Nervous System NPB 101 Cheat Sheet

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Diffusion Potential

The net movement of random collisions between molecules.	There are *two types* of diffusion
Diffusion down a concentration gradient	Concentration(chemical) gradient. eg. O_2, CO_2, and fatty acids, Na^+, K^+, Ca^{2+}, Cl^-
Rate of Diffusion *Through a Membrane* is dependent on five factors:	Electrical gradient. eg. Na^+, K^+, Ca^{2+}, Cl^-
1) Magnitude of the concentration gradient. As concentration gradient increases, the rate of diffusion increases.	These two together form the **electrochemical gradient**.

Diffusion Potential (cont)

2) Permeability of the membrane. As permeability increases, the rate of diffusion increases. The substance needs some base level of permeability	Diffusion down a *concentration (chemical)* gradient. High to low concentration.
3) Surface area of the membrane. As surface are increases, the rate of diffusion increases.	Movement along an *electrical* gradient
4) Molecular weight of the substance. As the molecular weight of the substance increases, the rate of diffusion decreases.	Movement along an electrical gradient. The electrostatic force (voltage) caused by the separation of electrical charge.

Diffusion Potential (cont)

5) Distance(thickness) over which diffusion takes place. As distance increases, the rate of diffusion decreases.	Movement along an electro chemical gradient the combined force of **concentration (chemical)** and **electrical** gradients.

Action Potential Terms

Hyperpolarization: Change in membrane potential to more negative values than membrane potential

Depolarization: Change in membrane polarization to more positive values than resting membrane potential.

Repolarization: Return to resting membrane potential after depolarization.

Action Potential: Brief all-or-nothing reversal in membrane potential (spike) lasting on the order of 1 millisecond. It is brought about by rapid changes in membrane permeability to Na^+ and K^+ ions.

Refractory Period

Absolute refractory period - a brief period during a spike. A second spike cannot be generated.	**Relative refractory period - a breif period following a spike. Capable of opening in response to depolarization
Repolarization: Voltage gated Na^+ channel inactivation gate closes	Hyperpolarization: a higher stimulus is needed

Membrane Potential

Membrane potential is a separation of opposite charges across the plasma membrane.

Potential is measured in volts which is then converted into millivolts(mV).

If there are equal charges on both sides of the plasma membrane then there is no membrane potential.

Most of the fluid is electrically neutral but the separated charges form a layer along the plasma membrane.

The magnitude of potential increases as the separation of charges along the membrane increase.

Resting Membrane Potential (-70mV)

1. K^+ high in ICF and Na^+ high in the ECF.

2. K^+ drives equilibrium potential for K^+ (E_{K^+}=-90mV)

3. Na^+ drives equilibrium potential for Na^+ (E_{Na^+}=+60mV)

Resting membrane potential: MIX with K^+ and Na^+ but consider the membrane permeability

The membrane is 20-30 times more permeable to K^+ than Na^+.

The large net diffusion of K^+ is slightly neutralized by the net diffusion of Na^+.

Leak channels: Permit ions to diffuse down concentration gradients.

Na^+/K^+ ATPase: Establishes and maintains concentration gradients. 3 Na^+ Out, 2 K^+ In and 1 ATP used.

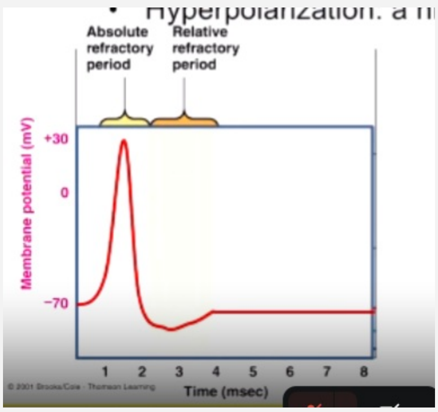
Different Phases of Action Potential

Rising Phase of the Action Potential	**Falling** Phase of the Action Potential

Different Phases of Action Potential (cont)

Voltage-gated Na^+ channel opens quickly (<0.5ms) in response to depolarization, allowing Na^+ to flow down its electrochemical gradient into the cell.	Voltage-gated K^+ channel opens slowly in response to depolarization allowing K^+ ions to flow out of the cell down their electrochemical gradient.
At the threshold (-50mV), Na^+ activation gate opens, and permeability of Na^+ rises. Na^+ enters the cell.	Na^+ inactivation gate closes. K^+ activation gate opens and permeability of K^+ rise. K^+ leaves the cell. At the resting potential, Na^+ activation gate closes and inactivation gate opens. K^+ ;eaves cell because the gate is still open.

Refractory Period Image



Equilibrium Potential

How Equilibrium Potential is Established	Equilibrium potential for K^+ (E_{K^+}=-90mV)	Equilibrium Potential for Na^+ (E_{Na^+}=+60mV)
1. Establishes and maintains concentration gradients for key ions (Na^+, K^+).	1. K^+ tends to move out of the cell.	1. Na^+ tends to move into the cell.
2. Ions *diffuse* through the membrane down their concentration gradients.	2. Outside of the cell becomes more positive.	2. Inside of the cell becomes more positive.
3. Diffusion through the membrane results in charge separation, creating a membrane potential (electrical gradient).	3. Electrical gradient tends to move K^+ into the cell.	3. Electrical gradient tends to move Na^+ out of the cell.

Equilibrium Potential (cont)

4. Net diffusion continues until the force exerted by electrical gradient exactly balances the force exerted by the concentration gradient.	4. Electrical gradient counte-rbalances concen-tration gradient.	4. Electrical gradient counte-rbalances concen-tration gradient.
5. This potential that would exist at this equilibrium is "*equilibrium potential*"	5. No further net movement of K^+ occurs	5. No further net movement of Na^+ occurs.

Action Potential Propagation

Propagation - action potentials propagate when locally generated depolarizing current spreads to adjacent regions of membrane causing it to depolarize.

Once initiated, action potentials are conducted throughout a nerve fiber

Contiguous conduction - porpagation of action potentials in unmyelinated fibers by spread of locally generated depolarizing current to adjacent regions of membrane, causing it to depolarize.

The original active area returns to resting potential, and the new activate area induces an action potential to the next inactive area. The cycle repeats down the length of the axon.

Action Potential Image