Important equations and expressions in Experimental Biophysics, spring 2021

— *OPTICS* —

Fluorescence resonance energy transfer (FRET), energy transfer efficiency is given by:

$$E = \frac{I_{donor}}{I_{acceptor} + I_{donor}} = \frac{1}{1 + \left(\frac{R}{R_0}\right)^6}$$

The Förster length is $R_0 \sim 5$nm.

Diffraction limited resolution:

$$r = \frac{0.61\lambda}{NA}, NA = n_{medium}\sin\theta$$

Positional uncertainty:

$$r = \frac{0.61\lambda}{NA}\frac{1}{\sqrt{N}}$$

Resolution in STED:

$$r = \frac{0.61\lambda}{NA}\frac{1}{\sqrt{1 + \frac{I_{STED}}{I_{SAT}}}}$$

Number of detected photons in a microscope:

$$N = D\varphi_F\left(\frac{\sigma_{abs}}{A}\right)\left(\frac{P_0}{hc/\lambda}\right)$$

Signal to noise ratio with typical sources of noise:

$$\frac{Signal}{Noise} = \frac{N}{\sqrt{\sigma_{shot}^2 + \sigma_{readout}^2 + \sigma_{background}^2 + \sigma_{dark}^2}}$$

$$\frac{Signal}{Noise} = \frac{N}{\sqrt{N + n_{readout} + (C_0 + C_b P_0) + c_d T}}$$

—— *FLUIDICS* ——

Diffusion in *n* dimensions:

$$\langle r^2 \rangle = n \cdot 2Dt$$

The Stokes-Einstein relation gives for the diffusion coefficient of a sphere:

$$D = \frac{k_B T}{f} = \frac{k_B T}{6\pi\eta a}$$

"Ohm's law" for fluidics:

$$\Delta P = QR$$

Flow resistance for a circular cross section:

$$R = \frac{8}{\pi}\frac{\eta L}{a^4}$$

Flow resistance for a square cross section:

$$R = 29\frac{\eta L}{a^4}$$

Flow resistance for a rectangular cross section:

$$R = 12\frac{\eta L}{wh^3}$$

Reynolds number:

$$Re = \frac{\rho v L}{\eta}$$

Péclet number:

$$Pe = \frac{vL}{D}$$