Electrophysiology and neurotransmission

- State how movement of Na⁺, K⁺, Ca²⁺ or Cl⁻ across a cell membrane will affect membrane potential.
- Explain the ionic basis for the resting membrane potential.
- Diagram a neuron and identify specialization.
- Describe the ionic basis for a graded potential, EPSP, IPSP and action potential.
There are two primary determinants of the resting membrane potential.

1. Concentration of ions inside and outside the cell.
2. Permeability of the membrane to these ions.

- Inside the neuron is high in K⁺ and low in Na⁺.
- Outside the neuron it’s opposite, high in Na⁺, low in K⁺.
- At rest, the permeability of the membrane is high for K⁺ and very low for Na⁺ and Cl⁻.

For the moment we will assume that the permeability of the membrane to Na⁺ and Cl⁻ is zero.

Membrane potential would be $V_m = E_K$.

K⁺ is the most permeable to a cell membrane, but the Na⁺, Ca²⁺, Mg²⁺ and Cl⁻ permeability is actually not zero.

Use the Goldman-Hodgkin-Katz equation to calculate membrane potential based on permeabilities of multiple ions.

$$V_m = \frac{RT}{F} \log \left( \frac{P_{K^+} \left[ K^+ \right]_{out} + P_{Na^+} \left[ Na^+ \right]_{out} + P_{Cl^-} \left[ Cl^- \right]_{out}}{P_{K^+} \left[ K^+ \right]_{in} + P_{Na^+} \left[ Na^+ \right]_{in} + P_{Cl^-} \left[ Cl^- \right]_{in}} \right)$$

$$V_m = \frac{RT}{F} \log \left( \frac{1 \left[ K^+ \right]_{out} + \frac{2}{3} \left[ Na^+ \right]_{out}}{1 \left[ K^+ \right]_{in} + \frac{2}{3} \left[ Na^+ \right]_{in}} \right)$$

$$V_m = 60 \log \left( \frac{1}{150} + \frac{2}{3} \times \frac{45}{15} \right)$$

$$= -82 \text{ mV}$$

Membrane potential changes with ion movement.

- +30 mV
- -55 mV
- -70 mV

EPSP EPSP

depolarizing stimulus

Summation
• Depolarization: V_m decreases, I_CF becomes more positive
• Repolarization: return to resting membrane potential
• Hyperpolarization: V_m increases, I_CF becomes more negative

Summation of graded potentials

Graded potential changes can cause action potential