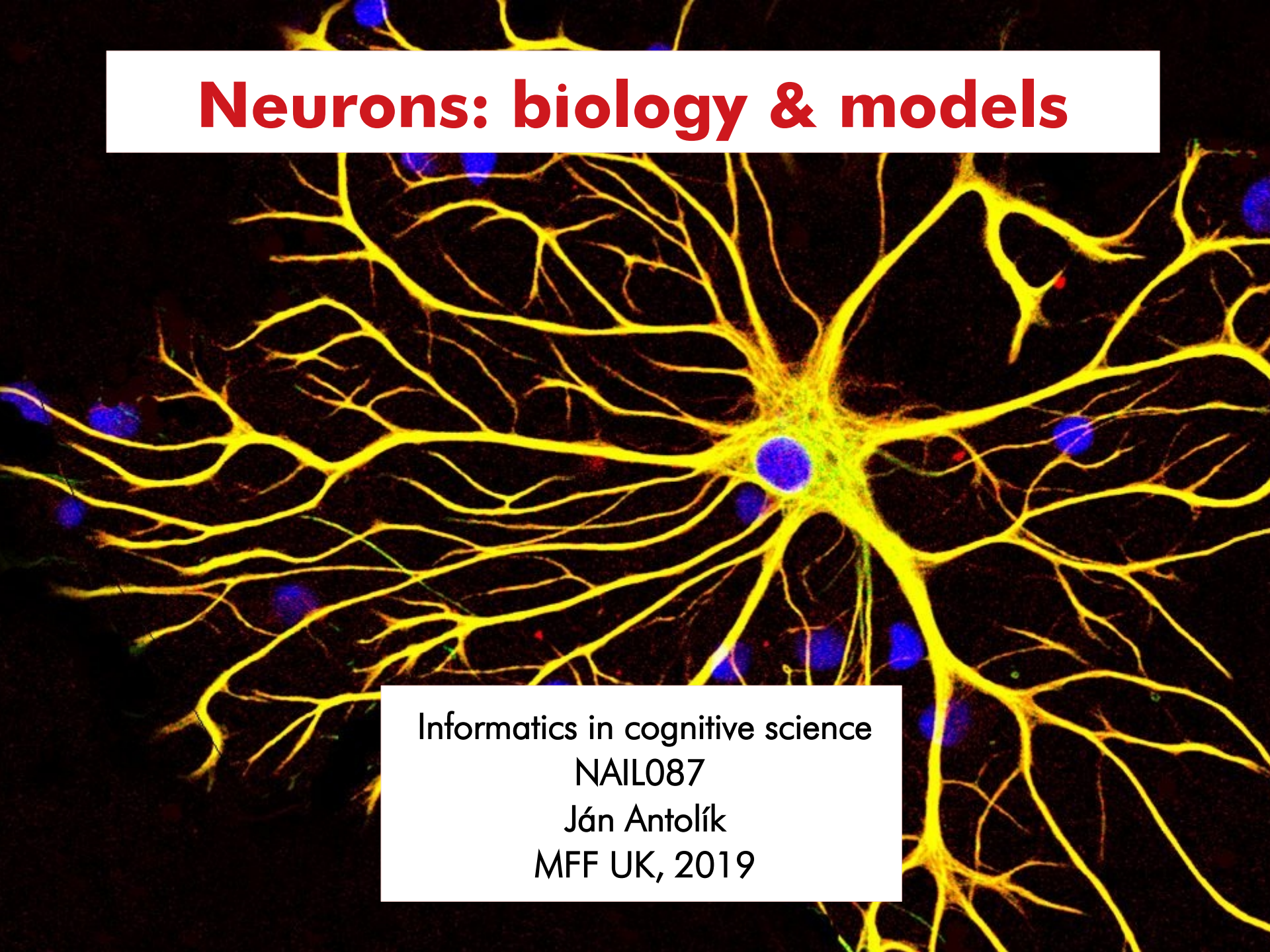
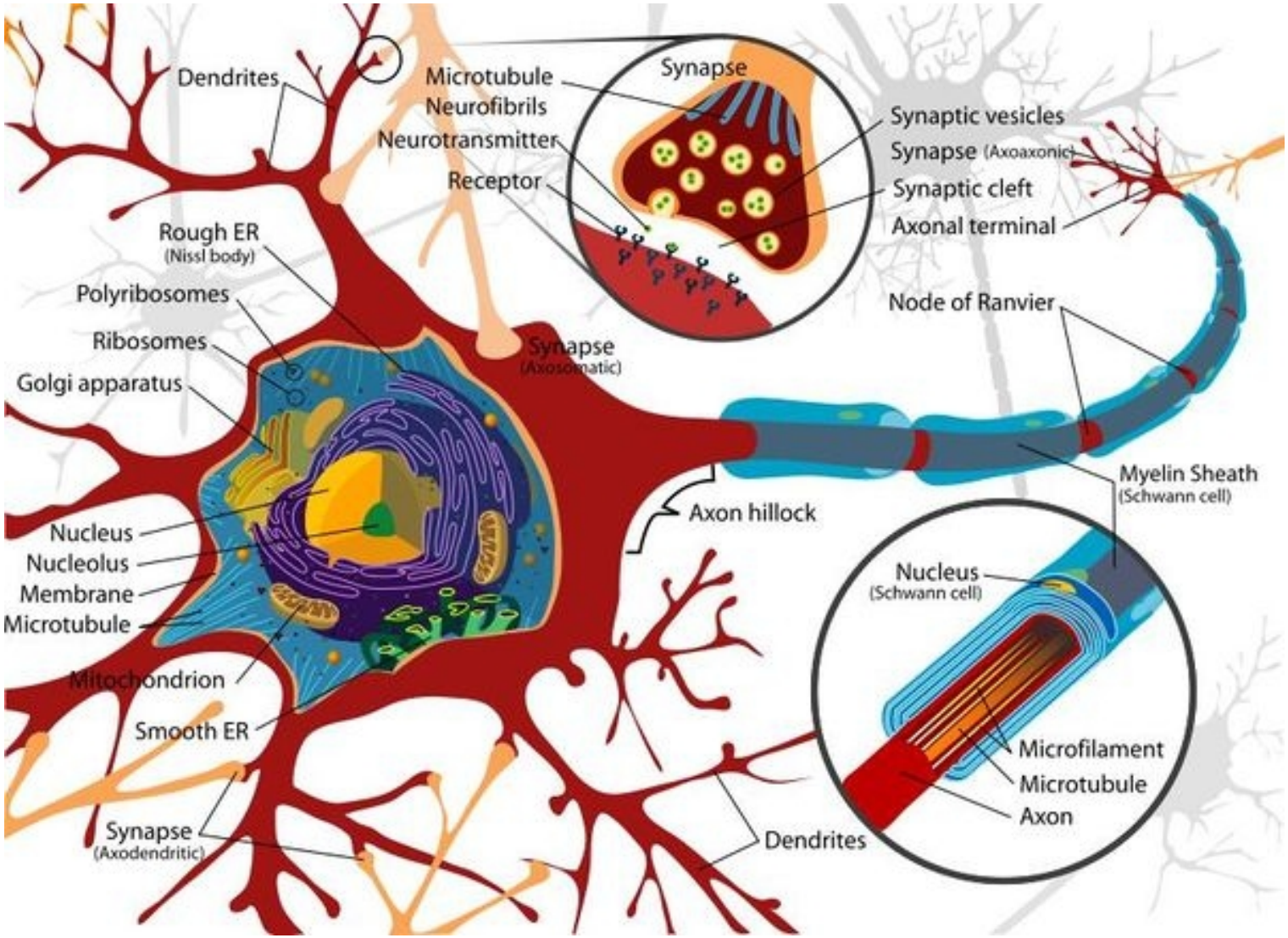
Neurons: biology & models

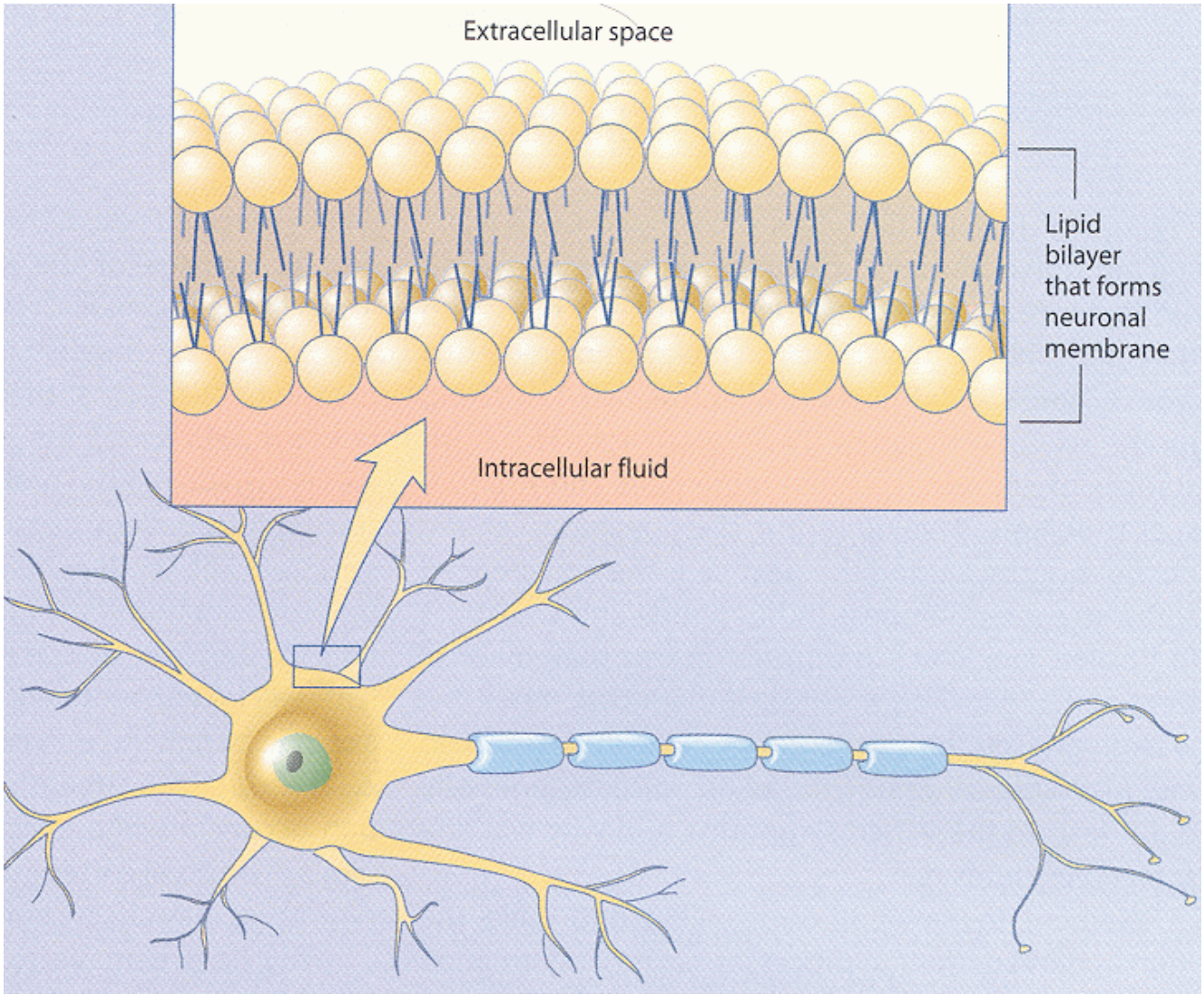


Informatics in cognitive science
NAIL087
Ján Antolík
MFF UK, 2019

The key components

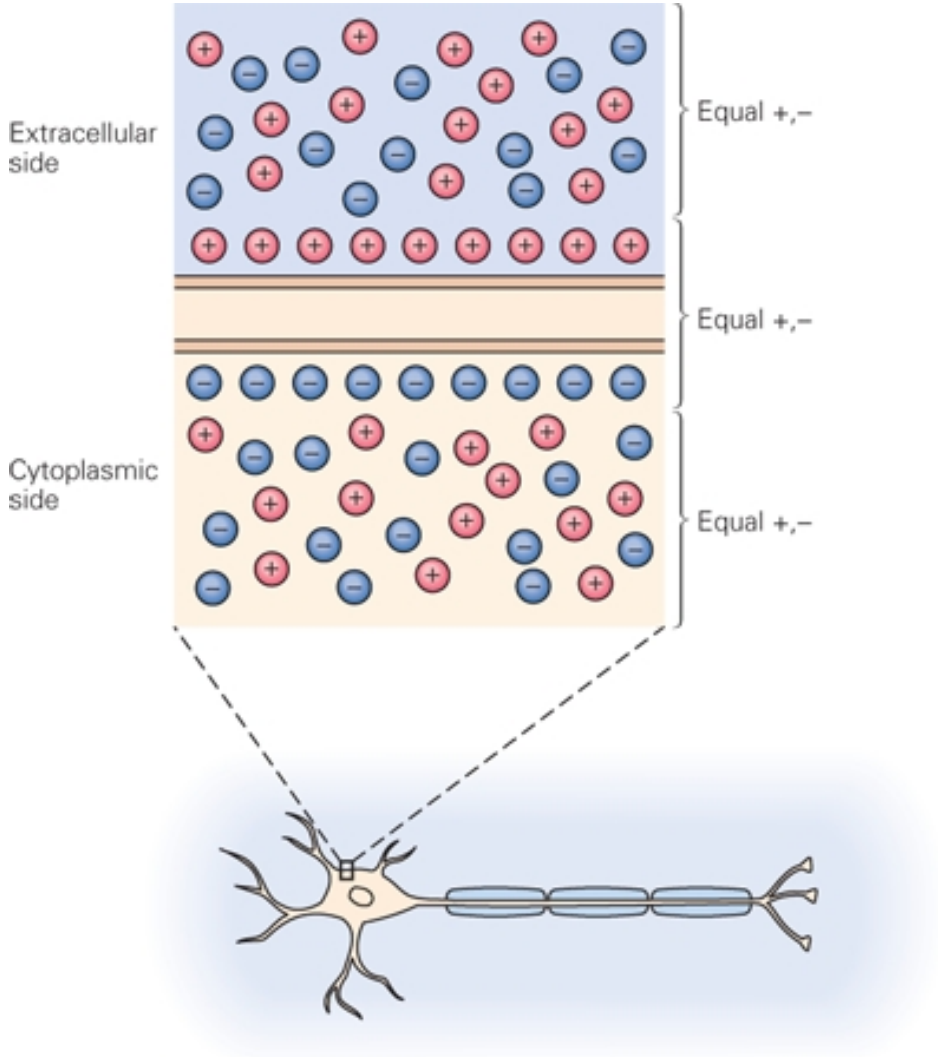


Neural membrane

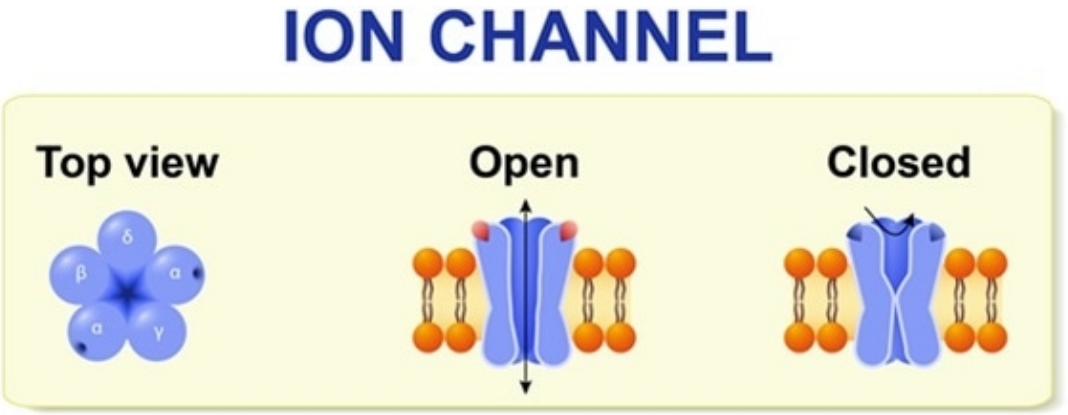


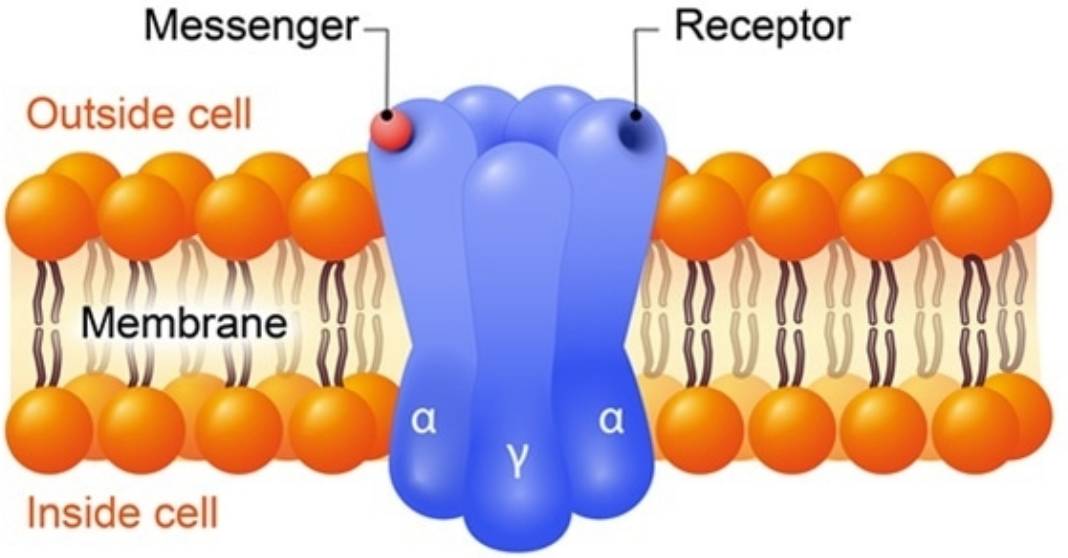
Membrane potential summary

- Equilibrium potential
  - single ion
  - concentration gradinet
    - remains constant
  - difference of charge
  - permeability
- Membrane potential
  - Equilibrium potential across all ions
- Changes in permeability for individual ions change membrane potential

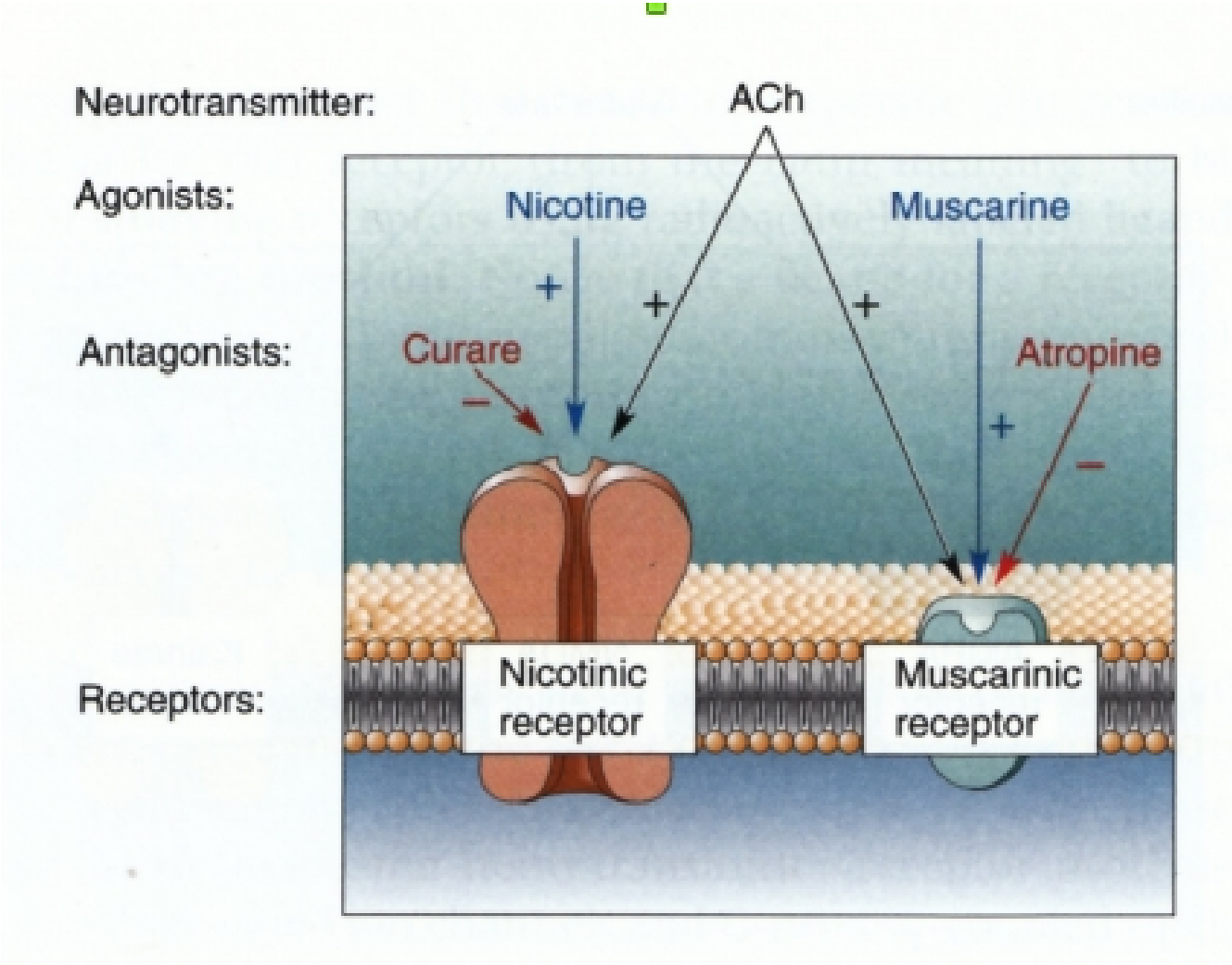


Memrane Channels



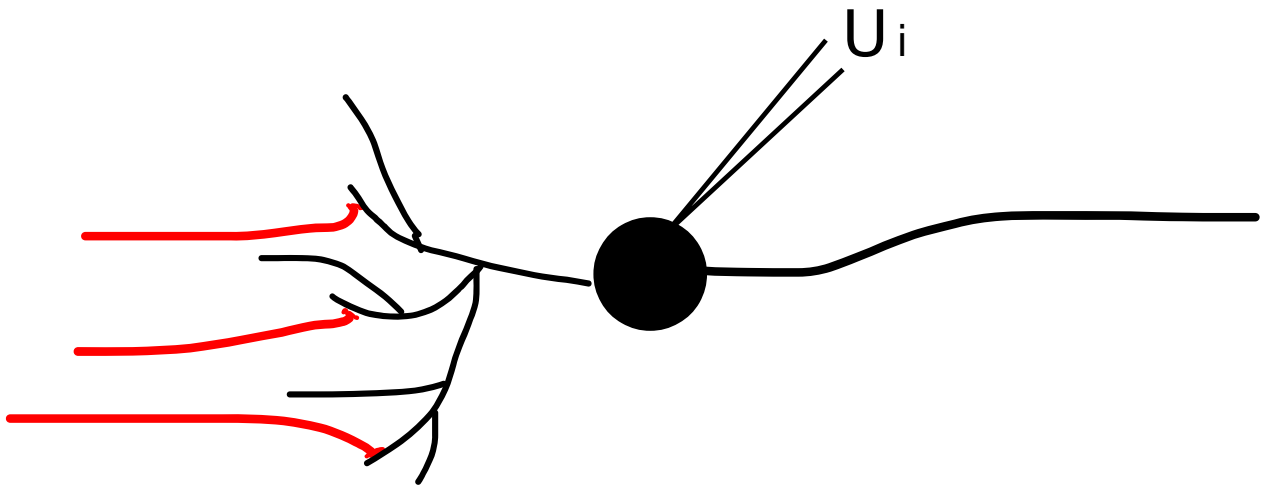


Neurotransmitters

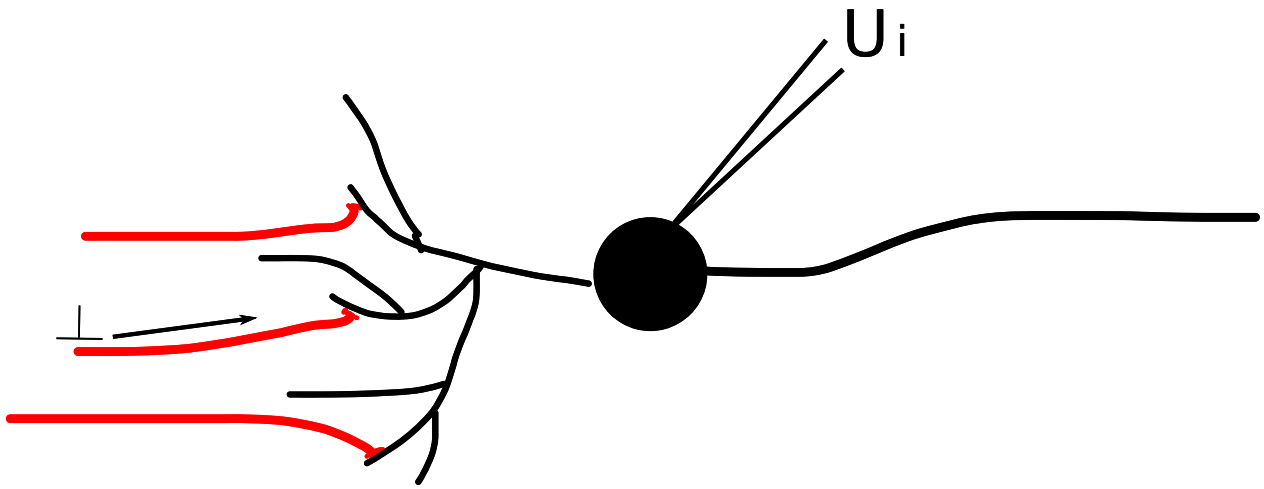


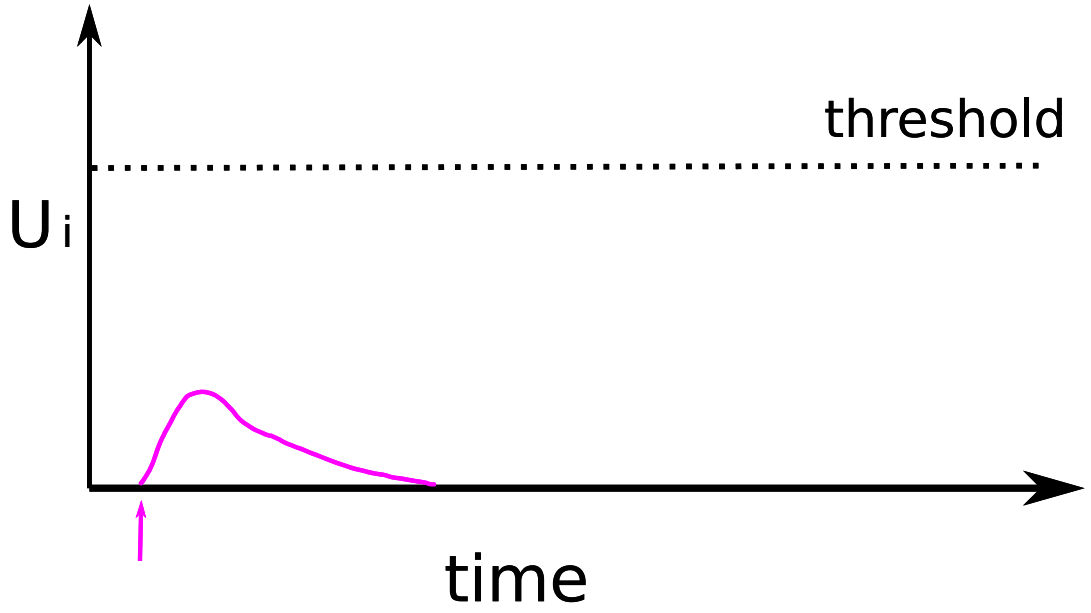
How to abstract everything we learned?

Leaky integrate & fire

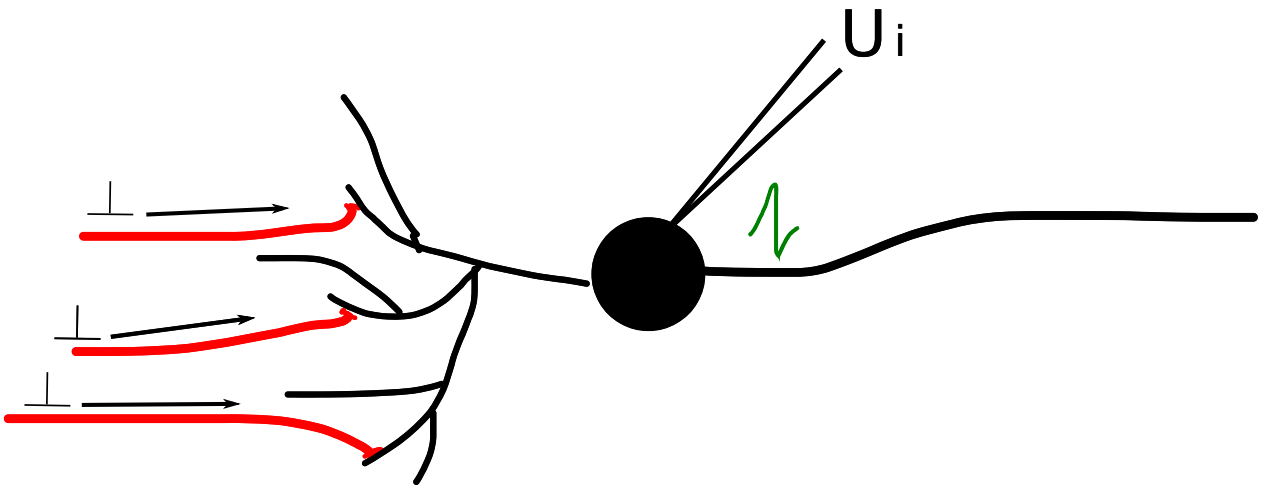


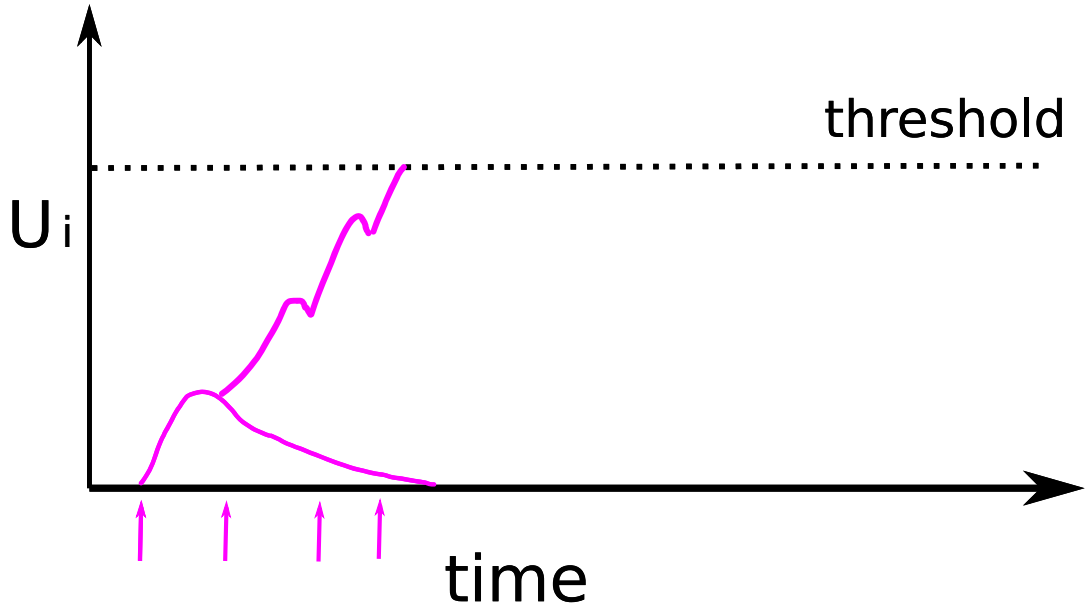
Leaky integrate & fire



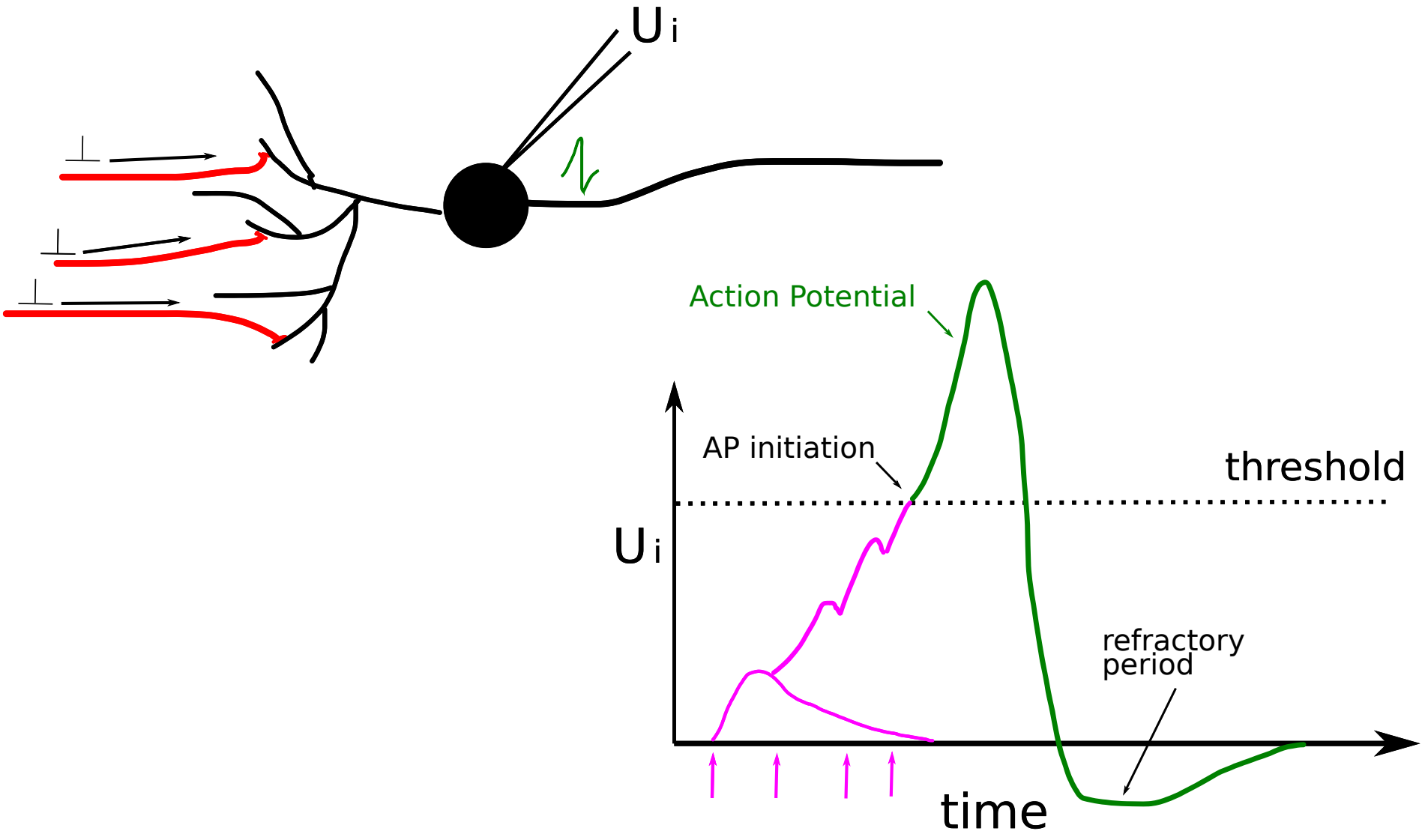


Leaky integrate & fire

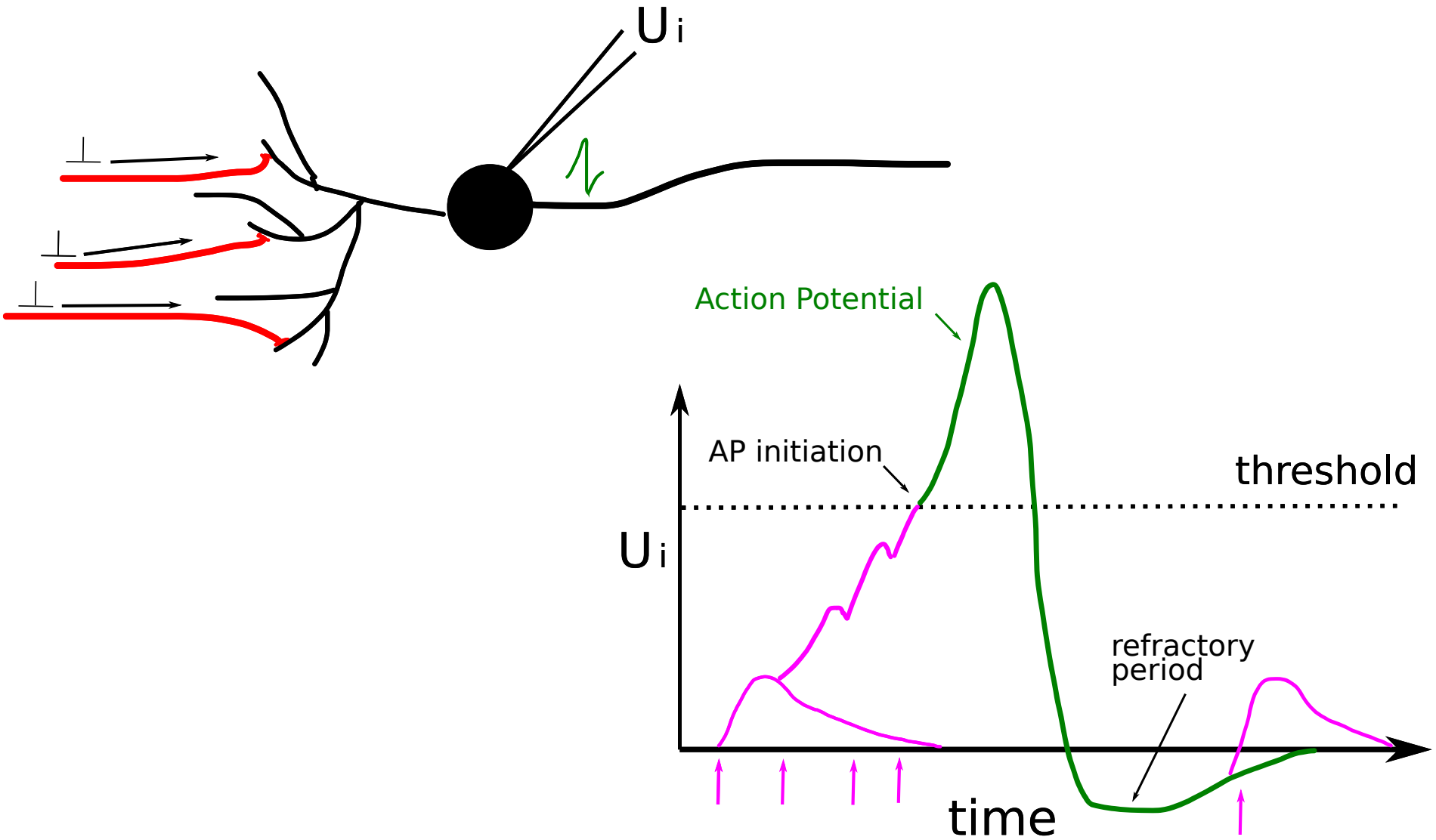




Leaky integrate & fire



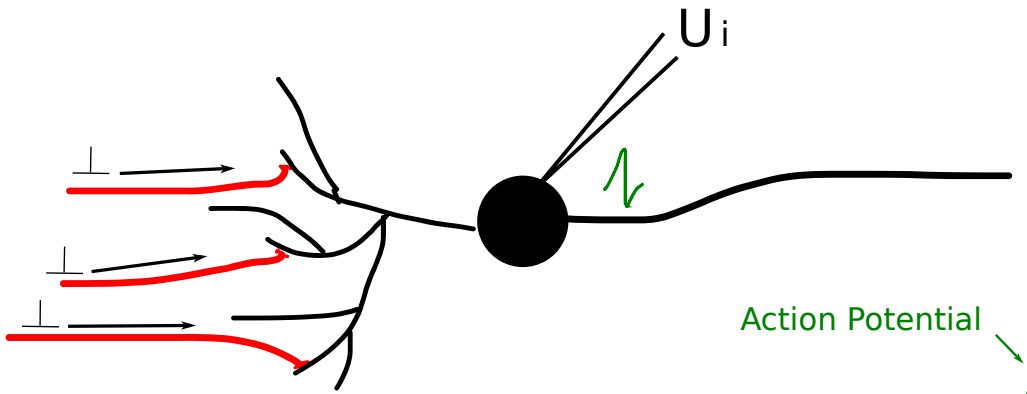
Leaky integrate & fire

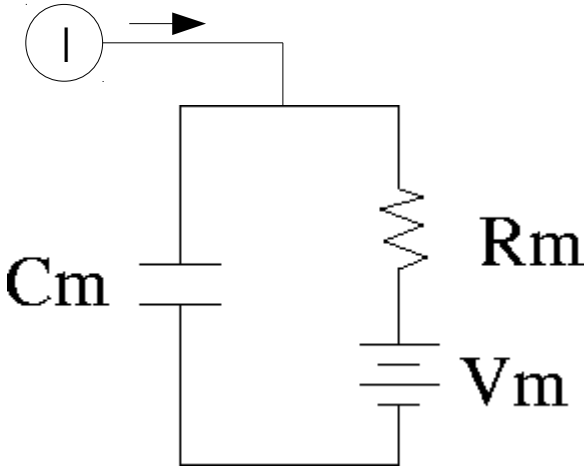


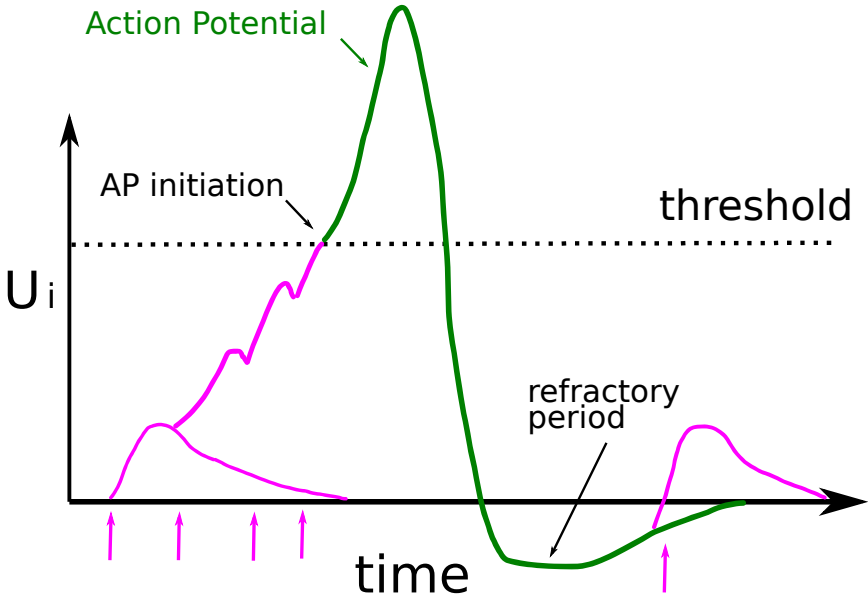
Leaky integrate and fire model

Blackboard time

Leaky integrate & fire





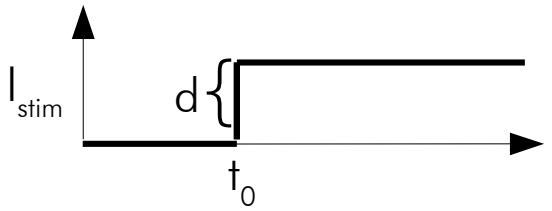


$$\tau \cdot \frac{d}{dt} u = -(u - u_{rest}) + RI(t)$$

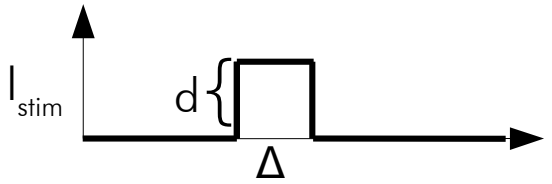
Question

What will be the evolution of Vm to

1. step current



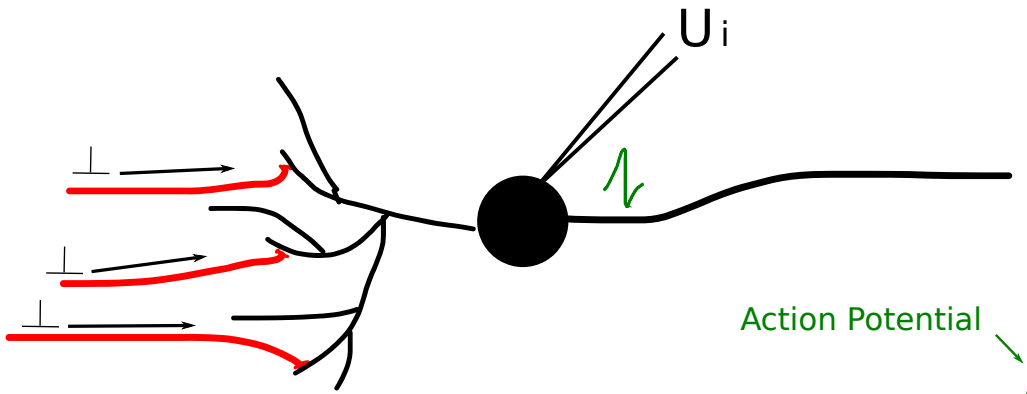
2. pulse current

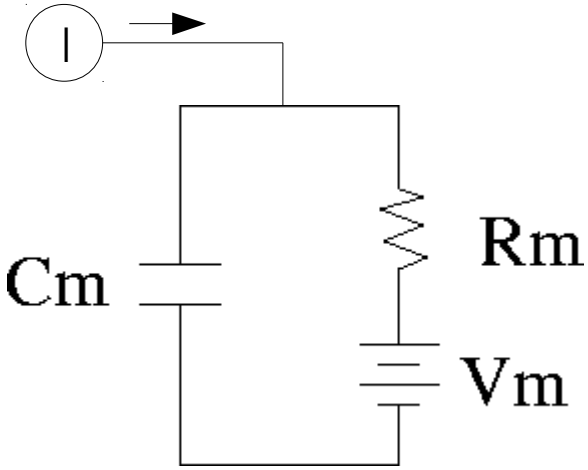


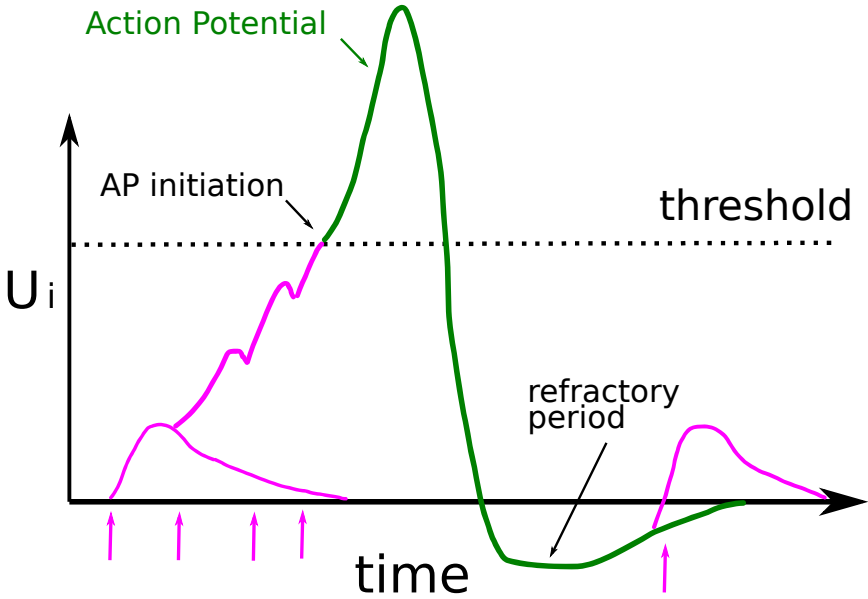
Response to step and pulse current

Blackboard time

Leaky integrate & fire

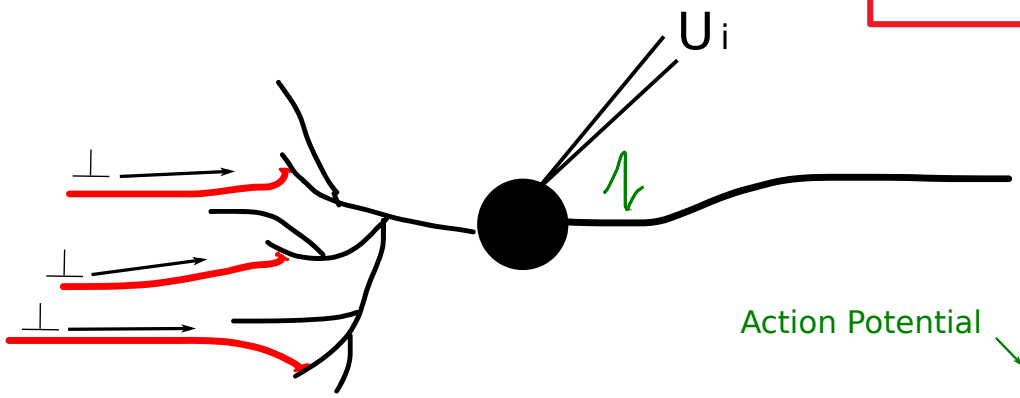


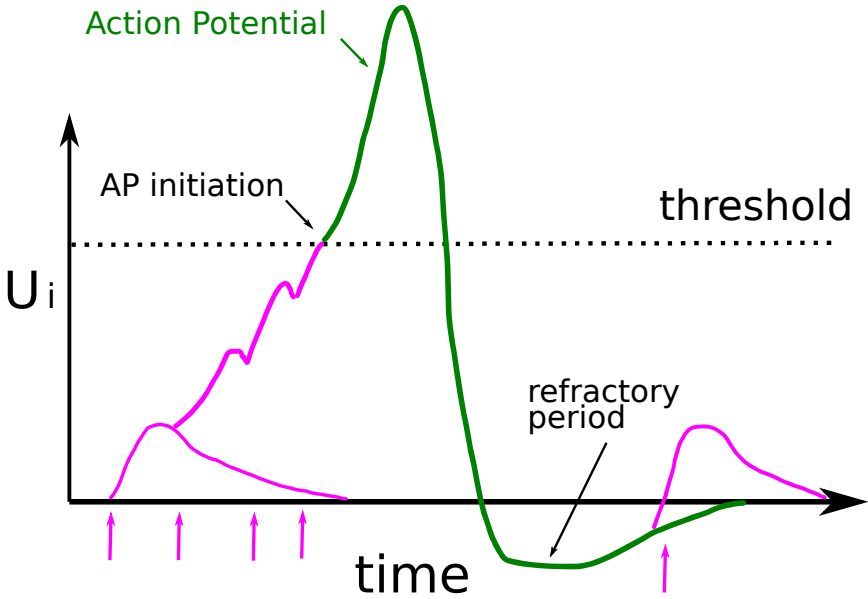




$$\tau \cdot \frac{d}{dt} u = -(u - u_{rest}) + RI(t)$$

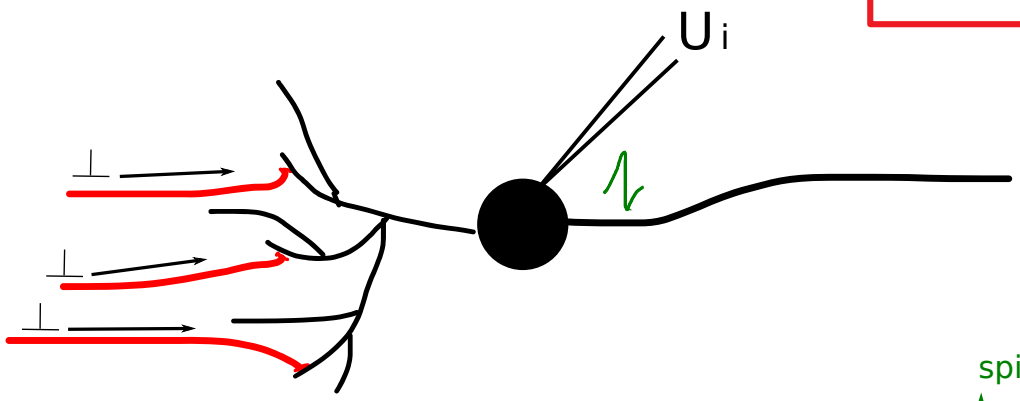
Leaky integrate & fire

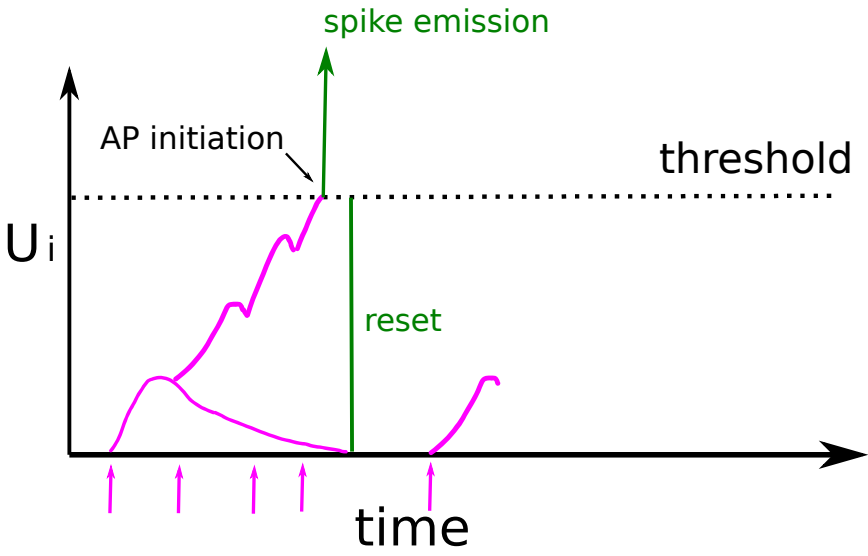




$$\tau \cdot \frac{d}{dt} u = -(u - u_{rest}) + RI(t)$$

Leaky integrate & fire





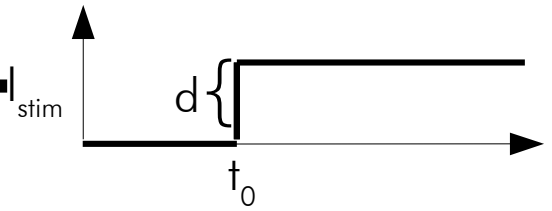
$$\tau \cdot \frac{d}{dt} u = -(u - u_{rest}) + RI(t)$$

$$u_i(t) = \vartheta \Rightarrow \text{Fire+reset}$$

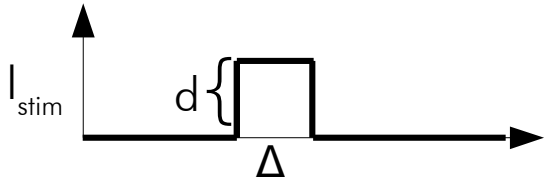
Question

What will be the response to a

1. constant current

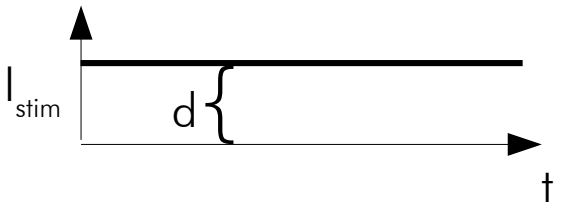


2. pulse current



Question

1. **What will be response to constant current**



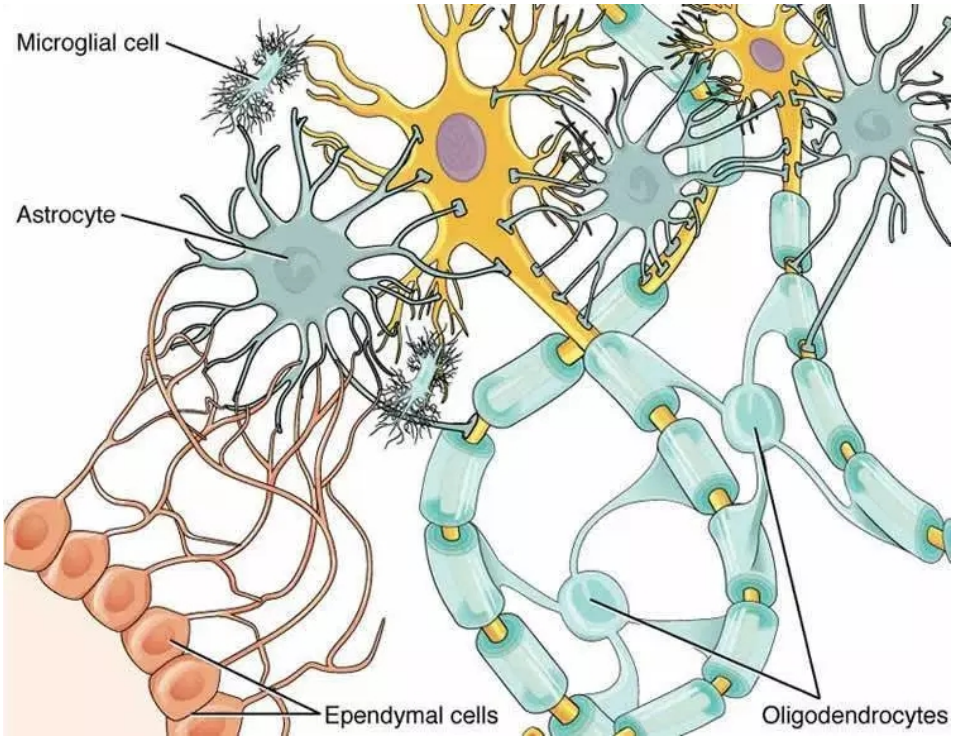
2. **what is minimal *d* for a spike?**

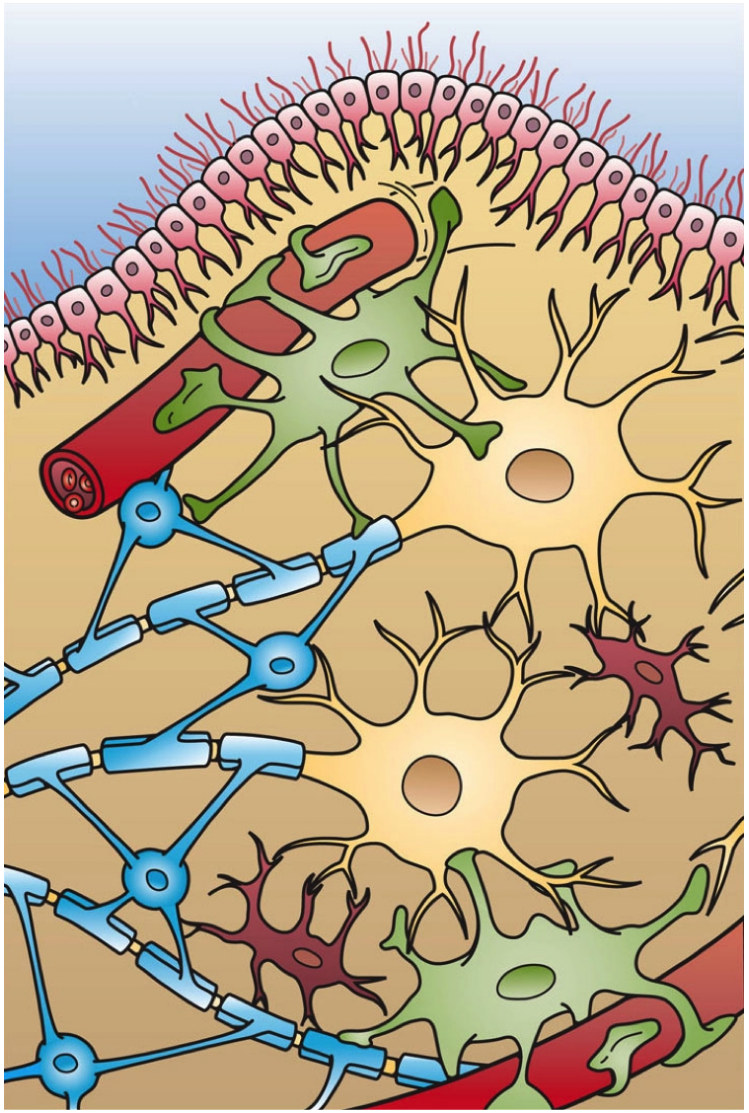
Caveats

Other cells in CNS

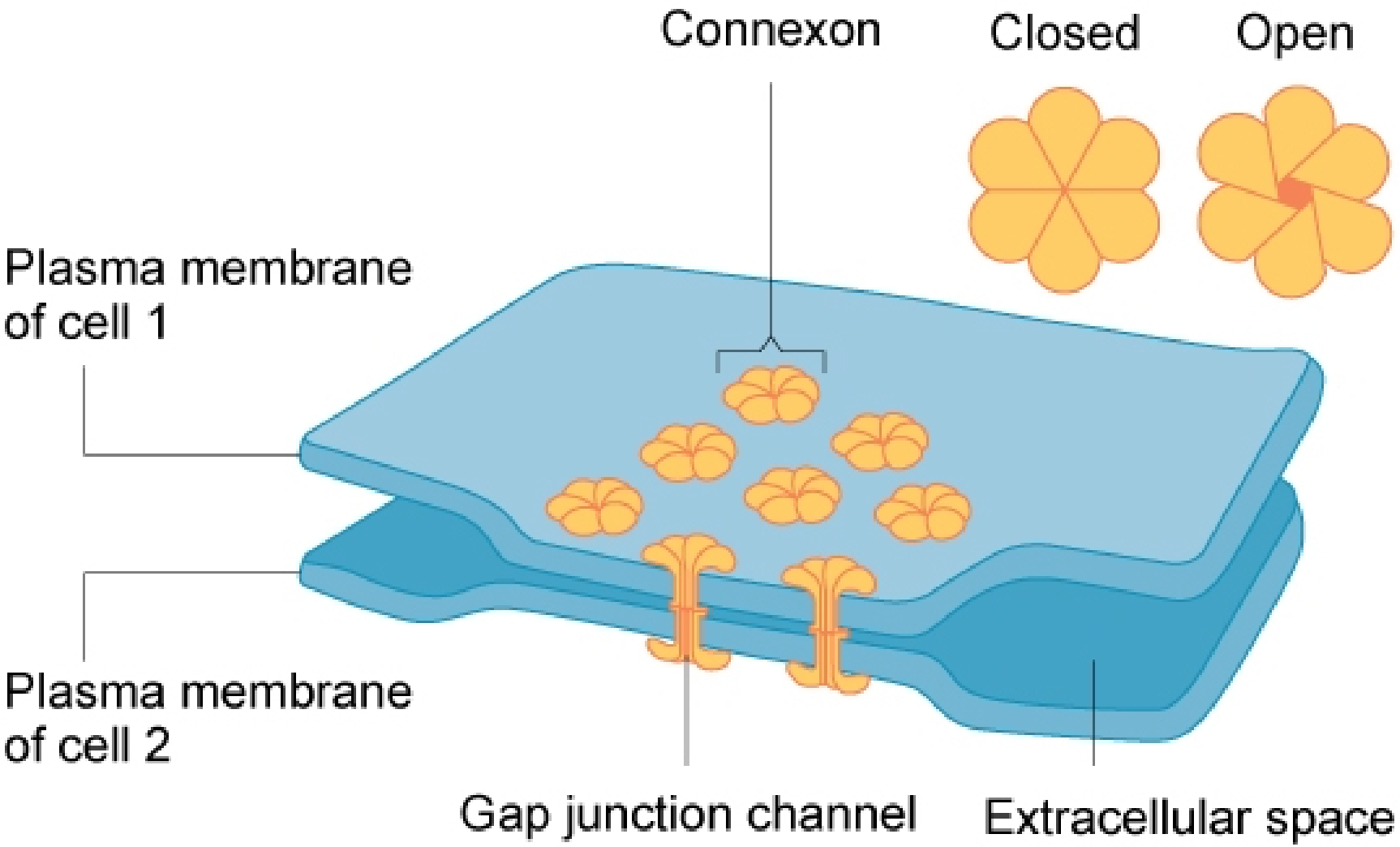
- Neurons: 10%
- Glia: 90%
  - astrocyty: cca 80%
  - ependymal cells: cca 5%
  - oligodendrocyty: cca 5%
  - mikroglie: cca 10%
- Glia as a support system for neural substrate

Glia


Microglial cell
Astrocyte
Ependymal cells
Oligodendrocytes



Gap junctions



Gap junctions

- Present throughout neural system
- Hypothesized in formation of neural rythms
- Weak neural-to-glial coupling via gap junctions
- Astrocytes and Oligodendrocytes coupled via gap junctions

Other

- Probabilistic nature of vesicle release – failure to initiate PSP
- Threshold is not fixed
- Dendritic integration