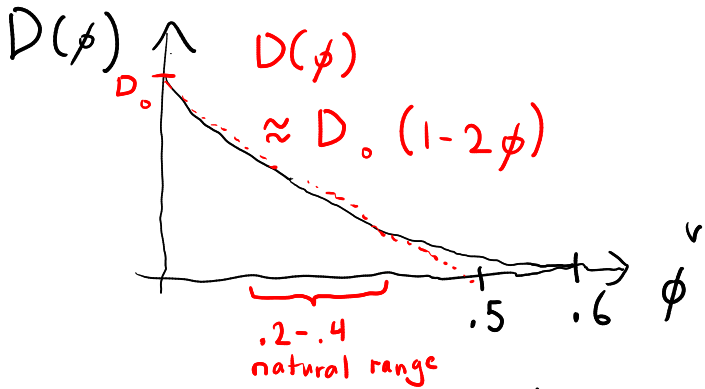
$$k \leq k_{smol} = 4\pi D R c$$



ϕ = vol. frac of proteins, DNA/RNA, etc.

$\approx$ dominated by proteins

$$\phi \approx \frac{n V_{prot}}{V}$$

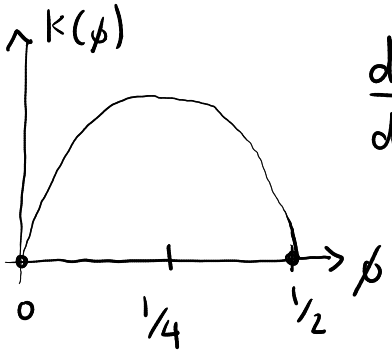
n ← # proteins; V_{prot} ← vol. per protein; V ← cell volume

max. $k(\phi) = 4\pi D(\phi) R c(\phi)$

$$\approx 4\pi D_0 (1-2\phi) R \phi V_{prot}^{-1}$$

$$= c V_{prot}$$

$$\Rightarrow c(\phi) = \phi / V_{prot}$$



$$\frac{dk}{d\phi} = 0$$

$$\Rightarrow \phi = \frac{1}{4}$$

is the maximum

estimate typical total cell concs: $c \sim \frac{\phi}{V_{prot}} = \frac{1/4}{60\ nm^3}$

↑ typ. prot. vol.

Conc. unit = molar (M) = $\frac{N_A}{L}$ (N_A: 6.022×10^{23}; L → liter)

$= 7$ mM

cell volume $\sim 1\ \mu m^3$ for bacteria

$$\Rightarrow n = cV \sim 4 \times 10^6 \text{ proteins/cell}$$

actual E. coli values: $3 \times 10^6 - 10^7$ proteins/cell

$$\Rightarrow \text{optimal } k \approx 2.6 \times 10^6\ s^{-1}$$

timescales for reactions $\tau \sim 0.4\ \mu s$

broad lessons: any one protein $c < mM$

$n < 10^6$

(for $V \sim 1\ \mu m^3$)

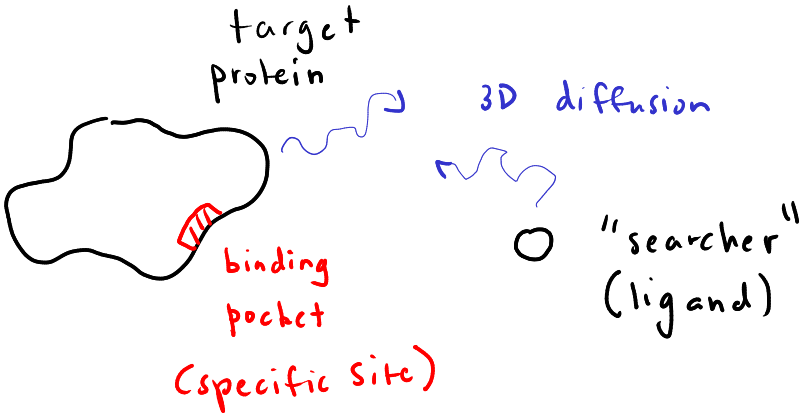
one last point: $\phi = \frac{n_{prot} V_{prot} + n_{bp} V_{bp}}{V}$ ~.005 for E. coli

bp = base pair of DNA/RNA

V_{bp} = volume per bp

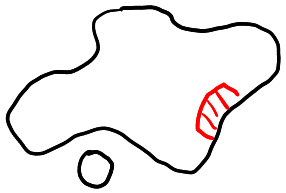
Next steps: what happens after diffusion?

3 state picture:



1) "FAR"

2) "NEAR"



3) "BOUND"