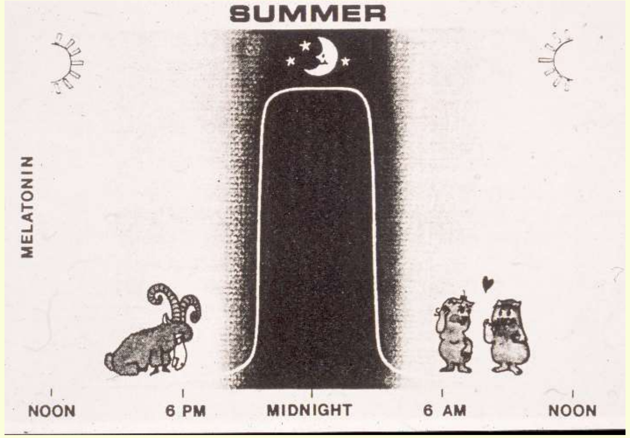
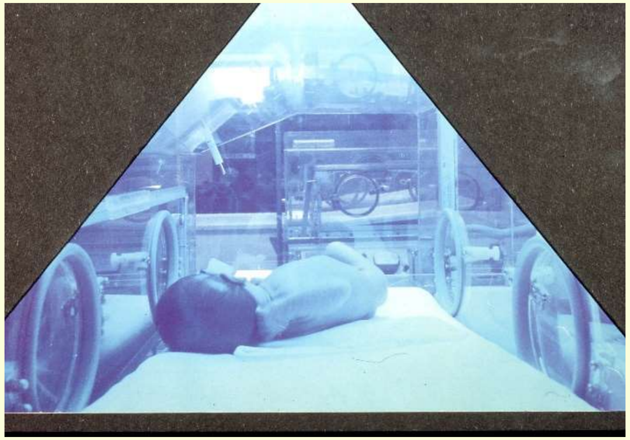
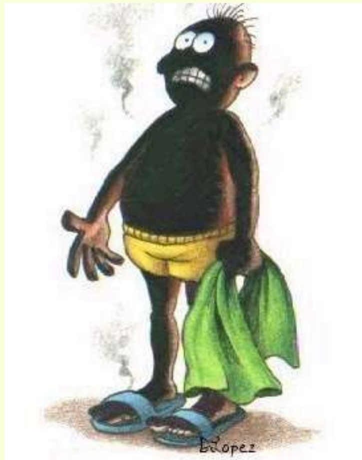
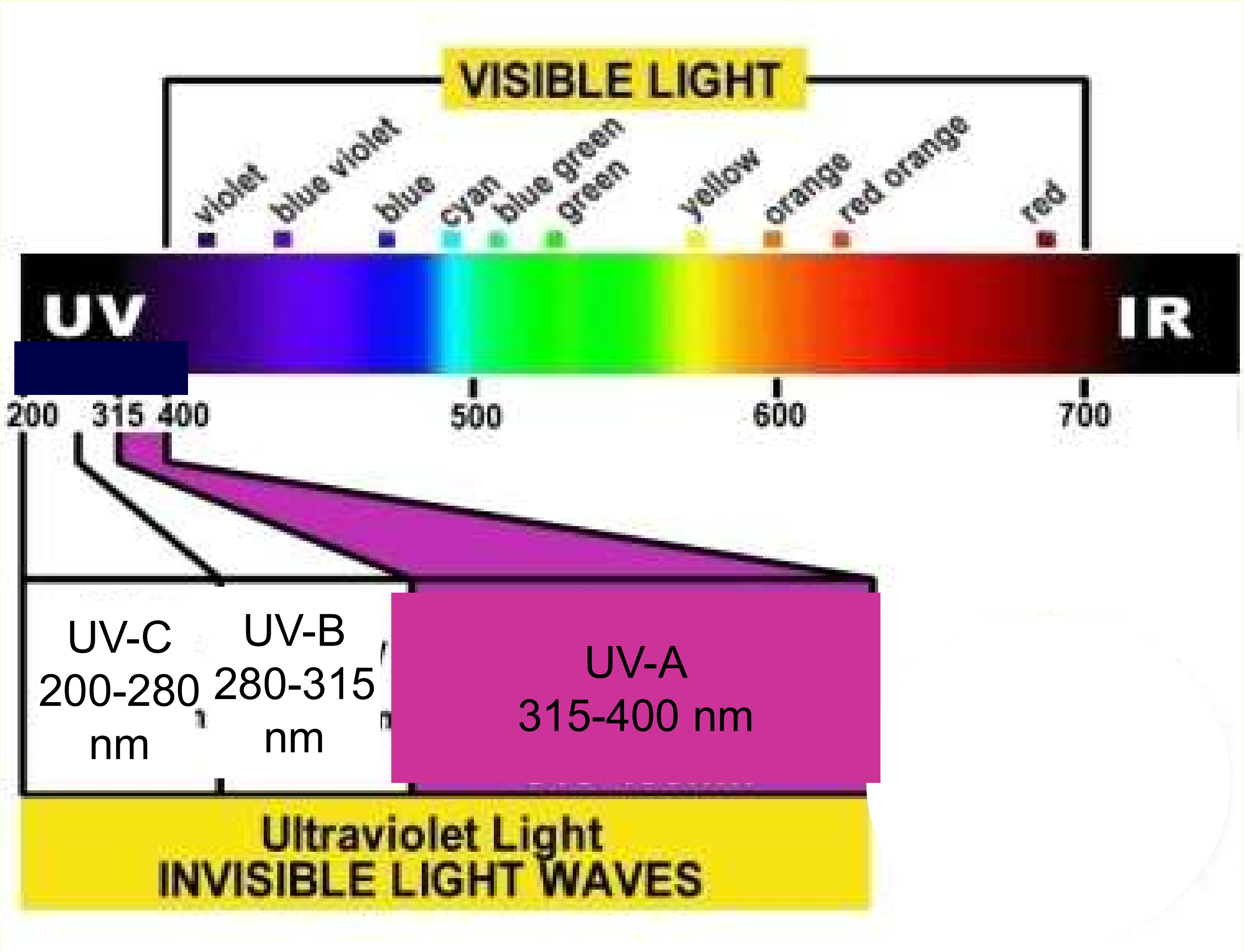


Biological effects of light





Optical reagon of EM spectrum



Steps leading to the photobiological alterations

Photophysical processe
(absorption of light)

↓

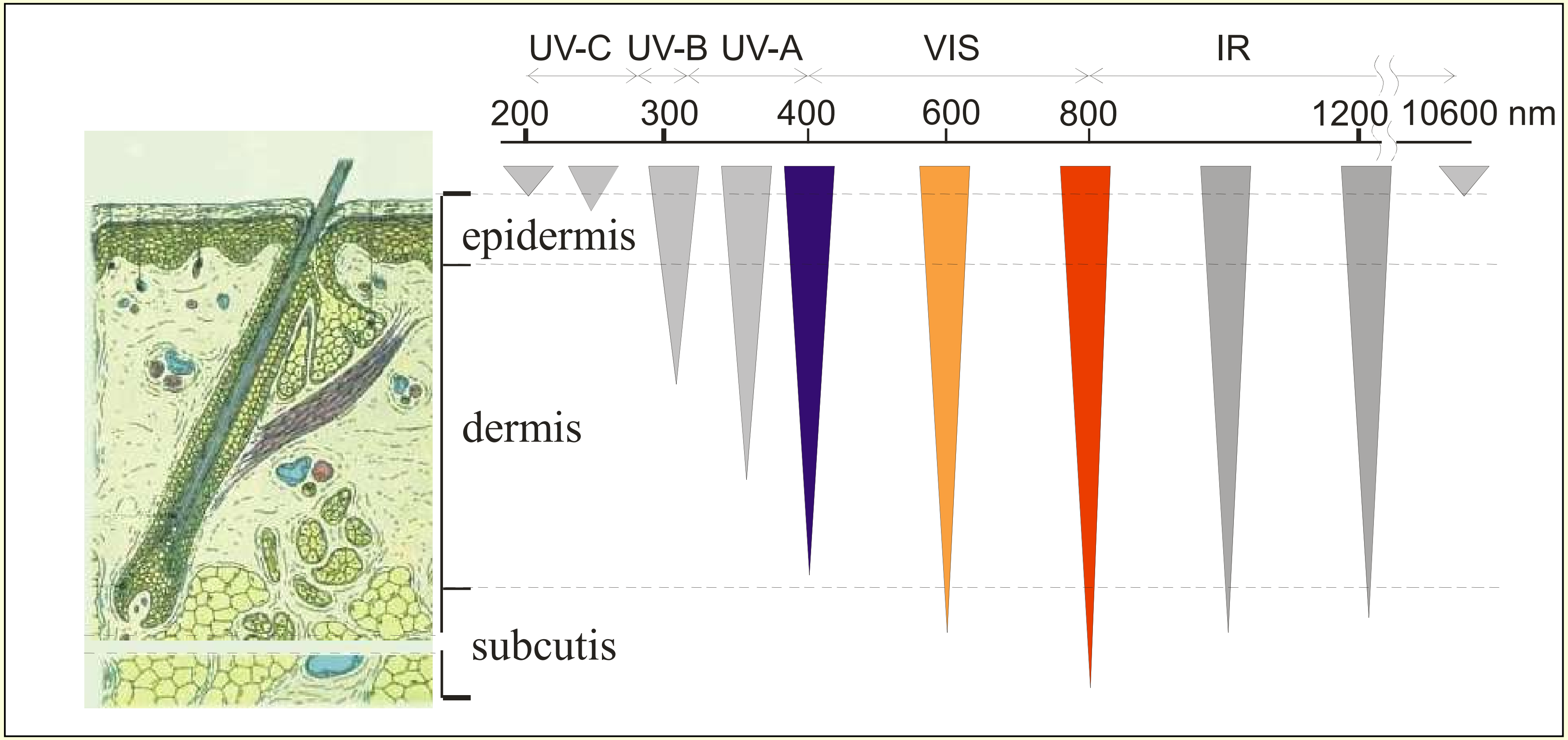
Photochemical reaction

↓

Photobiological processes

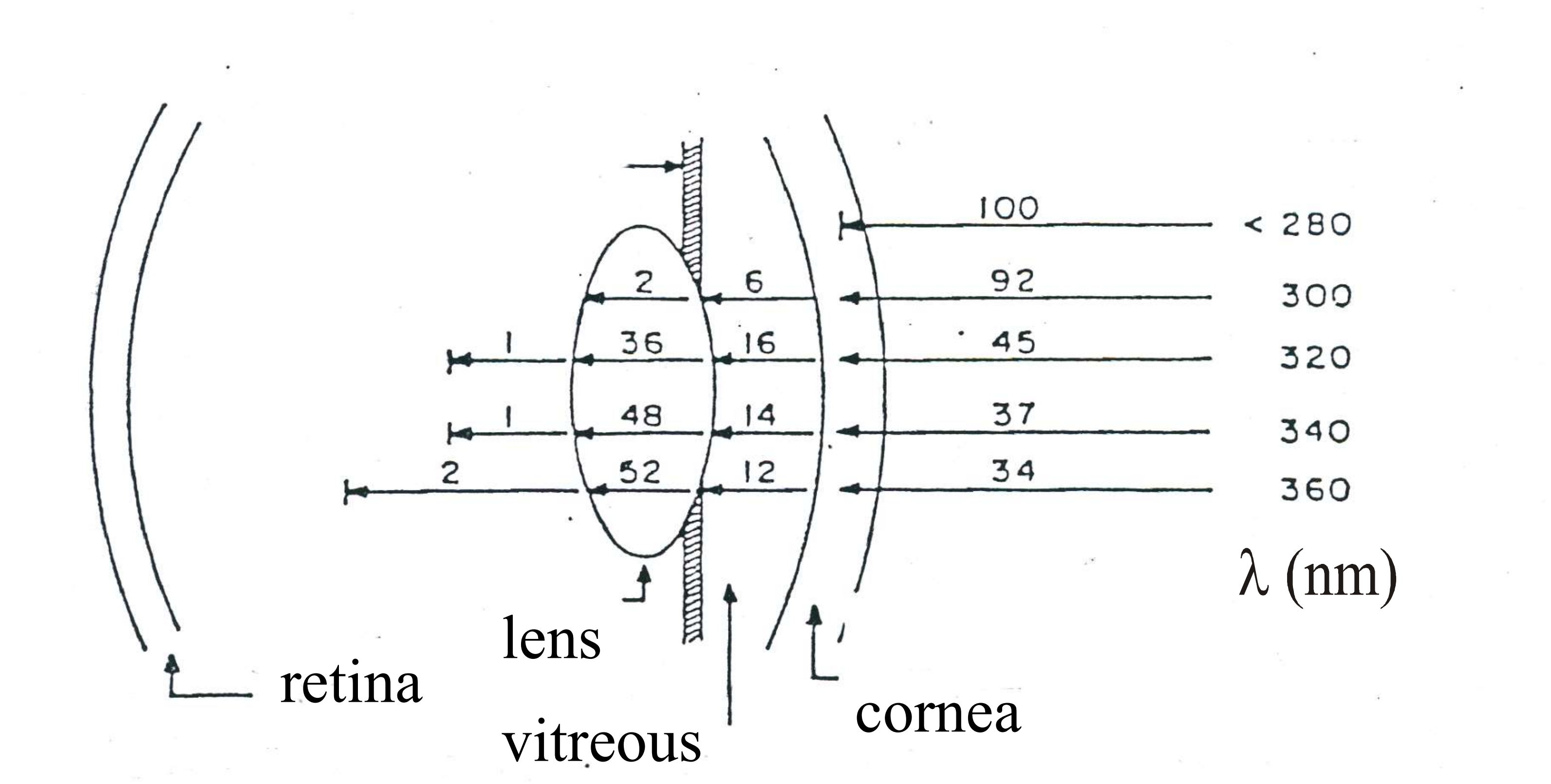
Absorption of light is a prerequisite of photobiological processes

Penetration distance of light into skin



Penetration depth is wavelength dependent

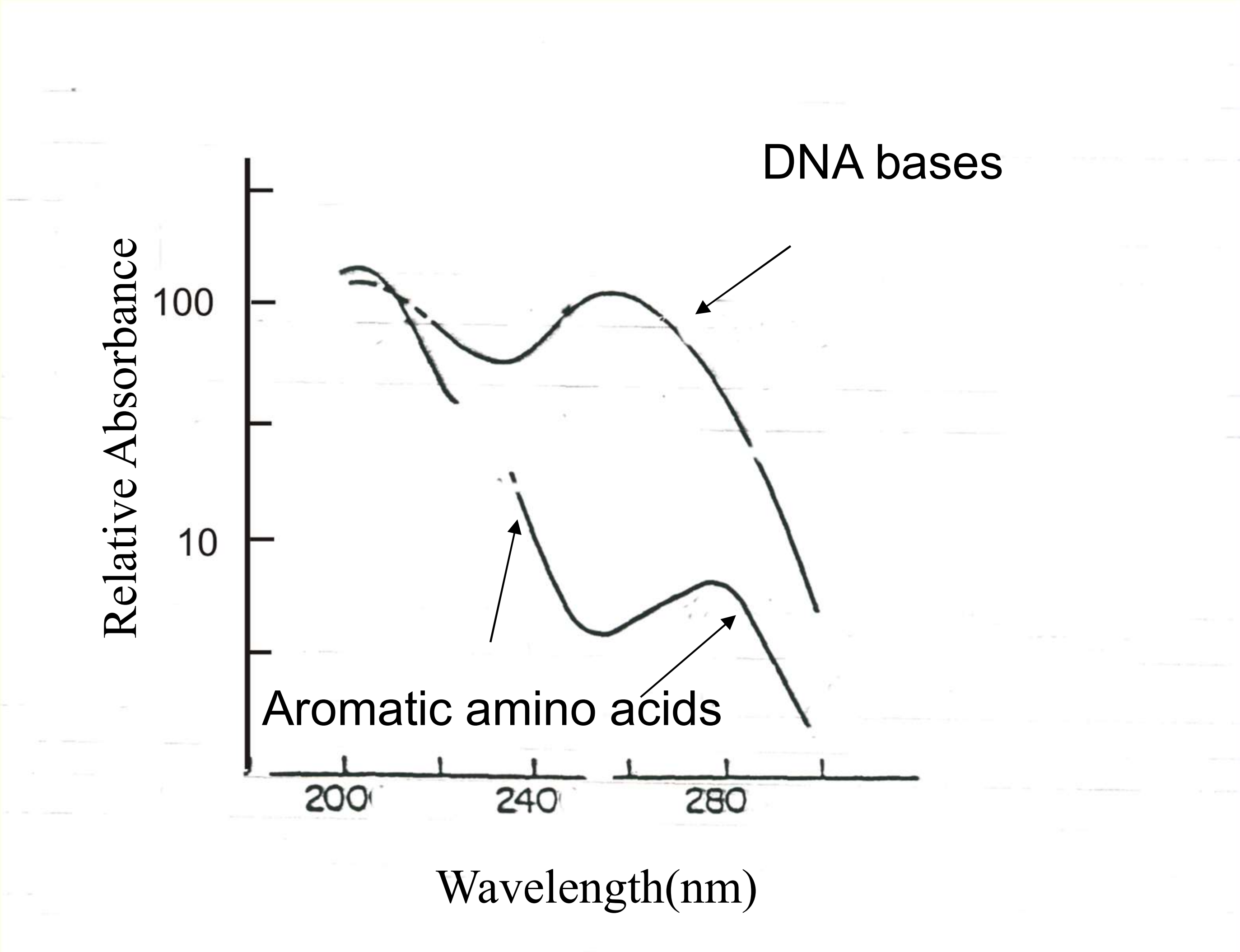
Penetration distance of light into eye



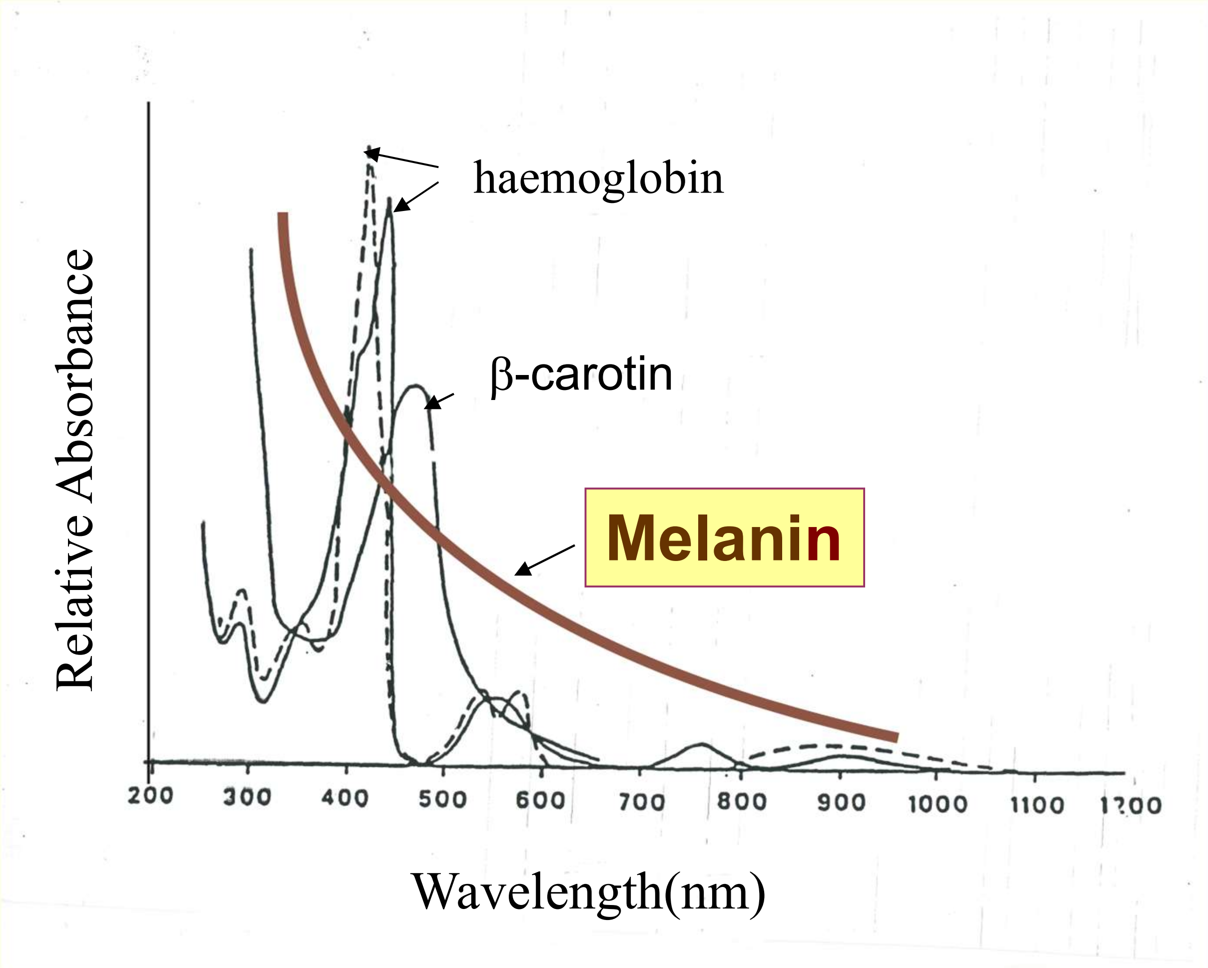
Ligth absorbers (chromophores) in human tissues

Endogenous	Exogenous
e.g. nucleic acids	e.g. food coloring dyes
proteins	cosmetics
melanin	drugs
opsins	

Absorption spectra of endogenous chromophores (1)



Absorption spectra of endogenous chromophores (2)



Consequence of light absorption:
Excited state

Relaxation of excited state

Light emission | Potochemical reaction | Thermal relaxation

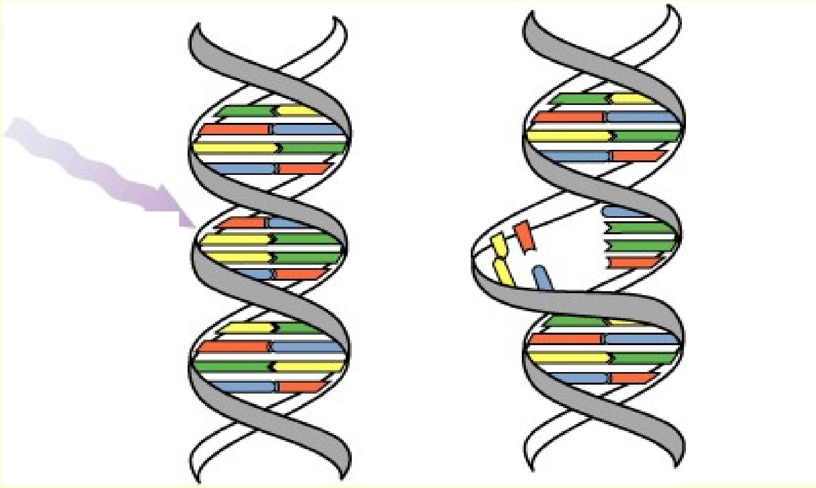
$$A \longrightarrow B$$

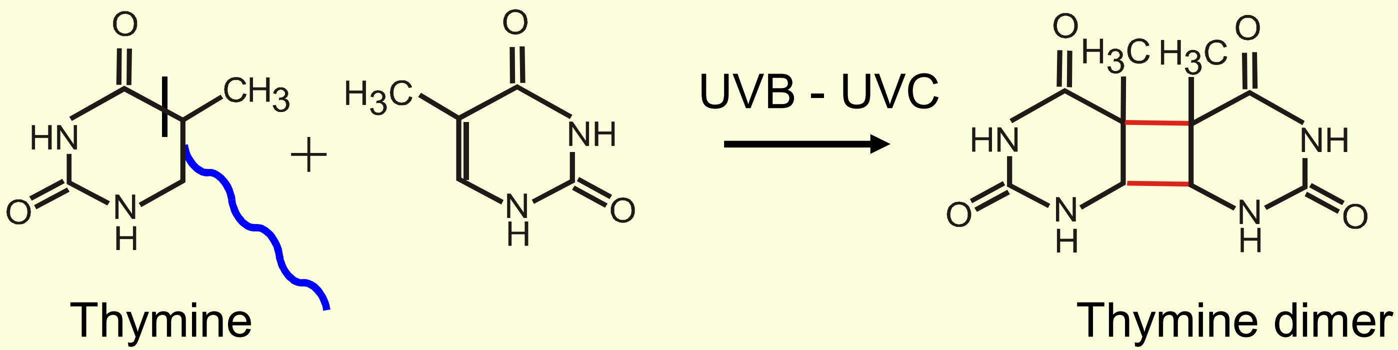
Quantum yield (Φ) : is the number of events (e.g., number of photochemical reactions) divided by the number of photons absorbed by the system.

$$\Sigma\Phi=1$$

Direct photochemical reactions

e.g. Formation of DNA damages





Pirimidin dimer formation in DNA

Indirect photochemical reactions

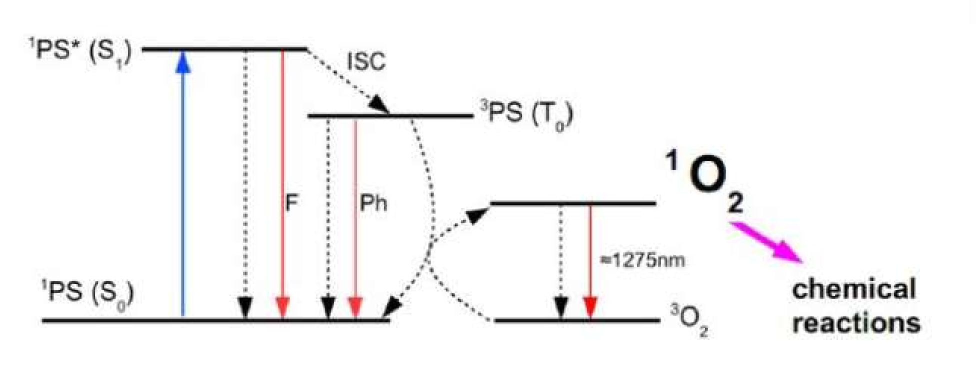
Step 1: excitation of photosensitizing compound by light

Step 2: generation of reactive

free radicals by electron transfer

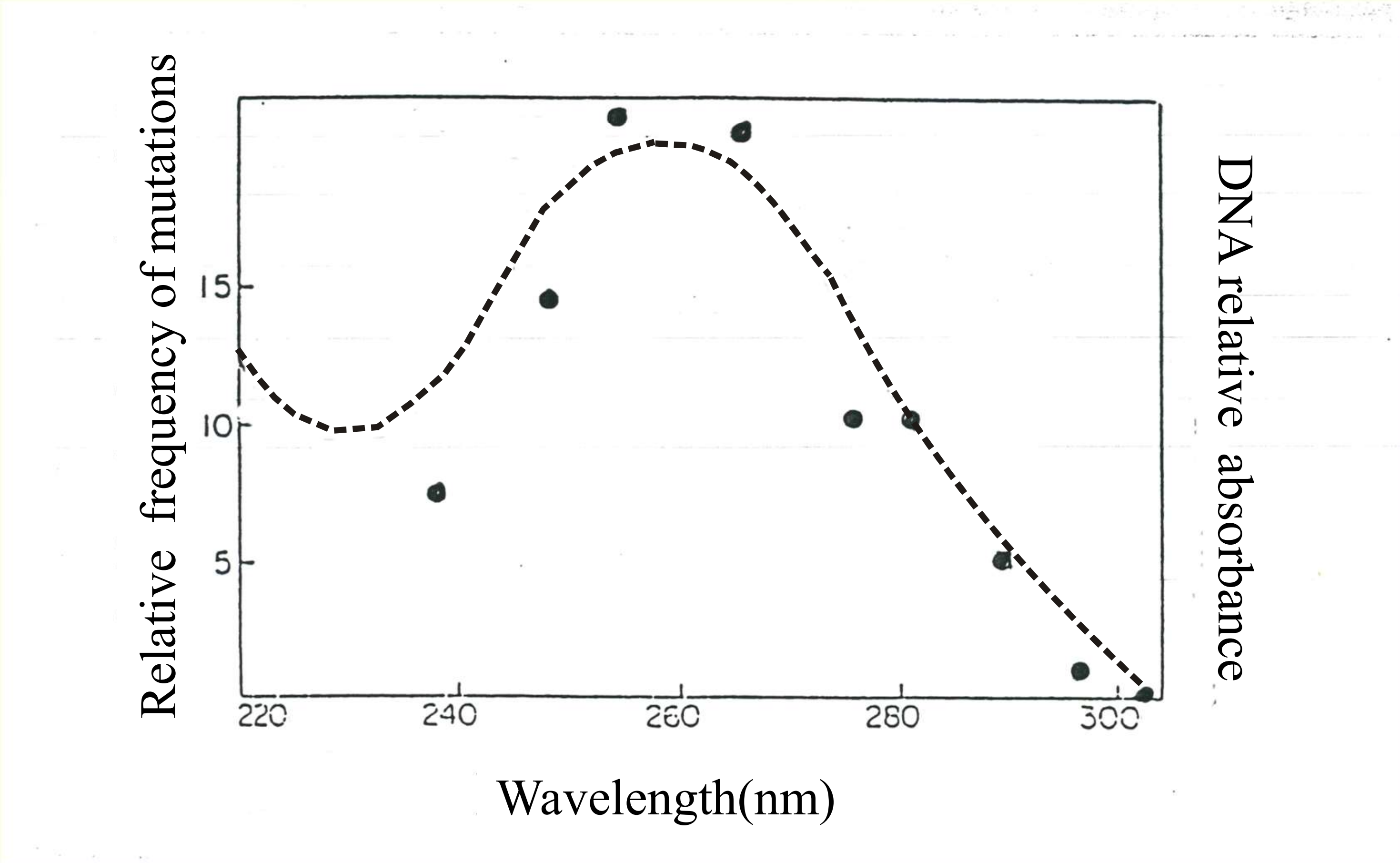
or

reactive oxygen species by energy transfer



Step 3: oxidativ damage of cellular structures

Spectral distribution of photobiologycal efficiency



Efficiency varies with the wavelength

Mutations are induced by the photons absorbed in DNA

Reciprocity?

$$\boldsymbol{J}_{(\lambda)}\ [\mathrm{J / s\ m^2}]\ \times\ \boldsymbol{t}\ [\mathrm{s}] = D_{(\lambda)}\ [\mathrm{J / m^2}]$$

The results depends only on the incident dose ($\boldsymbol{D}_{(\lambda)}$)

or

on ***J*** and on ***t*** separately

Reciprocity is valid for photochemical reactions but not for photobiological results.

Examples for the photobiolgical effects of light

Beneficial vs detrimental effects

examples

Vision
Vitamin-D production
Pigmentation
Daily and annual rhythms
Terapeutic applications

examples

Sunburn
Wrinkles
Age related pigmentation
Skin cancer
Immuno-suppression

Spatial distribution of alterations

Local effects

in the skin

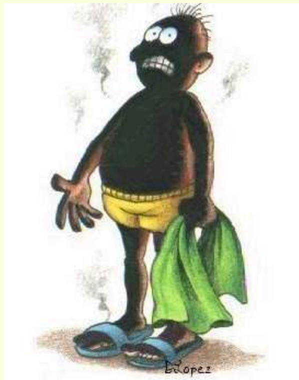
in the eye

target regions of therapies

Systemic effects

Temporal distribution of alterations

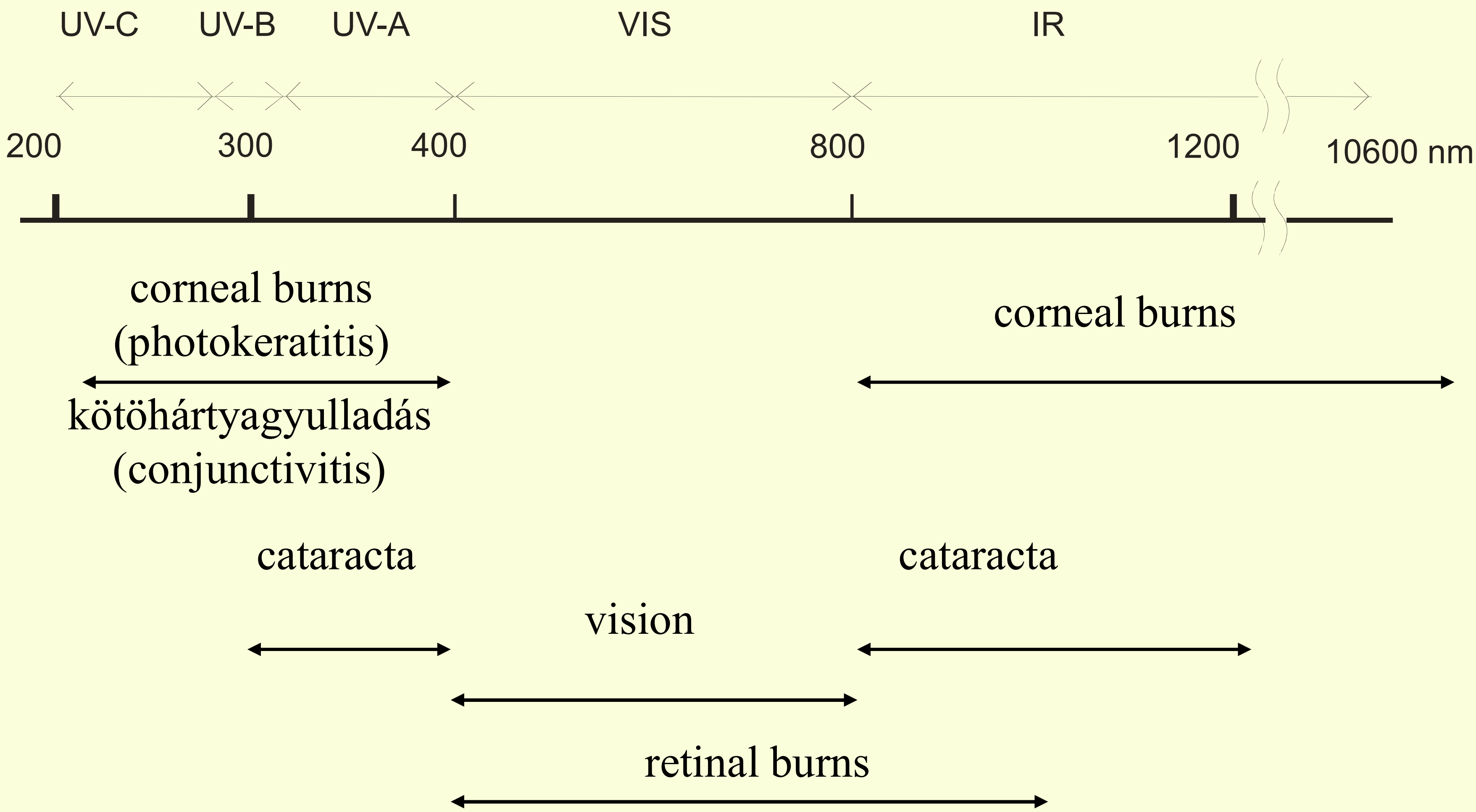
Short term: sunburn
immuno-suppression



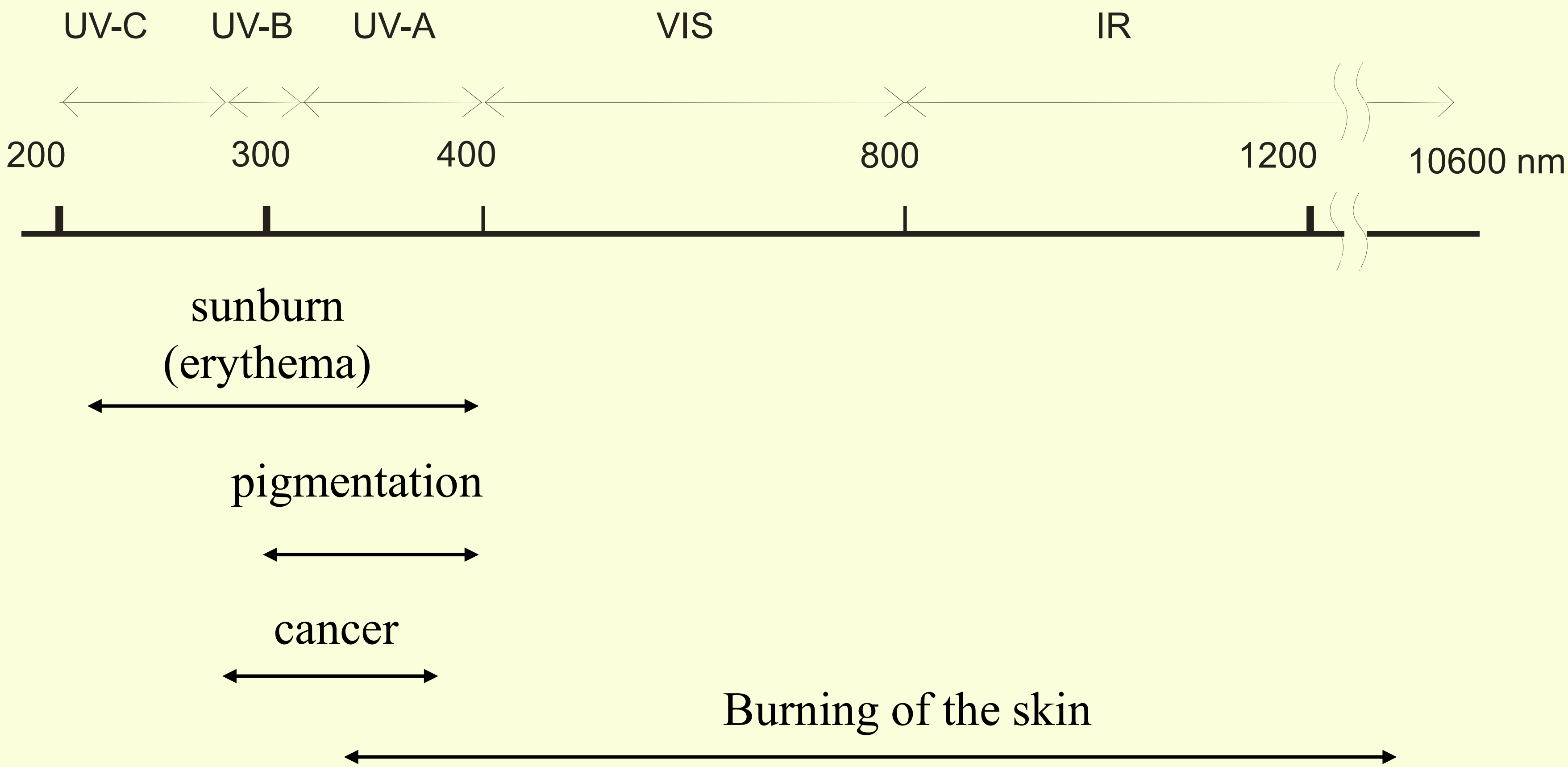
Long term: age related wrinkles
age related pigmentation
skin Cancer

Penetration distance and localization of damages

in the eye

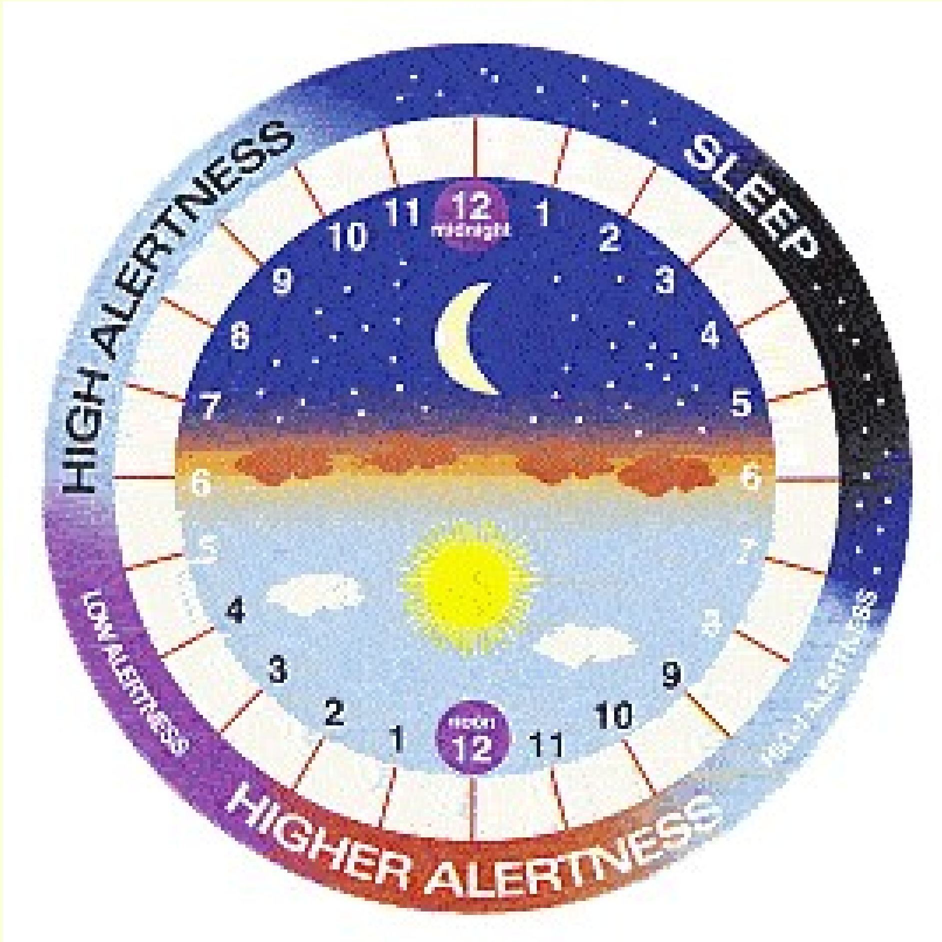


in the skin

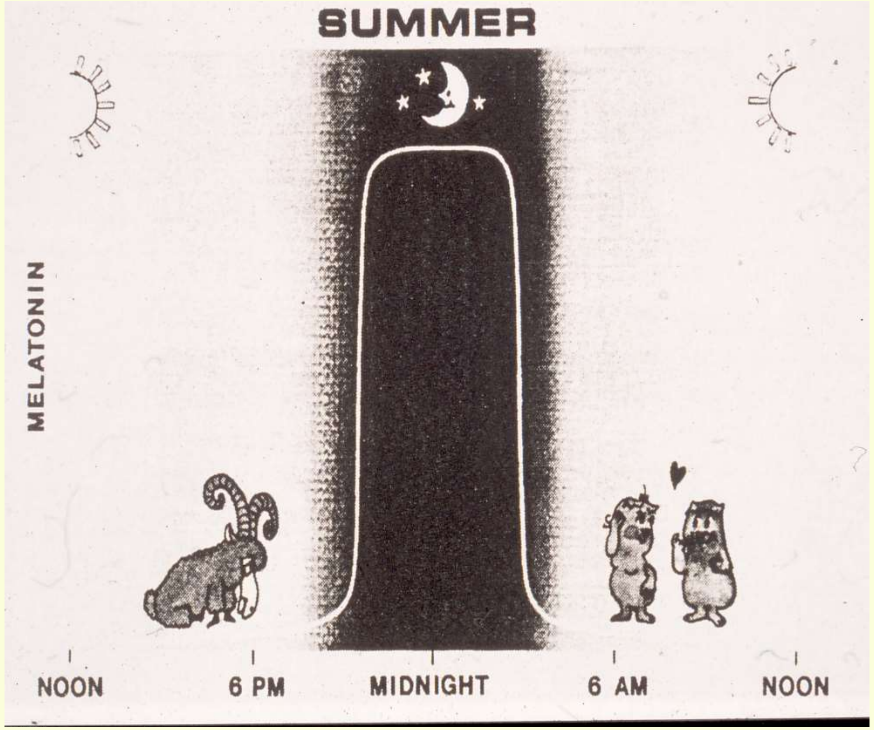

UV-C
UV-B
UV-A
VIS
IR
200
300
400
800
1200
10600 nm
sunburn
(erythema)
pigmentation
cancer
Burning of the skin

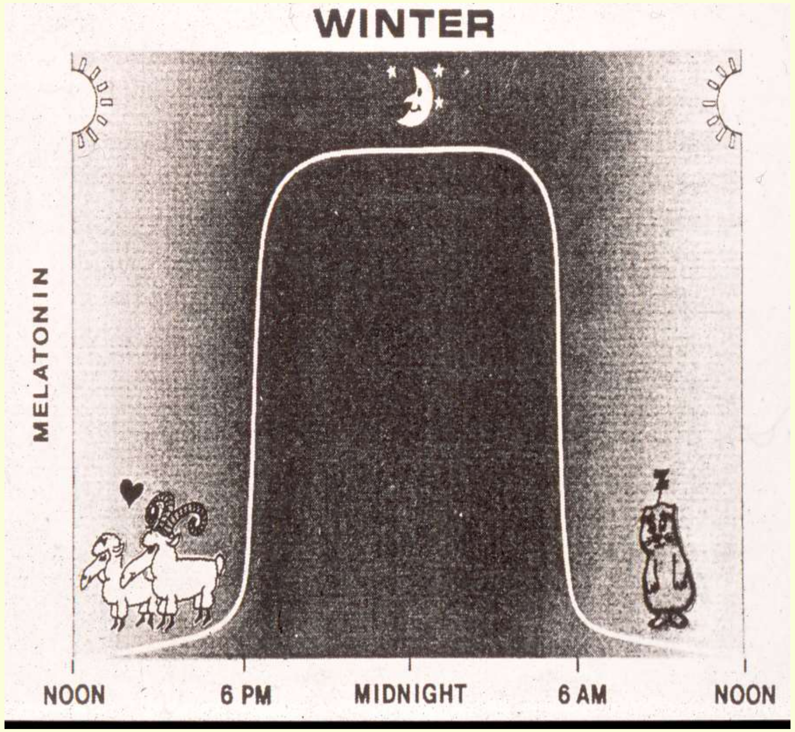
Daily and annual rhythms

e.g.
- temperature
- hormon production
- digestion
- sliping / wake

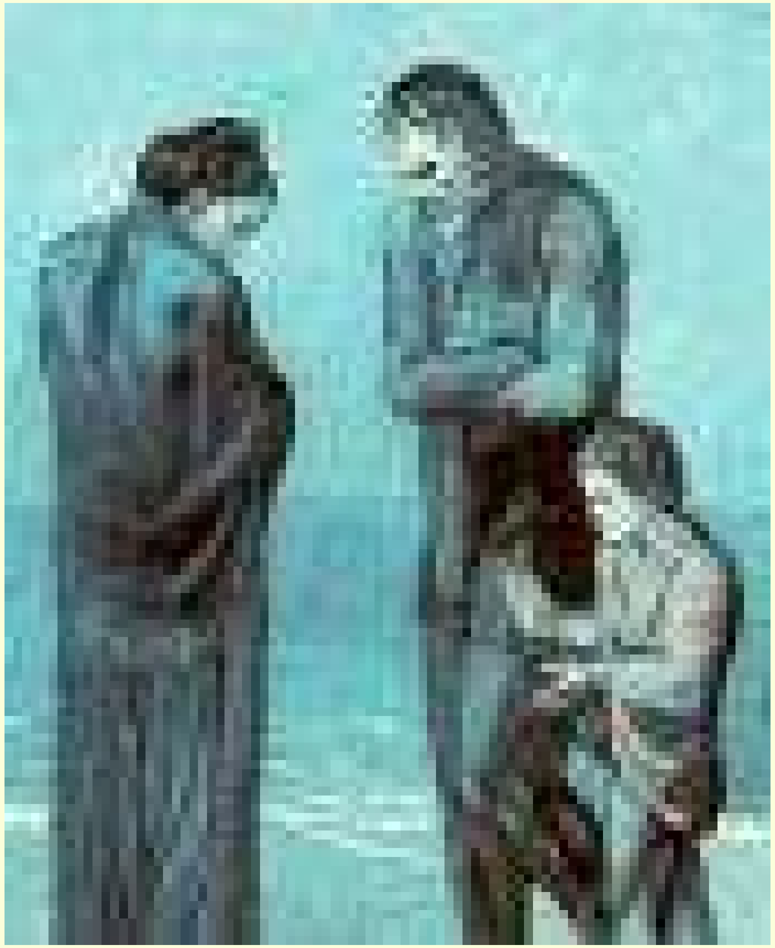


Light may play a role on the circadian rhythm

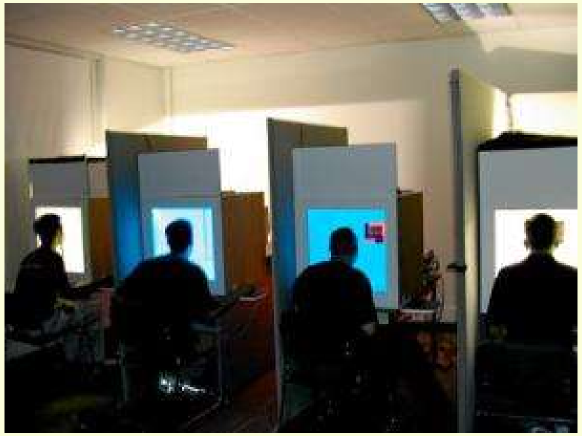


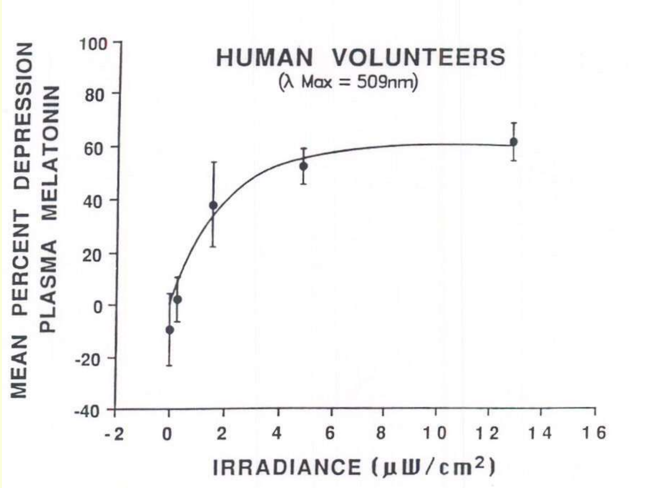


Seasonal Affective Disorder (SAD)
fényhiányos depresszió



Background of SAD：hight serum level of melatonin





Melatonin level is regulated by the intensity, wavelength and time period of the incident light into the eye

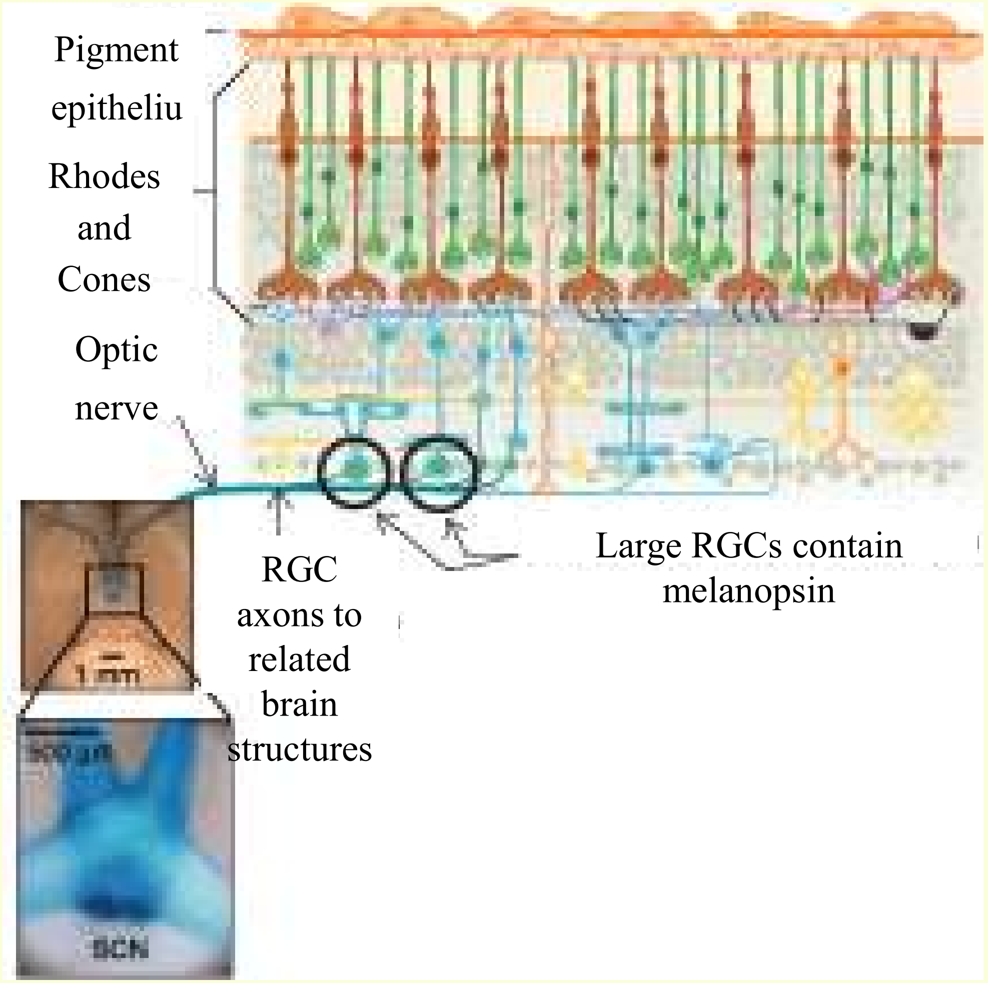
Melatonin level regulation is independent of vision – blindness do not oppose this process

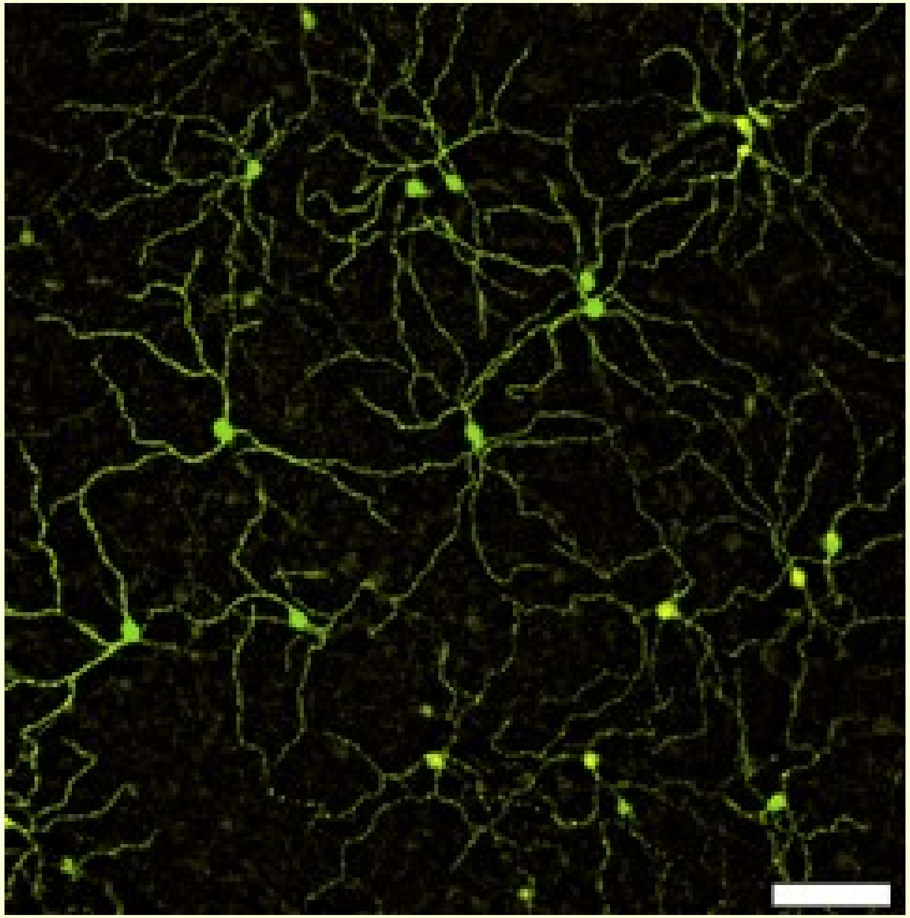
A new type of photosensitive cells (RGC) in retina

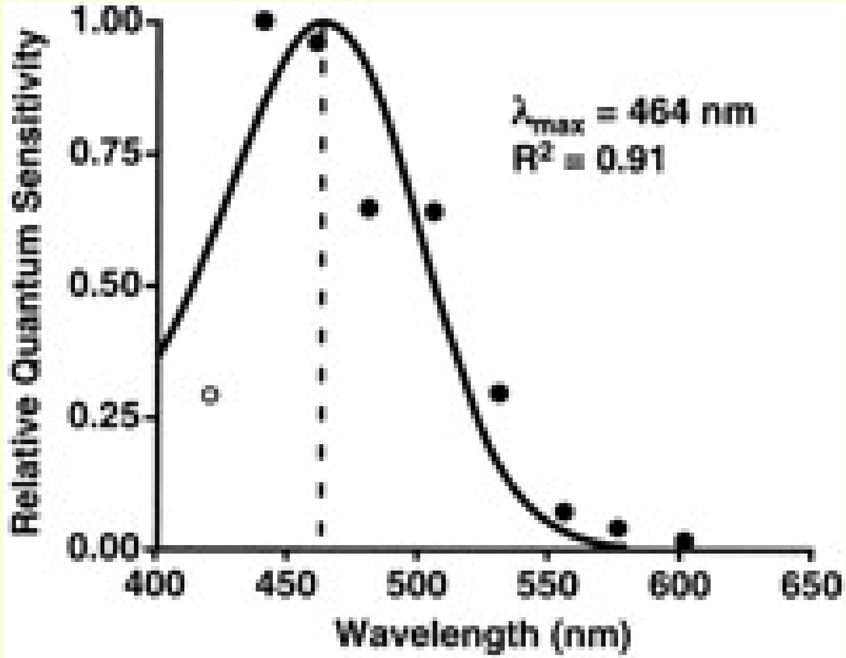
Discovery of non-visual pigment(s)

„melanopsin”

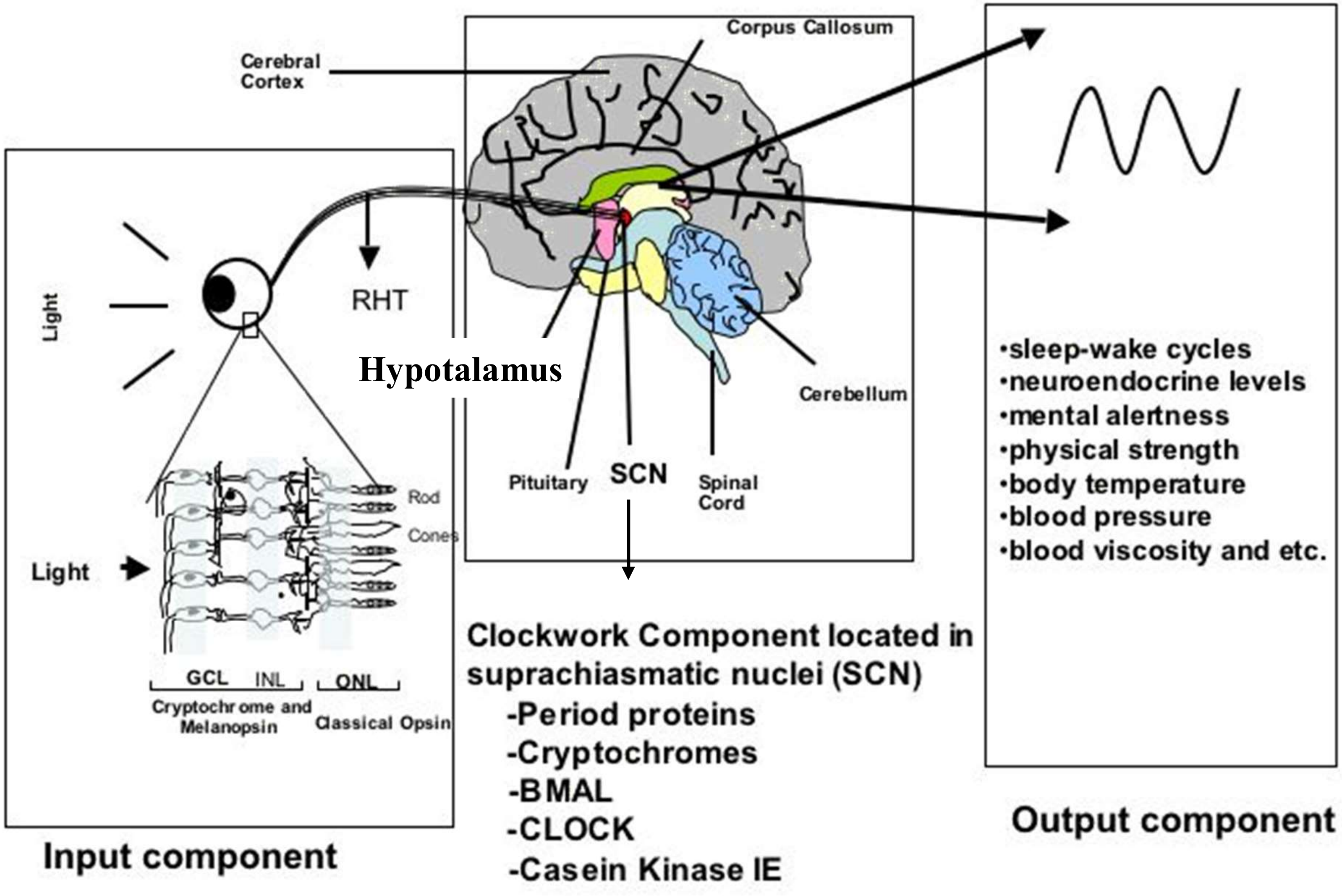
in the eye of vertebrates







Network of retinal
ganglion cells


Corpus Callosum
Cerebral
Cortex
Light
RHT
Hypotalamus
Pituitary
SCN
Spinal
Cord
Cerebellum
Rod
Cones
Light
GCL
INL
ONL
Cryptochrome and
Melanopsin
Classical Opsin
Input component
Clockwork Component located in
suprachiasmatic nuclei (SCN)
-Period proteins
-Cryptochromes
-BMAL
-CLOCK
-Casein Kinase IE
•sleep-wake cycles
•neuroendocrine levels
•mental alertness
•physical strength
•body temperature
•blood pressure
•blood viscosity and etc.
Output component

Seasonal Affective Disorder (SAD)

Treatment

Light sources

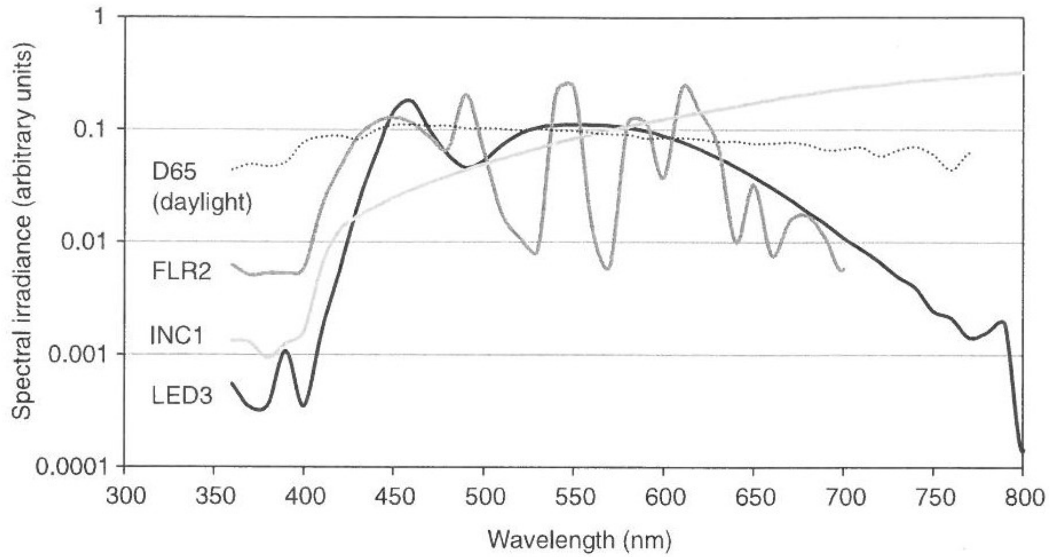


Figure 2 Typical spectra of seasonal affective disorder (SAD) lamps, sunrise simulators and daylight bulbs for emitting diodes (LED3), fluorescent (FLR2), incandescent (INC1) lamps and the CIE standard illuminant D representing natural daylight. The spectra are normalised for equal illuminance, and plotted in 10-nm steps

Therapeutic application of light

Phototherapy : light + endogenous chromophore

Therapy by light

Photchemotherapy: light + exogenous chromophore

Therapy by drug + light

Example for the medical application of light

Concept of photodynamic therapy (PDT) originally developed as tumor therapy

Light induced inactivation

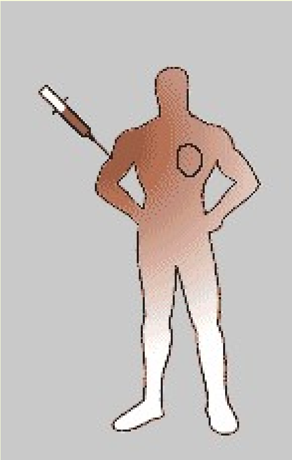
of photosensitized cells

in the presence of molecular

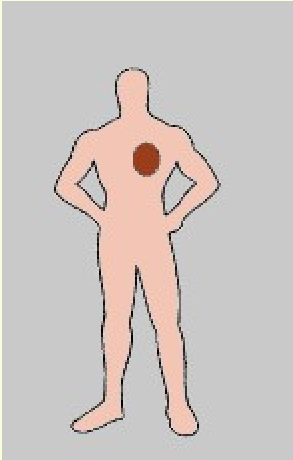
oxygen

T. Dougherty: Activated dyes as antitumor agents.
J. Natl. Cancer. Inst. 1974

A kezelés sémája

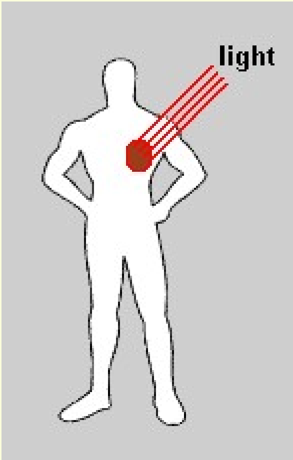


Injection of photosensitizer into the body

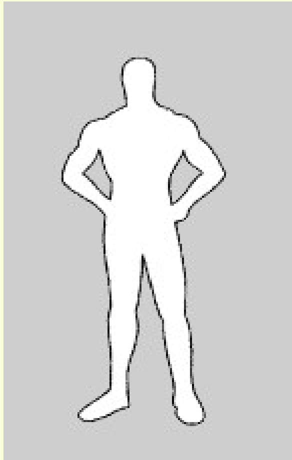


Accumulation of photosensitizer in tumor cells

Activation by light



Selective tumor destruction



PDT mechanism of action: Indirect photochemical reaction

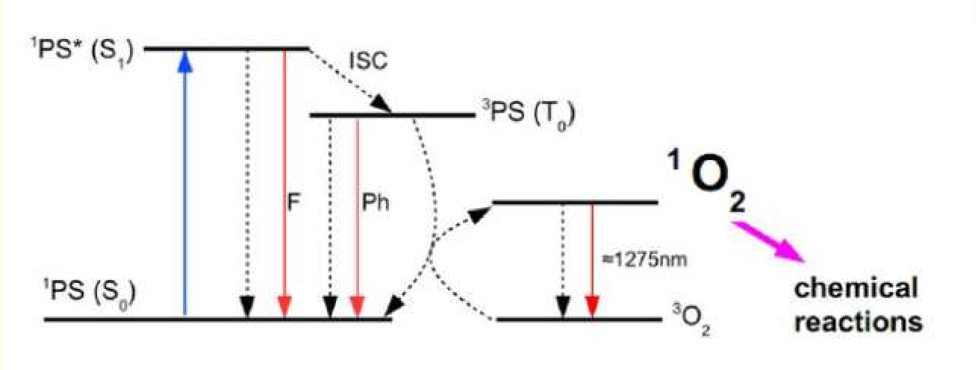
Step 1: excitation of photosensitizing compound by light

Step 2: generation of reactive

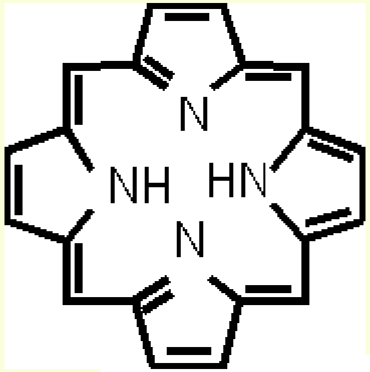
free radicals by electron transfer

or

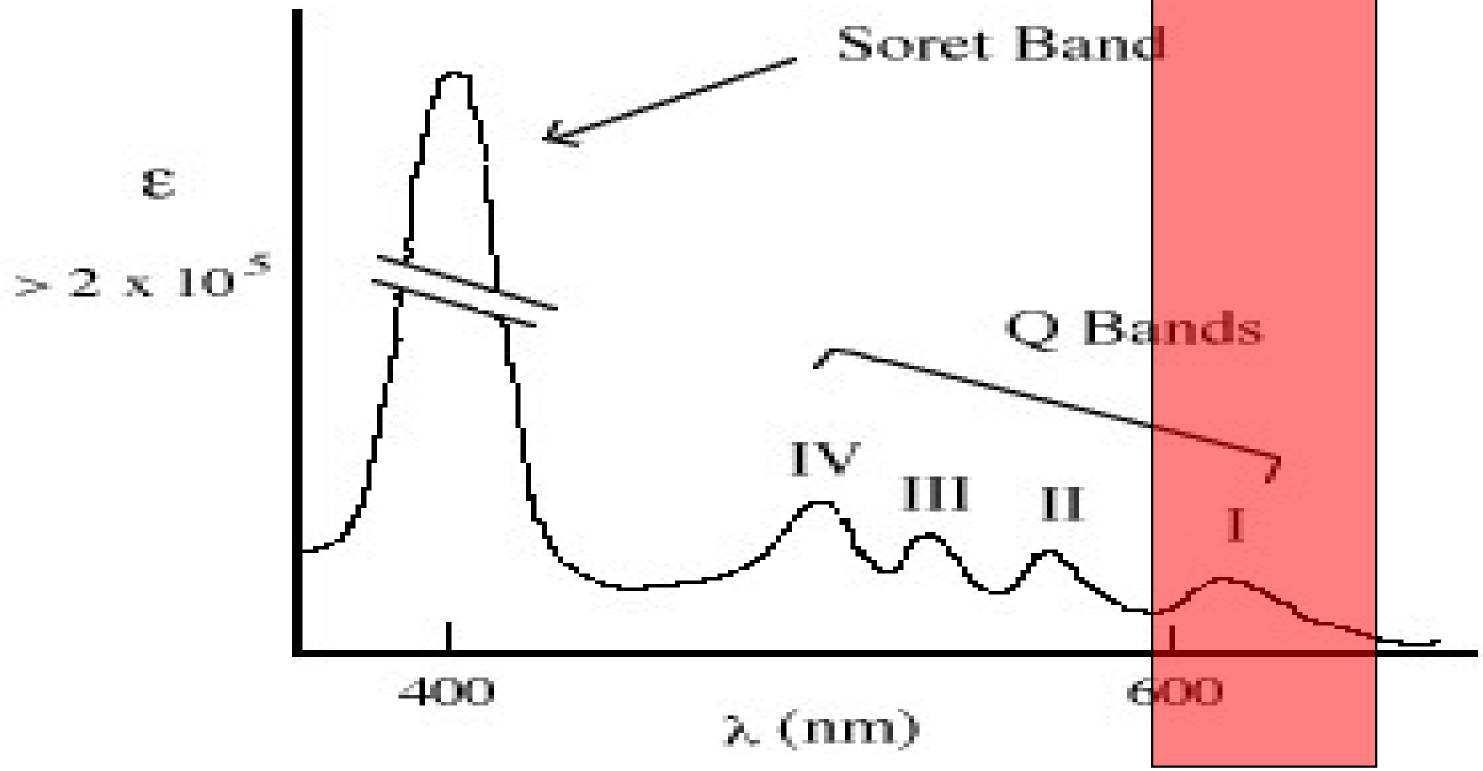
reactive oxygen species by energy transfer



Step 3: oxidativ damage of cellular structures



Absorption spectrum of porphyrins



Application fields of PDT

- *Treatment of various tumors (skin, lung, stomach, bladder, ….)*

- *Treatment of non-malignant skin disorders*

- *Inactivation of microorganisms*

Dental PDT
Treatment of periodontitis

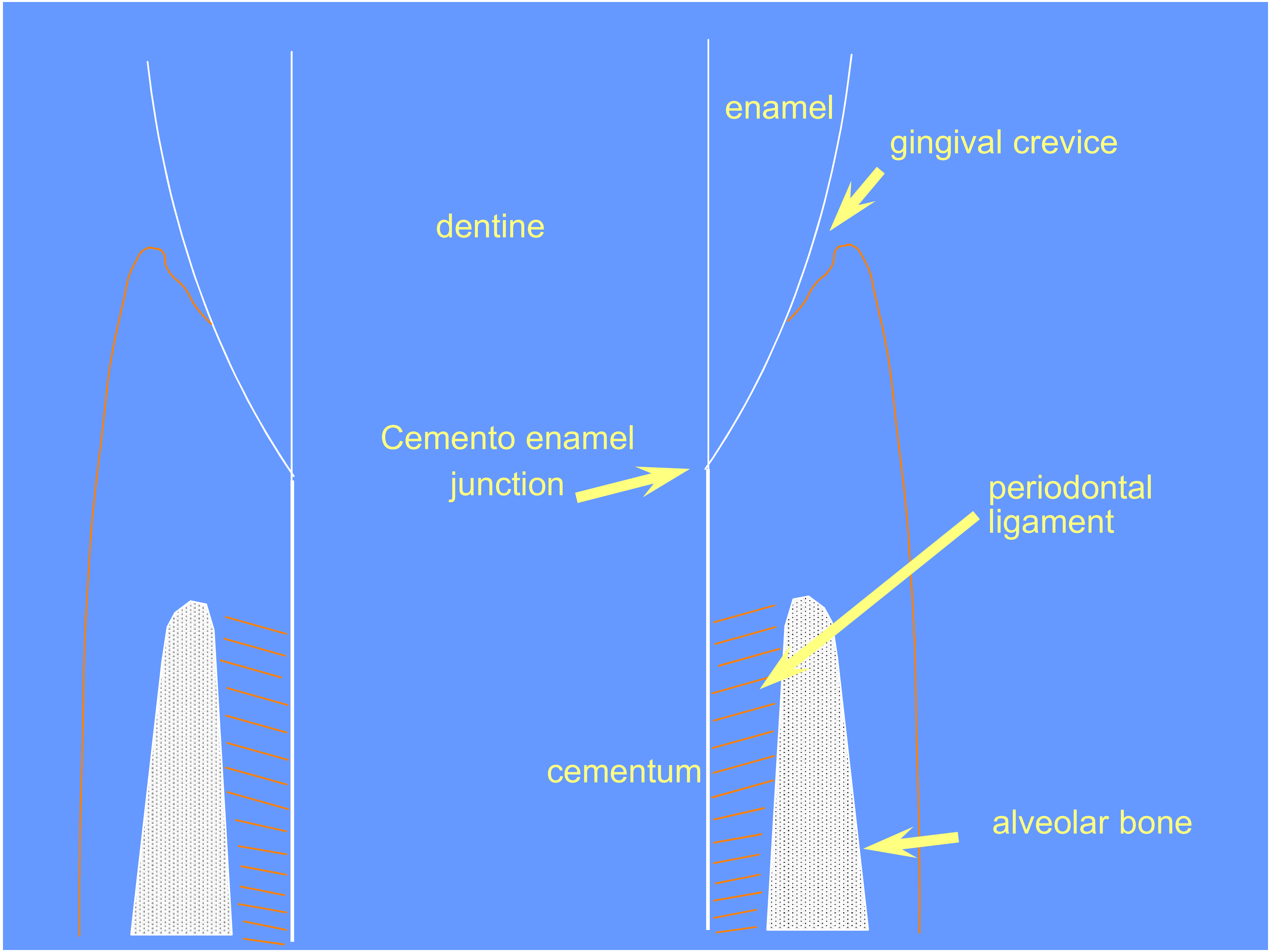
Photoinactivation of bacteria

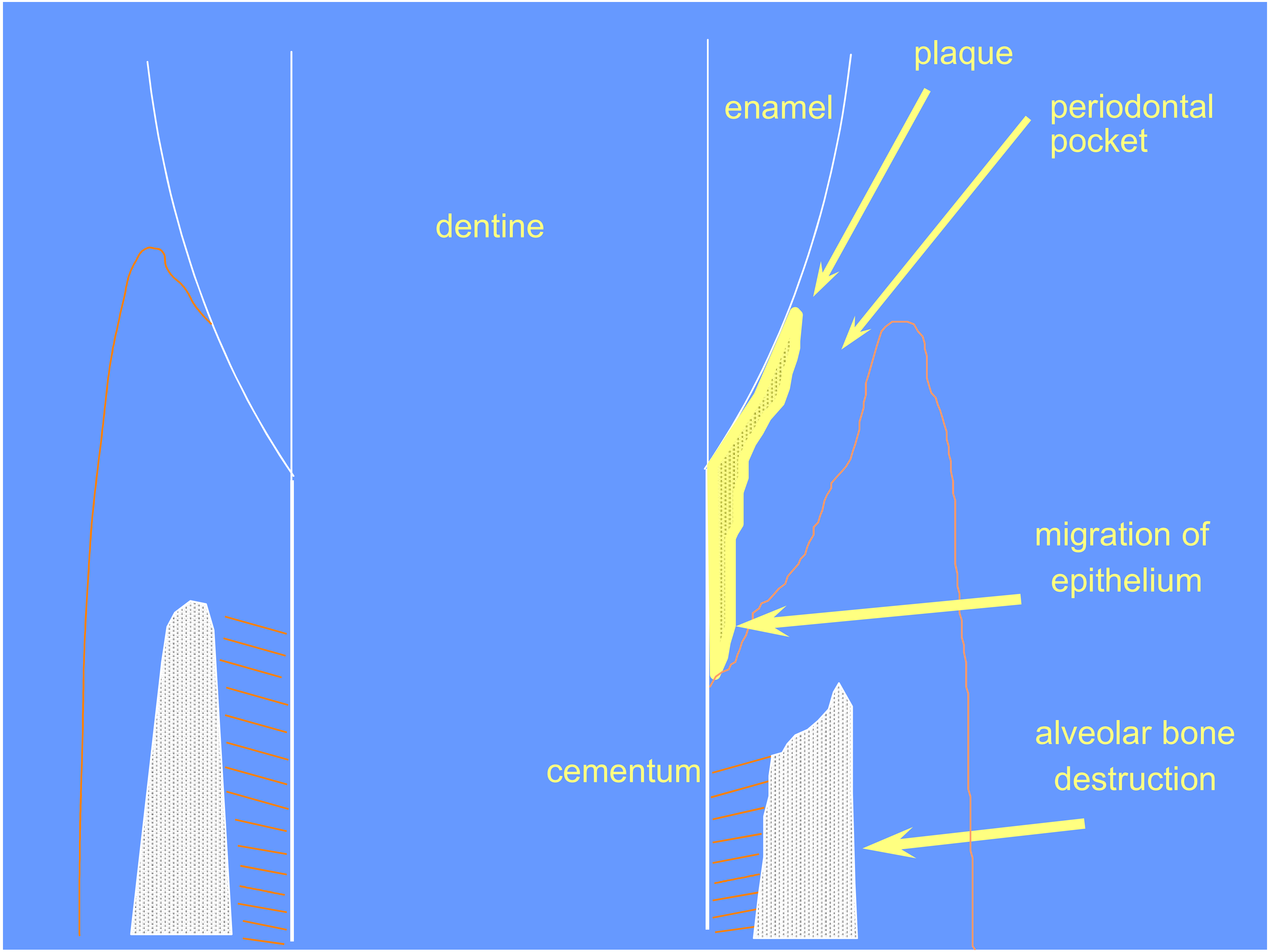
1. Application of photosensitizer

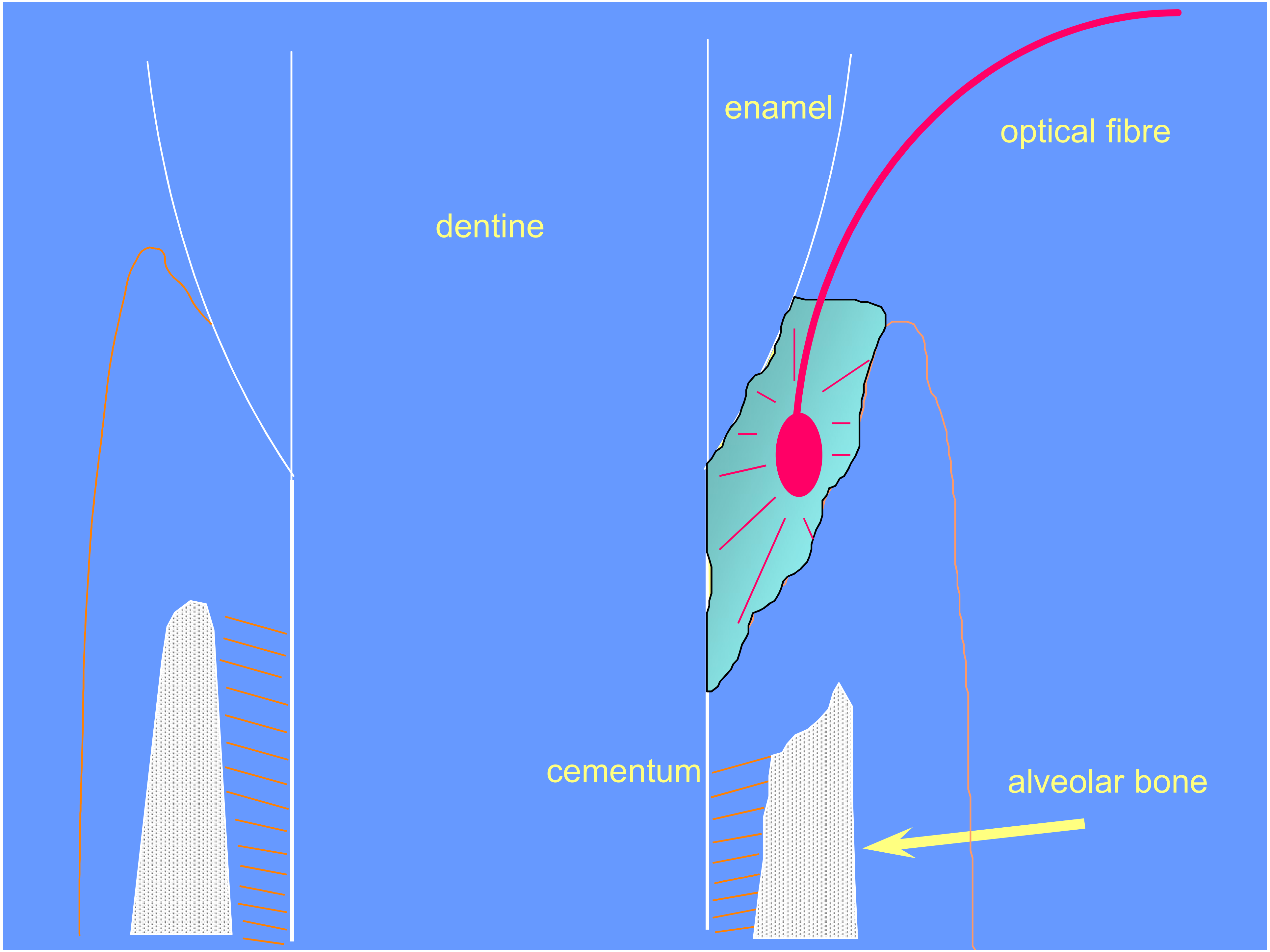
Dental PDT
Treatment of periodontitis

Photoinactivation of bacteria

2. Irradiation


enamel
gingival crevice
dentine
Cemento enamel
junction
periodontal
ligament
cementum
alveolar bone


plaque
enamel
periodontal pocket
dentine
migration of epithelium
alveolar bone destruction
cementum


enamel
optical fibre
dentine
cementum
alveolar bone

Damjanovich, Fidy, Szöllősi: Medical Biophysics

II. 2.3.3

II. 2. 3.4.

IX.2.