HW 9, ~~Questions~~ Problems 11/13/24 Zoe Schurman

Q1) We have the Stokes - Einstein formula to be

$$D = \frac{k_b T}{6\pi \eta R},$$

where D = diffusion constant

k_b = Boltzmann's constant $= 1.3 \cdot 10^{-23}$ J/K

$T = 300$ K

(given) $\eta = 10^{-3}$ kg/(m·s)

And, let's estimate R as ~3 nm, the lowerend of the range that most proteins tend to be in.

So, we have

$$D = \frac{1.3 \cdot 10^{-23}\,\text{J/K} \cdot 300\,\text{K}}{6\pi\,(10^{-3}\,\text{kg/m·s})(3\,\text{nm})}$$

$$\approx \frac{1.3 \cdot 10^{-23}\,\text{J/K} \cdot 300\,\text{K}}{2 \cdot 10^{-2}\,\text{kg/(m·s)} \cdot 3 \cdot \frac{1}{10^{9}}\,\text{m}} \approx 50\,\mu\text{m}^2/\text{s}.$$

Looking at the graph, we see a diffusion constant value of about $6\,\mu\text{m}^2/\text{s}$, while we got a value of around $50\,\mu\text{m}^2/\text{s}$.

This can be explained by noticing that the graph measures the diffusion constant in cytoplasm, while our calculation regards water, these having significantly different viscosities. As cytoplasm is thicker, it will be harder to travel through, and its diffusion constant lower, as we observe.

HW 9

Q2) We have:

area: few $\cdot 10^2$ μm

recovery time: 6 min = 360 sec

Let's estimate the diffusion constant.

$$\frac{300\ \mu m^2}{360\ sec} \approx 1\ \mu m^2/s.$$

Let's assume this protein is in the biggest size range, 70-250 kDa (and in E. coli cytoplasm). This returns a diffusion coefficient of .4-2 $\mu m^2/s$.

This aligns with our calculation!

Reading Questions

1) FRAP, or flourescence recovery after photobleaching is a techique where molecules in a small cell region that are labelled with a flourophore, then photobleached with a laser. By obsering how quickly unbleached molecules diffuse back into the area, researchers can make insights into the mechanics of diffusion in the cell.