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:
\[ \phi_n(t) = P_n (c_{ni}(t) - c_{no}(t)) \]

Two-compartment diffusion

Cell time constant
\[ t_{EQ} = \frac{1}{A P_n \left( \frac{1}{V_o} + \frac{1}{V_i} \right)} \]

Figure 3.30

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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
  → membrane is lipid (specifically cholesterol and phospholipids)
- certain cells concentrate some solutes → active transport
- potency of anesthetics correlated with lipid solubility
  → 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

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**Figure 3.33**

**Figure 3.38**
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 apparently transported by other mechanisms as well