Llum, química i vida: de la fotosíntesi a la teràpia optogenètica

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United Nations Educational, Scientific and Cultural Organization

International Year of Light 2015

ESCUELA TÉCNICA SUPERIOR

http://www.seas.harvard.edu/environmental-chemistry/projects/prebiotic.php

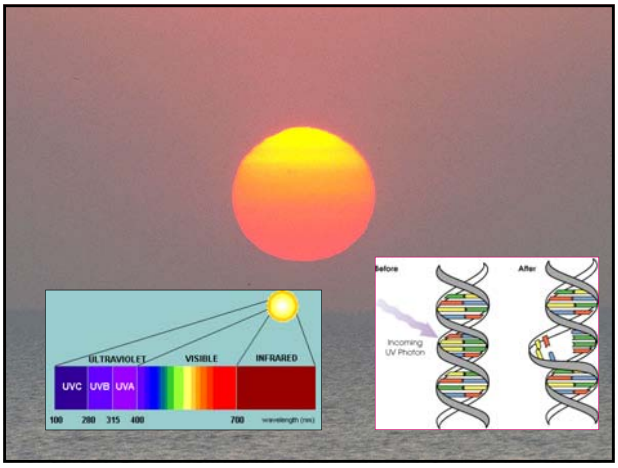
Four Billion Years Ago...

UV radiation (λ < 150nm): 1.6 x10^{-9}einsteins•cm^{-2}•sec^{-1}

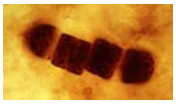
Early Atmosphere:
CO_2: 1 to 10 atm
N_2, CO,
H_2S: 10^{-4} atm
CH_4: 10^{-4} atm
O_2: No

How did life begin?

Early Ocean:
Na^+, Mg^{2+}, Cl^-, SiO_3^{2-}, HCO_3^-,
pH = 5.5, T > 50 °C

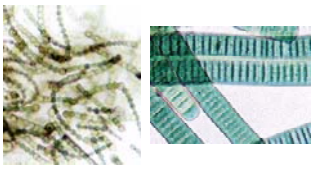


Fotosíntesi



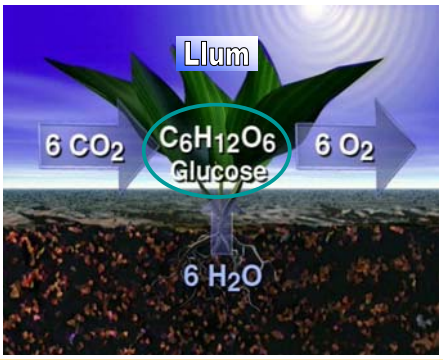
3500 milions d'anys

Fòssil de cianobacteri

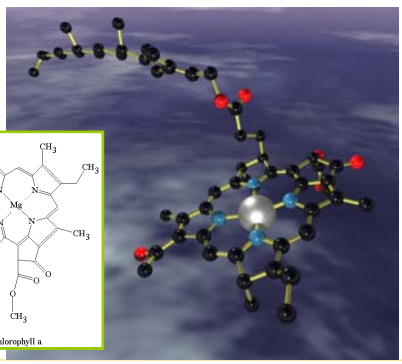


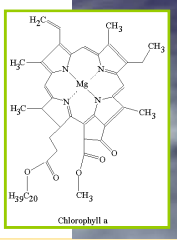
Cianobacteris actuals: Nostoc y *Oscillatoria*

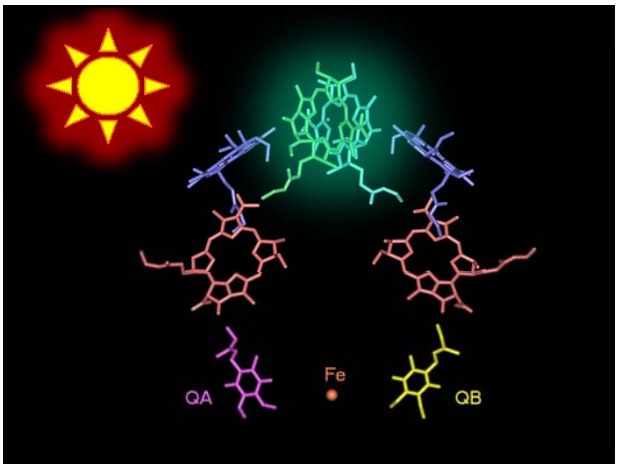
Fotosíntesi

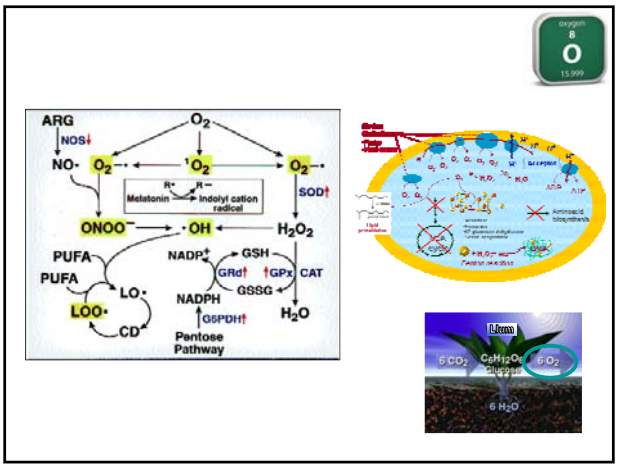


Fotosíntesi - Clorofil·la









Respiració

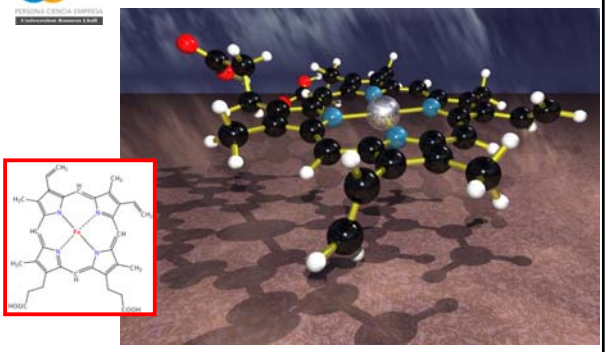
Carbohidrats, Proteïnes, Lípids

O_2

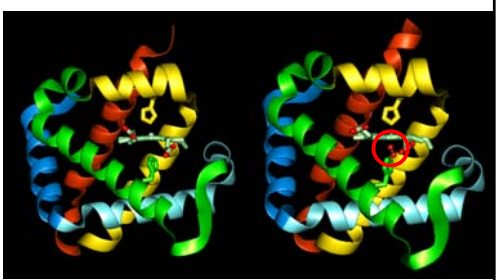
CO_2 + H_2O + Energia química (ATP)

L'oxigen és important!

Hemo - Transport d'oxigen



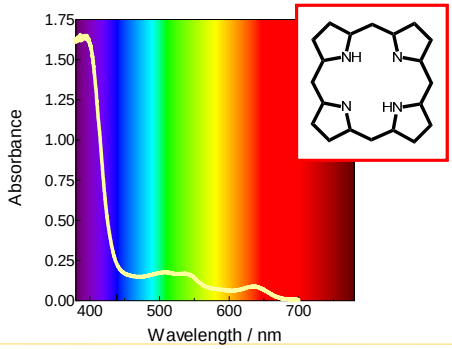
Hemo - Transport d'oxigen



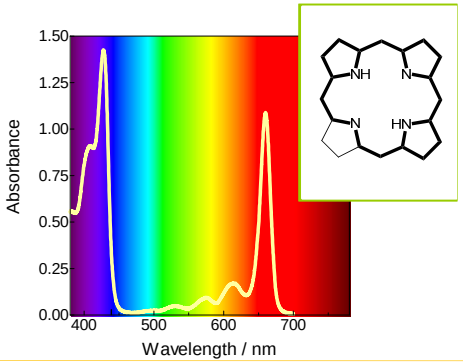
Desoxihemoglobina

Oxihemoglobina

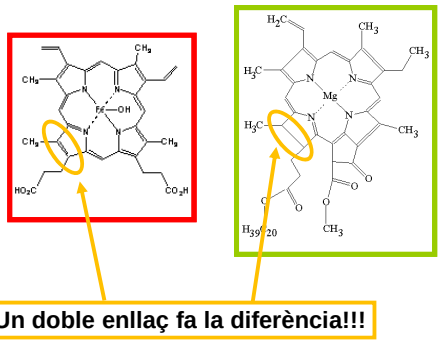
El color de la hemina



El color de la clorofil·la



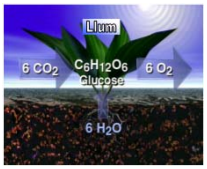
Clorofil·la i hemina



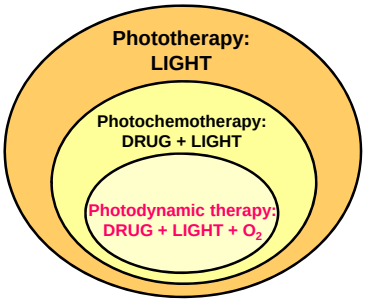
Els colorants i la llum

Donen color
(absorció / reflexió)

Fan reaccions fotoquímiques
(p.ex. La fotosíntesi)



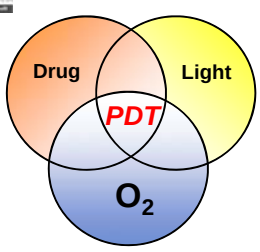
PHOTODYNAMIC THERAPY: THE PARADIGM

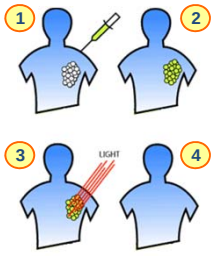


Phototherapy of neonatal jaundice (1847-1927)

PUVA therapy

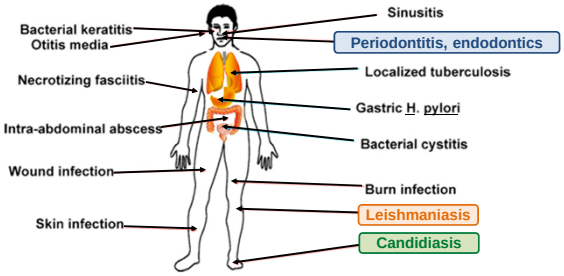
PHOTODYNAMIC THERAPY





1. Administration
2. Distribution and selective accumulation
3. Irradiation (production of *Reactive Oxygen Species*)
4. Photodynamic effect → cell death

Antimicrobial Photodynamic Therapy



Dai *et al.*, *Photodiagn Photodyn Ther*, **2009**; 6: 170–188

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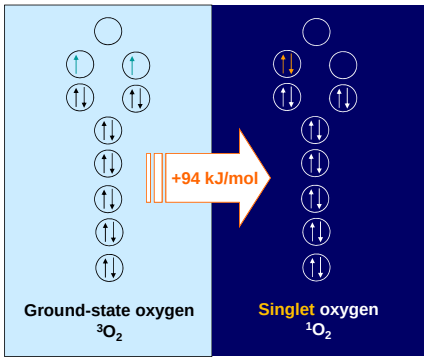
OXIGEN "*NORMAL*" i OXIGEN "*ACTIU*"



¿OXÍGEN ACTIU?

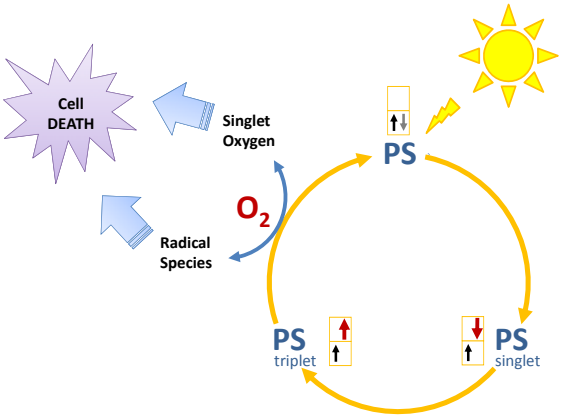
$^1RH + {}^3O_2 \xrightarrow{X} {}^1RO_2H$ **Prohibida**

$^1RH + {}^1O_2 \longrightarrow {}^1RO_2H$ **Permesa**

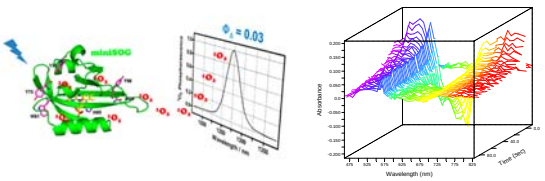
Química quàntica
Regles de spin de Wigner

Singlet oxygen reactivity (k / M^{-1} s^{-1})

Proteins	Cysteine	4×10^8
	Histidine	3×10^7
	Methionine	1×10^7
	Tryptophan	5×10^7
	Tyrosine	8×10^6
Membrane components	β-Carotene	1.3×10^{10}
	α-Tocopherol	7×10^8
	Methyl Linoleate	5×10^4
	Cholesterol	6.6×10^4
Nucleic acids	DNA	5×10^5
	Deoxiguanosine	5×10^6



DE LA fotoQUÍMICA A LA fotoMEDICINA



TERAPIA FOTODINÀMICA - FÀRMACS

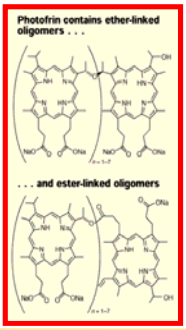
Hematoporfirina

1) AcOH /H_2SO_4 (20:1)
2) NaOH

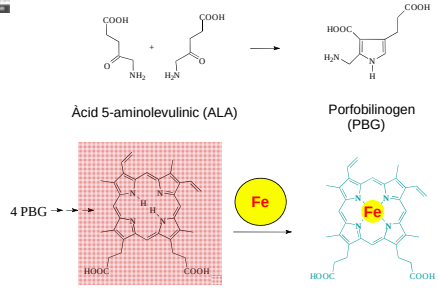
HpD

Purificació

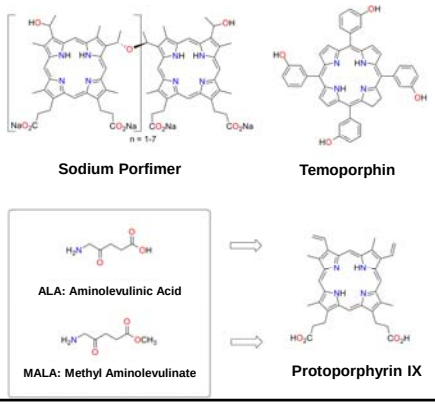
Photofrin®



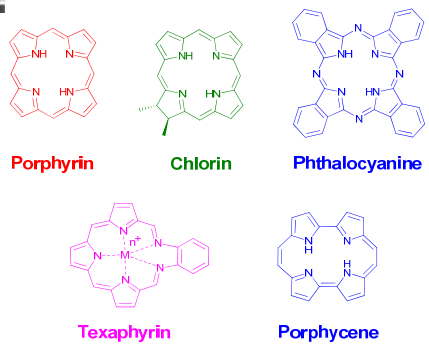
ALA – un Profàrmac d'èxit



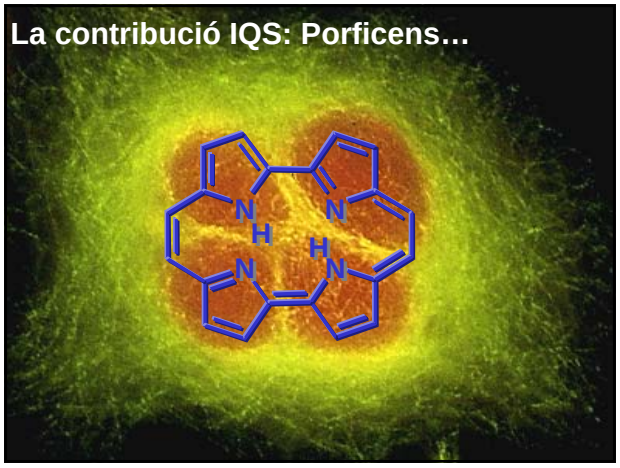
PHOTOSENSITISERS FOR CANCER PDT



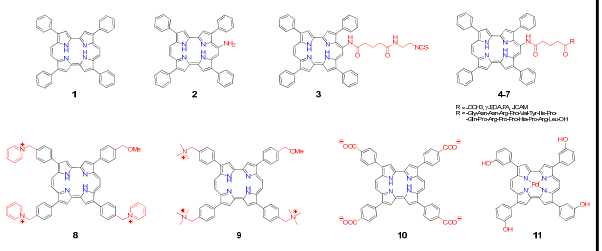
DRUGS UNDER DEVELOPMENT



La contribució IQS: Porficens…



Porphycenes for photodynamic therapy



Nonell Group @ IQS

Curr. Med. Chem. 2007, 14(9), 997-1026
J. Am. Chem. Soc., 2007; 129(16); 5188-5199
J. Med. Chem., 2010, 53 (21), 7796–7803
Med. Chem. Commun. 2011, 2 (7), 616-619
J. Control. Res., 2012, 162, 355-363
J. Med. Chem. 2013, 56(3), 1052–1063
Eur. J. Med. Chem., 2013, 63, 401-414
BBA – General Subjects 2013, 1830, (10), 4611–4620.
Langmuir. 2013. 29(31), 9734-9743

The Nobel Prize in Chemistry 2008

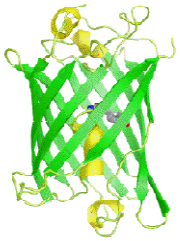
"for the discovery and development of the green fluorescent protein, GFP"

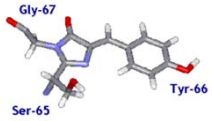
Photo: J. Henriksson/SCANPIX — **Osamu Shimomura**

Photo: J. Henriksson/SCANPIX — **Martin Chalfie**

Photo: UCSD — **Roger Y. Tsien**

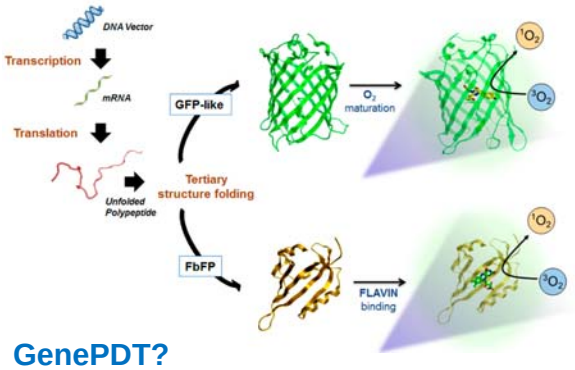
GREEN FLUORESCENT PROTEIN





4-(p-hydroxybenzylidene)imidazolidin-5-one

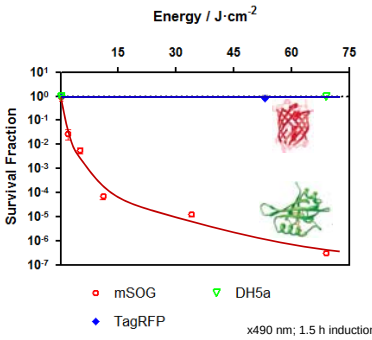
Genetically-Encoded Photosensitisers



GenePDT?

Nat Biotechnol. 2006, **24**, 95

MiniSOG and TagRFP kill *E. coli*



x490 nm; 1.5 h induction w/ arabinose 0.1 %

Proc. of SPIE 2013, 859609