

Conference on the physics, Chemistry and Biology of Water
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Photosynthesis & water: why researches have created a divorce between them?

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This talk cover physics on:

Plants,

Optics,

Water,

Bandgap engineering (interfaces),

Electrical charges separation,

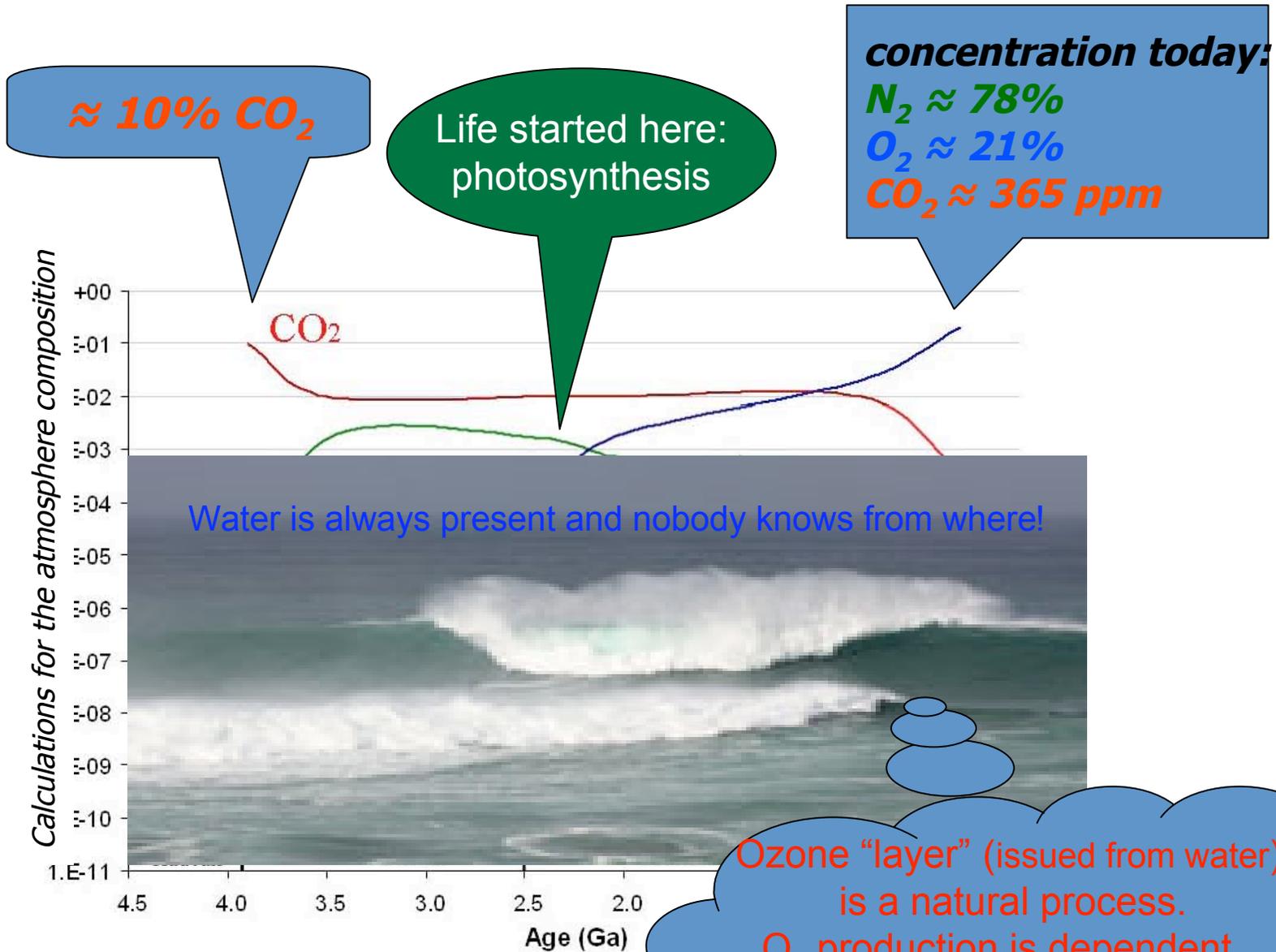
Some conclusions.

Some references:

G. Pollack et al: <http://www.youtube.com/watch?v=XVBEwn6iWOo>

G. Pollack: book: www.ebnerandsons.com

M. Sacilotti et al, june 2012, WJNSE: <http://www.scirp.org/journal/wjnse/>

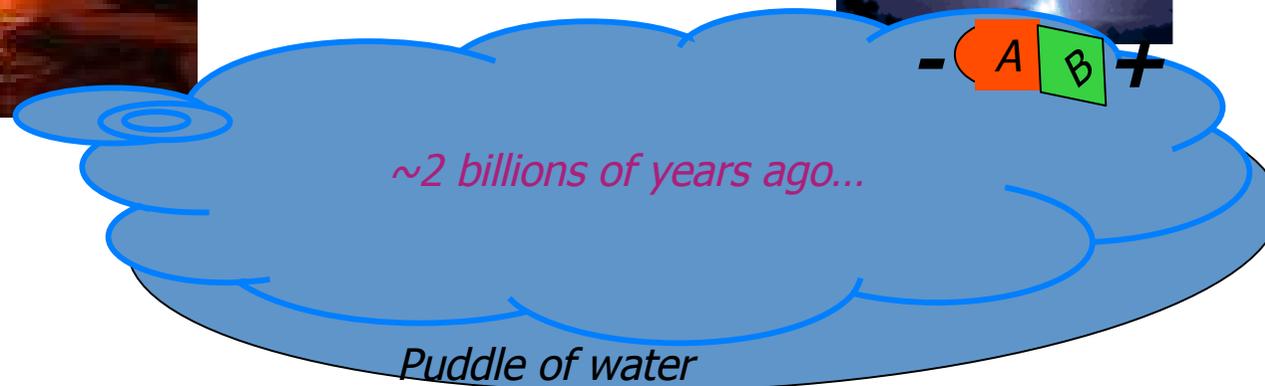


: Schematic evolution of abundances of key atmospheric species (2004)

Arxiv: lkaltenegger@cfa.harvard.edu & J. Kasting Scientific American

... evolution of Nature over 2-4 billions years,
... is based on the charge separation mechanism...

A puddle composed of water, chemicals & in a N_2 & $\sim 10\%CO_2$
atmosphere (**no O_2 & no O_3**) and ...
illuminated by the sun and/or ...:



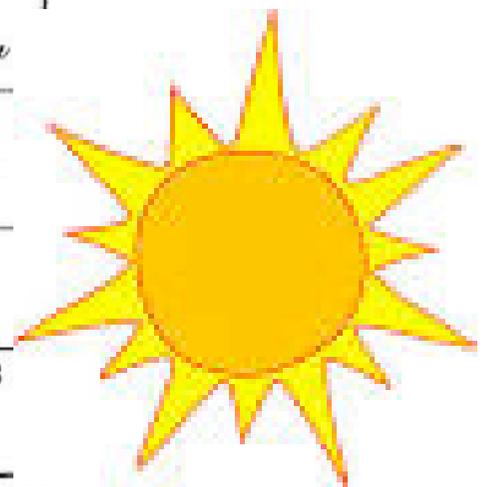
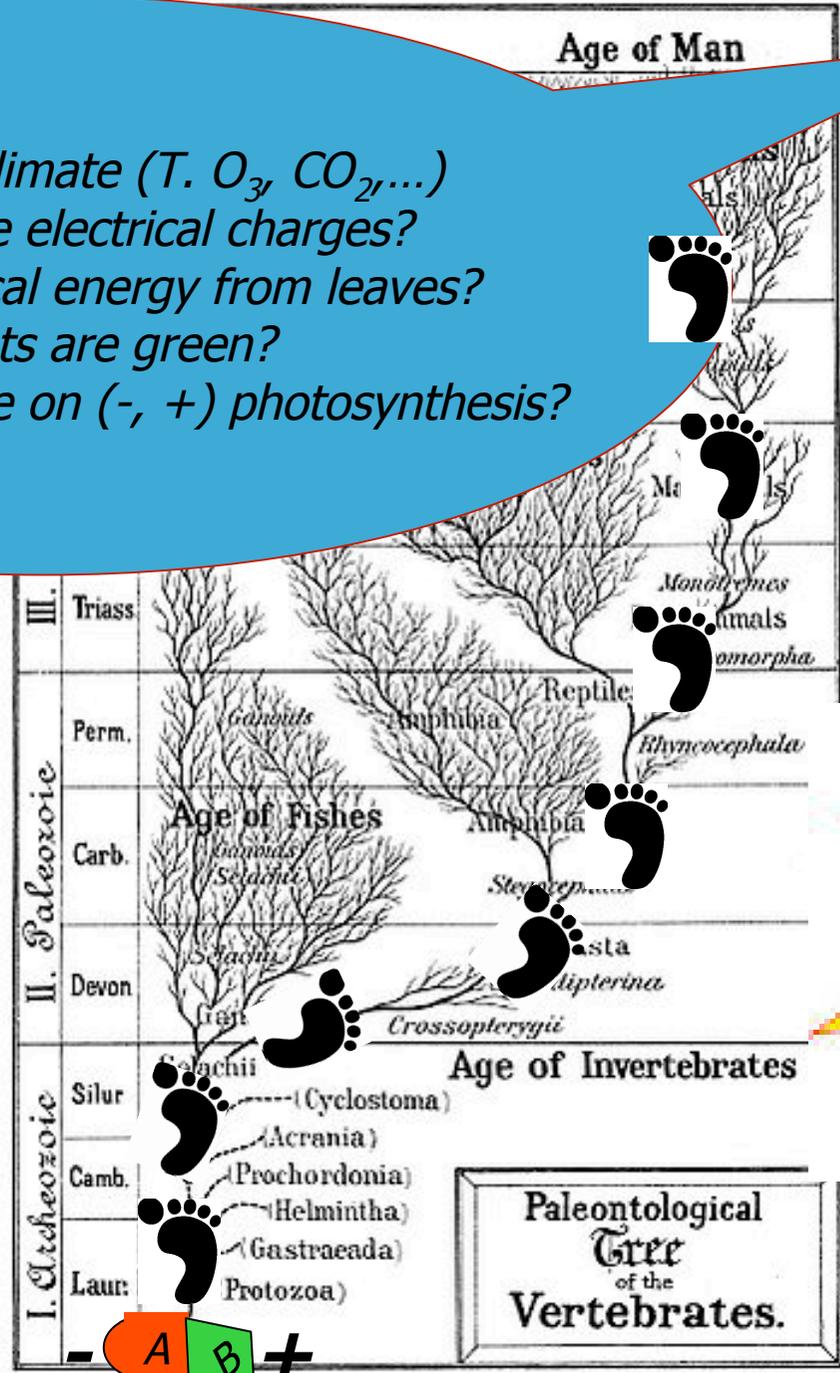
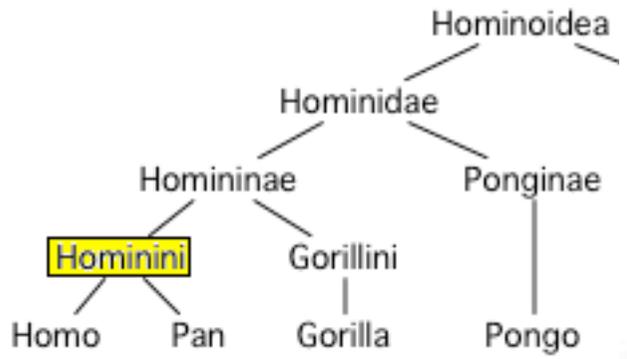
Leaves' like

Horse sea family



... so life evolved ...

Origin of life & climate (T , O_2 , CO_2 , ...)
 How to separate electrical charges?
 How to waste optical energy from leaves?
 Why plants are green?
 What is the water's role on (-, +) photosynthesis?



Questions:

Two billions of years ago Nature created only one mechanism to separate O_2 from H_2O .

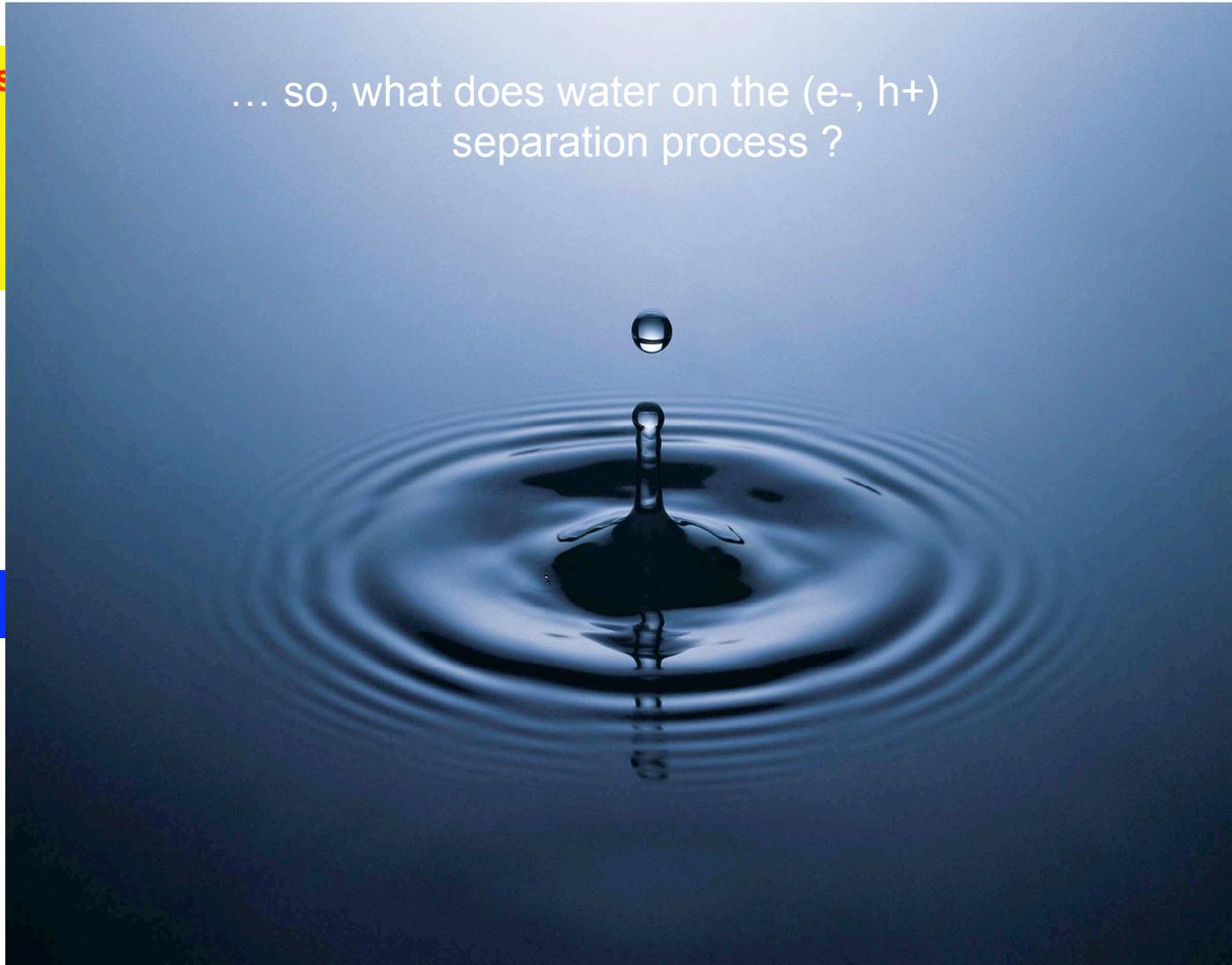
This

... so, what does water do on the (e^- , h^+)
separation process ?

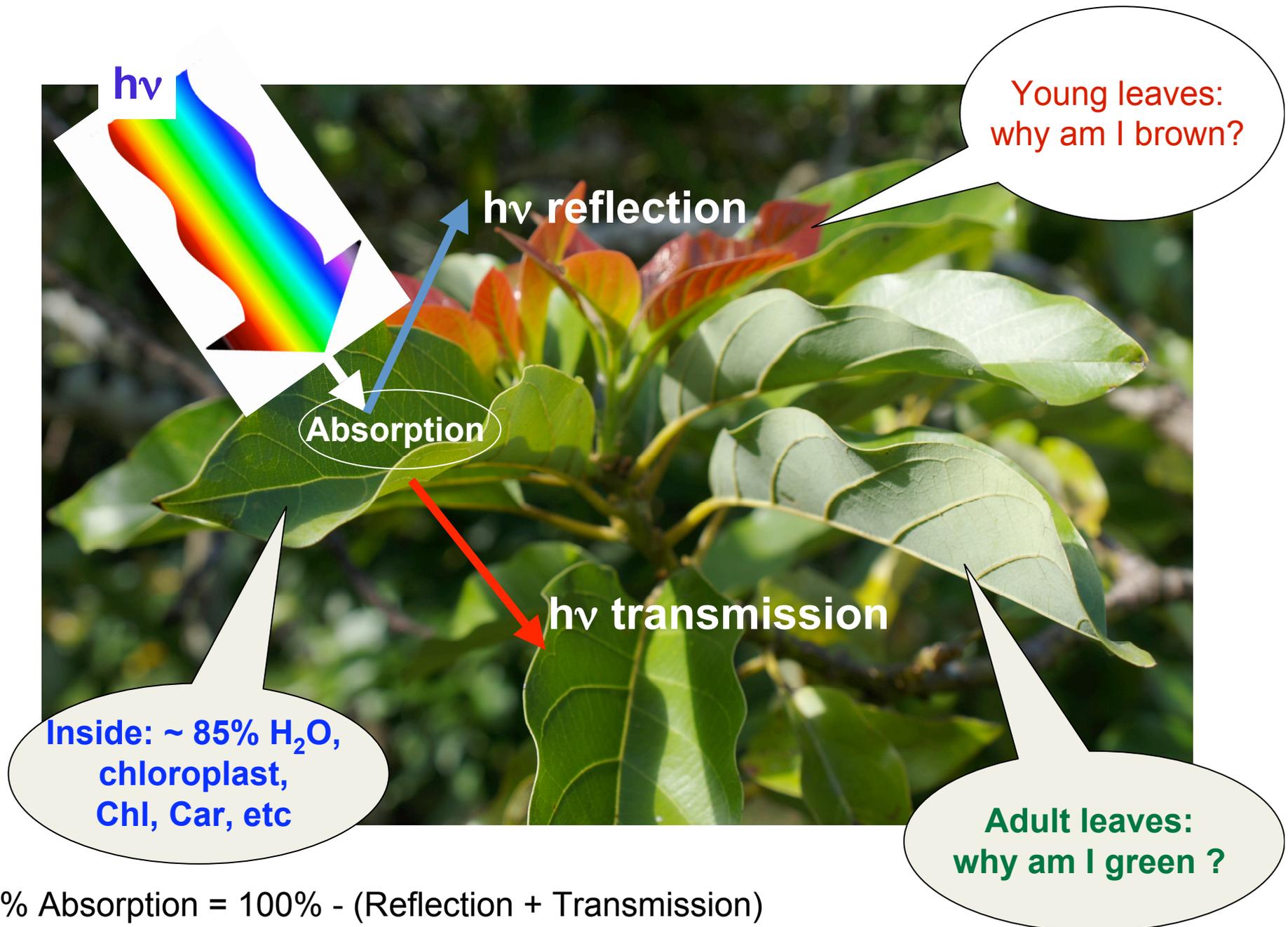
s)

How many

ed? One?

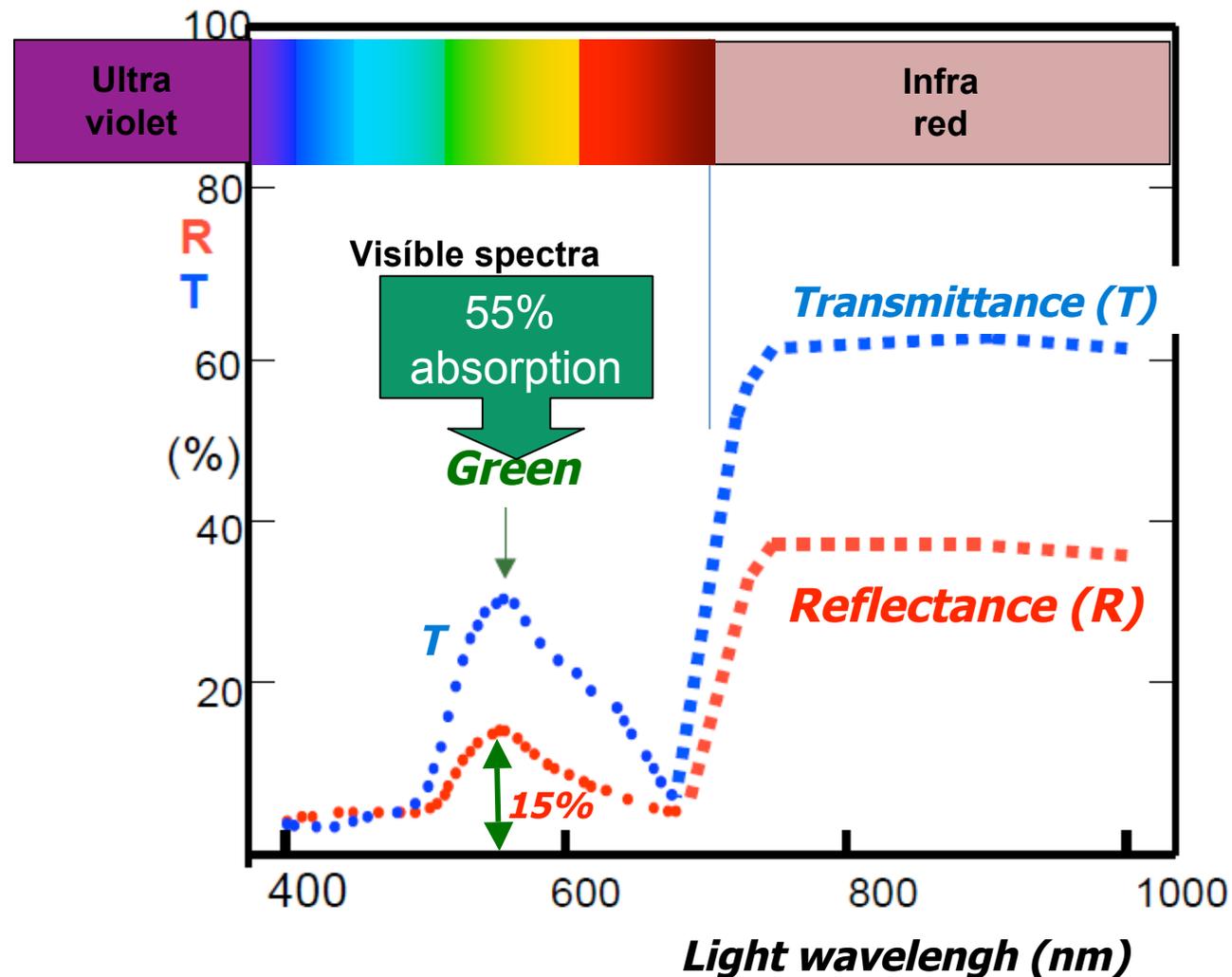


For leaves: reflection and transmission experiments.



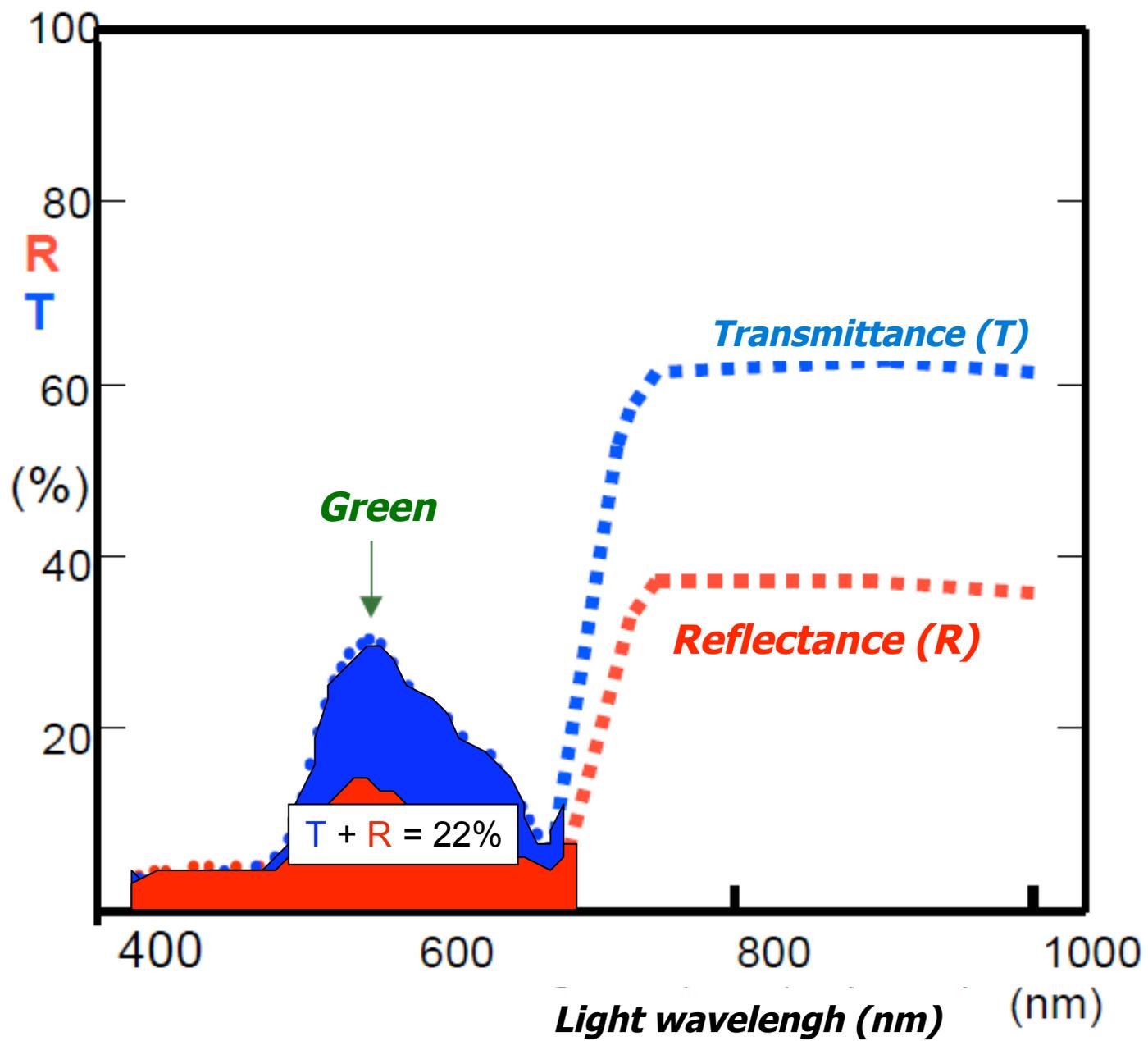
$$\% \text{ Absorption} = 100\% - (\text{Reflection} + \text{Transmission})$$

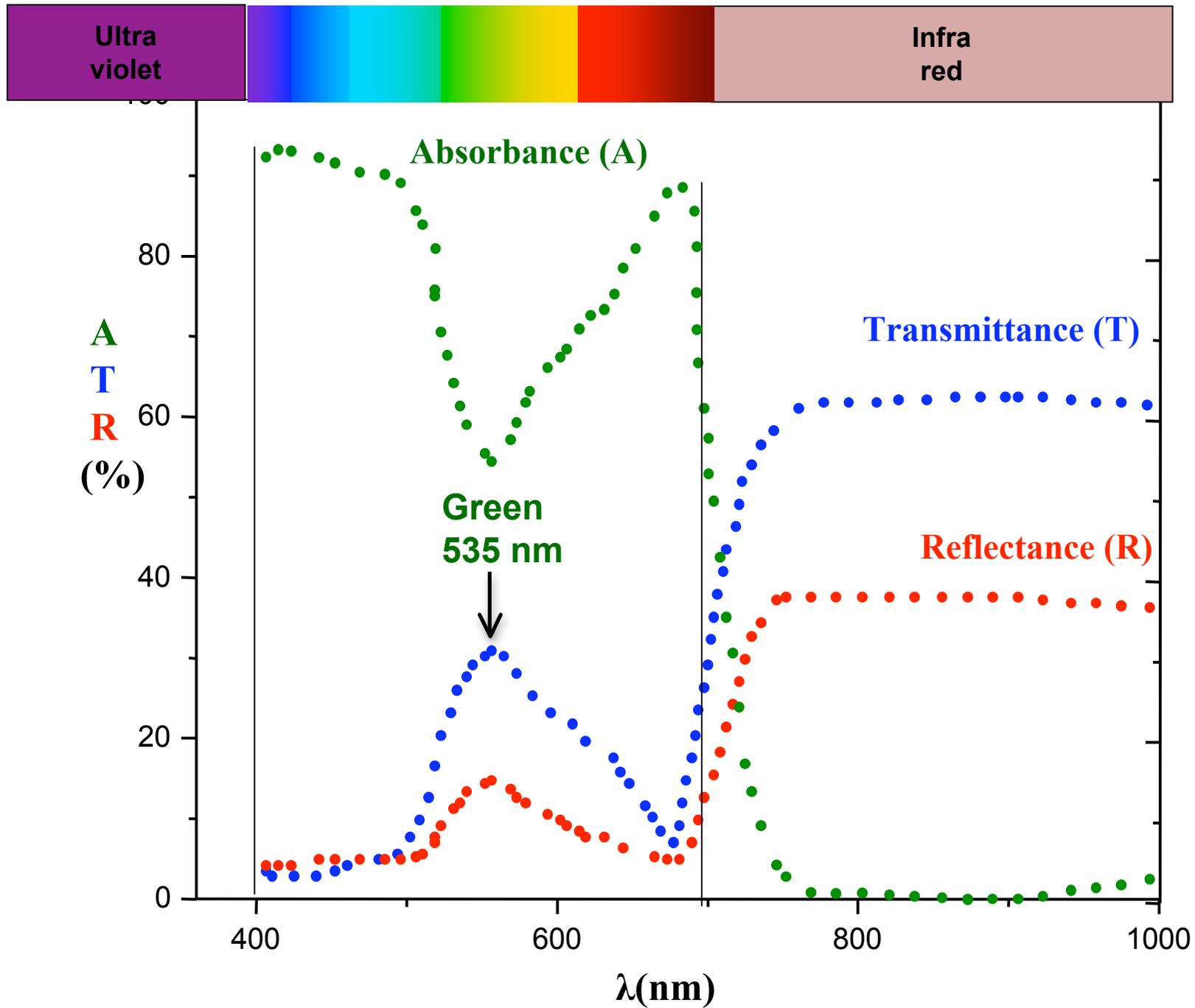
Standard curves for Transmittance, Reflectance and Absorption for leaves.
A mystery never discussed ... Why?



S. Seager arXiv:astro-ph/0503302v1 14 Mar 2005

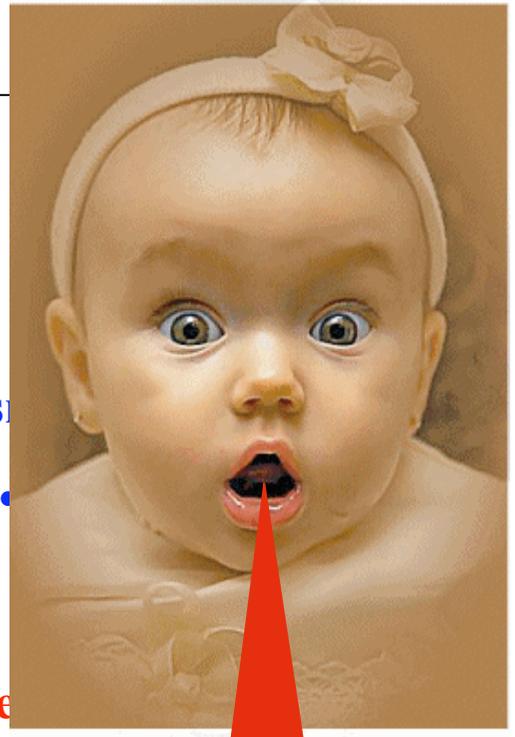
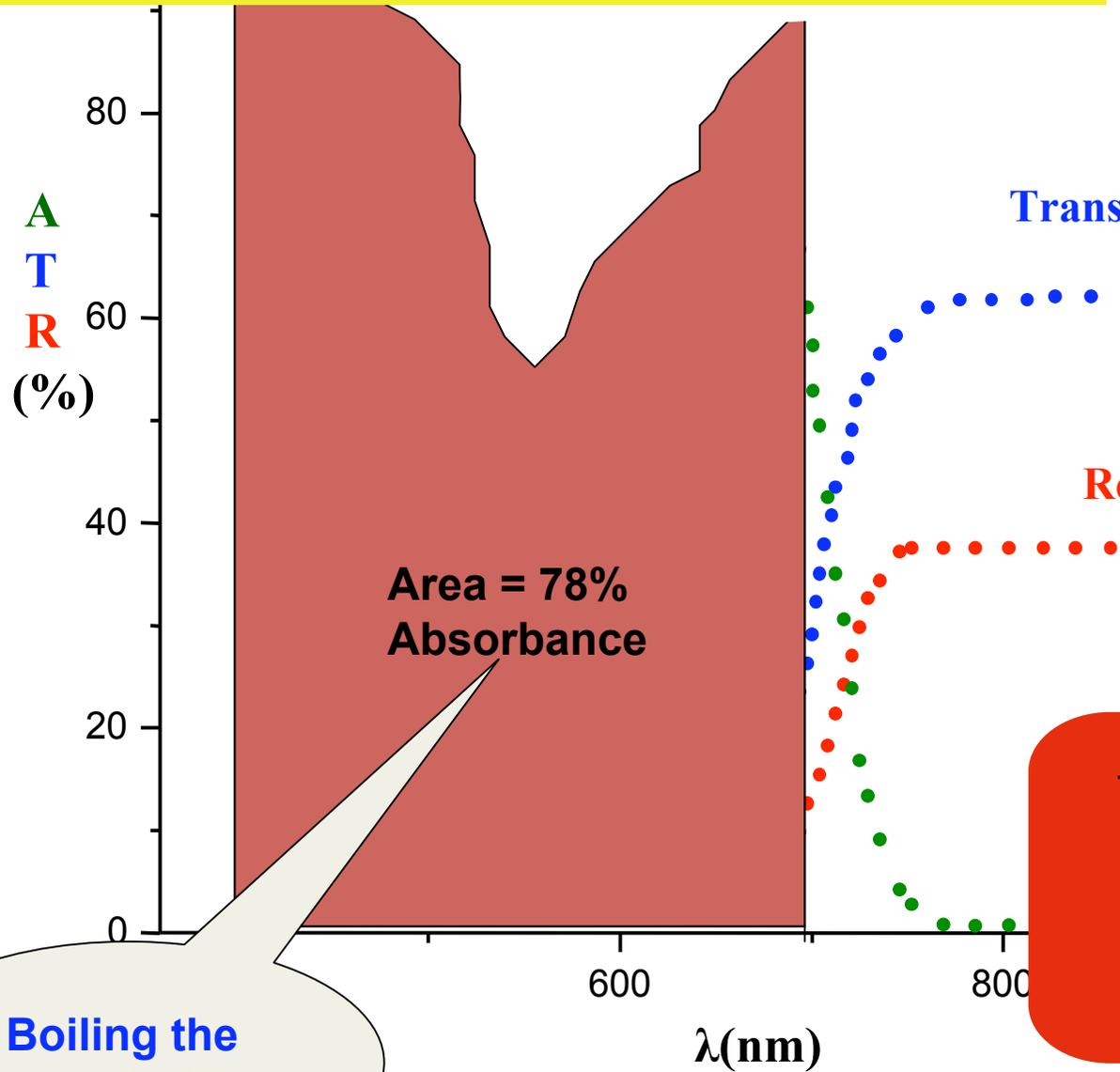
Only 15% of reflectance (535 nm) does not explain the green colour intensity of plants.
Is there any scientific proof that Chlorophyll does not absorb green light?
What about absorption and emission at nearly the same (green) wavelength?





Note: for green colour there is only 15% of reflectance. This does not explain the green intensity of the leaves.

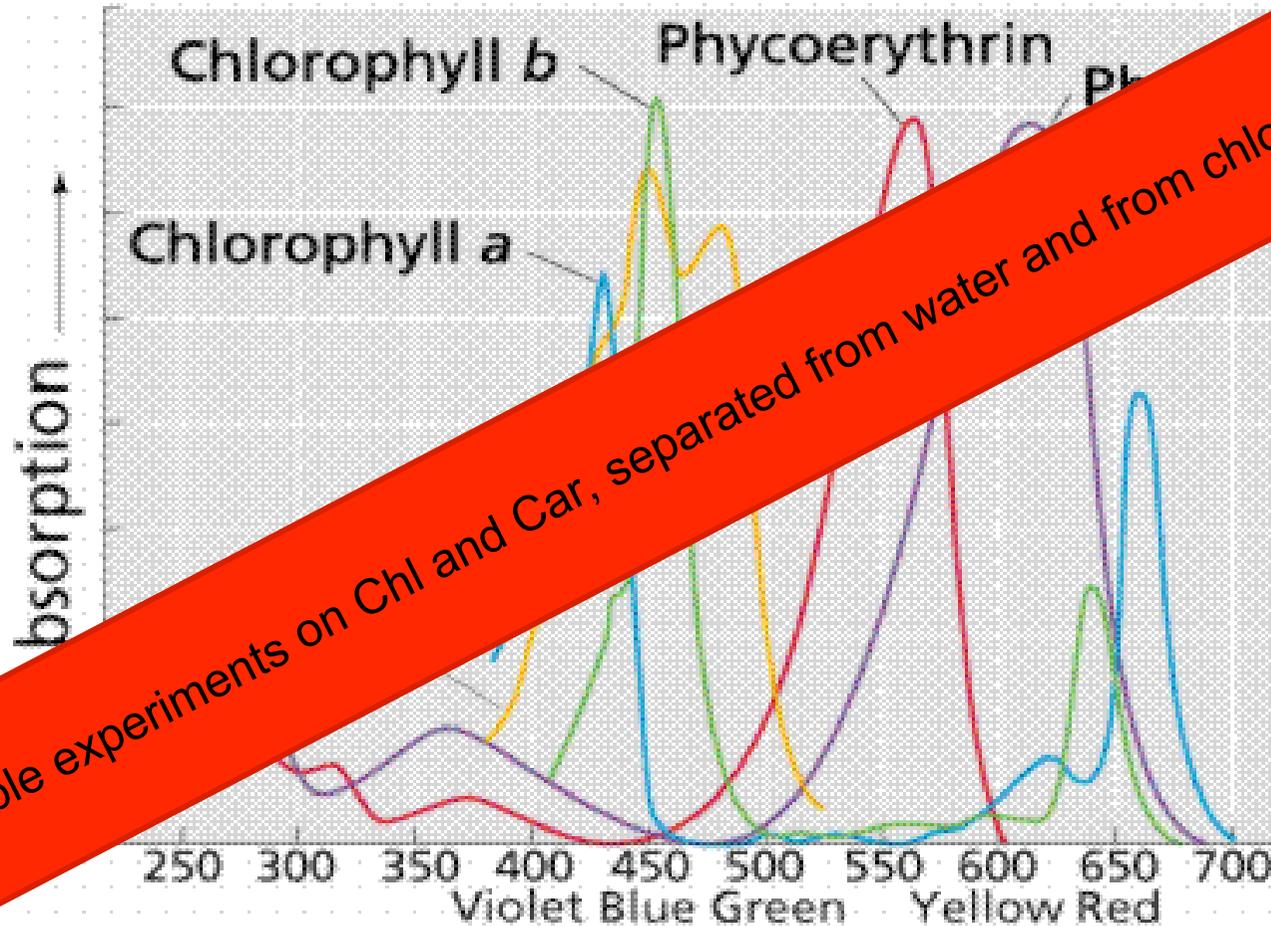
78% of absorbance will kill leaves in few minutes in sunny days. How to get rid of this problem? How to explain that leaves have to waste about 70% of absorbed visible light?



Boiling the water inside

Unbelievable!
They have never seen this before ?
Why?
Physicist
where are you?

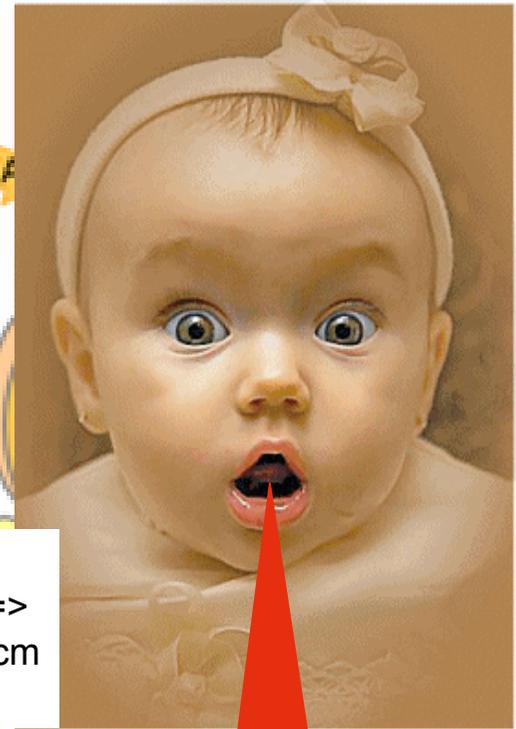
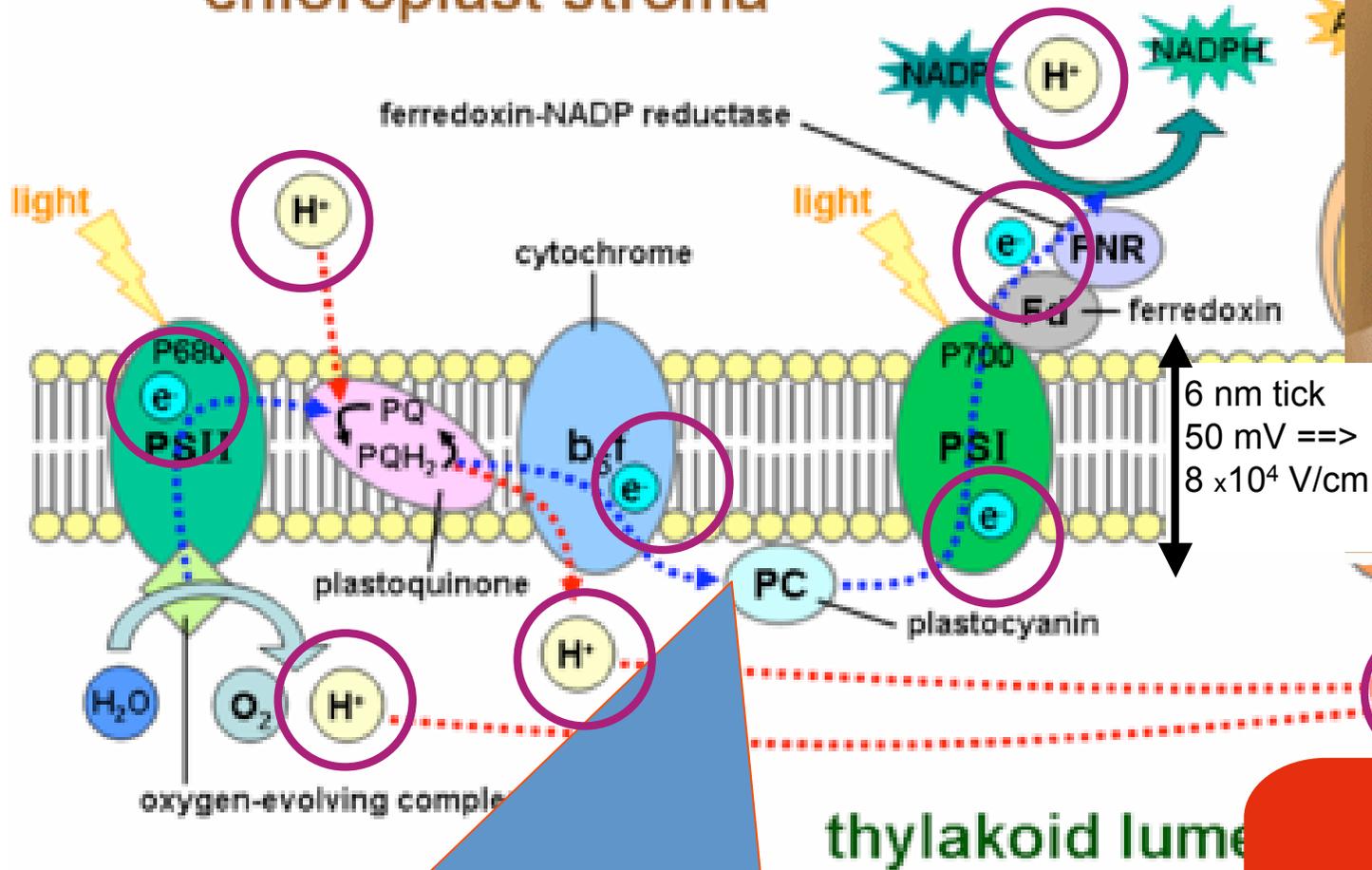
How molecules from leaves are studied?



Note: absorption peaks from chemicals, from leaves.

*« in vivo », these peak should change their position and intensities
... 'in vivo' means with water and membranes ...*

chloroplast stroma



*where is it the driving force to
electrical charges somewhere*

All books on photosynthesis have this picture: it violates physical laws. http://en.wikipedia.org/wiki/Light-dependent_reactions

SEM picture of a dry spinach chloroplast membrane

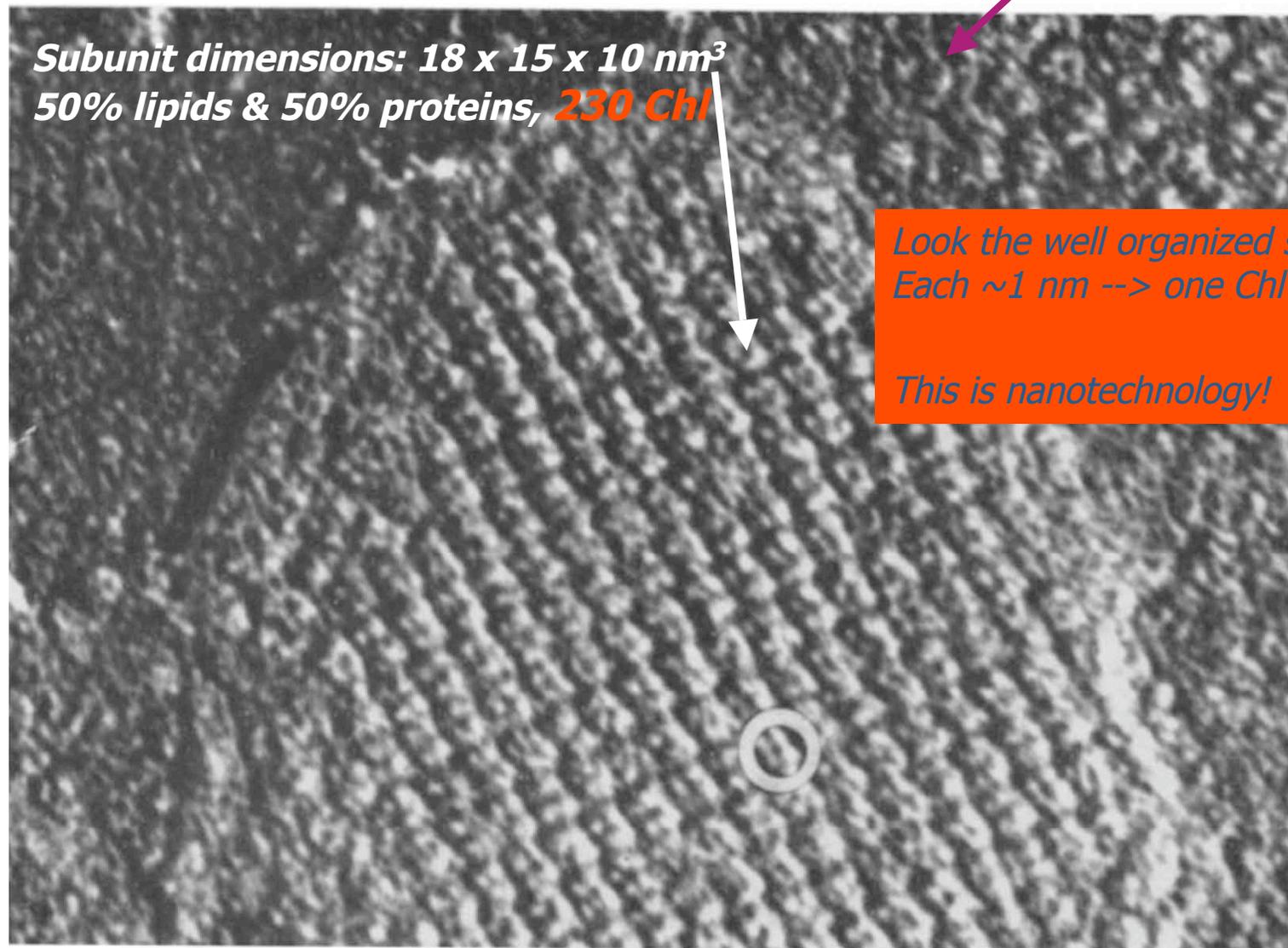
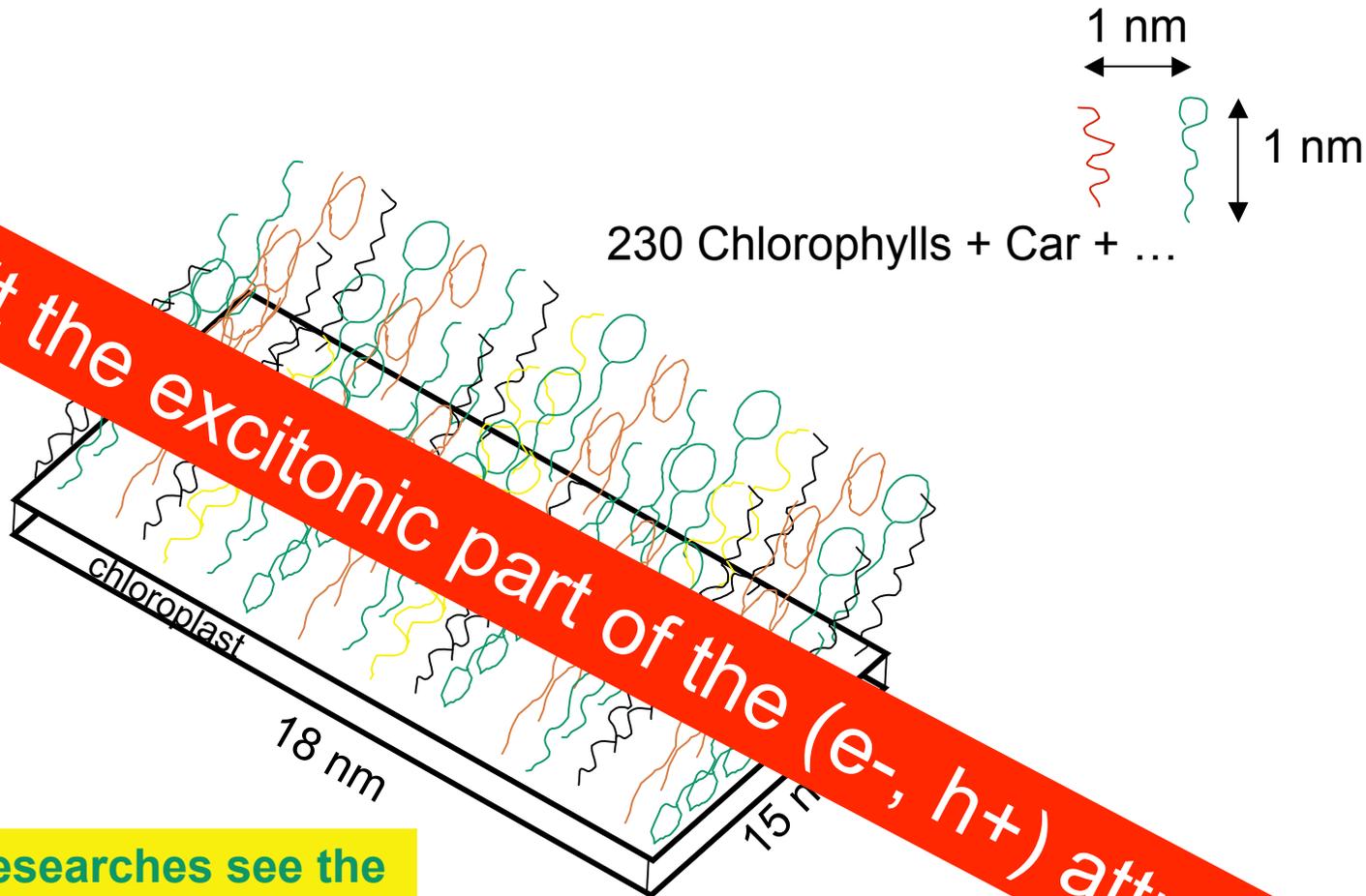


FIGURE 2. Shadowed paracrystalline quantasome array. Quantasome with contained subunits is circled.

$\times 330,000$.

R. B. Park *The Journal of Cell Biology*, vol. 27, p. 151 (1965)

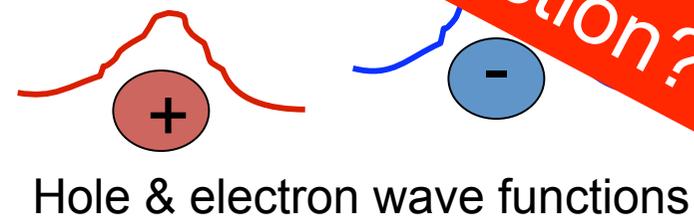
Where is it the excitonic part of the (e^- , h^+) attraction?

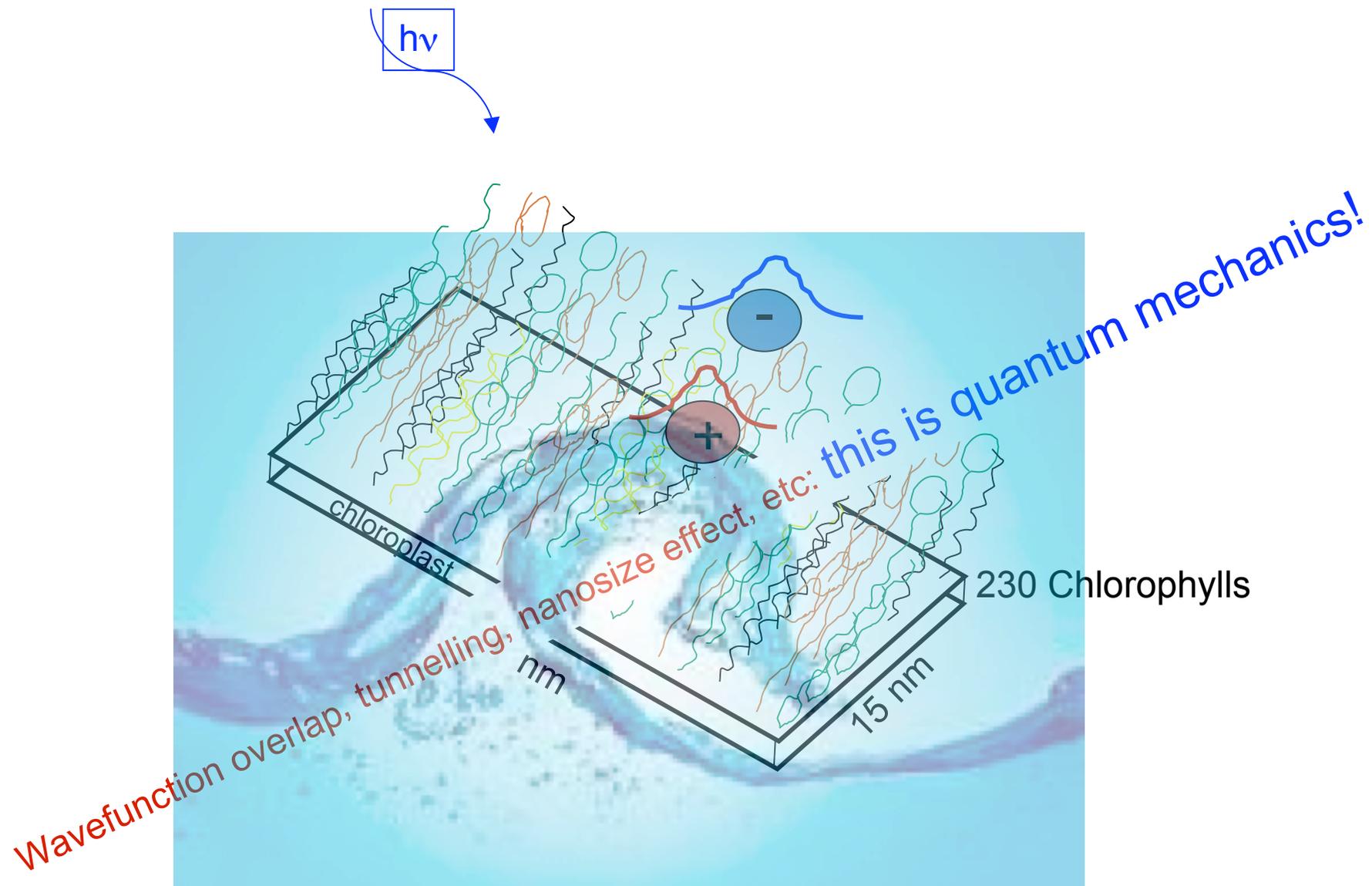


Question: how researches see the charges separation mechanism?

Answer: with the absorption of a photon and (e^- , h^+) are already separated...

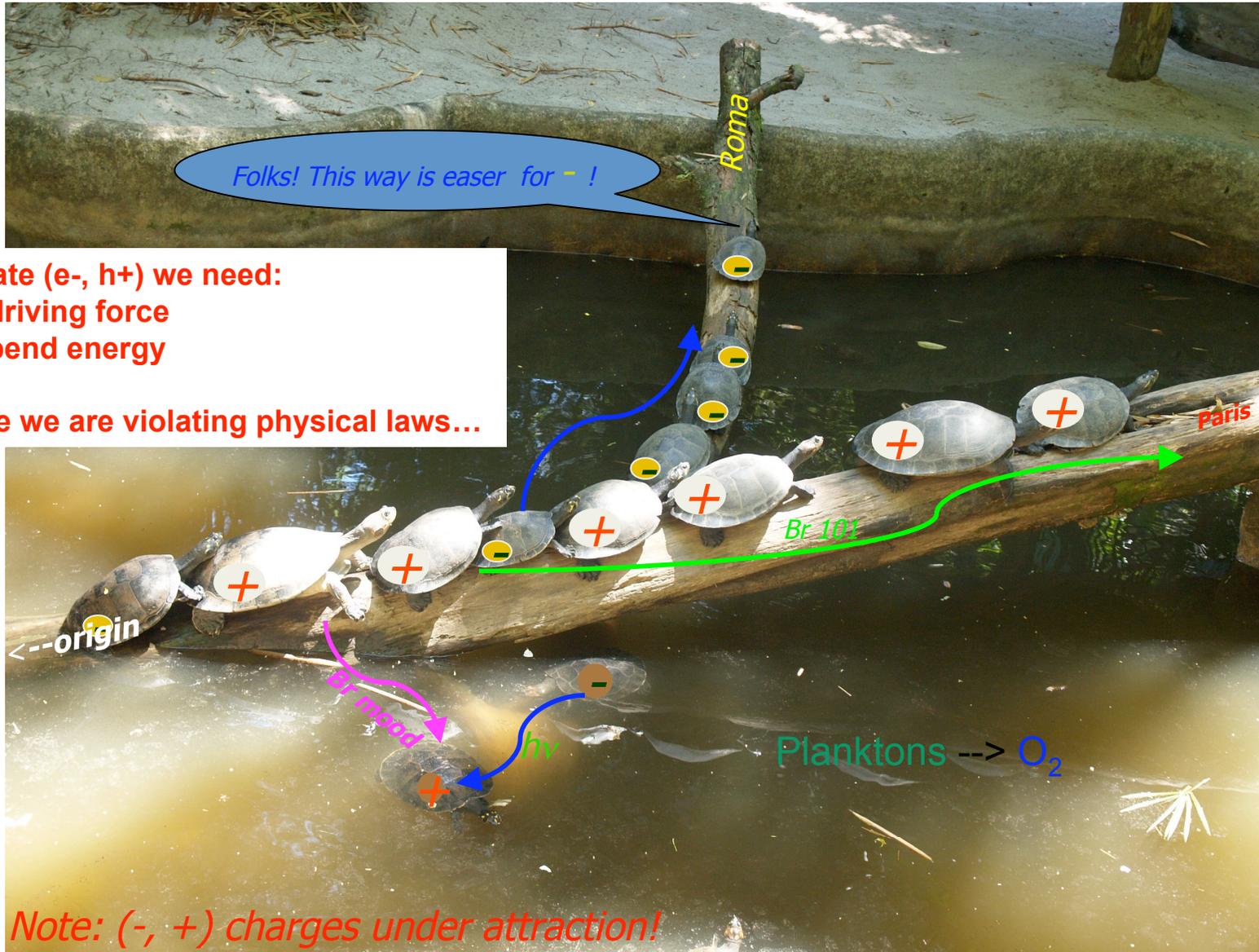
Comments: never, jamais, nunca, Никого!





Note: there is no relationship between the light emission, reflection and absorption peaks of Chl, Car, etc, separated from water and the E, R & A peaks on leaves...

Meanwhile, we don't know the most important physical mechanism on Earth : e.g. ==>the electrical charges separation !?!?



To separate (e-, h+) we need:

- a) The driving force
- b) To spend energy

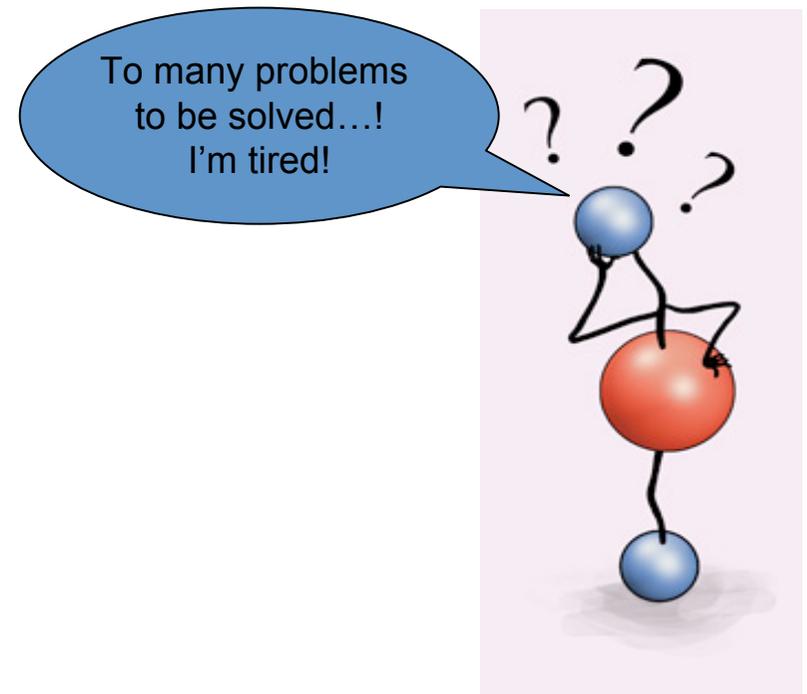
Otherwise we are violating physical laws...

Note: (-, +) charges under attraction!

Conclusions about the photosynthesis' charges separation mechanism :

- a) The energetic bandgap between the molecules don't exist in Nature (physics),
- b) The driving force to separate (e^- , h^+) is absent,
- c) The spent energy to separate (e^- , h^+) is absent,
- d) Water is not considered for the experimental results,
- e) The molecule's size and distance are nm dimension ==>

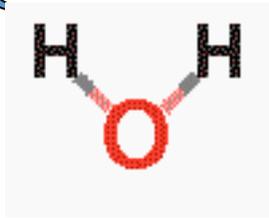
Quantum mechanics is necessary.
Tunneling effects should be considered...



Why should water exist?
It bothers us!

Plant's bar philosophy

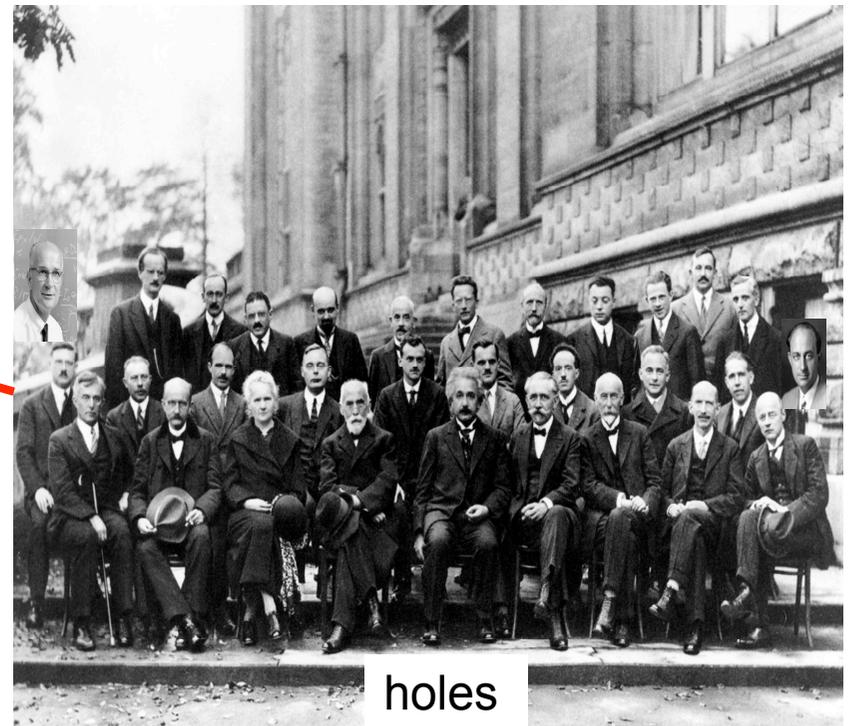
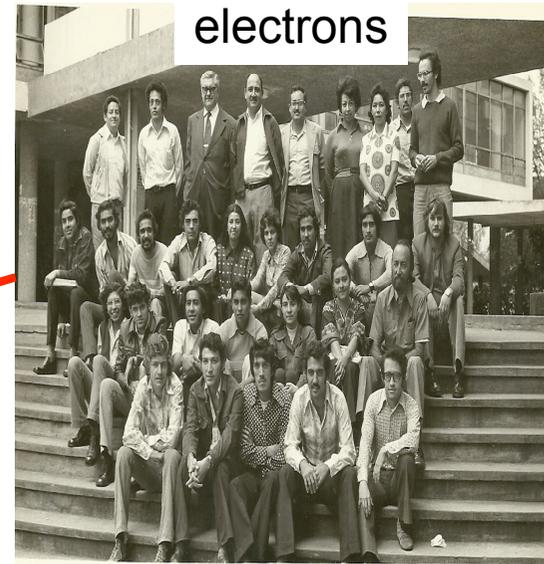
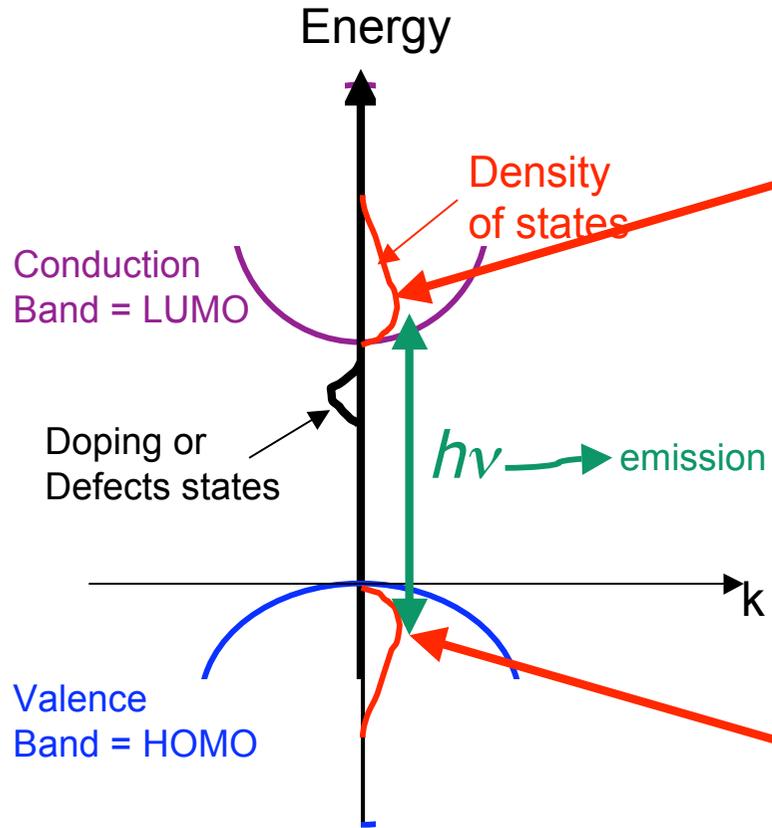
Let's see some ideas from
solid state physics!

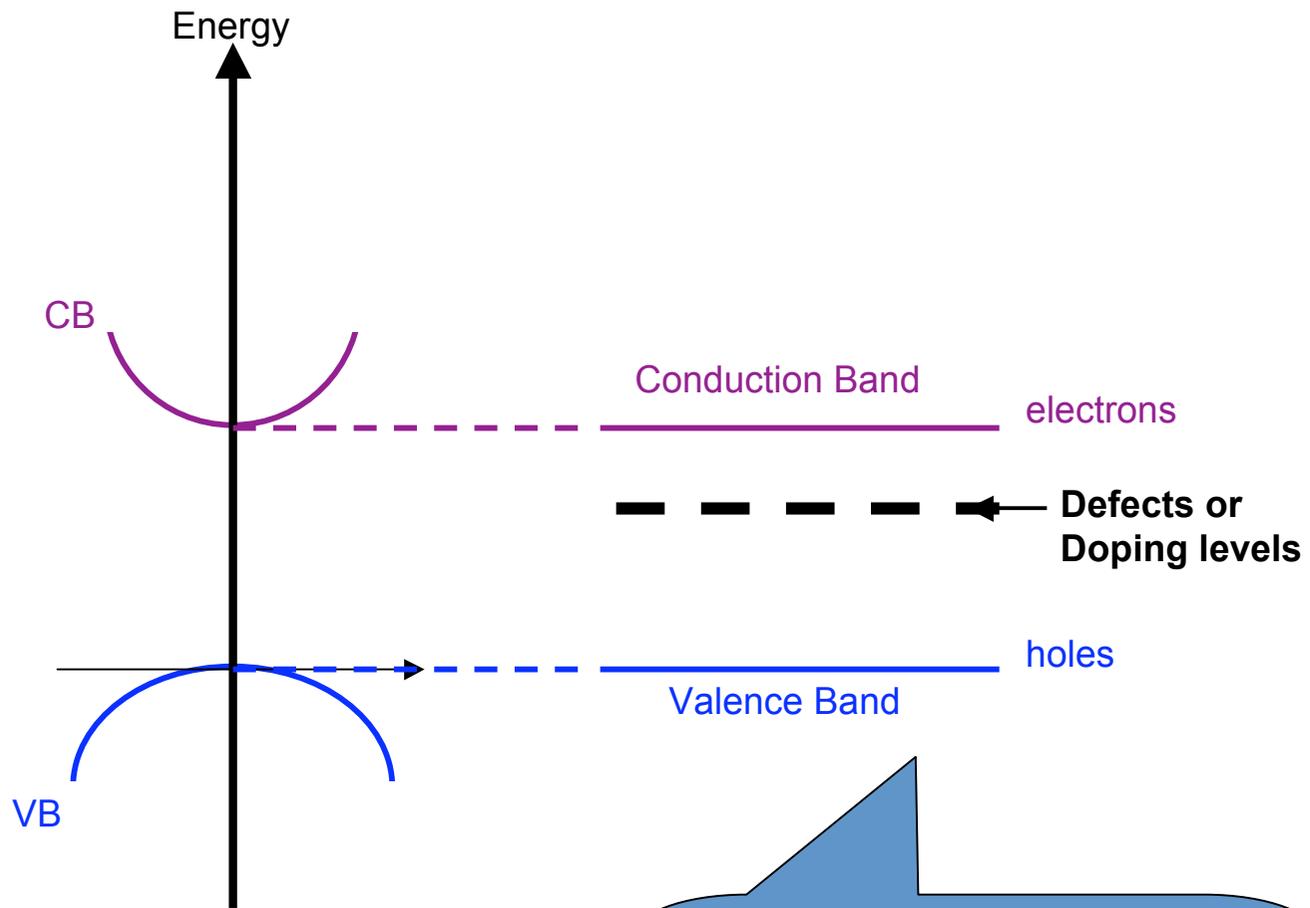


What does it mean bandgap engineering ?

From solid state physics, organic LEDs and organic solar cells.

Density of states and fluorescence from materials.





From this we go to the
bandgap engineering.

Based on 3 Nobel Prizes works' on semiconductor physics...
& one in organic chemistry.

Herbert Kroemer, Nobel lecture: quasioelectric fields and band offsets. *Reviews of Modern Physics* **2001**, 73, 783-793.

(Nobel Prize on Physics, 2000).



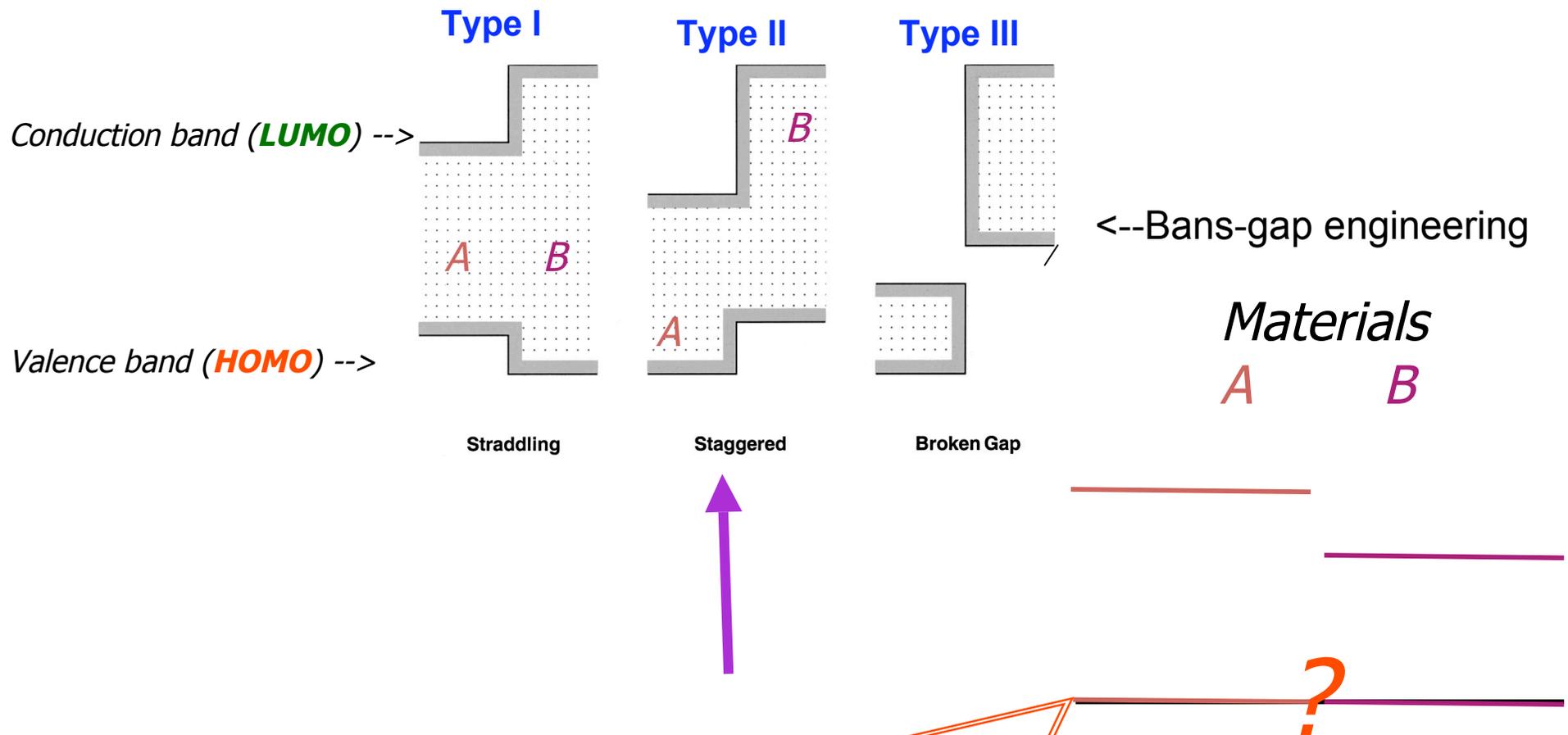
Leo Esaki Journal de Phys. (France) C5-1, 48, 1987.

(Nobel Prize on Physics, 1973).



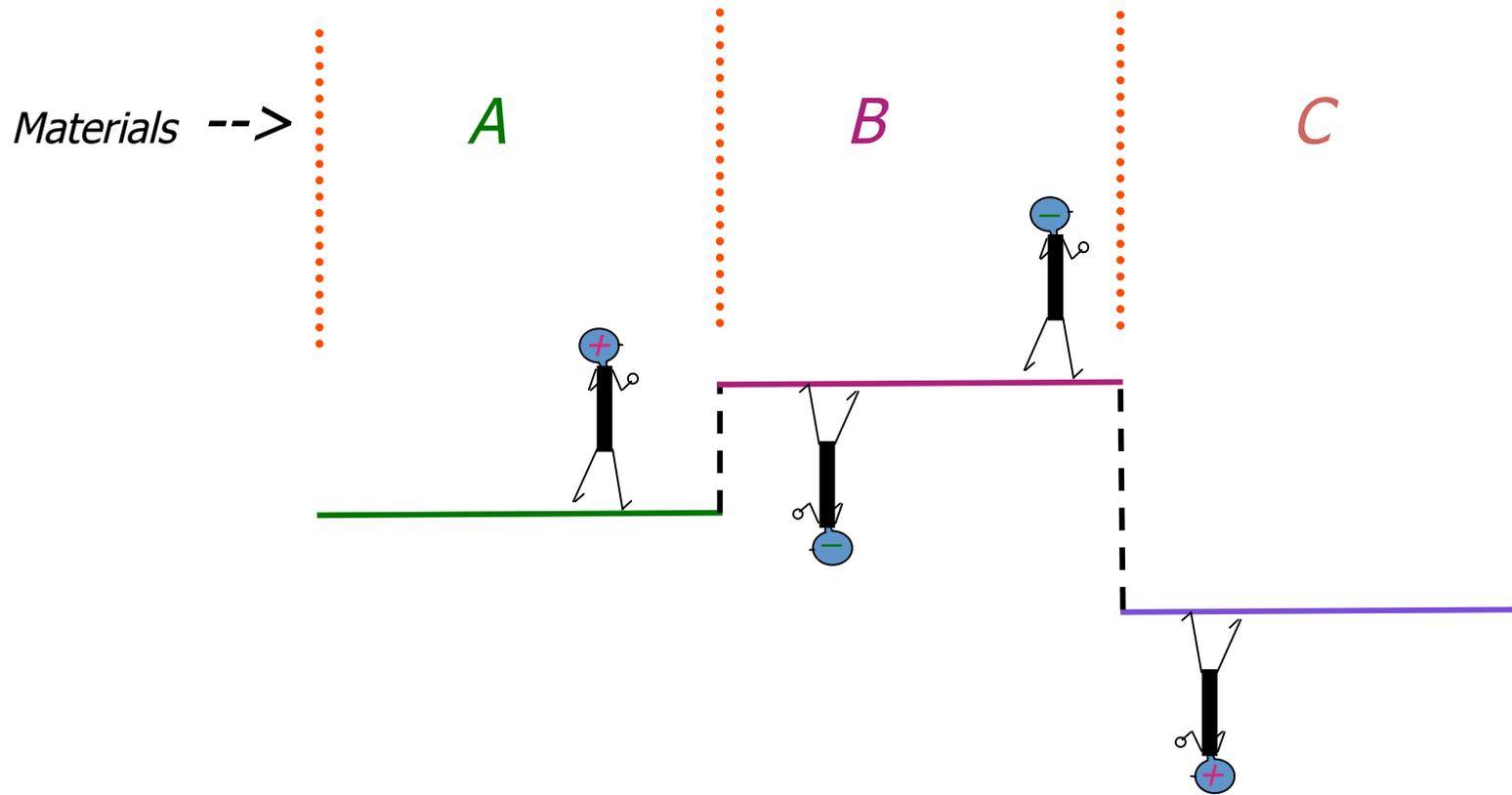
A. Heeger, 2000 Chemistry Nobel Prize Laureate

Band gap energy alignments: there are only 3 types

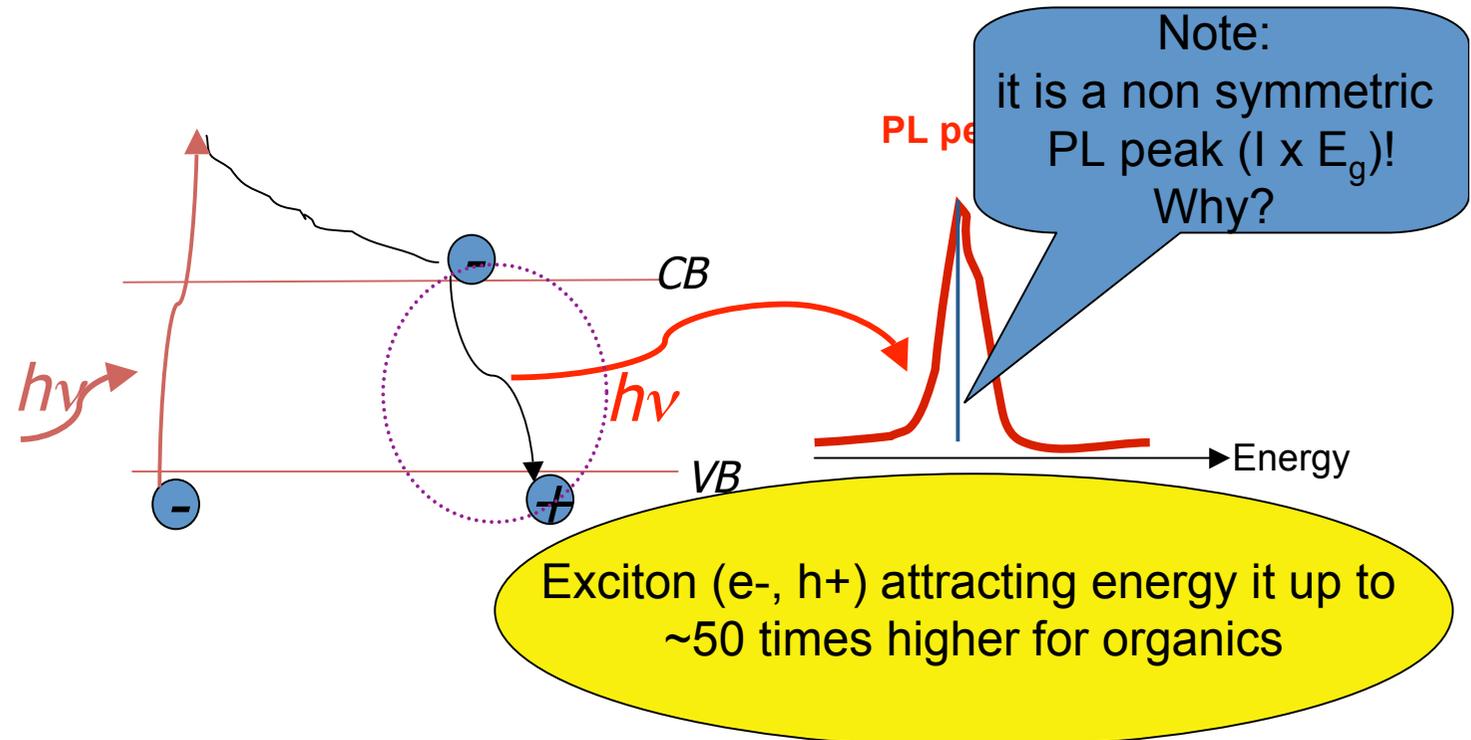


Ground state energy ??? This energetic configuration does not exist in s. s. physics !!! It does not corresponds to any existing physical situation (idem for FRET).

Charges flowing from one material or molecule to another :
they have always energetic steps.



Excitation and emission from a material band gap energy

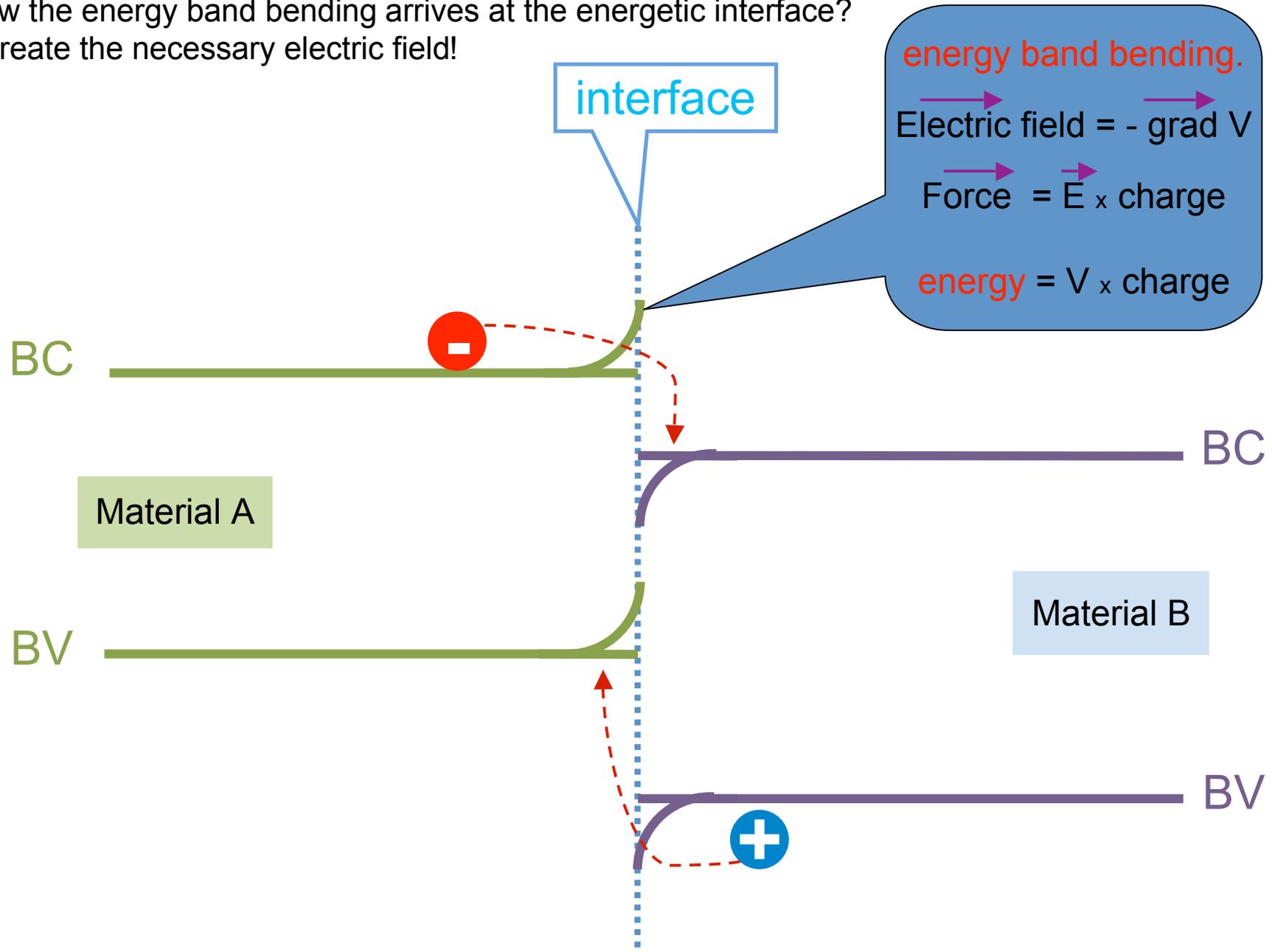


Excitons: attraction energy between negatives and positives charges (e⁻, h⁺).

Excitons in inorganic materials: few meV to few tens of meV.

Excitons in organic materials: few hundreds of meV.

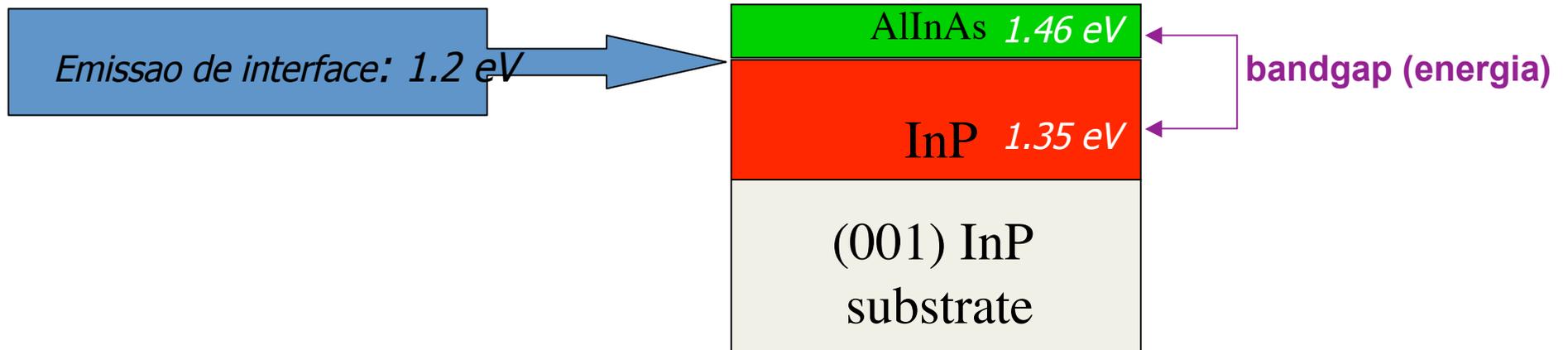
Energy staggered interface: electrical charge separation mechanism.
How the energy band bending arrives at the energetic interface?
It create the necessary electric field!



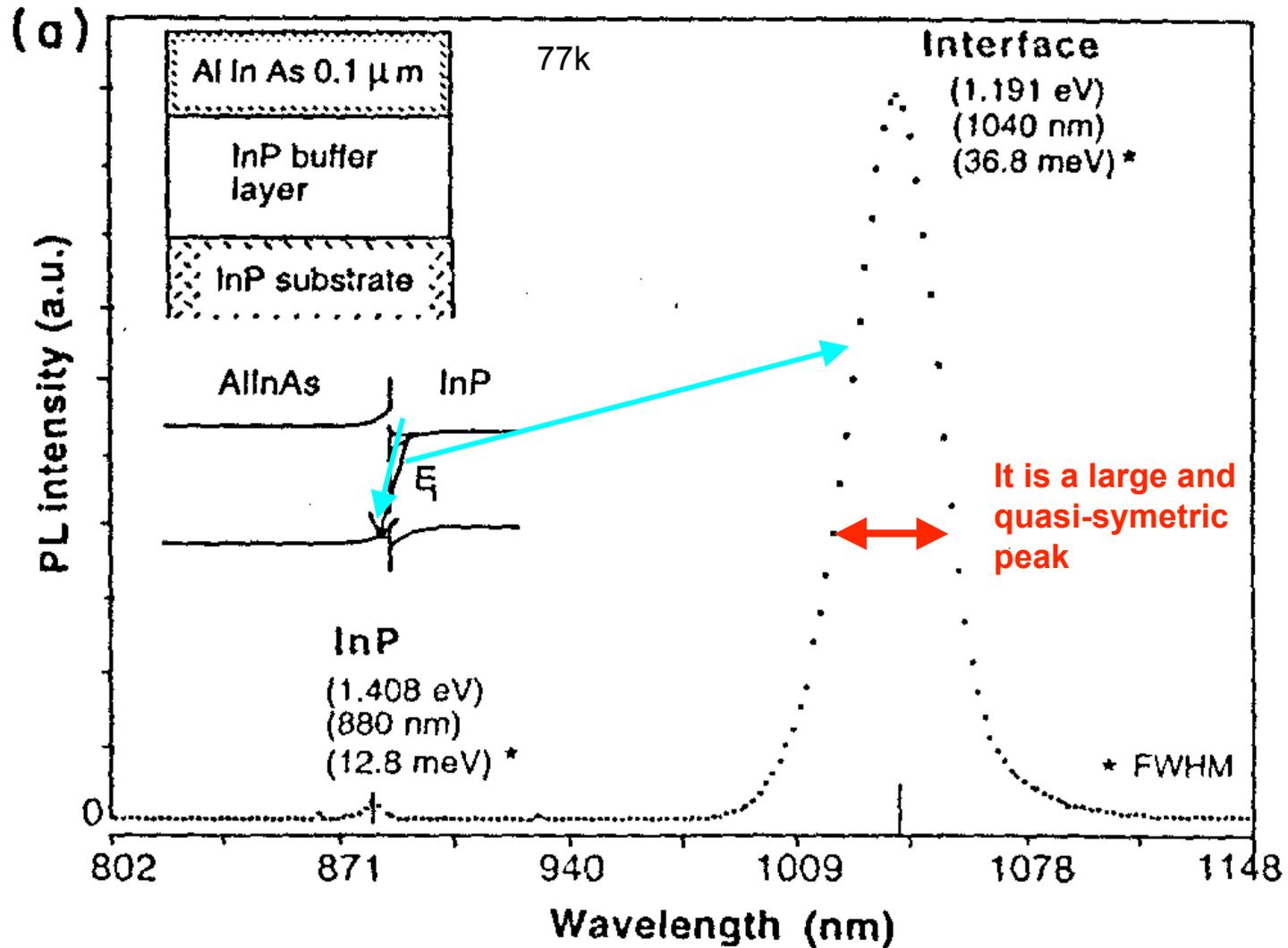
The present model is based on the work of two Nobel Prize laureates in physics: H. Kroemer and Leo Esaki.

Examples of inorganic & organic type II energetic interfaces (able to separate electrical charges).

One example of a flat interface on solid state physics



Interfate emission peak (quasi-symmetric)

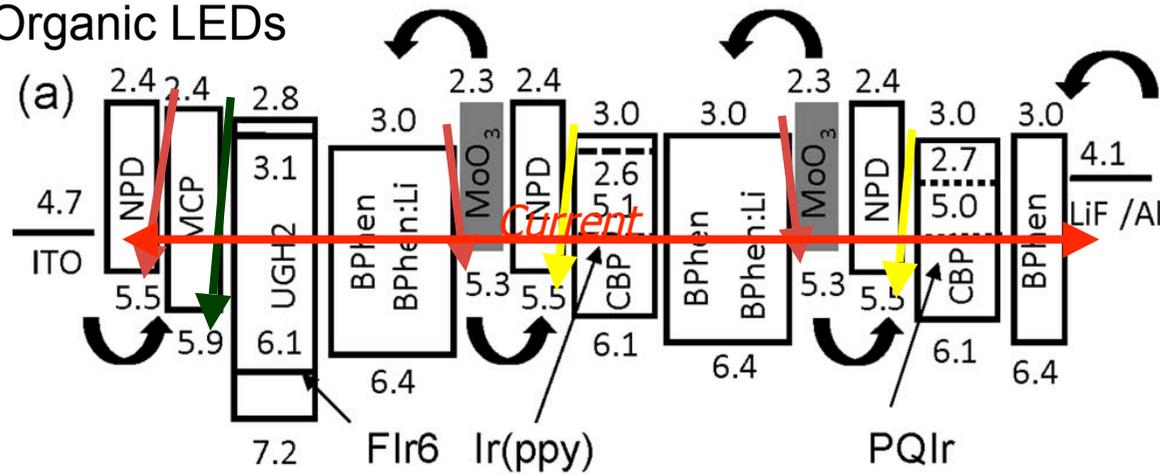


$$h\nu = \Delta S + \Delta Q_e + \Delta Q_h - \Delta E_{ex}$$

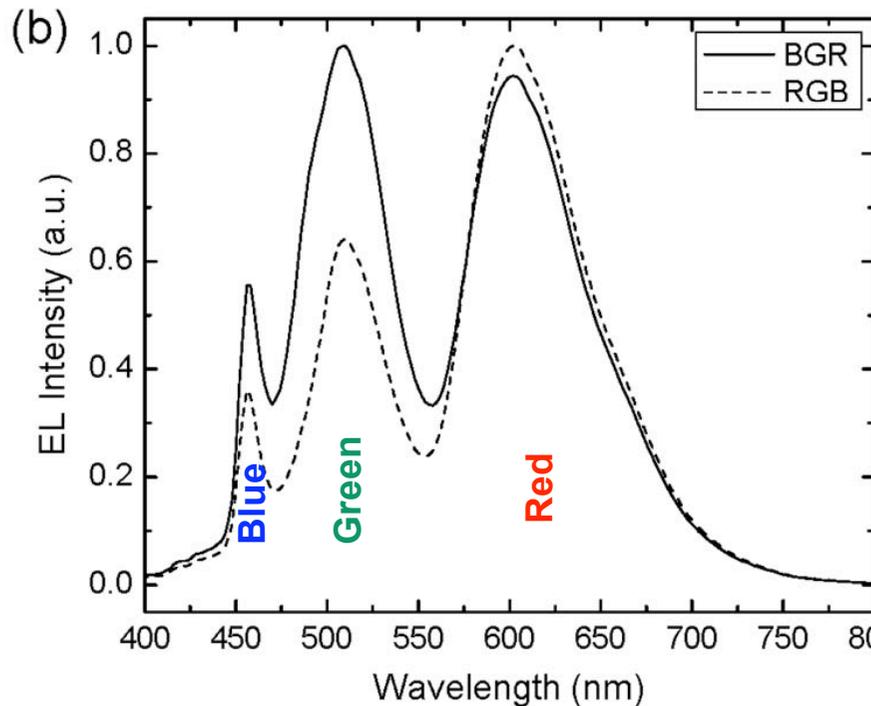
$$1,191 \text{ eV} = 1,109 + 0,158 - \Delta E_{ex} \Rightarrow \Delta E_{ex} = 76 \text{ meV}$$

For 3D inorganic QD
this value ~ double.

Organic LEDs



Stacked white organic light emitting devices consisting of separate red, green, blue elements



Xiangfei Qi et al

APPLIED PHYSICS LETTERS 93, 193306 2008

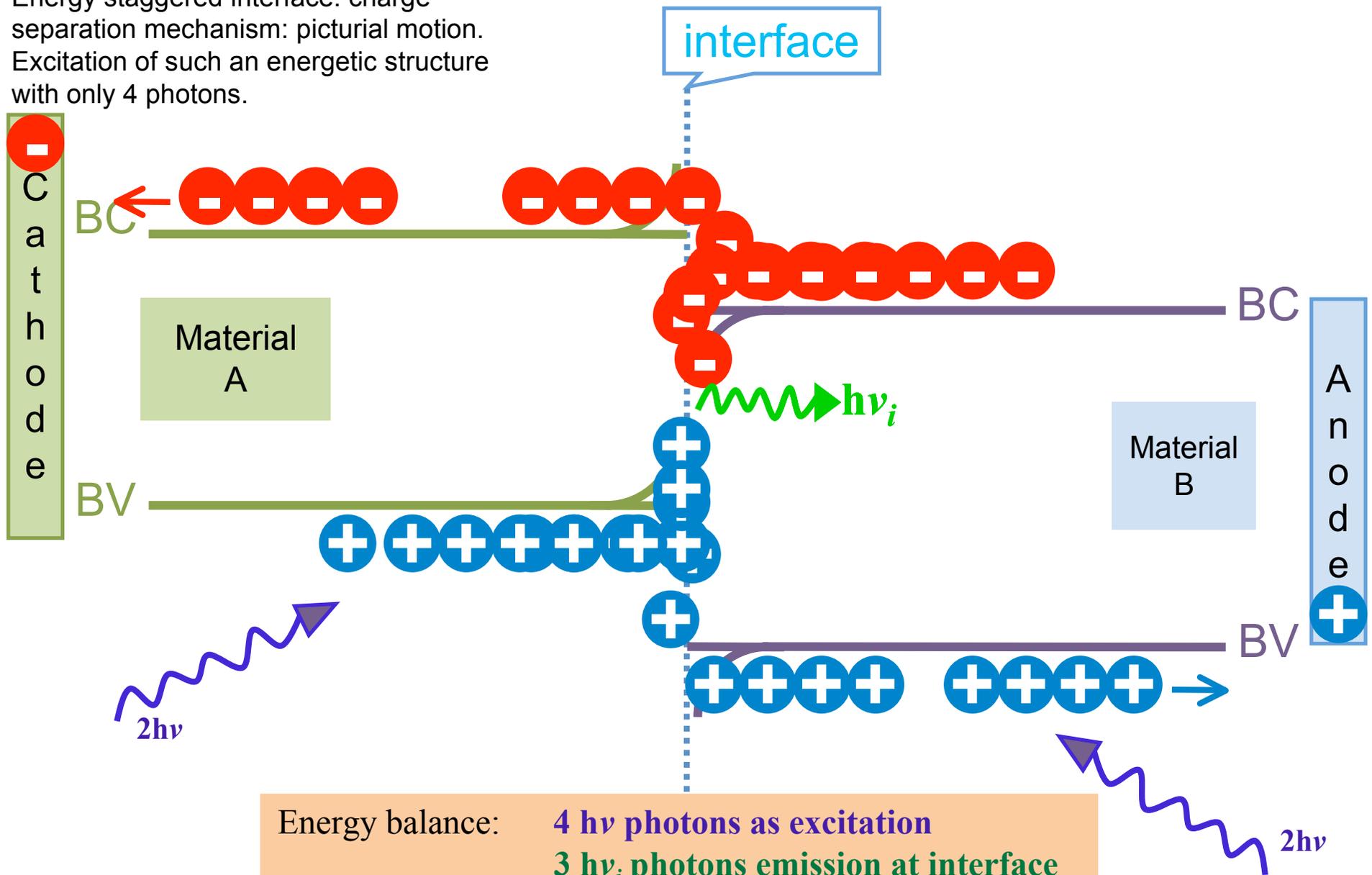
Structure composed of 10 organic layers:
With plenty of type II interface emission possibilities...

& also A. Heeger Nobel L. on chemistry for his work on organic solar cells

FIG. 1. a Proposed energy-level diagram of the RGB SOLED. Numbers indicate the highest occupied molecular orbital (HOMO) and lowest unoccupied molecular orbital (LUMO) energies relative to vacuum in eV. The HOMO and LUMO energies of Fir6, Ir(ppy)₃, and PQIr are 6.1 and 3.1 eV, 5.1 and 2.6 eV, and 5.0 and 2.7 eV, respectively. Arrows indicate carrier injection from electrodes and the MoO₃ charge-generation layer. b Spectrum of the optically optimized B-G-R (with R adjacent to the ITO anode) ordered device (solid line) and spectrum of the R-G-B ordered structure (dashed line).

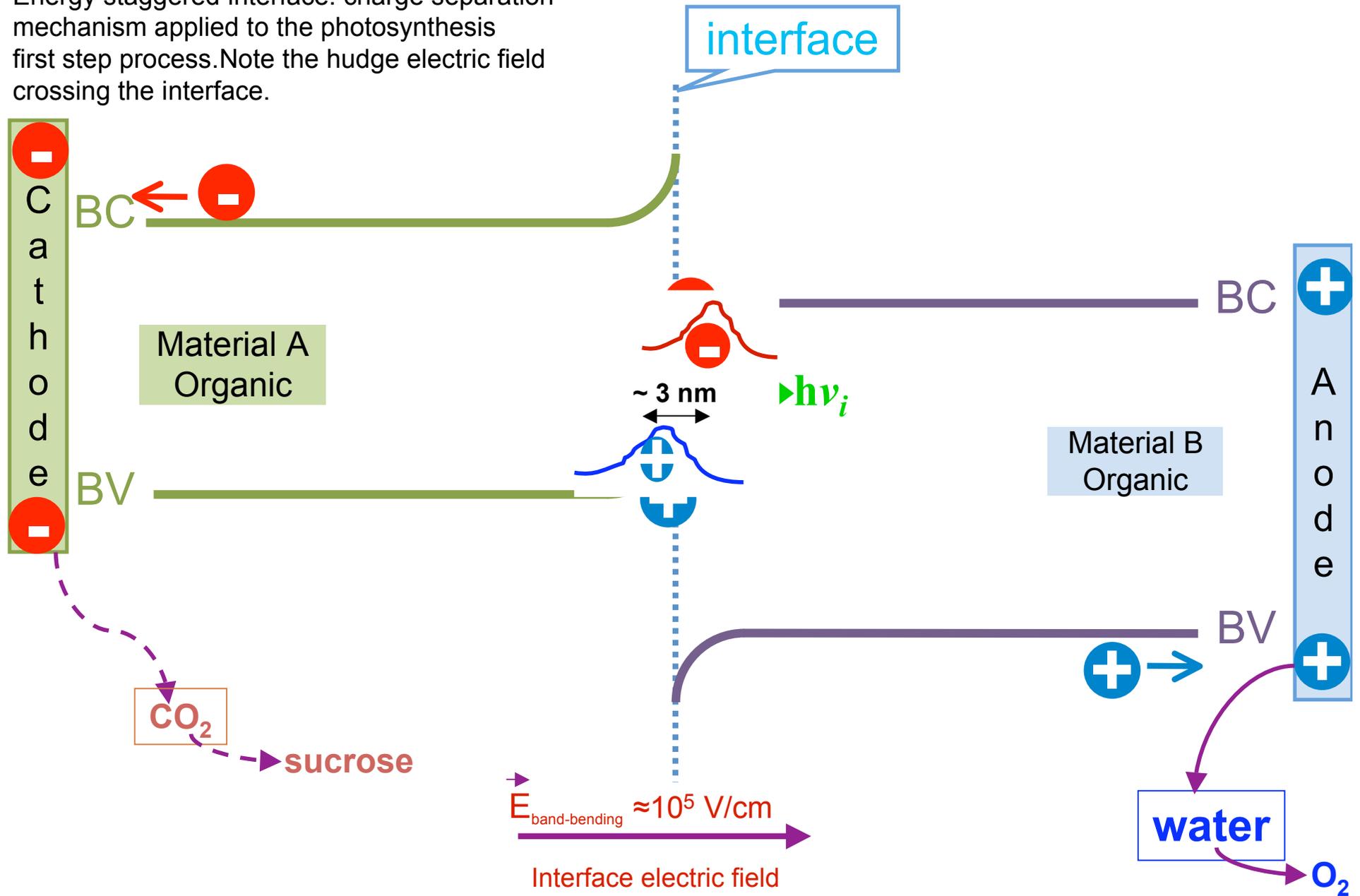
Our model to separate (e⁻, h⁺) charges.

Energy staggered interface: charge separation mechanism: pictorial motion.
 Excitation of such an energetic structure with only 4 photons.



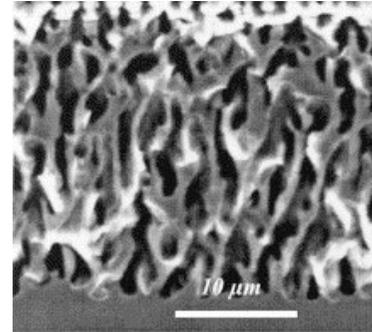
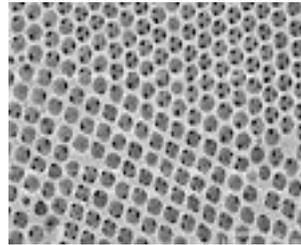
Energy balance: **4 $h\nu$ photons as excitation**
3 $h\nu_i$ photons emission at interface
 1 (e^- , h^+) separated: 25% efficiency
 $h\nu_i$ is related to the spent energy to separate (e^- , h^+).
 Note: photosynthesis is about 5% efficiency.

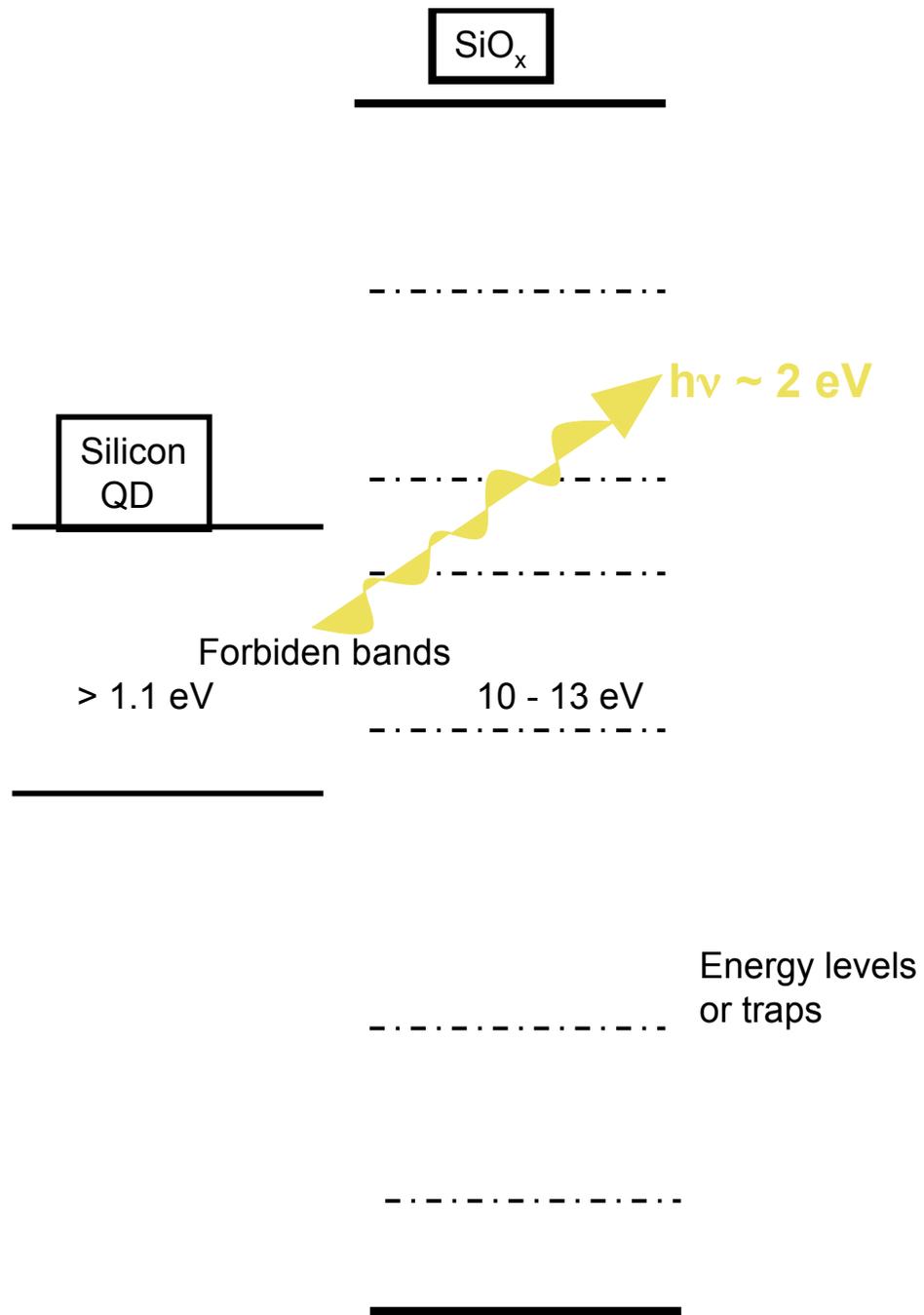
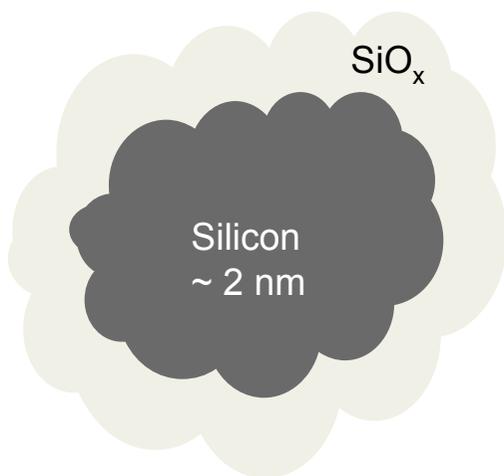
Energy staggered interface: charge separation mechanism applied to the photosynthesis first step process. Note the huge electric field crossing the interface.



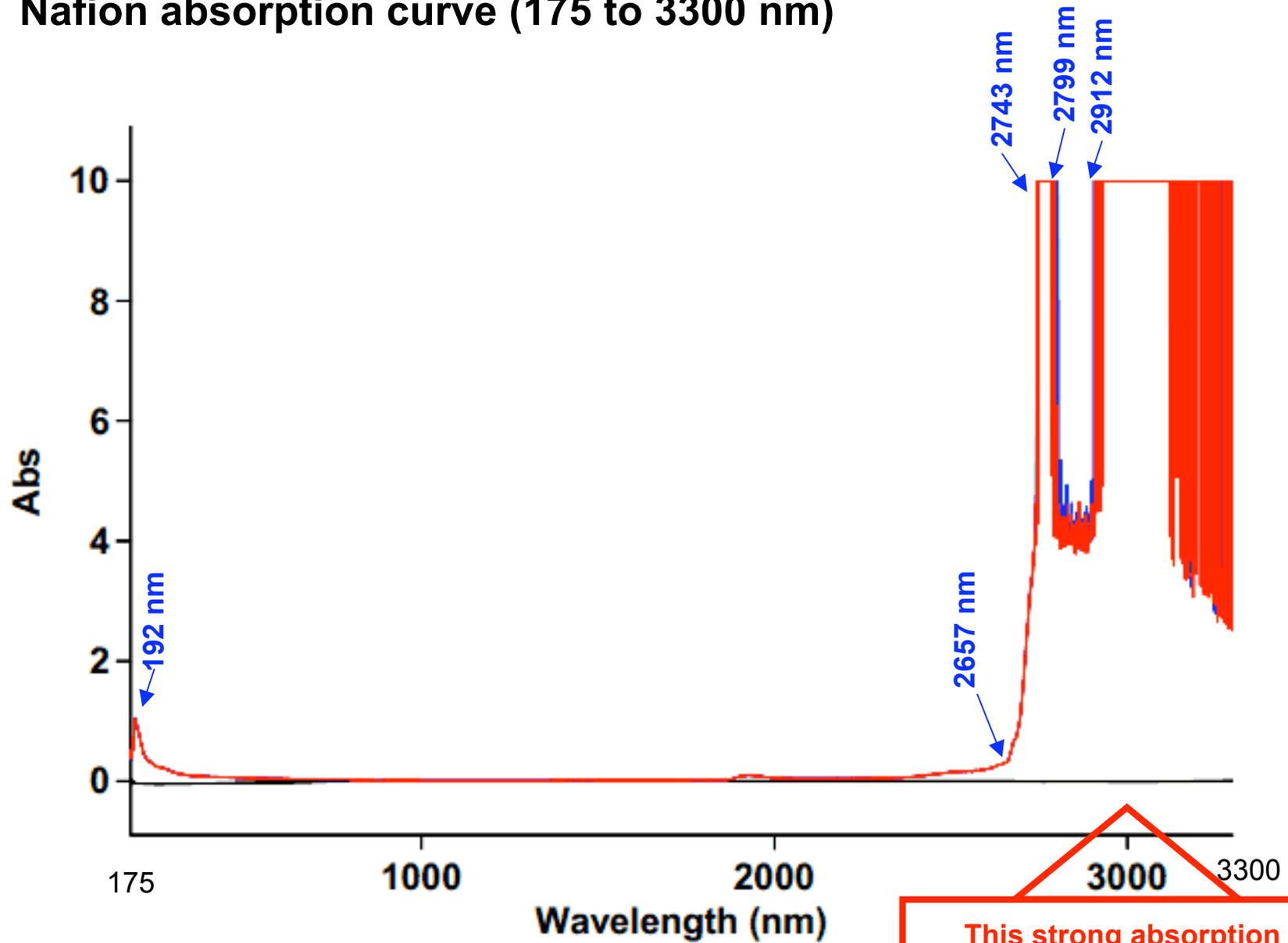
Let's see 3D quantum dots, with large bandgap material (glass).

Porous silicon: a quantum sponge-like structure

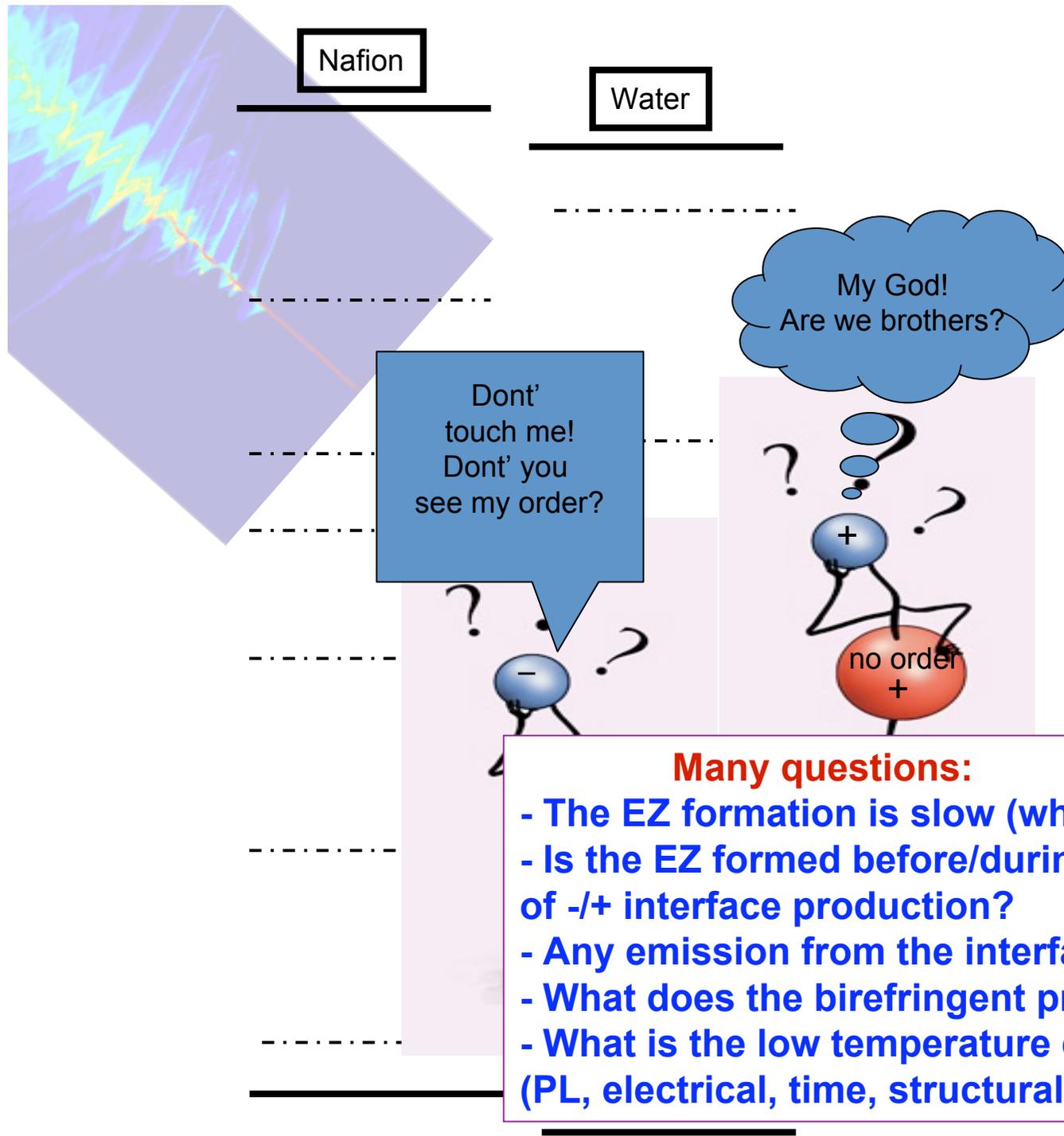




Nafion absorption curve (175 to 3300 nm)



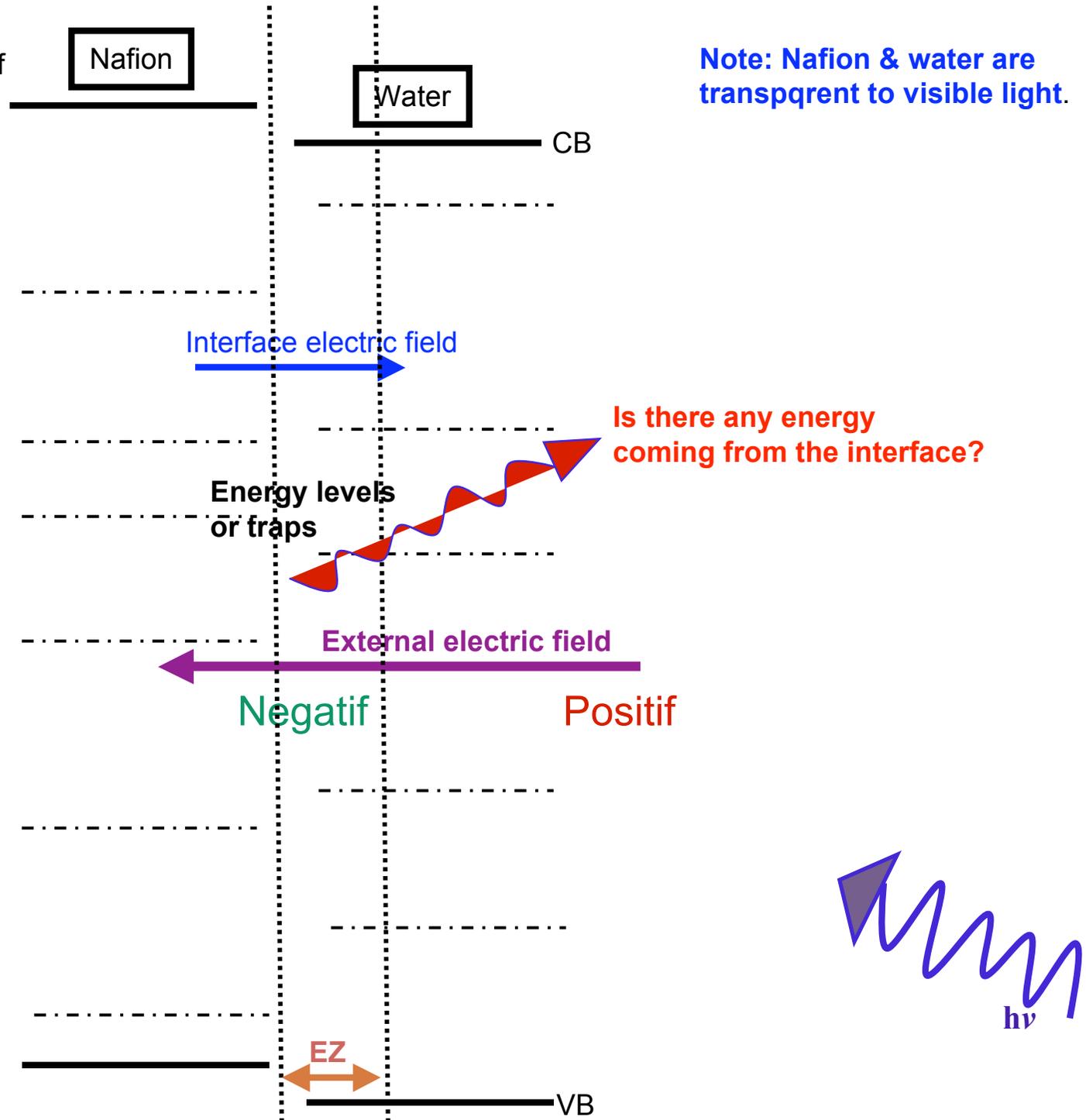
This strong absorption should explain why the 3 μm (0.41 eV) excitation gives a so large EZ extension.



To know the mechanism of EZ formation we need:

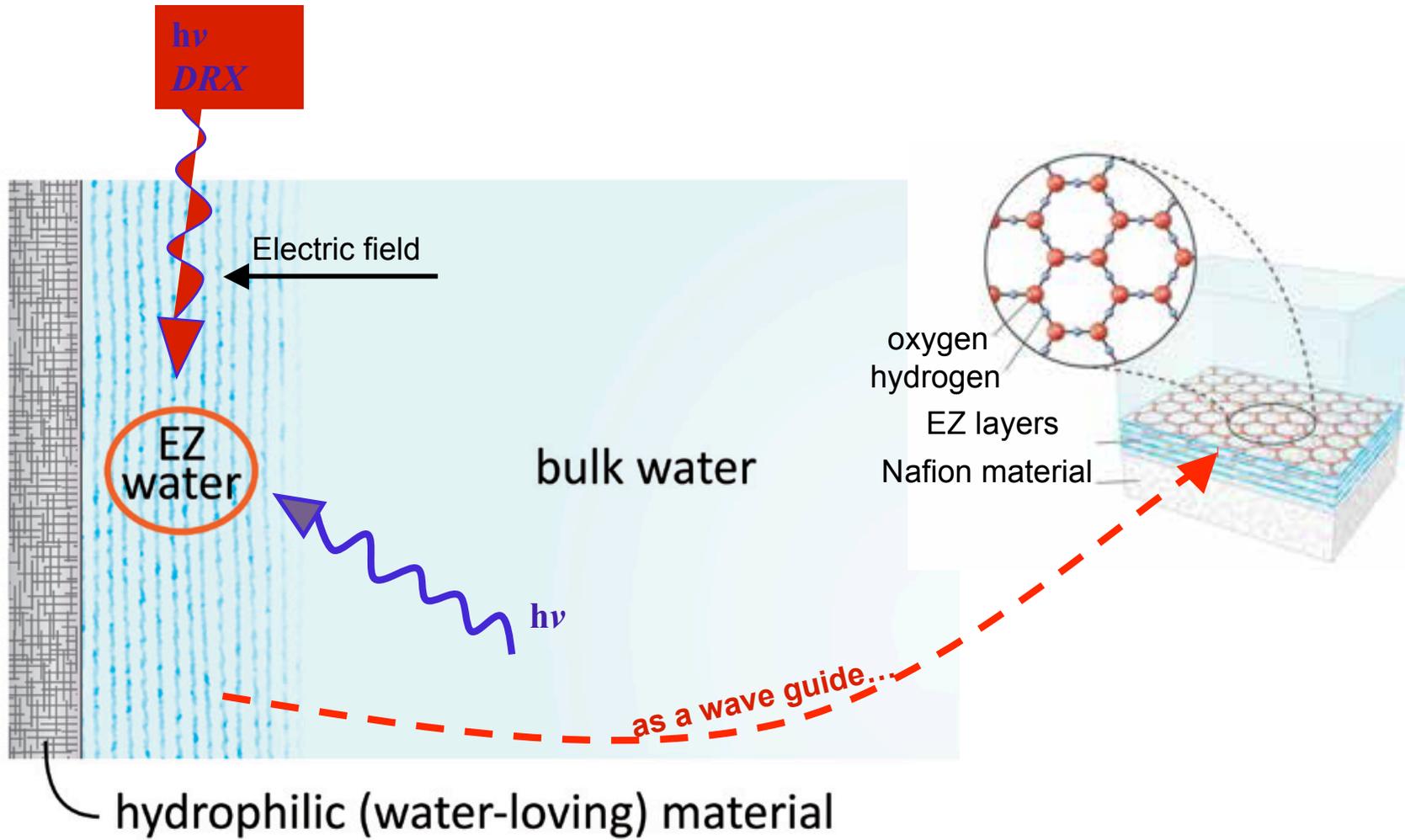
- a) The driving force
- b) The spent energy to separate (e^- , h^+)

Note: Nafion & water are transparent to visible light.

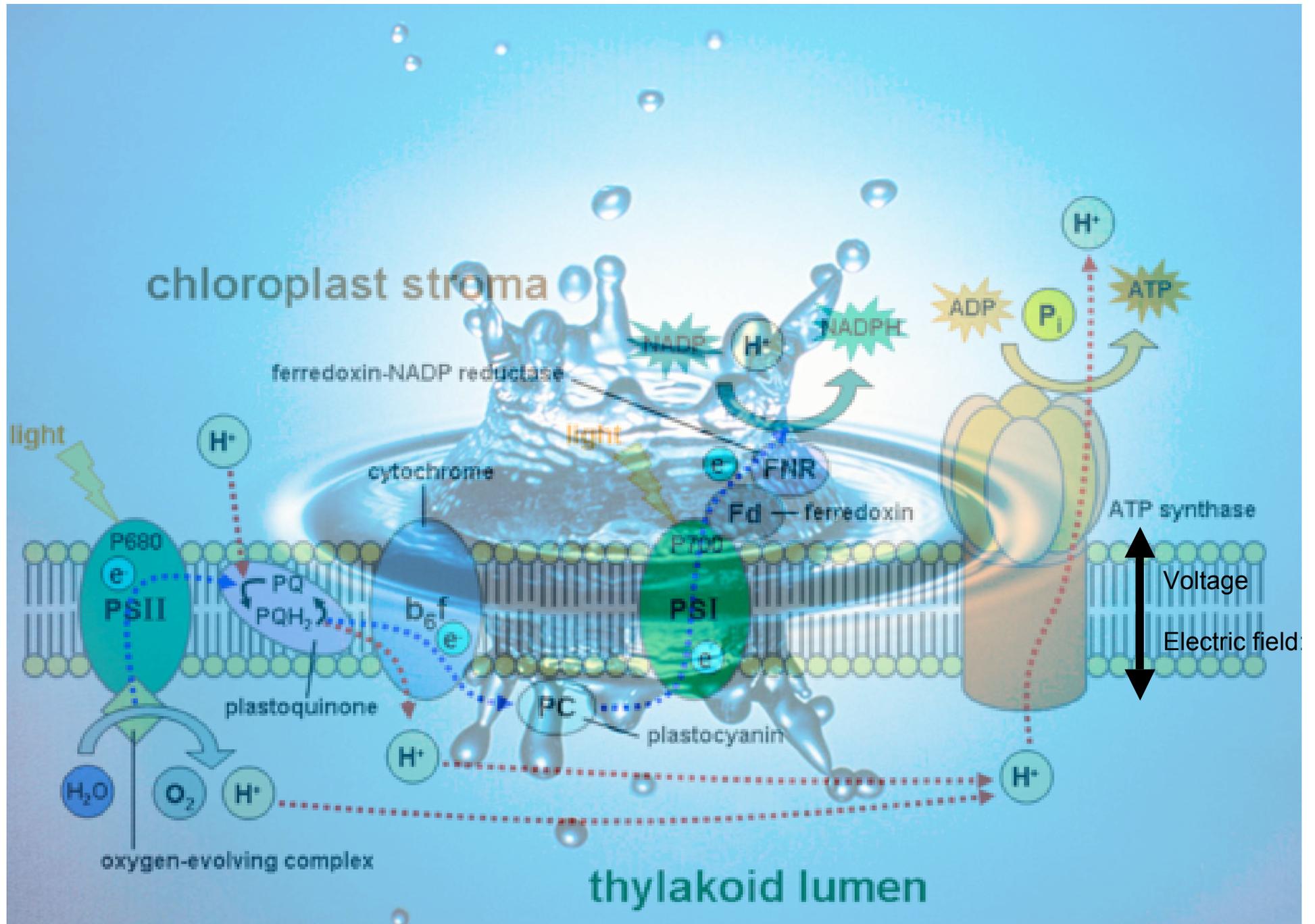


What is the water's role on Natural photosynthesis?

We are working with the charges separation mechanism, using existing physical model, DRX, plasmonics, OCT, etc, to bring some more information to the photosynthesis & EZ mechanism (s?).



Modeling photosynthesis with water:



Answer to the question:

Photosynthesis & water:

why researches have created a **divorce** between them?

H₂O being a so simple molecule it represents a very hard task... and researches decide to delete it... from the medium where organic molecules and chloroplast are immersed!

**Chl, car, etc (hydrophobic)
deteriorate under water.**

Why, if both are at the origin of life?



Difficulties? Yes!

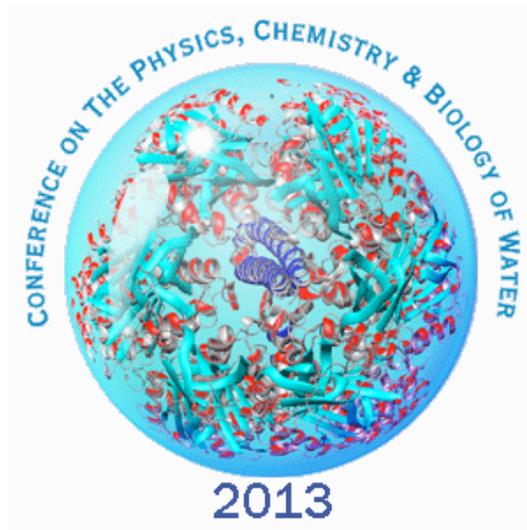


For scientific considerations

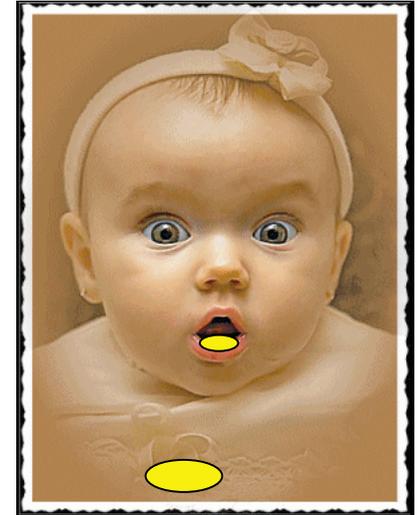
Let's work!
We are just born!



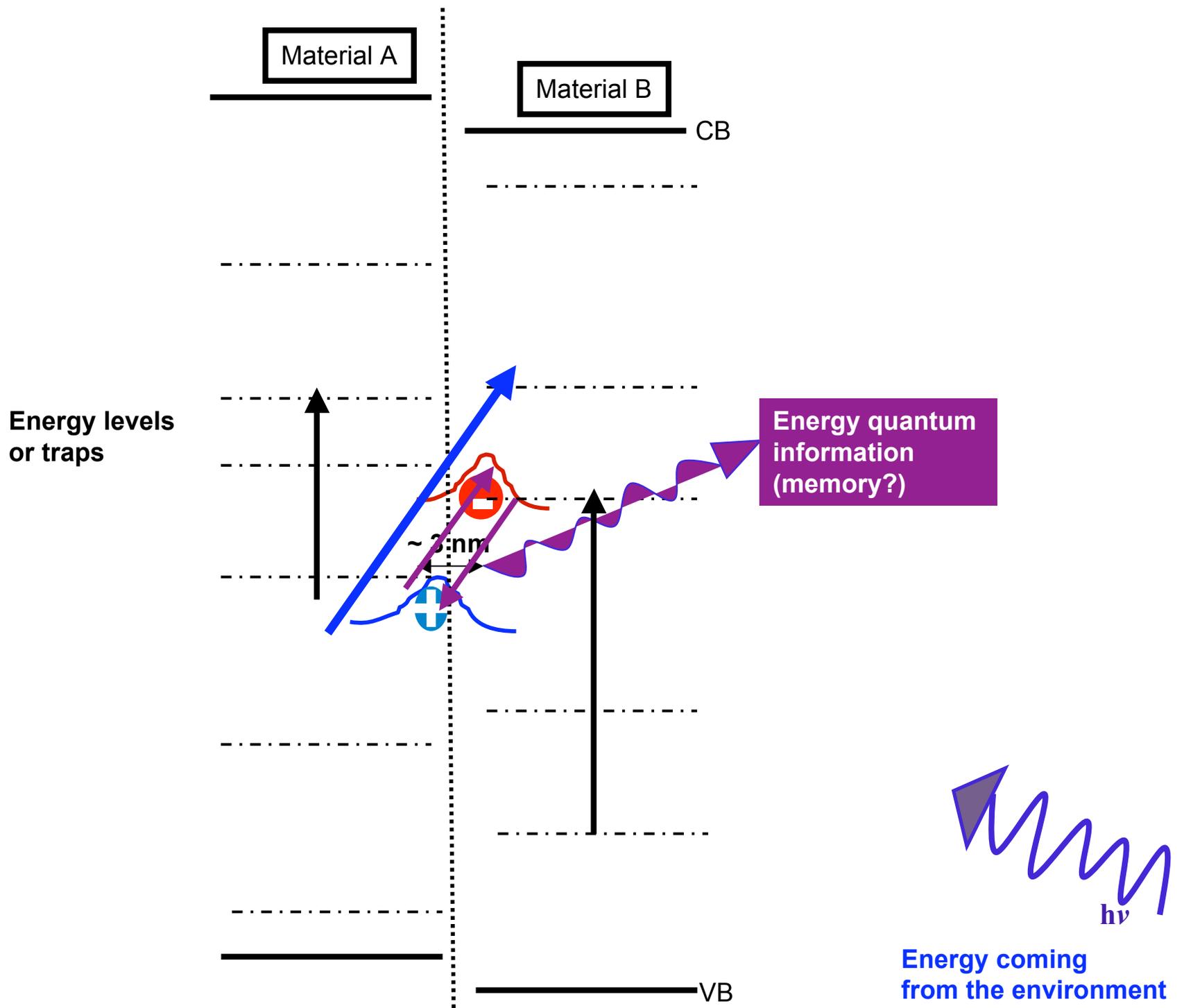
Thanks FACEPE and **Conference on Water** for supporting this presentation and travel funding.



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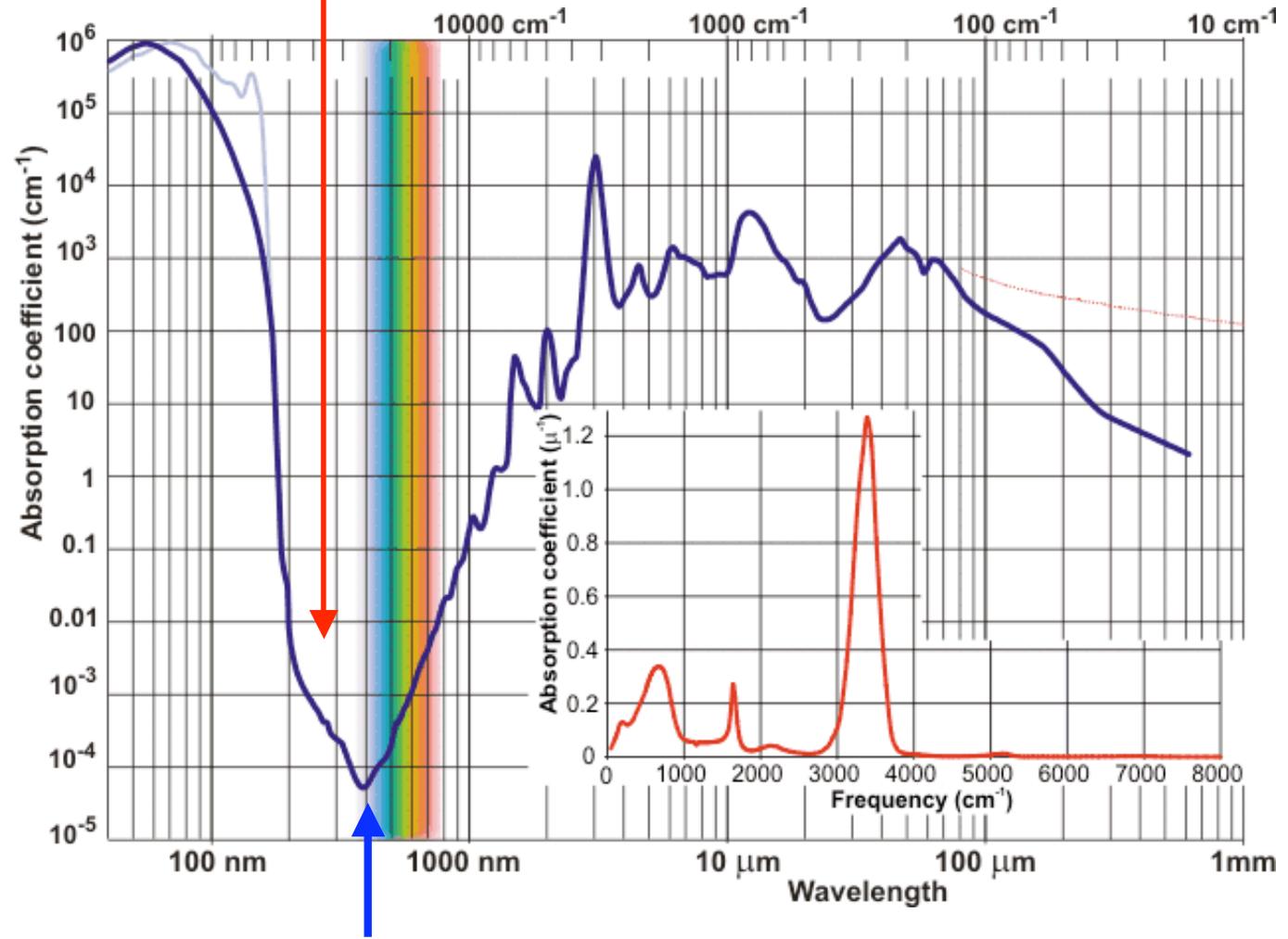


Questions? Discussions? Please! : msacilot@gmail.com



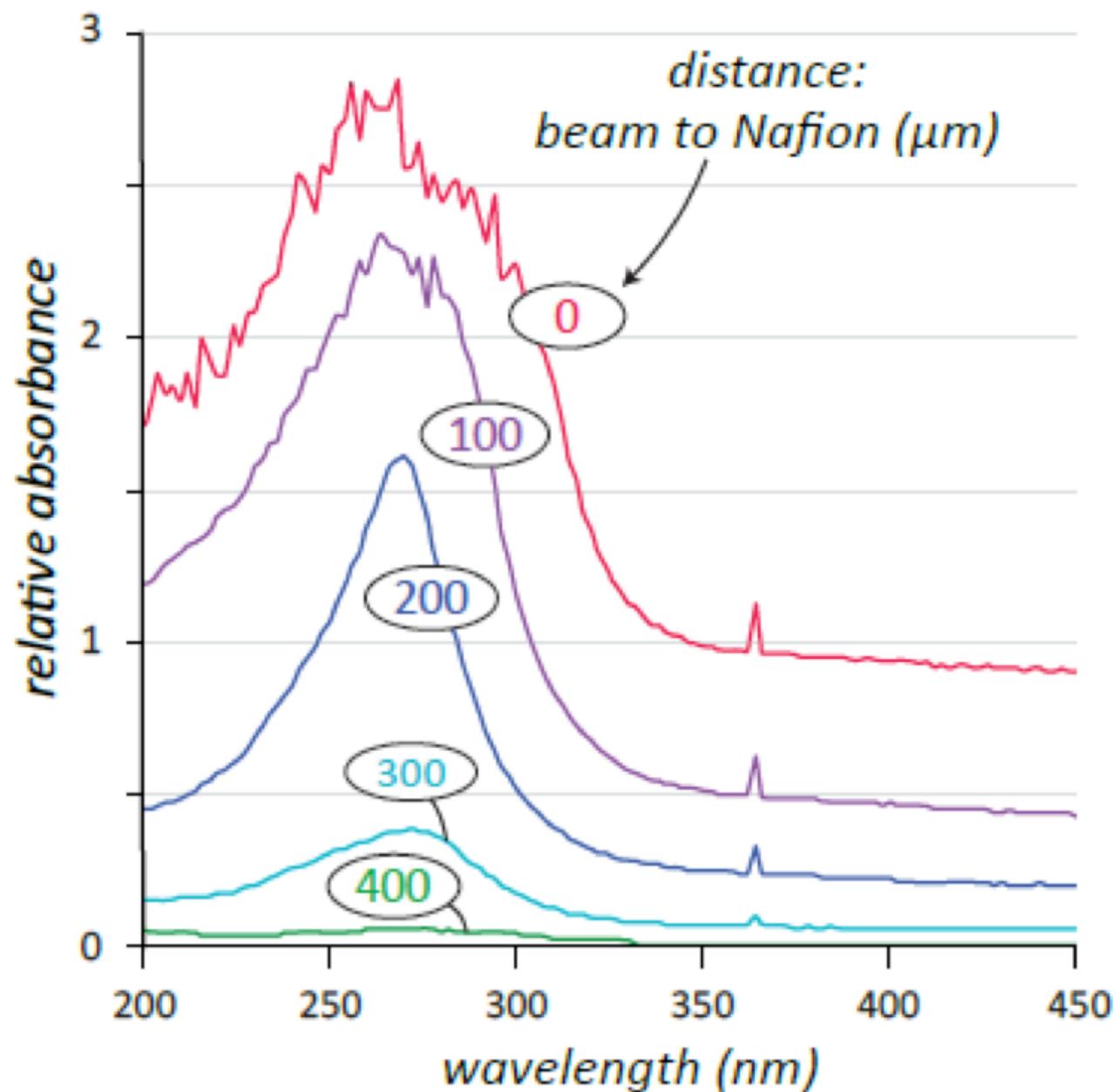
Absorption curve of pure water, at room temperature.

Note : no absorption peak at 270 nm (EZ characteristic).



The deep valley (low absorption) that allow deep sea penetration to feed planktons and produce O_2 and biomass from H_2O & CO_2 , respectively.

EZ absorption curves: 270 nm peak



Emission spectra for ordinary water (room temperature).
 Its emission range resemble the EZ of ordered water
 (400 to 500 nm).

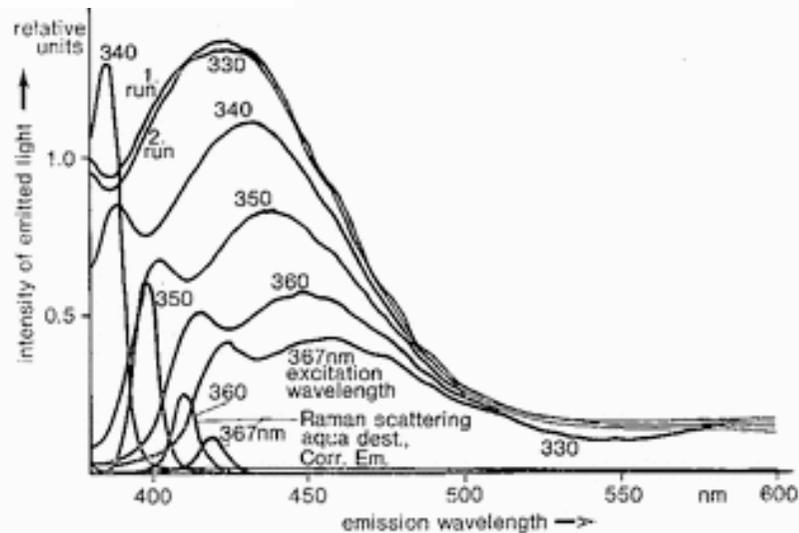
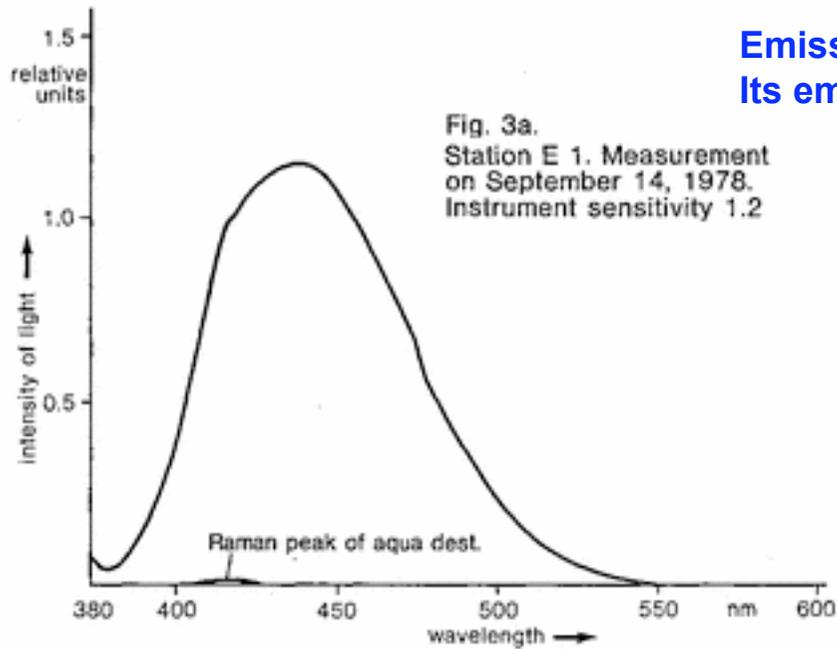


Fig. 5. (Gross-) Emission spectrum of filtered water of station E 13. Corrected emission at different excitation wavelength. Numerals at the curves indicate excitation wavelength. Sensitivity 3.3 (seawater) and 10.4 (dist. water). Slit width both 10 nm

Emission curves of Nafion 177 (excited with many $h\nu$), at room temperature. (400 to 500 nm).

