


IV. Neural Networks and Learning

B. Biological Neural Networks

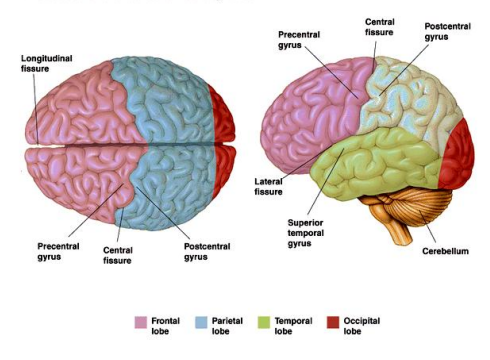
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A Very Brief Tour of
Real Neurons




(and Real Brains)

► The Lobes of the Cerebral Hemispheres



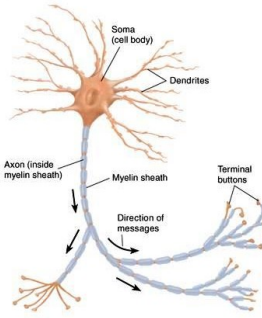
3/7/12 (fig. from internet) 3

Left Hemisphere




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Typical Neuron



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Overview of Brain to Neurons



<http://www.youtube.com/watch?v=DF04XPBj5uc>

(play flash video)


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Animation of Neuron

- An animated film about nicotine addiction
- A good visualization of a single neuron
- ©2006, Hurd Studios
- Winner of NSF/AAAS Visualization Challenge
- [View flash video](#)

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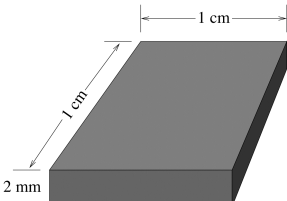
Grey Matter vs. White Matter



(fig. from Carter 1998)

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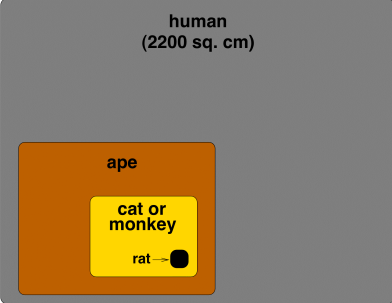
Neural Density in Cortex



- 148 000 neurons / sq. mm
- Hence, about 15 million / sq. cm

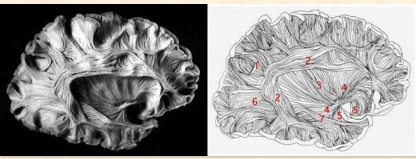
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Cortical Areas



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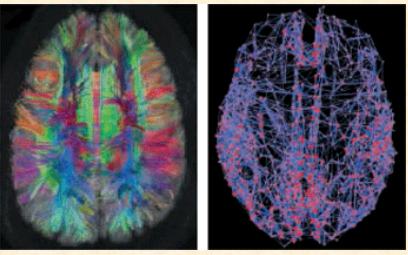
Intercortical Connections



- (1) Short arcuate bundles, (2) Superior longitudinal fasciculus, (3) External capsule, (4) Inferior occipitofrontal fasciculus, (5) Uncinate fasciculus, (6) Sagittal stratum, (7) Inferior longitudinal fasciculus


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Intercortical Connections (diffusion spectrum imaging)



G. Miller Science 330, 164 (2010) (2010)

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Published by AAAS

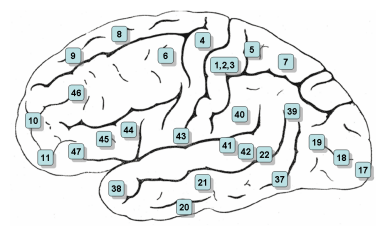


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Neural Representations

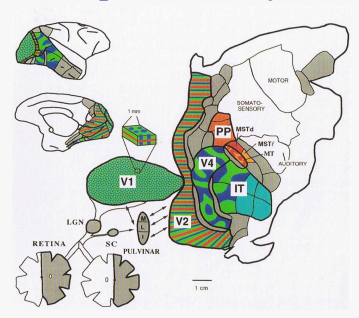
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Brodmann's Areas



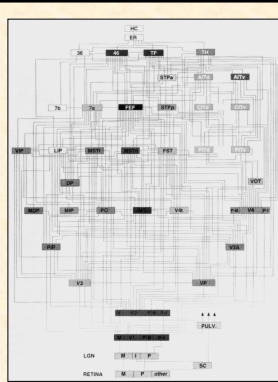
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Macaque Visual System



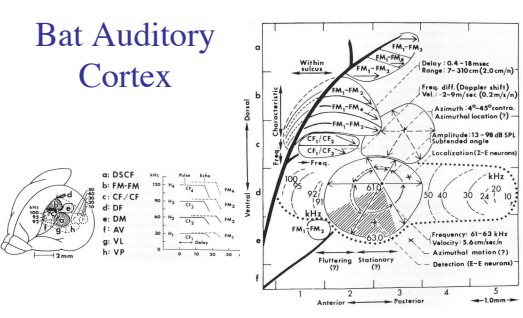
3/7/12 15
(fig. from Clark, *Being There*, 1997)

Hierarchy of Macaque Visual Areas



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(fig. from Van Essen & al. 1992)

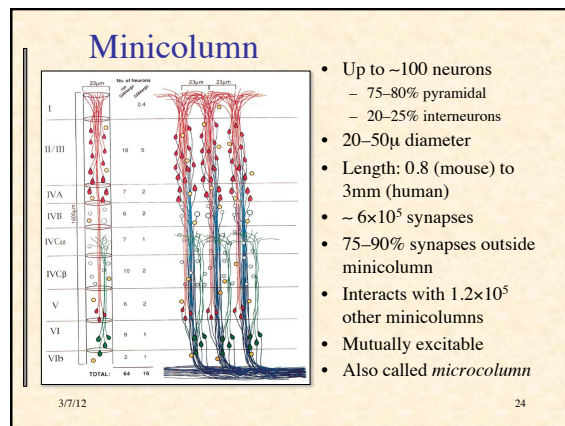
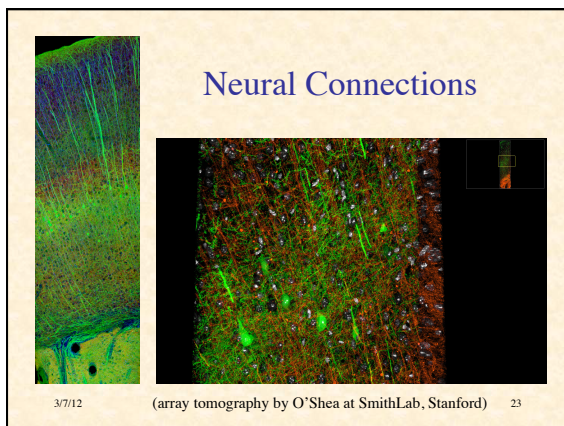
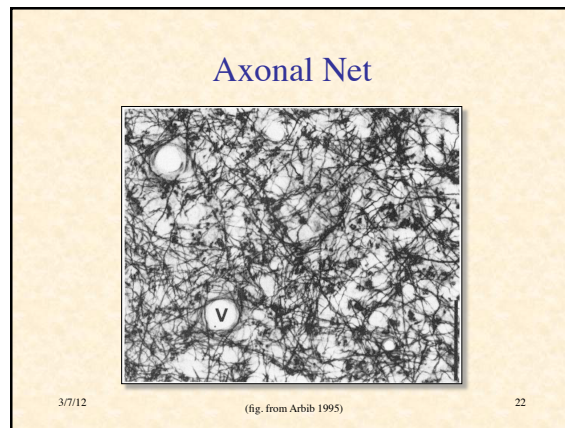
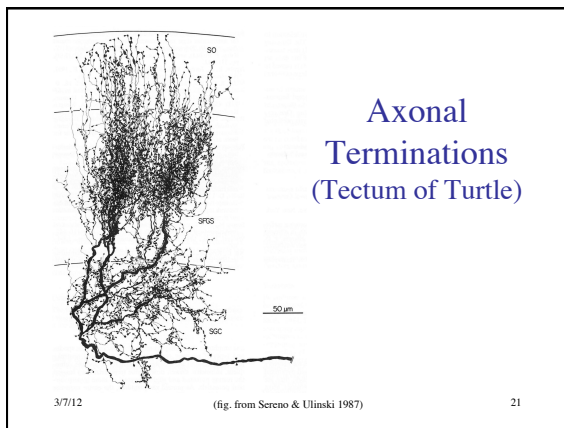
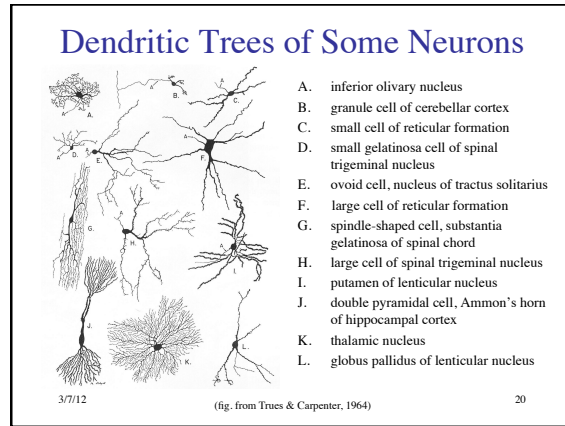
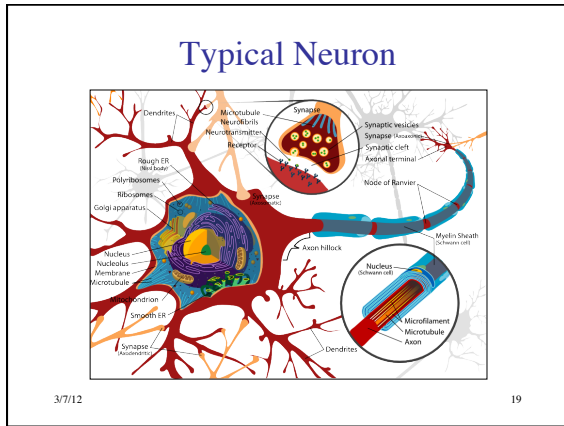
Bat Auditory Cortex

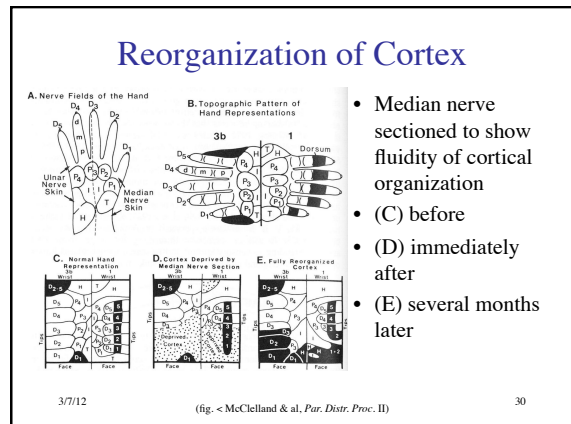
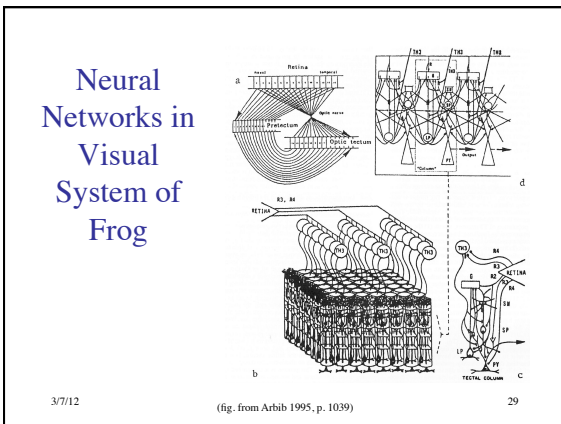
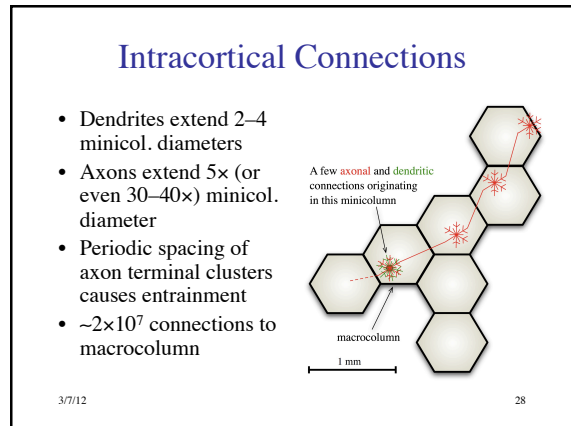
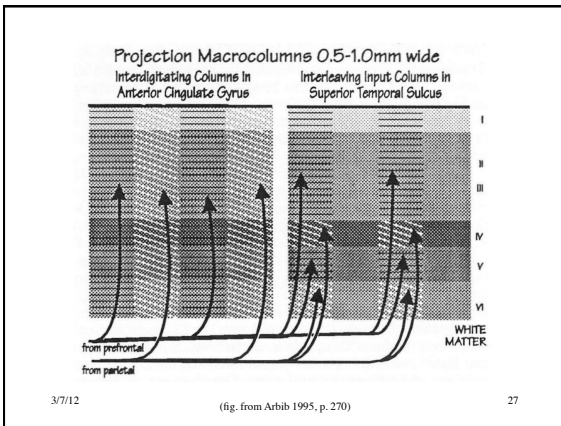
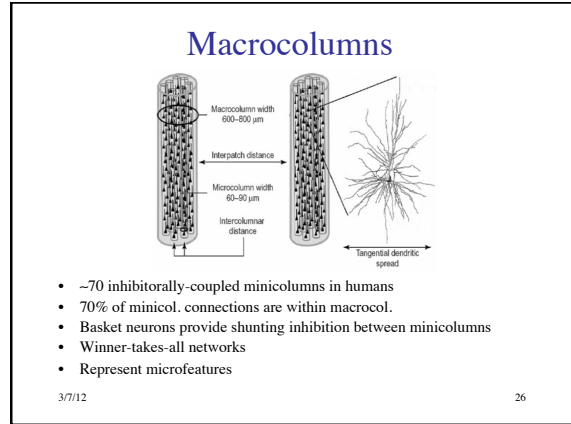
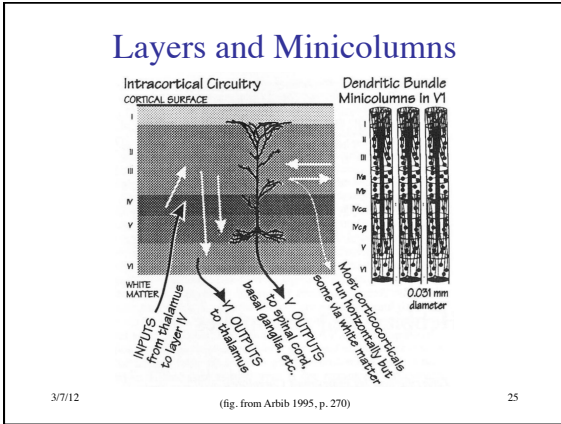


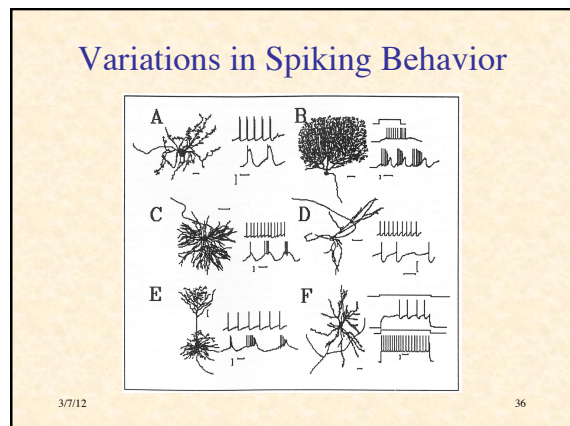
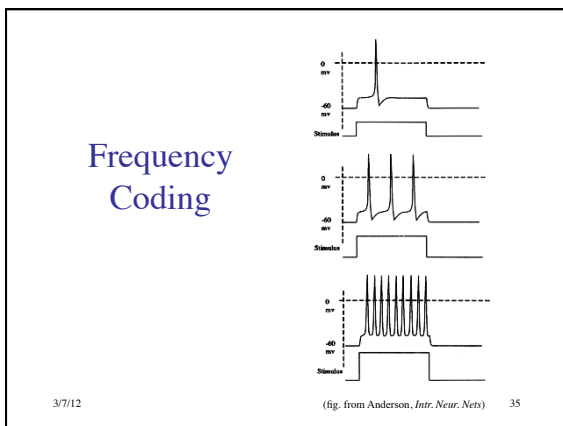
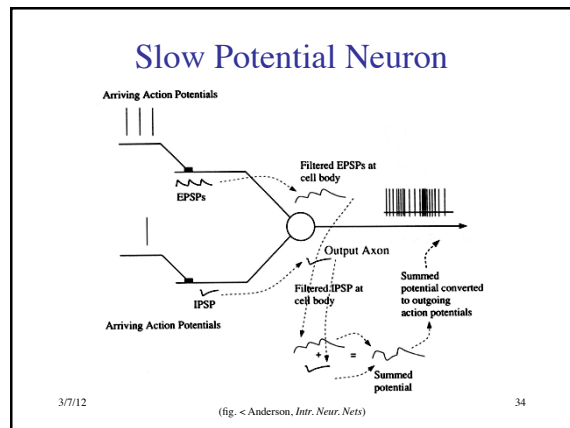
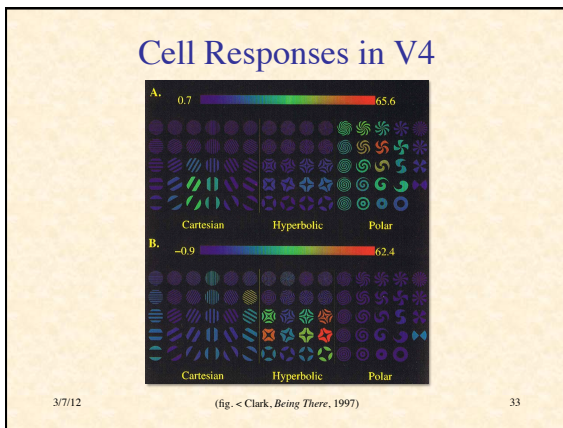
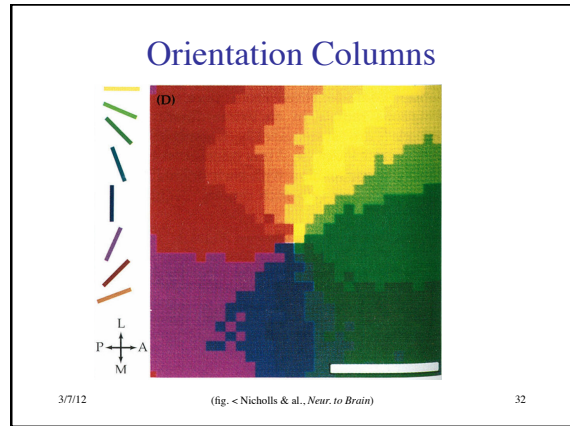
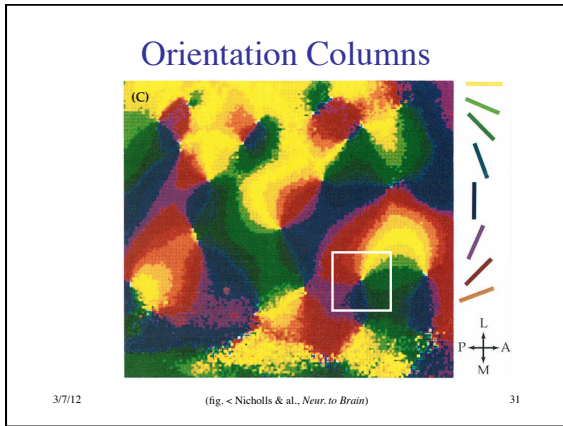
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(figs. from Suga, 1985)

Neurons


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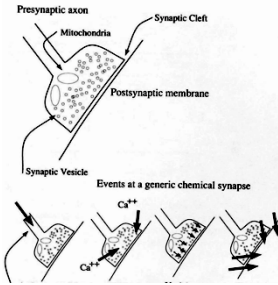
Synapses



video by Hybrid Medical Animation

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Chemical Synapse

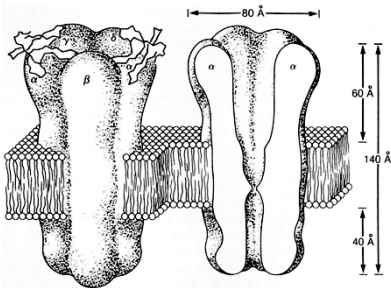


1. Action potential arrives at synapse
2. Ca ions enter cell
3. Vesicles move to membrane, release neurotransmitter
4. Transmitter crosses cleft, causes postsynaptic voltage change

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(fig. from Anderson, *Intr. Neur. Nets*)

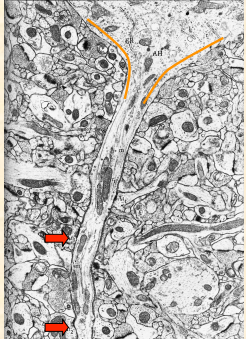
Typical Receptor



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(fig. from Anderson, *Intr. Neur. Nets*)

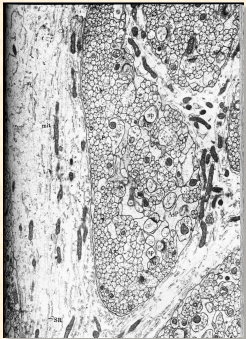
Axon Hillock



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(fig. from Peters, Palay & Webster)


Dendrite & Dendritic Branches



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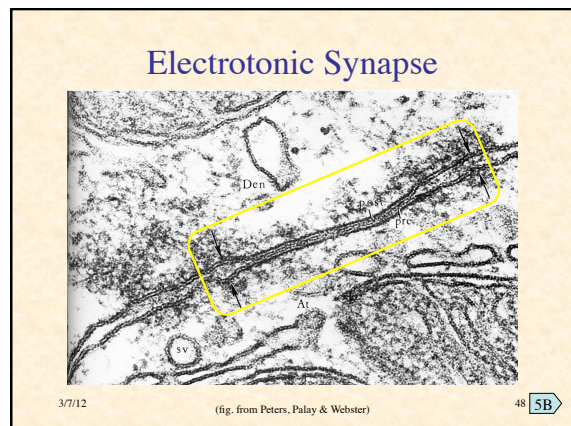
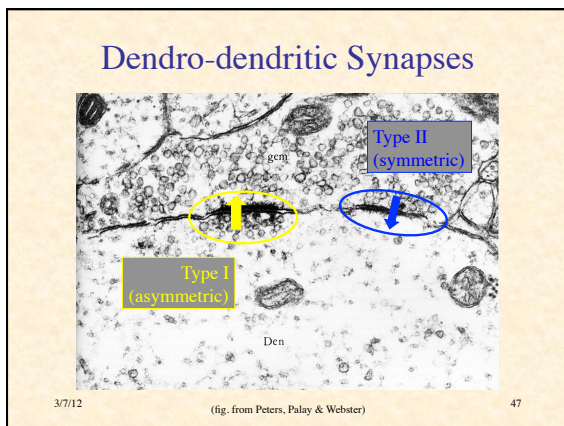
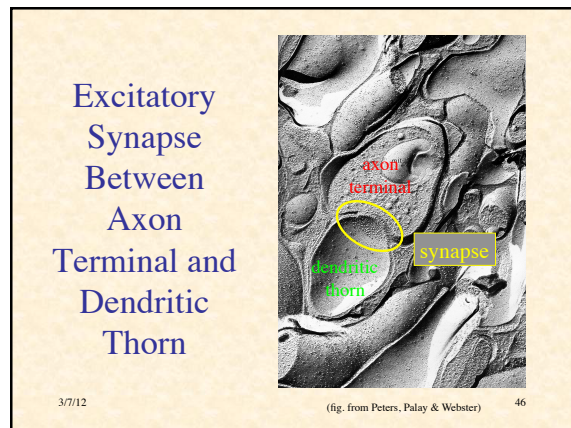
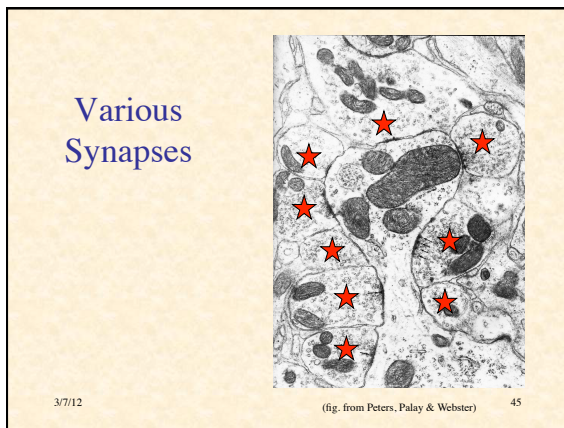
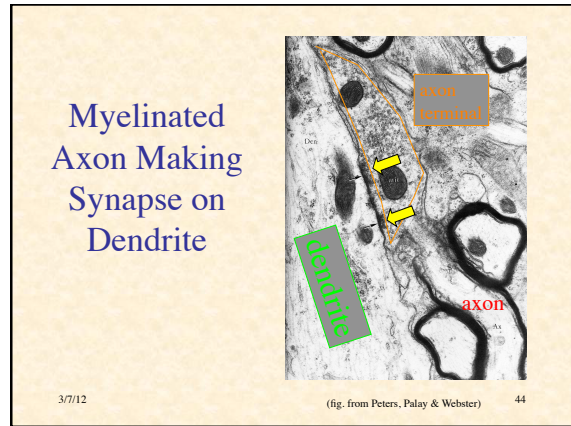
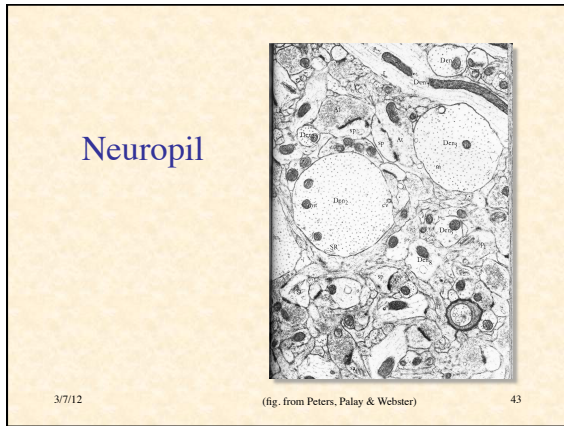
(fig. from Peters, Palay & Webster)

Dendrite & Dendritic Spine



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(fig. from Peters, Palay & Webster)



Nonsynaptic Communication ("twitching neurons")

- When neurons fire, the axons swell slightly
- This opens channels, releasing neurotransmitters (e.g., ATP)
- A form of nonsynaptic communication between neurons and glia
- May control formation of myelin and other processes
- See Fields & Ni, *Science Signaling*, 5 Oct. 2010

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Release of ATP from Axons Firing Action Potentials

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Published by AAAS

R. D. Fields et al., *Sci. Signal.* 3, ra73 (2010)

Science Signaling
AAAS

Neuronal Group Selection ("Neural Darwinism")

- Theory developed in '70s and '80s by Gerald Edelman (Nobel Prize, 1972)
- Diversity
 - of neural responses to stimuli
 - disjunctive representations of categories
- Competitive Amplification
 - winner-take-all adaptation to stimuli
- Reentry
 - spatiotemporal continuity and coherence

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Read Flake, ch. 20

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