al. (2002) measured:
  * Fast, strong inhibition in hippocampal basket cells
  * Yielded robust synchrony (together with axonal delays)
* Jonas et al. (2006) showed that inhibition was shunting:
  * More robust synchrony

GABAergic synapses

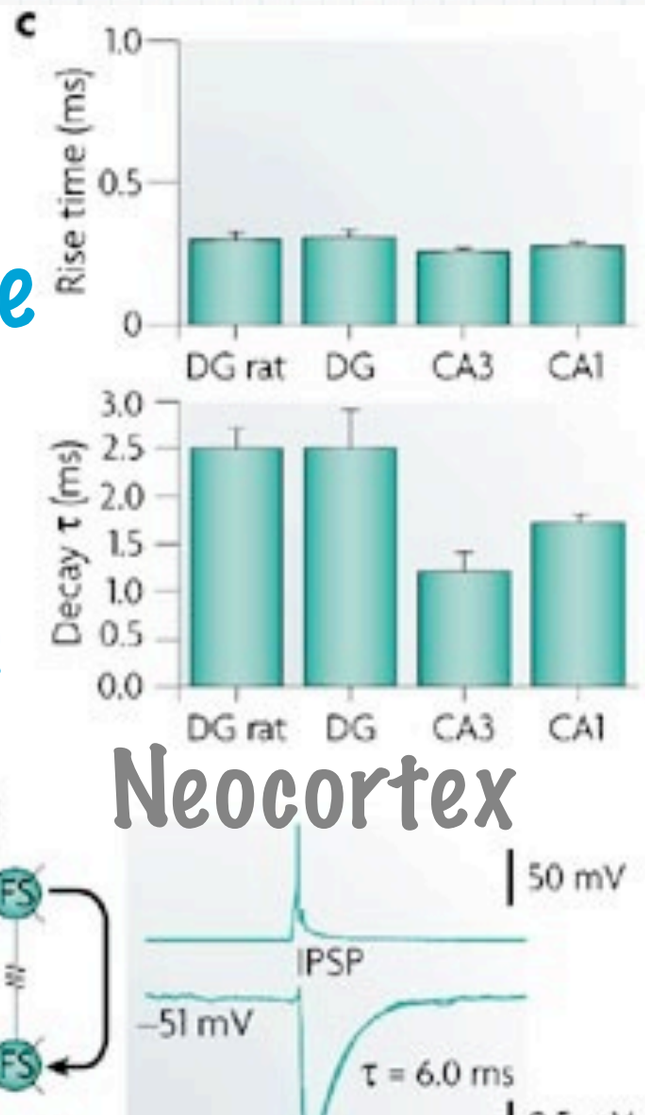
DG Basket cells



Postsynaptic currents



Neocortex

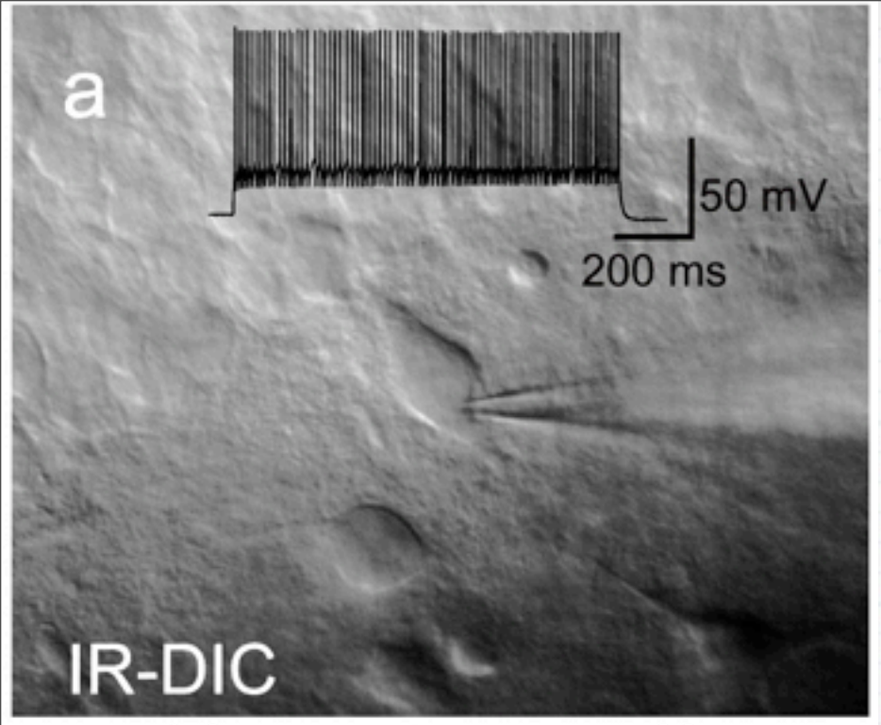


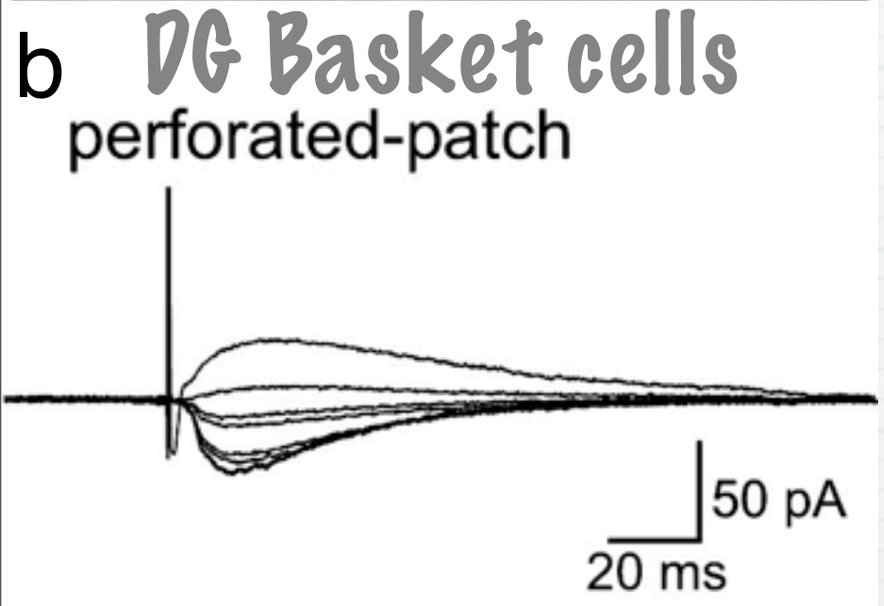
Jonas 07

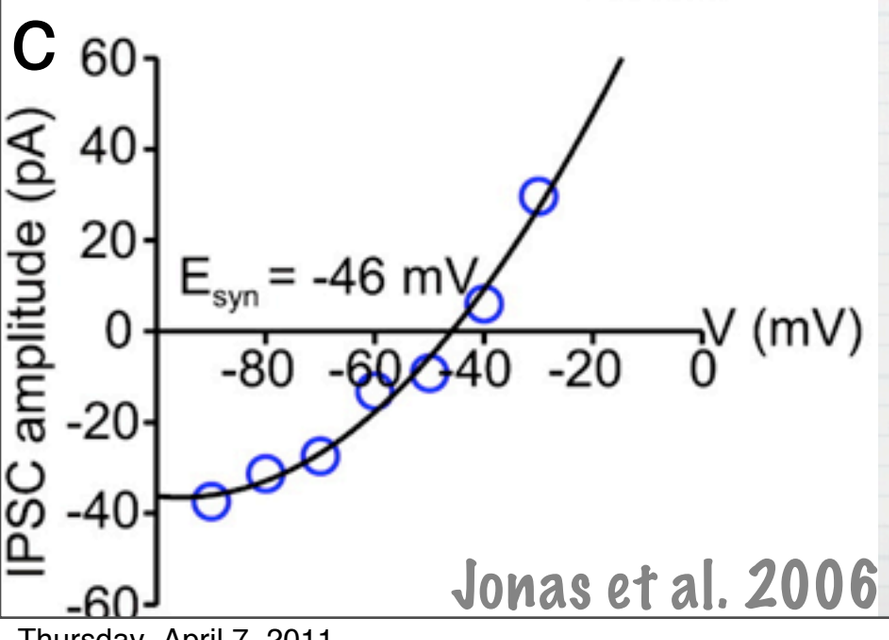
a. Synaptically coupled pair of basket cells.
b. Basket cell synapses onto basket cells are faster than those onto granule cells.
c. Postsynaptic currents' rise-time and decay-constant are fast in every region.
d. Fast-spiking cortical cells also induce fast currents (IPSC); resulting voltage signals are slower (IPSP).

Shunting inhibition

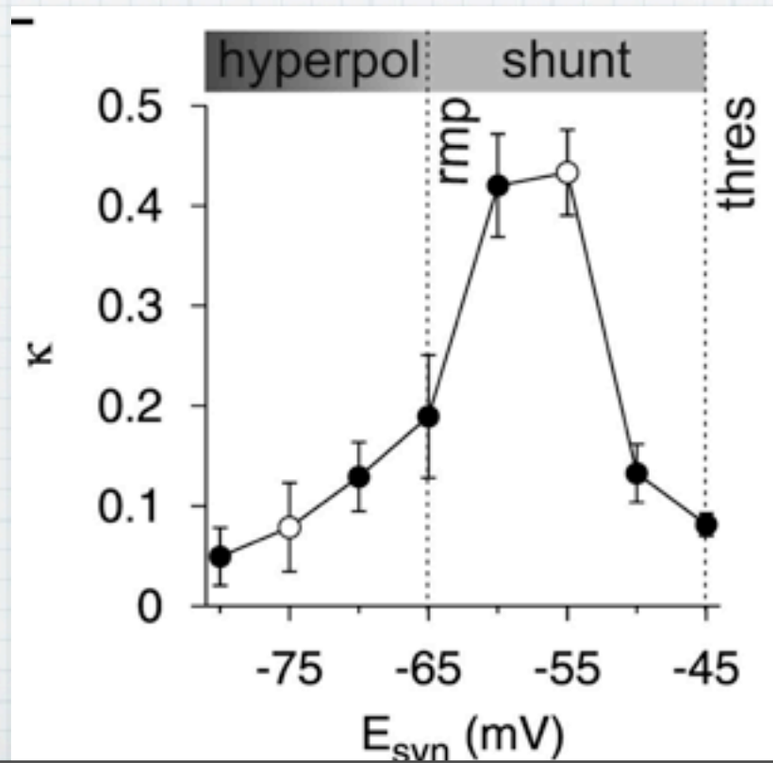
a. Recording showing fast-spiking phenotype superimposed on image of basket cell soma.
b. Postsynaptic currents evoked at various holding potentials.
c. Current-voltage relationship from the data. Resting potential is -59mV; spike threshold is -38mV.

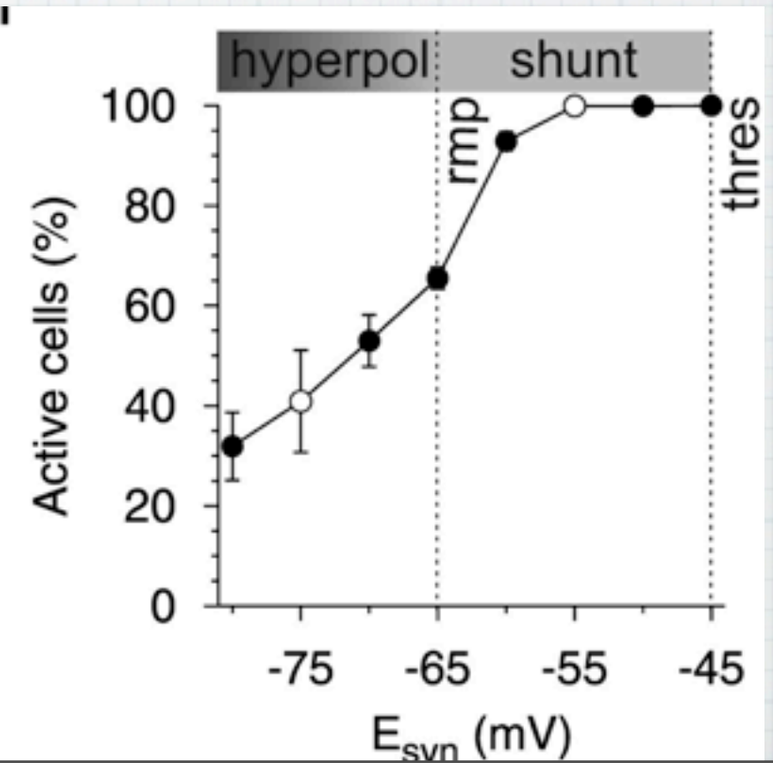


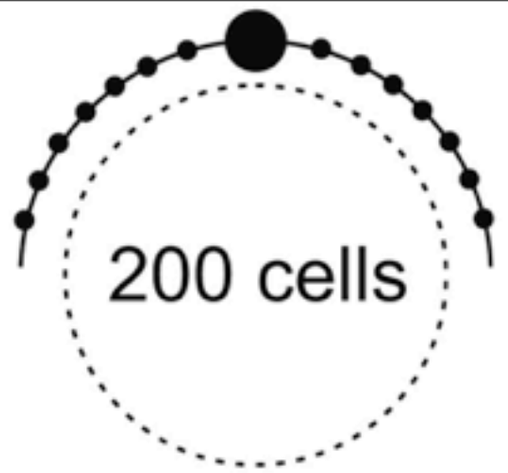


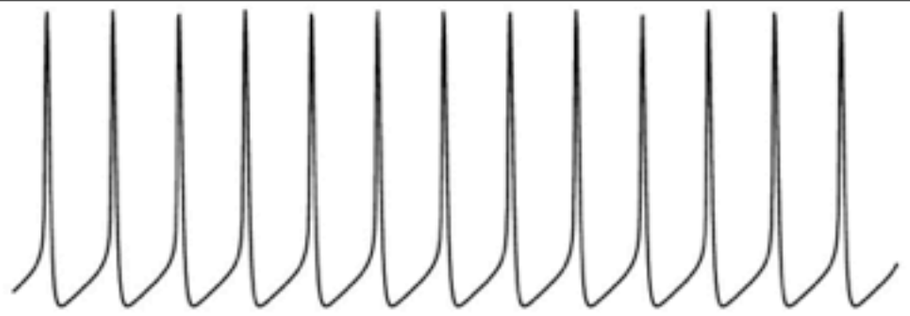


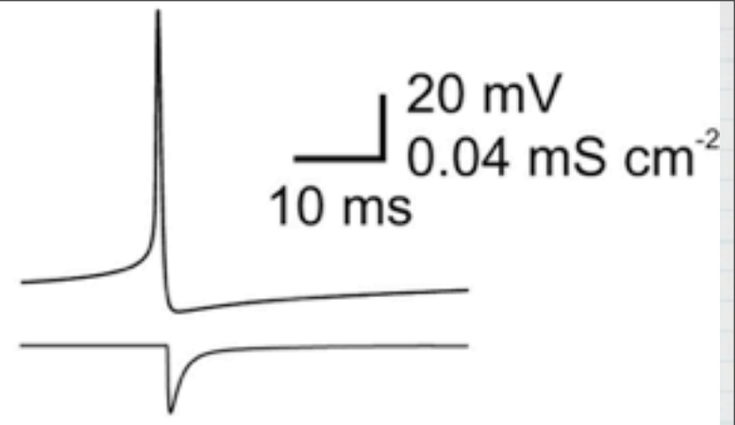
Modeling results: Shunting is more robust

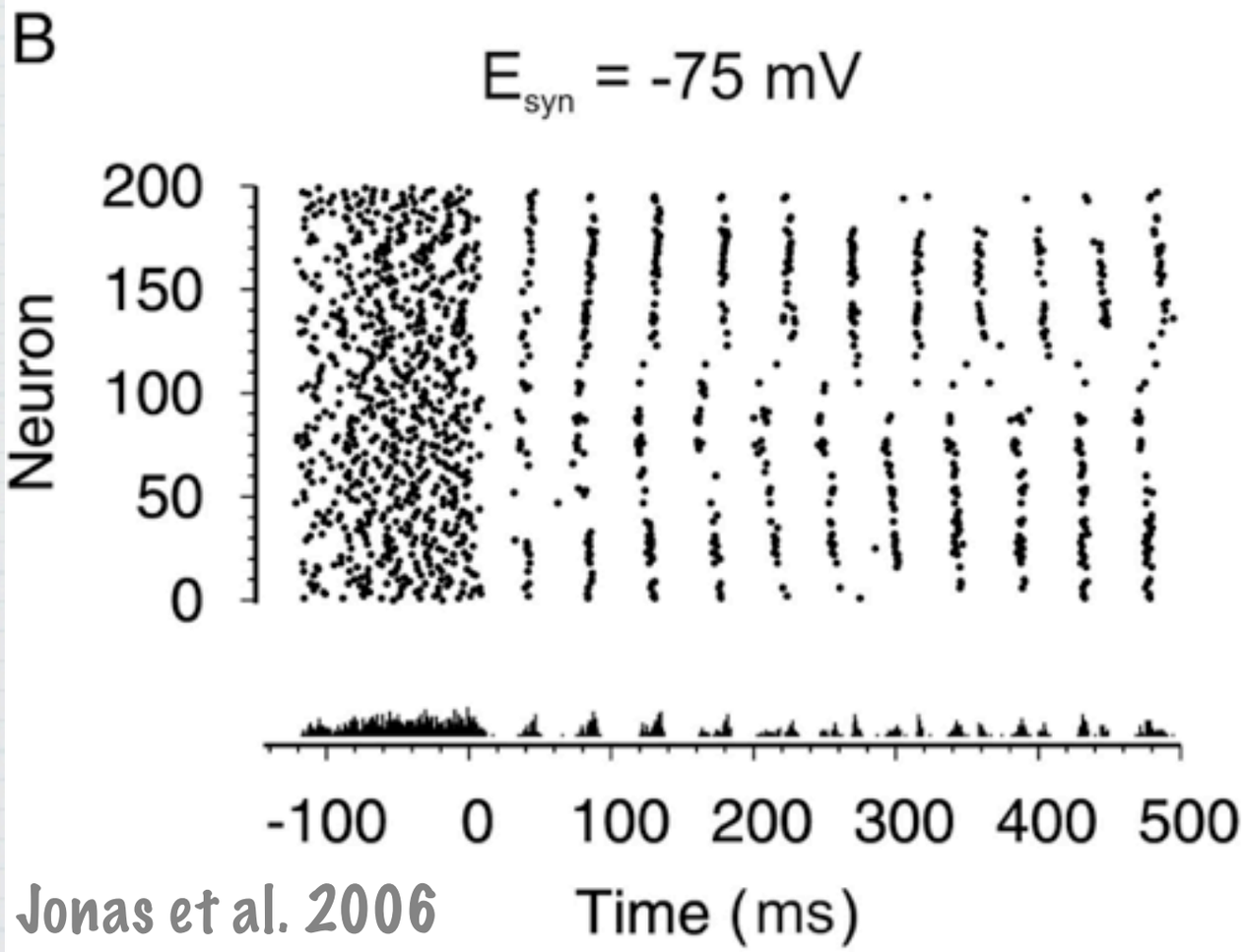


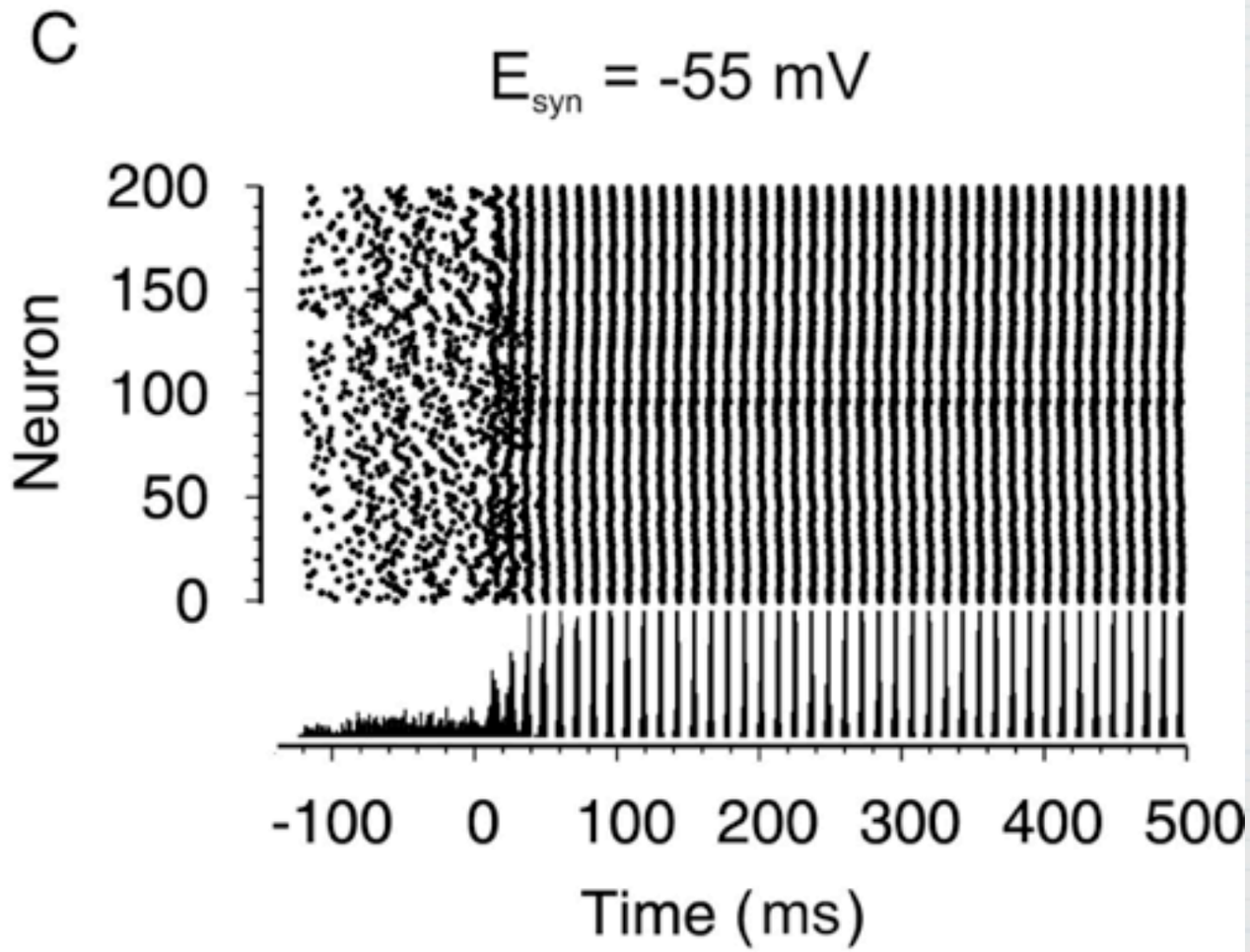








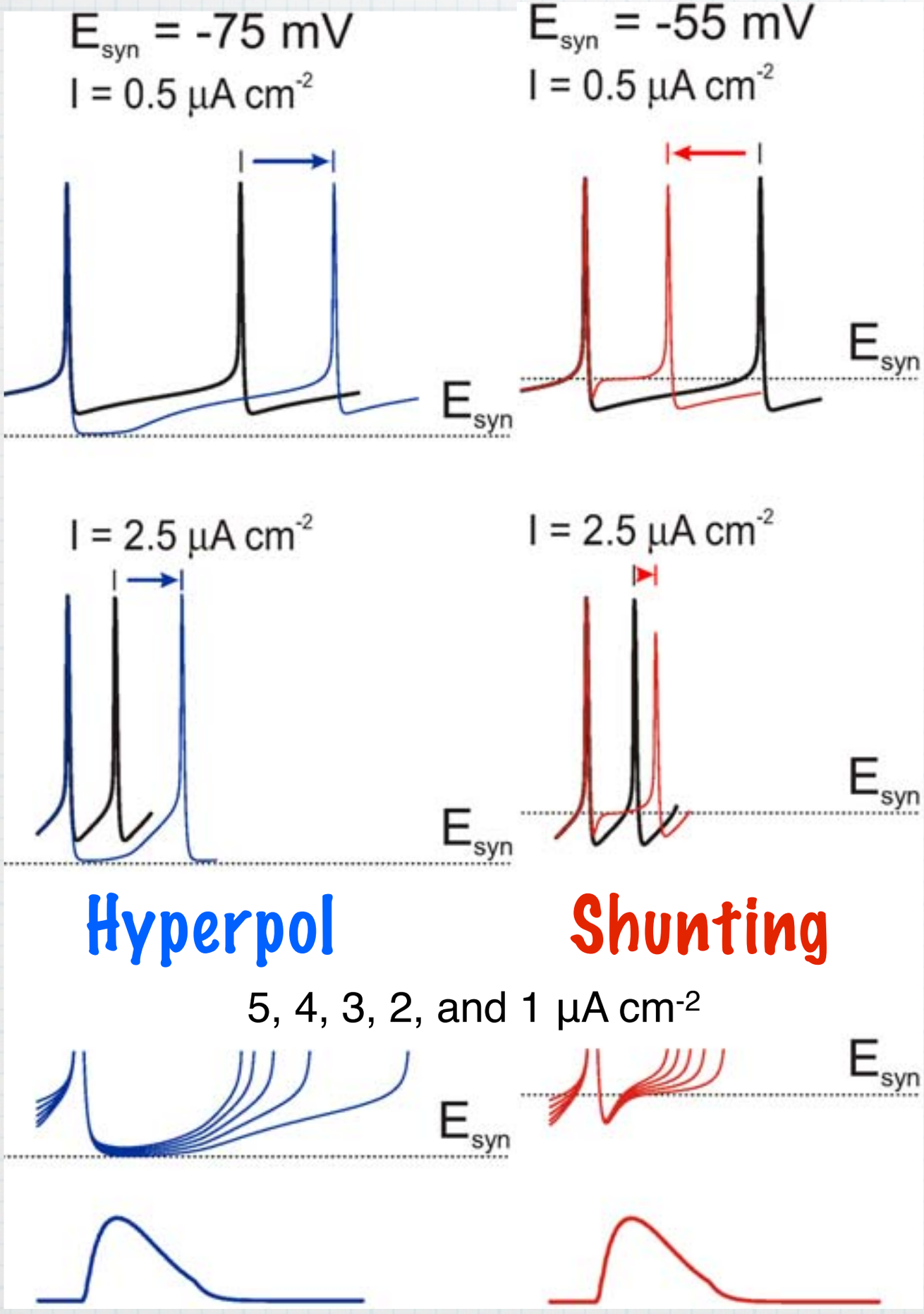




Jonas et al. 2006

Model had 200 neurons, each inhibited to 57 of its 100 nearest-neighbors on a ring, with 0.25m/s axonal conduction delay (0-10ms) and 0.5ms synaptic delay. In addition, each neuron was electrically coupled to 4 of its 8 nearest neighbors.

Why is shunting more robust?



* It homogenizes firing rates:
  * Slows down fast cells
  * Speeds up slow cells
* In contrast, hyperpolarizing slows down both fast and slow cells.