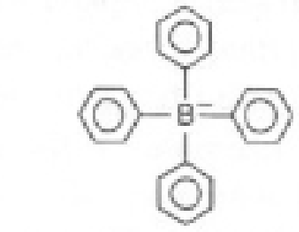
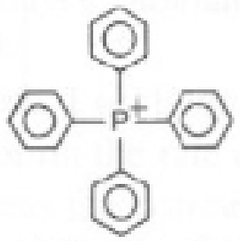
Electrical Properties of Membranes

- Internal Dipole Potential –probably due to the oriented carbonyl of acyl chains
- Born Energy – Work to move charges into the bilayer
- Membrane Surface Potential –due to charges on the surface
    - Local pH at Membrane Surfaces
    - Metal Ion Binding
    - Probe Binding/Hydrophobic Ions/Cell Penetrating Peptides
- Transmembrane Potential – due to ion permeabilities leading to gradients on either side of the bilayer (can also be protein transport driven)
    - Ions and Protons
    - Energized Membranes
    - Permeability to Ions
    - Transmembrane Potential Diffusers

Internal Dipole Potential ~ 240mV positive inside the bilayer



Tetraphenylboron (TPB^-)



Tetraphenylphosphonium (TPP^+)

Born model – work required to transfer a charged species from water to the bilayer

$$W_B = \frac{q^2}{2r}\left(\frac{1}{\varepsilon_1} - \frac{1}{\varepsilon_2}\right)$$

$W_B = (81Z^2/r)$ kcal/mol

Dielectric constant for water ~ 80

Dielectric constant for membrane ~2

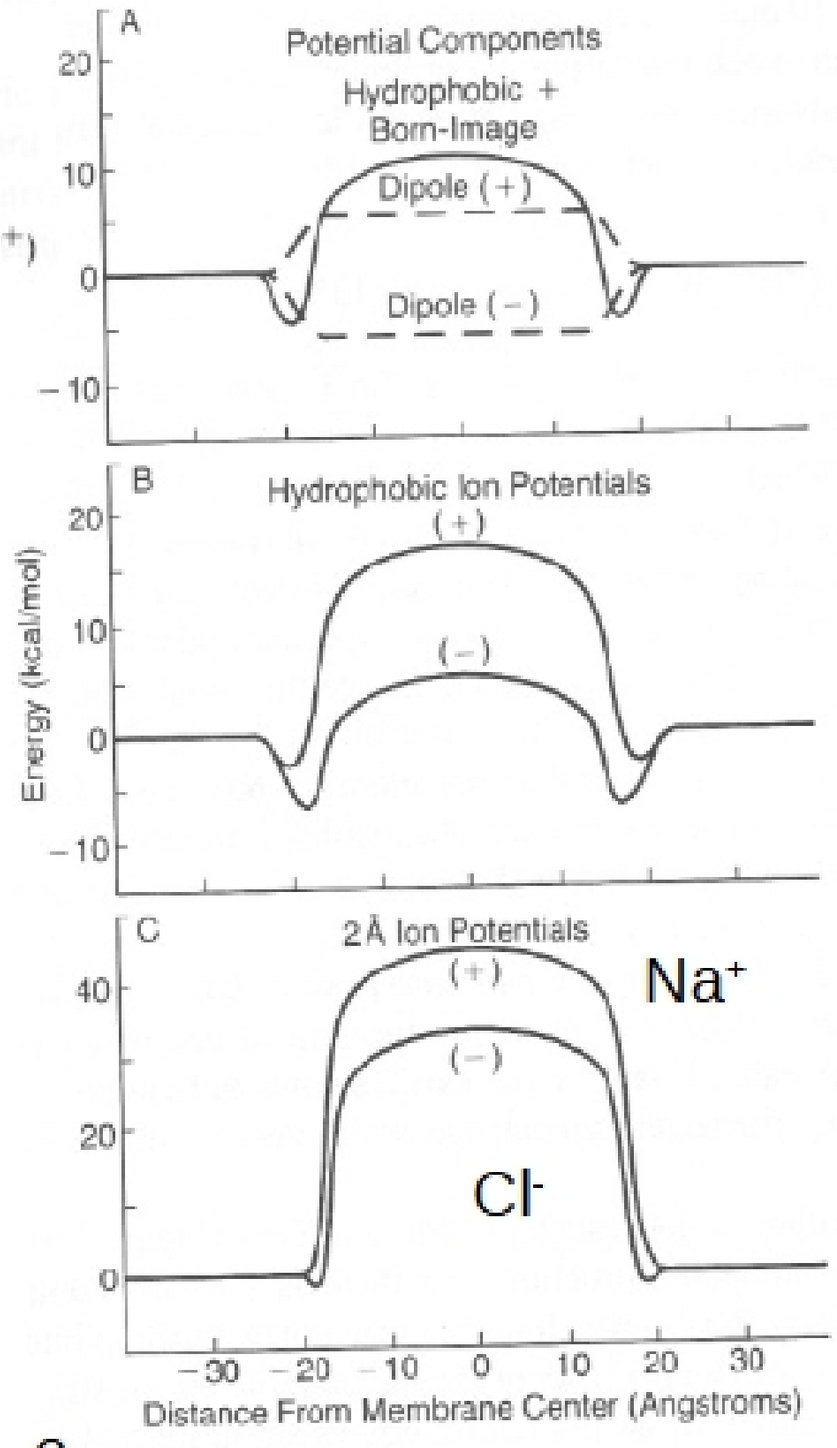


Figure 7.4. Theoretical membrane free energy profiles showing contributions from the Born, image, dipole, and hydrophobic (neutral) components. (A) *Hydrophobic ions*. The Born, image, and hydrophobic contributions (——) are the same for ions that are identical except for the sign of the charge. The dipole potentials (– – –) are very different and this stabilizes anions within the bilayer. (B) *Hydrophobic ions*. Total free energy profiles for an anion and cation, assuming a 4 Å radius. Note the adsorption sites near the bilayer surface and the relatively low barrier for translocation of the hydrophobic anion across the membrane. (C) *Ions with 2 Å radii*. The total potential for ordinary inorganic ions presents a large barrier against translocation which is slightly less for anions due to the dipole potential. Adapted from ref. 646. Reproduced, with permission, from the *Annual Review of Biophysics and Biophysical Chemistry*, vol. 15. © 1986 by Annual Reviews Inc.

Table 7.1. Permeability and partition data on selected solutes.

Compound	Membrane[1]	Permeability coefficient (cm/sec)	Rate constant (sec^{-1})	Partition coefficient into hexadecane[2]	Ref.
1. Water	Egg phosphatidylcholine (planar)	3.4×10^{-3}	$6.0 \times 10^{+6}$	4.2×10^{-5}	(1546)
	Egg phosphatidylcholine (liposome)	2.0×10^{-4}			(311)
	Red blood cell	1.2×10^{-3}			(856)
2. Urea	Egg phosphatidylcholine (planar)	4.0×10^{-6}	$3.6 \times 10^{+7}$	2.8×10^{-7}	(1546)
	Red blood cell	7.7×10^{-7}			(856)
3. Glycerol	Egg phosphatidylcholine (planar)	5.4×10^{-6}	$2.5 \times 10^{+7}$	2.0×10^{-6}	(1546)
	Red blood cell	1.6×10^{-7}			(856)
4. Tetraphenyl-phosphonium (TPP^+)	Egg phosphatidylcholine (planar)	10^{-7}	$\sim 10^{-2}$	$\sim 10^{+2}$	(439)
5. Tetraphenyl-boron (TPB^-)	Egg phosphatidylcholine (liposome)	10^{-1}	$\sim 10^{+1}$	$\sim 10^{+5}$	(439)
6. Na^+	Egg phosphatidylcholine (liposome)	$\sim 10^{-14}$	—	—	(601)
7. Cl^-	Egg phosphatidylcholine (liposome)	$\sim 10^{-11}$	—	—	(601)
8. H^+/OH^-	Egg phosphatidylcholine	10^{-4}–10^{-8}	—	—	(1139, 563)

[1]Measurements on phospholipid bilayers were done either with planar membranes separating two aqueous compartments or using liposomes (see 311, 1386).
[2]The partition coefficients for TPP^+ and TPB^- are for the lipid bilayer, not hexadecane.