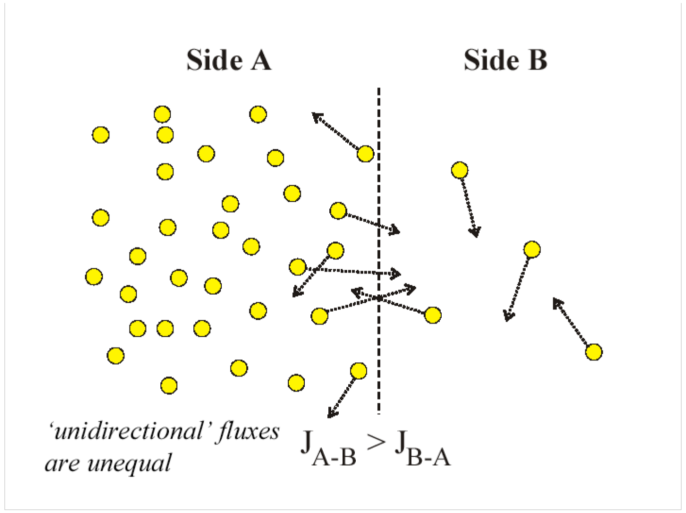
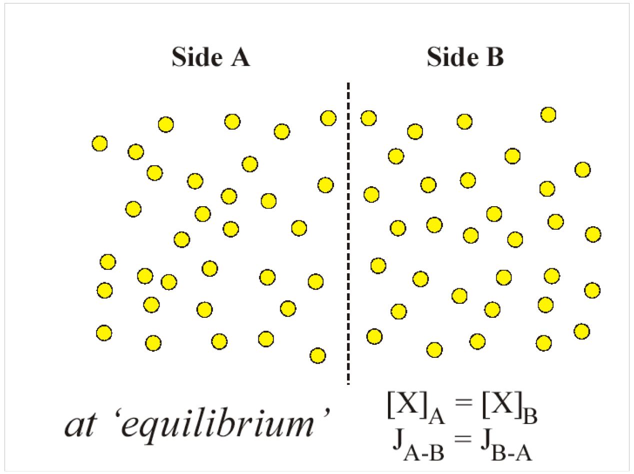
DIFFUSION

Molecular diffusion, often simply called diffusion, is the thermal motion of all particles at temperatures above absolute zero

A single molecule moves around randomly.

With more molecules, there is a clear trend where the solute fills the container more and more uniformly.





With an enormous number of solute molecules, all randomness is gone: The solute appears to move smoothly and systematically from high-concentration areas to low-concentration areas, following Fick's laws.

flux

$$J = \frac{dn}{dt}\frac{1}{A}$$

n=number of particles

t=time

A=area

$$J = -D\frac{dc}{dx}$$

I FICK'S LAW

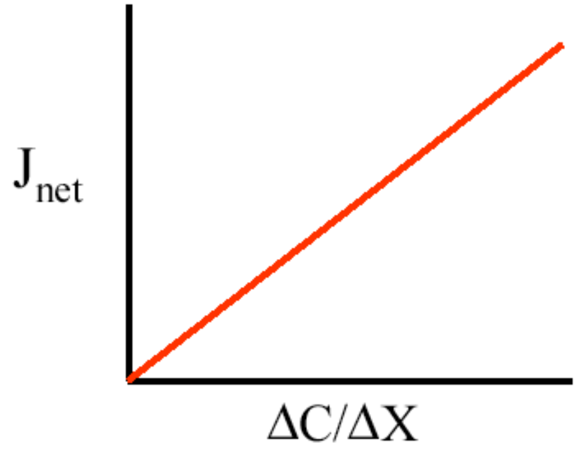
Free diffusion of

<u>uncharged</u> particles in

1 spatial dimension

Fick's law in finite form:

$$J = -D\frac{\Delta c}{\Delta x}$$



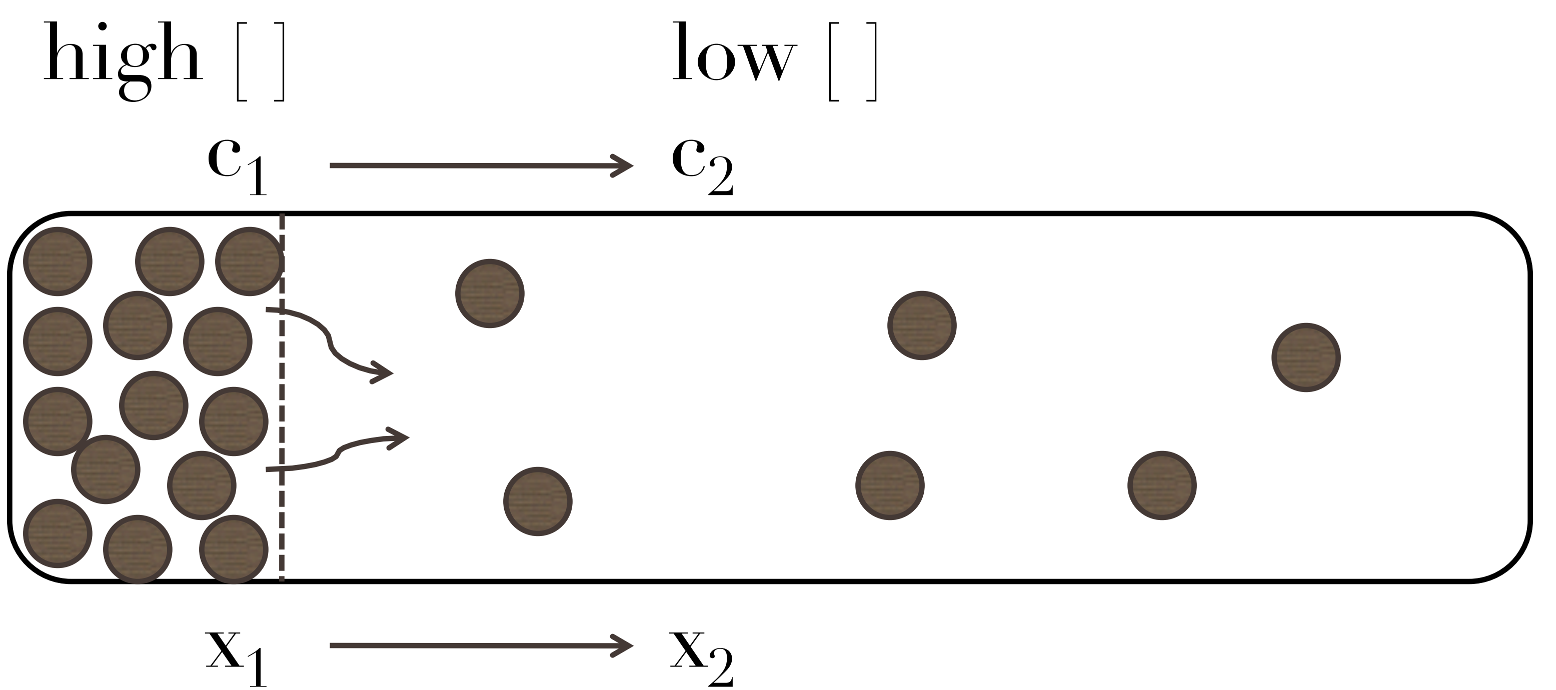
$$J = -D\frac{\Delta c}{\Delta x}$$

since

$\Delta c < 0 \quad (c2 < c1)$

$\Delta x > 0 \quad (x2 > x1)$

to have a positive flux



http://www.youtube.com/watch?v=Hmfnolr47Zw diffusion constant $D = \frac{RT}{Nf}$

for a solid macroscopic body STOKES law can be applied:

$v = \frac{F}{f}$ (STOKES)

F = *force* (on a single particle) v = *velocity* f = *f*rictional resistance

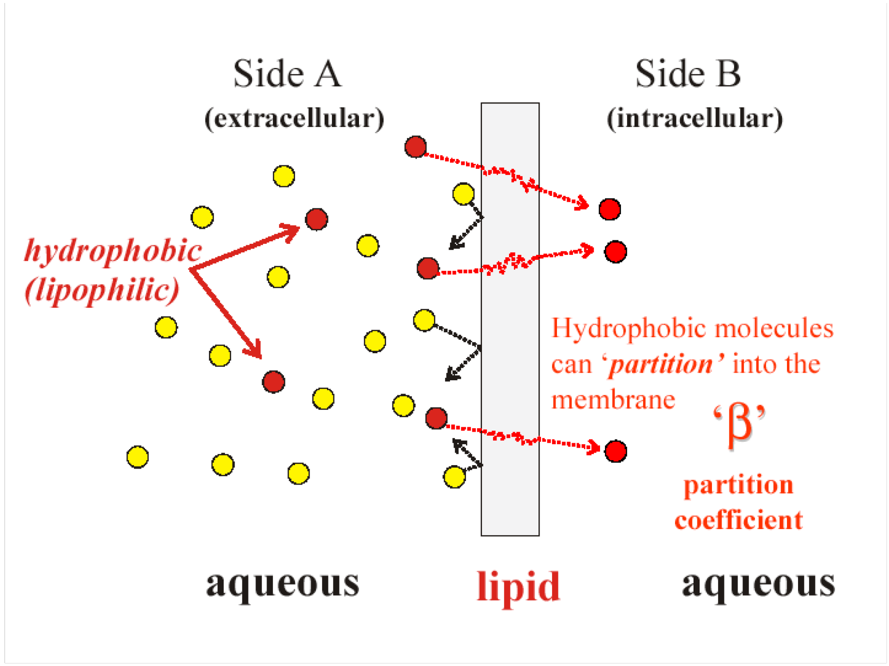
$f = 6\pi\eta r$ η = solvent viscosity r=particle radius

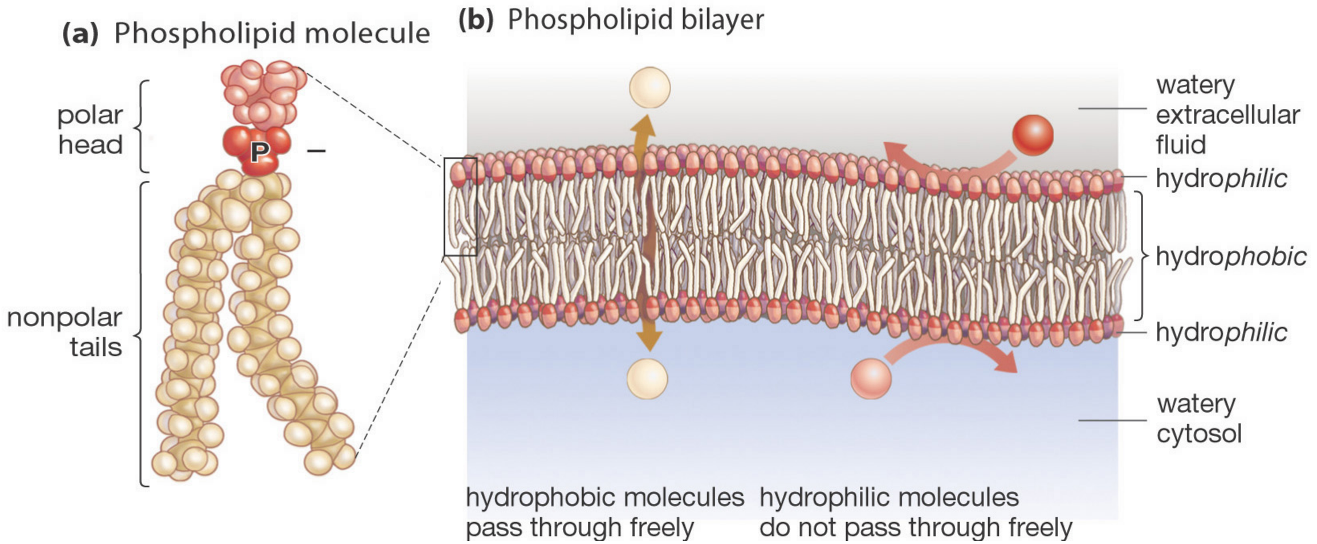
$$D = \text{velocity} = \frac{A}{t} = \frac{\mu m^2}{s}$$

$$J = \frac{\mu m^2}{s}\,\frac{mol}{\mu m^3}\,\frac{1}{\mu m} = \frac{mol}{\mu m^2 s}$$

$$D \qquad \Delta c \qquad \frac{1}{\Delta x}$$

Diffusion through a biological membrane





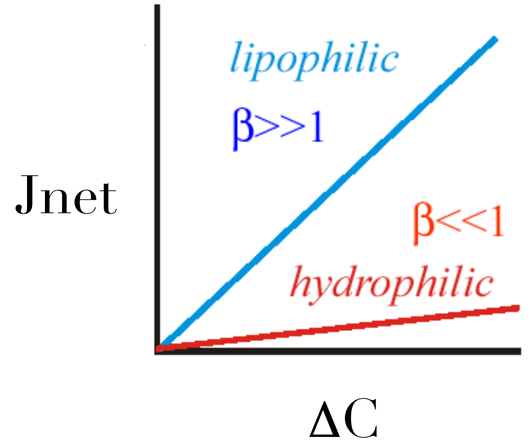
In the case of a diffusional flux through a real biological membrane FICK's law can be written as

$$J = D\beta \frac{\Delta c}{\Delta x}$$

in which β= partition coefficient = $\frac{c_m}{c}$

gives the actual concentration of the particle in the membrane

Δx is now the membrane thickness

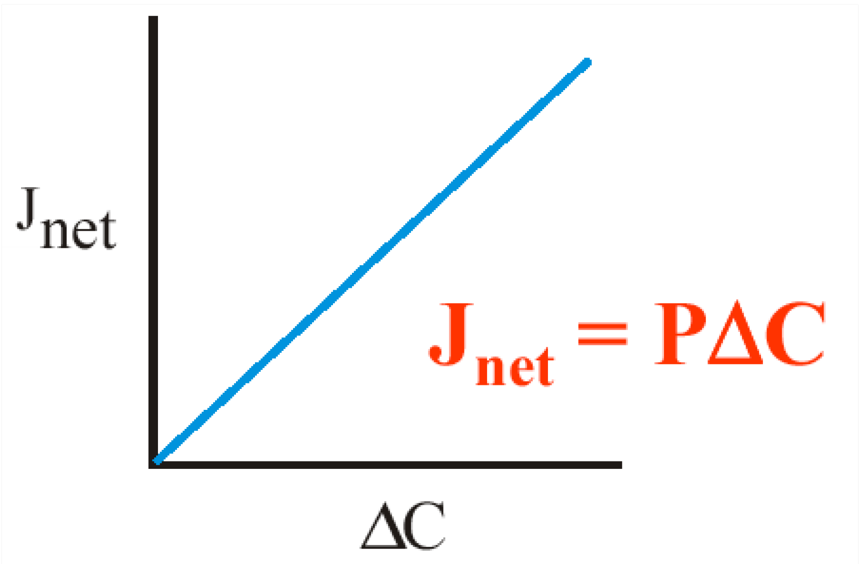


$$J = D\beta \frac{\Delta c}{\Delta x}$$

if we call PERMEABILITY $P = \dfrac{D\beta}{\Delta x}$

FICK'S equation finally becomes very simple!

$$J = P_m \Delta c$$



FICK's laws apply to un-charged particles.

WHAT ABOUT ION FLUXES?

the driving force is the ELECTROCHEMICAL POTENTIAL (CHEMICAL + ELECTRICAL POTENTIAL)

$\mu_c = RT \ln c$ $\mu_e = zF\varphi$

$$\mu_{ec} = \mu_c + \mu_e = RT \ln c + zF\varphi$$

$$J = -D\left(\frac{dc}{dx} + c\frac{zF}{RT}\frac{d\varphi}{dx}\right)$$ NERNST-PLANCK