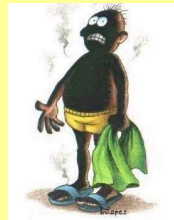
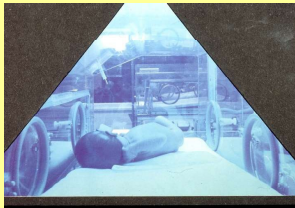
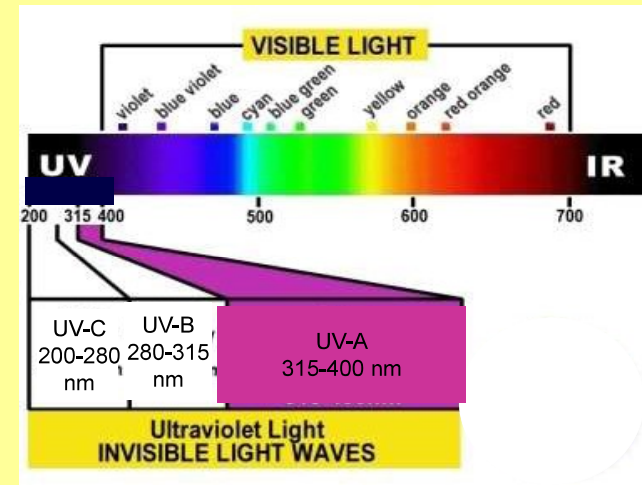


Biological effects of light



Optical region of EM spectrum



Steps leading to the photobiological alterations

Photophysical processes
(absorption of light)



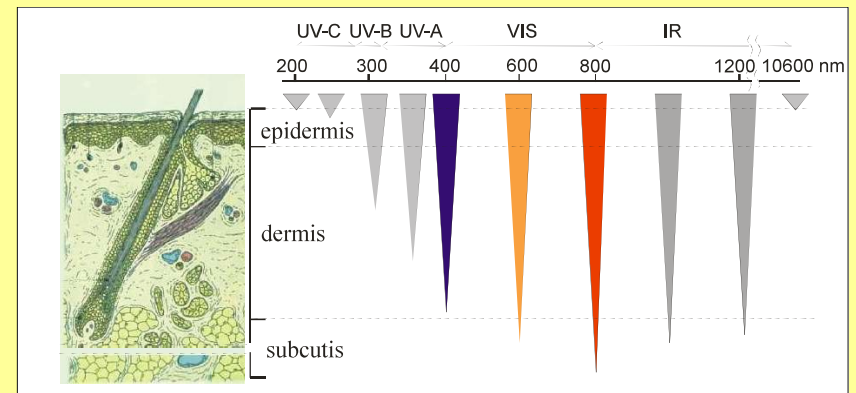
Photochemical reaction



Photobiological processes

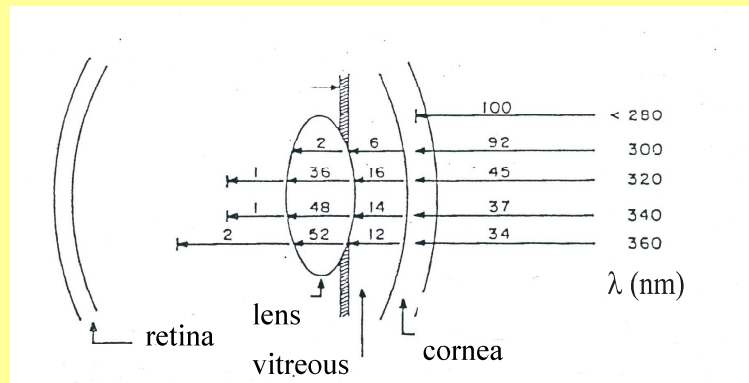
Absorption of light is a prerequisite of photobiological processes

Penetration distance of light into skin



Penetration depth is wavelength dependent

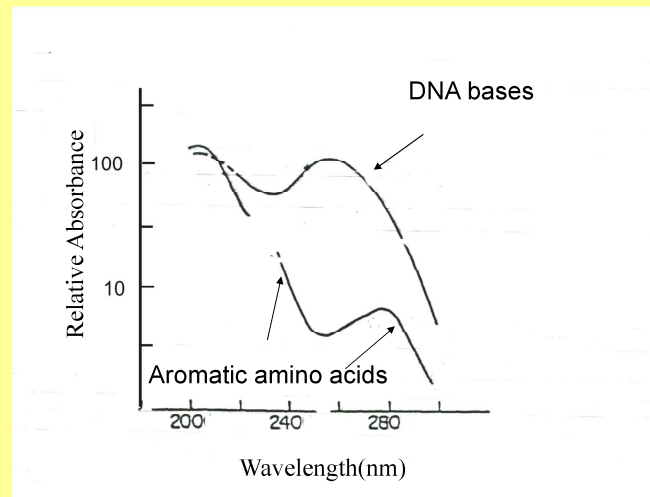
Penetration distance of light into eye



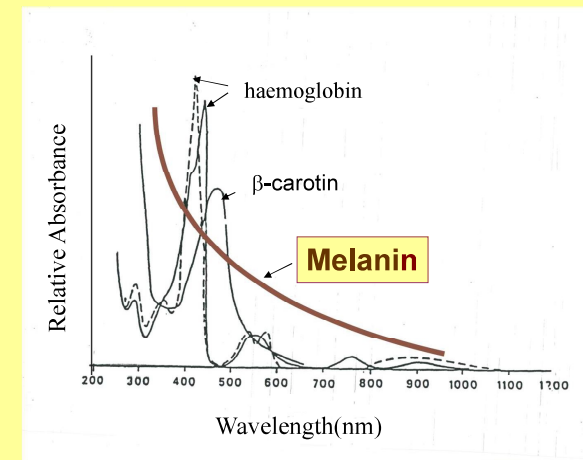
Light absorbers (chromophores) in human tissues

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

Absorption spectra of endogenous chromophores (1)



Absorption spectra of endogenous chromophores (2)



Consequence of light absorption:
Excited state

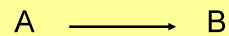


Relaxation of excited state

Light emission

Photochemical reaction

Thermal relaxation

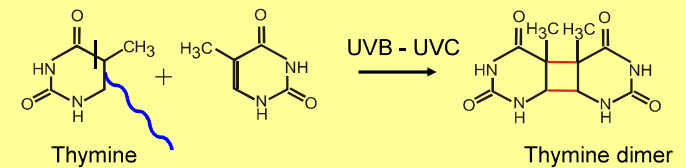
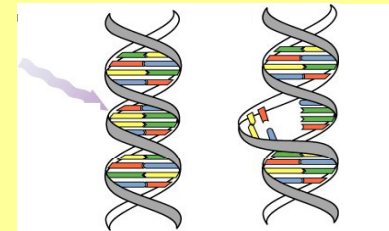


Quantum yield (Φ) : is the number of events (e.g., number of photochemical reactions) divided by the number of photons absorbed by the system.

$$\Sigma\Phi=1$$

Direct photochemical reactions

e.g. Formation of DNA damages



Pyrimidin dimer formation in DNA

Indirect photochemical reactions

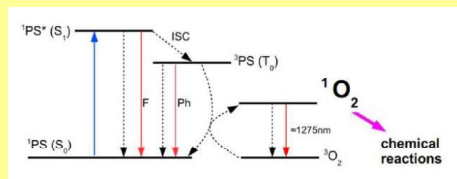
Step 1: excitation of photosensitizing compound by light

Step 2: generation of reactive

free radicals by electron transfer

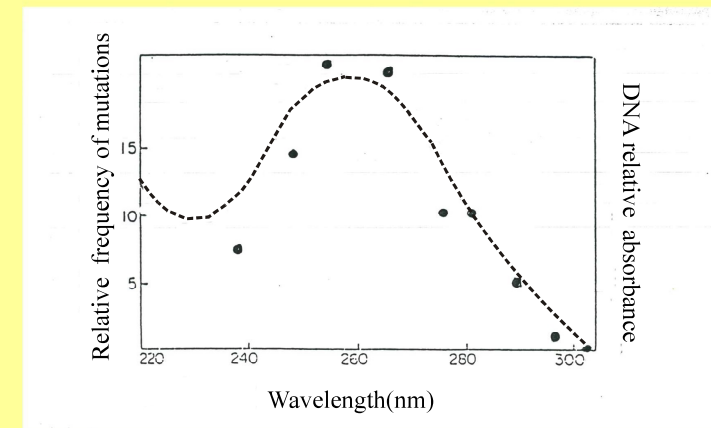
or

reactive oxygen species by energy transfer



Step 3: oxidative damage of cellular structures

Spectral distribution of photobiological efficiency



Efficiency varies with the wavelength

Mutations are induced by the photons absorbed in DNA

Reciprocity?

$$J_{(\lambda)} [\text{J} / \text{s m}^2] \times t [\text{s}] = D_{(\lambda)} [\text{J} / \text{m}^2]$$

The results depends only on the incident dose ($D_{(\lambda)}$)
or
on J and on t separately

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

Examples for the photobiological effects of light

Beneficial vs detrimental effects



examples

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



examples

Sunburn
Wrinkles
Age related pigmentation
Skin cancer
Immuno-suppression

Spatial distribution of alterations

Local effects

in the skin

in the eye

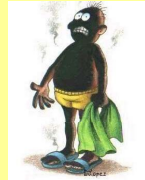
target regions of therapies

Systemic effects

Temporal distribution of alterations

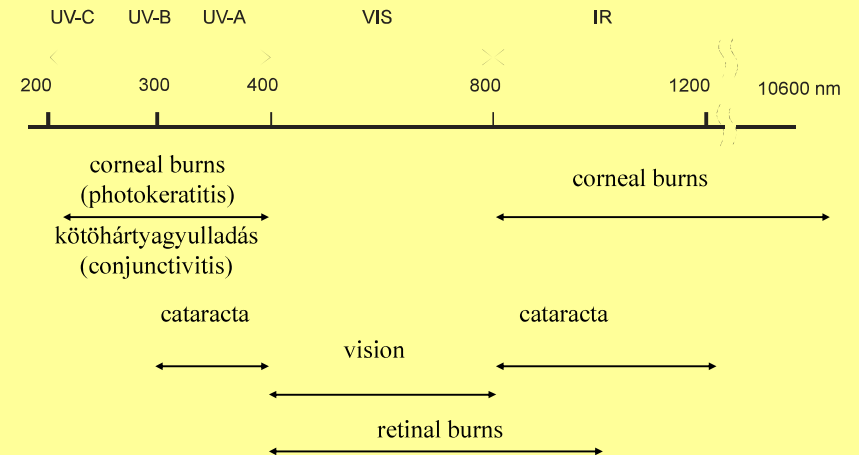
Short term: sunburn
immuno-suppression

Long term: age related wrinkles
age related pigmentation
skin Cancer

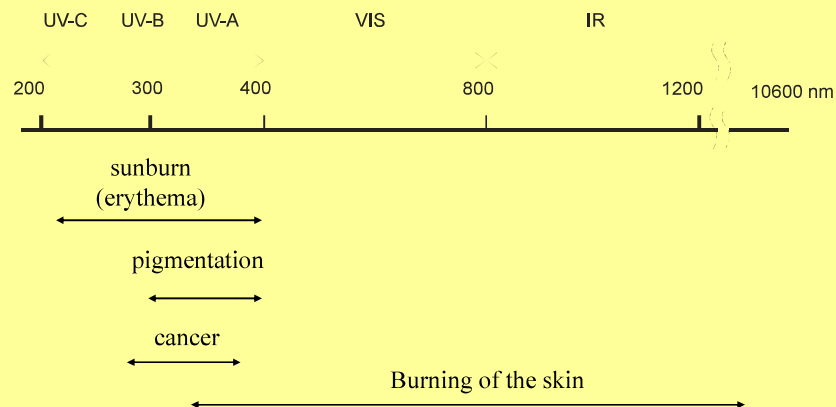


Penetration distance and localization of damages

in the eye



in the skin

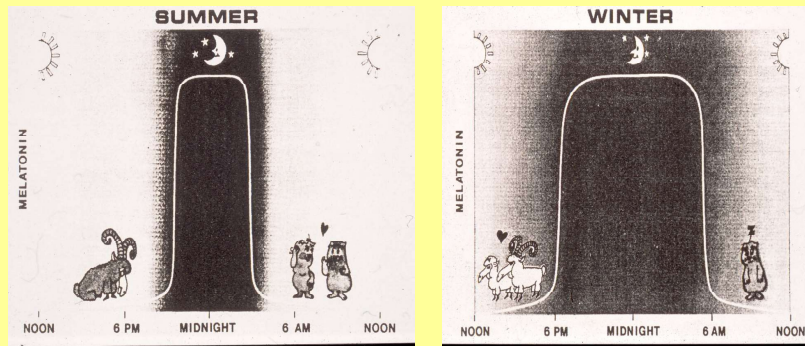


Daily and annual rhythms

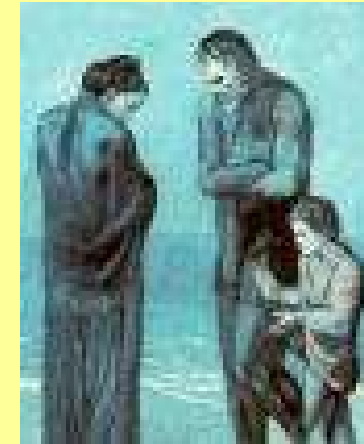
e.g. temperature
hormon production
digestion
slipping / wake



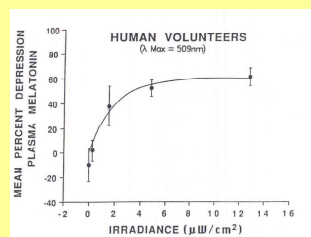
Light may play a role on the circadian rhythm



Seasonal Affective Disorder (SAD) fényhiányos depresszió



Background of SAD : high serum level of melatonin



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

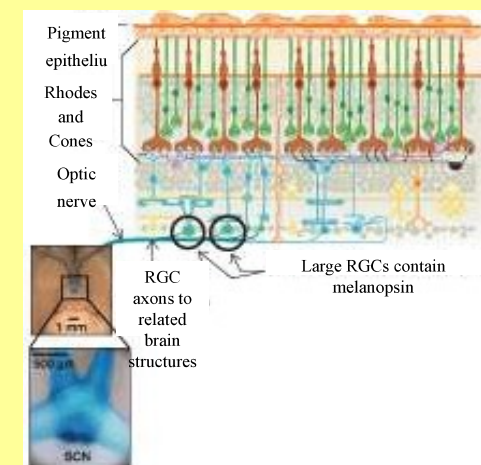
Melatonin level regulation is independent of vision – blindness do not oppose this process

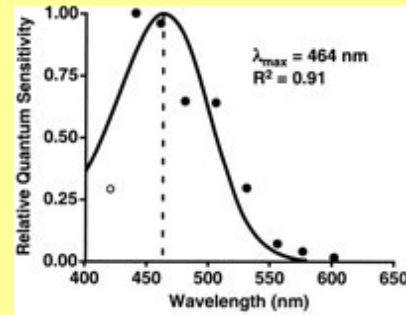
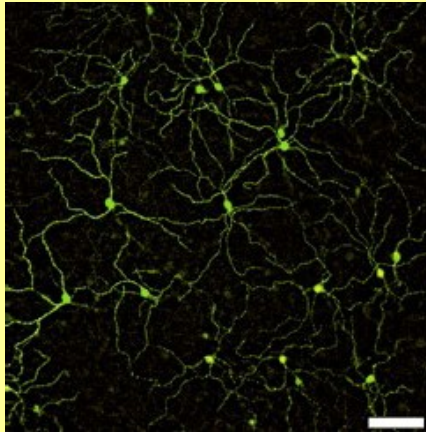
A new type of photosensitive cells (RGC) in retina

Discovery of non-visual pigment(s)

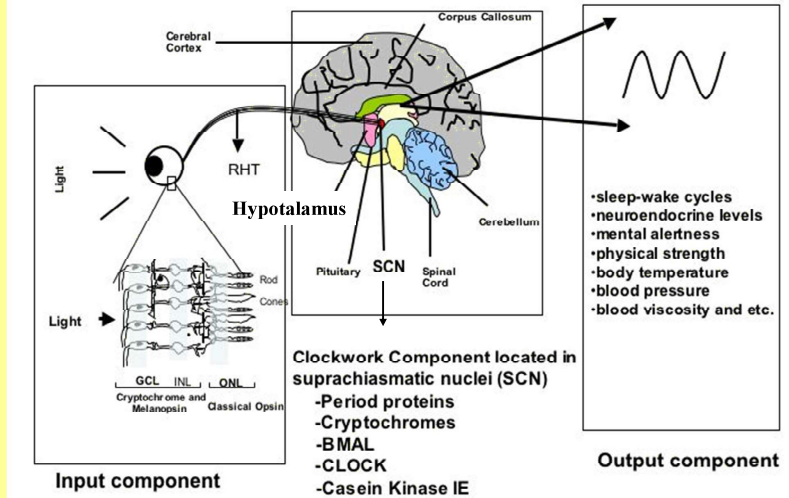
„melanopsin”

in the eye of vertebrates





Network of retinal ganglion cells



Seasonal Affective Disorder (SAD)

Treatment

Light sources

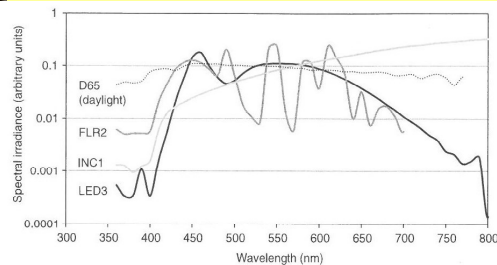


Figure 2 Typical spectra of seasonal affective disorder (SAD) lamps, sunrise simulators and daylight bulbs for emitting diodes (LED3), fluorescent (FLR2), incandescent (INC1) lamps and the CIE standard illuminant D representing natural daylight. The spectra are normalised for equal illuminance, and plotted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

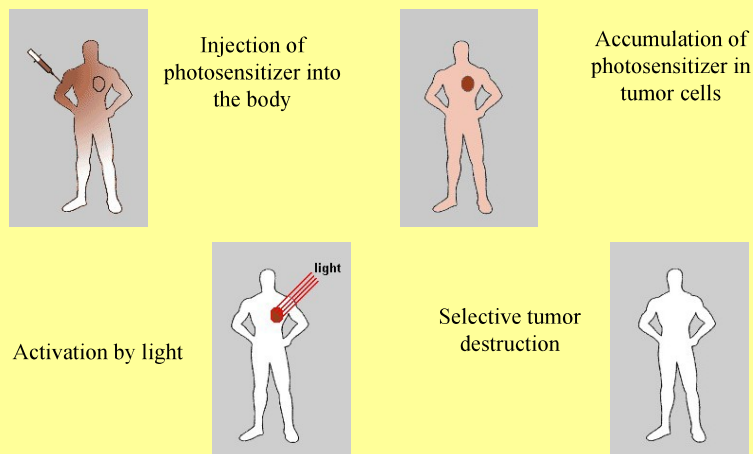
Concept of photodynamic therapy (PDT) originally developed as tumor therapy

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



PDT mechanism of action: Indirect photochemical reaction

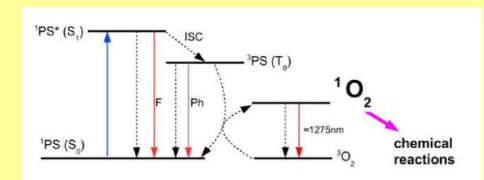
Step 1: excitation of photosensitizing compound by light

Step 2: generation of reactive

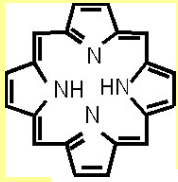
free radicals by electron transfer

or

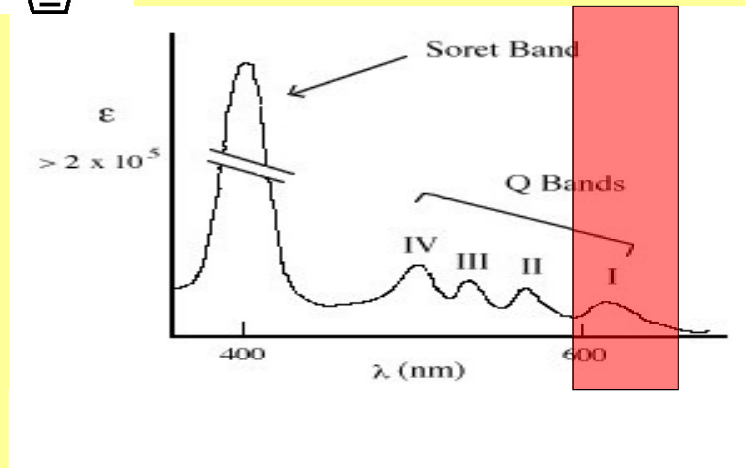
reactive oxygen species by energy transfer



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



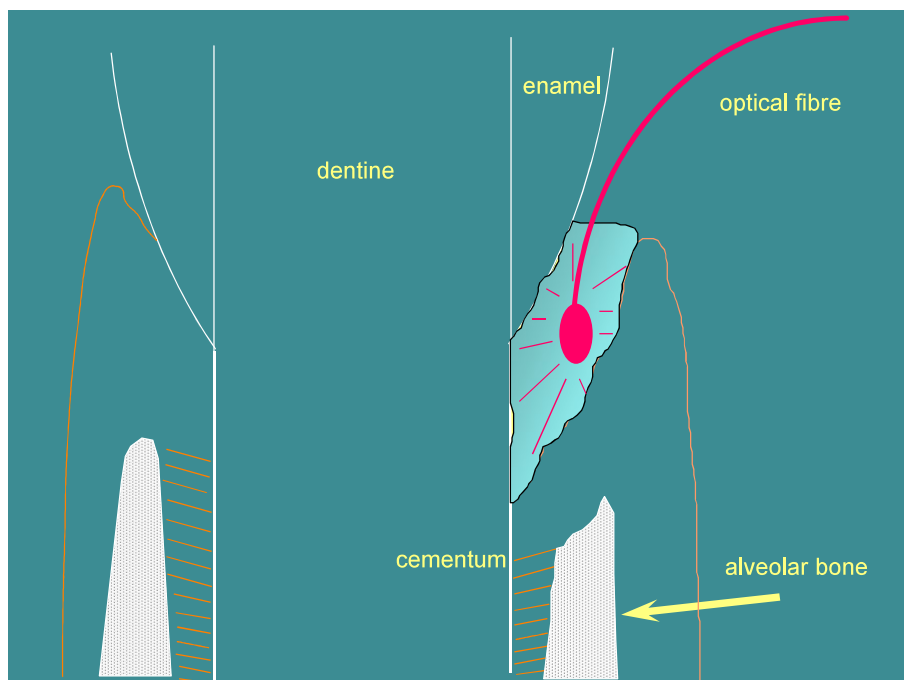
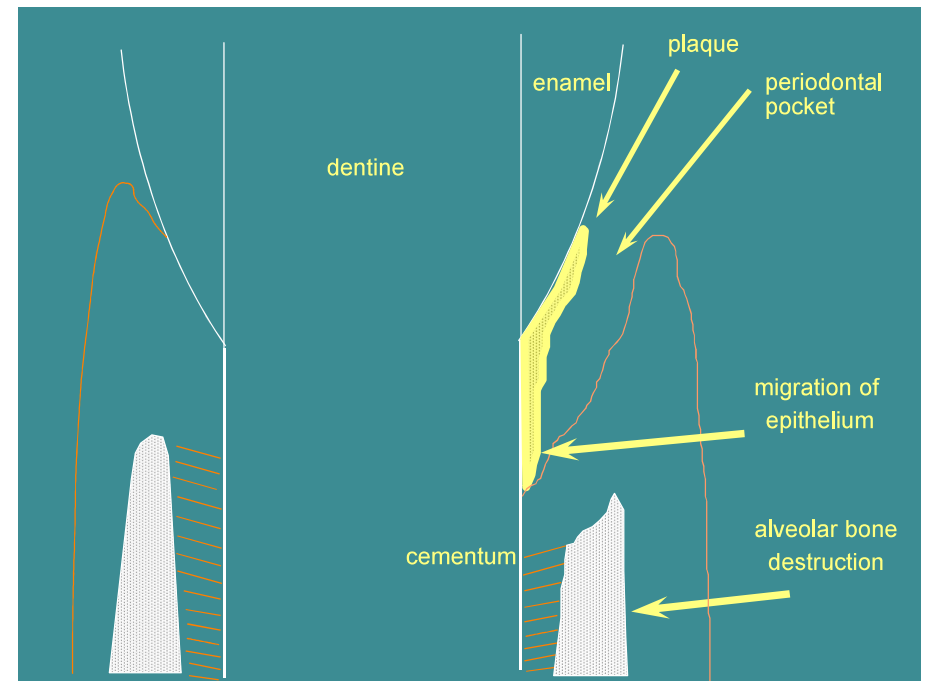
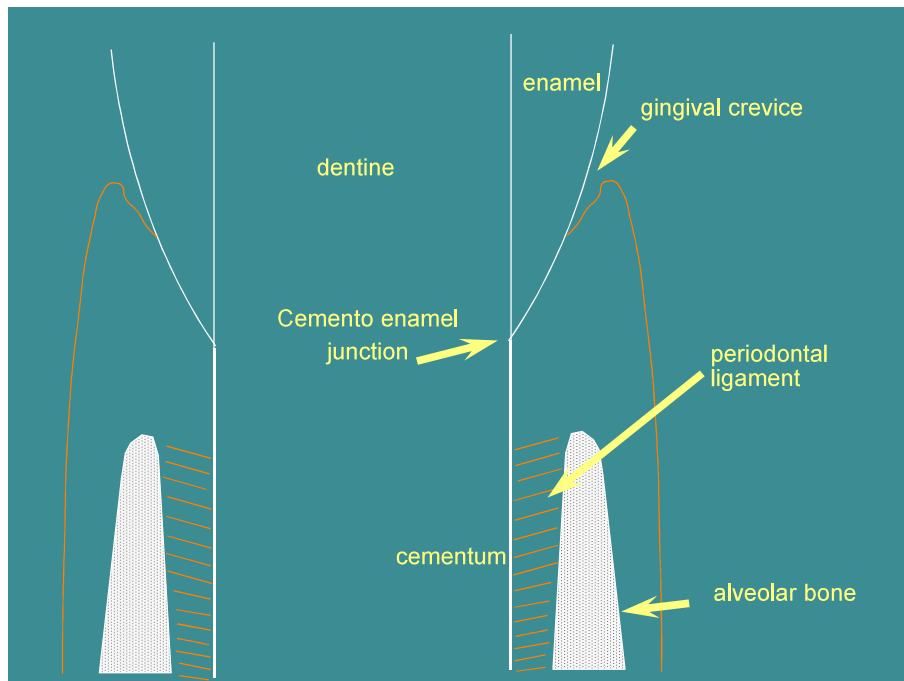
1. Application of photosensitizer

Dental PDT Treatment of periodontitis

Photoinactivation of bacteria



2. Irradiation



Damjanovich, Fidy, Szöllősi: Medical Biophysics

II. 2.3.3

II. 2. 3.4.

IX.2.