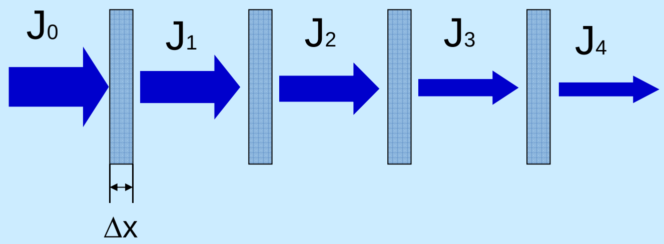
Interaction of light with matter 2.

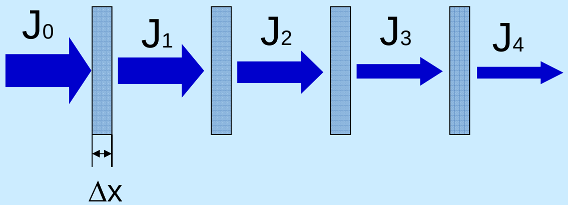
Absorption



Intensity of radiation is attenuated when passing through material

Law of attenuation

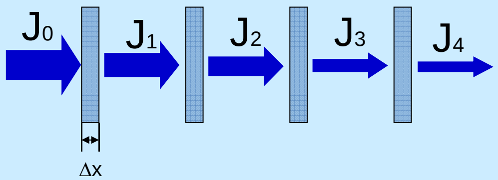
$$\Delta J = J_0 - J_1 = J_1 - J_2 = ...$$



$$\frac{\Delta J}{\Delta x} = -\mu \times J$$

Differential form

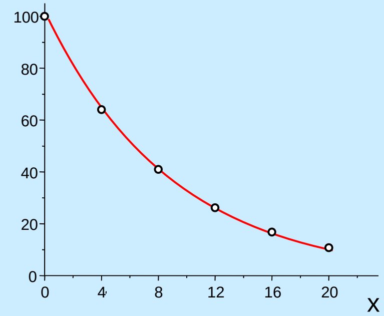
Law of attenuation



$$\frac{\Delta J}{\Delta x} = -\mu \times J$$

solution

$$J = J_0 e^{-\mu x}$$



Macroscopic function

Integral form

Exponential law of radiation attenuation

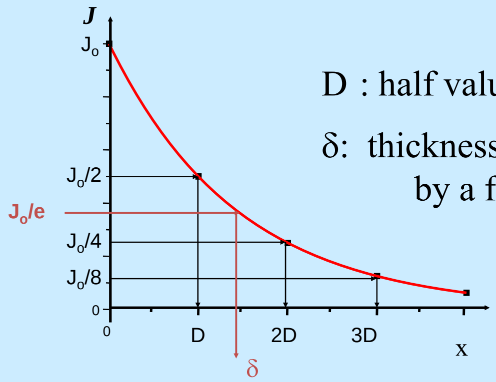
$$J = J_0 e^{-\mu x}$$

J is exponential function of the thickness of the layer.

J_0 : incident intensity [W/m^2]
J : intesity after passing trough x thickness
μ: attenuation coefficient [1/m]

Graphical representation

$$J = J_0 e^{-\mu x}$$



D : half value thickness

δ: thickness decreasing the intensity by a factor e

Definition of attenuation coefficient

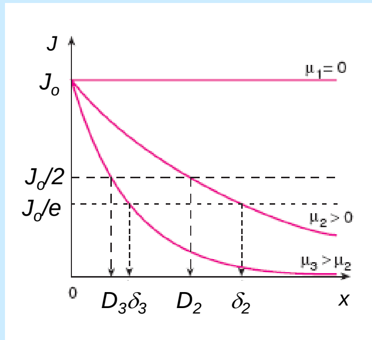
$$J = J_0 e^{-\mu x}$$

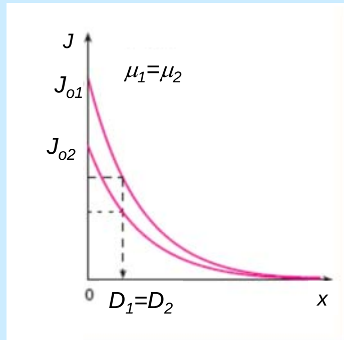
If x = D ⟹ $J_0 / 2 = J_0 e^{-\mu D}$

$$\mu = \frac{\ln 2}{D} = \frac{0.693}{D}$$

If x = δ ⟹ $J_0 / e = J_0 e^{-\mu \delta}$

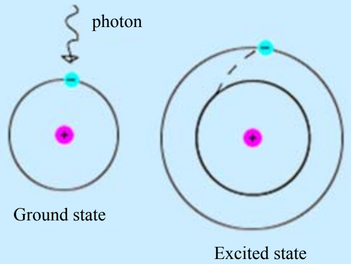
$$\mu = \frac{1}{\delta}$$





Mechanism of light absorption

Repetition: structure of atom

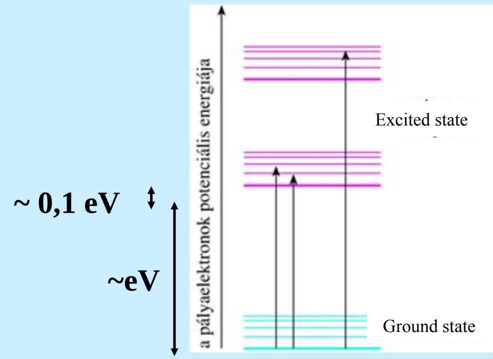


$$hf = \Delta E = E_{n+1} - E_n$$

$E_{VIS} = 1.6 – 3.1\ eV$

Excitation of outer shell electrons

Electronic and vibronic energy levels



Fate of excited electron will be discussed later

Laboratory application of light absorption

$$J = J_0 \cdot e^{-\mu x}$$

$$\lg \frac{J_0}{J} = \mu \cdot x \cdot \lg e$$

in dilute solutions :
μ ~ concentration

$\mu \lg e = \varepsilon_{(\lambda)}\, c$

$$\lg \frac{J_0}{J} = \varepsilon_{(\lambda)} \cdot c \cdot x$$

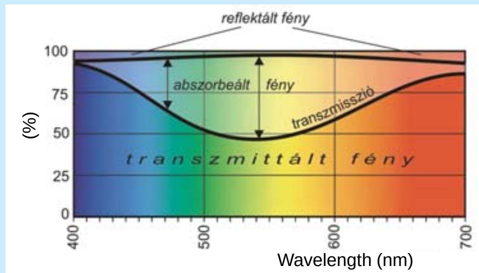
Lambert – Beer law

Absorbance
or
Optical density

$$\lg \frac{J_0}{J} = \varepsilon_{(\lambda)} \cdot c \cdot x$$

Transmittance

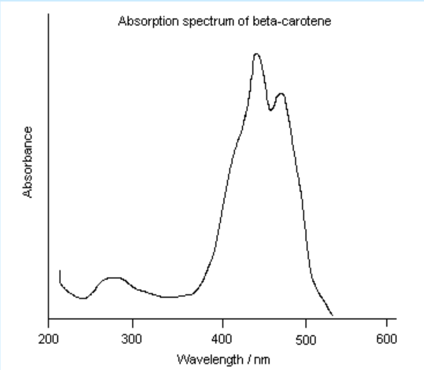
$$\tau = \frac{J_{transmit}}{J_{incident}}$$



Specra of red glace

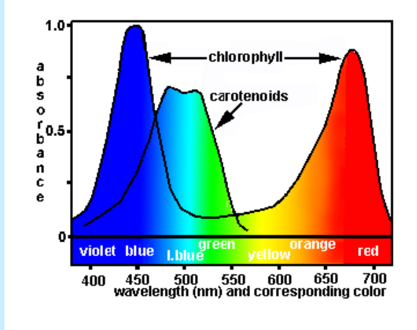
$$\lg \frac{J_0}{J} = \varepsilon_{(\lambda)} \cdot c \cdot x$$

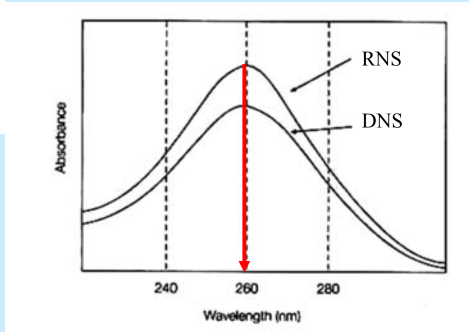
Absorbance – is the function of the wavelength

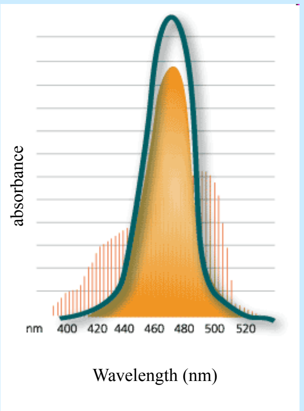


Absorption spectrum:

absorption spectrum of some biological macromolecules

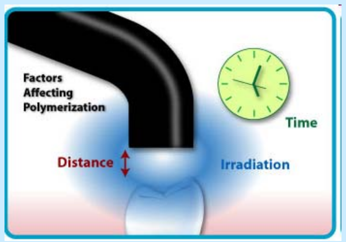




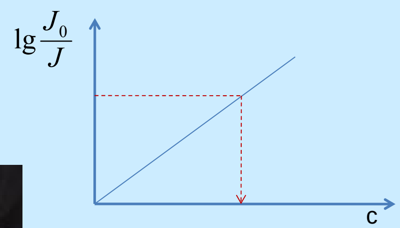


Camphor chinone

Application in dentistry



$$\lg \frac{J_0}{J} = \varepsilon_{(\lambda)} \cdot c \cdot x$$



Absorption based determination of concentration

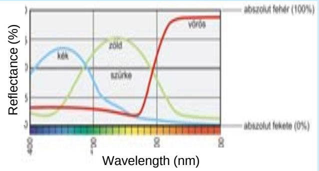
Why do objects appear the color they are?

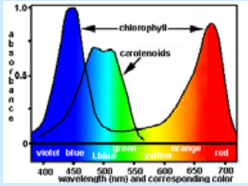
reflection

scattering

absorption

$$\rho(\lambda)+\sigma(\lambda)+\alpha(\lambda)=1$$





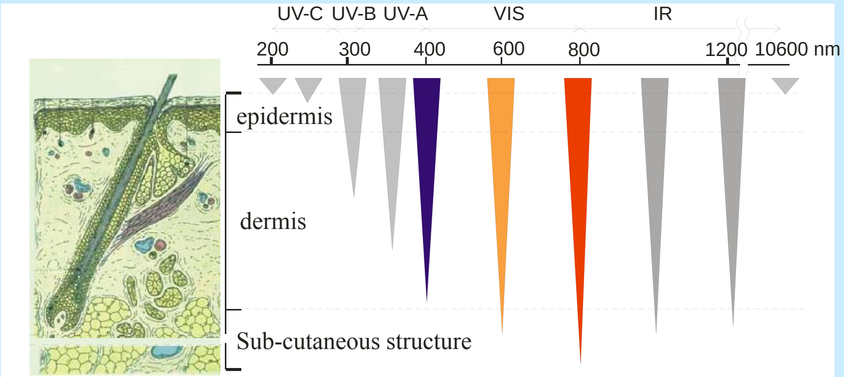
e.g. reflection of red
↓
red

Influenced by the relative position of the light source and observer, size of particles etc

e.g. red absorption
↓
green in transmitted light

Some aspectrs of biological effects of light

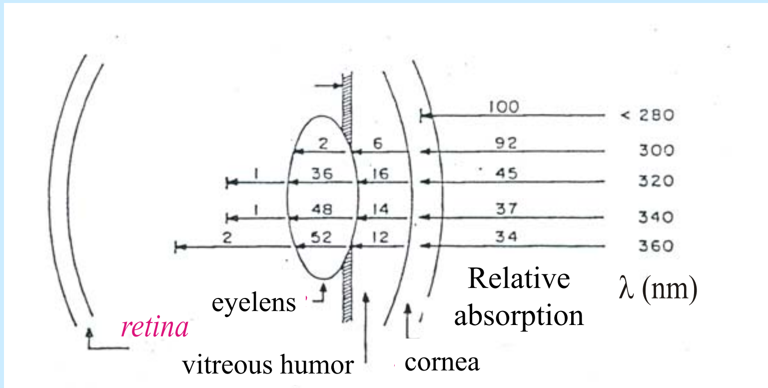
Penetration of light into the skin



Light intensity is attenuated due to absorption, reflection, refraction.

Penetration depth depends on the wavelength.

Penetration of light into the skin



Molecules absorbing light in our body - chromophores

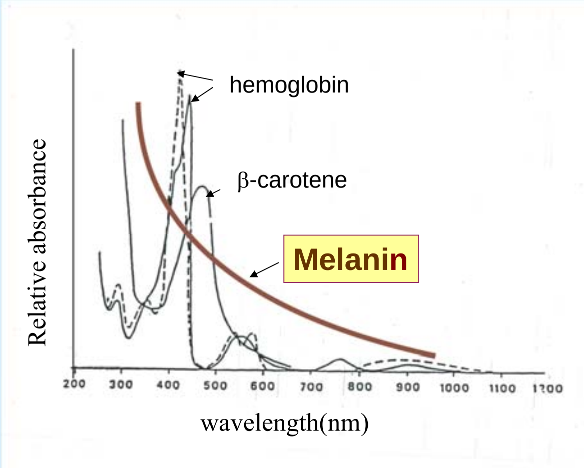
Endogenous chromophores

e.g.
- nucleic acids
- proteins
- melanins
- urocanic acid

Exogenous chromophores

e.g.
- dyes in food
- cosmetics
- drugs

Endogenous chromophores absorbing in VIS



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II. 1.1.
- 1.1.1
- 1.1.3

II. 2. 1.
- 2.1.1
- 2.1.2
- 2.1.3
- 2.1.4
- 2.1.5
- 2.1.8

VI.3
- 3.1.1
- 3.1.2