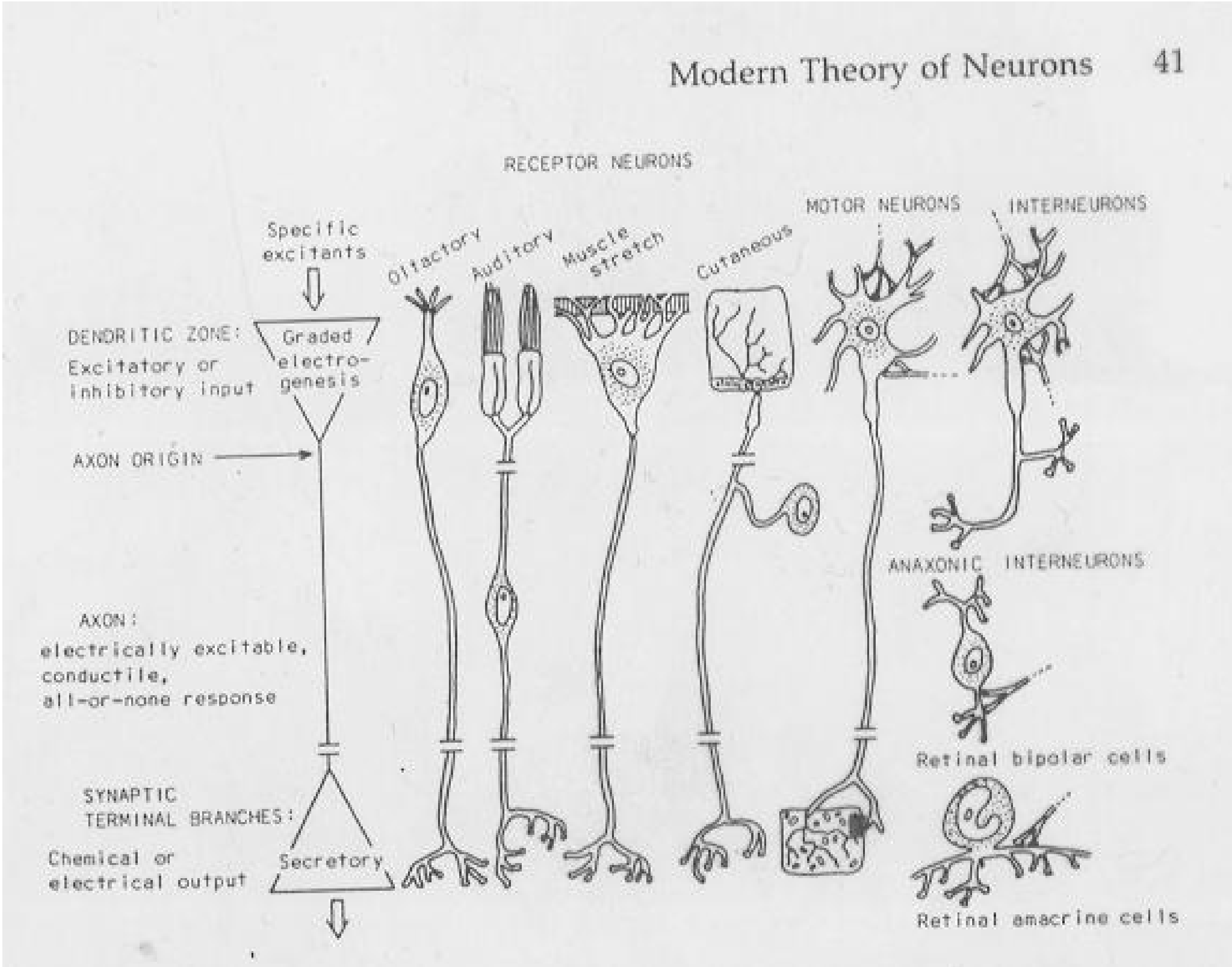
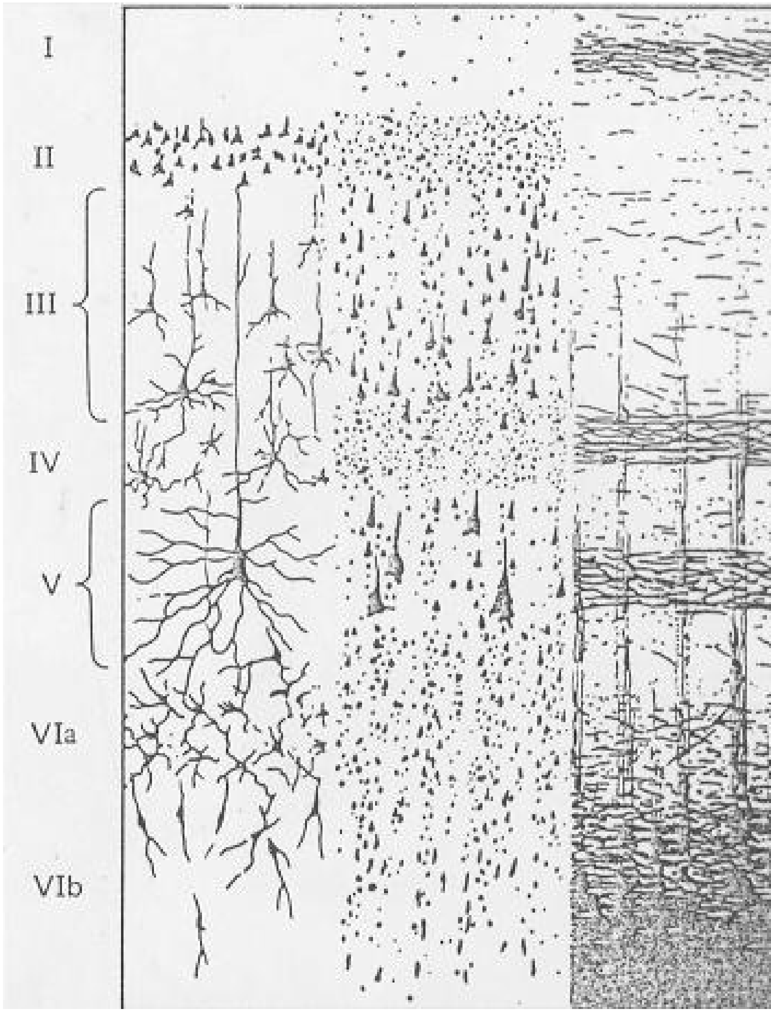
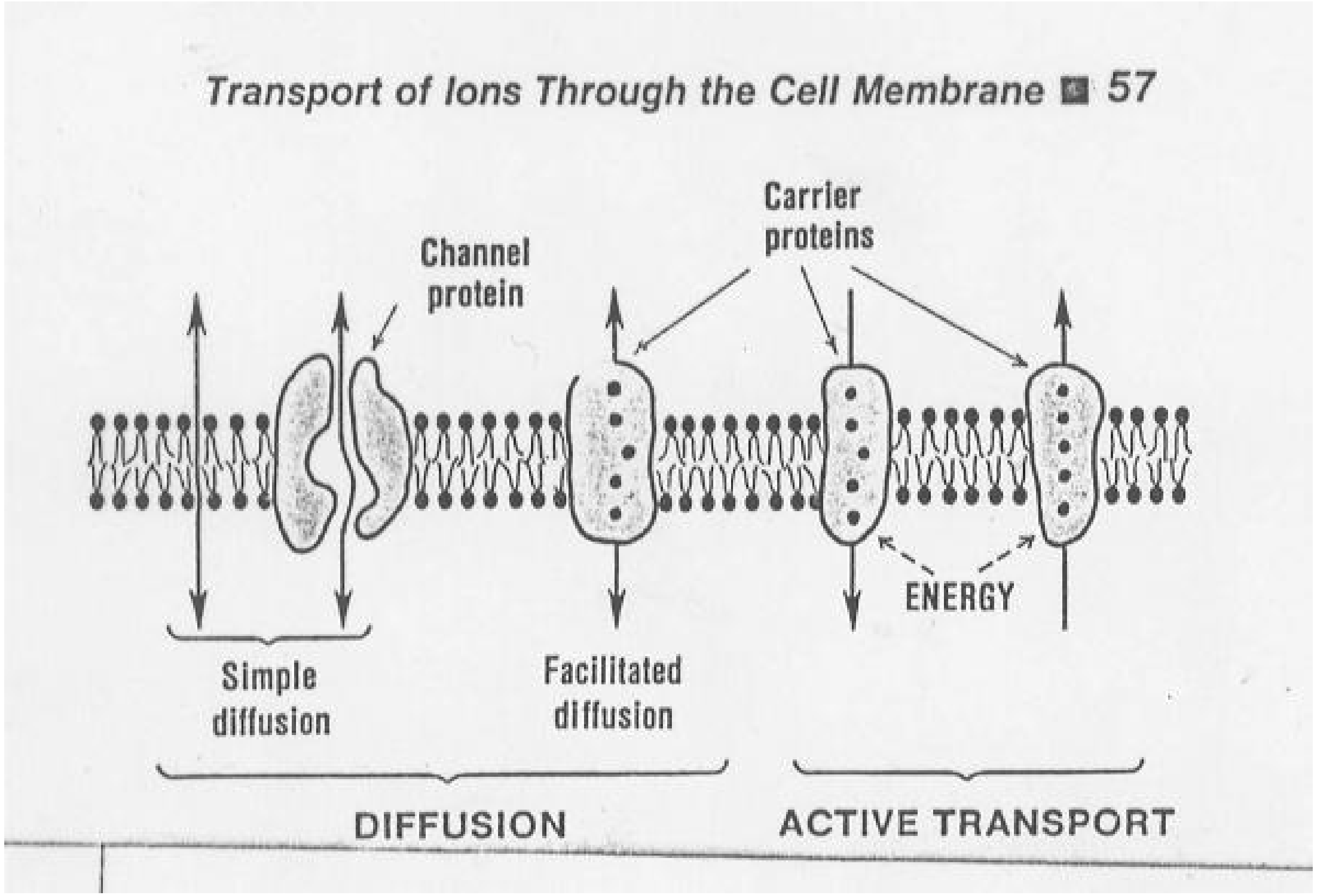
Nerve cells types



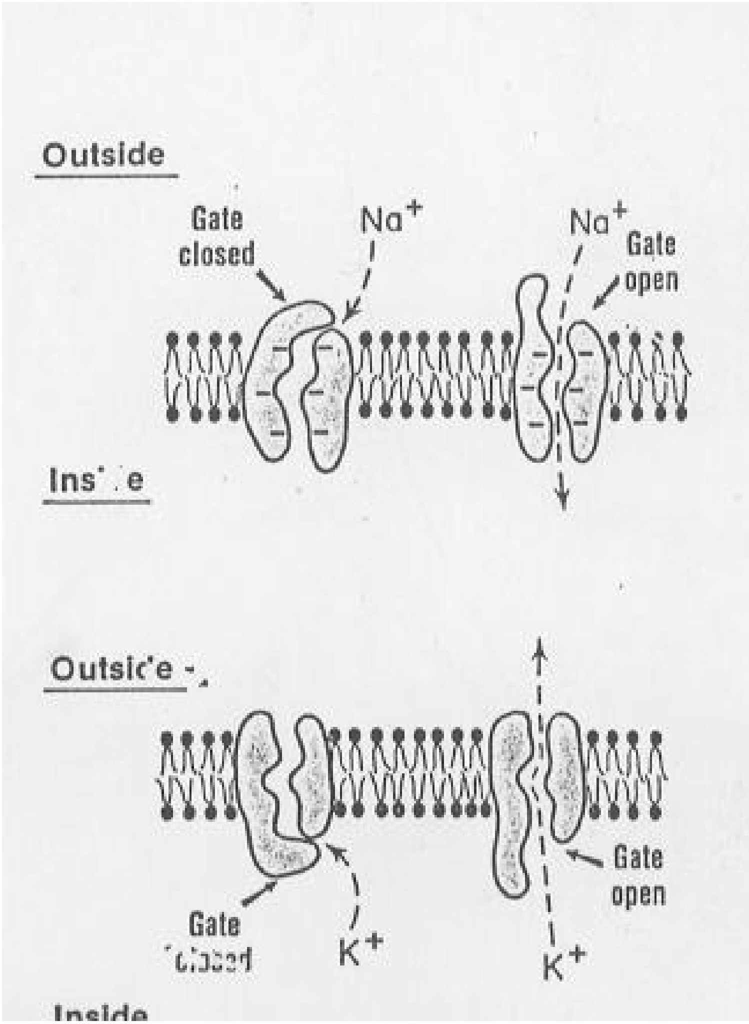
Cortical Layers

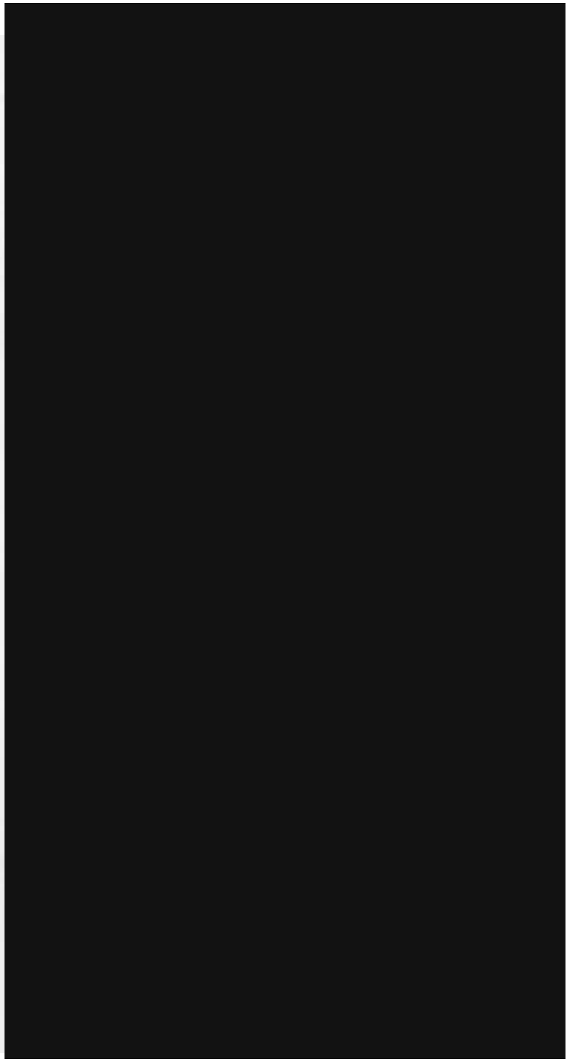


Action Potentials

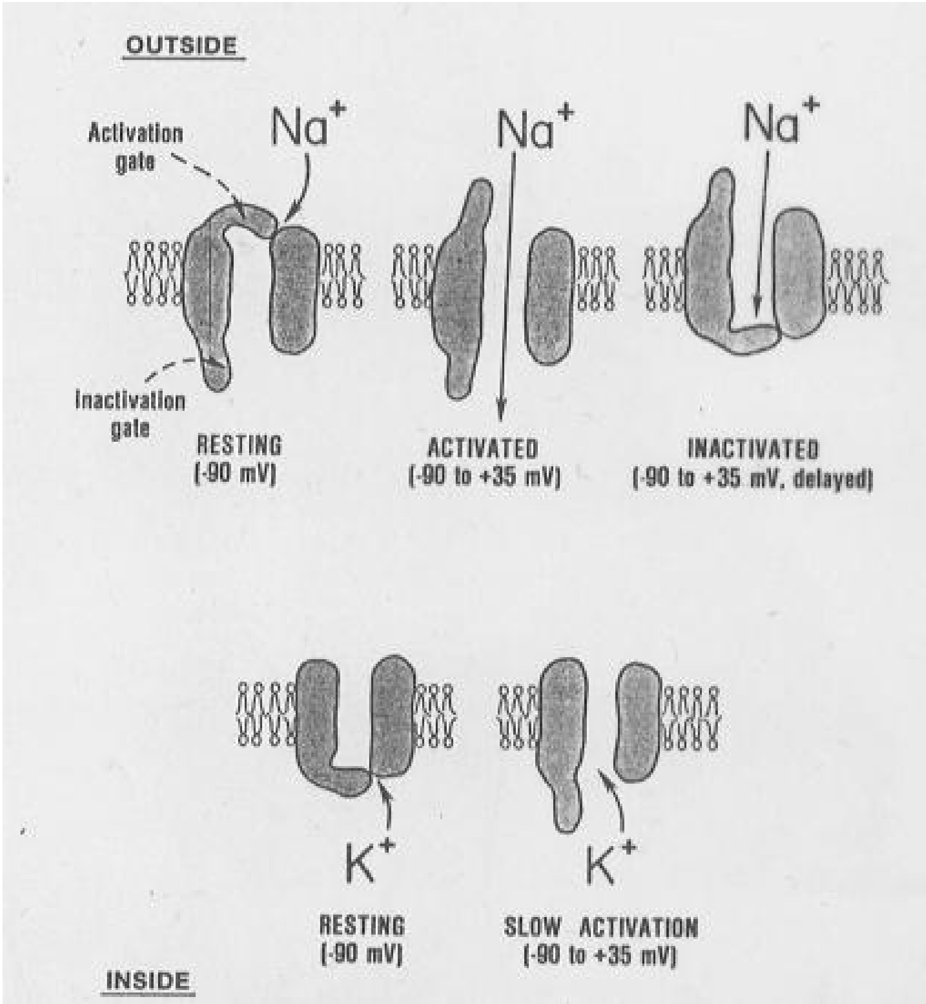


Action Potentials





Action Potentials



Synapses

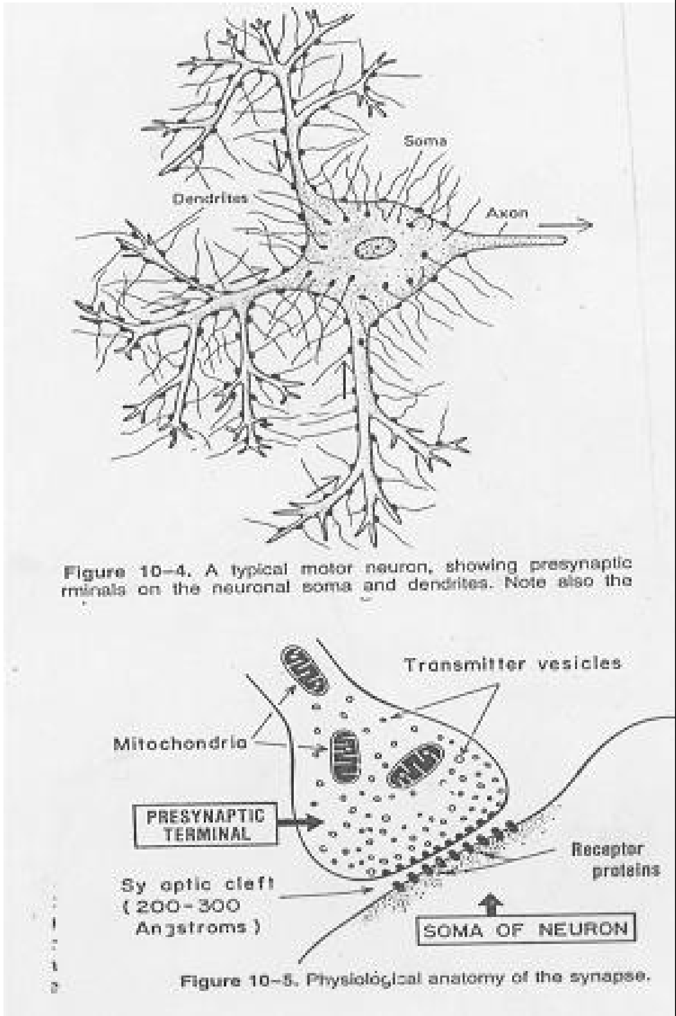
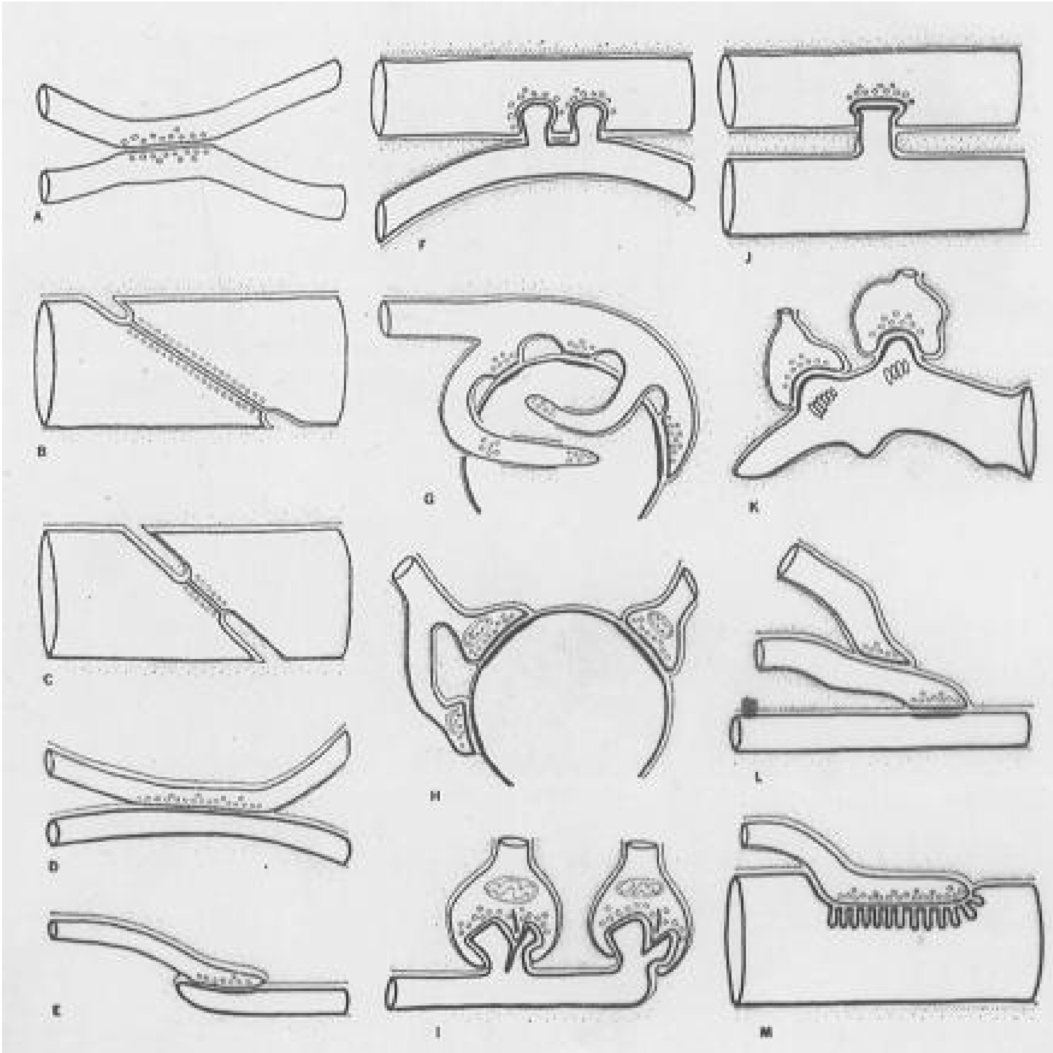


Figure 10–4. A typical motor neuron, showing presynaptic rminals on the neuronal soma and dendrites. Note also the

Figure 10–5. Physiological anatomy of the synapse.

Synapses



Neural circuits

- Receptive field model: somatic/visual/auditory

  Binary/continuous
- Barlow’s dogma
- Kernel representation

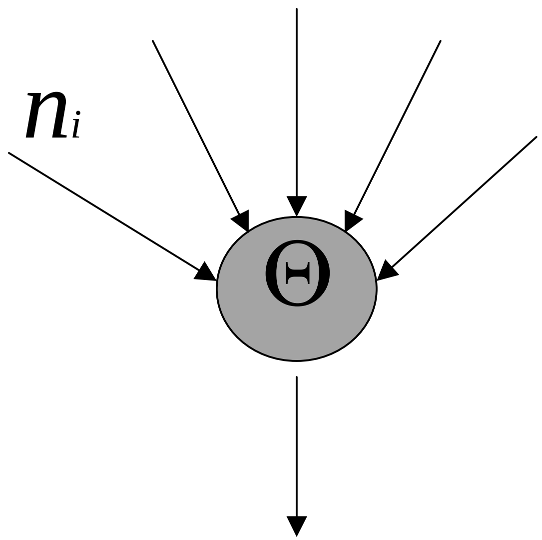
Neural circuits

- Spatial summation: amount of active fibers
- Temporal summation: intensity of firing
- Excitatory and Inhibitory circuits
- Converging signals
- Lateral Inhibition
- Reverberation by synaptic delay

Measuring methods

- Intra cellular
- Single unit Extra cellular
- PSTH
- Multi unit Extra cellular
- Large scale (CNV/P300)
- fIMAGING

McCulloch & Pitts 1943: Formal Neurons



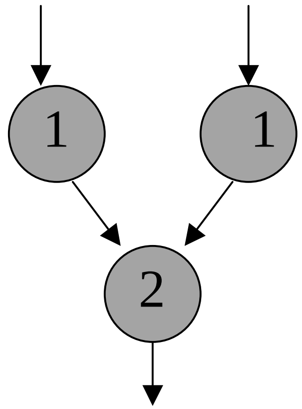
1 if $\Sigma n_i > \Theta$

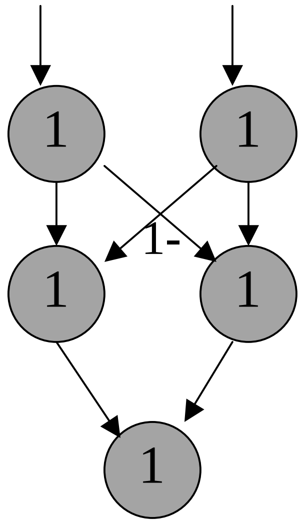
0 otherwise

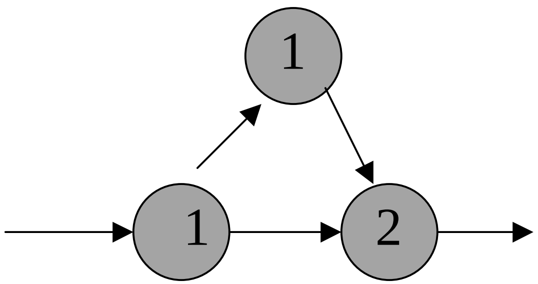
Formal Neuron extensions

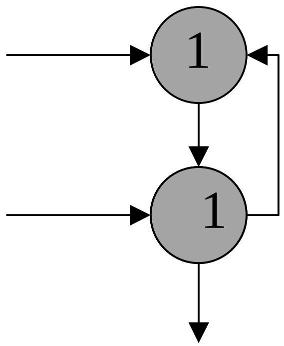
- Discrete - continuous
- Different threshold functions
- Integrate & Fire models

Formal Neural Networks









Psychological level

If a cold material is applied and immediately removed, it feels hot. If it is not removed, it feels cold. If hot material is applied it feels hot.

Sensory level

“Heat receptors” and “Cold Receptors”

Logical level

C(dt) and C(2dt) --> “cold”

C(dt) and not C(2dt) --> “hot”

H(dt), H(2dt) --> “hot”

Psychological level

If a cold material is applied and immediately removed, it feels hot. If it is not removed, it feels cold. If hot material is applied it feels hot.

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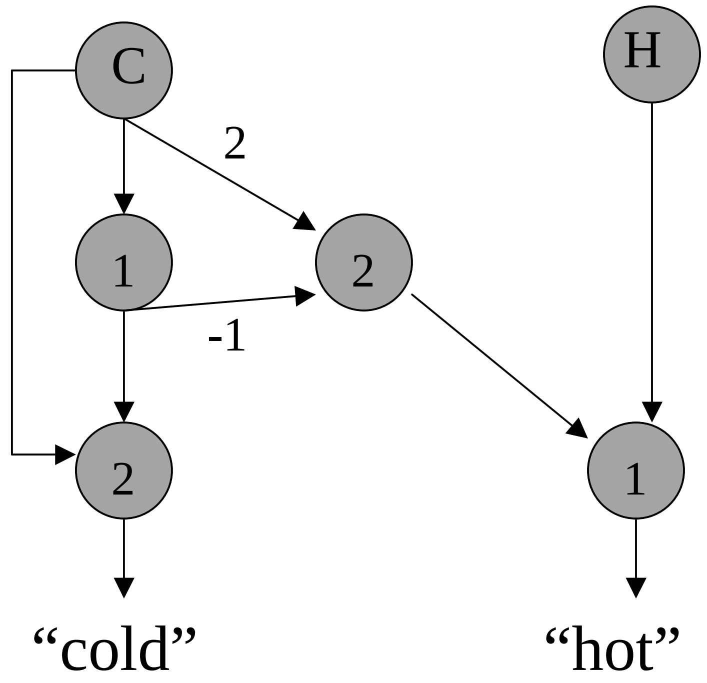


Any behavior that can be unambiguously described in a finite number of words can be realized by a formal neural network

The fallacy of the first step

Models and reality: the right scale

- Evoked potentials
- Multi units
- Single units
- Intracellular
- Synaptic

Models and reality: the right scale

- Discrete or continuous ?
- Synchronized ?
- Uniform processor ?
- The information carrier is:

  spikes/frequency/inter-spikes/synchrony ?

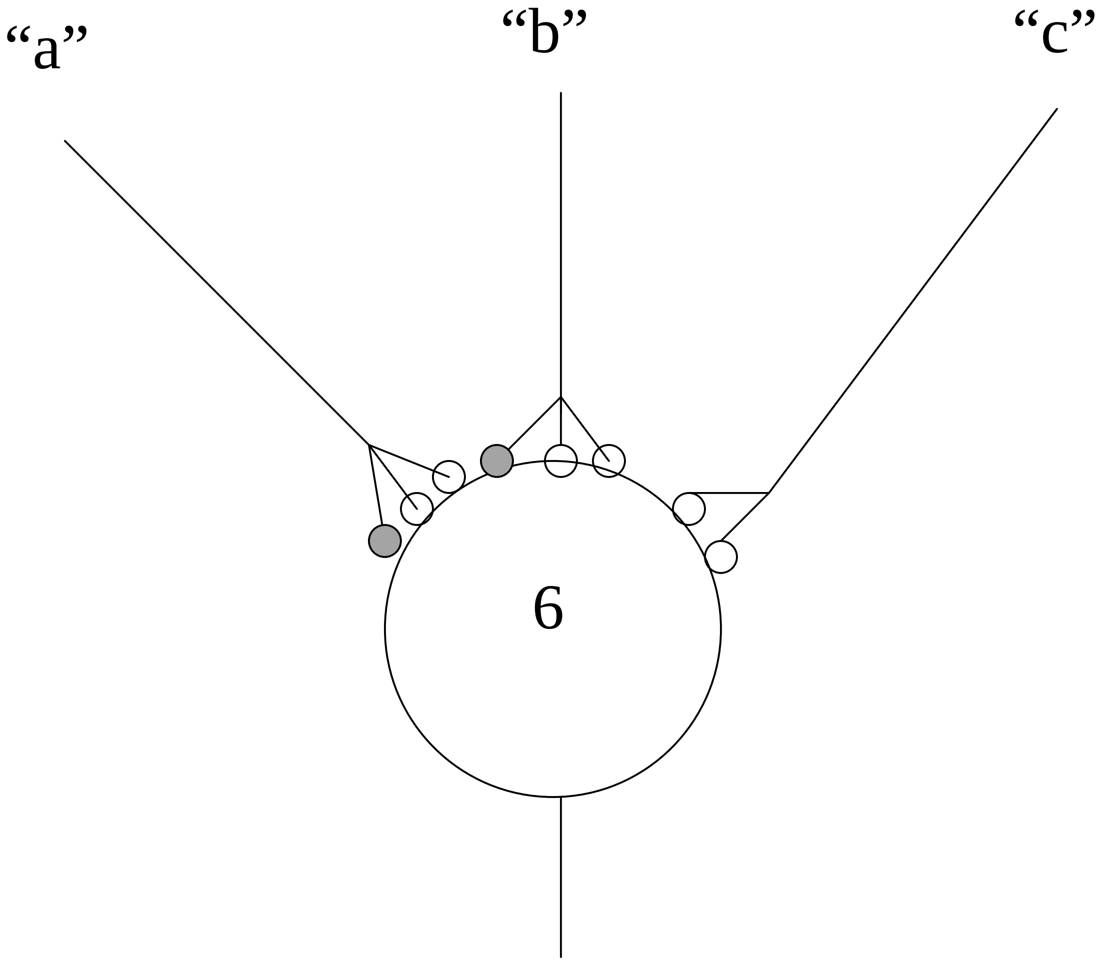
Hebb principle (1949):

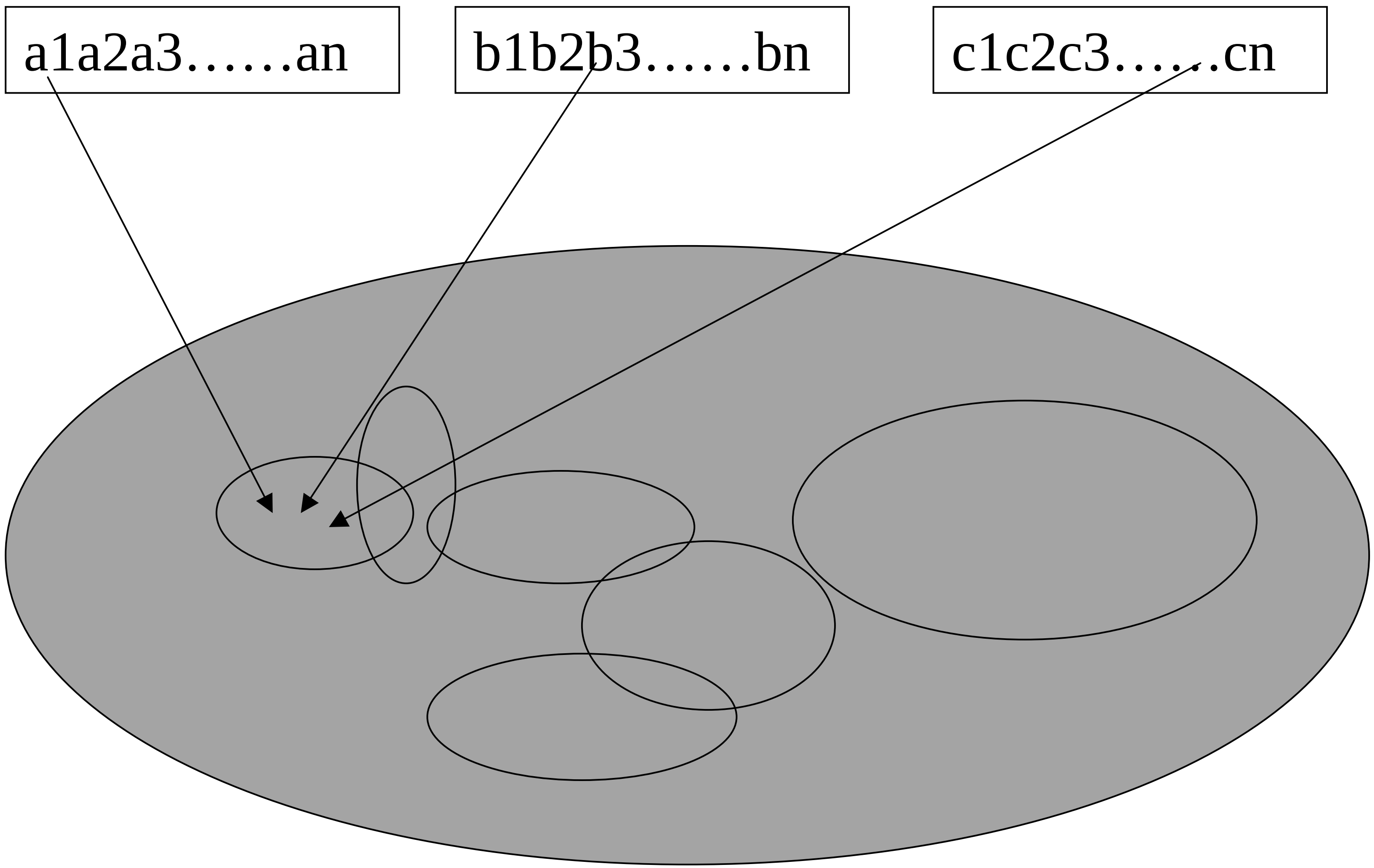
when an axon of cell A is near enough to excite cell B, and repeatedly and persistently takes part in firing it, some growth process or metabolic change take place in one or both cells, such that A’s efficacy as one of B’s excitators is increased

Interaction of presynaptic/postsynaptic excitation/inhibition

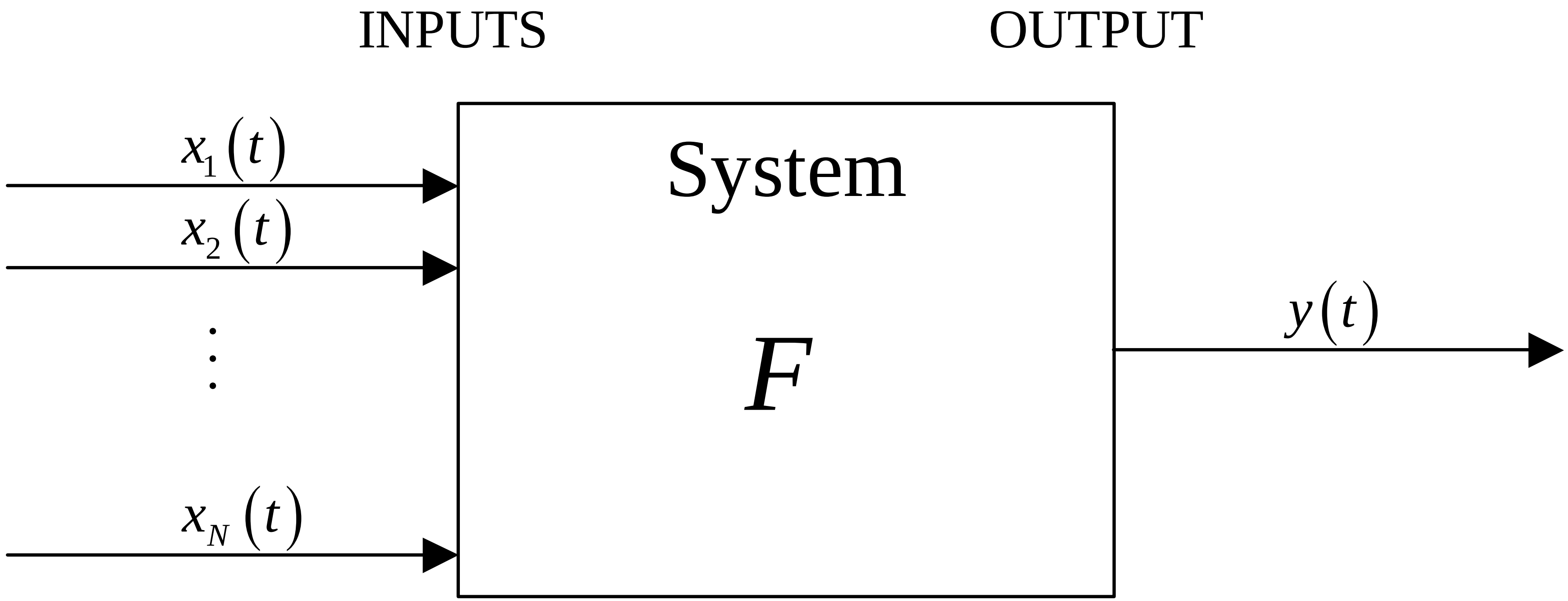
Implementing memory in NN

- Memory – variable strength synapses


"a"
"b"
"c"
6



a1a2a3……an
b1b2b3……bn
c1c2c3……cn



INPUTS
OUTPUT
System
F
$x_1(t)$
$x_2(t)$
$x_N(t)$
$y(t)$

$$y(t) = F\left\{x_1(t), x_2(t), \ldots, x_N(t)\right\}$$

$$y(t) = \sum_{r=1}^{N} \int_0^M h_r(\tau) x_r(t-\tau) d\tau + \sum_{r=1}^{N} \sum_{s=1}^{N} \int_0^M \int_0^M h_{rs}(\tau_1, \tau_2) x_r(t-\tau_1) x_s(t-\tau_2) d\tau_1 d\tau_2$$

kernels approximated by basis functions $\left\{Q_i(\tau)\right\}_{i=1}^{K}$

$$h_r(\tau) = \sum_{i=1}^{K} \alpha_i^r Q_i(\tau)$$

$$h_{rs}(\tau_1, \tau_2) = \sum_{i=1}^{K} \sum_{j=1}^{K} \alpha_{ij}^{rs} Q_i(\tau_1) Q_j(\tau_2)$$

$$y(t) = \sum_{r=1}^{N} \sum_{i=1}^{K} \alpha_i^r g_i^r(t) + \sum_{r=1}^{N} \sum_{s=1}^{N} \sum_{i=1}^{K} \sum_{j=1}^{K} \alpha_{ij}^{rs} g_i^r(t) g_j^s(t)$$

$$g_i^r(t) = \int_0^M Q_i(\tau) x_t(t-\tau) d\tau$$