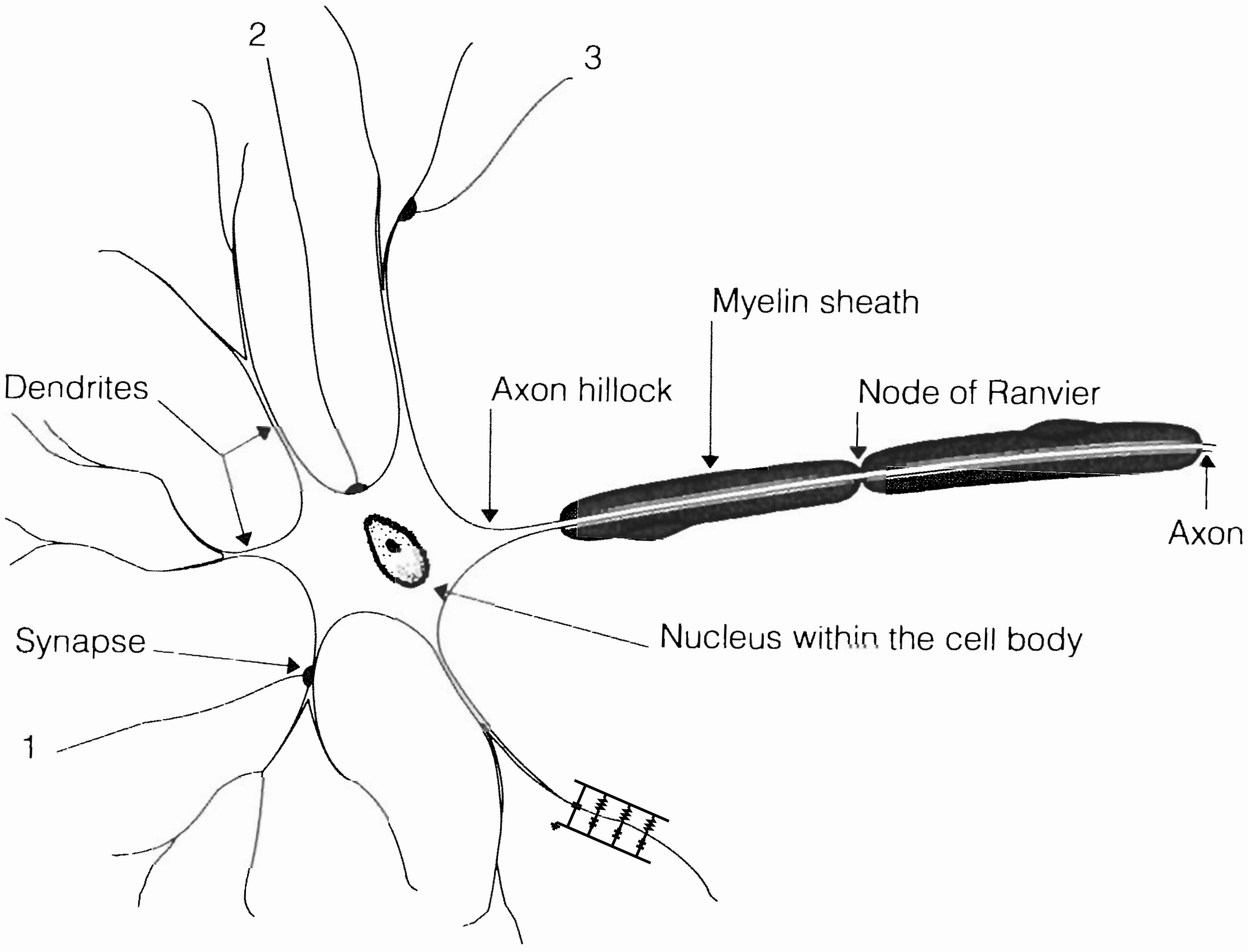
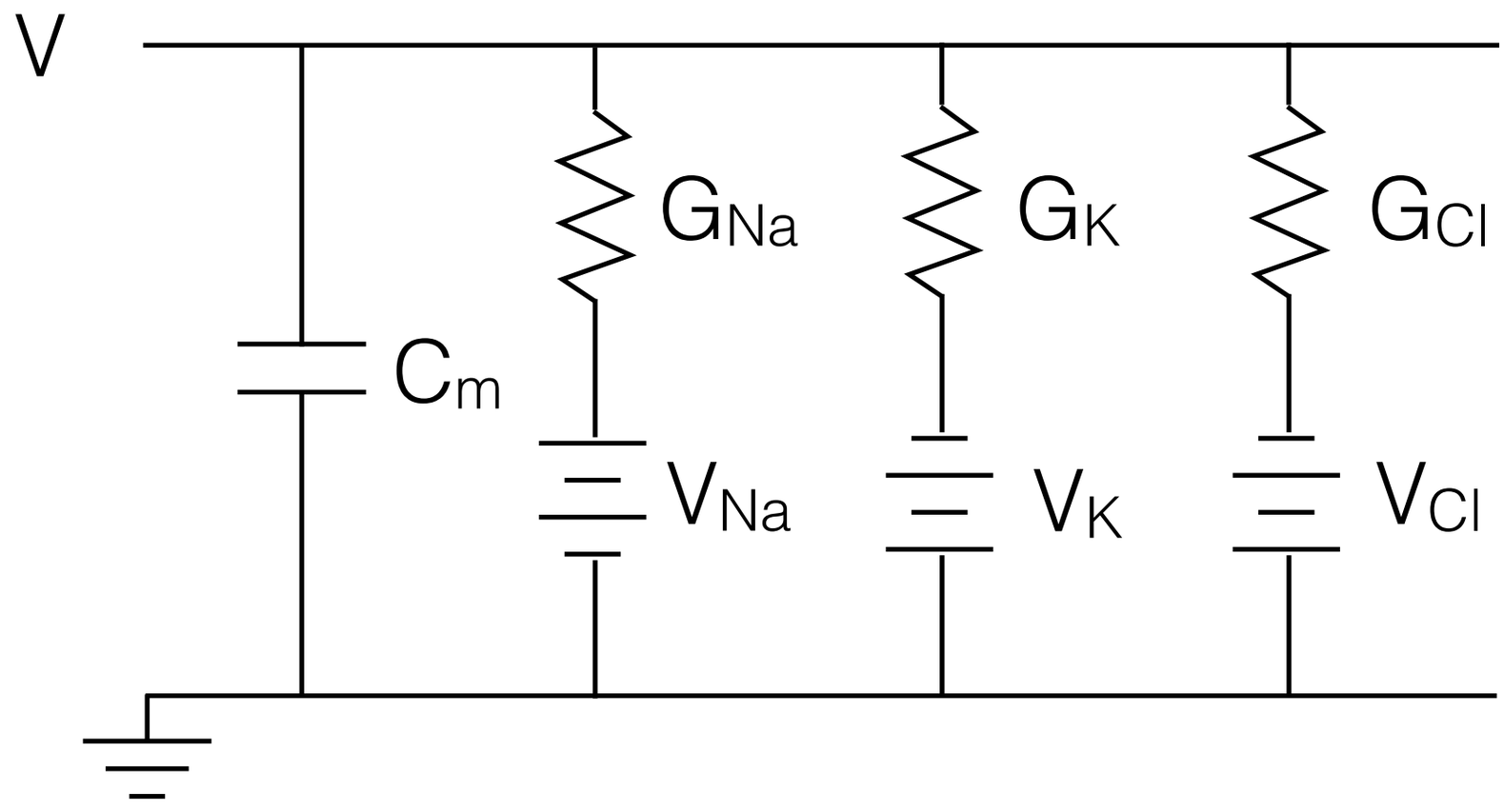

2
3
Myelin sheath
Dendrites
Axon hillock
Node of Ranvier
Axon
Synapse
Nucleus within the cell body
1

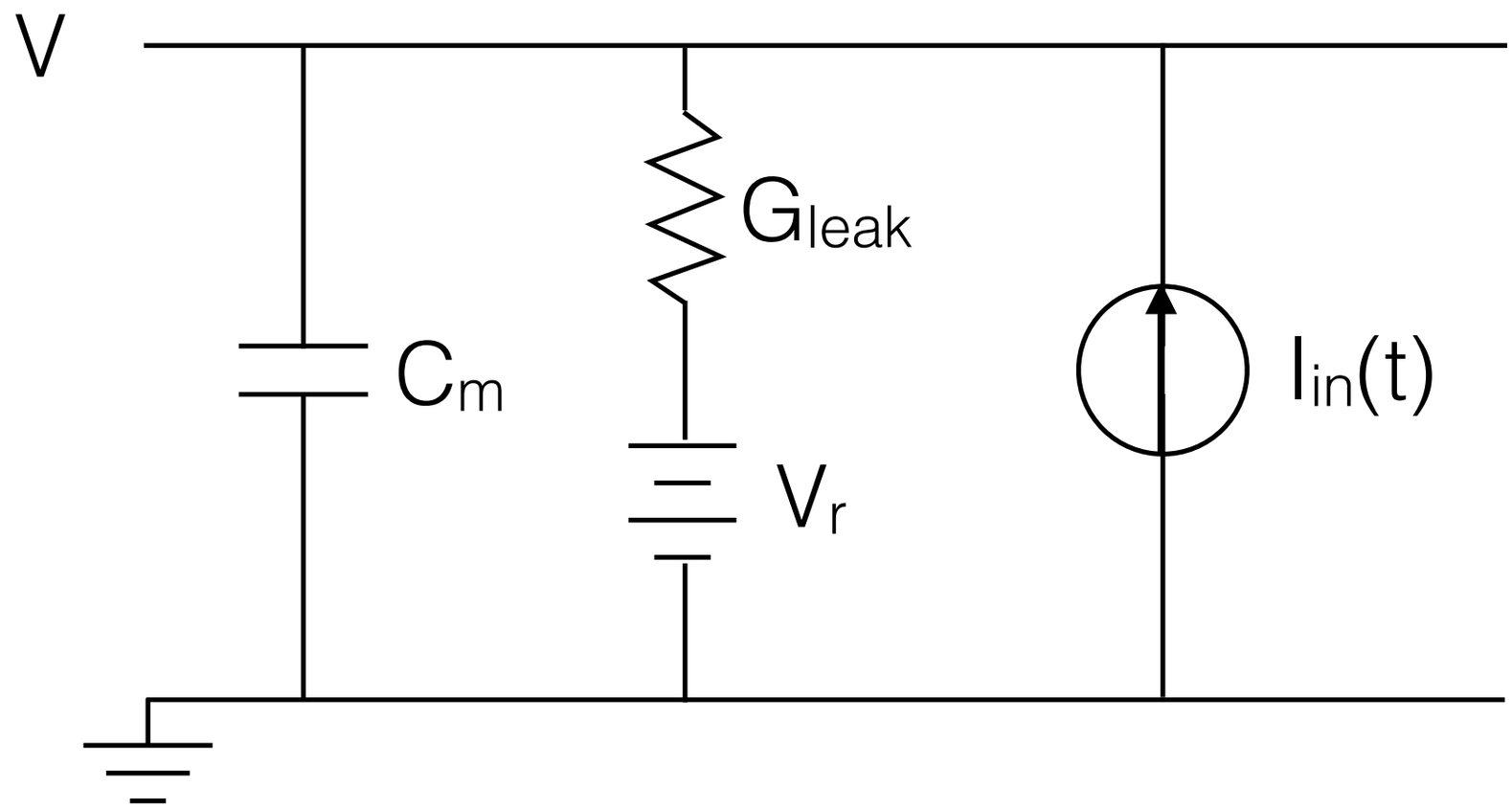
Membrane equation



$$\tau \frac{dV}{dt} + V = \frac{V_{Na}\, G_{Na} + V_K\, G_K + V_{Cl}\, G_{Cl}}{G_{\text{total}}}$$

$$G_{\text{total}} = G_{Na} + G_K + G_{Cl} \qquad \tau = \frac{C_m}{G_{\text{total}}}$$

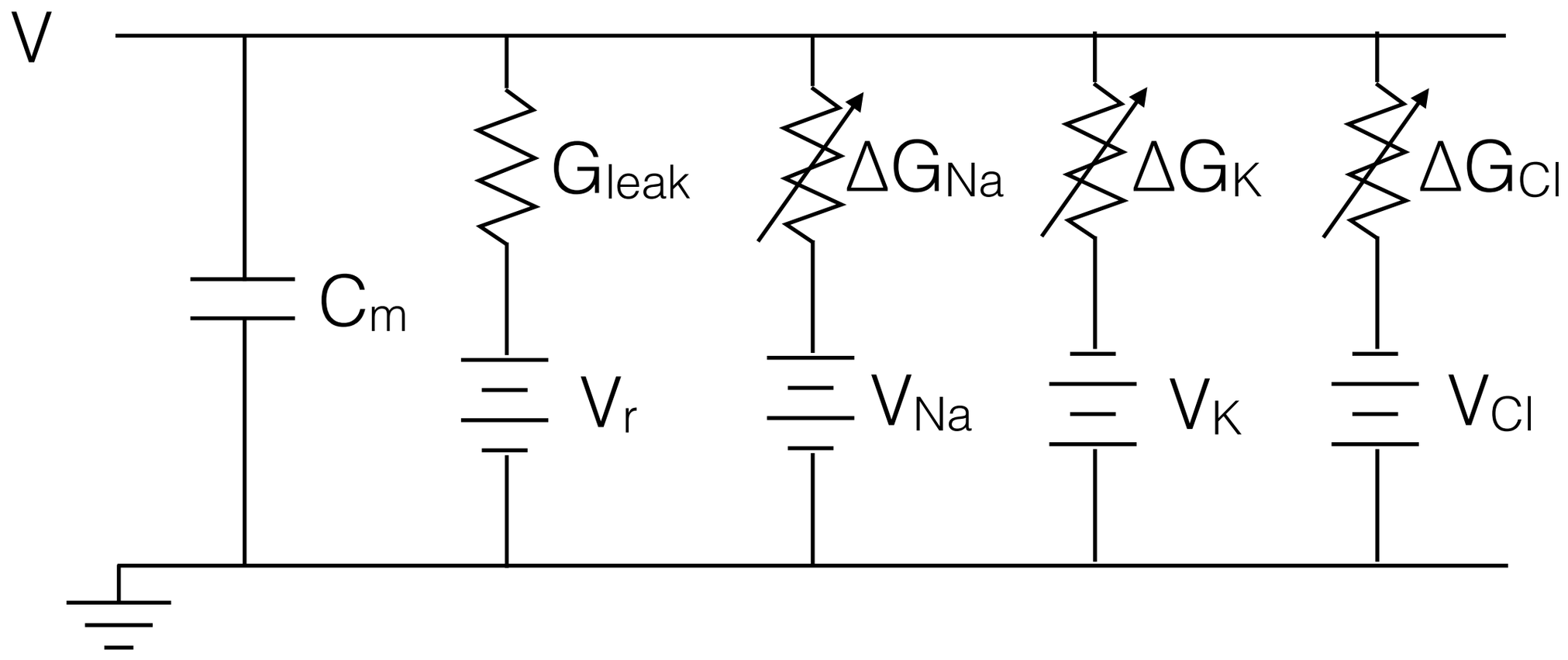
Membrane with input current



$$\tau \frac{dV}{dt} + V = V_r + \frac{1}{G_{\text{leak}}} I_{\text{in}}(t)$$

$$G_{\text{leak}} = G_{Na} + G_K + G_{Cl} \qquad \tau = \frac{C_m}{G_{\text{leak}}}$$

Membrane with synaptic inputs



$$\tau \frac{dV}{dt} + V = \frac{V_r\, G_{\text{leak}} + V_{Na}\, \Delta G_{Na} + V_K\, \Delta G_K + V_{Cl}\, \Delta G_{Cl}}{G_{\text{total}}}$$

$$G_{\text{total}} = G_{\text{leak}} + \Delta G_{Na} + \Delta G_K + \Delta G_{Cl} \qquad \tau = \frac{C_m}{G_{\text{total}}}$$

Channel types

Passive

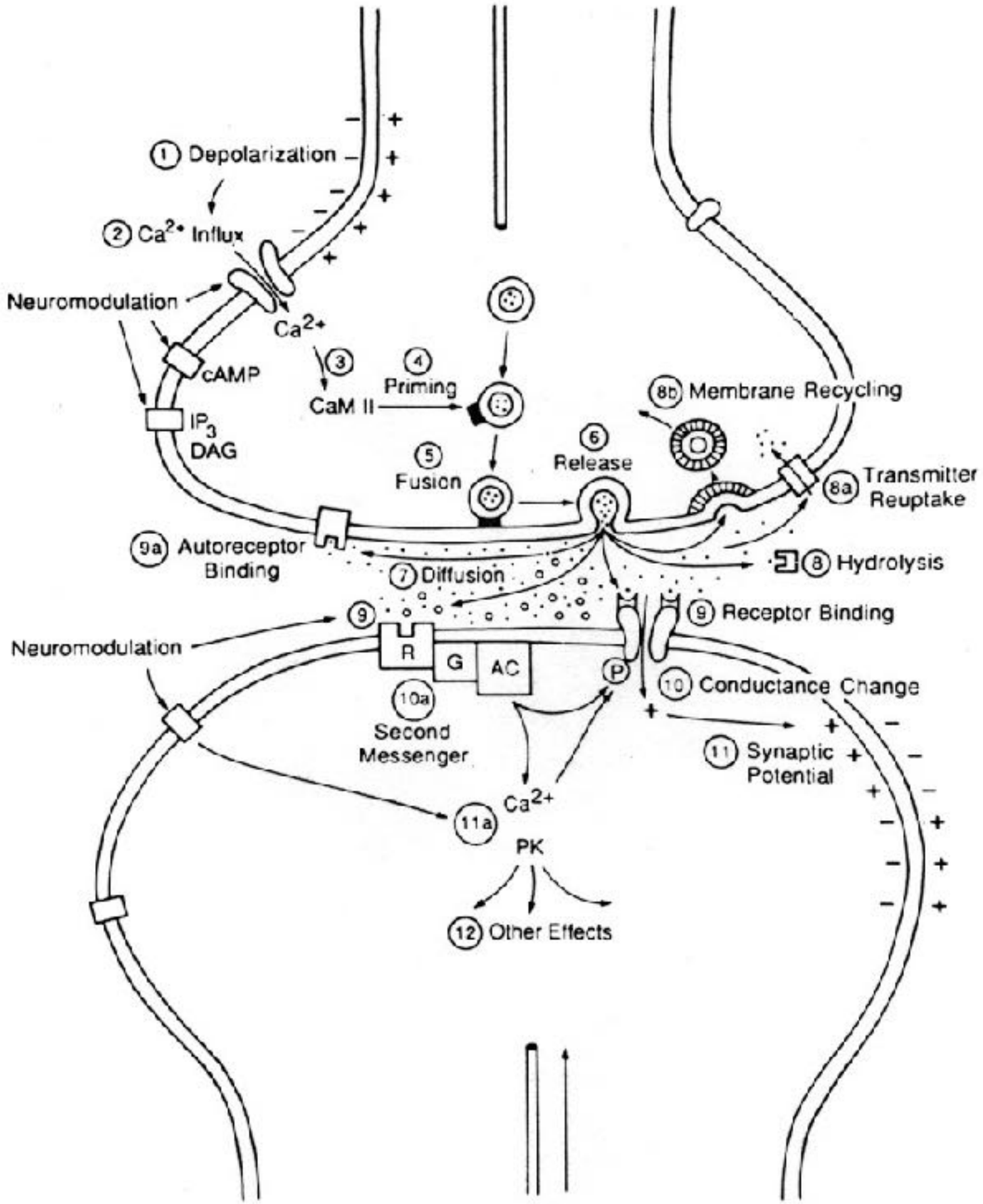
G_{ion} = f(molecules_outside)	**ionotropic**
G_{ion} = f(molecules_inside) molecules_inside = g(molecules_outside)	**metabotropic**
G_{ion} = f(light_intensity)	**photoreceptor**
G_{ion} = f(mechanical_deflection)	**hair cell**

‘Active’*

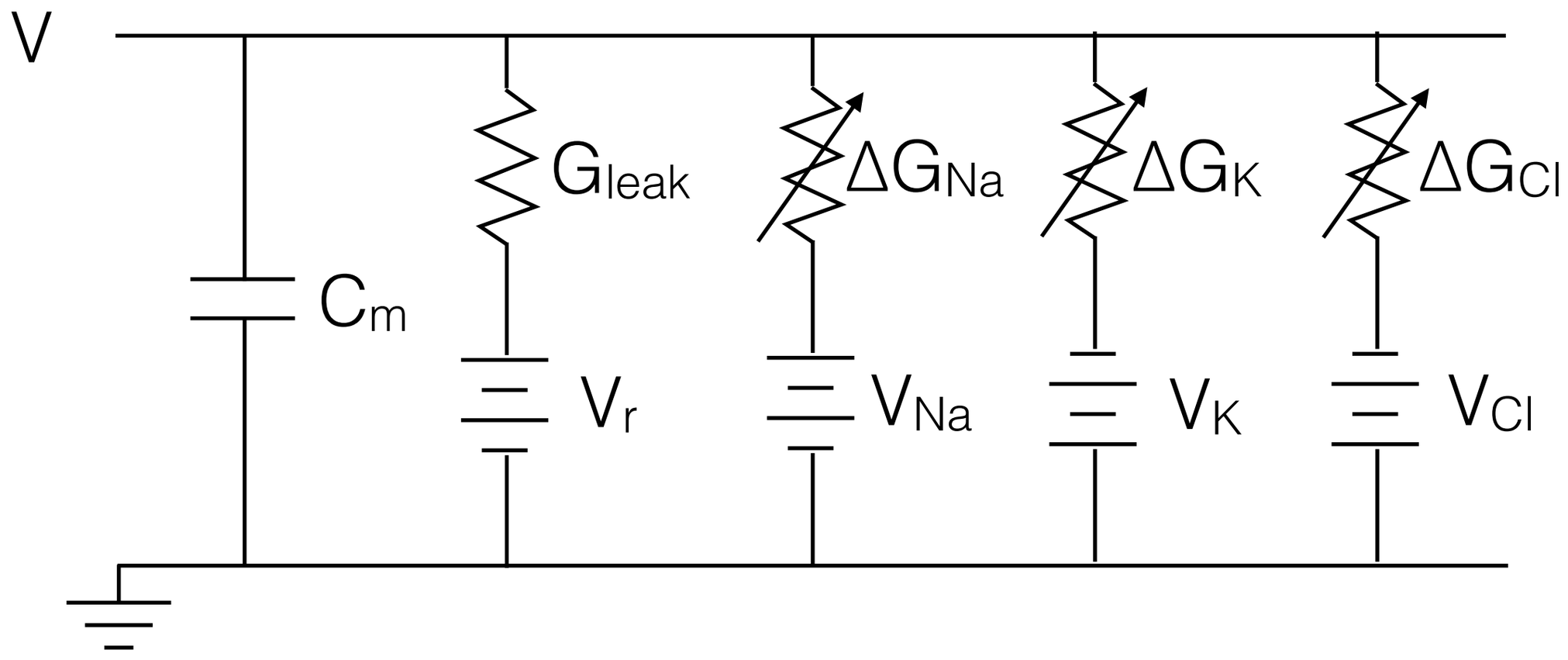
G_{ion} = f(membrane_voltage)	**voltage-gated**

*in the sense of providing gain, not in the sense of requiring active ATP transport

Anatomy of a synapse

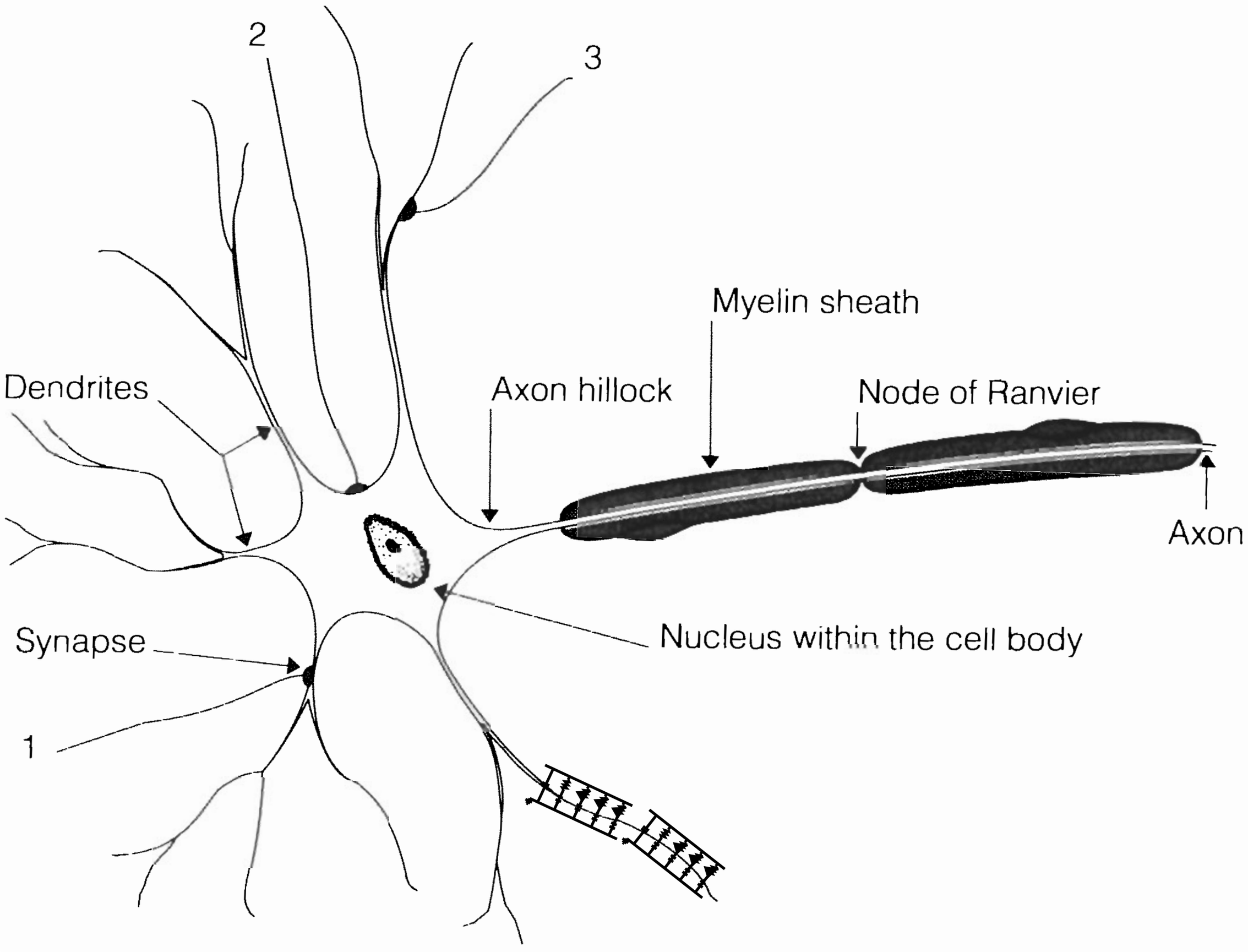


Membrane with synaptic inputs



$$\tau \frac{dV}{dt} + V = \frac{V_r\, G_{\text{leak}} + V_{Na}\, \Delta G_{Na} + V_K\, \Delta G_K + V_{Cl}\, \Delta G_{Cl}}{G_{\text{total}}}$$

$$G_{\text{total}} = G_{\text{leak}} + \Delta G_{Na} + \Delta G_K + \Delta G_{Cl} \qquad \tau = \frac{C_m}{G_{\text{total}}}$$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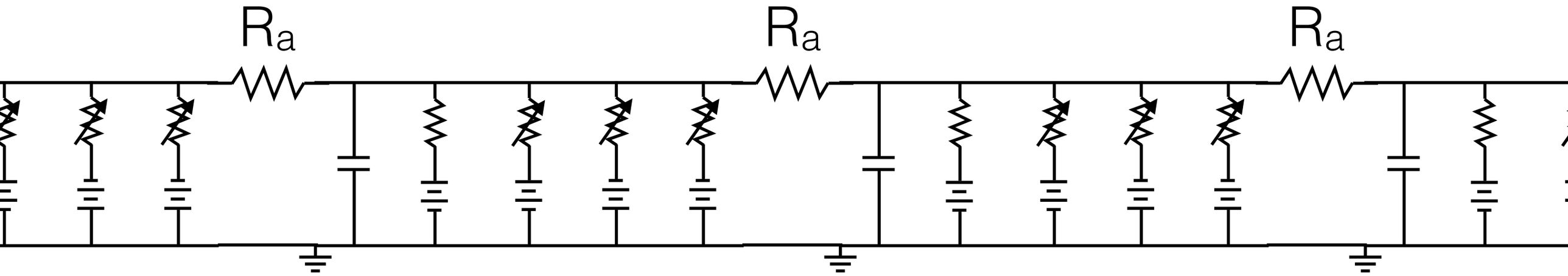
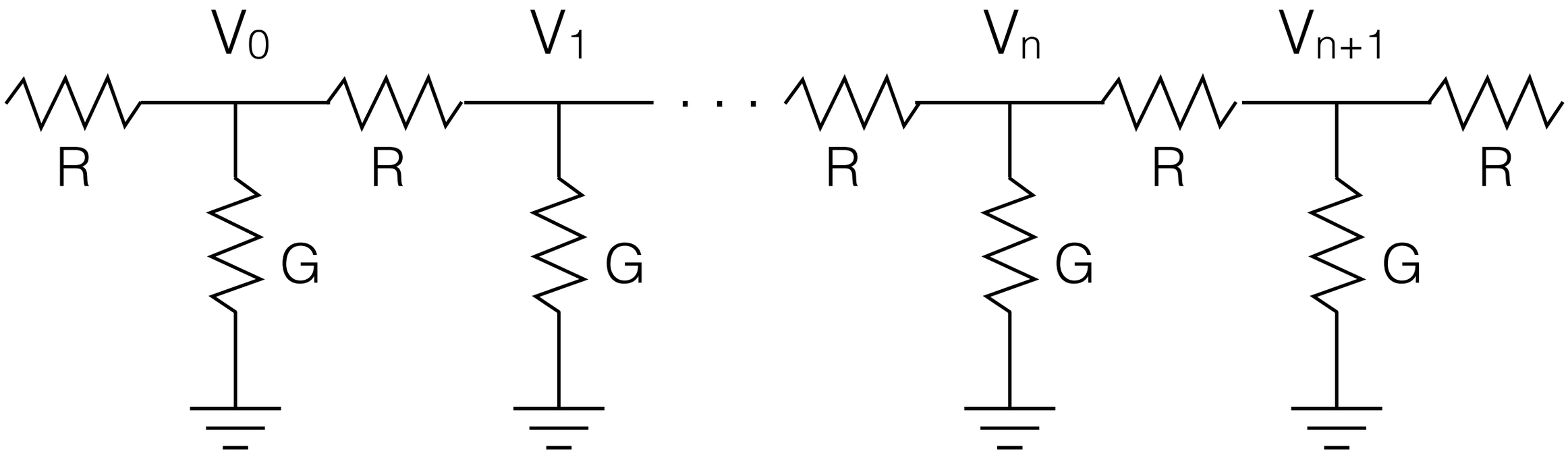

Ra
Ra
Ra

Resistive network



$$\frac{d^2V}{dx^2} = R\,G\,V$$

$$V = V_0\, e^{-\frac{|x|}{L}} \qquad\qquad L = 1/\sqrt{R\,G}$$