Biomedical Optics VIII

Devices and protocols

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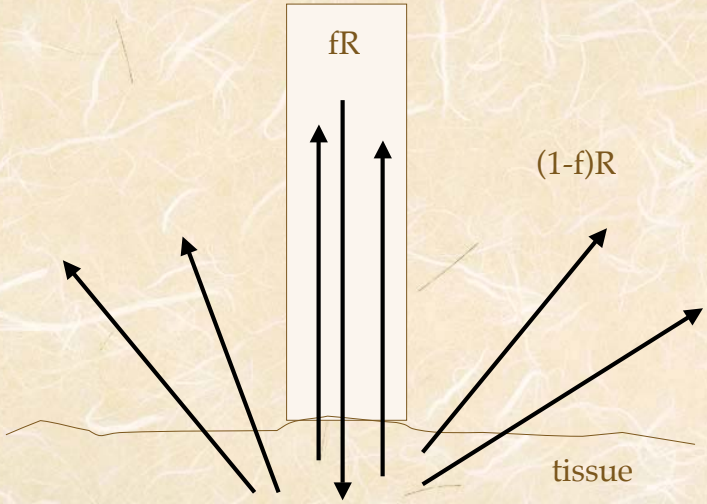
Optical fiber bundle

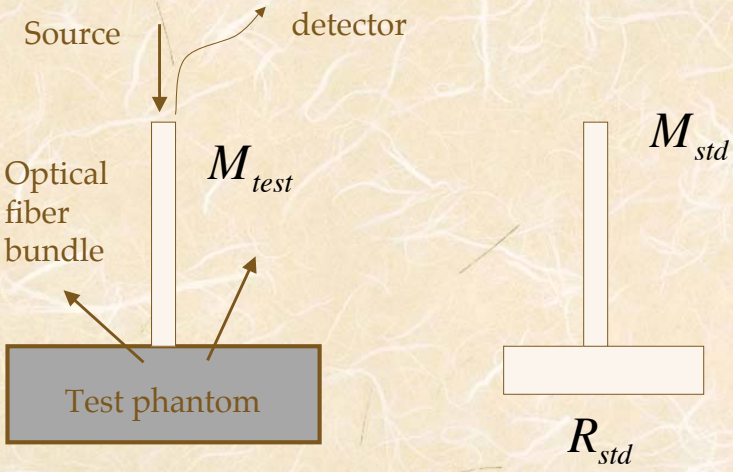


Measurement situation

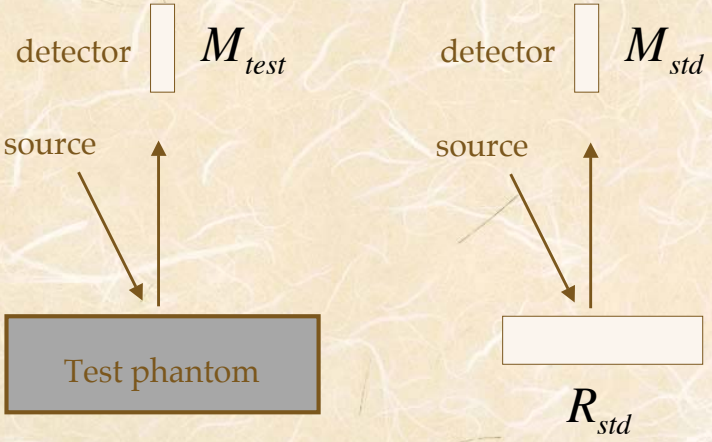
$$M = \frac{M_{tissue}}{M_{std}} = \frac{Sf_{tissue}R_{tissue}D}{Sf_{std}R_{std}D} = \frac{f_{tissue}R_{tissue}}{f_{std}R_{std}} = f^{*}R_{tissue}$$

$$f^{*} = \frac{f_{tissue}}{f_{std}R_{std}} = \frac{M}{R}$$

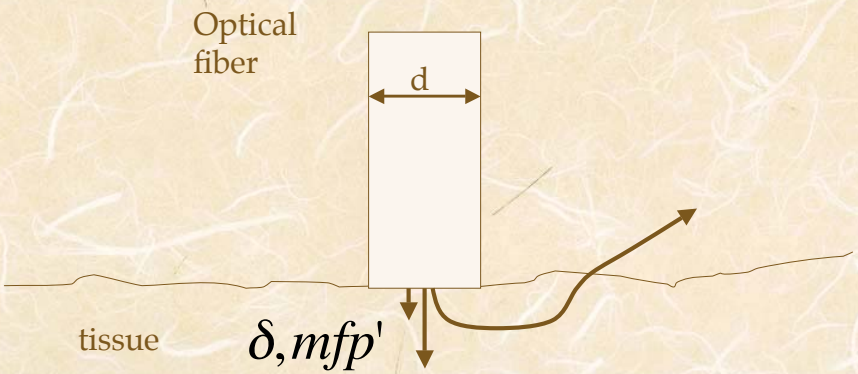
$$M = M_{test} / M_{std}$$



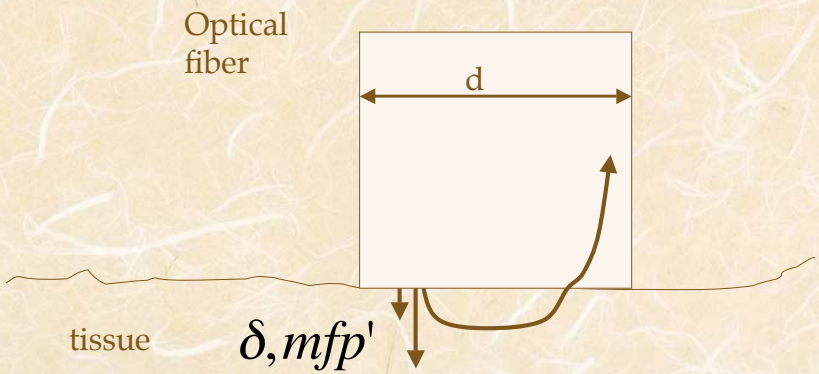
$$R = \frac{M_{test}}{M_{std}} R_{std}$$



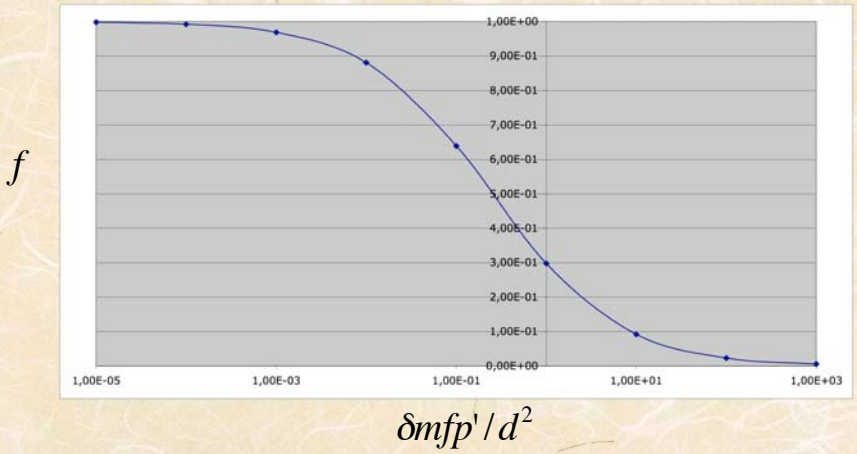
Low f



High f



Collection efficiency, f, depends on optical properties



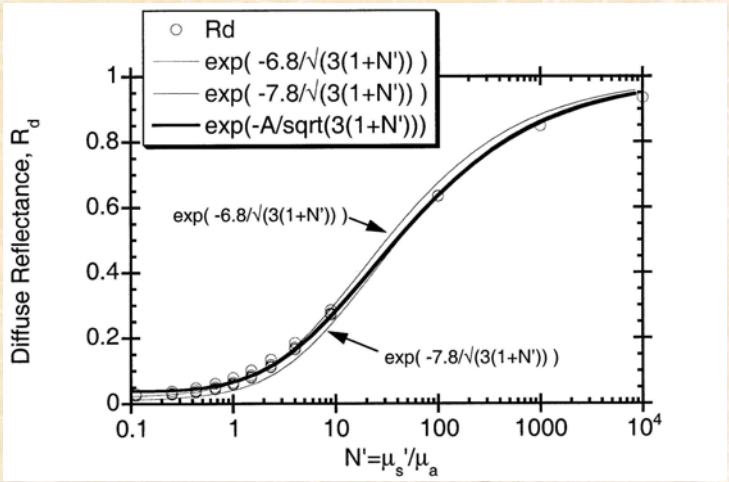
$$f = 1 - (1 + \tanh(x))/2$$

$$\text{where } x = A(\ln(\delta * mfp'/d^2) + B$$

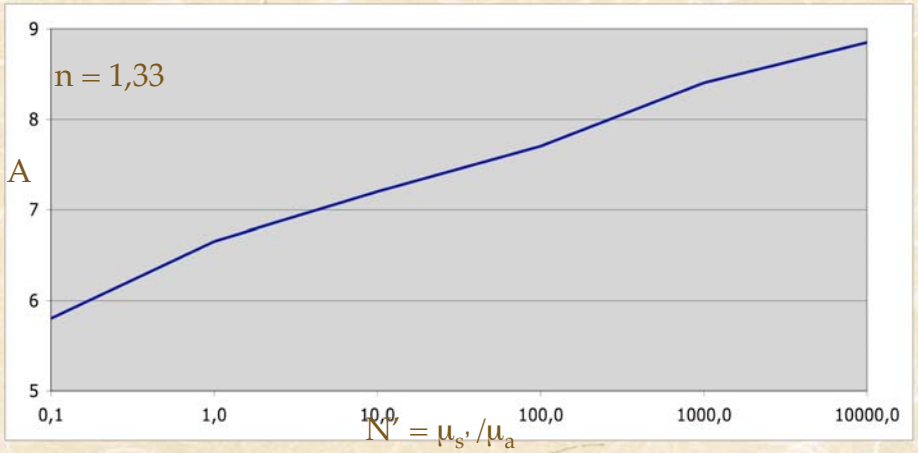
$$A = 0{,}310$$

$$B = 1.38$$

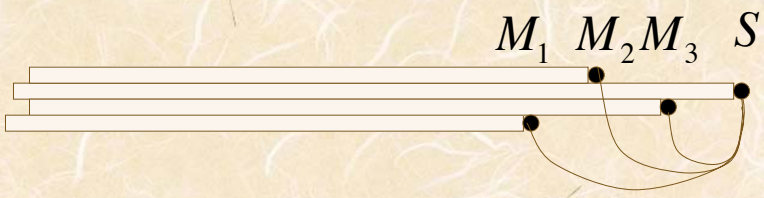
How reflectance depends on the ratio of scattering to absorption



$$R = \exp(-\mu_a A \delta)$$

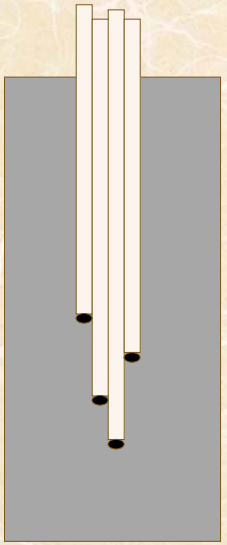


Multifiber probe



Titanium dioxide and epoxy at optical fiber termini

Calibration measurements of fluence rate, F [W / cm²]

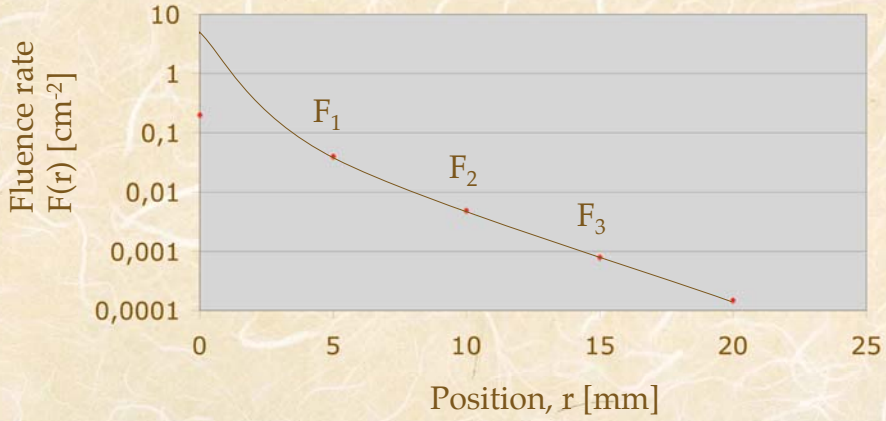


$$F_1 = \text{calib}_1 M_1$$
$$F_2 = \text{calib}_2 M_2$$
$$F_3 = \text{calib}_3 M_3$$

Insert in phantoms with known optical properties

Specify δ and D

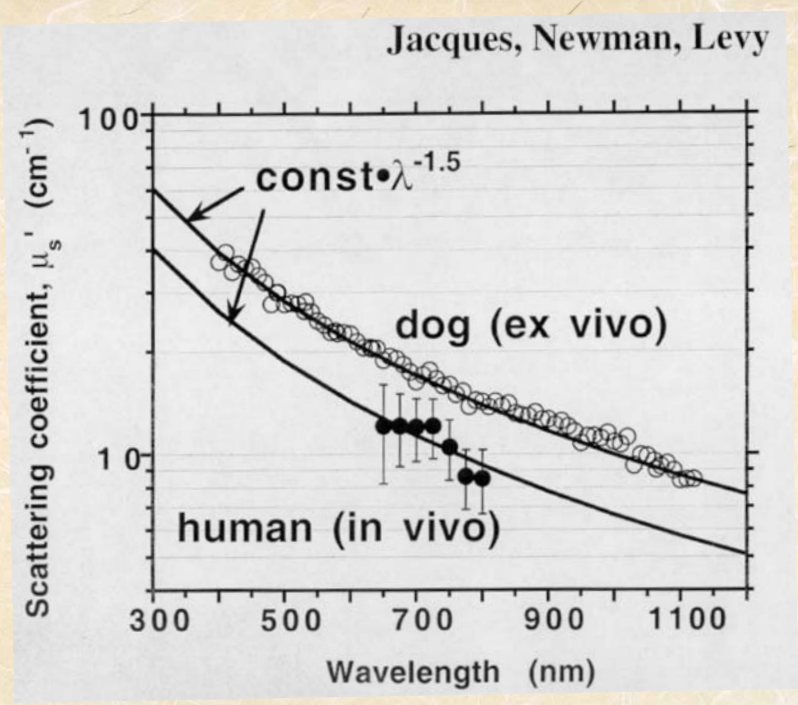
$$F(r) = \exp(-r/\delta)/(4\pi D r), \text{ ger } \delta,\ D$$



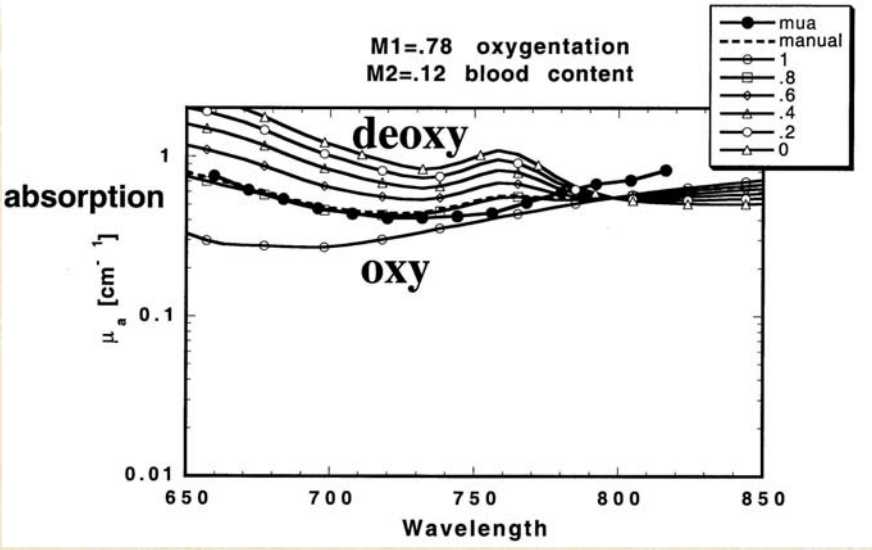
Results

$$\mu_a = \frac{D}{\delta^2}$$

$$\mu_s' = \frac{1}{3D} - \mu_a$$

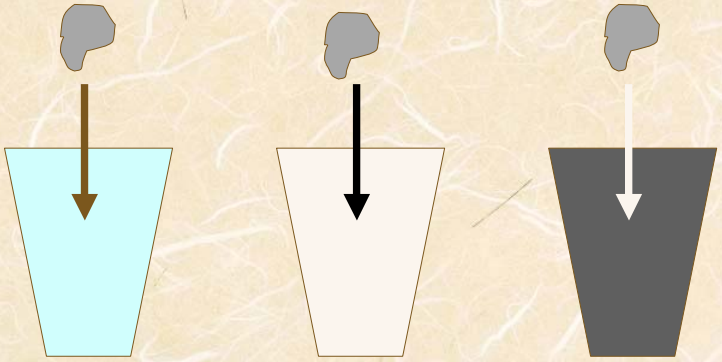


Oxygenation and blood content



Flourescence

Add fluorophore to 3 different solutions



Observed fluence

$$F_{obs} = \int_V Exc * Conv * Esc * dV$$

$\varepsilon C\Phi$

$Ek\exp(-z/\delta)_{ex}$

$b\exp(-z/\delta)_f$

Observed fluence

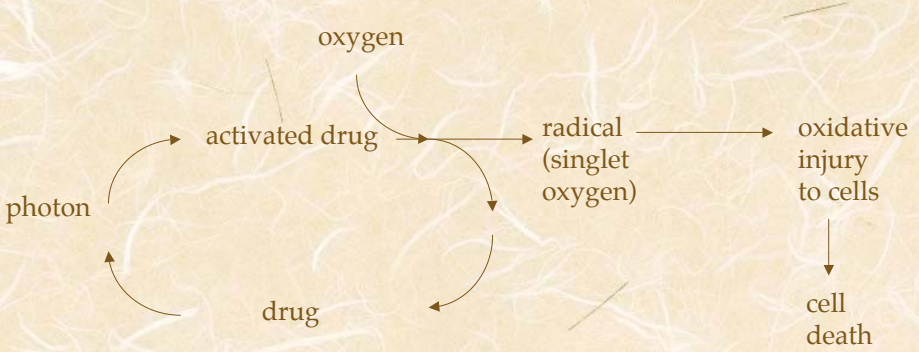
$$F_{obs} = E\varepsilon C\Phi \int_0^{\infty} k\exp(-z/\delta)_{ex} * b\exp(-z/\delta)_f * dz$$

$$F_{obs} = E\varepsilon C\Phi\chi$$

Fluorescence
Exc. irradiance

Tissue optics
Quantum yield
Concentration
Extinction coeff

PDT



PDT treatment

$$P_{th} = Etkb\varepsilon C\Phi\exp(-z_{necrosis}/\delta)$$

E = irradiance

t = time

k = backscatter factor

b = photons per J energy

ε = extinction coefficient

C = concentration

Φ = quantum yield for singlet oxygen

$z_{necrosis}$ *= depth of necrosis*

δ = penetration depth

P_{th} *= threshold radical production for necrosis*

$$z_{necrosis} = \delta\frac{\ln(b\Phi\varepsilon CEtk)}{P_{th}}$$

To double $z_{necrosis}$?