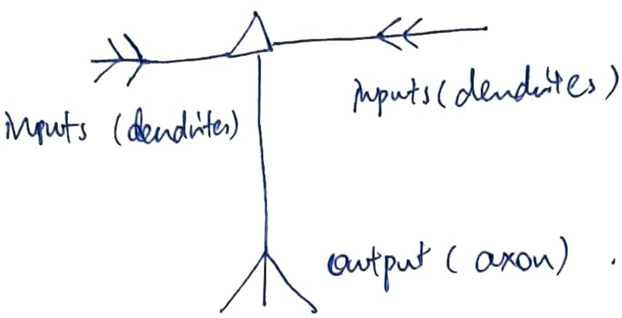
Review on Neuroscience lecture 1.

- The neuron (simplified):



- Mechanisms for neural potential:

① Neurons have semi-permeable membrane.

→ electrostatics.

differential equation: $$\frac{dn}{dh} = -\frac{mg}{KT} n.$$ constant.

(The rate at which the density of atoms changes at every instant of height is inversely proportional to the density of atoms present at that height.)

Solution: $$n = n_0 e^{-\frac{mg}{KT}h}$$
↑ initial condition

Thus, we have the Boltzmann Relationship:

the density of atoms at a particular height is proportional to $e^{-\text{potential energy of each atom}/KT}$.

⇒ Boltzman r/s → ion distribution across neural membrane

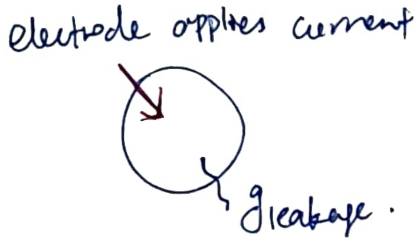
→ electric field across neural membrane

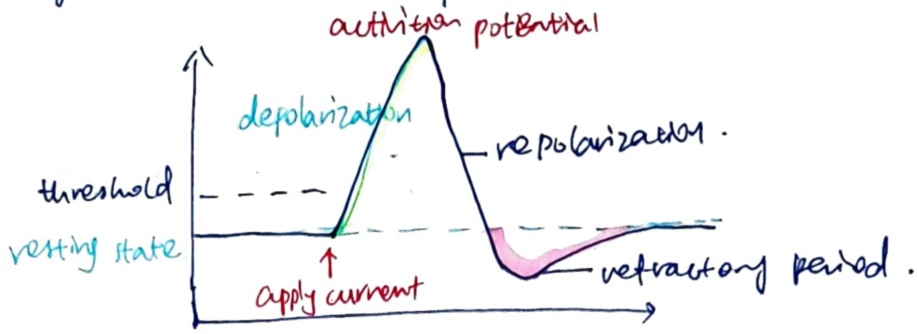
and V (voltage) $\propto$ Q (charge).

i.e., $V = C_m Q$

constant, "membrane capacitance".

② . Ion channel activity leads to action potential :



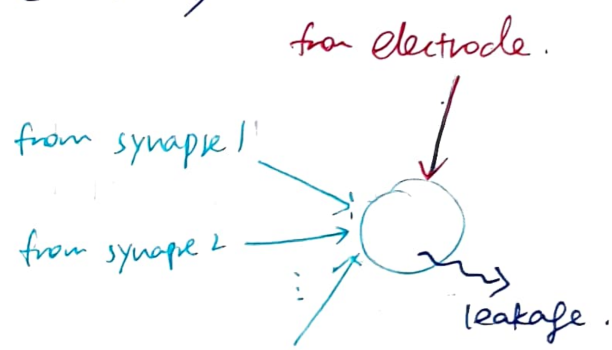


$V = C_m Q$. (from ①) .

$$C_m \frac{dV}{dt} = \frac{dQ}{dt} = I \leftarrow \text{the current}$$

③ . Activation potentials propagate along the axon , until they reach a synapse .

2 types of synapses — excitatory
— inhibitory



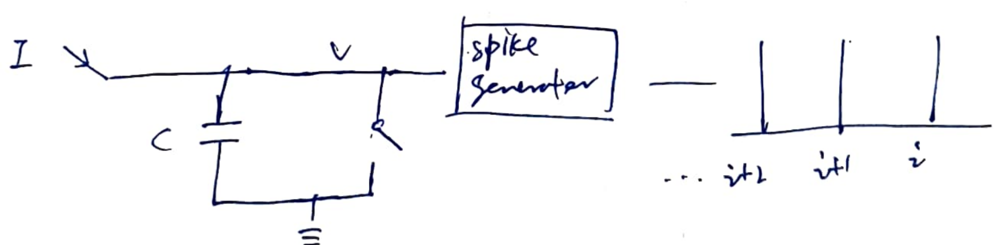
what happened here is modelled by :

(a)
$$C_m \frac{dV}{dt} = I_{total} \text{ (sum of all input currents)} .$$
$$= -\text{leakage} + \text{from synapses} + \text{from electrode} .$$
$$= -i_m + I_{synapses} + I_e / A$$

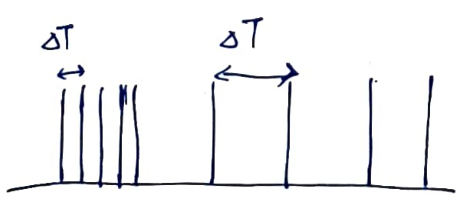
+

$$= -g_{leakage}(V - E_i) + g_{synaptic}(V - E_i) + I_e / A .$$

(b) integrate - and - fire circuit .

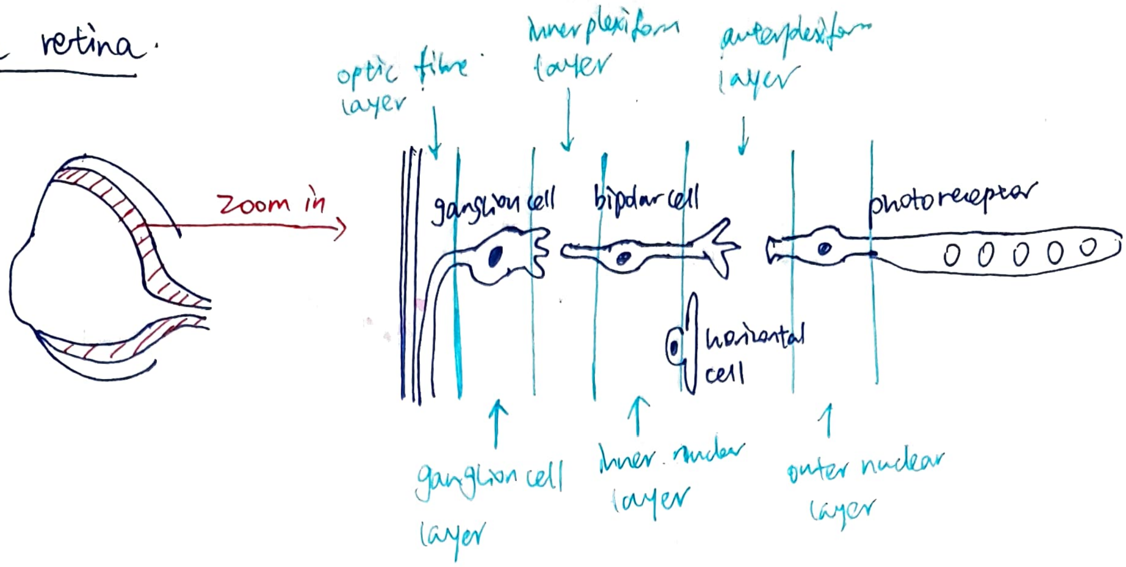


⑤ The spike generated in (3b) encodes information .

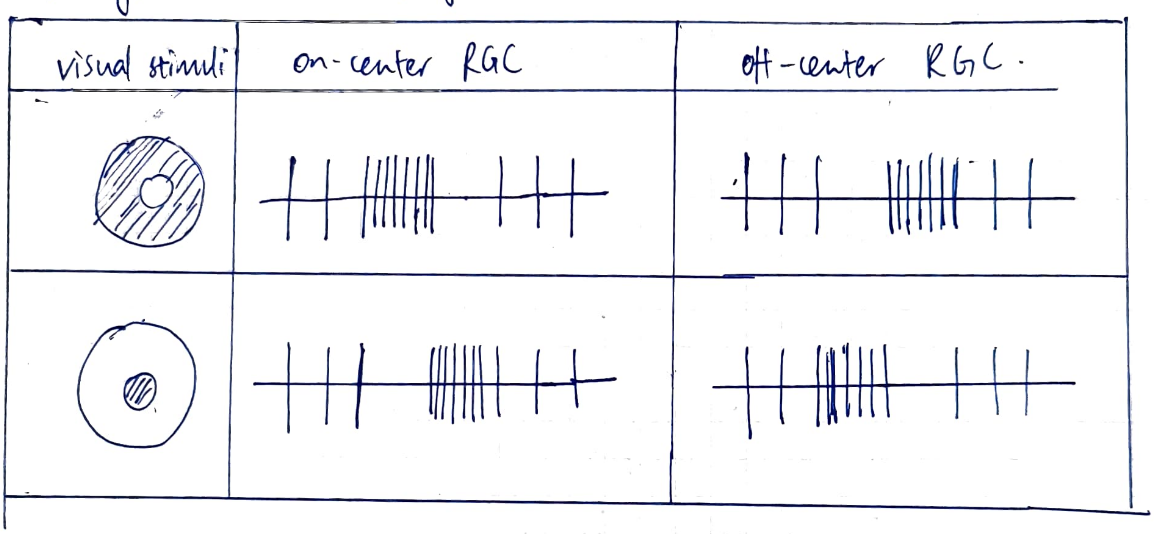


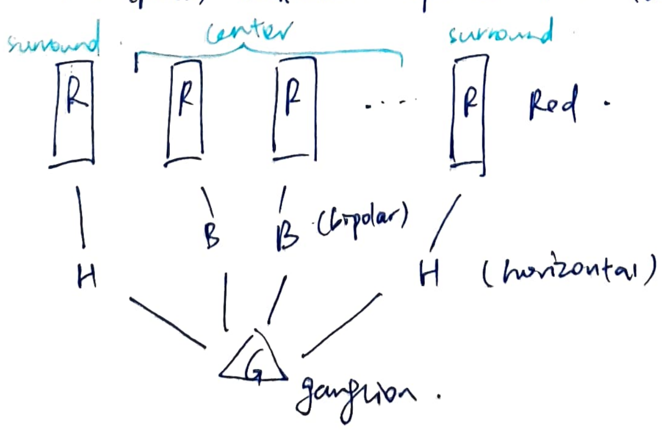
$$f = \frac{1}{\Delta T} .$$

The retina.



2 types of retinal ganglion cell (RGC):



- Each ganglion cell has a receptive field.
- Depending on its type (on-center or off-center), the ganglion cell responds with (outputs) different spikes from the receptive field.
- 

- This arrangements enable the RGC to detect contrast, and hence identify edges in image.

① Each RGC is a "simple cell".

The firing response of each simple cell is selective to the specific orientation. → each simple cell detects one edge of a particular orientation.

② **Convolution**: Sum of output spikes produced by many simple cells.
→ sum of all edges detected.

Formally, given two spikes $h(t)$ and $f(t)$, the result of convolution:

$$y(t) = h(t) * h(t)$$
$$= \int_{-\infty}^{+\infty} h(t-\lambda) f(\lambda)\, d\lambda$$

If $h(t) = 0 \ \forall t < 0$ and $f(t) = 0 \ \forall t < 0$, then

$$y(t) = \int_0^t h(t-\lambda) f(\lambda)\, d\lambda .$$

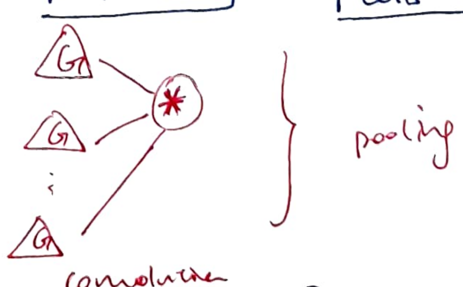
③ **pooling**: "pooling operation" takes place at the complex cells.

This produces output of edges in generalized position.
(i.e. makes the model invariant to local translation).

④ hypercomplex cells etc.
↓
recognize the object.

Summary:

retina → LGN → simple cells → complex cells → hypercomplex cells → recognition



① images → ② edges → ③ edges in generalized position → ④ objects.