Bio 6160, F02 - Lecture 21

**Membrane Structure**

Lipid bilayers and micelles represent a balance between headgroup interaction and the hydrophobic effect. These factors determine an optimum surface area to volume ratio.

**Membrane Potential**

Charge separation creates membrane potential. Capacitance determines the dependence of membrane potential on charge separation 
\[ C = \frac{q}{\Delta \psi} \].

Capacitance of biological membranes is such that a relatively small amount of ion movement makes a big change in membrane potential.

**Surface Potential**

This derives from surface charge, which for biological membranes is typically negative. Positive ions (K⁺ and Na⁺) diffuse away from the membrane leading to charge separation. Charge separation creates surface potential. Surface potential is generally smaller because of high dielectric constant of water. Surface potential is smaller at higher ionic strength.

**Permeability**

Permeability depends on polarity and size. Larger molecules are less permeable. Polar molecules and ions are less permeable. Charge delocalization increases permeability (SCN⁻ is a fairly permeant anion). Anions permeate more easily than cations. This is probably because of the surface dipole potential.

Rate of permeation depends on permeability coefficient and concentration gradient.
\[ J = -P(C_i - C_o) \]

The permeability coefficient includes both polarity and size effects. This can be thought of as partitioning between the aqueous and membrane phases (polarity) and diffusion through the membrane (size).

Permeability coefficients range between \(10^{-2}\) and \(10^{-14}\) cm/sec.

<table>
<thead>
<tr>
<th>Substance</th>
<th>Permeability Coefficient</th>
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<tbody>
<tr>
<td>H₂O</td>
<td>(2 \times 10^{-5} - 2 \times 10^{-2}) cm/sec</td>
</tr>
<tr>
<td>Na⁺ (lipid bilayer)</td>
<td>(10^{-10} - 10^{-14}) cm/sec</td>
</tr>
<tr>
<td>K⁺ (lipid bilayer)</td>
<td>(10^{-10} - 10^{-14}) cm/sec</td>
</tr>
<tr>
<td>Na⁺ (squid axon)</td>
<td>(8 \times 10^{-9}) cm/sec</td>
</tr>
<tr>
<td>K⁺ (squid axon)</td>
<td>(6 \times 10^{-7}) cm/sec</td>
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The fact that the squid axon is more permeable than lipid bilayers to Na$^+$ and K$^+$ implies the existence of ion channels.

Weak acids and bases represent a special case of permeability. Although the charged forms of the weak acids and bases are relatively impermeant, the neutral species (though low in concentration) are relatively permeant and equilibrate across the lipid bilayer. For a weak base:

$$[	ext{B}]_{\text{out}} = [	ext{B}]_{\text{in}}$$

Since

$$K_a = [	ext{B}]_{\text{out}}[\text{H}^+]_{\text{out}}/[	ext{BH}^+]_{\text{out}} = [	ext{B}]_{\text{in}}[\text{H}^+]_{\text{in}}/[	ext{BH}^+]_{\text{in}}$$

weak bases reach the equilibrium

$$[	ext{BH}^+]_{\text{in}}/[	ext{BH}^+]_{\text{out}} = [\text{H}^+]_{\text{in}}/[\text{H}^+]_{\text{out}}$$

Weak acids reach the inverse equilibrium

$$[	ext{A}^-]_{\text{in}}/[	ext{A}^-]_{\text{out}} = [\text{H}^+]_{\text{out}}/[\text{H}^+]_{\text{in}}$$