V. Natural & Analog Computation
A Very Brief Tour of Real Neurons

(and Real Brains)
The Lobes of the Cerebral Hemispheres

- Frontal lobe
- Parietal lobe
- Temporal lobe
- Occipital lobe
Left Hemisphere
Typical Neuron
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

human
(2200 sq. cm)

ape

cat or monkey

rat
Neural Representations
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)
Layers and Minicolumns

(fig. from Arbib 1995, p. 270)
Projection Macrocolumns 0.5-1.0mm wide

Interdigitating Columns in Anterior Cingulate Gyrus

Interleaving Input Columns in Superior Temporal Sulcus

from prefrontal

from parietal

WHITE MATTER

(fig. from Arbib 1995, p. 270)
Neural Networks in Visual System of Frog

(fig. from Arbib 1995, p. 1039)
Frequency Coding

(fig. from Anderson, *Intr. Neur. Nets*)
Variations in Spiking Behavior
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

(fig. from Peters, Palay & Webster)
Dendrite & Dendritic Spine
(fig. from Peters, Palay & Webster)
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

Type I (asymmetric)

Type II (symmetric)

gem

Den

(fig. from Peters, Palay & Webster)
Electrotonic Synapse

(fig. from Peters, Palay & Webster)