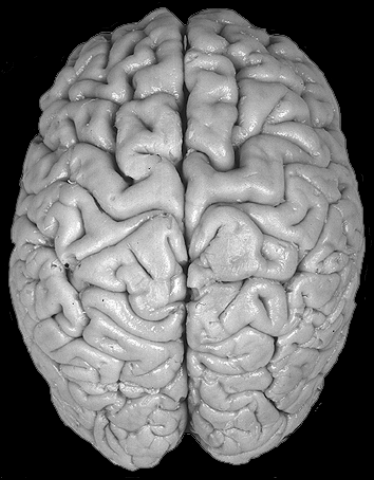
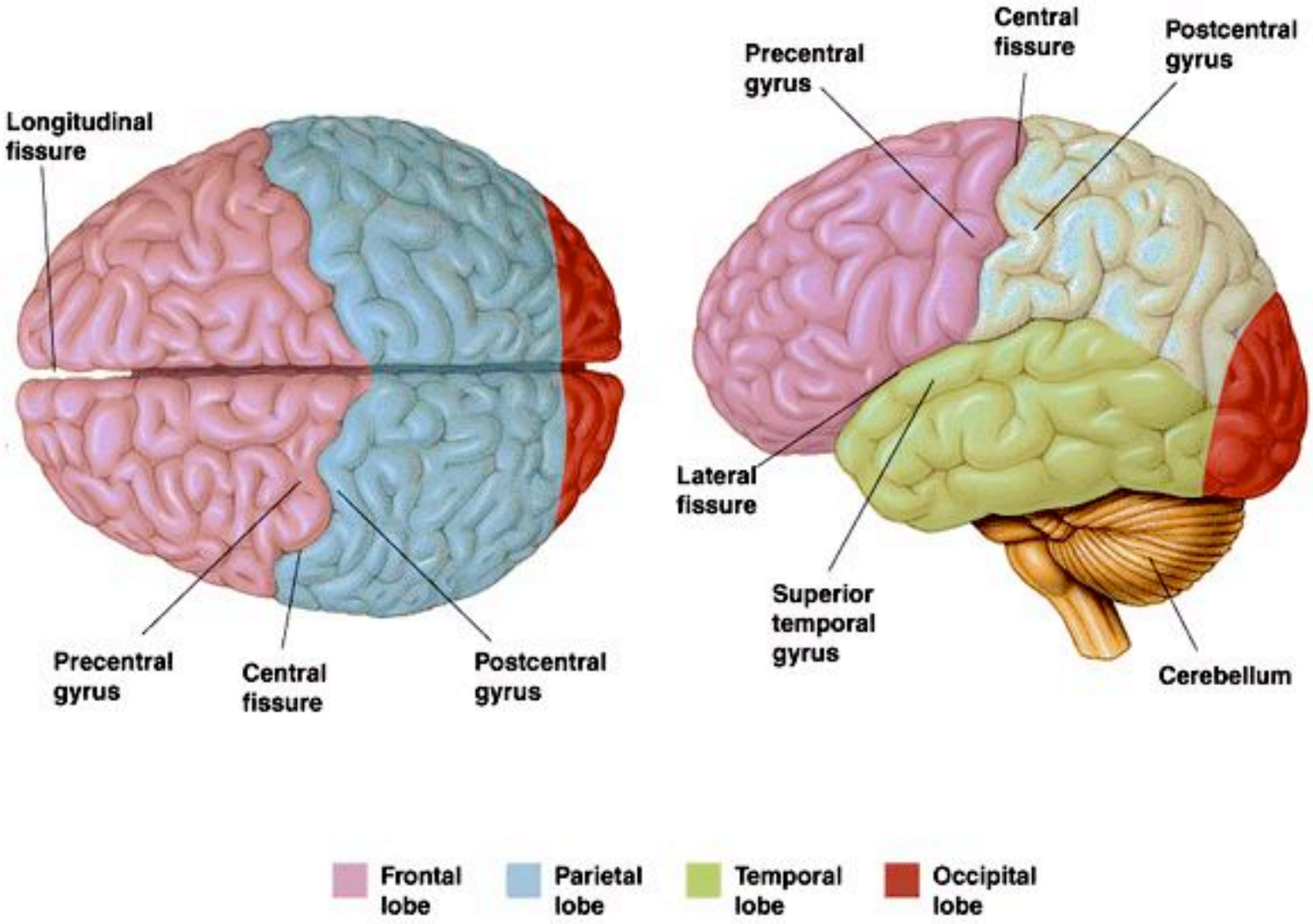
A Very Brief Tour of Real Neurons



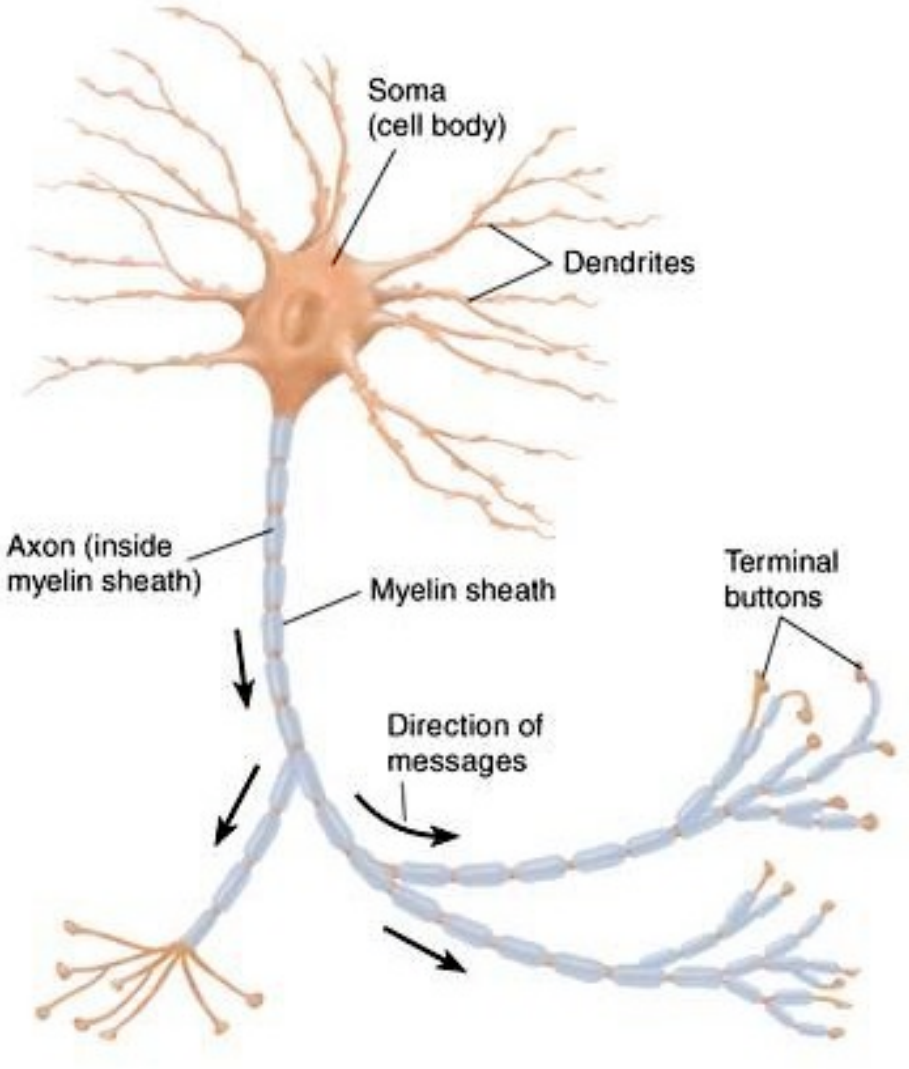
(and Real Brains)

▶ The Lobes of the Cerebral Hemispheres



Left Hemisphere

Typical Neuron



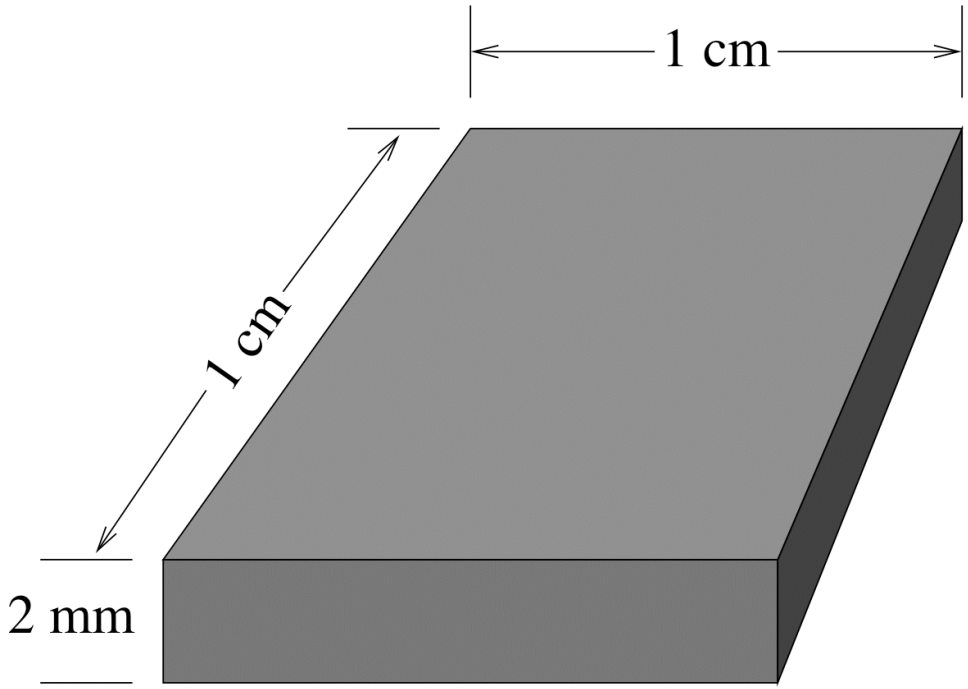
Animation of Neuron

- 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

Grey Matter vs. White Matter

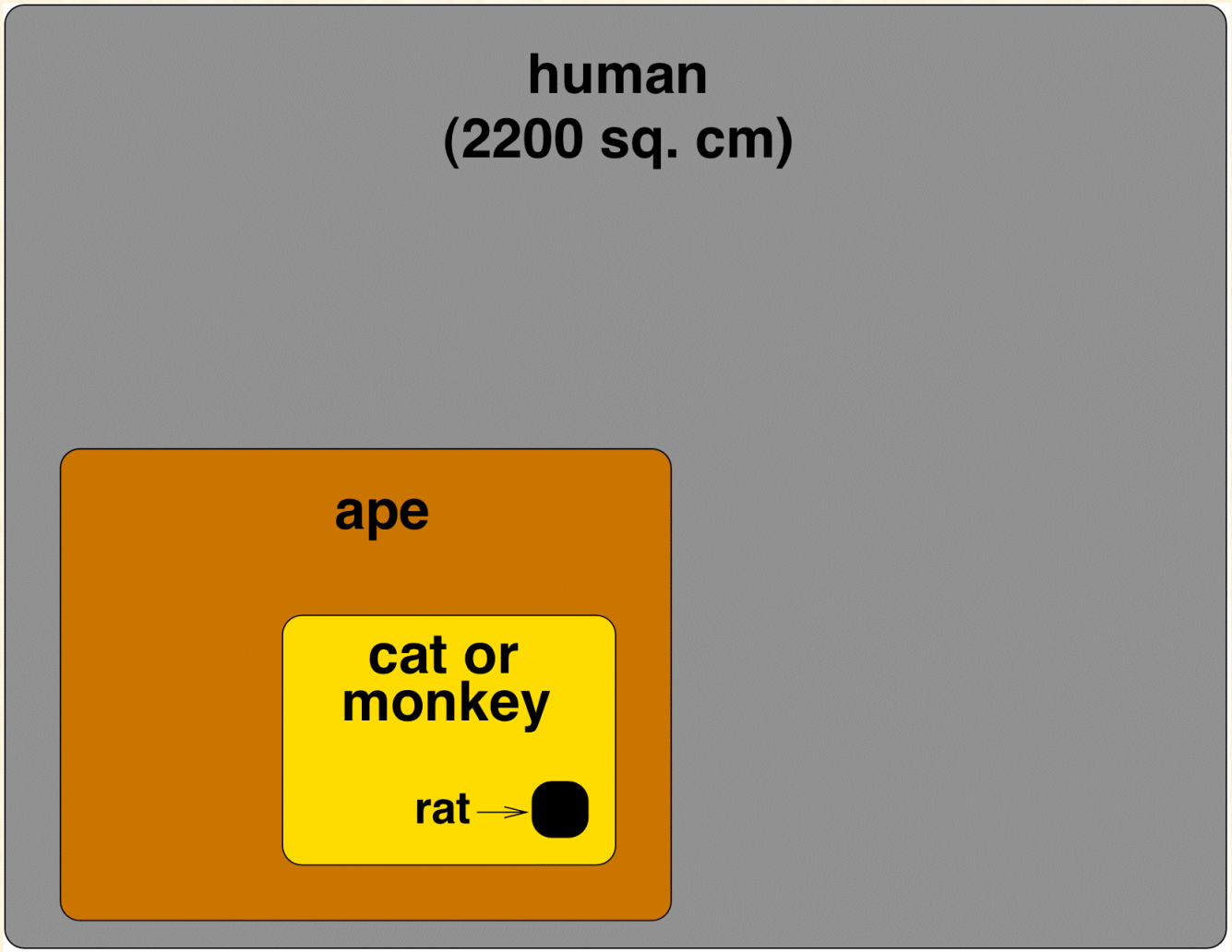
(fig. from Carter 1998)

Neural Density in Cortex

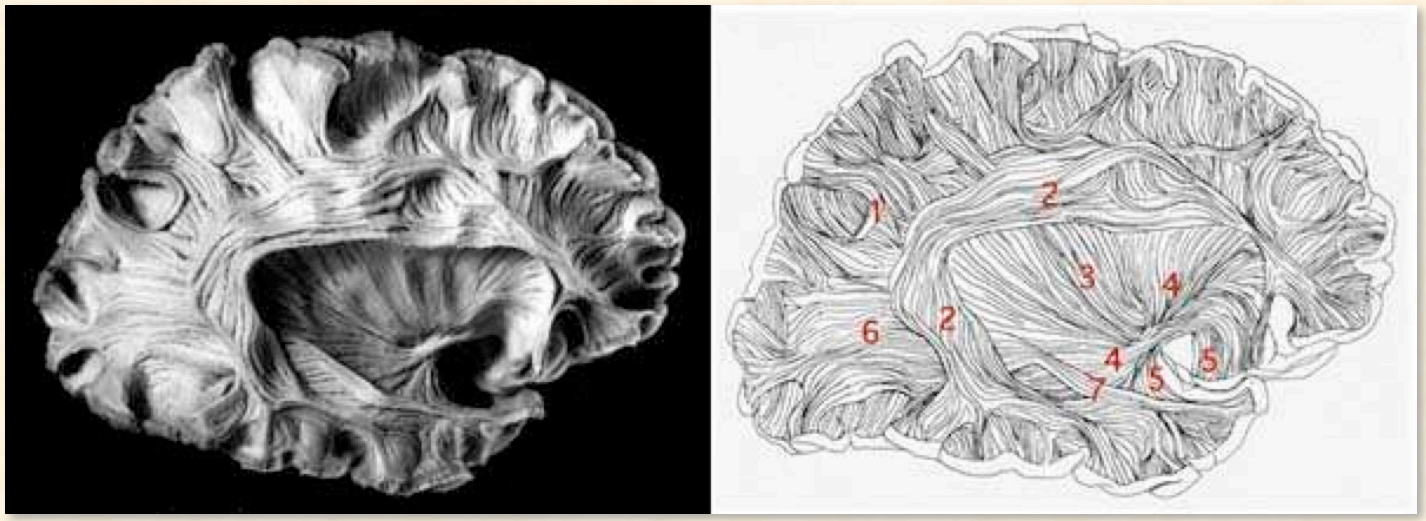


- 148 000 neurons / sq. mm
- Hence, about 15 million / sq. cm

Cortical Areas



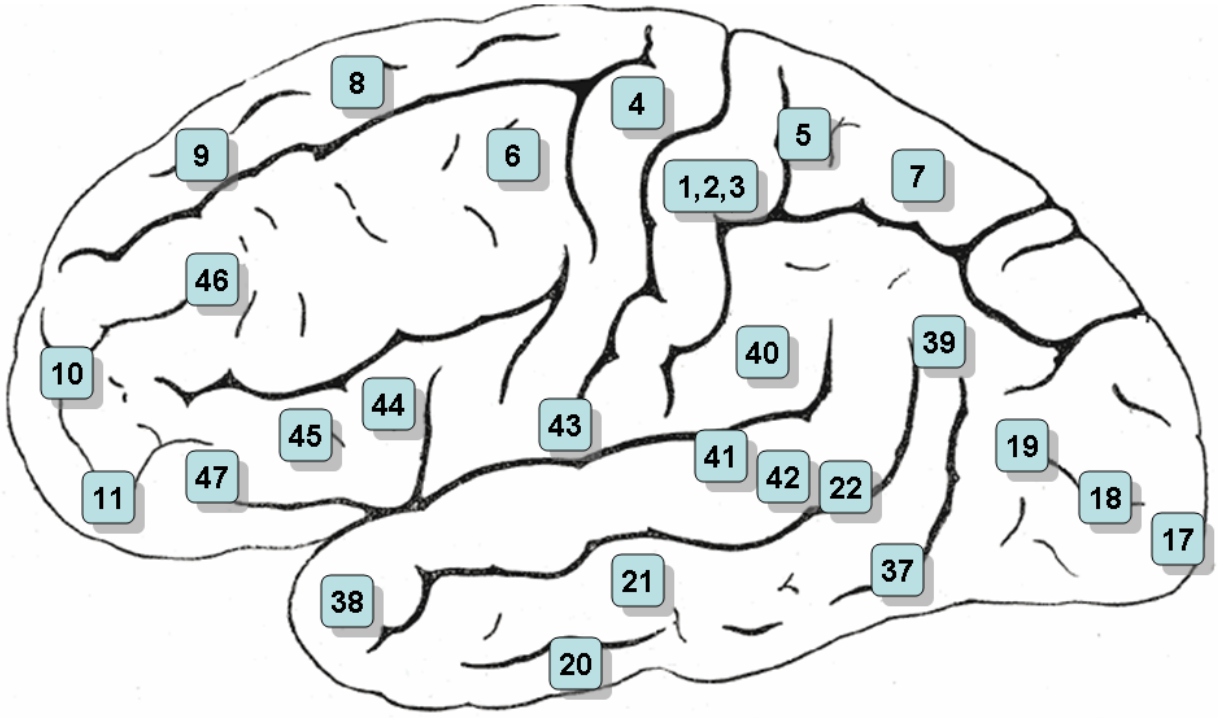
Intercortical Connections



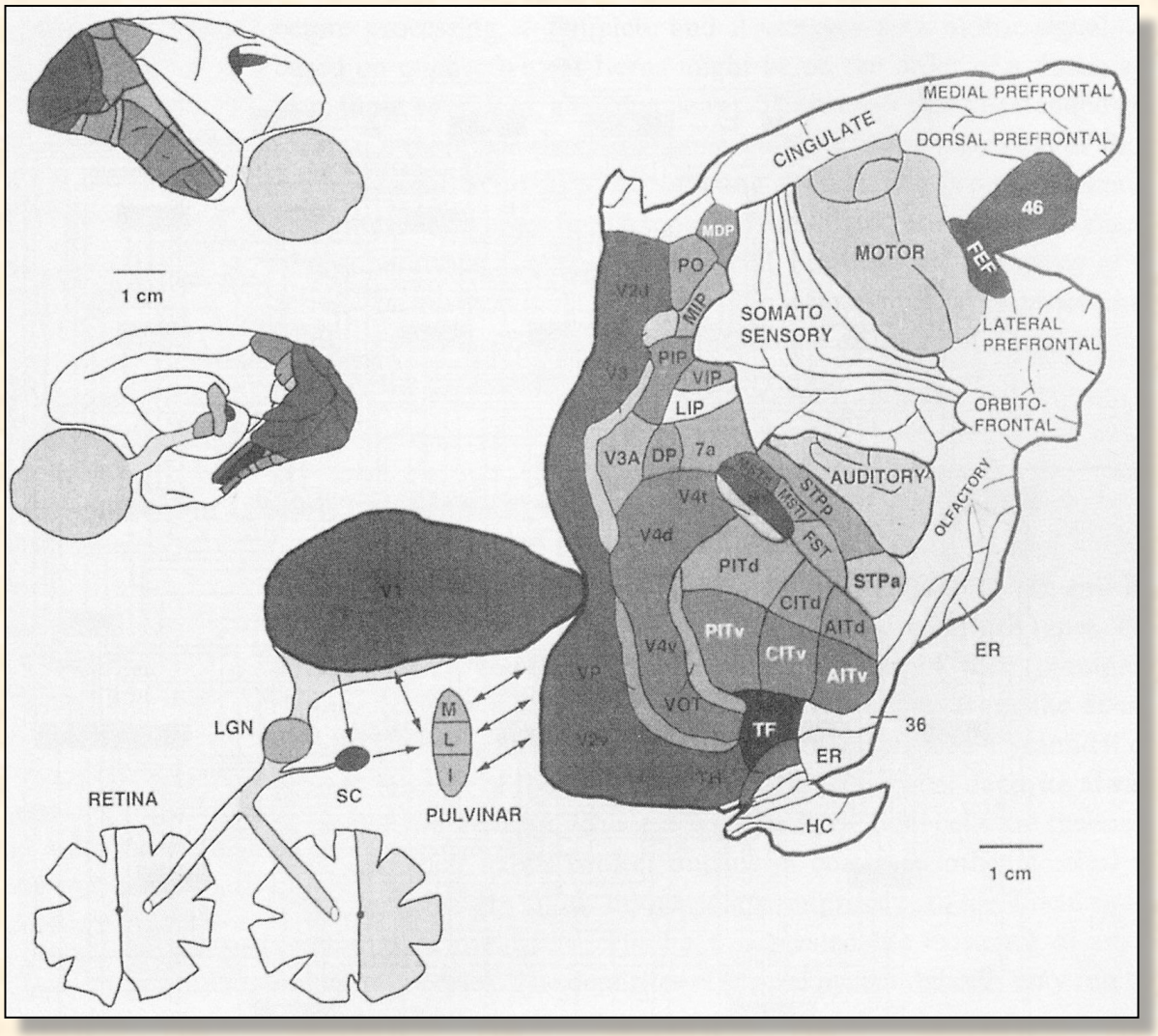
- (1) Short arcuate bundles, (2) Superior longitudinal fasciculus, (3) External capsule, (4) Inferior occipitofrontal fasciculus, (5) Uncinate fasciculus, (6) Sagittal stratum, (7) Inferior longitudinal fasciculus

Neural Representations

Brodmann's Areas

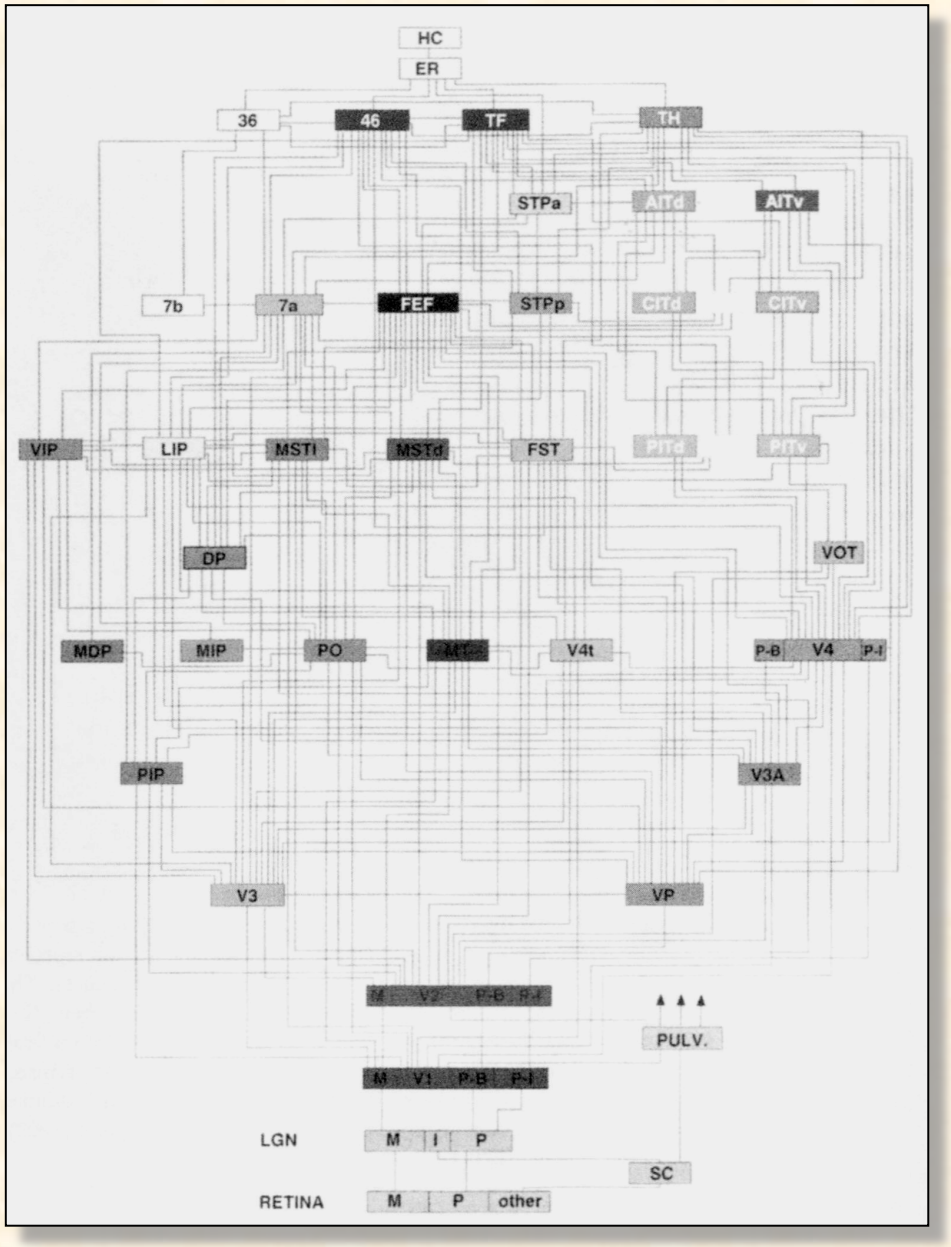


Macaque Visual System



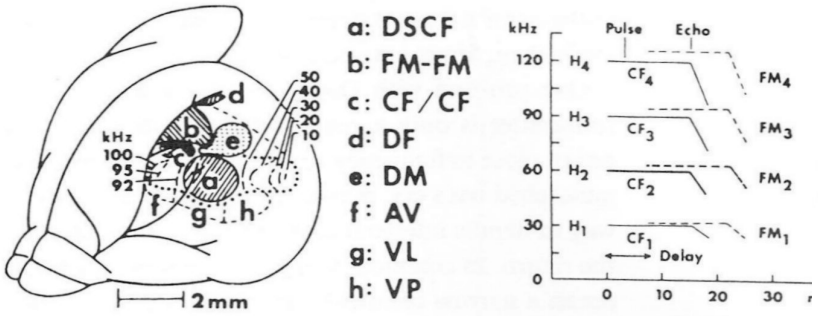
(fig. from Van Essen & al. 1992)

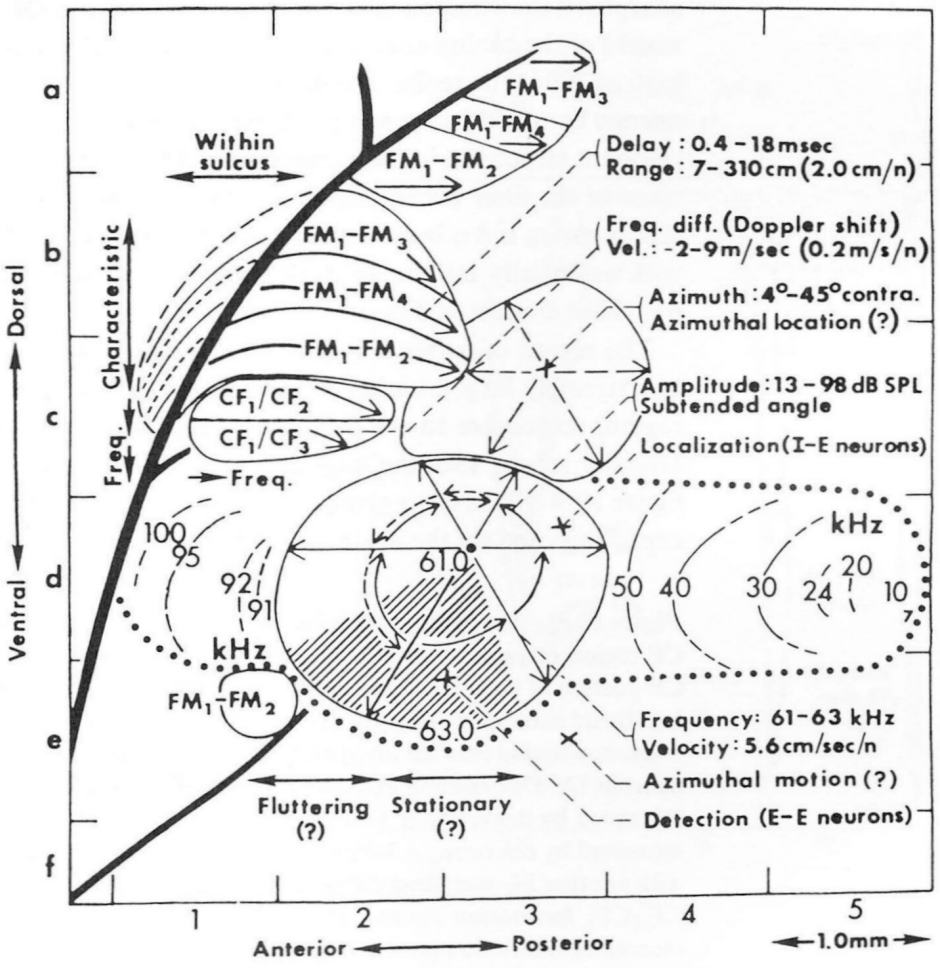
Hierarchy of Macaque Visual Areas



(fig. from Van Essen & al. 1992)

Bat Auditory Cortex

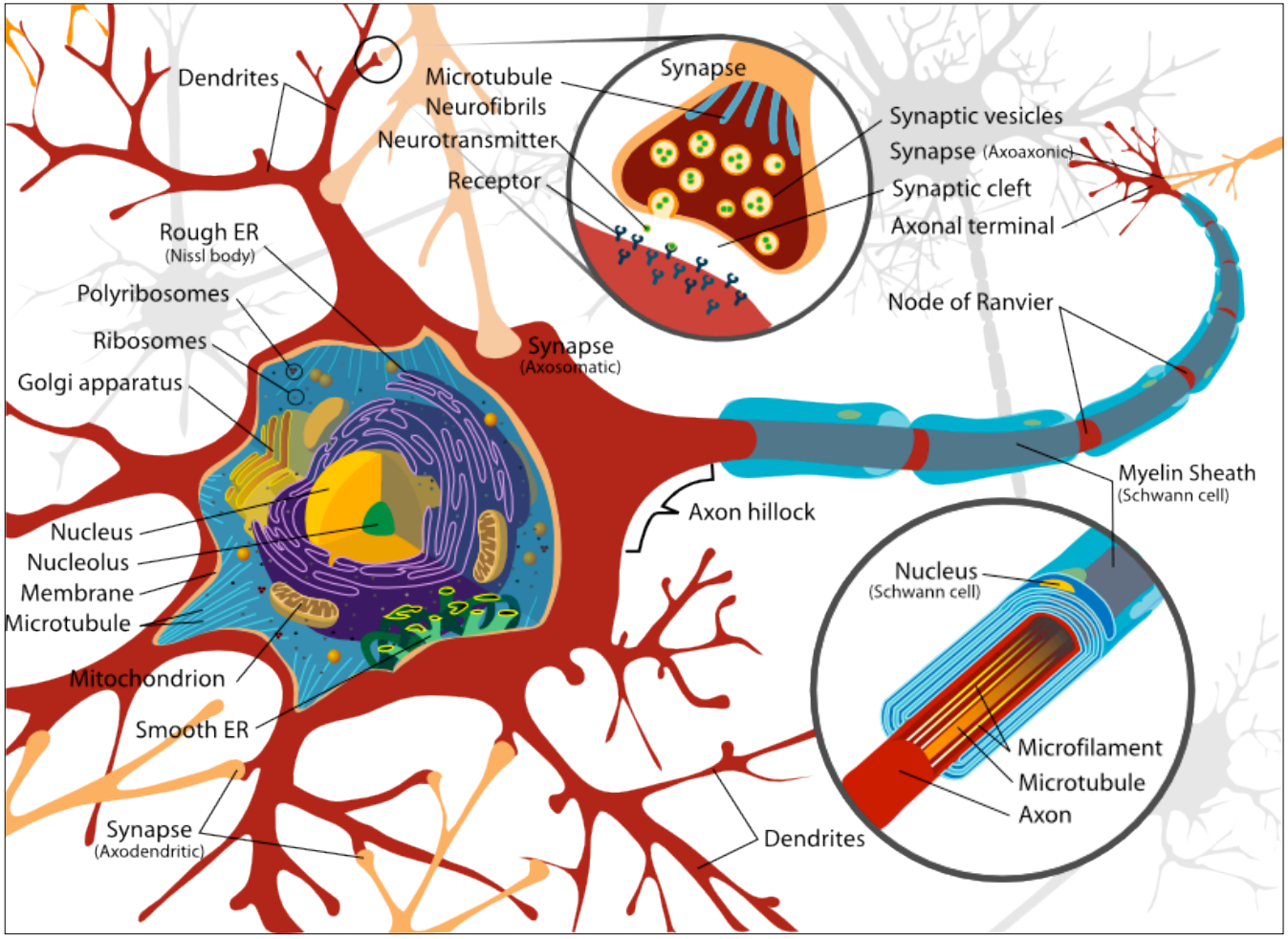




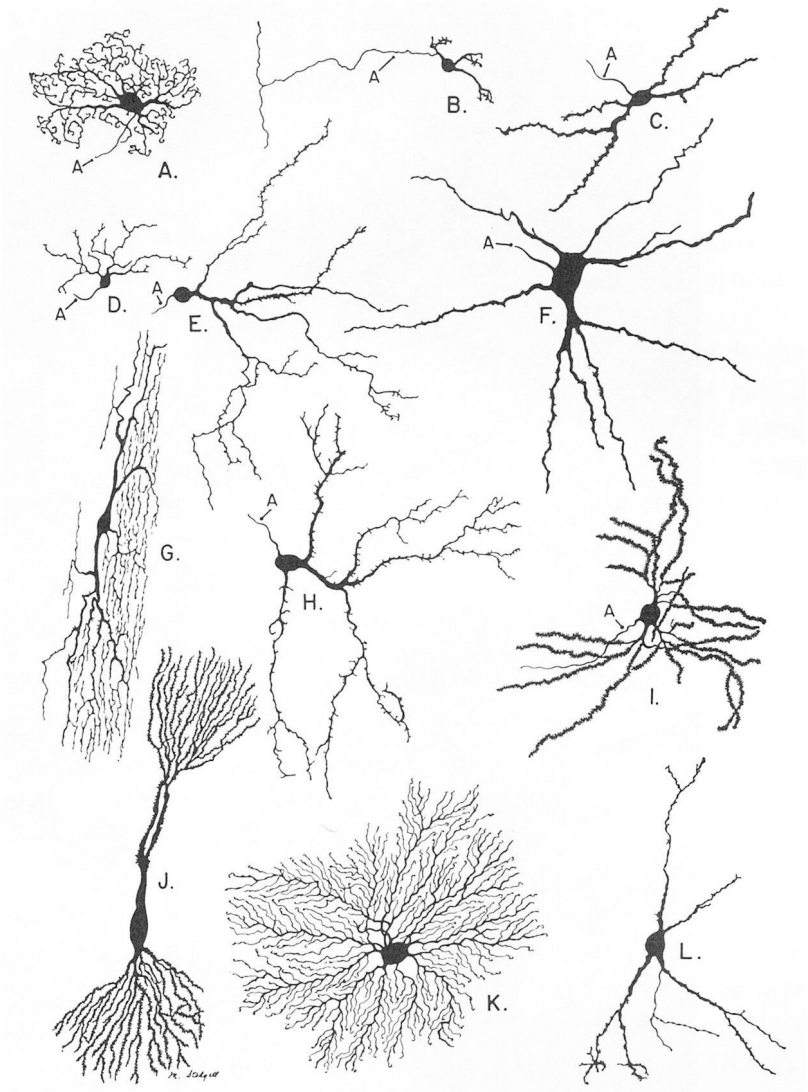
(figs. from Suga, 1985)

Neurons

Typical Neuron

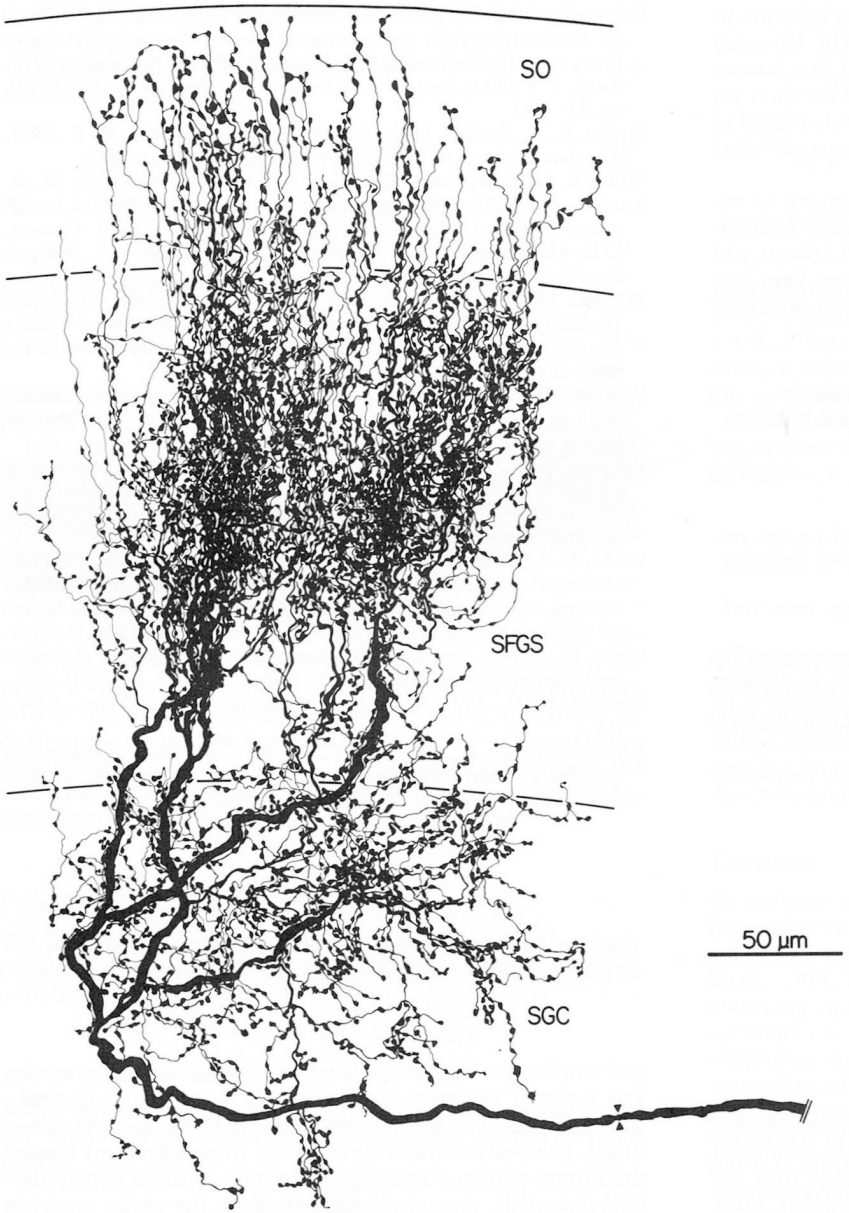


Dendritic Trees of Some Neurons



A. inferior olivary nucleus
B. granule cell of cerebellar cortex
C. small cell of reticular formation
D. small gelatinosa cell of spinal trigeminal nucleus
E. ovoid cell, nucleus of tractus solitarius
F. large cell of reticular formation
G. spindle-shaped cell, substantia gelatinosa of spinal chord
H. large cell of spinal trigeminal nucleus
I. putamen of lenticular nucleus
J. double pyramidal cell, Ammon's horn of hippocampal cortex
K. thalamic nucleus
L. globus pallidus of lenticular nucleus

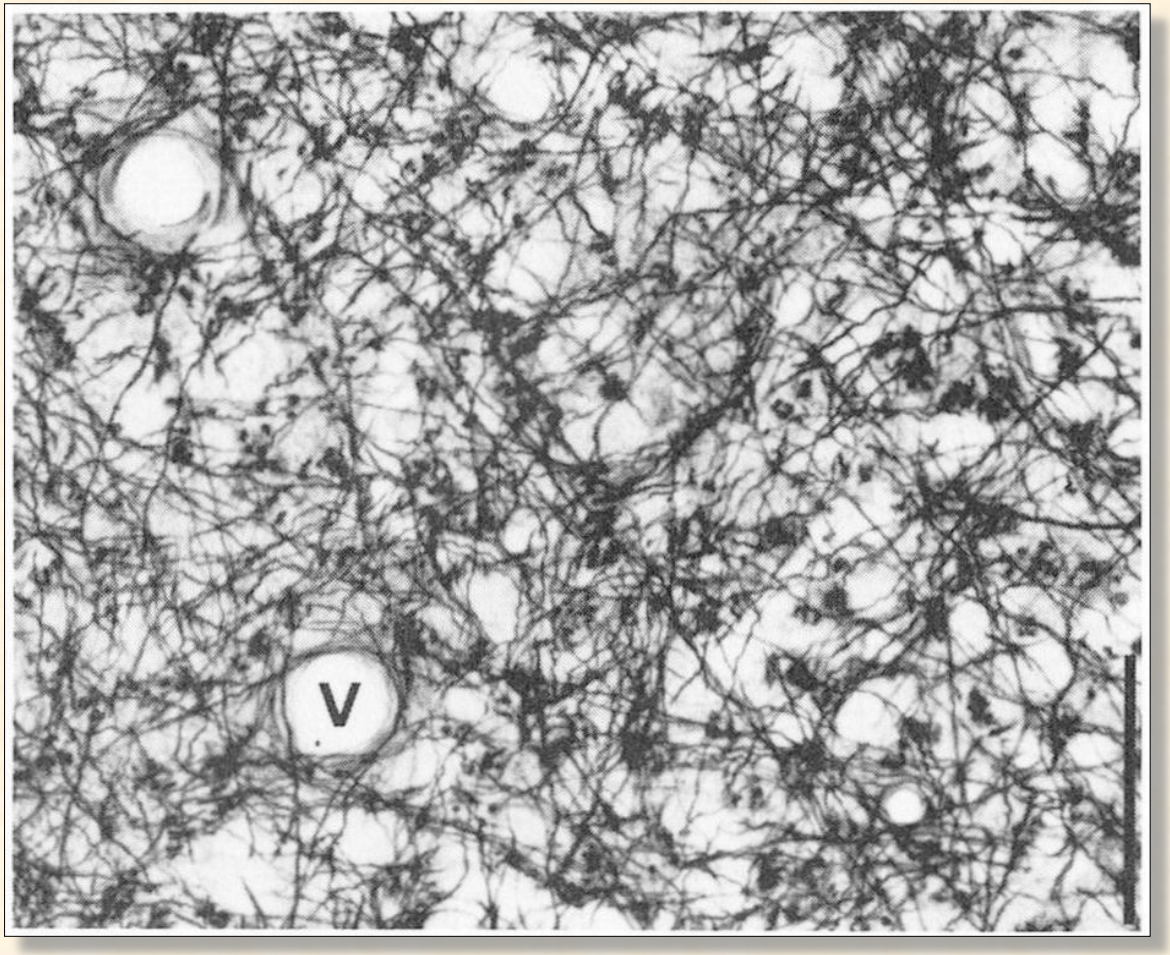
(fig. from Trues & Carpenter, 1964)



Axonal Terminations (Tectum of Turtle)

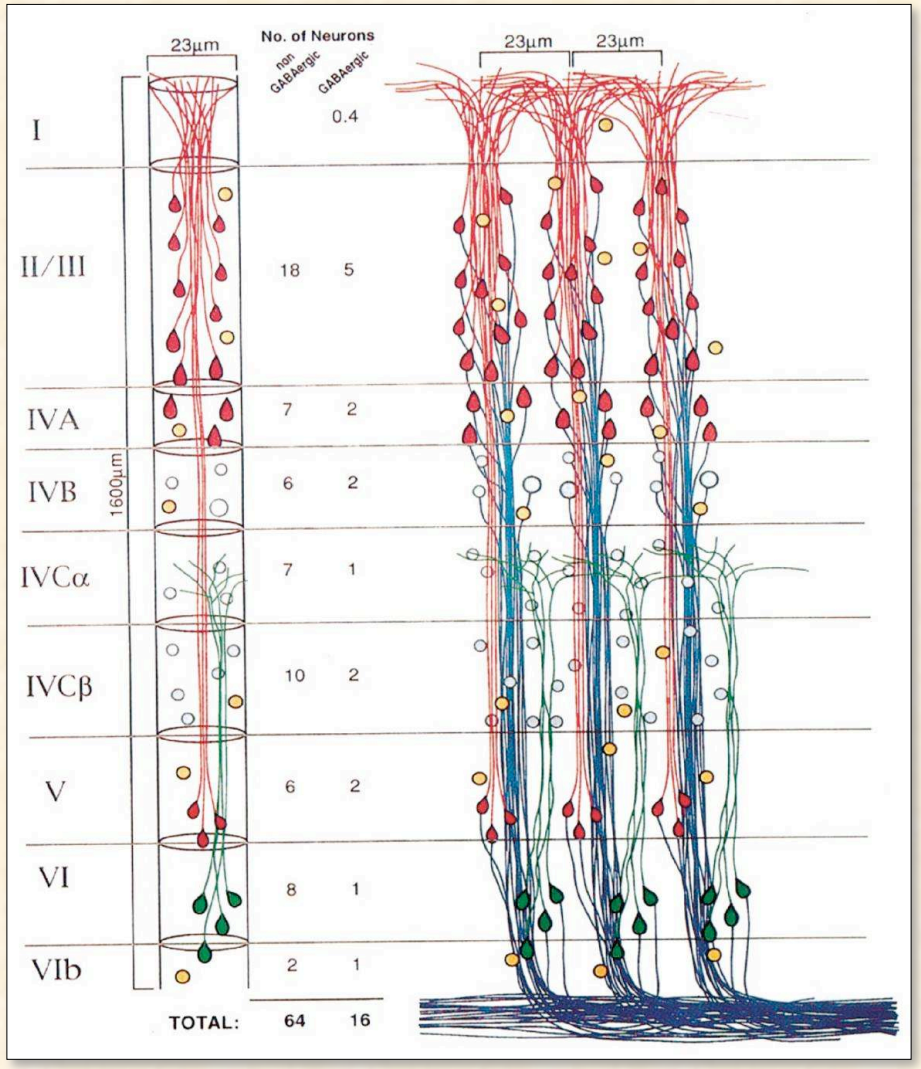
(fig. from Sereno & Ulinski 1987)

Axonal Net



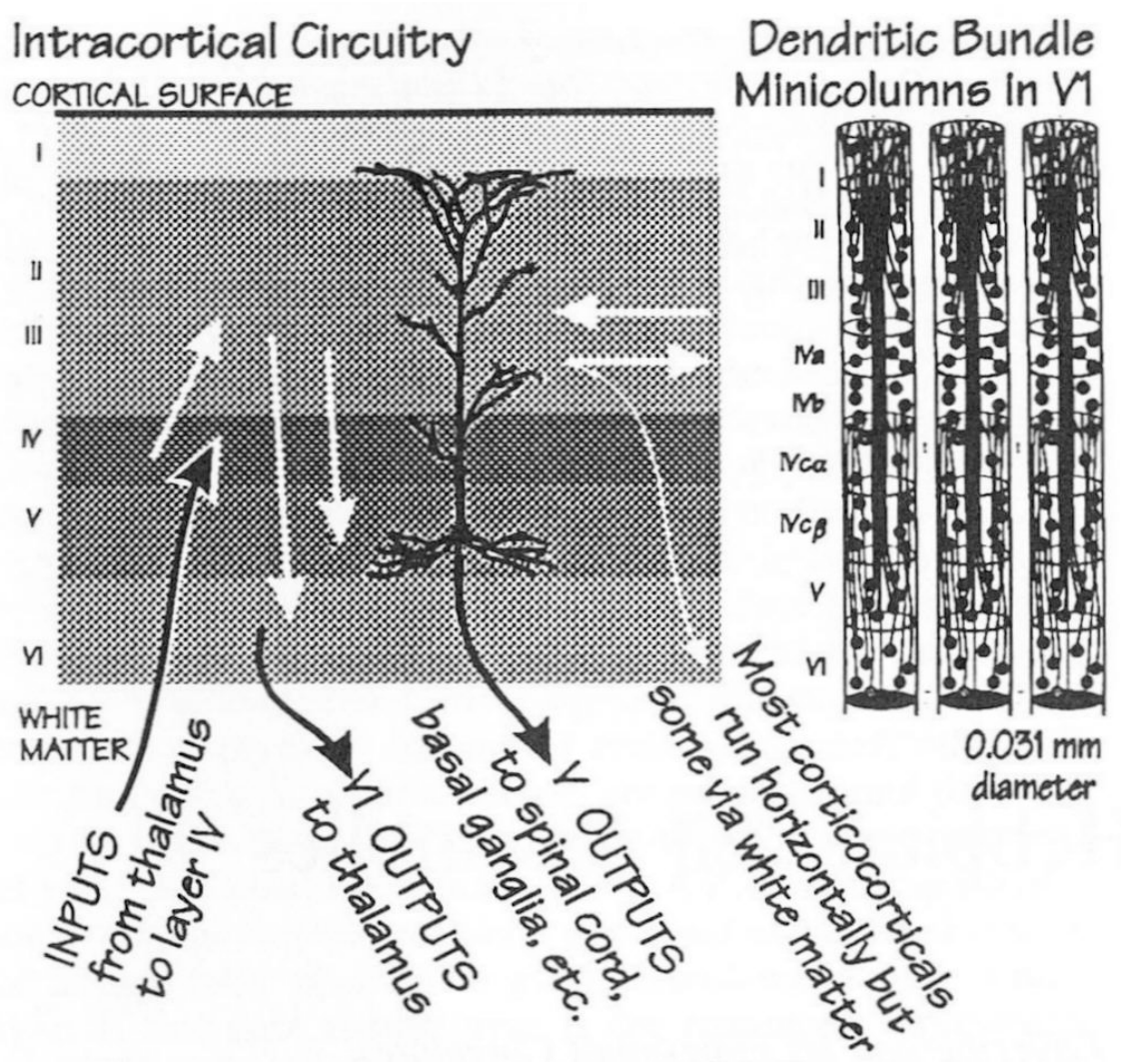
(fig. from Arbib 1995)

Minicolumn



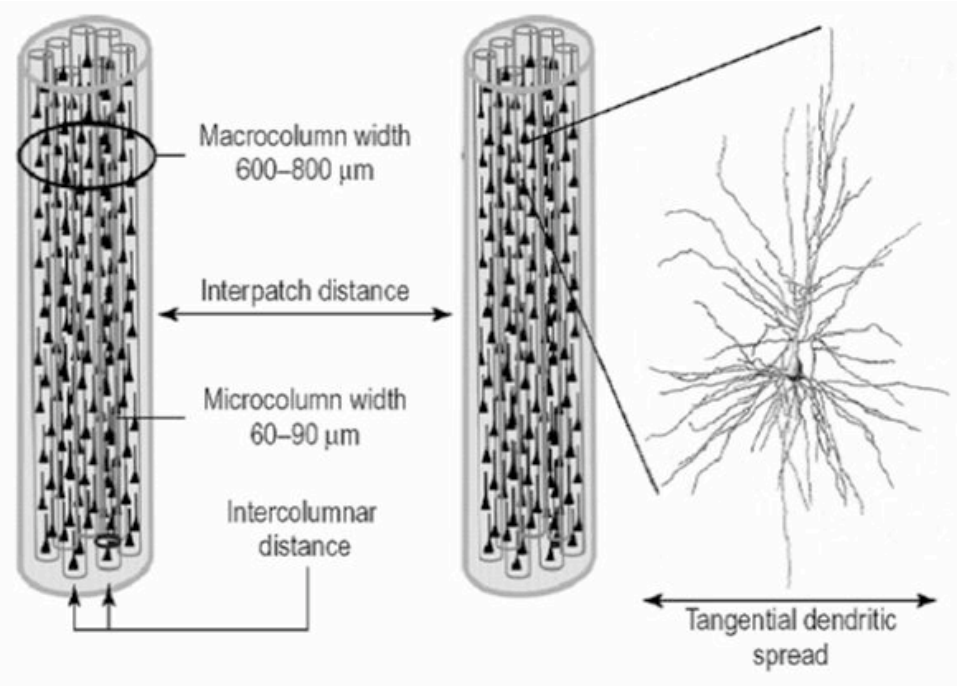
- Up to ~100 neurons
  - 75–80% pyramidal
  - 20–25% interneurons
- 20–50µ diameter
- Length: 0.8 (mouse) to 3mm (human)
- ~ 6×10^5 synapses
- 75–90% synapses outside minicolumn
- Interacts with 1.2×10^5 other minicolumns
- Mutually excitable
- Also called *microcolumn*

Layers and Minicolumns

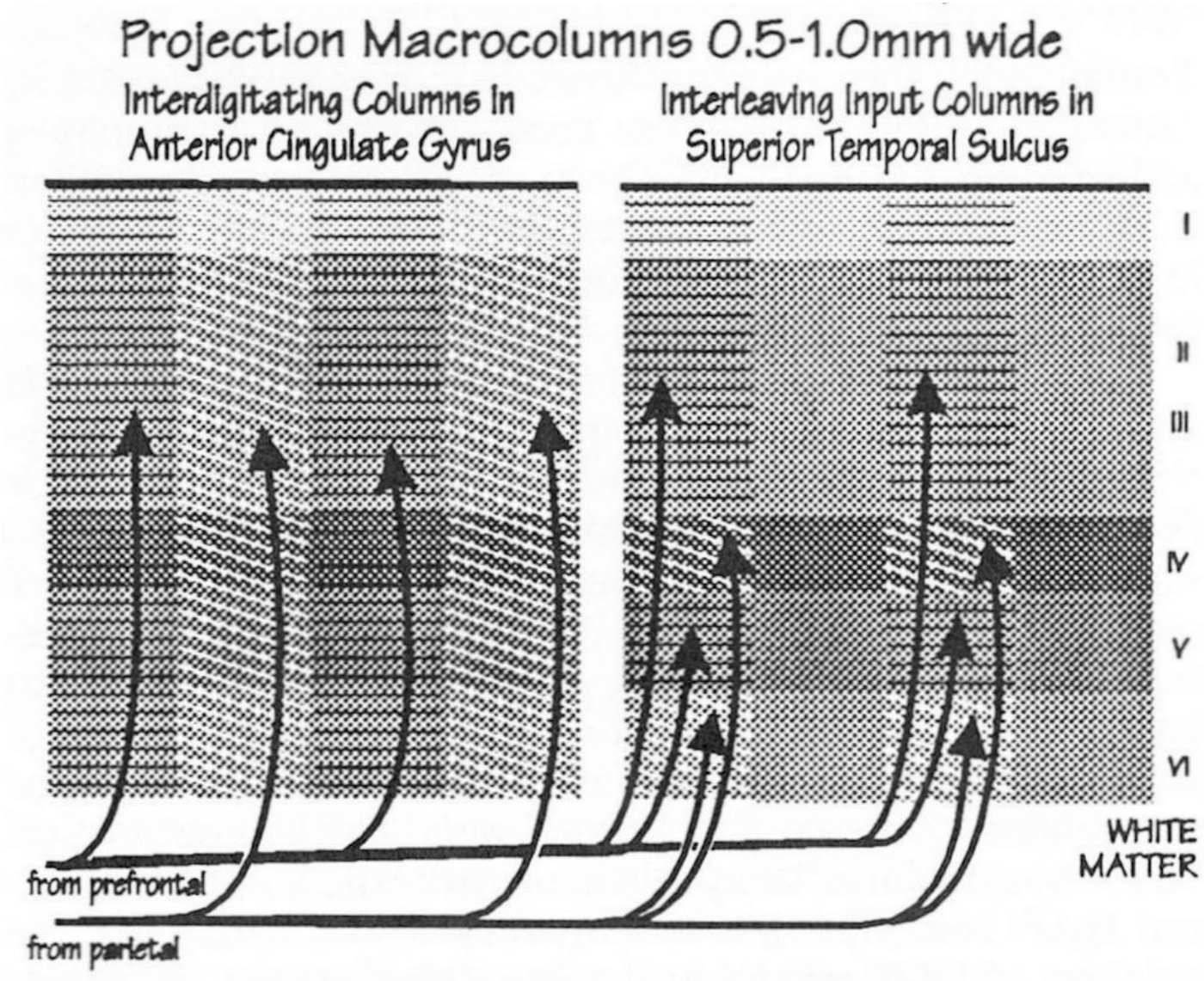


(fig. from Arbib 1995, p. 270)

Macrocolumns



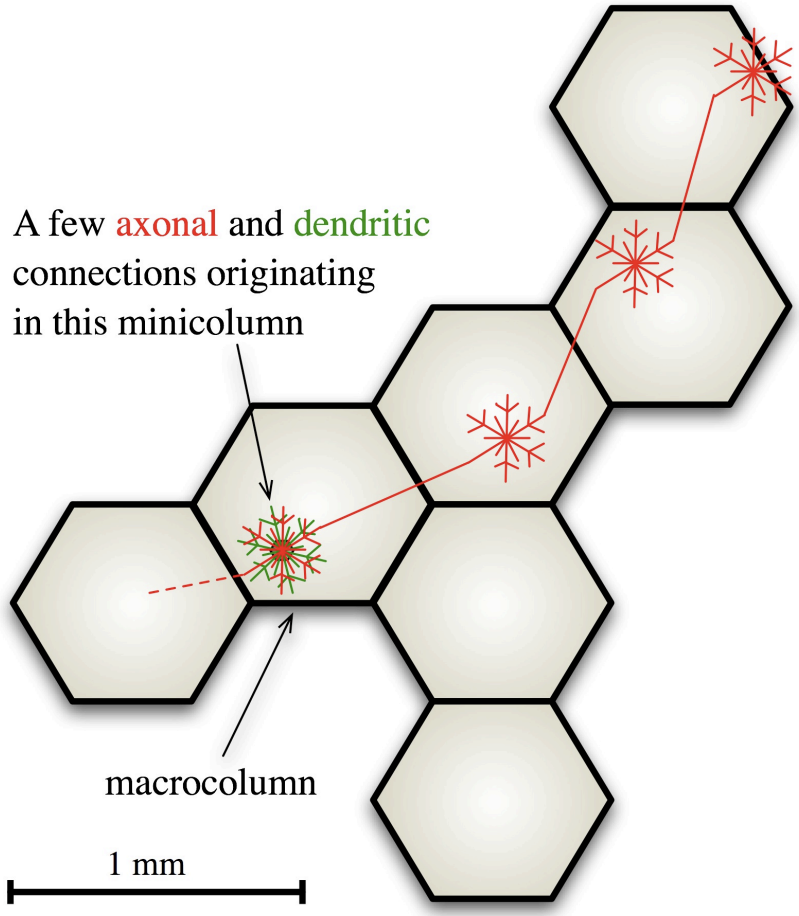
- ~70 inhibitorally-coupled minicolumns in humans
- 70% of minicol. connections are within macrocol.
- Basket neurons provide shunting inhibition between minicolumns
- Winner-takes-all networks
- Represent microfeatures



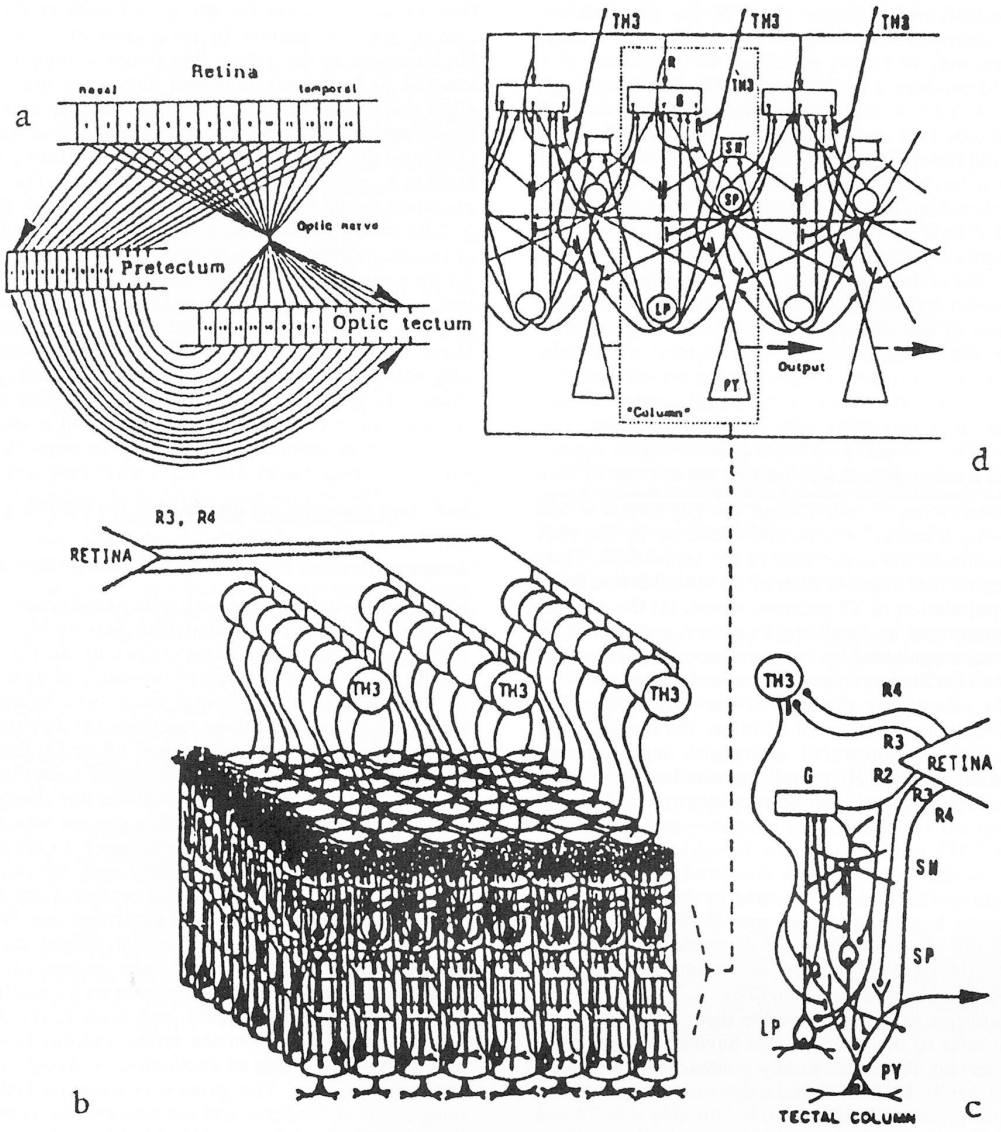
(fig. from Arbib 1995, p. 270)

Intracortical Connections

- Dendrites extend 2–4 minicol. diameters
- Axons extend 5× (or even 30–40×) minicol. diameter
- Periodic spacing of axon terminal clusters causes entrainment
- ~2×10^7 connections to macrocolumn

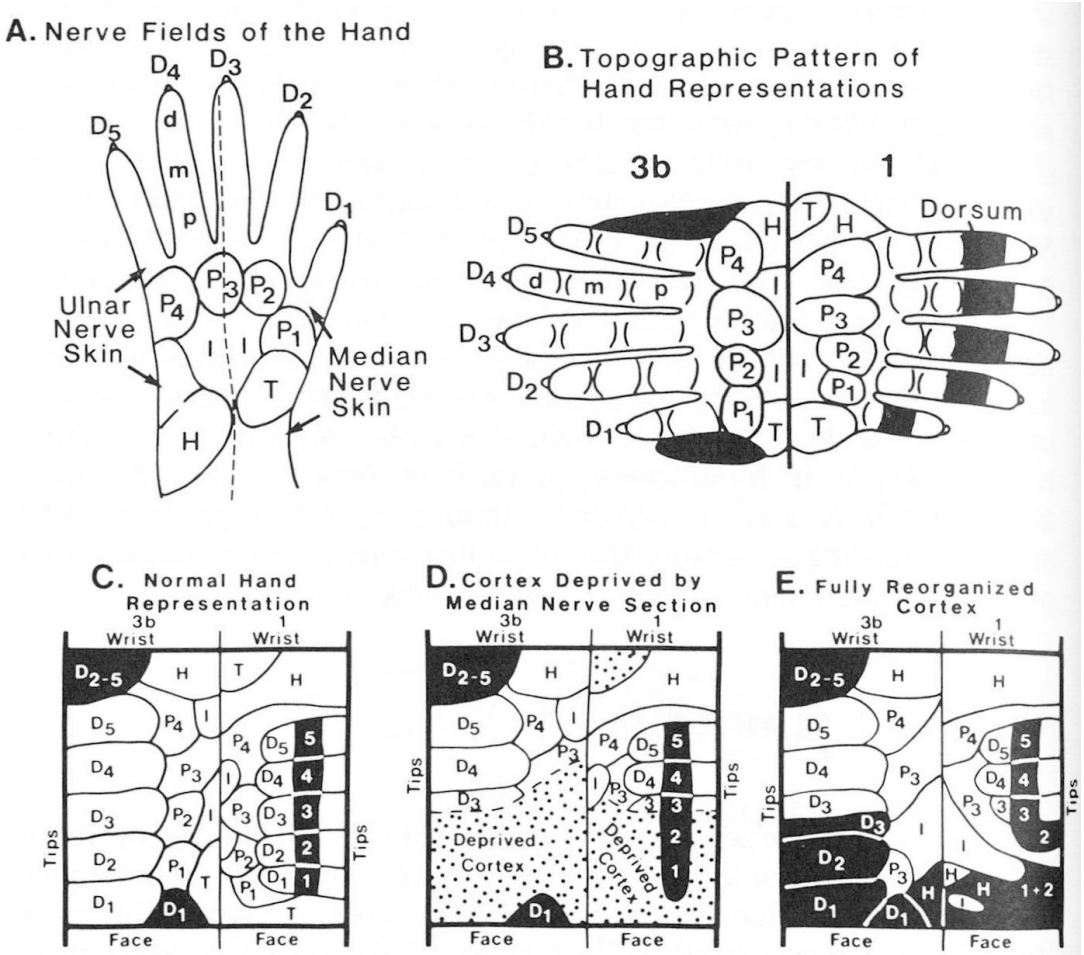


Neural Networks in Visual System of Frog



(fig. from Arbib 1995, p. 1039)

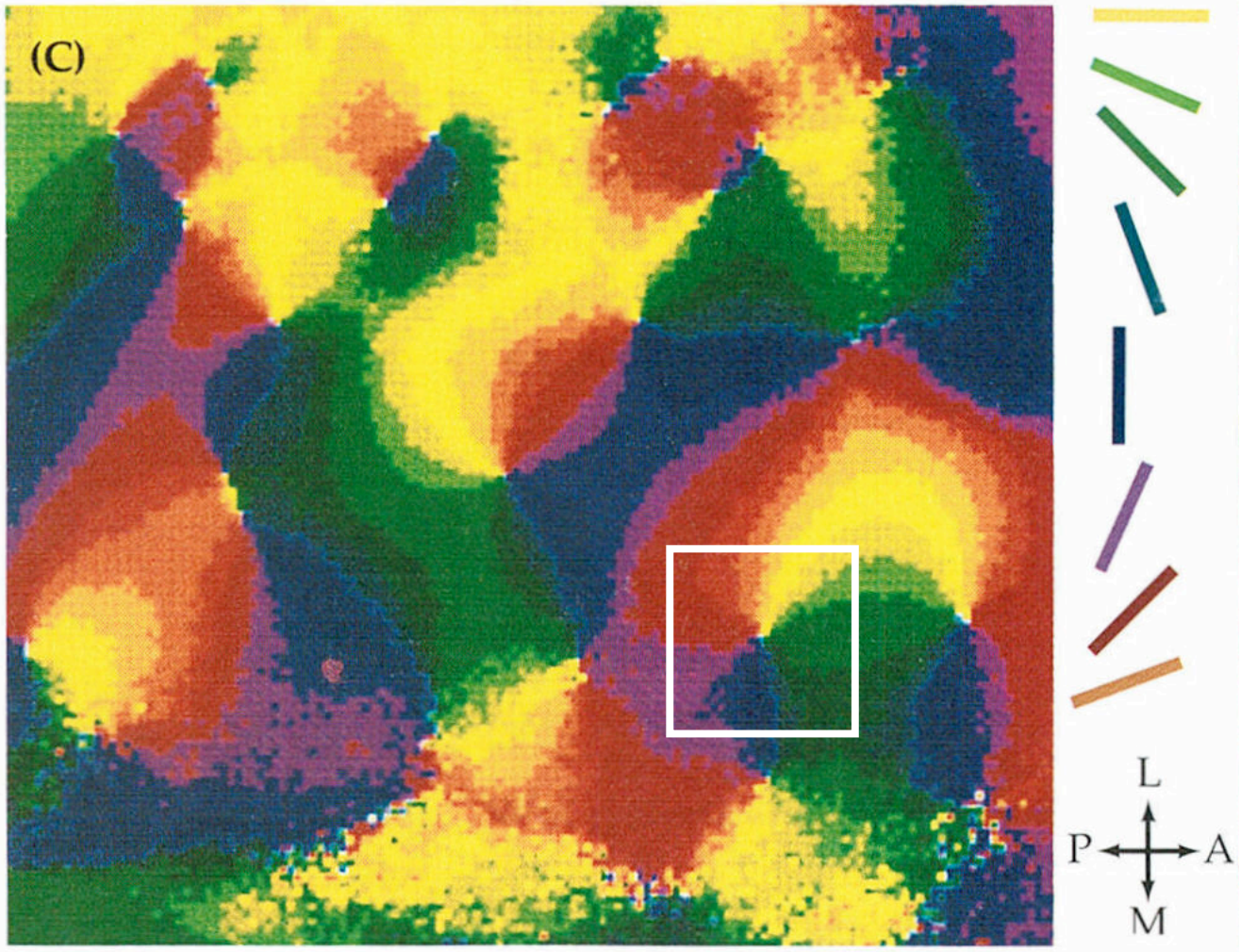
Reorganization of Cortex



- Median nerve sectioned to show fluidity of cortical organization
- (C) before
- (D) immediately after
- (E) several months later

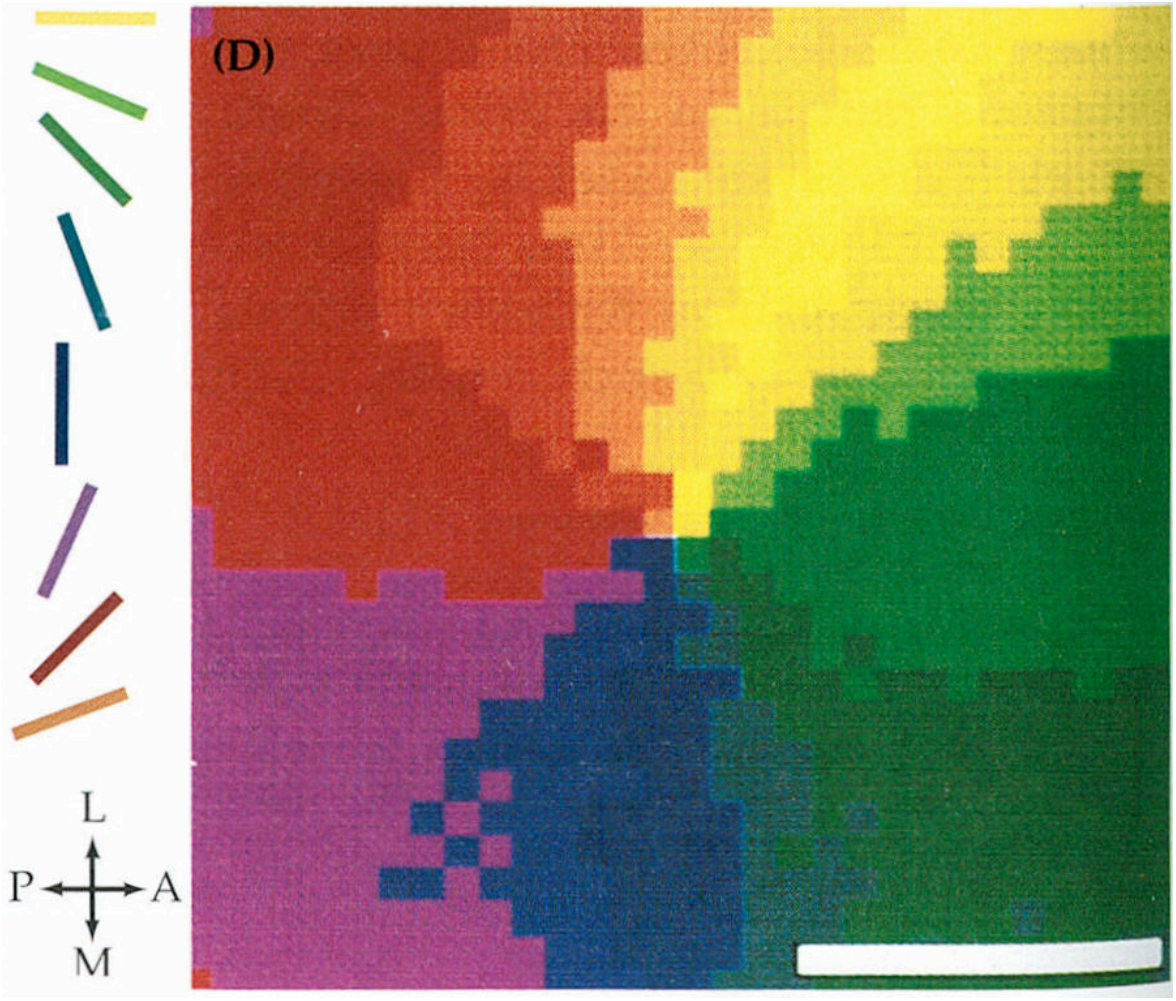
(fig. < McClelland & al, *Par. Distr. Proc*. II)

Orientation Columns



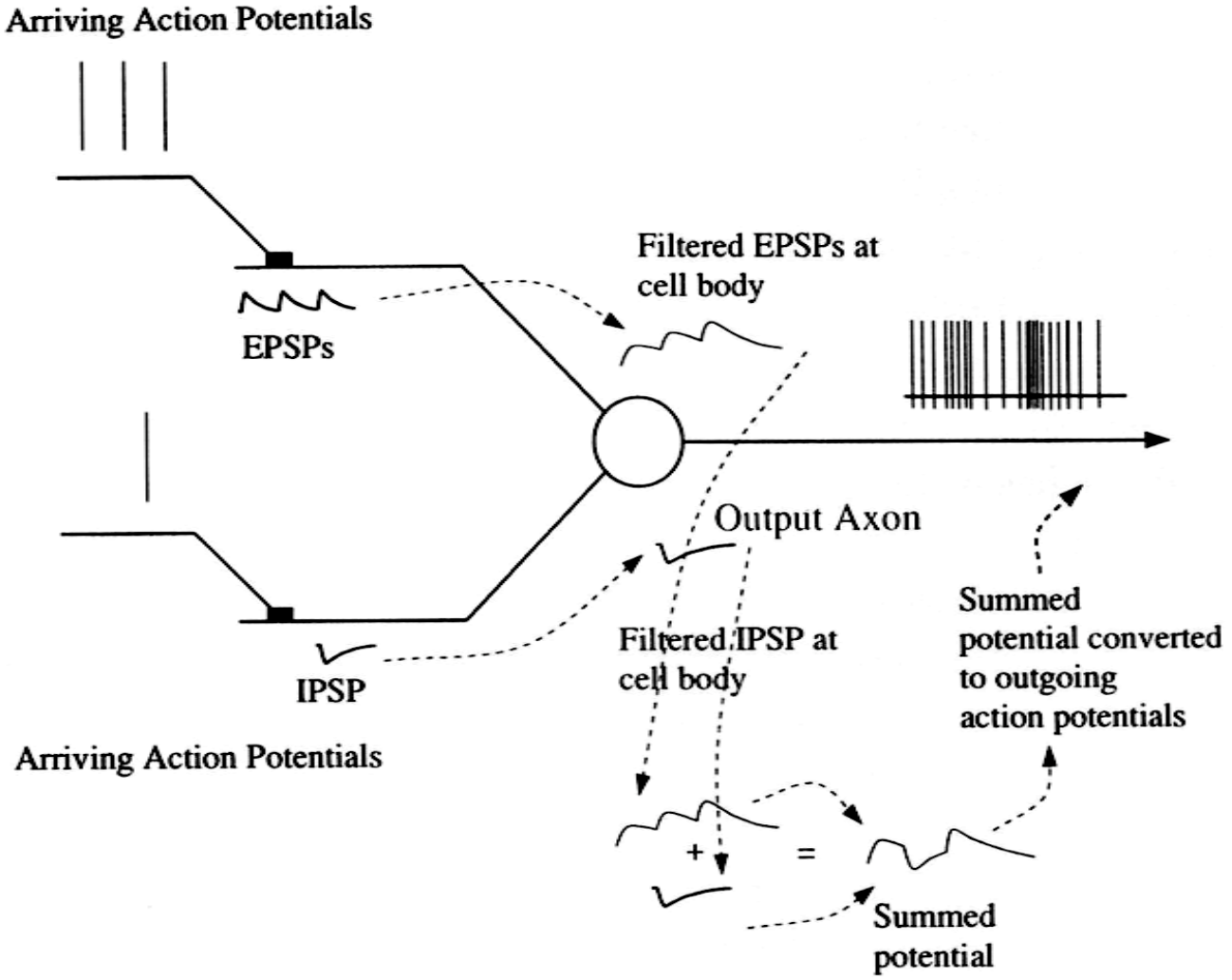
(fig. < Nicholls & al., *Neur. to Brain*)

Orientation Columns



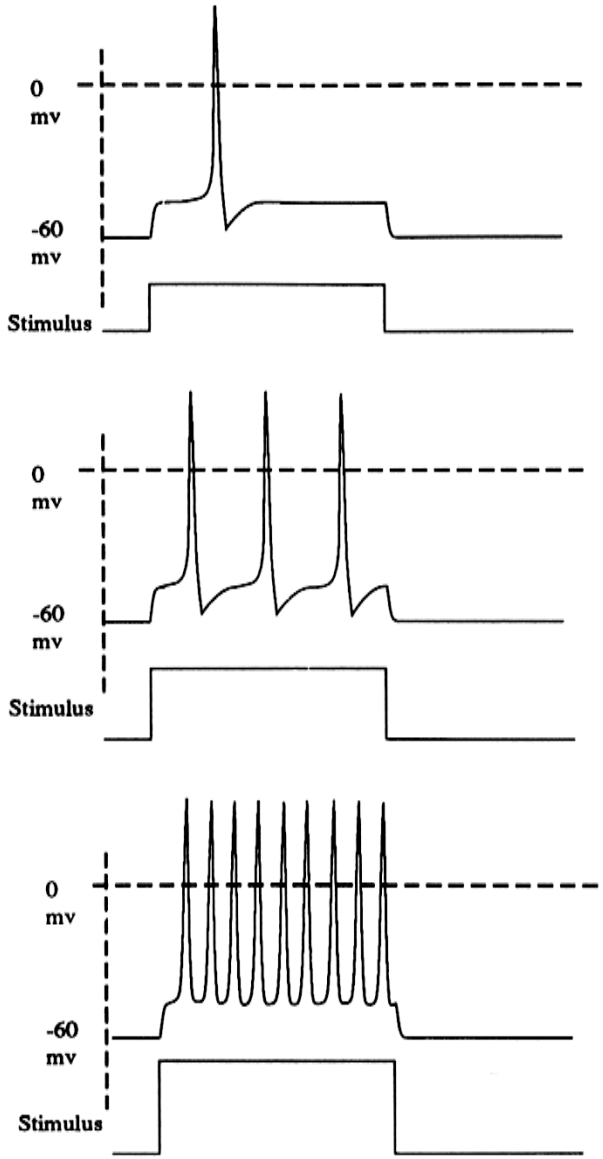
(fig. < Nicholls & al., *Neur. to Brain*)

Slow Potential Neuron



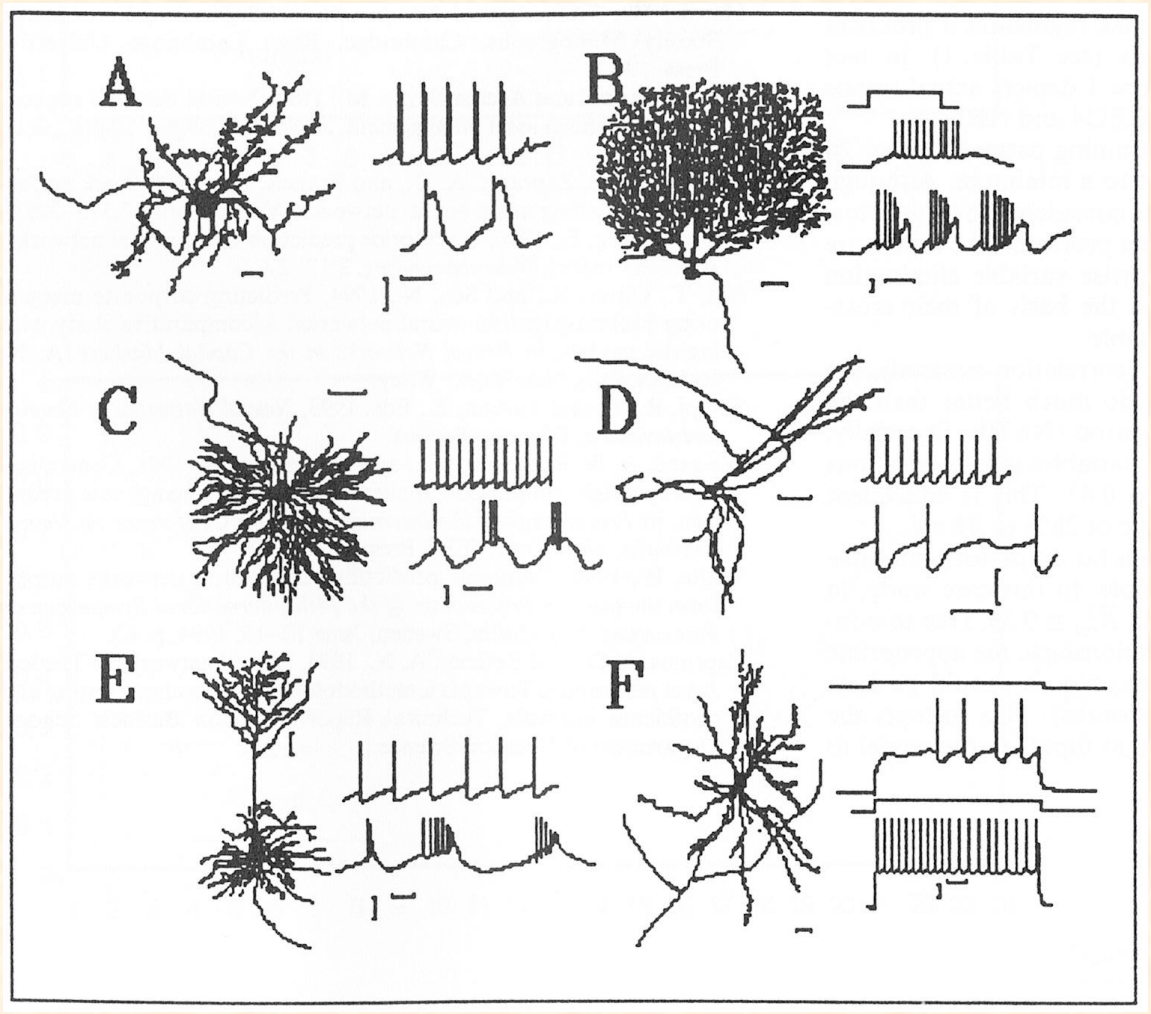
(fig. < Anderson, *Intr. Neur. Nets*)

Frequency Coding



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

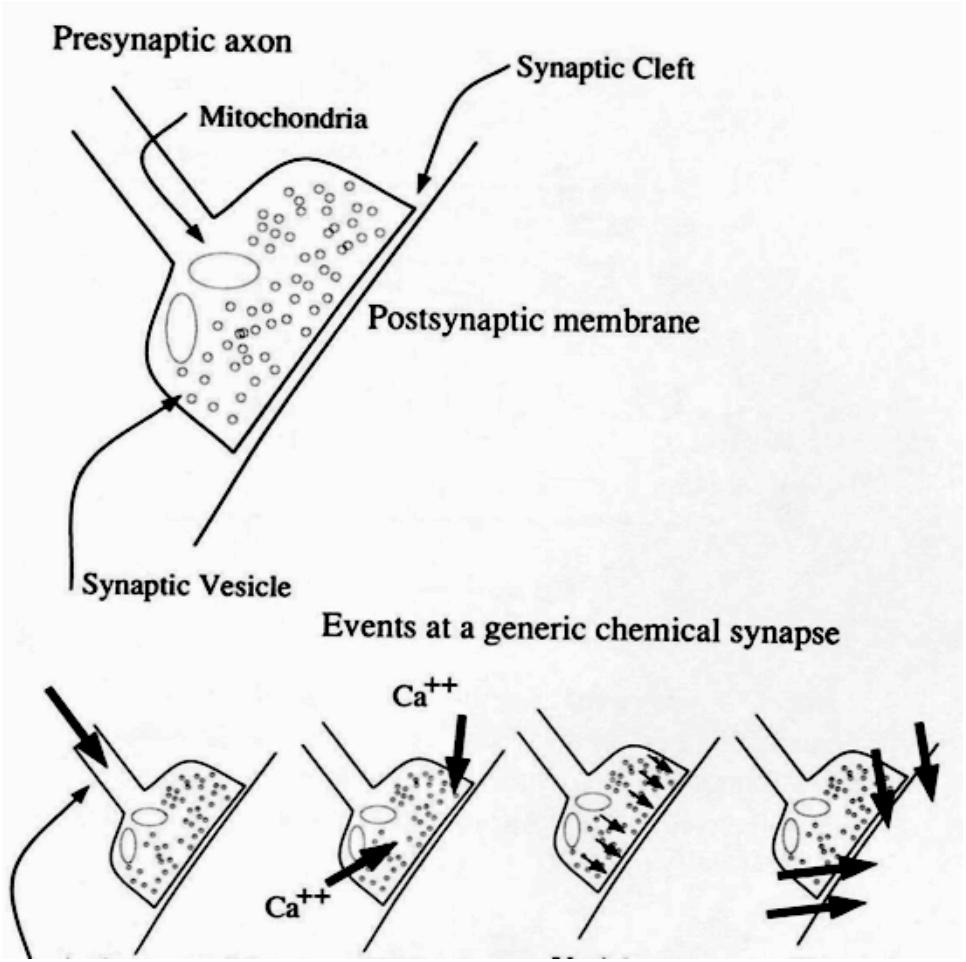
Variations in Spiking Behavior



Synapses

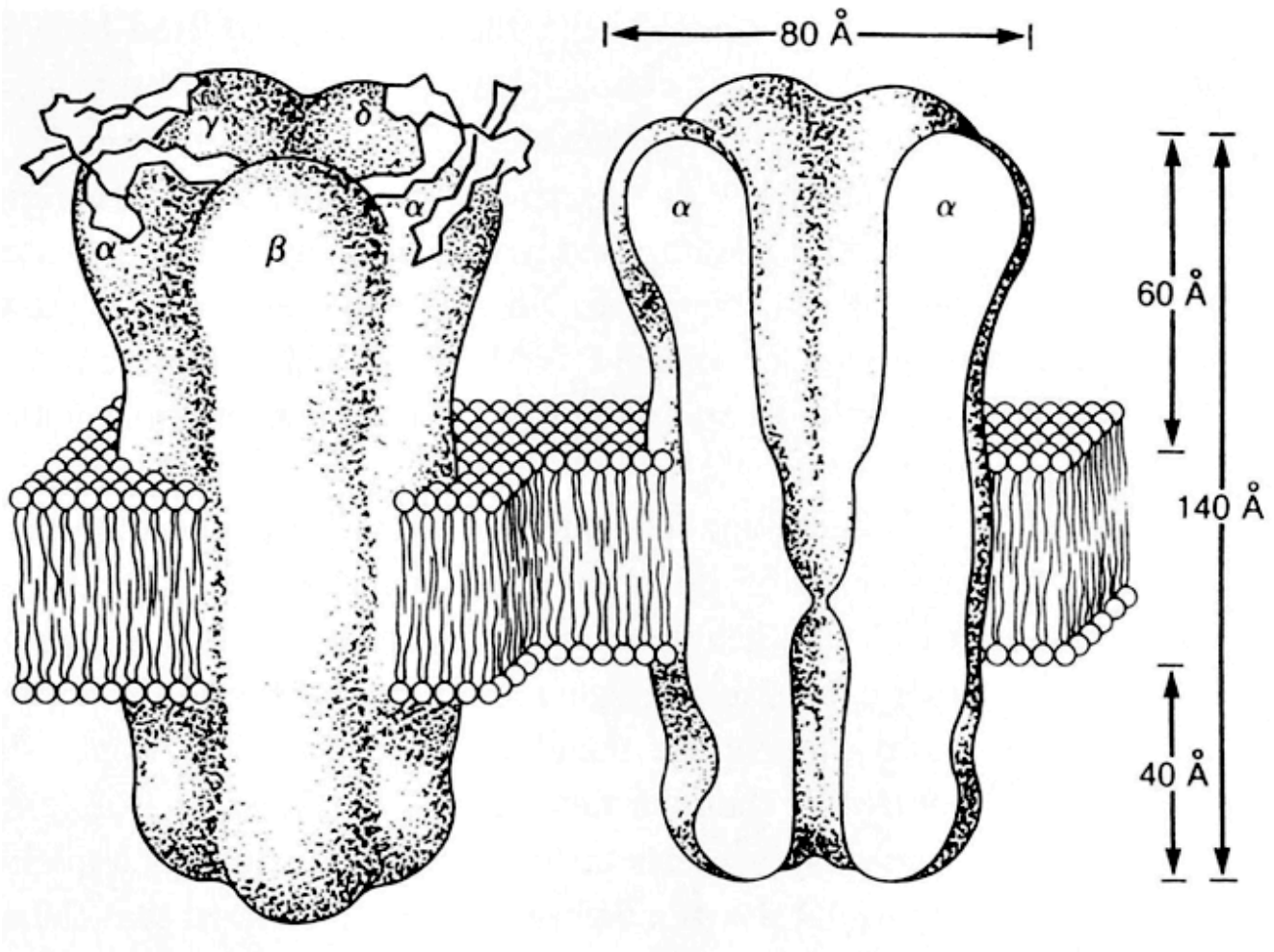
video by Hybrid Medical Animation

Chemical Synapse



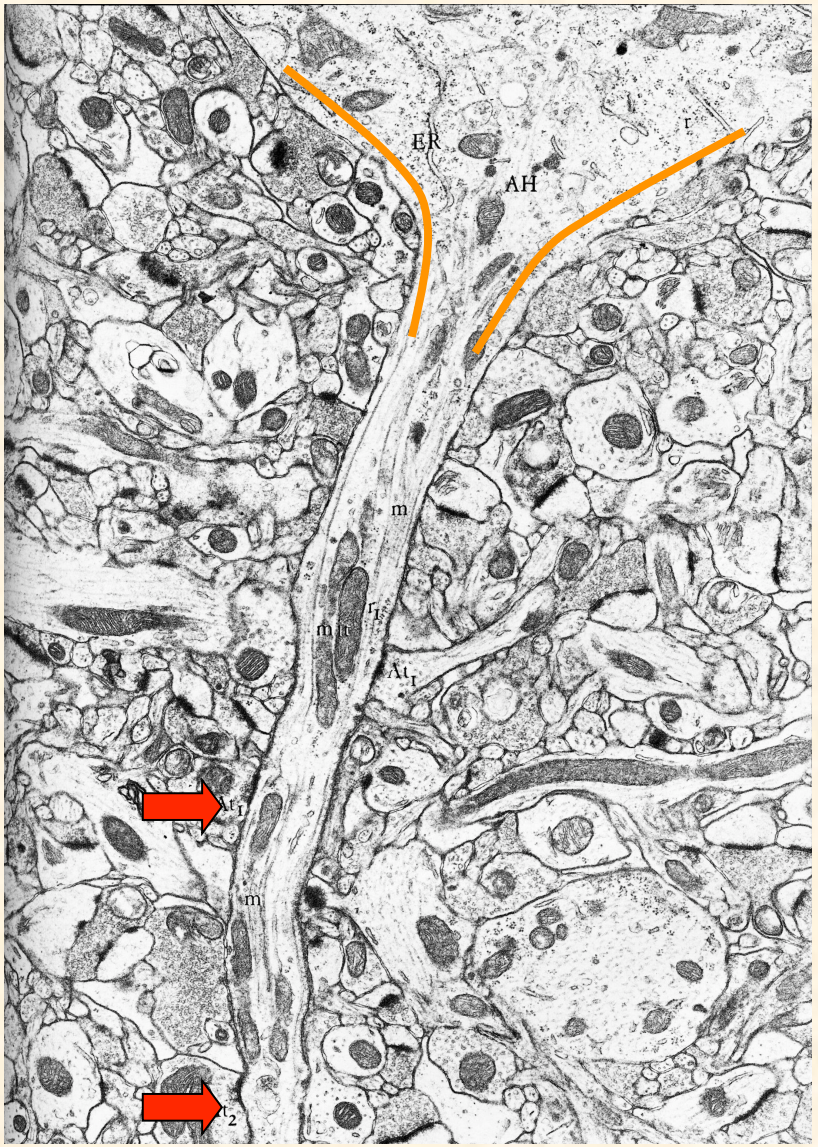
1. Action potential arrives at synapse
2. Ca ions enter cell
3. Vesicles move to membrane, release neurotransmitter
4. Transmitter crosses cleft, causes postsynaptic voltage change

Typical Receptor

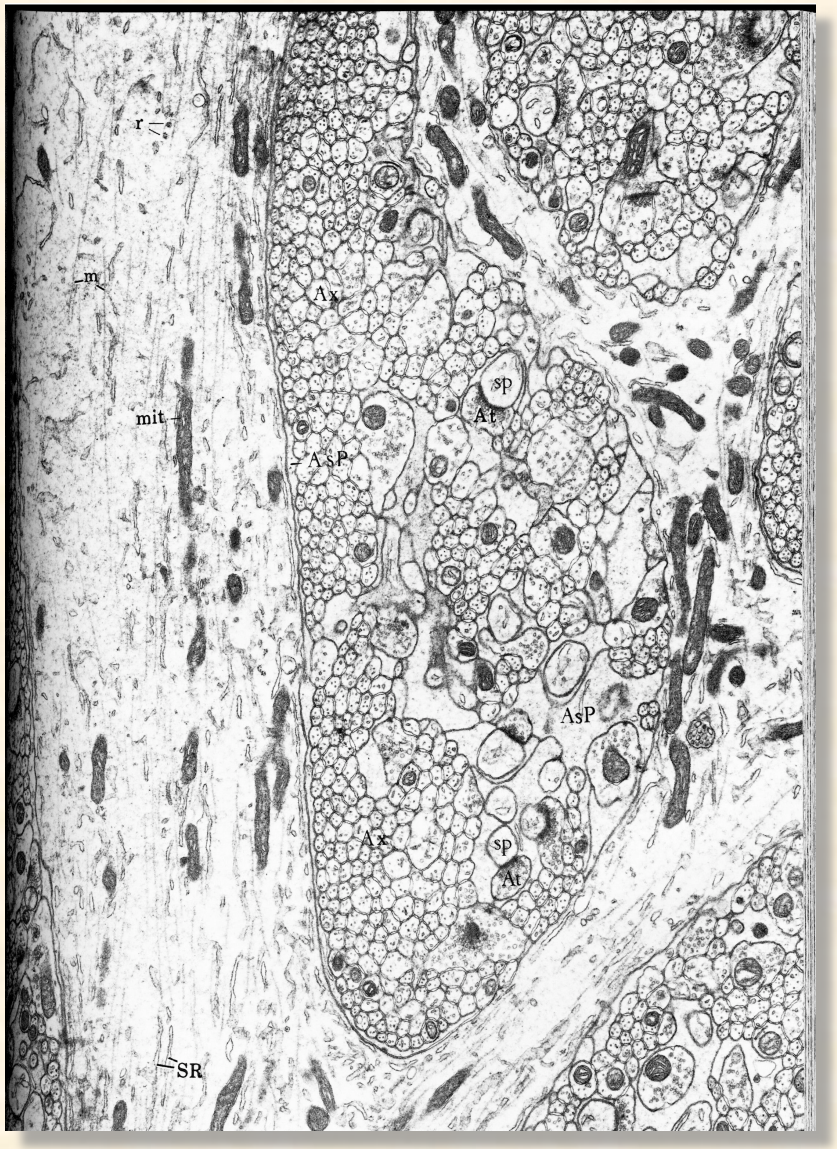


(fig. from Anderson, *Intr. Neur. Nets*)

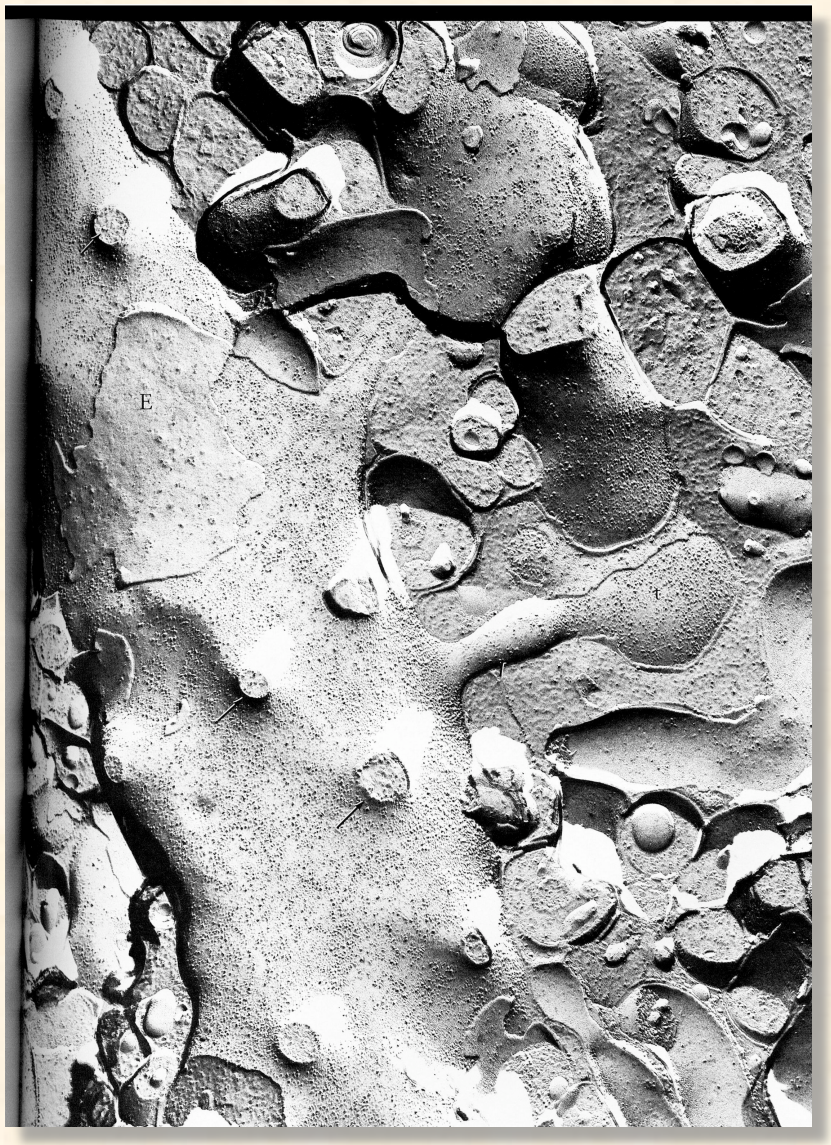
Axon Hillock



(fig. from Peters, Palay & Webster)



Dendrite & Dendritic Branches

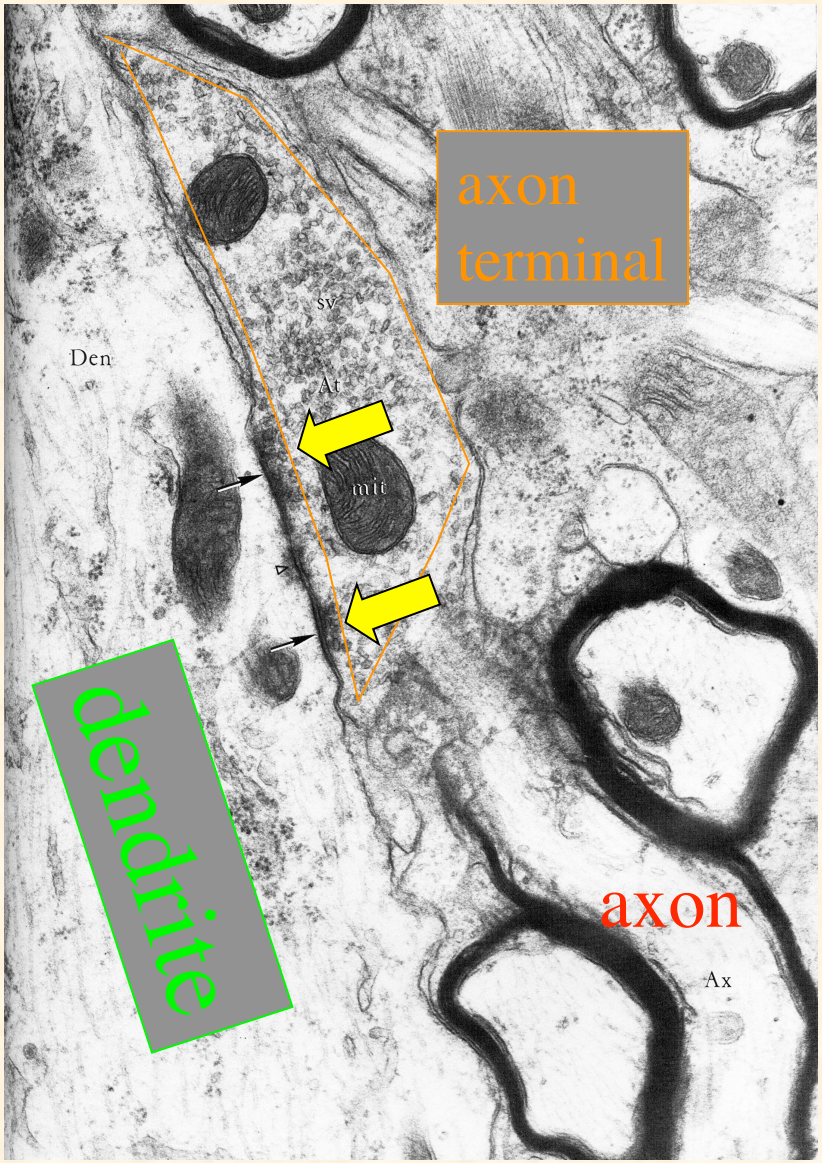


Dendrite & Dendritic Spine

Neuropil

(fig. from Peters, Palay & Webster)

Myelinated Axon Making Synapse on Dendrite

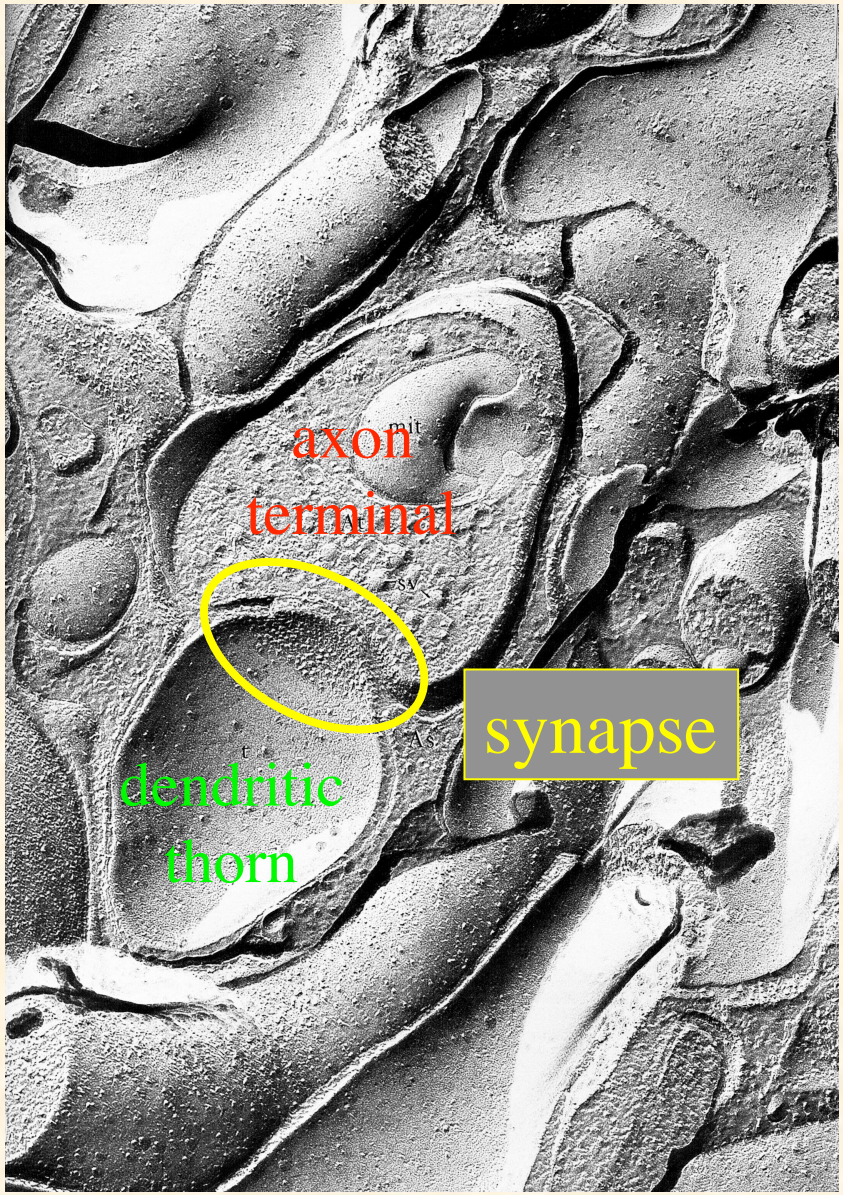


(fig. from Peters, Palay & Webster)

Various Synapses

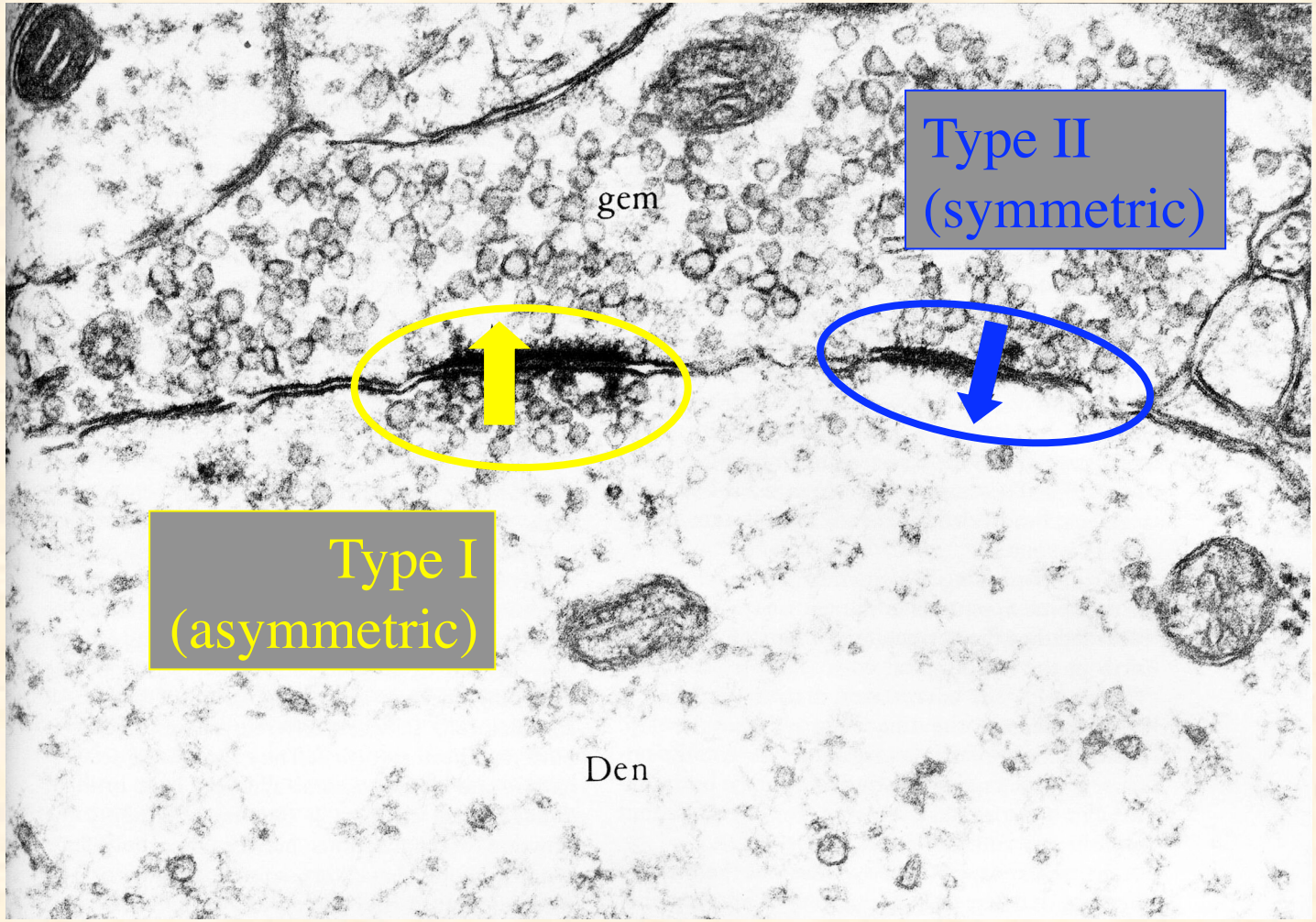
(fig. from Peters, Palay & Webster)

Excitatory Synapse Between Axon Terminal and Dendritic Thorn



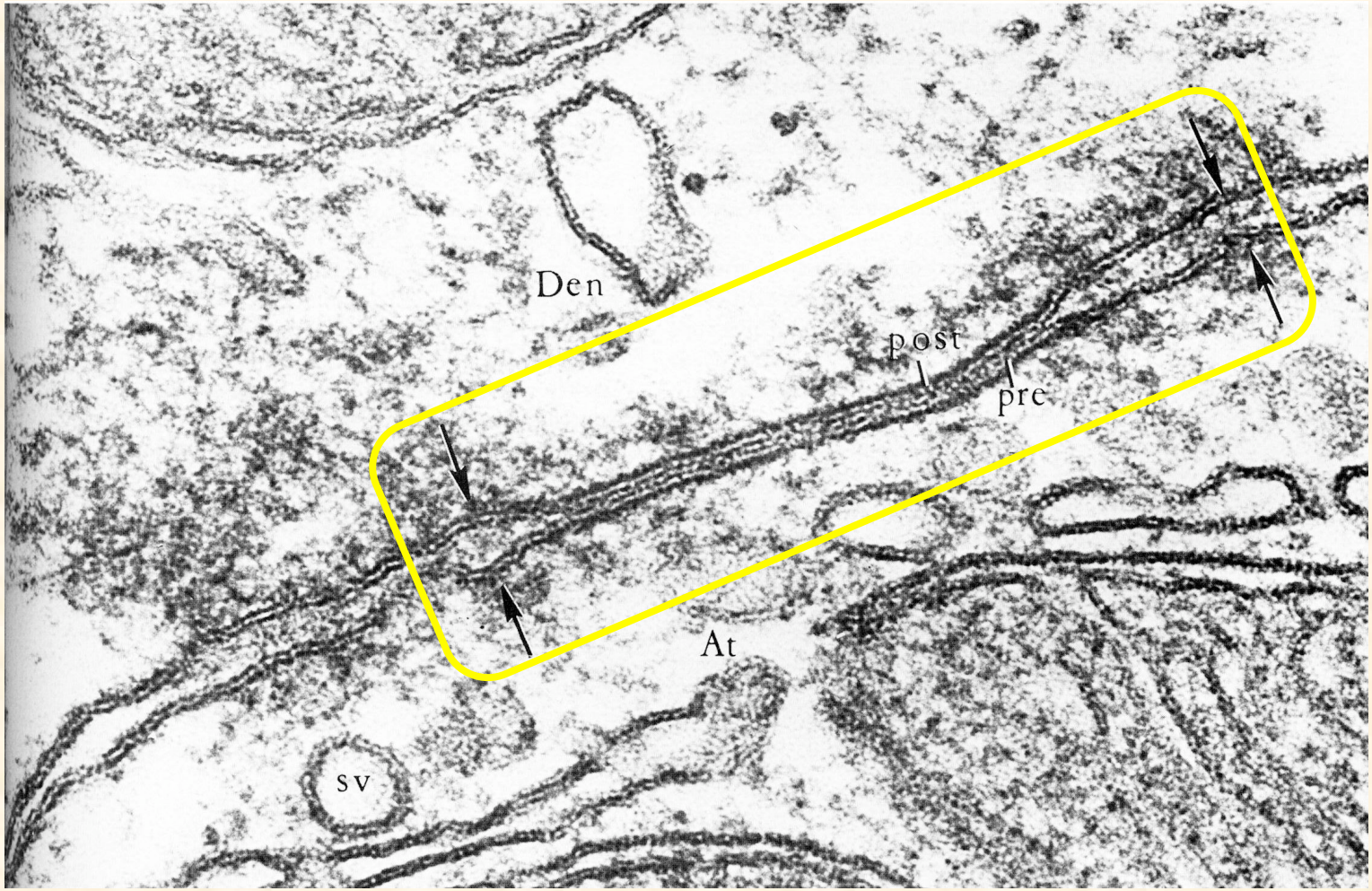
(fig. from Peters, Palay & Webster)

Dendro-dendritic Synapses



(fig. from Peters, Palay & Webster)

Electrotonic Synapse



(fig. from Peters, Palay & Webster)


V