The outlook of investigations of photochemical, photo- and radiobiological processes of vision at JINR basic facilities

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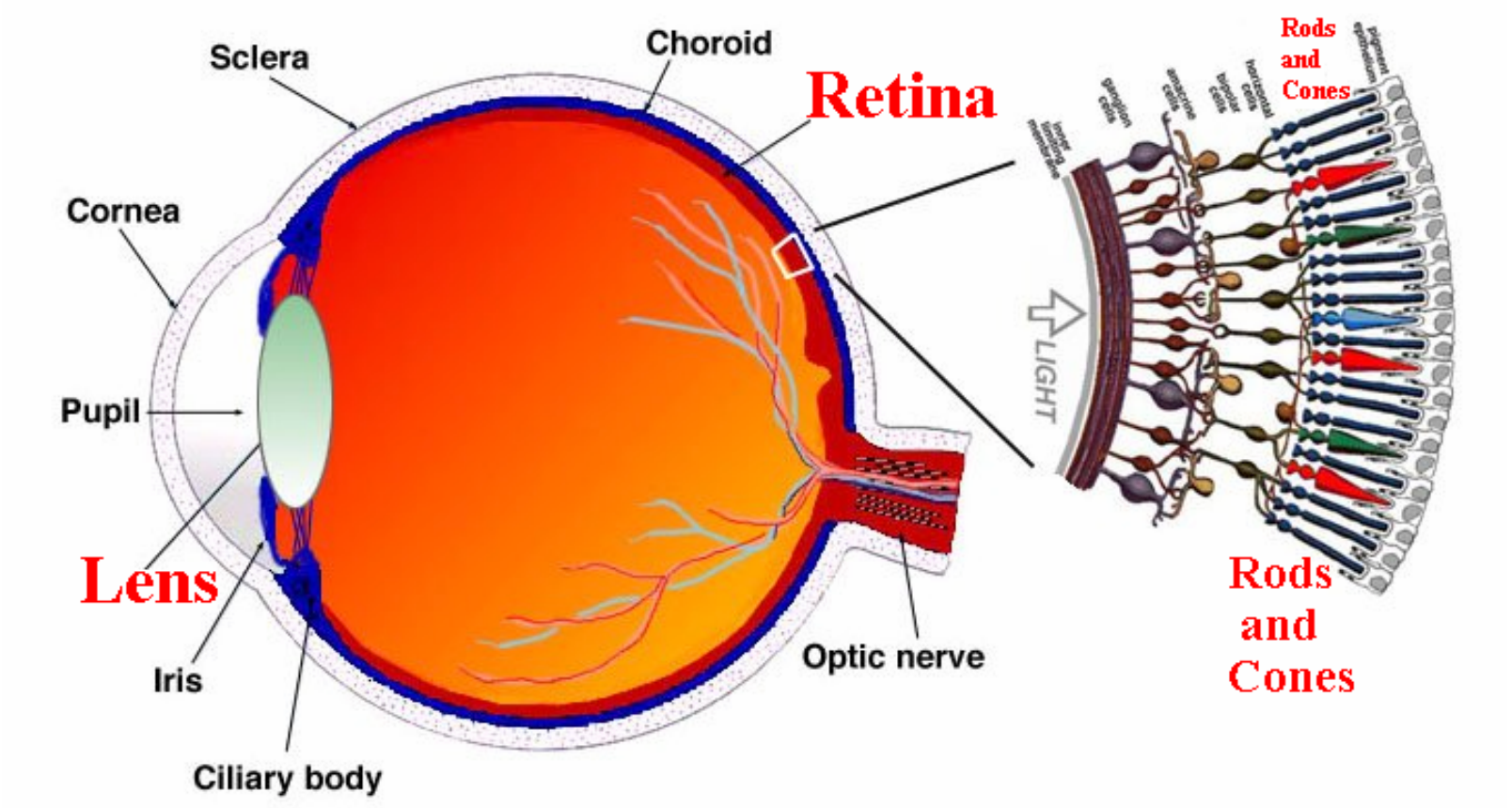
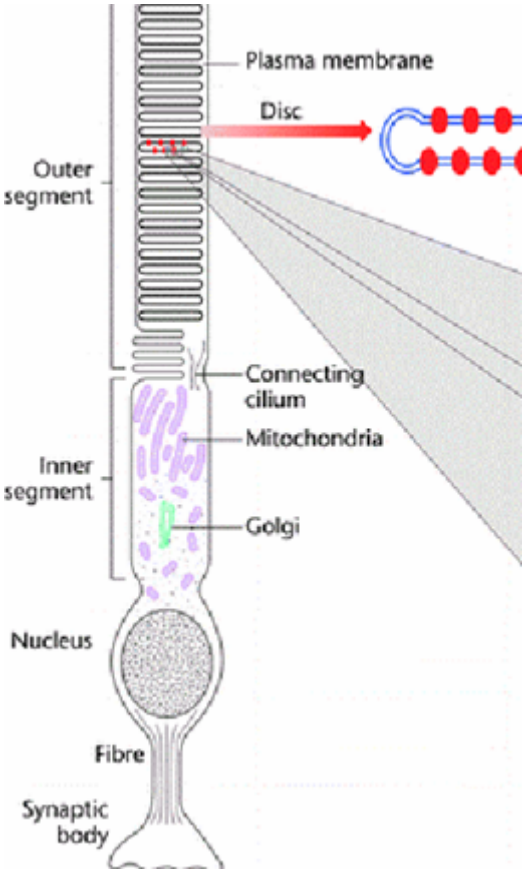
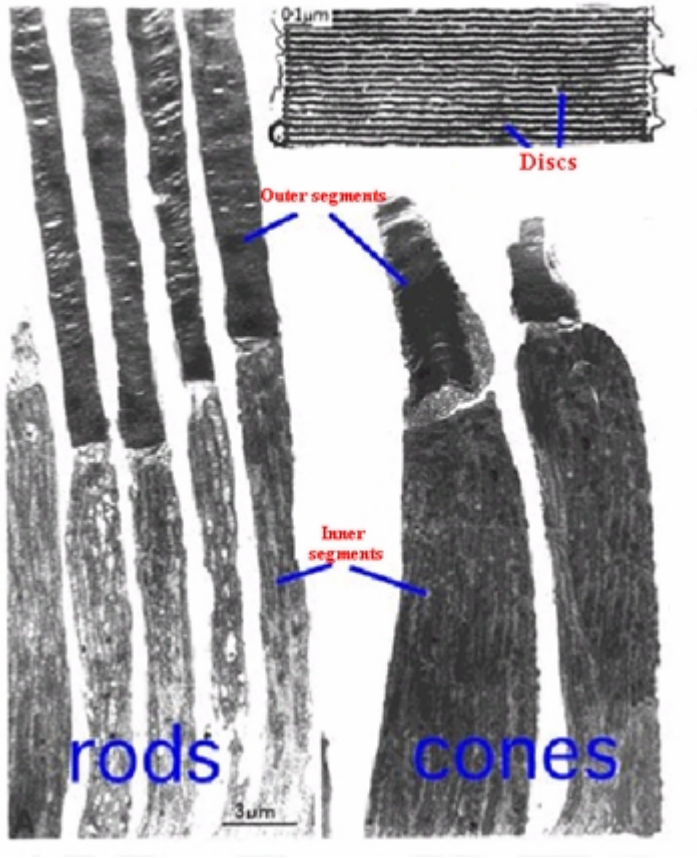
Eye:
Lens and crystallines,
Retina and visual cells (rods and cones)

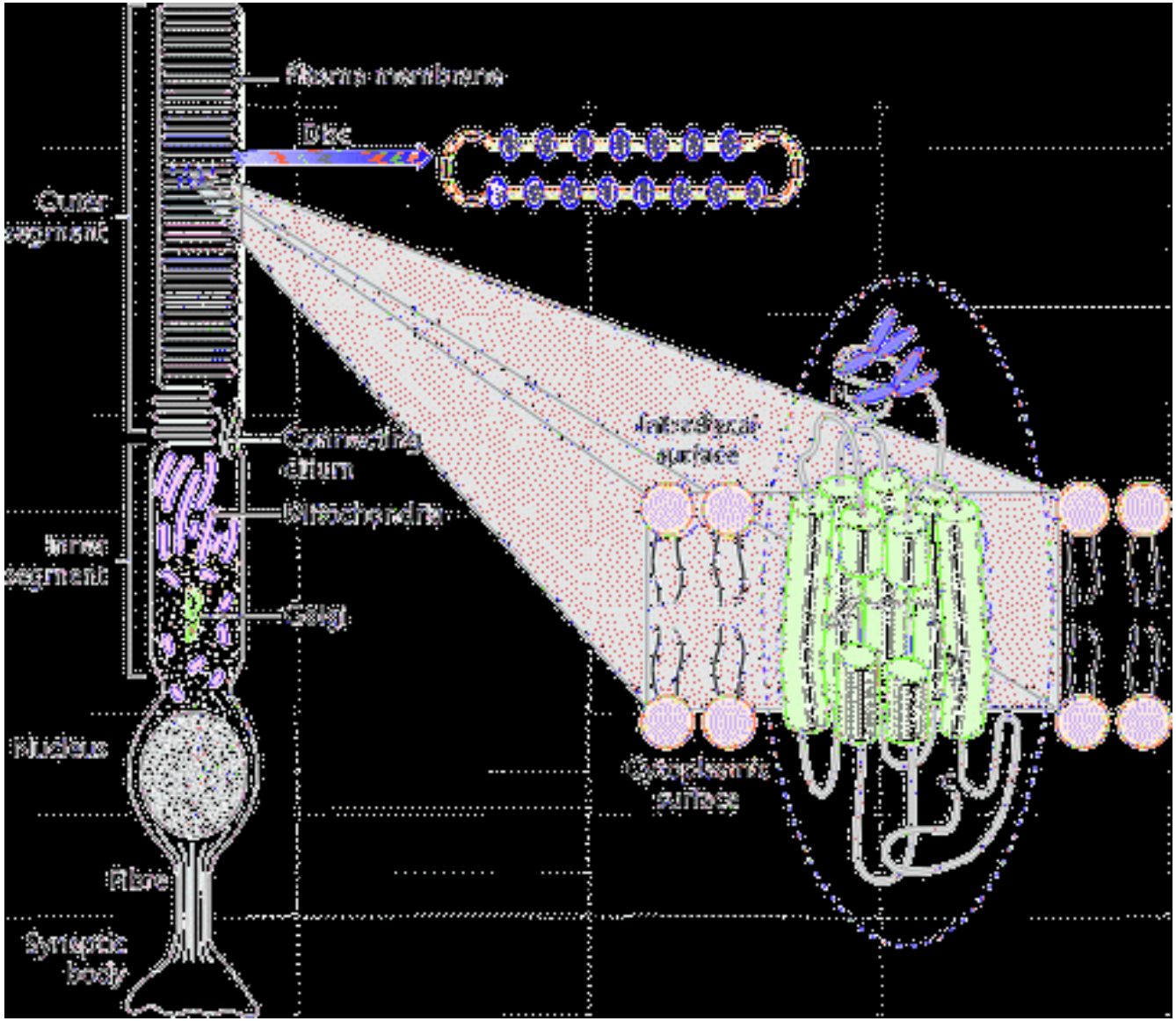


A study of lamellar structure of rod outer segments and its photoreceptor discs at different physiological and radiological conditions is a possible goal of future investigations at JINR basic facilities

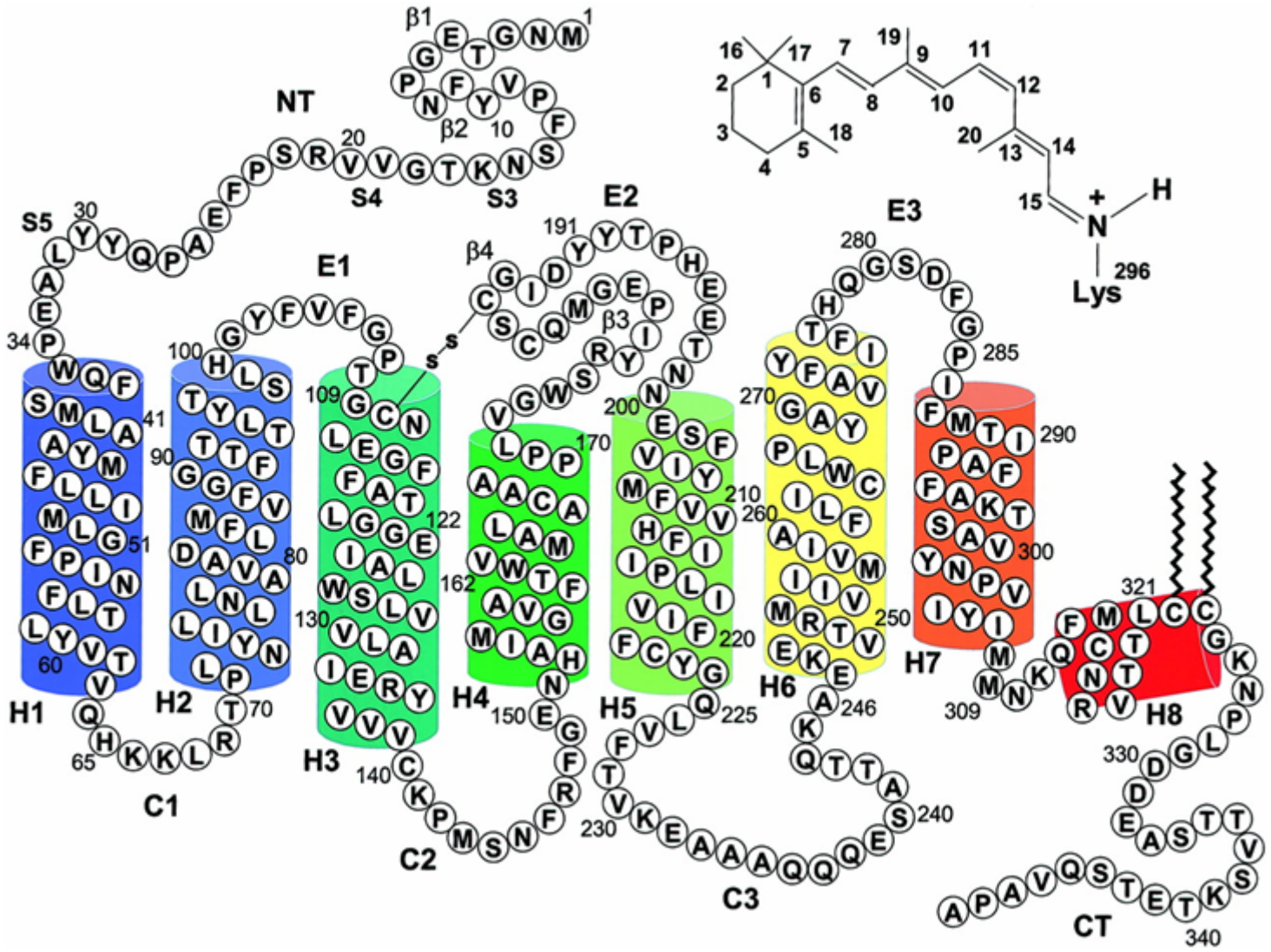




Rod cell, photoreceptor disc and helix bundle model of rhodopsin



Two-dimensional model of rhodopsin molecule



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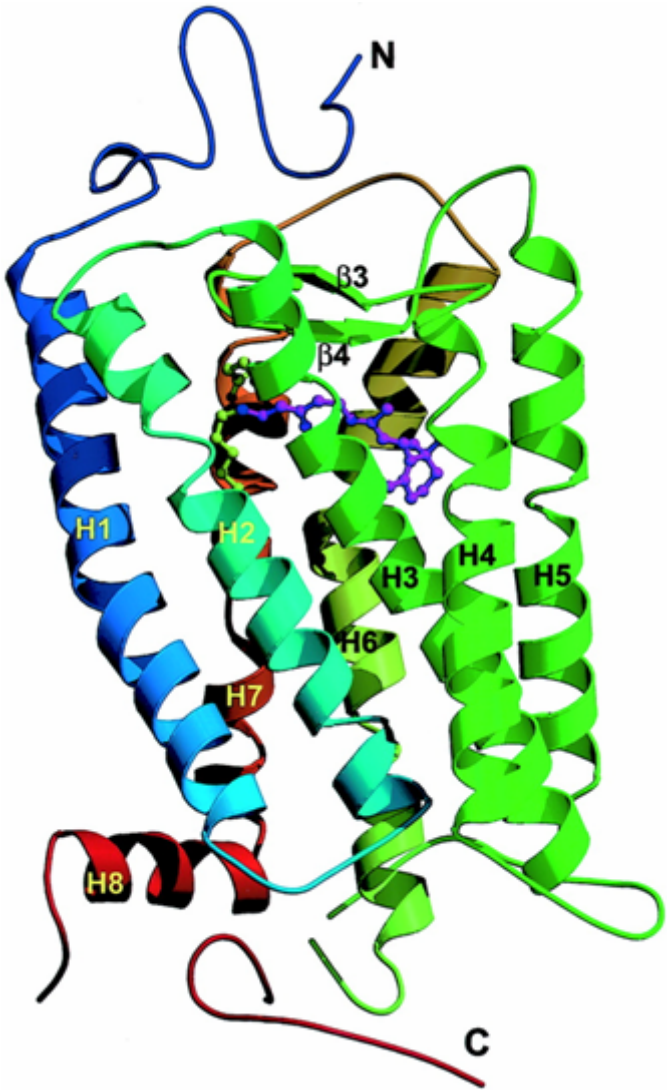
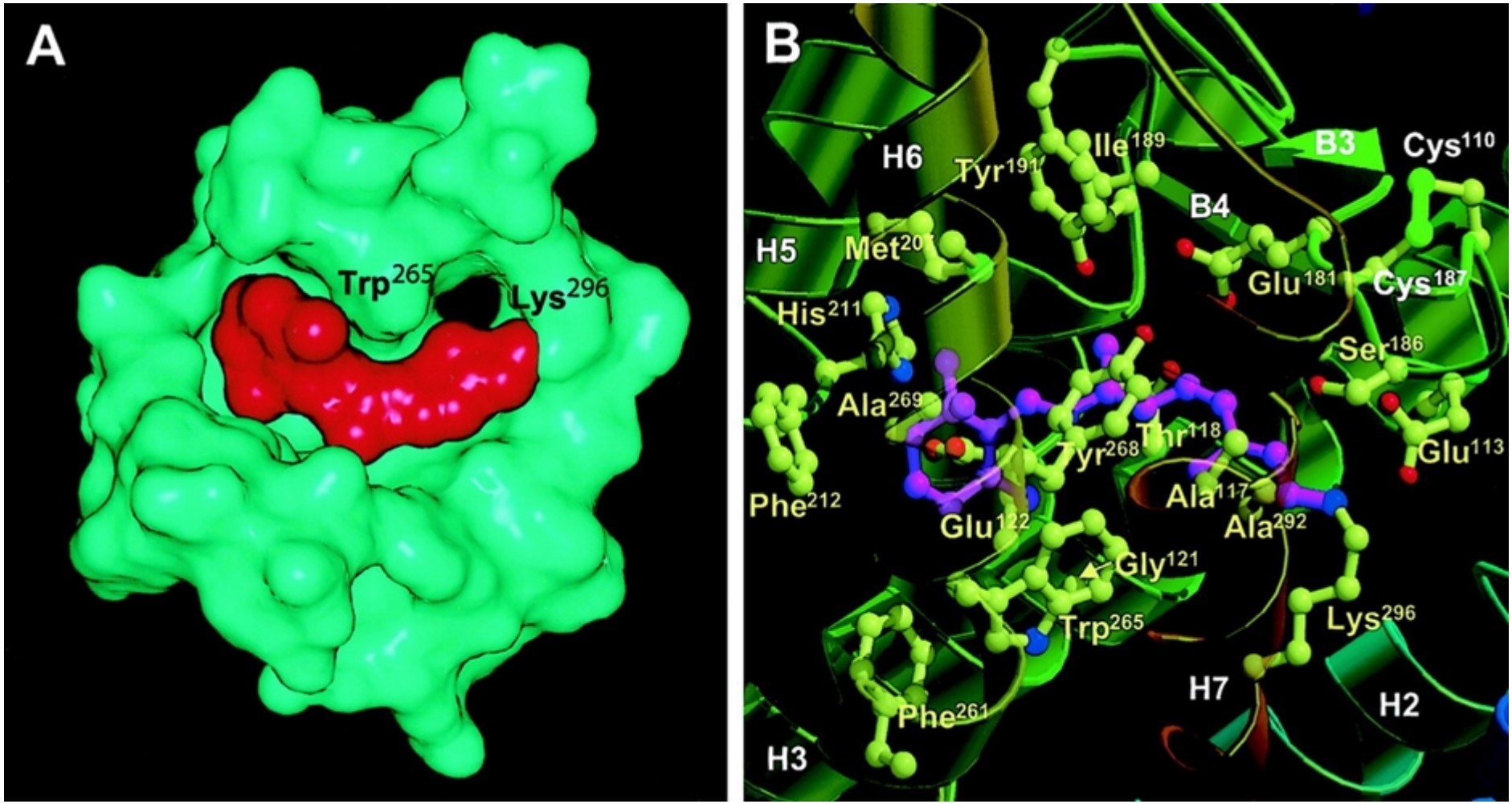
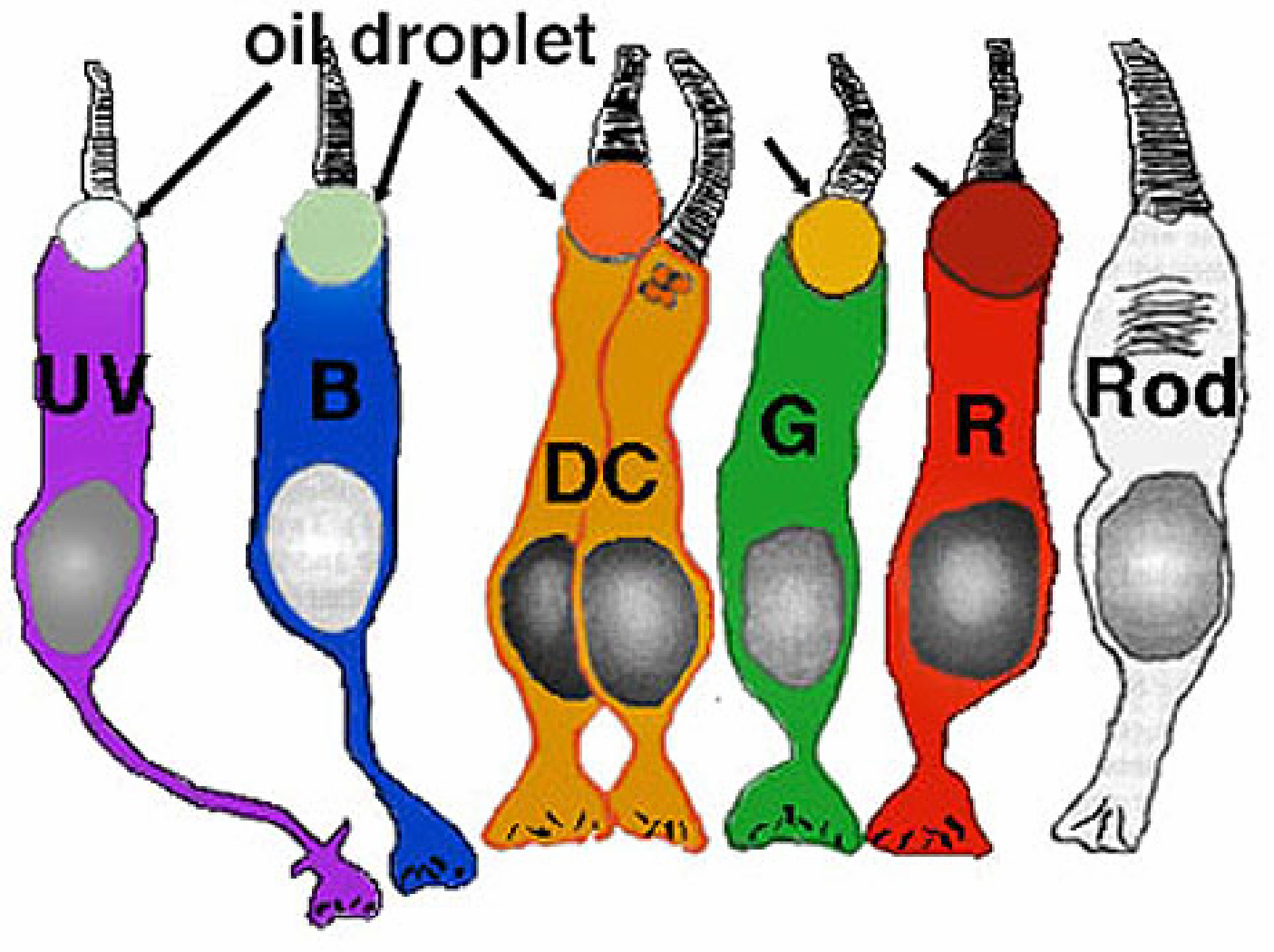


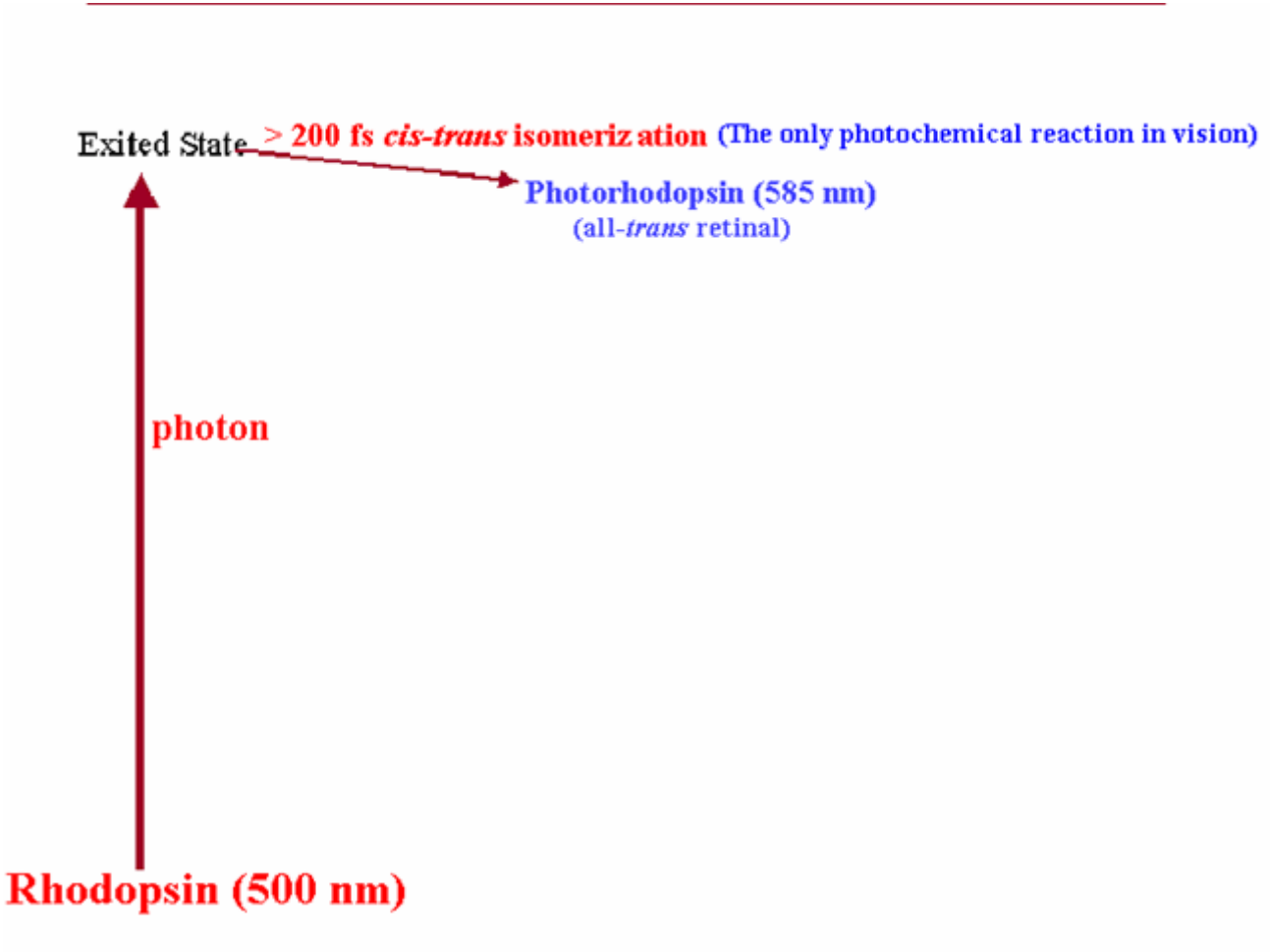
The retinal chromophore-binding pocket of rhodopsin molecule:
A: a cut-away surface map - from the extracellular surface
B: a view from within the plane of the membrane bilayer
(retinal is colored magenta)



Spectral diversity of visual pigments within the rods and cones of turtle retina

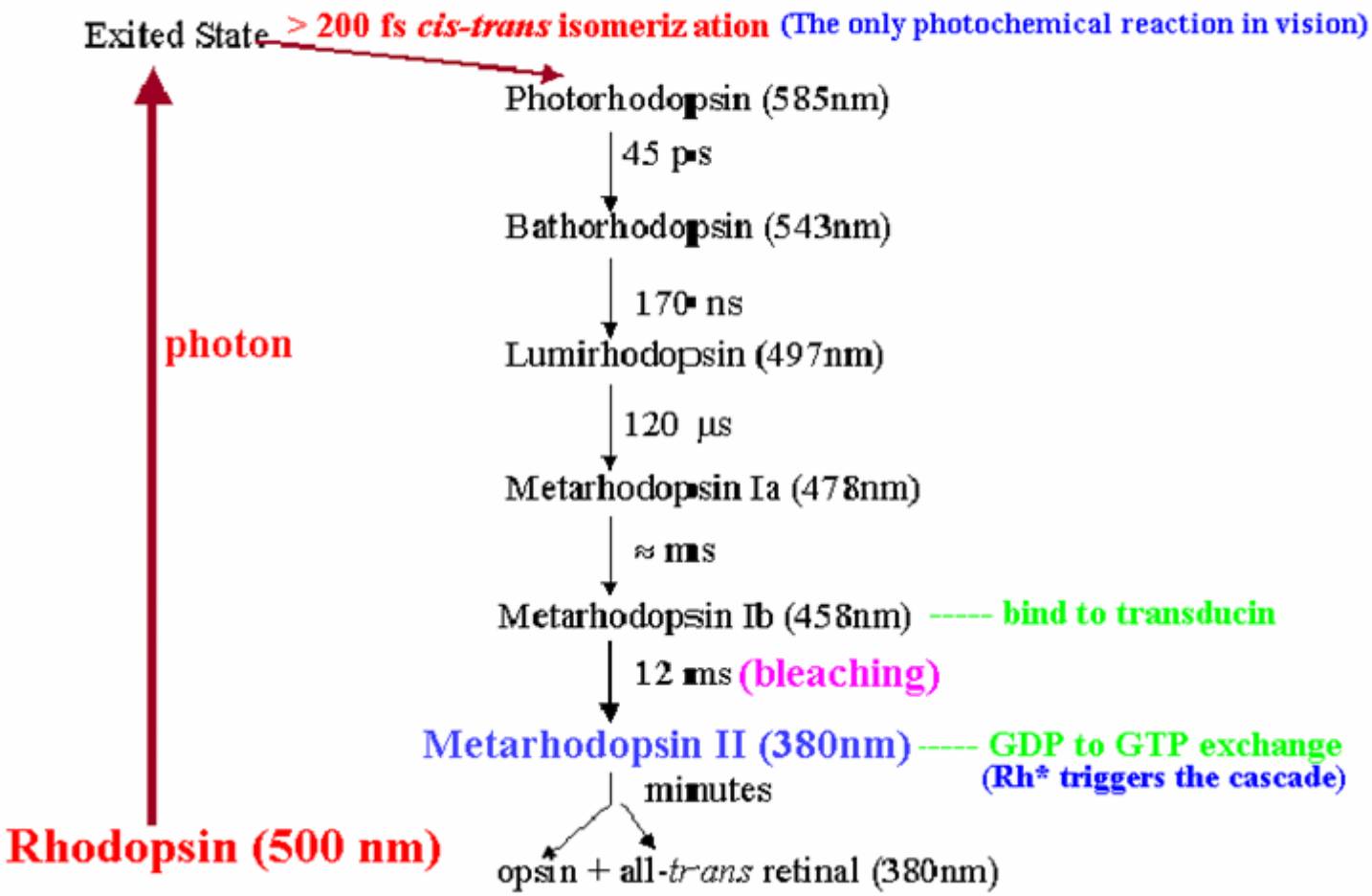


Photochemistry of vision:
primary photoreaction of rhodopsin chromophore – 11-*cis* retinal



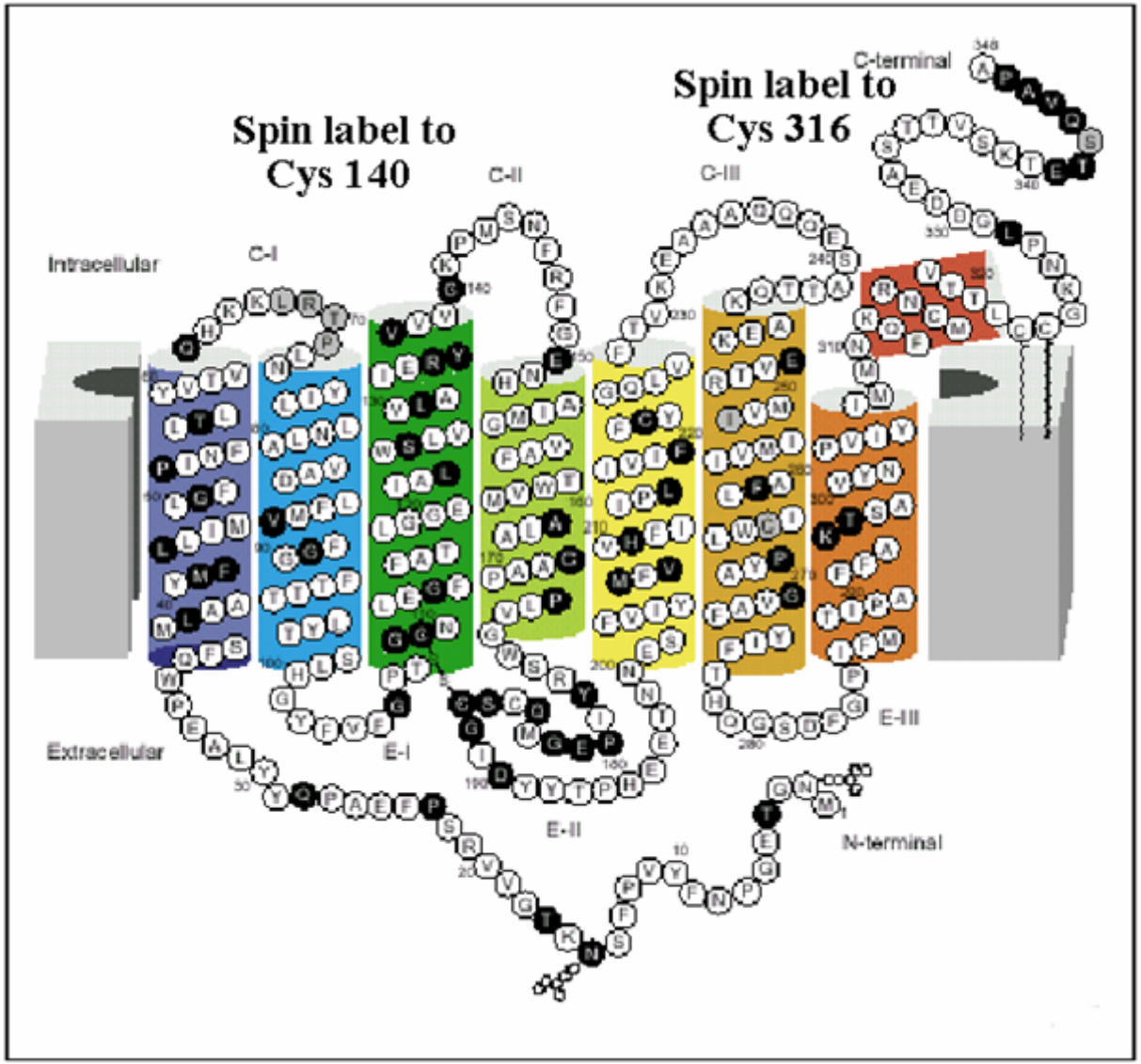
Theoretical and experimental studies of
spectral tuning
and
ultrafast (fs) **photoisomerization**
of 11-*cis* retinal as a chromophore
within the rhodopsin molecule are
tempting goals of future investigations
at JINR basic facilities

Photobiology of vision:
bleaching of rhodopsin and triggering of visual cascade



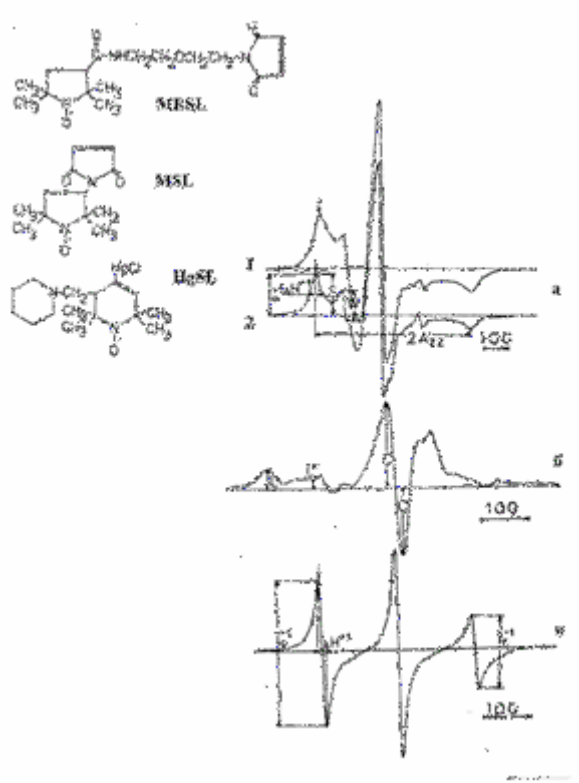
Conformational changes of rhodopsin molecule:
Site-directed spin labeling of rhodopsin (Cys140 and Cys316)

(Pogozeva et al., 1985)



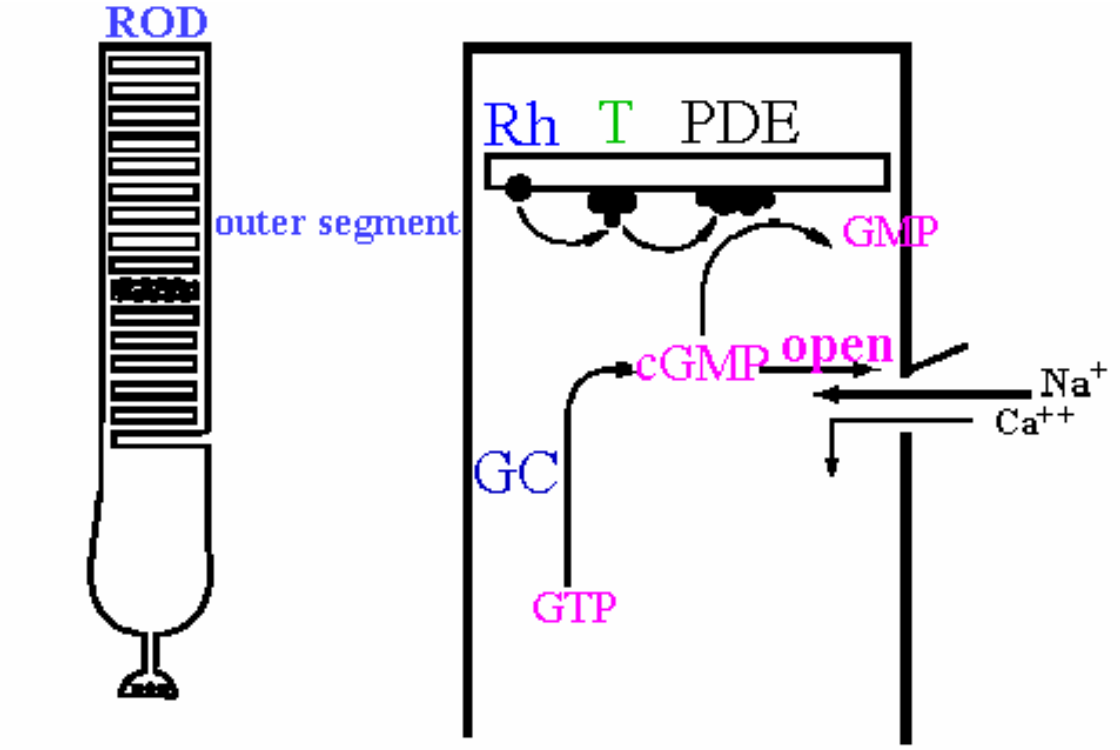
Conformational changes of rhodopsin molecule:

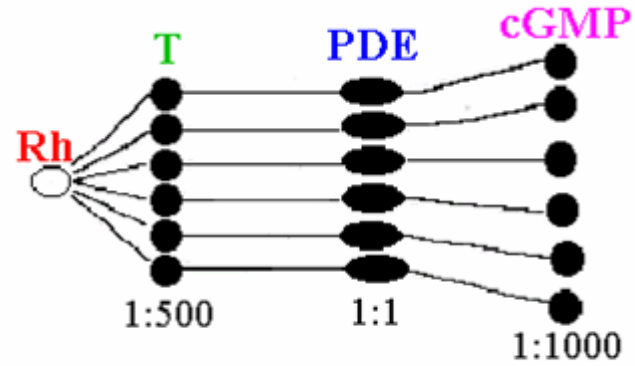
Spin-label mobility increase during the transition from rhodopsin to metarhodopsin II (Pogozeva et al., 1985)



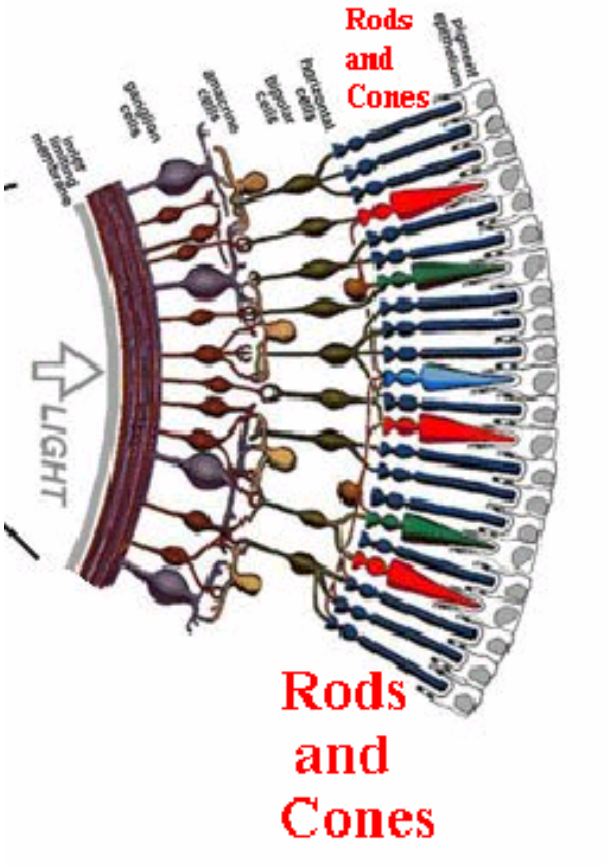
Visual cascade:

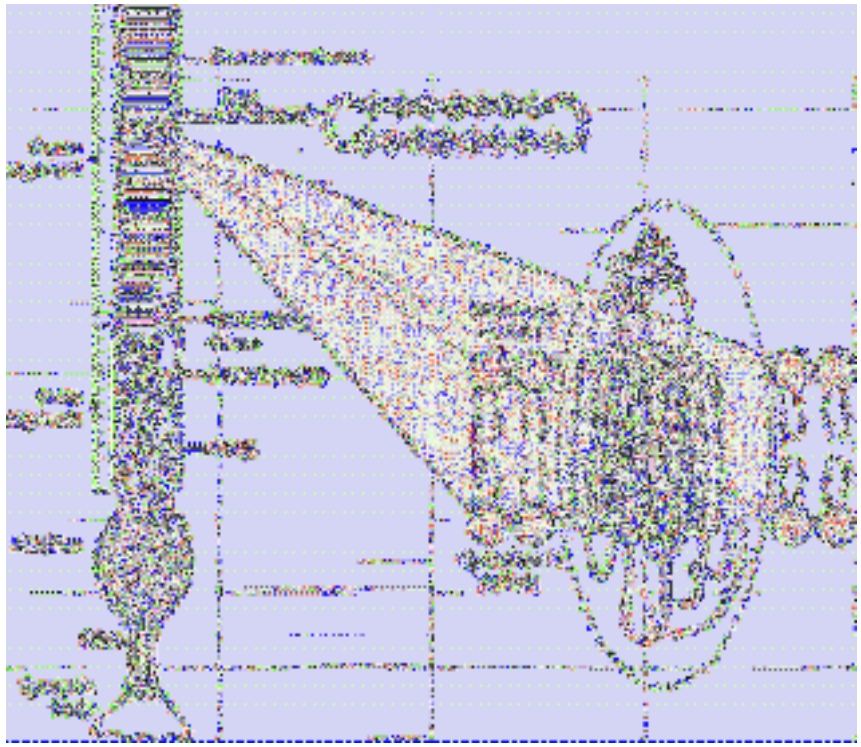
Phototransd ... ...noton signal





Radiobiology of vision:
Effects of heavy charged particles
on function of retina and visual cells (electrical activity),
and rhodopsin molecule (bleaching and regeneration)

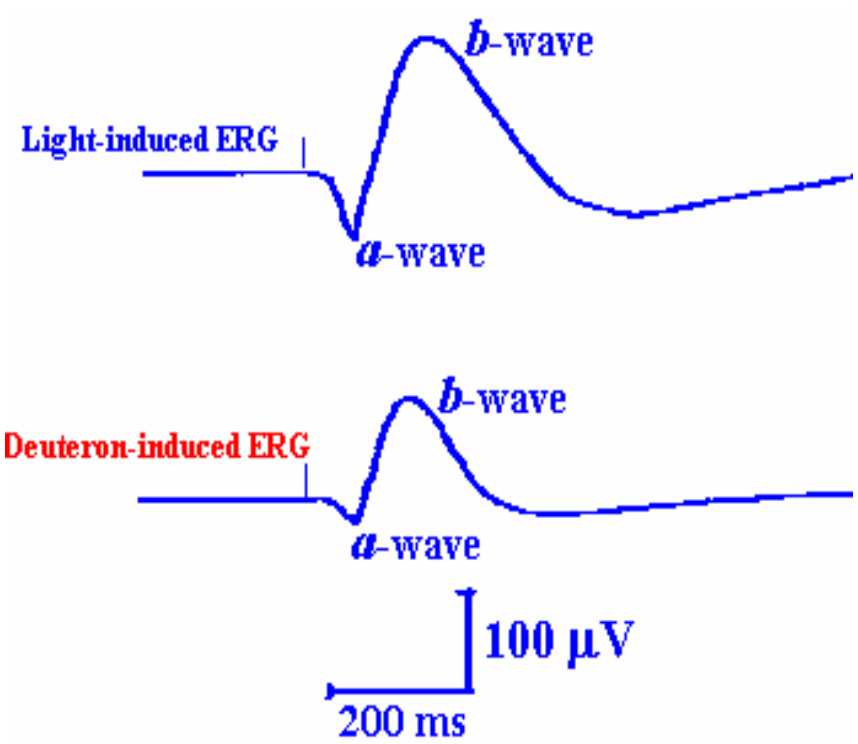


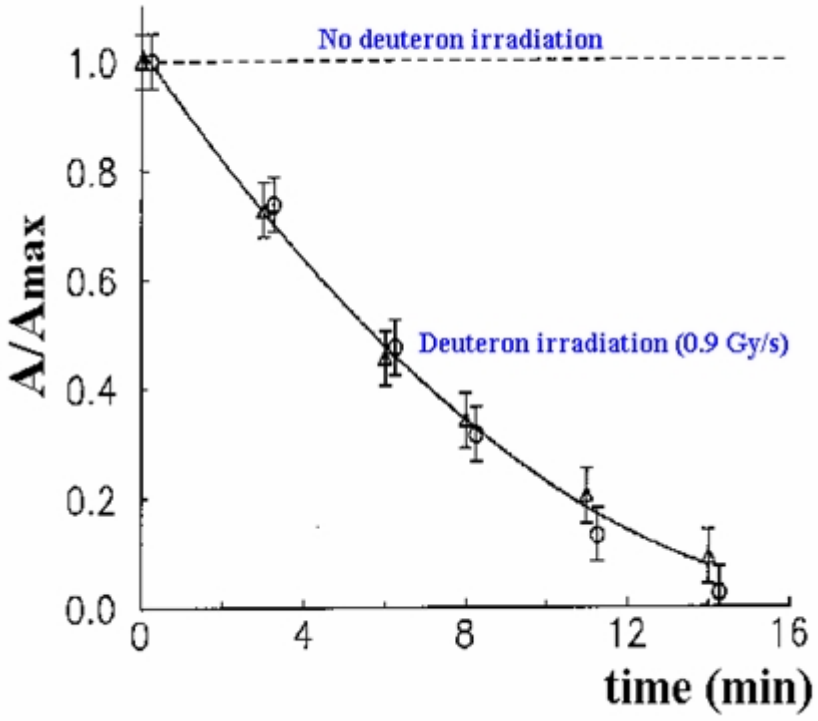


Effects of heavy charged particles on electrical activity (ERG) of isolated frog retina (Trukhanov et al., 2001)

Left: ERG induced by light and deuteron pulses are similar

Right: Irreversible fall of electrical activity of isolated retina as a result of deuteron irradiation



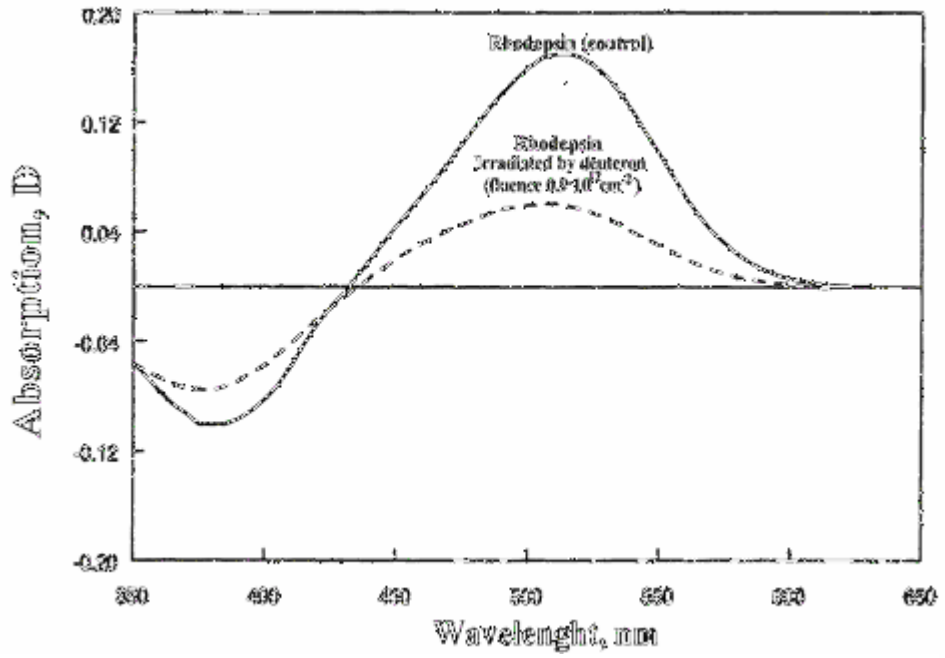


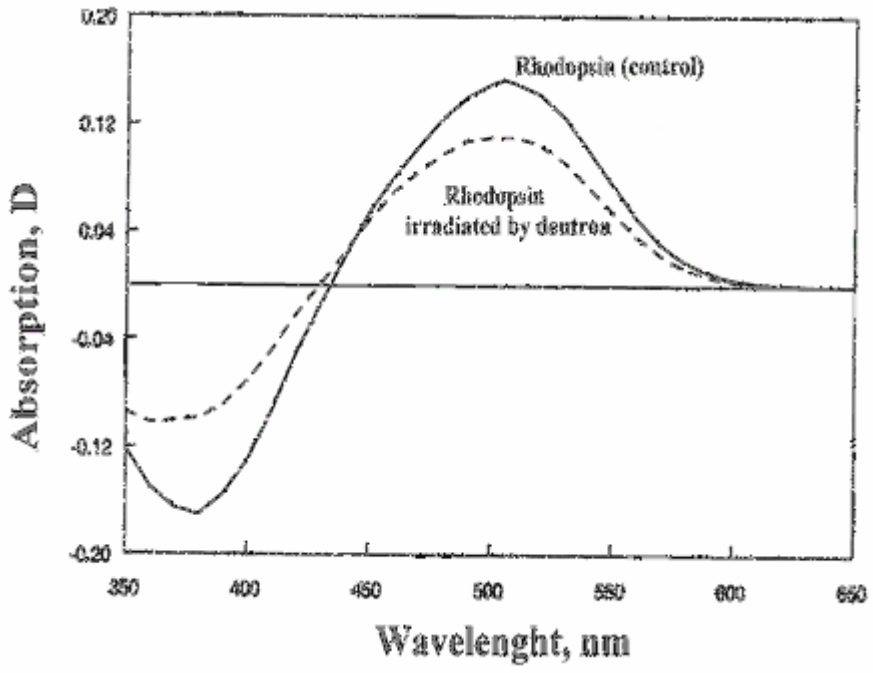
Effects of heavy charged particles on rhodopsin in solution

(Differential absorption spectra of rhodopsin)

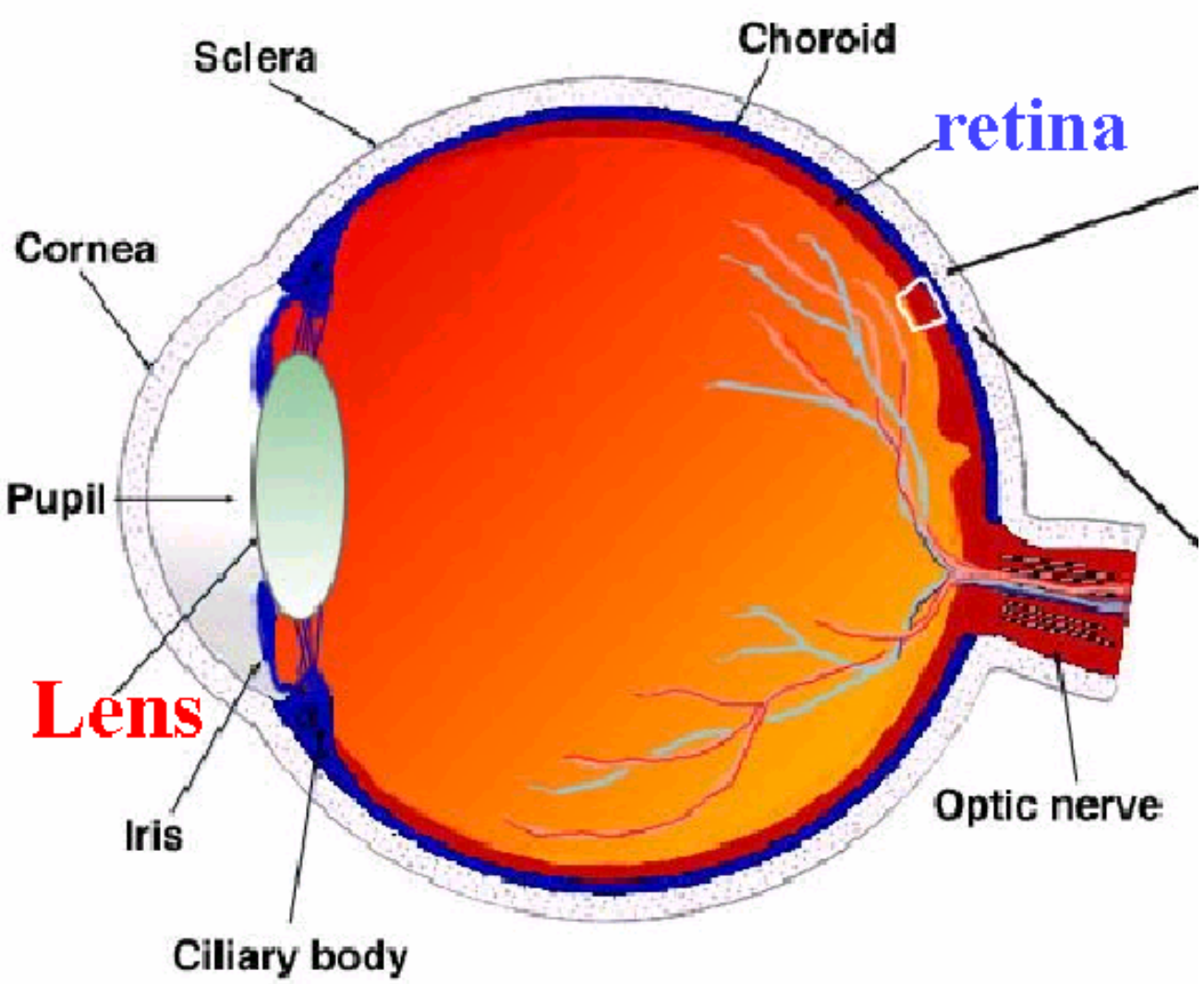
Left: Deutrons irradiation induces a partial rhodopsin bleaching.

Right: The ability of rhodopsin for regeneration after 11-*cis* retinal adding is reduced as a result of deutrons irradiation





Lens and Radiation-induced cataract



"Radiation-induced cataract in astronauts and cosmonauts"

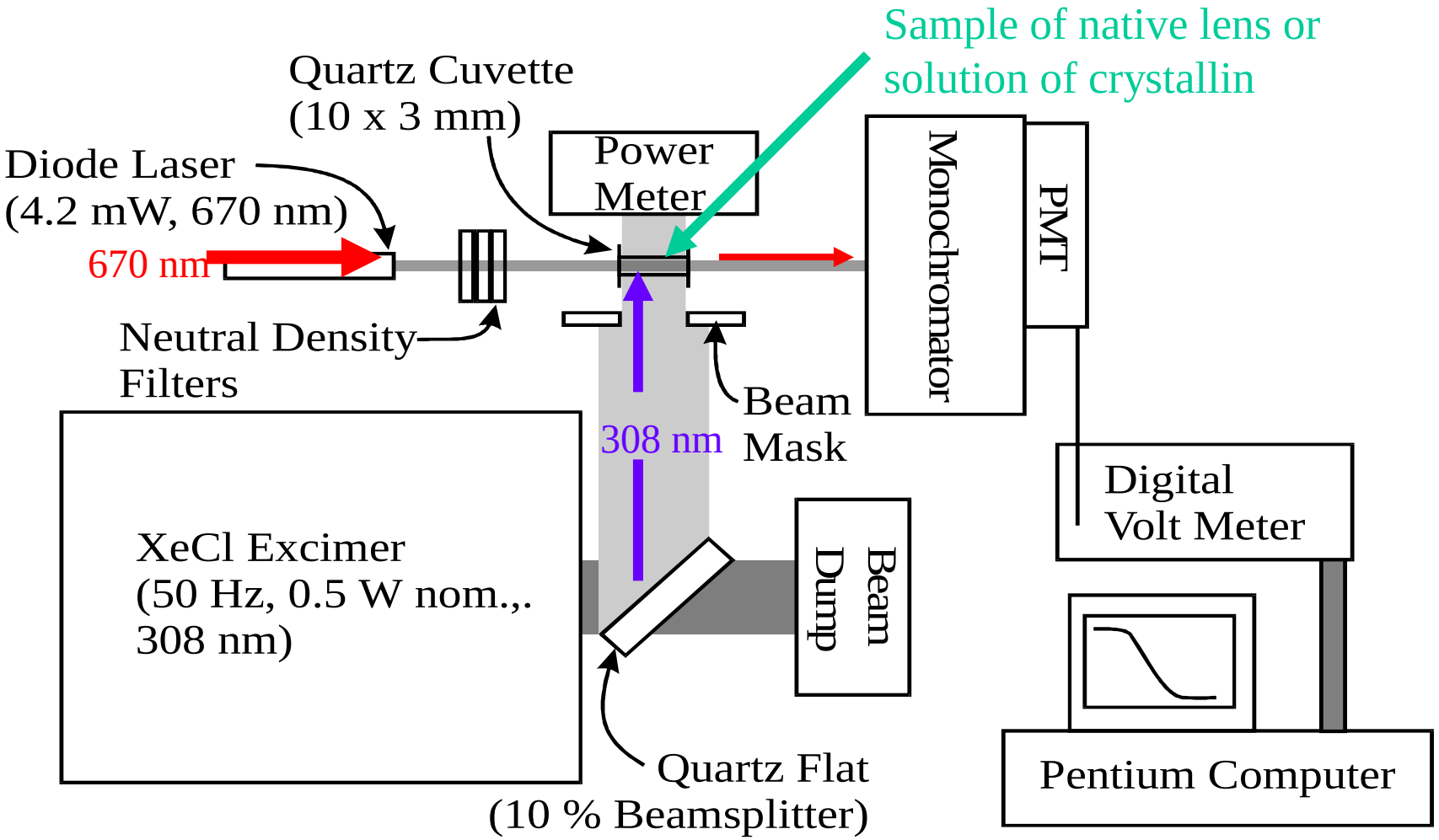
Rastegar et al, 2002

- From **Abstract:**

- **Background. "……**Astronauts and cosmonauts are exposed to relatively high doses of all types of radiation in space, **including high-energy particle radiation…"**

- **Results.** **"**Initial results indicated that opacity values in most of the astronauts and cosmonauts were **slightly to strongly increased…"**

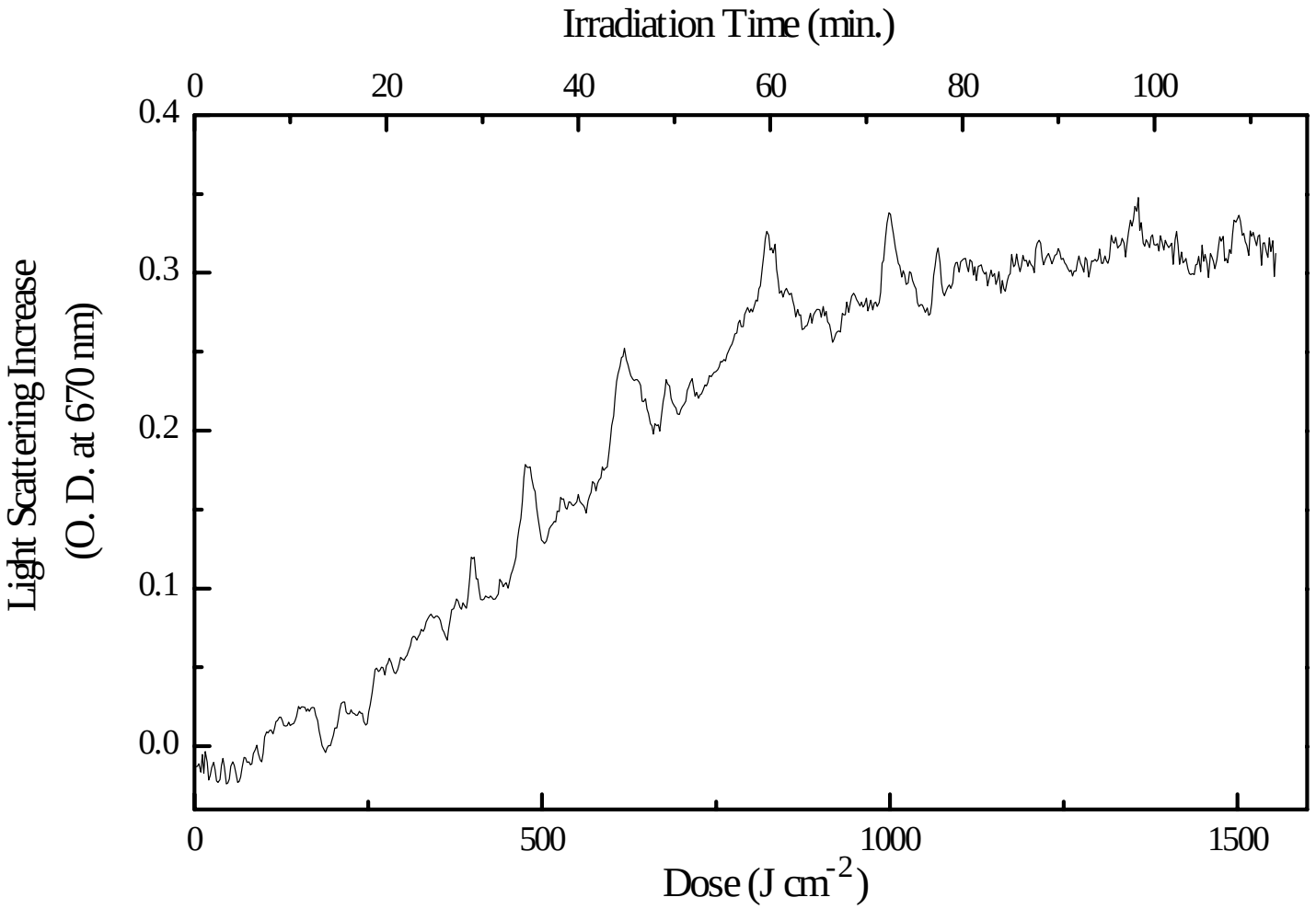
Simultaneous eximer laser (308 nm) irradiation and transmittance measurement (Ostrovsky et al., 2002)



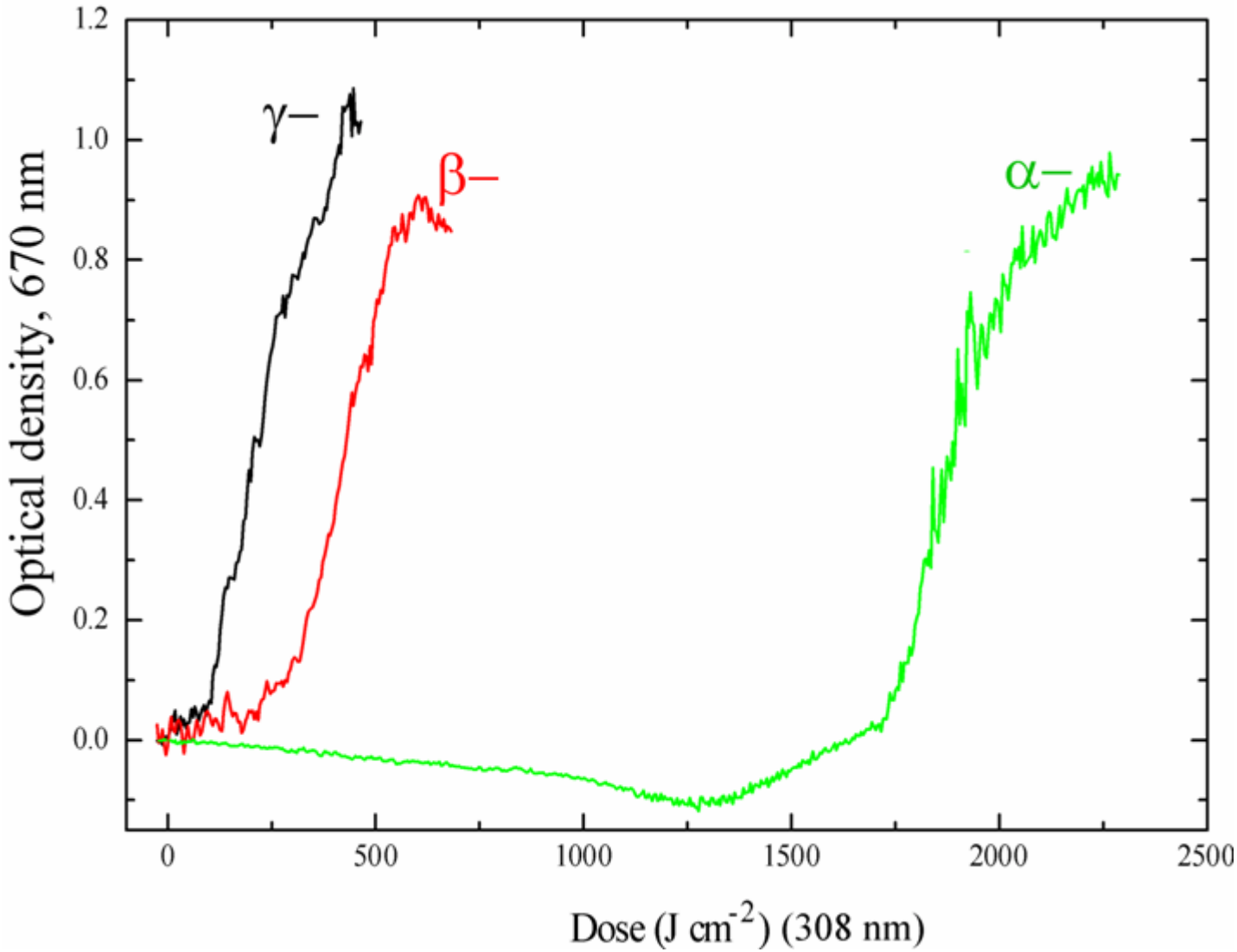
Isolated mouse lens nucleus:

UV-induce light scattering increase (lose of lens transparency)

(Ostrovsky, 2002)

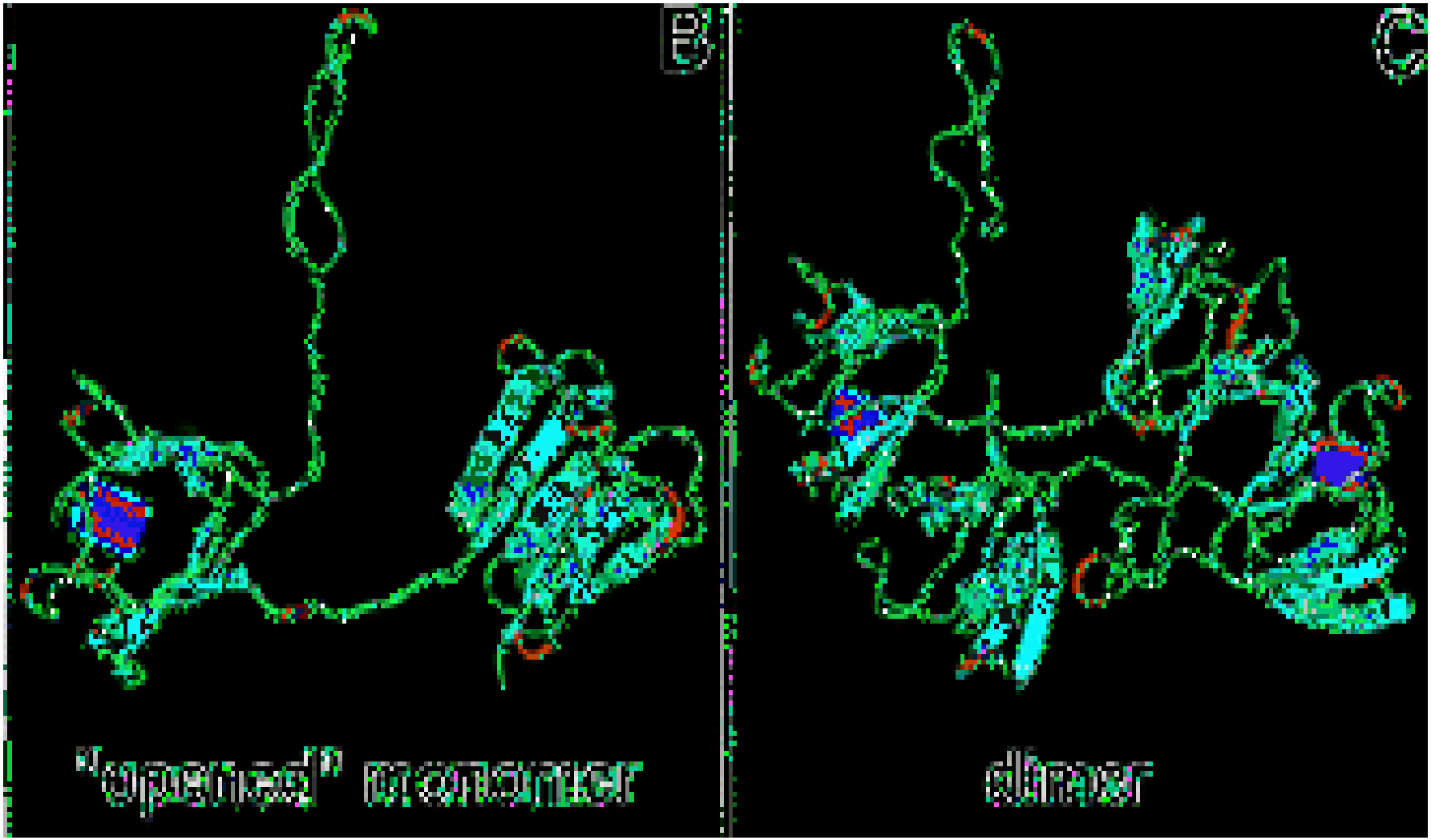


Sensitivity of three major classes of crystallins to UV-induce aggregations is: γ>β>>>α (Ostrovsky et al., 2002)

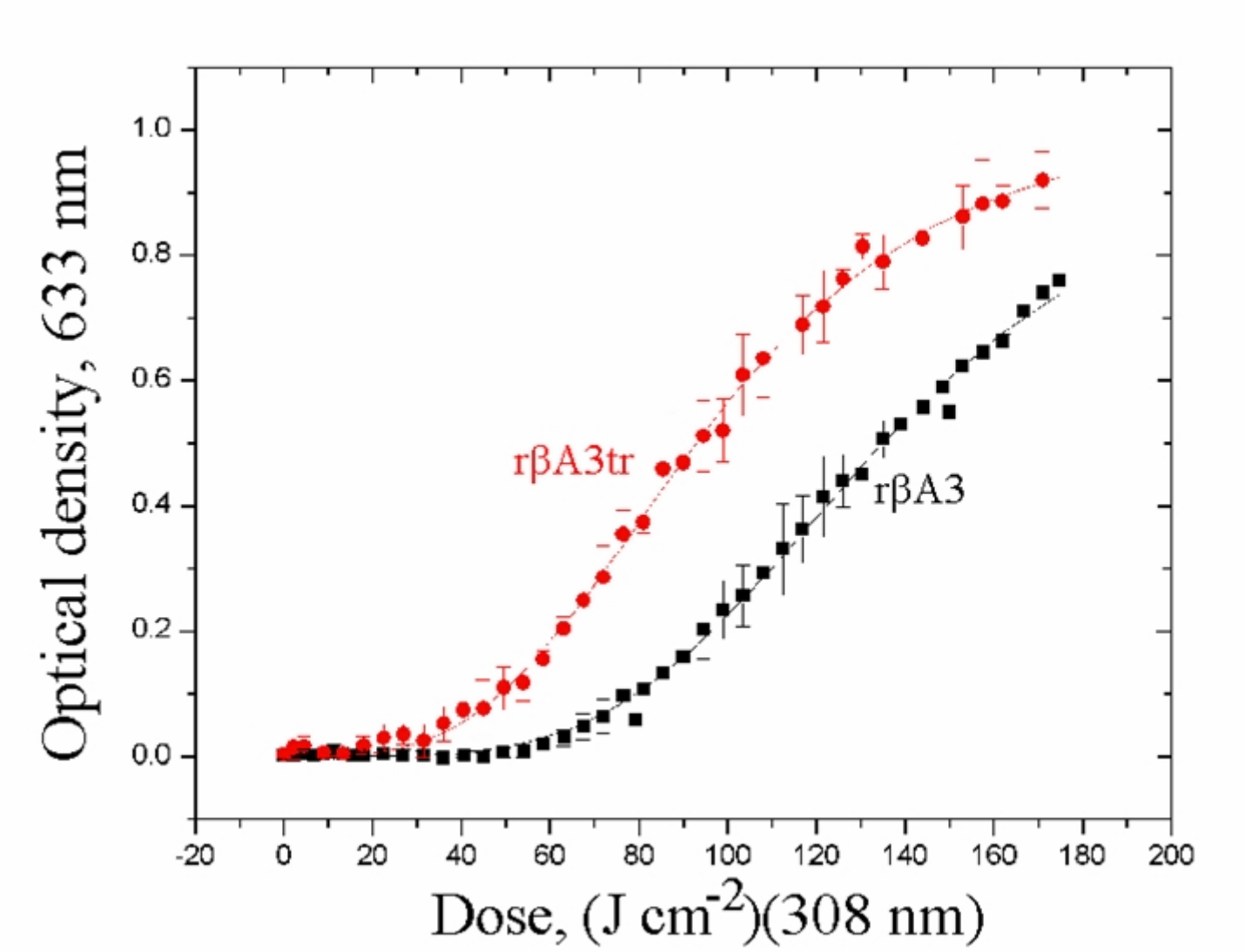


A study of recombinant rβA3 crystallin

Three-dimensional structure of rβA3 crystallin in monomer (left) and dimer (right) forms (Sergeev et al., 2000)



The loss of the terminal extension increases the tendency of rβA3tr-crystallin to aggregate (in press)



So, the loss of the terminal extension increases the tendency of truncated β-crystallin (rβA3tr):

-- to associate into dimers (Sergeev et al., 1998),

-- to aggregate as a result of UV-irradiation (Ostrovsky et al., in press).

It could be assumed that similar damage to lens crystallins molecules induced by UV light, X-rays, **high-energy particle radiation** can leads to similar consequence: **insoluble protein formation and cataract.**

Future: Simultaneous high-energy particles irradiation and transmittance measurement can be useful technique to study molecular mechanisms of radiation-induced cataract.

A future structural and functional studies of vision at JINR basic facilities are:

- molecular mechanisms of heavy particles-induced cataract: damage to lens crystallines and whole lens;
- molecular mechanisms of heavy particles-induced damage to rhodopsin molecule and retina cells;
- fine structure of rod outer segment, disk membrane, rhodopsin molecule and its light- and radiation-induced changes;
- nature of spectral tuning and ultrafast photochemical reaction of visual pigments.