

Resting membrane potentials and ion movement

The following table lists the ion concentrations inside muscle cells and for the extracellular fluid surrounding them. At steady-state, calculate the equilibrium potential for each of these ions (use the equation

$$E_x (\text{mV}) = \frac{-60 \text{ mV}}{z} \times \log \frac{[E_x]_{in}}{[E_x]_{out}}$$

<u>ionic species</u>	<u>inside concentration (mM)</u>	<u>outside concentration (mM)</u>	<u>E_x (mV)</u>
K ⁺	145	4	
Na ⁺	10	142	
Cl ⁻	4	104	
Ca ²⁺	0.00002	2	
A ⁻	54	13	

If the resting membrane potential is -85 mV, which ion(s) most likely has the greatest membrane permeability?

At the resting membrane potential, what direction (in, out) is the most thermodynamically favorable for the movement of each ion?

If the peak of the action potential is +40 mV, the membrane permeability for which ion(s) most likely increased?

At the peak of the action potential, what direction (in, out) is the most thermodynamically favorable for the movement of each ion?

If you measure a membrane potential of zero, the membrane permeability for which ion(s) most likely increased?

Some compounds that affect ion movement

1. Local anesthetics and tetrodotoxin

These compounds (e.g., lidocaine, marcaine, and cocaine) prevent sodium from moving through the voltage-gated sodium channel.

- a. What is their effect on the peak of the action potential? Why?

- b. What is their effect on nerve conduction? Why?

- c. What is their effect on the action potential in ventricular muscle? Why?

2. Ca²⁺-channel blockers

These compounds (e.g., nifedipine, verapamil) prevent calcium from moving through voltage- and ligand-gated calcium channels.

- a. In low dose, what is their effect on vascular smooth muscle? Why?

- b. In high dose, what is their effect on ventricular muscle contraction? Why?

- c. What is their effect on skeletal muscle contraction?

3. Caffeine and Ryanodine

These alkaloids cause Ca²⁺ release by opening calcium channels in sarcoplasmic reticulum. Caffeine is reversible, the pesticide ryanodine (from the tropical shrub *Ryania speciosa*) is not.

- a. Caffeine is sometimes considered a physical performance-enhancing drug? Why?

- b. What might be a clinical symptom of ryanodine poisoning?

- c. Which type of muscle would probably be most affected by low doses of these compounds: cardiac, smooth, or skeletal? Why?

4. Acetylcholinesterase inhibitors

These compounds slow the hydrolysis of acetylcholine.

- a. What might their effect be given that there is always random, spontaneous release of acetylcholine quantal packets at the motor end-plate? Why?

- b. Why are these compounds important for the treatment of myasthenia gravis (an autoimmune disease that inhibits acetylcholine receptor function)?

c. Why are these compounds used for chemical warfare?

5. Curare

The term “curare” is often used generically to refer to several different forms of alkaloids that block neuromuscular activity and are the principal component in poison arrows. True curare, from the plant *Chondrodendron tomentosum*, blocks the acetylcholine receptor.

a. Why is this class of drug important for many surgical procedures?

b. What is a potential antidote for curare poisoning?

c. How do poison arrows do their lethal work?