Problem #13: Egg White

“White light appears red when it is transmitted through a slice of boiled egg white. Investigate and explain this phenomenon. Find other similar examples”

Brazilian Team

1.0 THEORETICAL BACKGROUND

Light

- Analysing light as a wave, we can say that:

$$v = \Delta s / \Delta t = \lambda / T = \lambda . f$$

$$\boxed{c = \lambda f}$$

- Analyzing light as packets of energy, we can say that:

$$\boxed{E = hf}$$

Visible Light

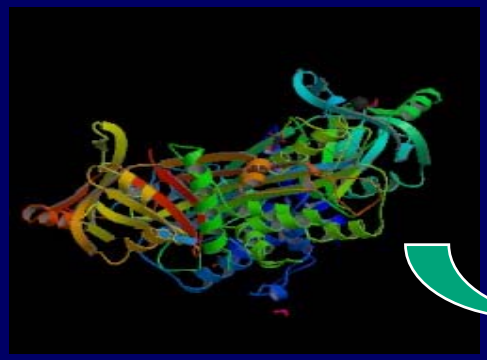
$\boxed{400nm < \lambda < 700nm}$ $\boxed{3.2\ eV < E < 1.7\ eV}$

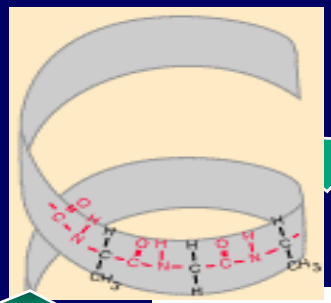
1.1 THEORETICAL BACKGROUND

The egg white:

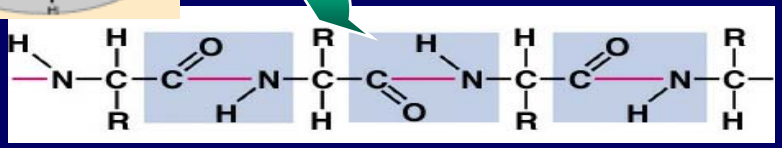
Water 88%
Proteins 11%
Fat 0.2%
Carbohydrates 0.8%

Ovoalbumin 54%
Ovotransferrin 12%
Ovocoid 11%
Other 33%





Polypeptide chain



2.0 HYPOTHESIS

Light is attenuated (scattered or absorbed);

- Pair Production
- Photoelectric effect
- Rayleigh Scattering
- Compton scattering

$$\mu = \sigma_c + \kappa + \sigma + \tau$$

μ – Total attenuation coefficient
σ_c – Rayleigh attenuation coefficient
κ – Photoelectric attenuation coefficient
σ – Compton attenuation coefficient
τ – Pair production attenuation coefficient

2.1 HYPOTHESIS (cont.)

A) Pair production:

A photon interacts with a nuclear field and creates a pair eletron-positron.

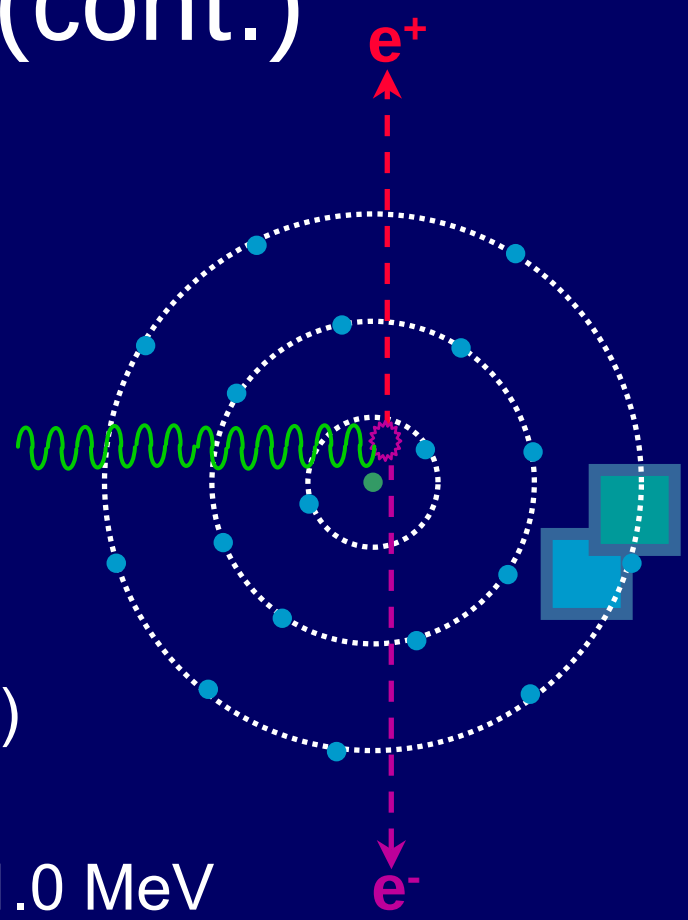
- Relativistic energy conservation:

$$E_f = E_e + E_p = (K_e + m_o c^2) + (K_p + m_o c^2)$$

E_f minimum = $2\ m_o c^2 = 2 * 0.50$ MeV = 1.0 MeV

Visible → 3.2 eV < E < 1.7 eV

Not visible!



2.2 HYPOTHESIS (cont.)

B) Photoelectric effect:

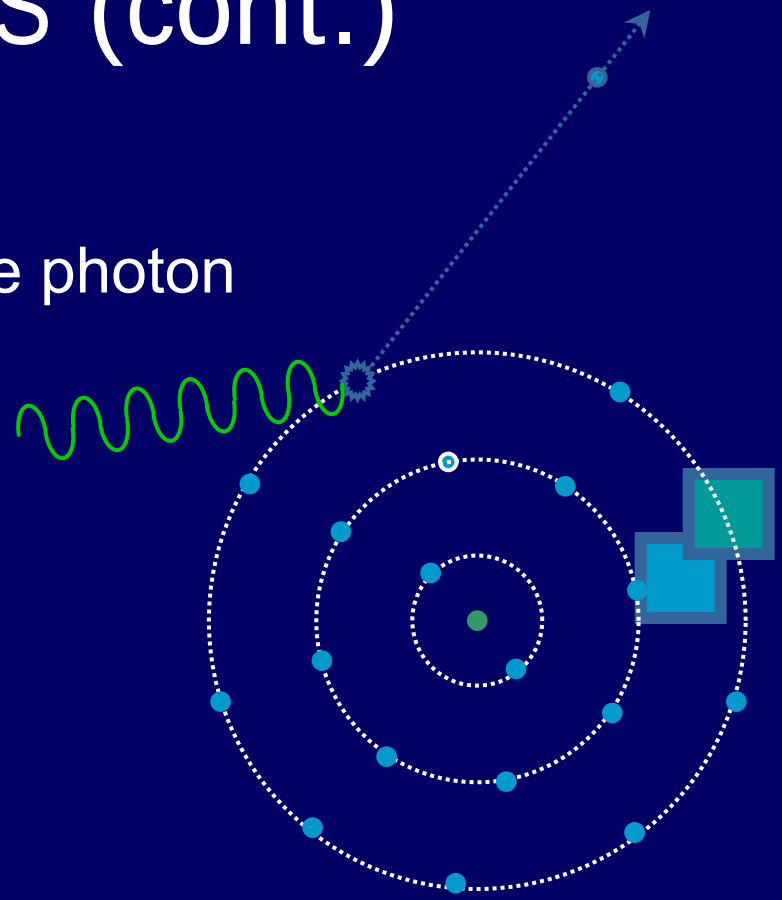
Eletron absorbs energy from the photon and is released from the atom.

Energy conservation:

$$E_f = E_C + K_e$$

Energy of conection of atoms (eV):

	C	O	N	H
1s	288.2	538.3	403.8	13.6
2s	16.6	28.7	20.3	
2p	11.3	13.6	14.5	



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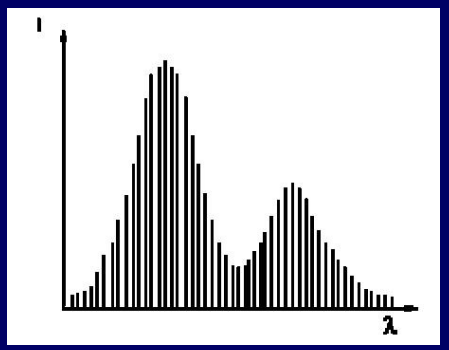
2.3 HYPOTHESIS (cont.)

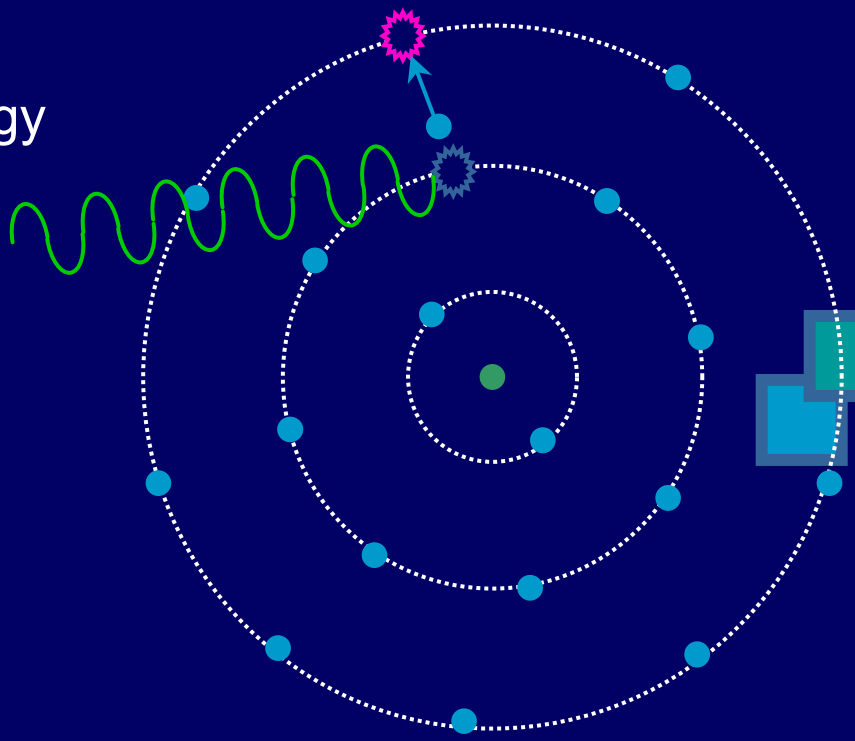
C) Electronic Excitation:

Eletron absorbs the photon energy and goes to a higher energy layer.

$$E = E_f - E_i$$

When the electronic excitation happens, the graph shows bands.





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2.4 HYPOTHESIS (cont.)

D) Elastic scattering:

Light interacts with electric charges, scattering light.

- Particles: Thomson Scattering effect

- Molecules: Rayleigh scattering effect

<u>It will depend on</u>:

- Difference of refractive index

- Density of the material

2.5 HYPOTHESIS (cont.)

C) Rayleigh scattering effect:

- Rayleight Scattering occurs with particles much smaller than the light wavelength

$$\mu = \frac{8\pi^4 N r^6}{\lambda^4 d^2}\left|\frac{m^2-1}{m^2+2}\right|^2\left(1+\cos^2\theta\right) \longrightarrow \Rightarrow \mu \propto \frac{1}{\lambda^4}$$

- μ is the coefficient of extinction of light
- Blue light is more scattered than red light

3.0 EXPERIENCE

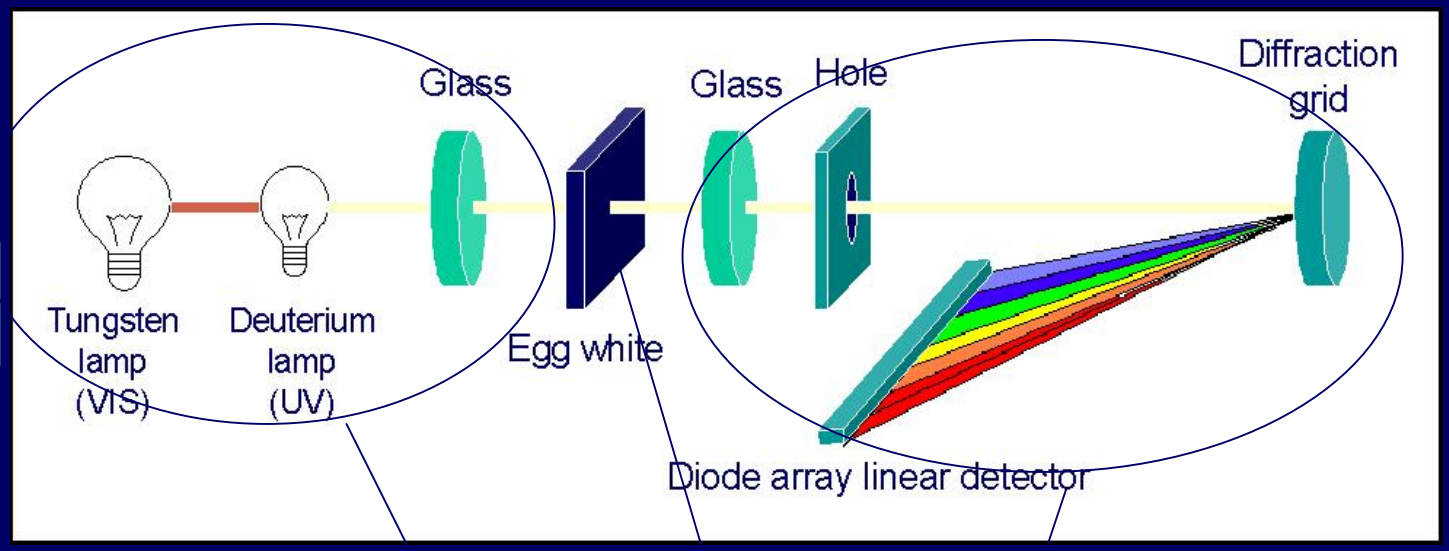
a) Material

- Spectrophotometer
- Four slices of boiled egg with different thickness
- Microscope
- Origin software

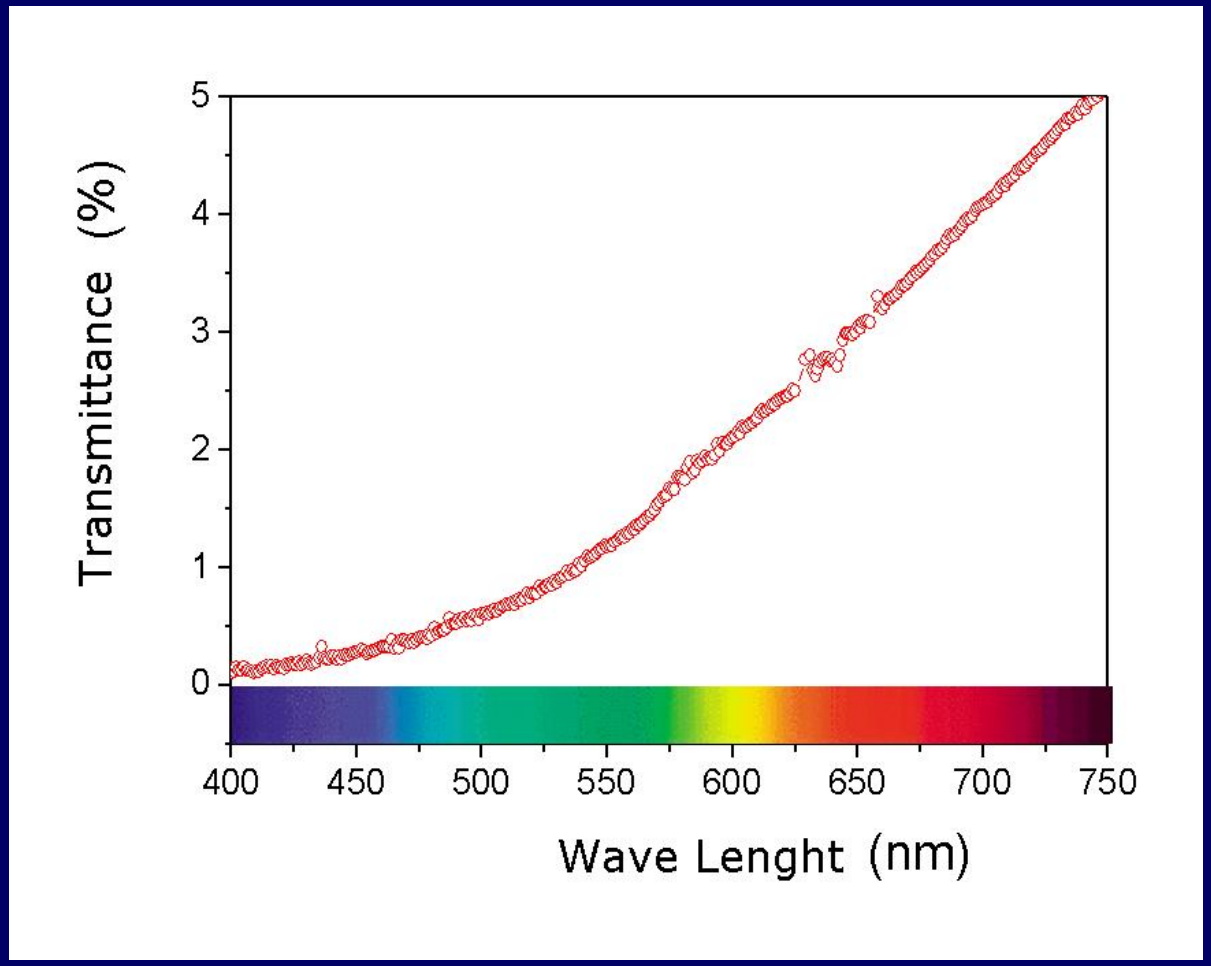
b) Procedure

- Measure the transmittance of the light of the slice #1
- Measure the thickness of the slices #1, #2, #3 and #4
- Compare the absorbance of each slice

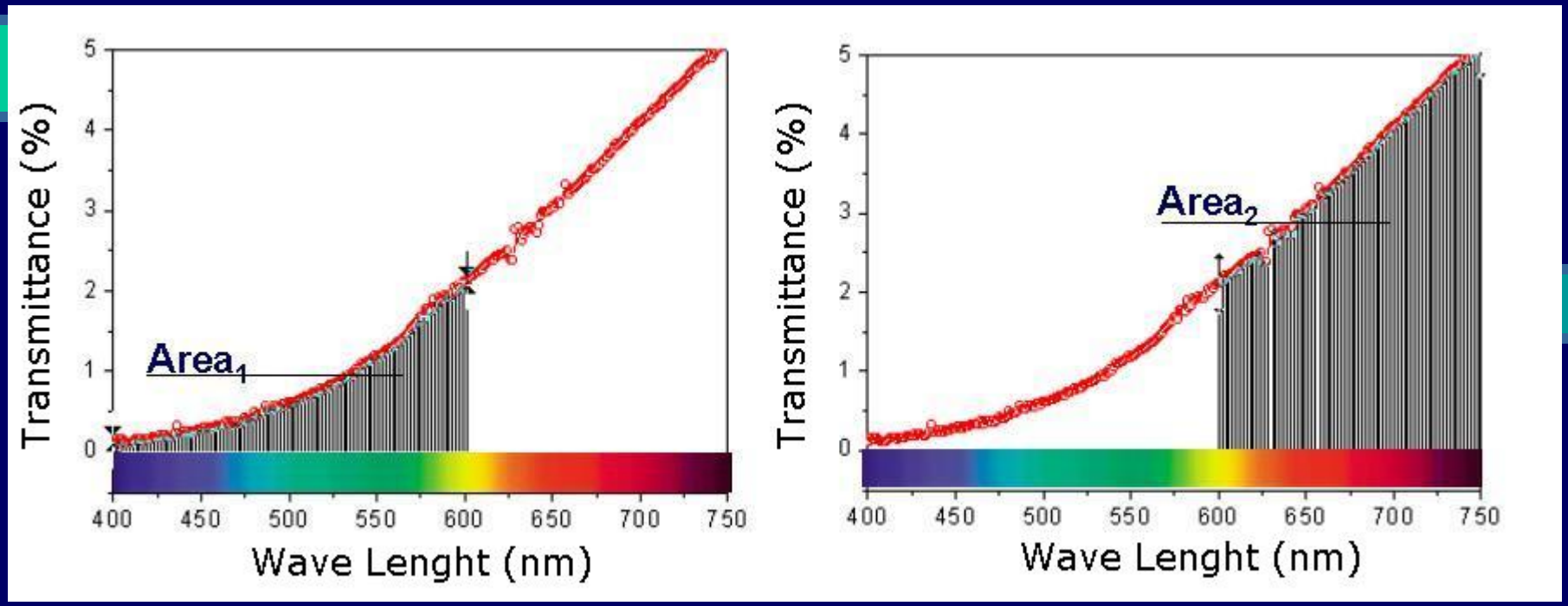
3.1 EXPERIENCE (cont.)



3.2 EXPERIENCE (GRAPH)



3.2.1 WHY RED?



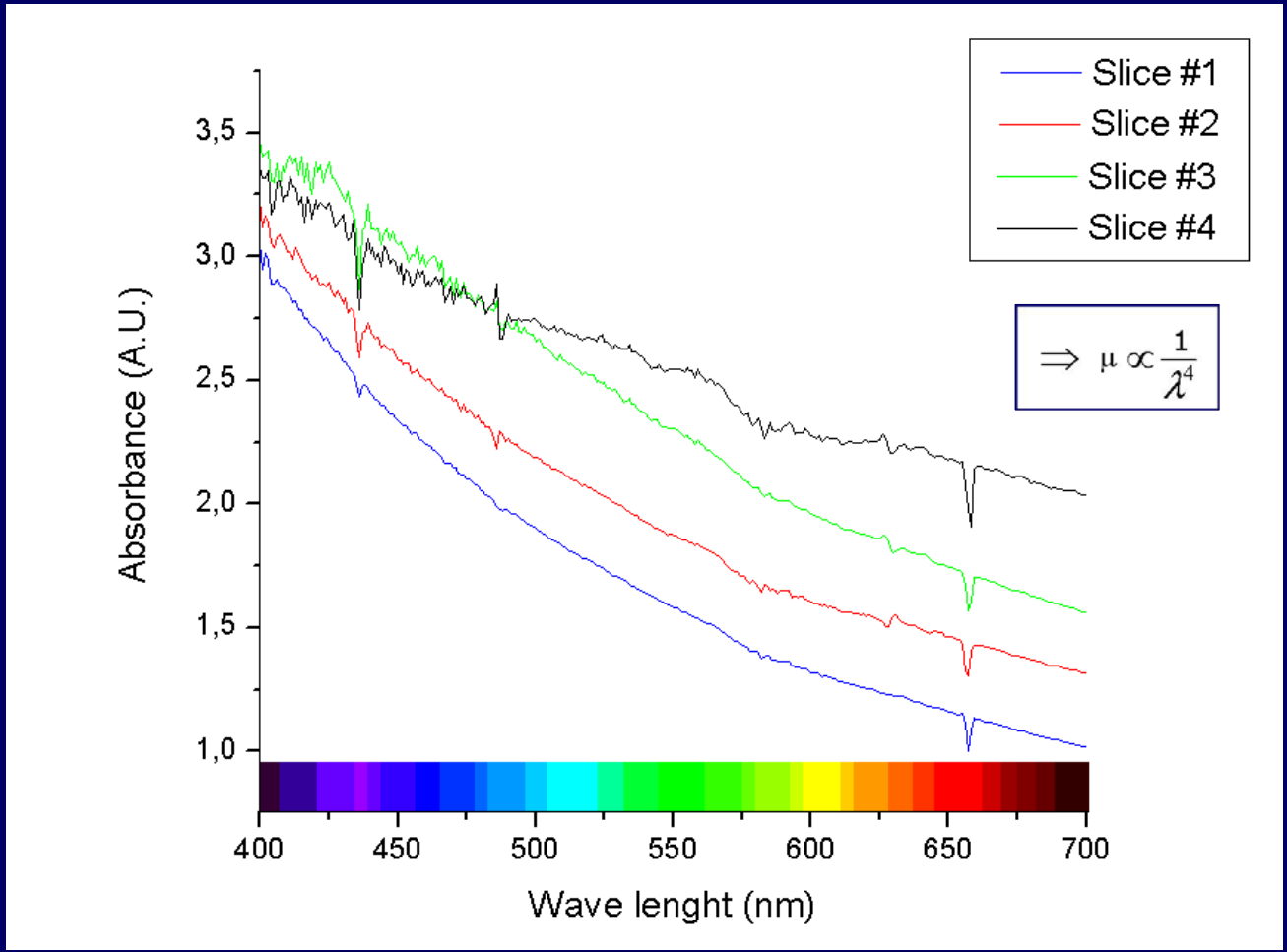
$Area_2 > Area_1$

3.3 EXPERIENCE (cont.)

Thickness

	Thickness
Slice #1	1.7×10^{-8} m
Slice #2	2.0×10^{-8} m
Slice #3	3.5×10^{-8} m
Slice #4	6.2×10^{-8} m

3.4 EXPERIENCE (GRAPH)



Slice #1 < Slice #2 < Slice #3 < Slice #4

4.0 SIMILAR EXAMPLES

a) The sky

- At noon, less space to go through

- At dawn and dusk, more space to go through

4.1 SIMILAR EXAMPLES (bcont.)

b) Human fingers

- Shining a bright light on our thumbs we can see a red light
- Absorption of lower wave lenghts, leaving red to expose itself

c) Sky clouds

- Water drops scatters light almost equally (Mie Scattering)

d) Optic fiber

- Minimum attenuation of light