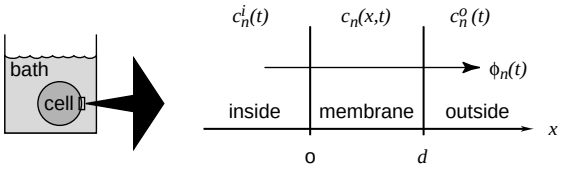
Review of Lecture 4

Membrane diffusion



Dissolve and diffuse model
- solute outside cell dissolves into cell membrane
- solute diffuses through membrane
- solute dissolves into cytoplasm

Membrane time constant $t_{SS} = \frac{d^2}{\pi^2 D_n}$

Fick's law for membranes: $\phi_n(t) = P_n\,(c_n^i(t) - c_n^o(t))\,; \quad P_n = \frac{D_n k_n}{d}$

Two-compartment diffusion

Cell time constant $t_{EQ} = \dfrac{1}{AP_n\left(\frac{1}{V_o} + \frac{1}{V_i}\right)}$

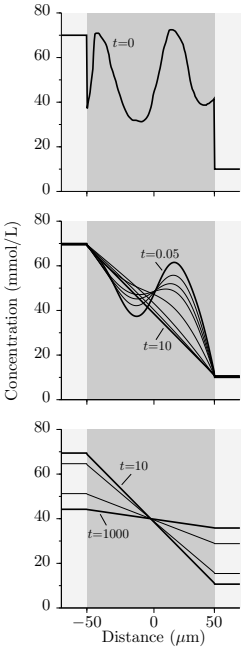


Figure 3.30

Diffusion through Cell Membranes

Charles Ernest Overton (late 1800s): first systematic studies
- qualitative:
  - put cell in bath with solute
  - wait, rinse, squeeze
  - analyze to see how much got in (+ = some; +++ = a lot)
- 100's of solutes, dozens of cell types
- surprising results: previously cell membranes had been thought to be impermeant to essentially everything but water

Overton's Rules:
- cell membranes are semi-permeable
- relative permeabilities of plant and animals cells are similar
- permeabilities correlate with solubility of solute in organic solvents
  $\rightarrow$ membrane is lipid (specifically cholesterol and phospholipids)
- certain cells concentrate some solutes $\rightarrow$ active transport
- potency of anesthetics correlated with lipid solubility
  $\rightarrow$ Meyer-Overton theory of narcosis
- muscles don't contract in sodium-free media

Diffusion through Cell Membranes

Paul Runar Collander (1920-1950): first quantitative studies
- large cells (cylindrical algae cells, 1 mm diameter, 1 cm long)
- bathe cell in solute for time t_1, squeeze out cytoplasm, analyze
- repeat with new cell and new time t_2
- plot intracellular quantity versus time
- fit with exponential function of time (two-compartment theory)
- infer permeability from time constant

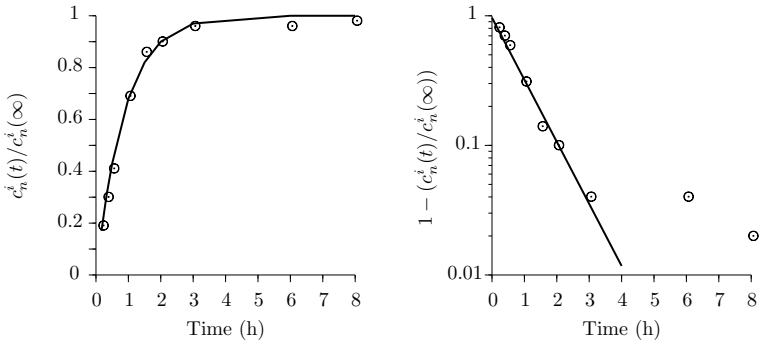


Figure 3.33

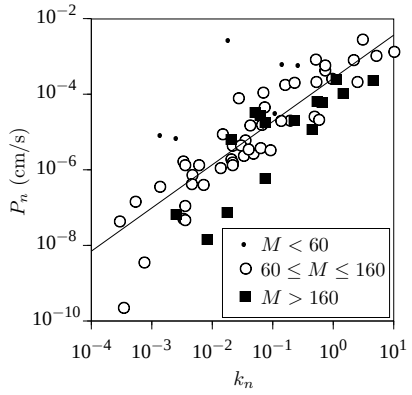


Figure 3.38

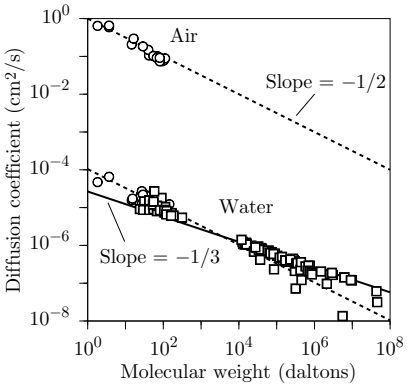


Figure 3.11

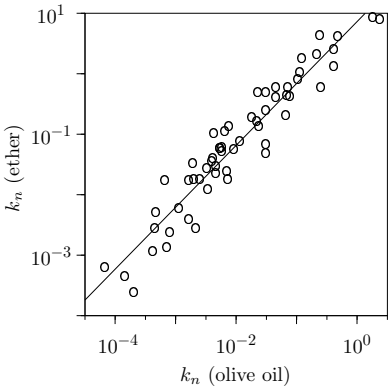


Figure 3.39

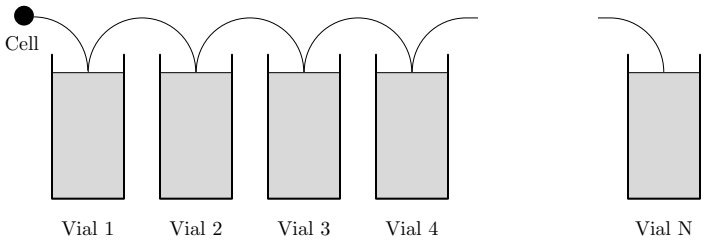


Figure 3.34

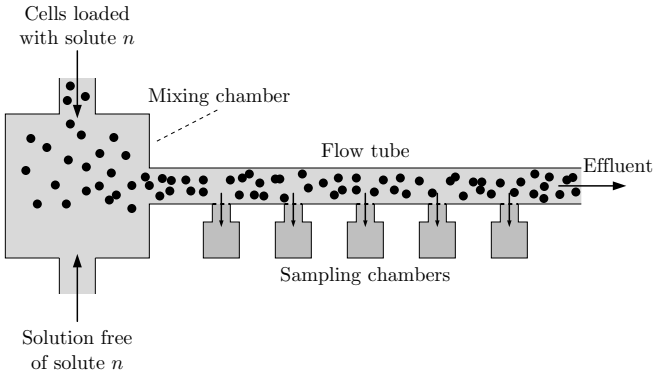


Figure 3.35

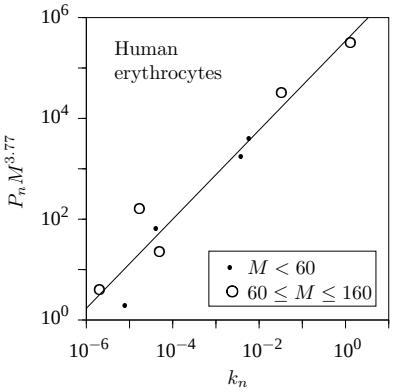


Figure 3.42

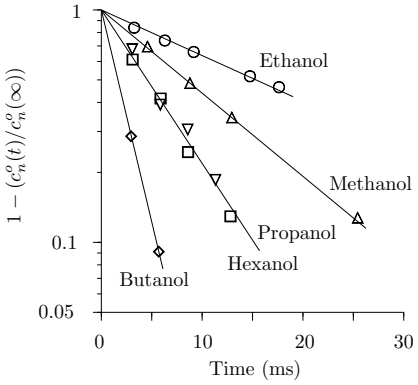


Figure 3.36

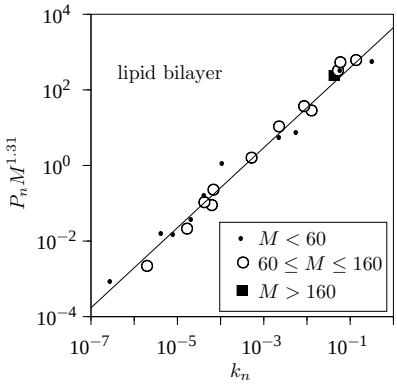


Figure 3.43

Conclusions from Transport Experiments

- transport of many substances consistent with dissolve and diffuse mechanism
- some of these substances are biologically important
  – gases
  – steroid hormones
  – anesthetics
- others are useful as probes (e.g., Overton' s reasoning that membrane is lipid)
- many substances dissolve and diffuse, but are apparantly transported by other mechanisms as well

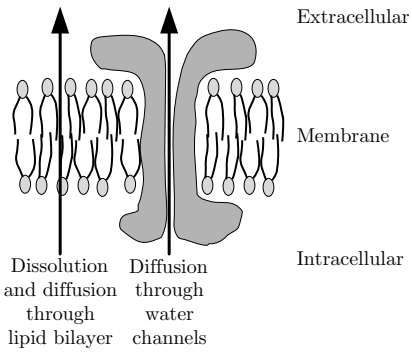


Figure 3.46