I. Neural Generators

Reading: W.J. Freeman, Mass Action in the Nervous System, chapter 1.

Neurons are cells specialized for the generation, integration, and conduction of excited states.

Like all cells, neurons consist of a collection of chemically active structures embedded in a watery medium called the cytoplasm, and bounded over its entire surface by a thin layer of fatty material called the membrane.

The membrane is thin but provides a relatively strong diffusion barrier and separates the intracellular from the extracellular spaces.

Neurons differ from other cell types in that their role is to process information. They also have great diversity of shape. Each neuron's morphology is related to its function.

Neurons have one or more processes (extensions) which arise from the soma (cell body) and which may arborize (branch) profusely, making synaptic contacts with other neurons, receptor cells, or effector cells.

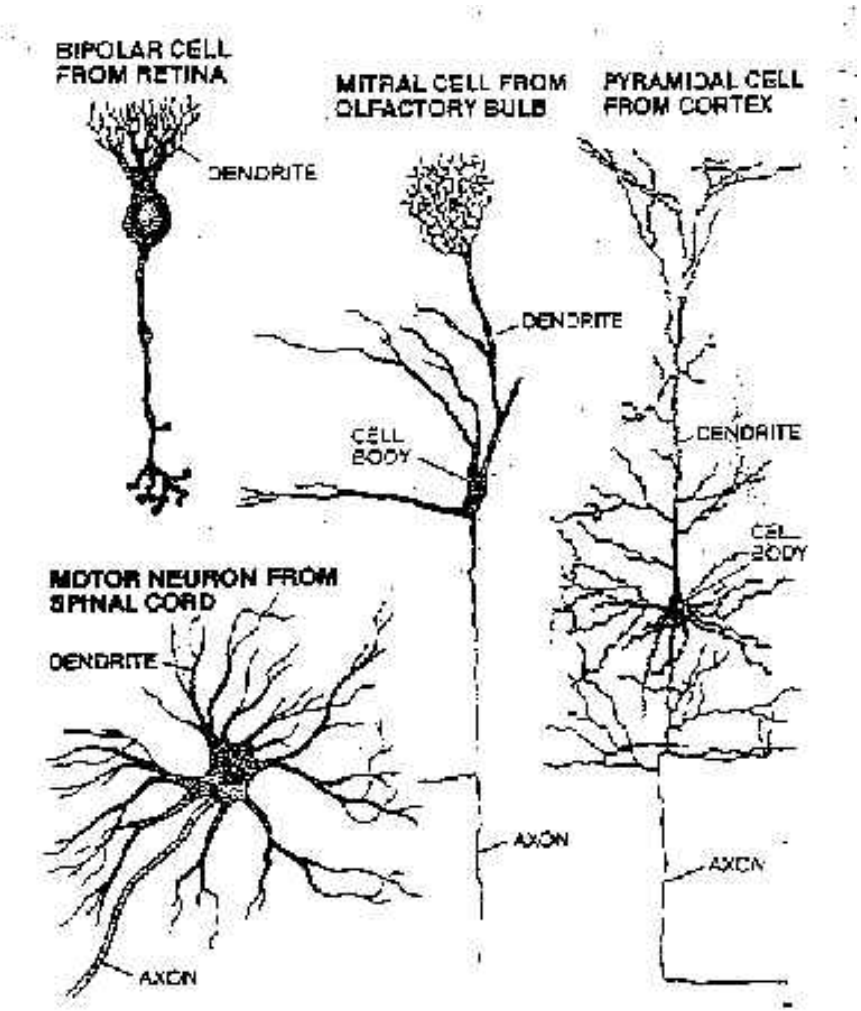
There are two kinds of neuronal process: dendrites and axons.

Characteristics of dendrites:

1) relatively short
2) unmyelinated
3) branched near soma
4) spines are common
5) usually post-synaptic

Characteristics of axons:
1) often long
2) often myelinated
3) branched away from soma
4) no spines
5) usually presynaptic

Classical model of neuron: dendrites specialized for reception and axons specialized for transmission. Largely true, but dendrites can be presynaptic and axons can have receptive (postsynaptic) junctions.


BIPOLAR CELL
FROM RETINA
DENDRITE
MITRAL CELL FROM
OLFACTORY BULB
DENDRITE
CELL
BODY
PYRAMIDAL CELL
FROM CORTEX
DENDRITE
CEL
BODY
MOTOR NEURON FROM
SPINAL CORD
DENDRITE
AXON
AXON
AXON

(1) Bipolar cell: retinal interneuron; one dendritic stalk has diffuse branching for reception of synaptic contacts from receptor cells; axon not branched near soma; branches at distance from soma for contact with ganglion cells.

(2) Mitral cell: one apical dendrite also has diffuse branching for reception of synaptic contacts from axons of primary olfactory nerve; basal dendrites extend horizontally for lateral interactions; axon also not branched near soma.

(3) Pyramidal cell: apical dendrite more widely branched; more complex branching of basal dendrites for greater degree of lateral interaction; axon branches near soma for more lateral interaction.

(4) Motor cell: many dendrites extending radially from soma reflecting large number of inputs from many sources; single axon going to muscles.

Conclusion about the typical neuron:
(1) it receives pulses
(2) it converts pulses to waves
(3) it sums and attenuates the waves over space and time
(4) it focuses the resultant
(5) it reconverts the resultant to pulses
(6) it transmits the pulses with delays, multiplication, and divergence.

The prime function of dendrites is integration in the wave mode. They provide for convergence, summing, and smoothing of their input.

The prime function of axons is transmission in the pulse mode. They chop the resultant of dendritic integration into fixed size pulses with varying intervals between pulses. They multiply the pulse by branching and disperse it temporally and spatially.