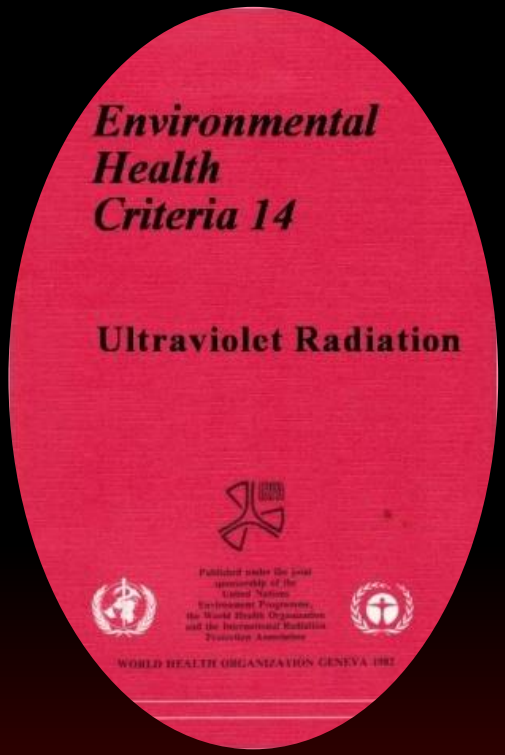
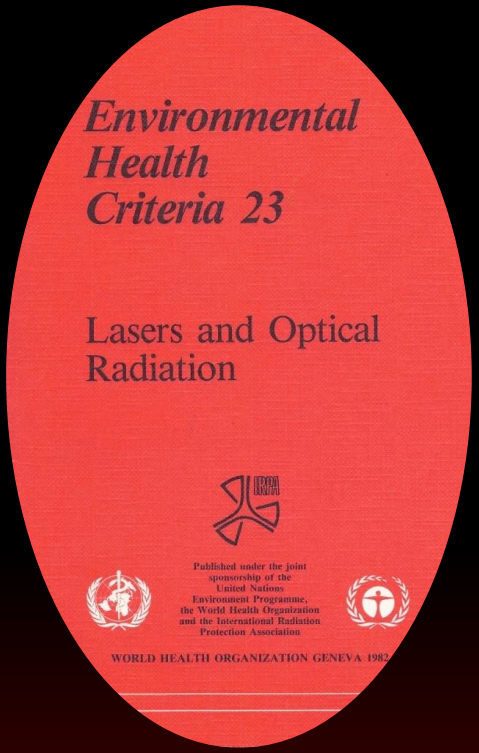
Ultraviolet Radiation & The Eye

National Institute for Health and Care Excellence
London 22nd July 2014

David Sliney



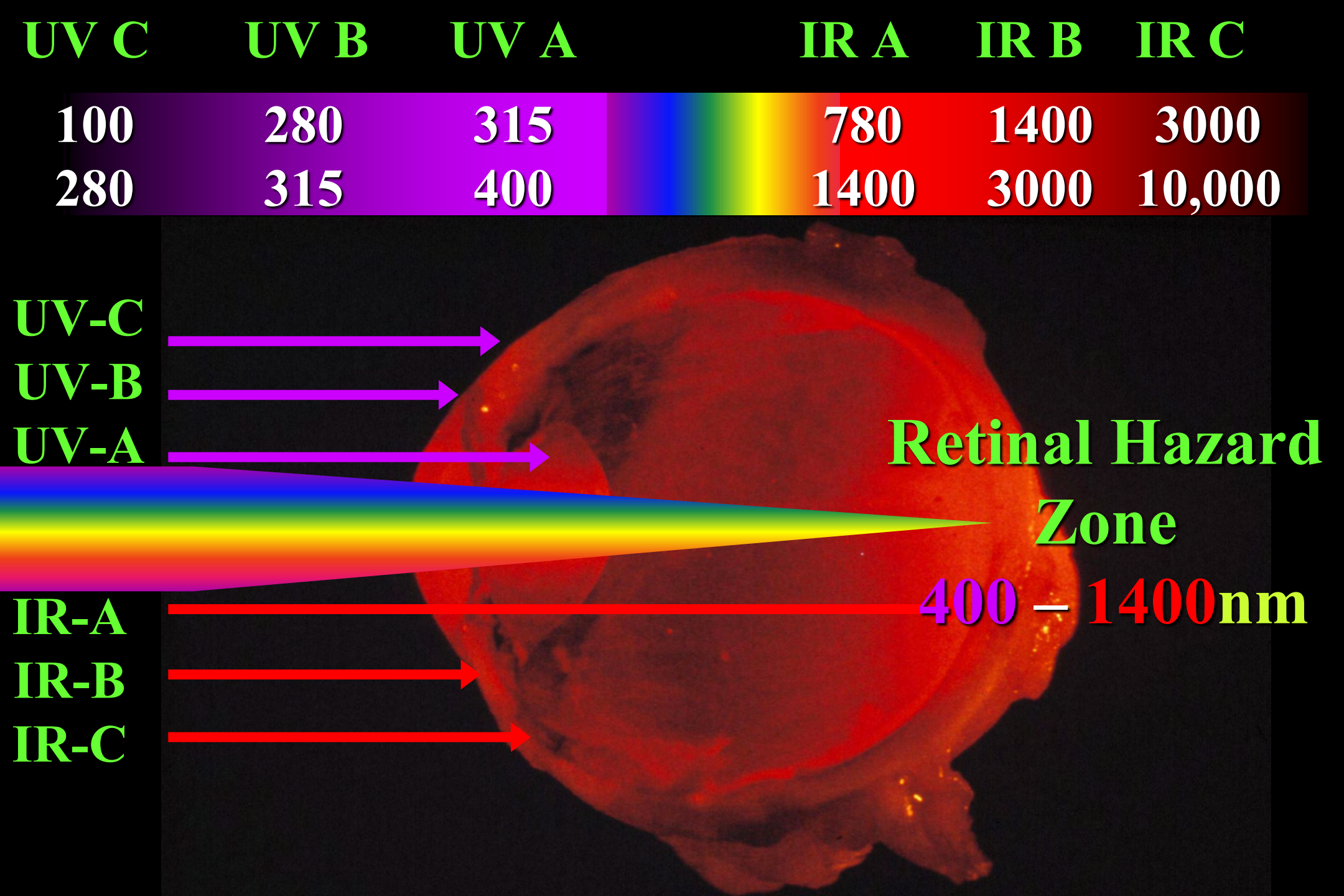


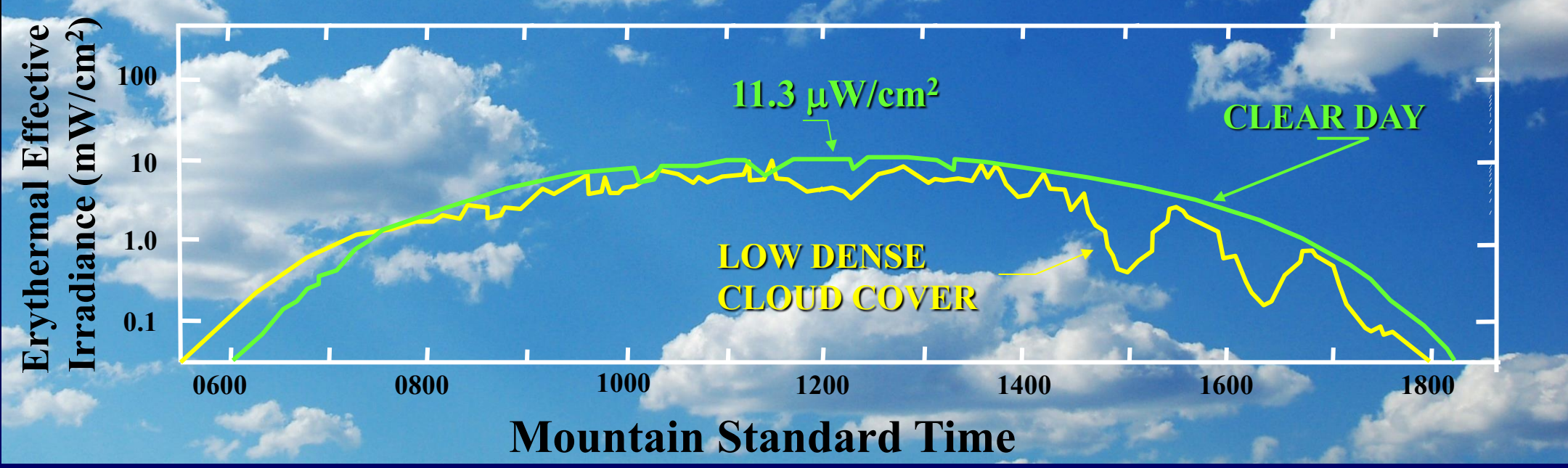
British Standards Institution (BSI)
National Radiological Protection Board (NRPB)
European Community Non Ionising Radiation Advisory Group (EC)
International Electro-Technical Commission (IEC)
International Committee of the Red Cross (ICRC)
International Standards Organization Light Hazards Task Group (ISO)
Non-ionizing Radiation Committee of the
International Radiological Protection Association
United Nations Environmental Programme
World Health Organisation (WHO)

Time (mins) to Exceed UV Exposure Limit (8hr Day)

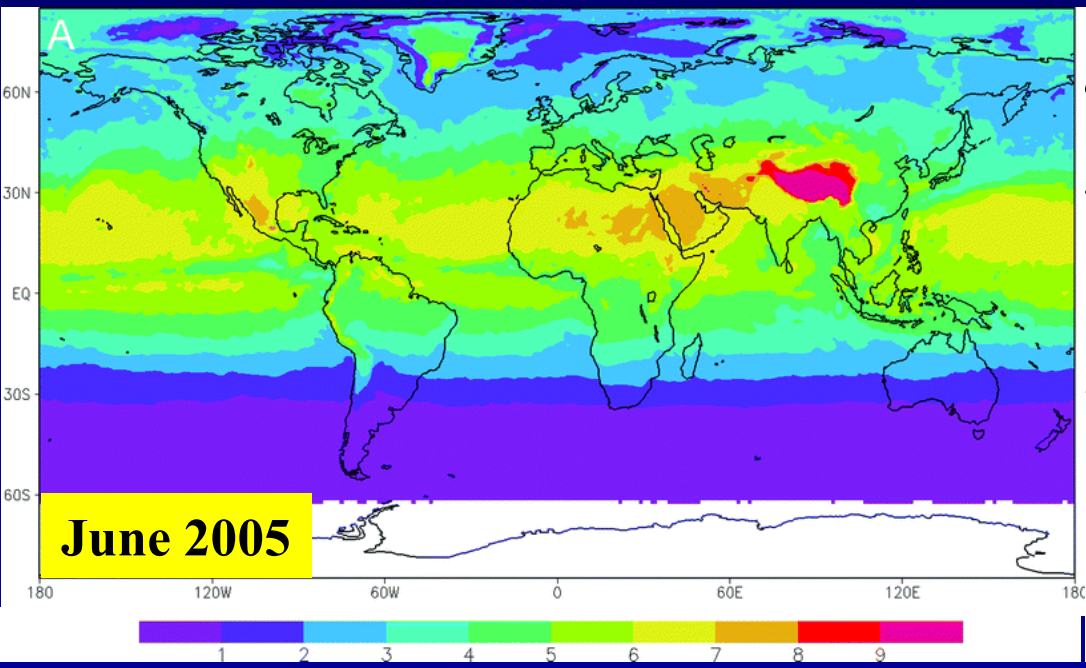
City	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Oslo 60°	>8h	209	99	39	28	20	22	31	67	174	417	>8h
London 50°	174	95	39	25	18	14	15	20	27	74	139	260
Mallorca 40°	74	34	22	15	14	12	12	13	17	29	63	99
Tucson 20°	26	19	13	12	11	10	10	11	11	18	25	37

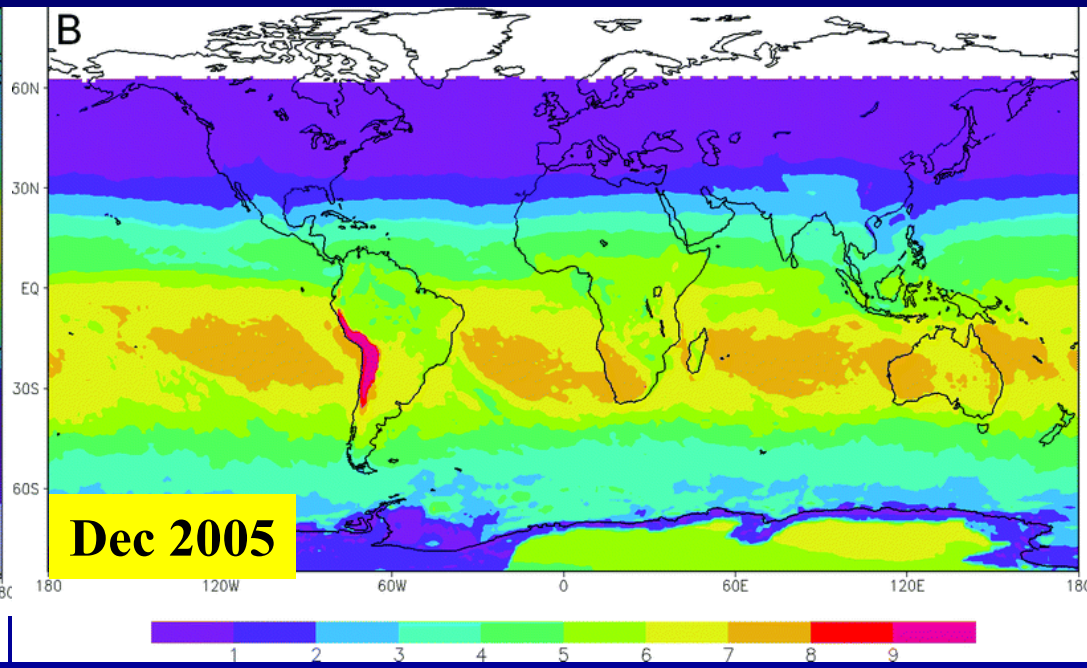
International Commission on Non Ionising Radiation Protection (ICNIRP 1999)


UV C
UV B
UV A
IR A
IR B
IR C
100
280
315
780
1400
3000
280
315
400
1400
3000
10,000
UV-C
UV-B
UV-A
IR-A
IR-B
IR-C
Retinal Hazard
Zone
400 – 1400nm

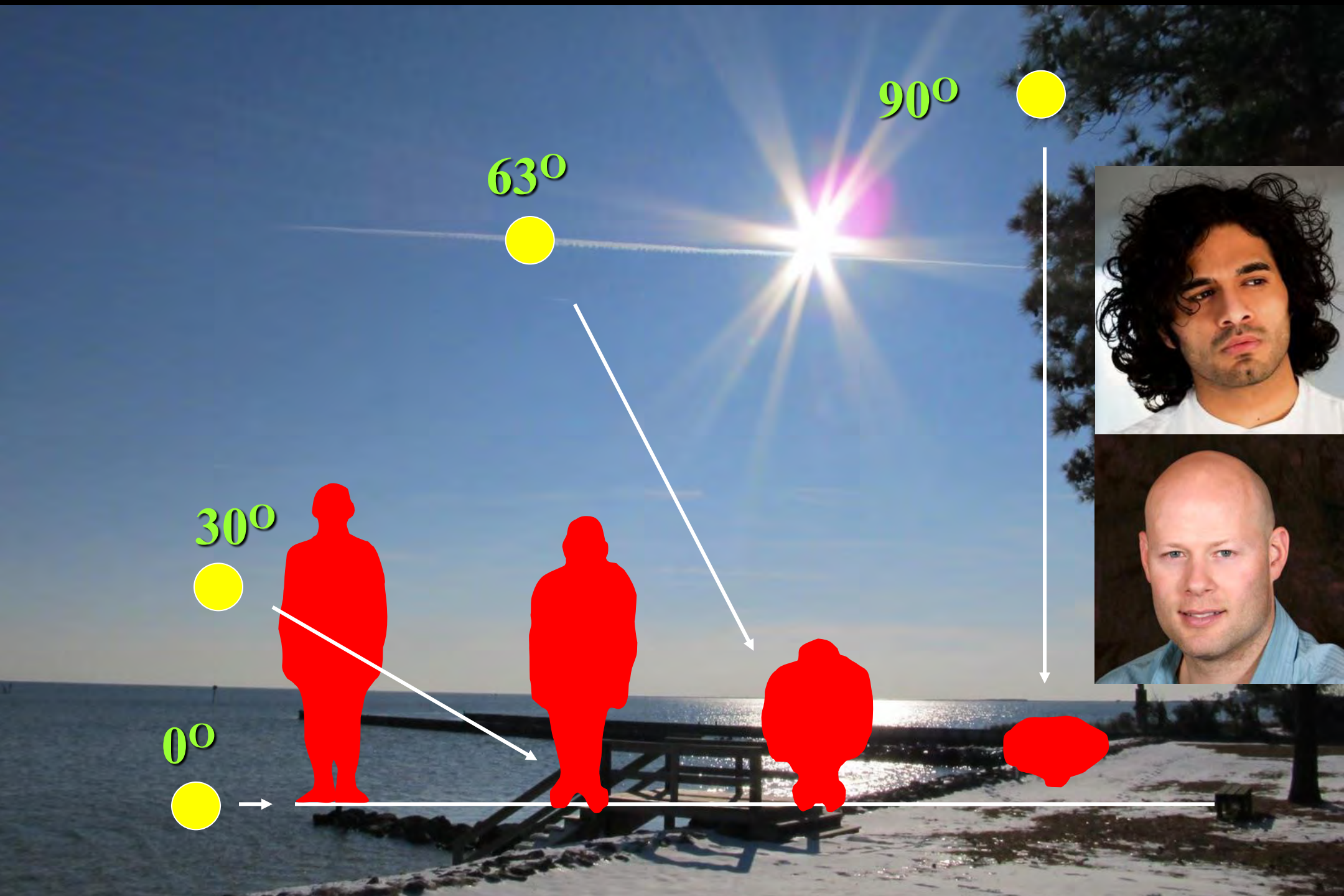


Global distribution of the average cloud-corrected erythemal daily dose (in kJ m^{-2})

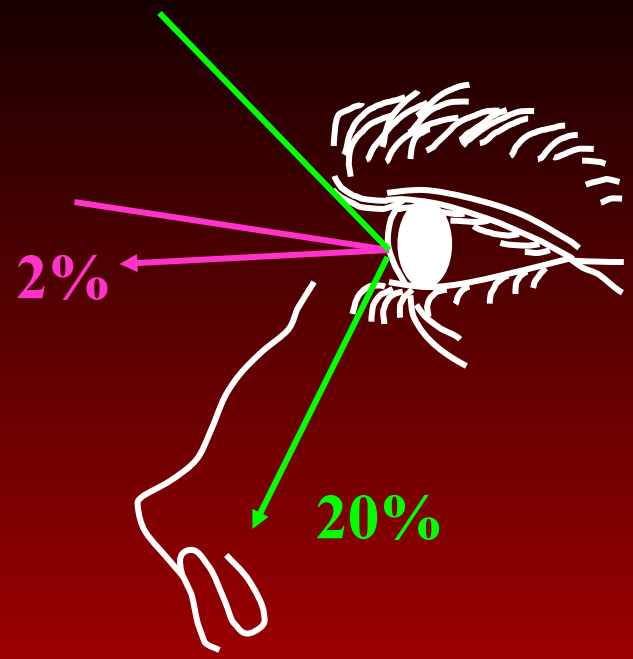




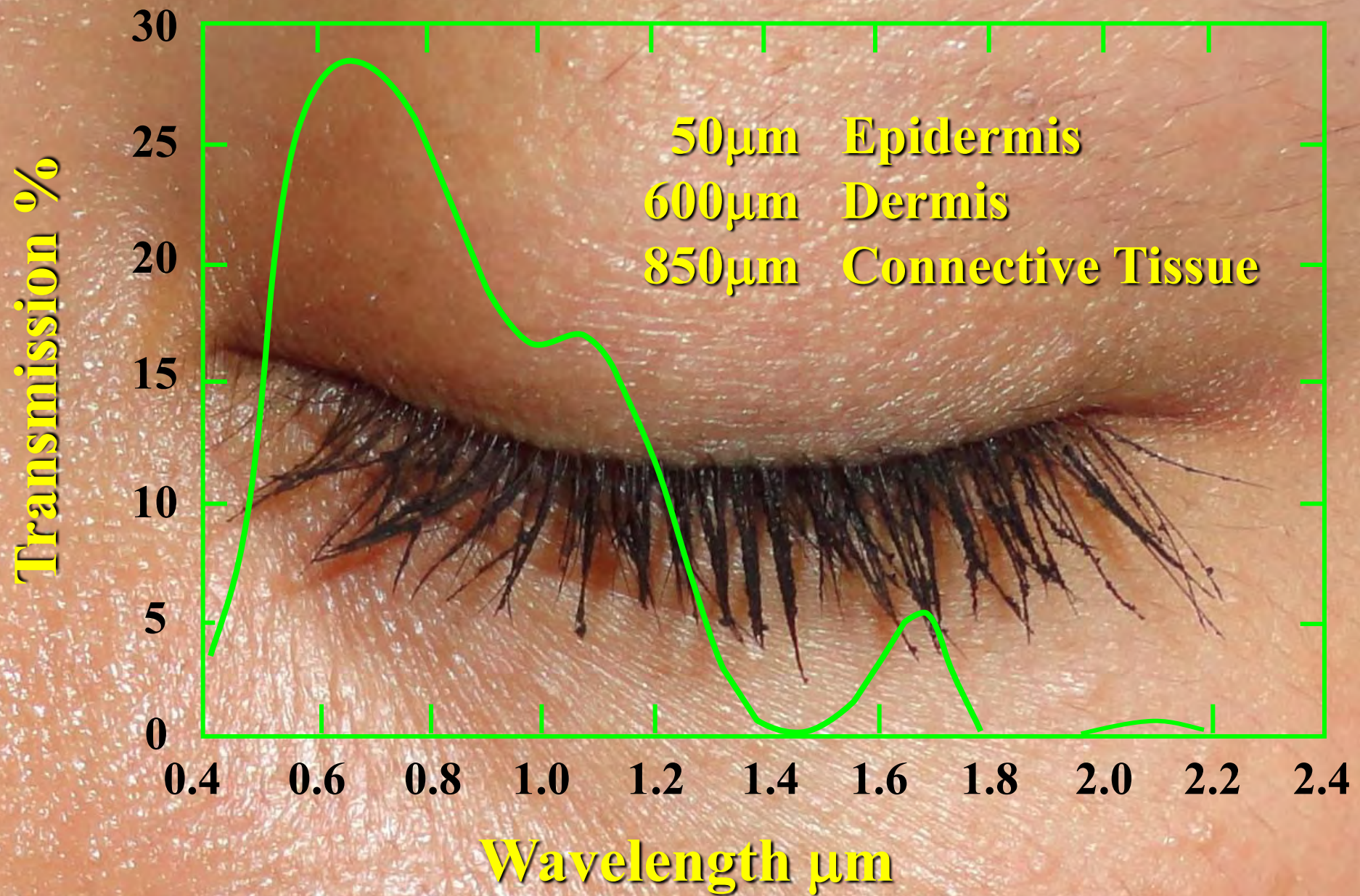
Photochem. Photobiol. Sci., 2007,**6**, 218-231

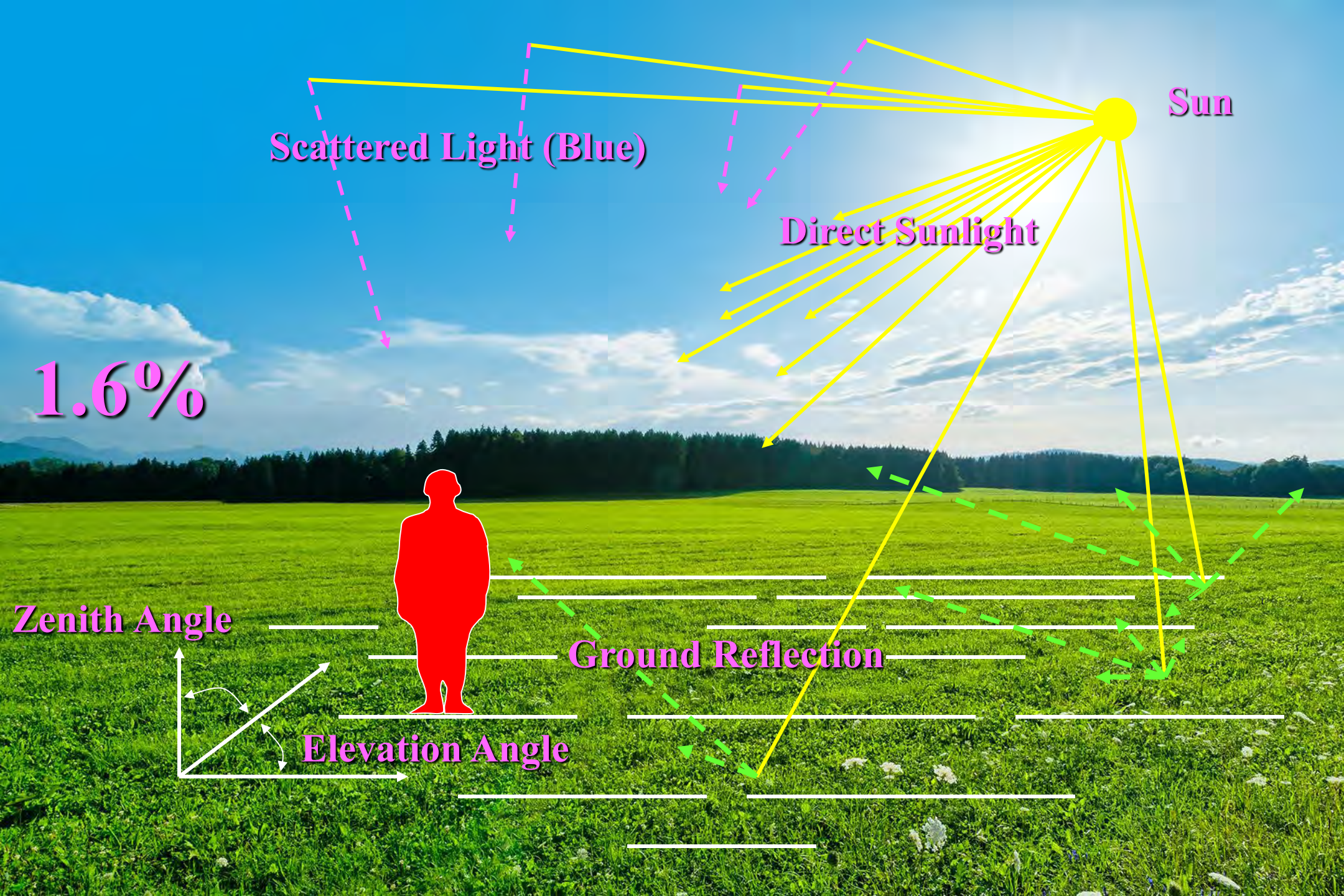

90º
63º
30º
0º

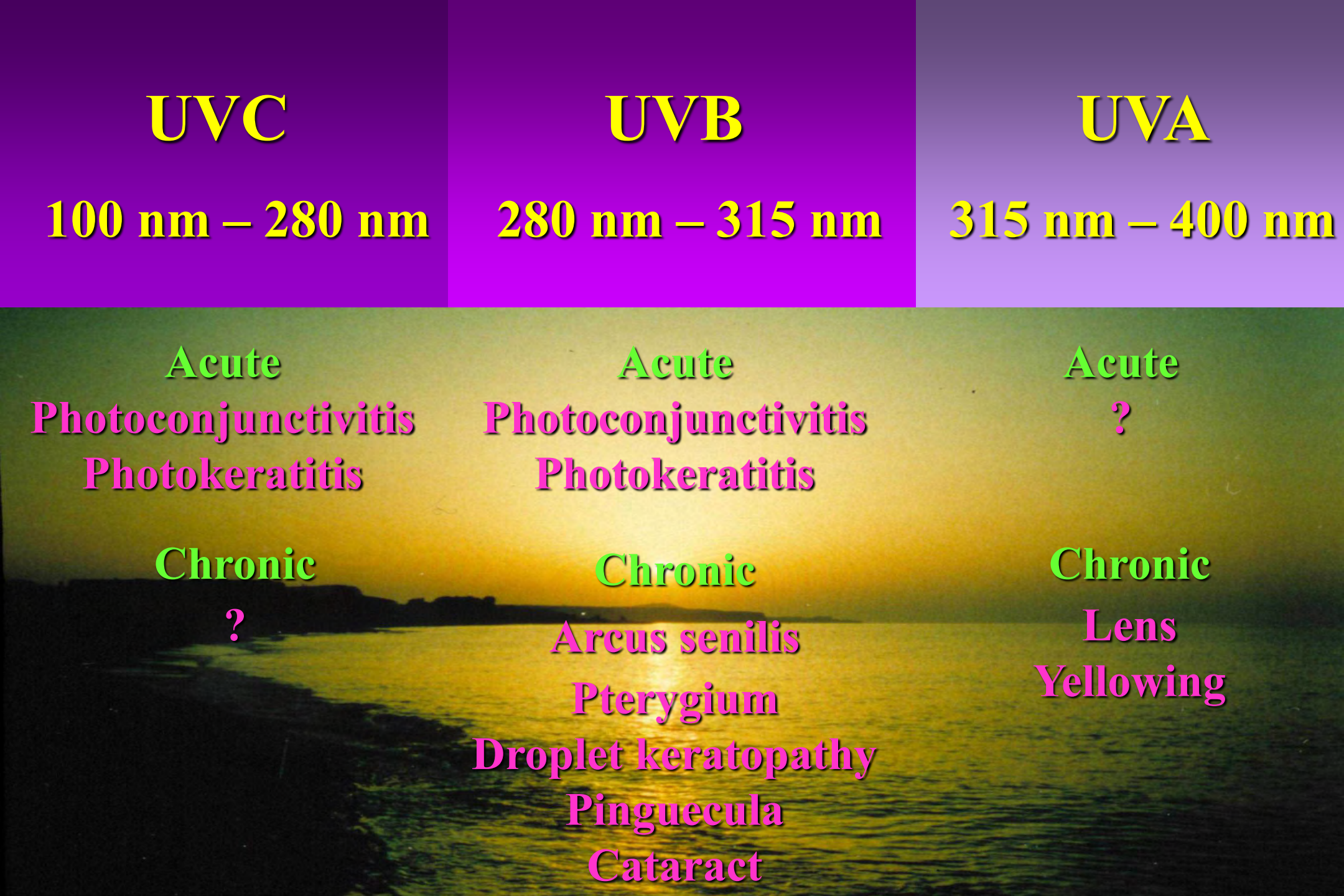
Reflection of UV

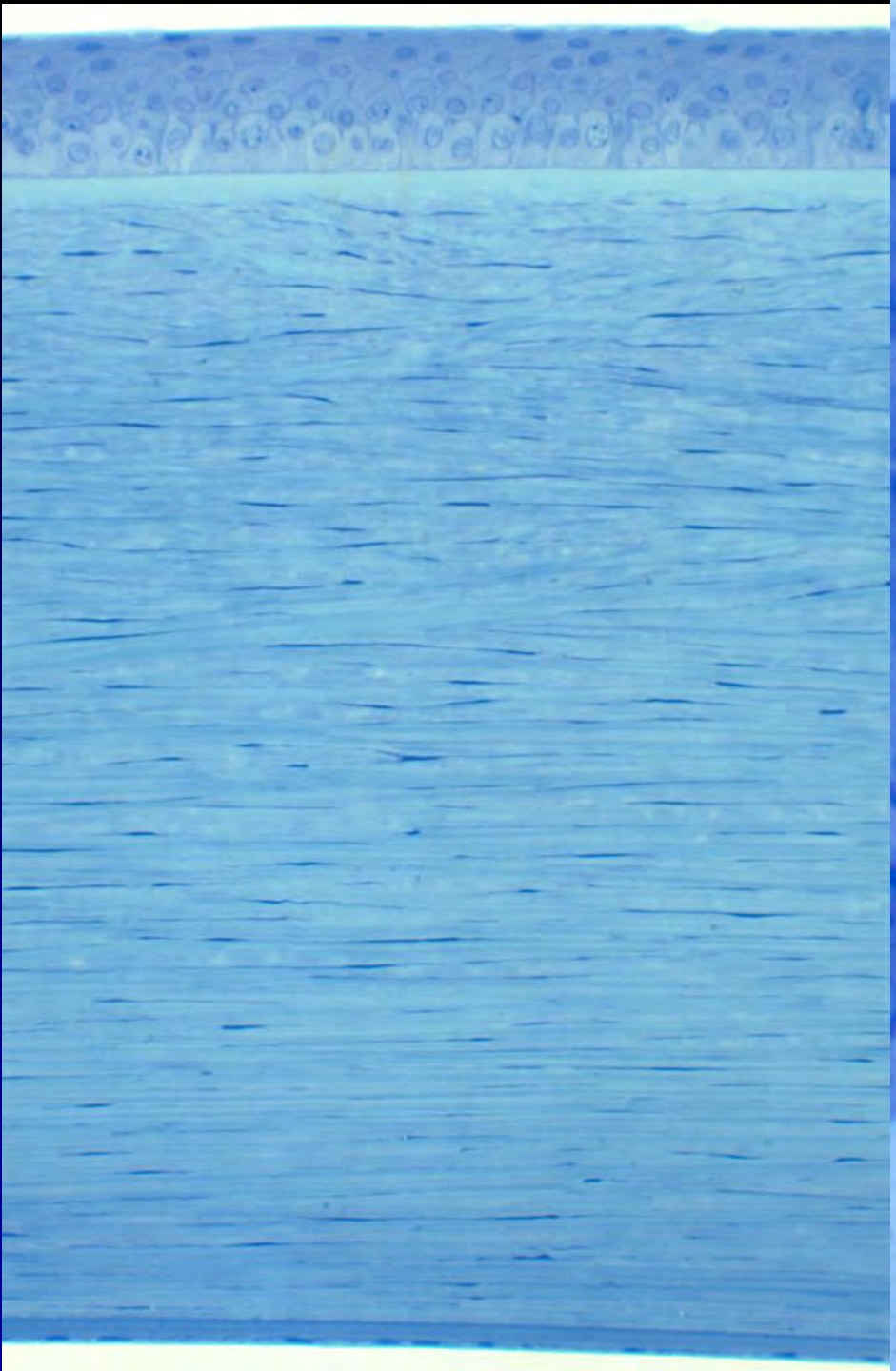


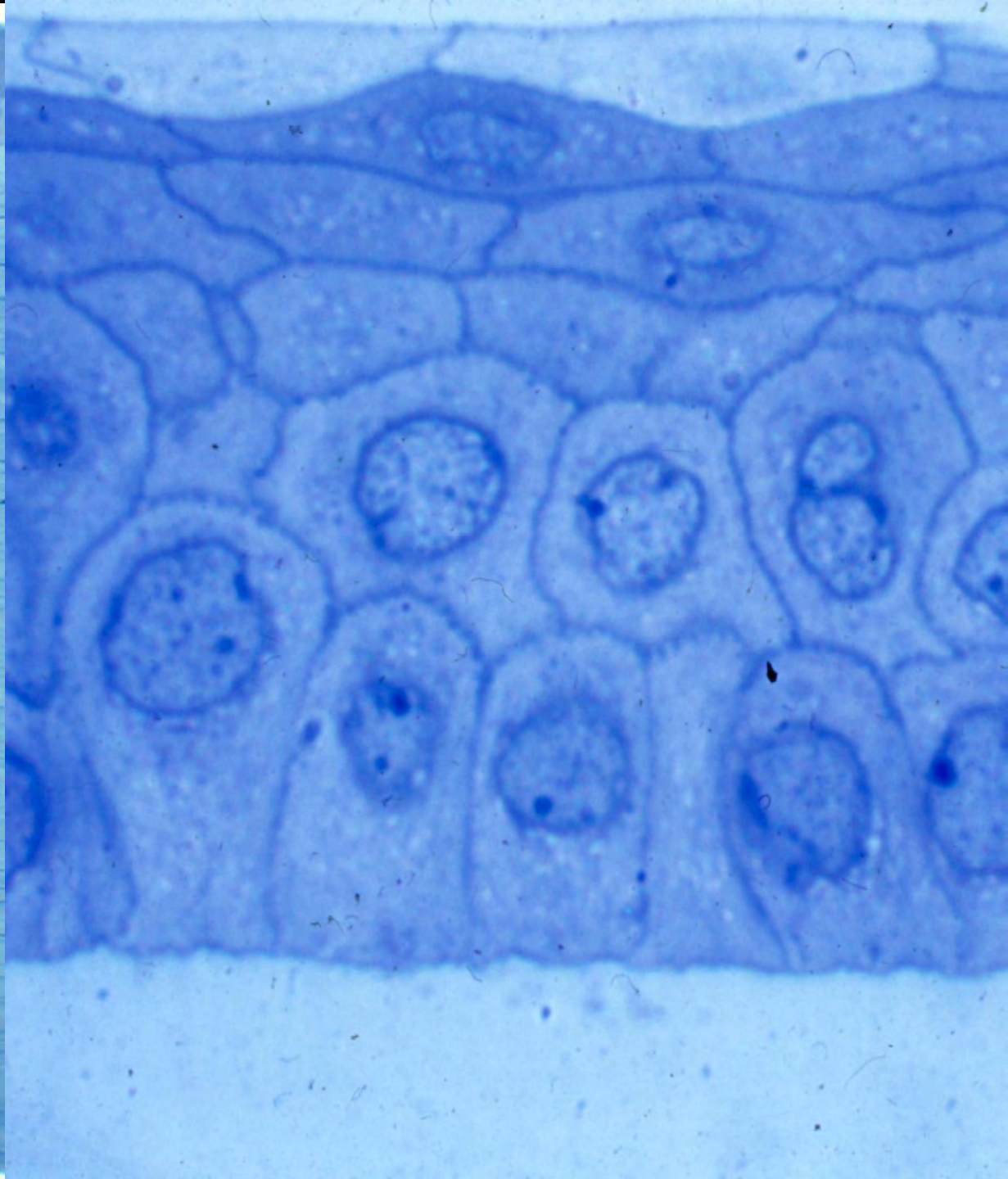
TRANSMISSION THROUGH EYELIDS

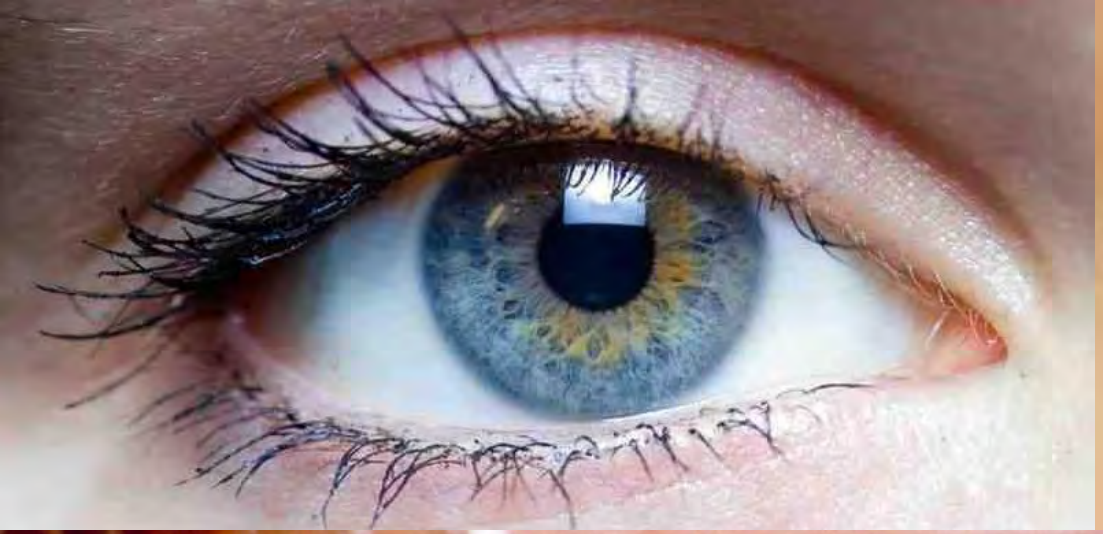



Sun
Scattered Light (Blue)
Direct Sunlight
1.6%
Zenith Angle
Ground Reflection
Elevation Angle


UVC
100 nm – 280 nm
UVB
280 nm – 315 nm
UVA
315 nm – 400 nm
Acute
Photoconjunctivitis
Photokeratitis
Chronic
?
Acute
Photoconjunctivitis
Photokeratitis
Chronic
Arcus senilis
Pterygium
Droplet keratopathy
Pinguecula
Cataract
Acute
?
Chronic
Lens
Yellowing

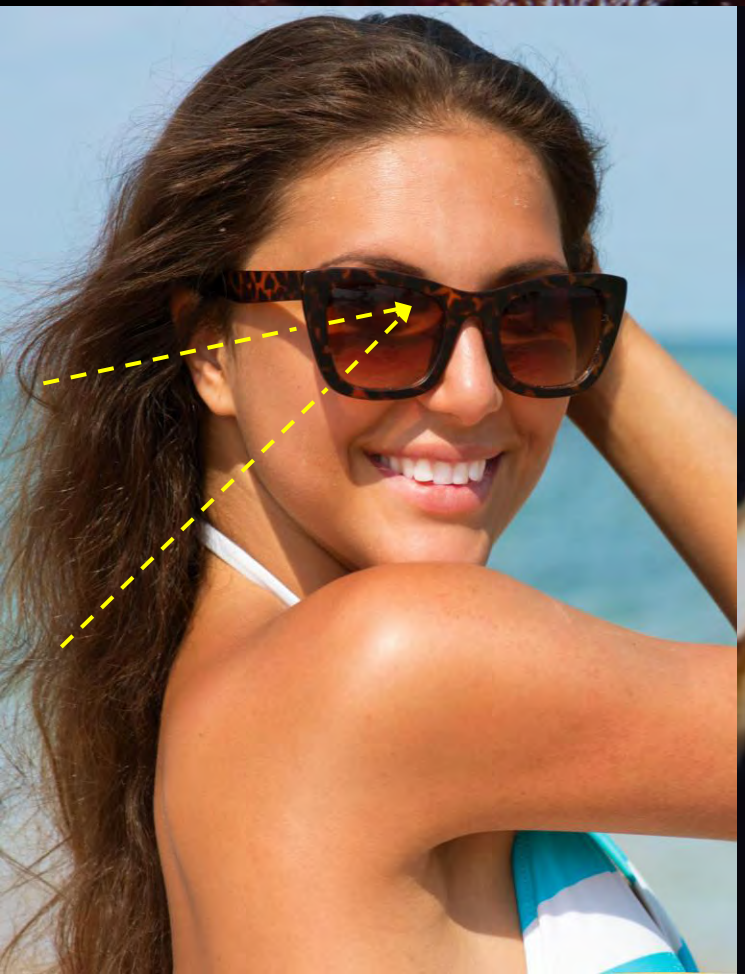


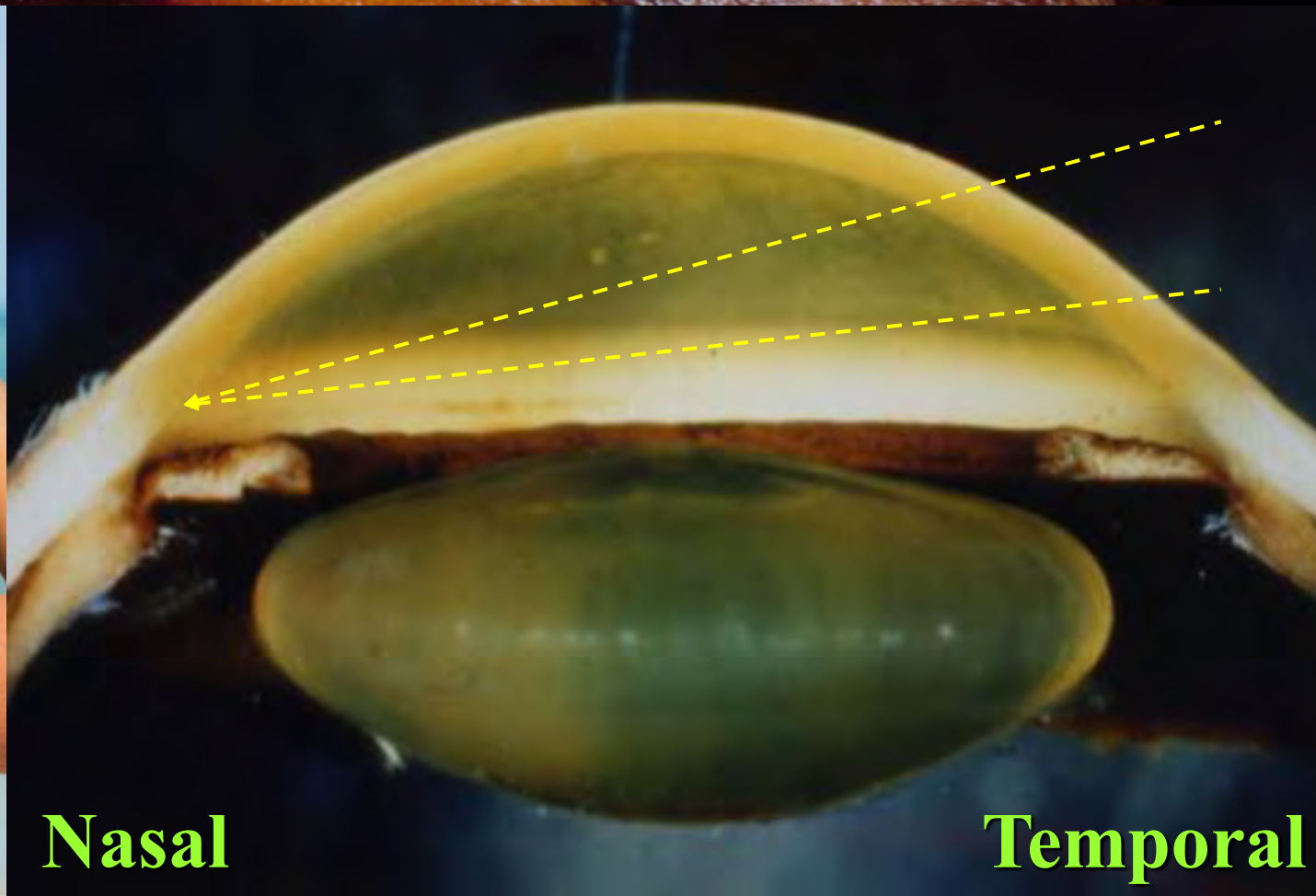




BAND KERATOPATHY

PTERYGIA

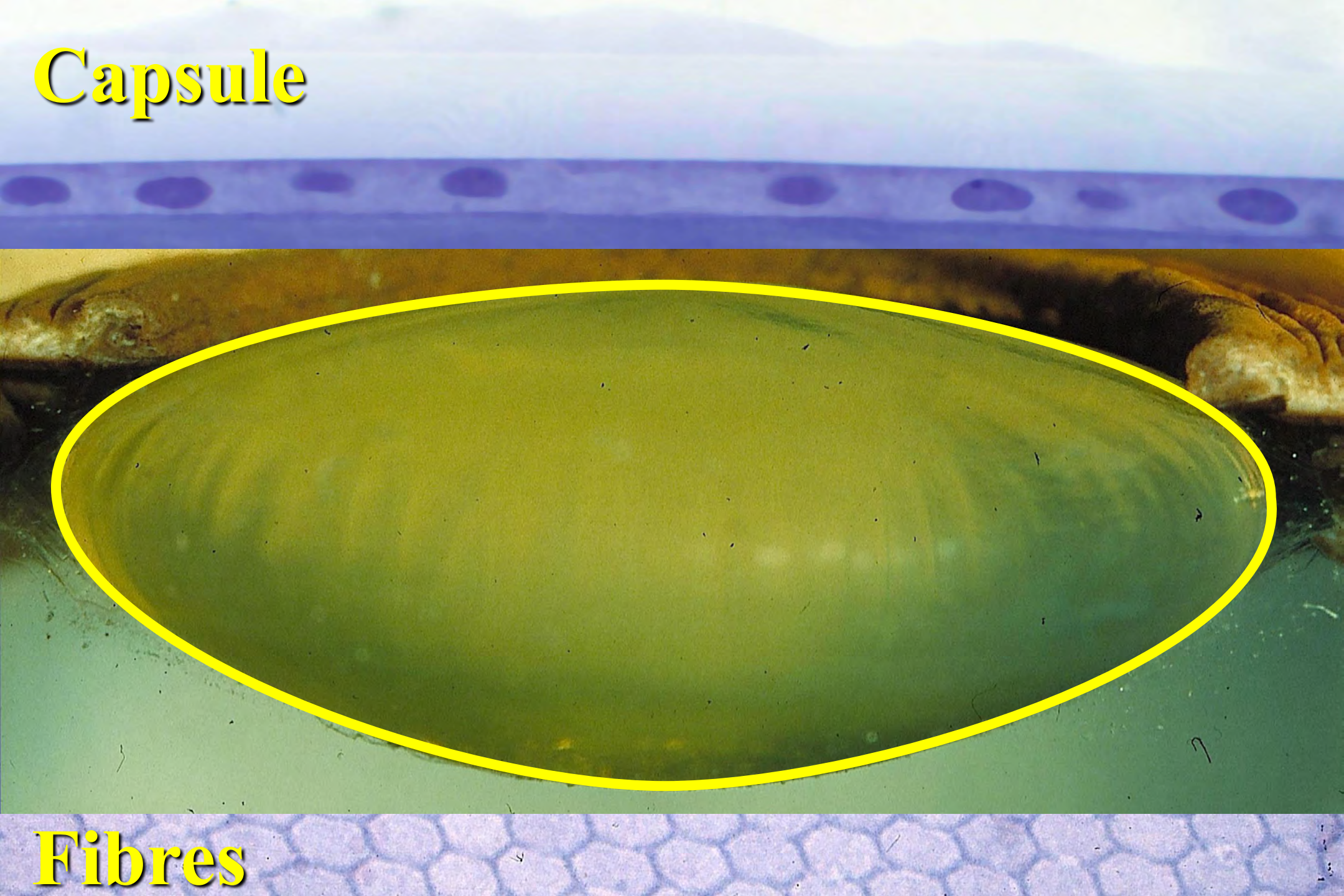


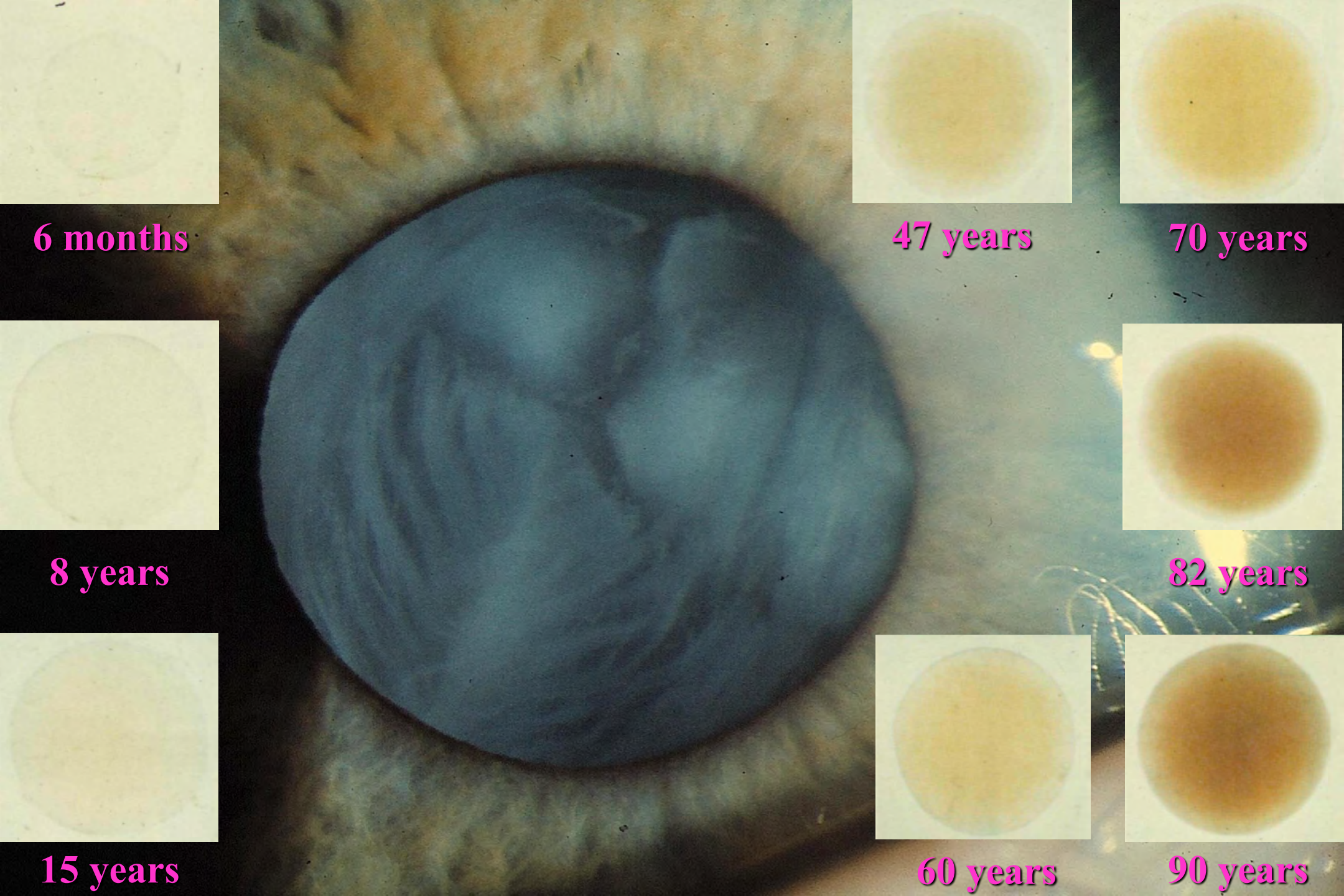


Nasal

Temporal

Arcus Senilis


Capsule
Fibres


6 months
47 years
70 years
8 years
82 years
15 years
60 years
90 years

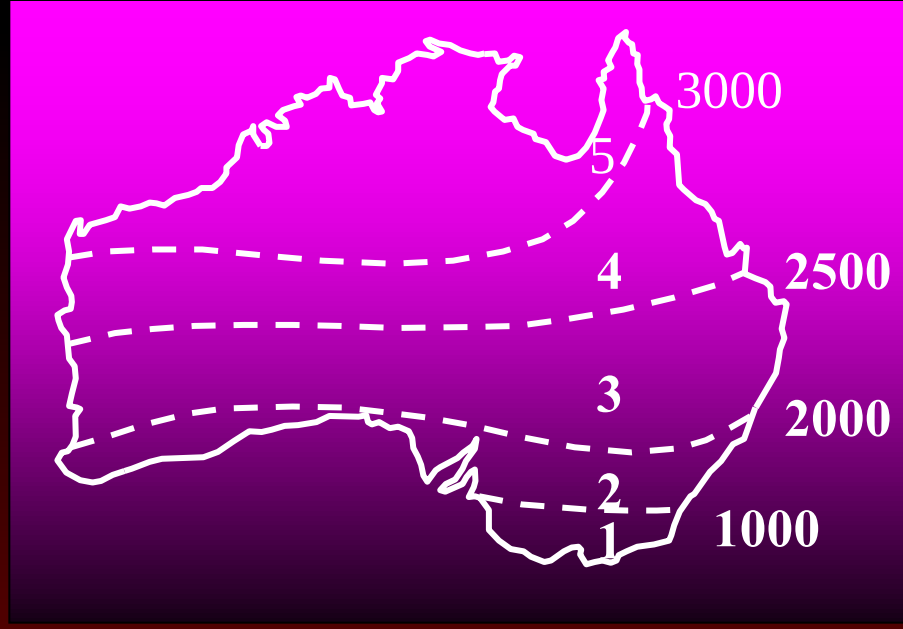
Waterman Chesapeake Bay (1989)

(1) People with Cortical Lens Opacities had a 21% higher UV-B exposure per year of life than those without

(2) A doubling of lifetime UV-B exposure gives a 60% increase in risk of Cortical Opacities

(3) High annual exposure to UV-B increased risk over threefold

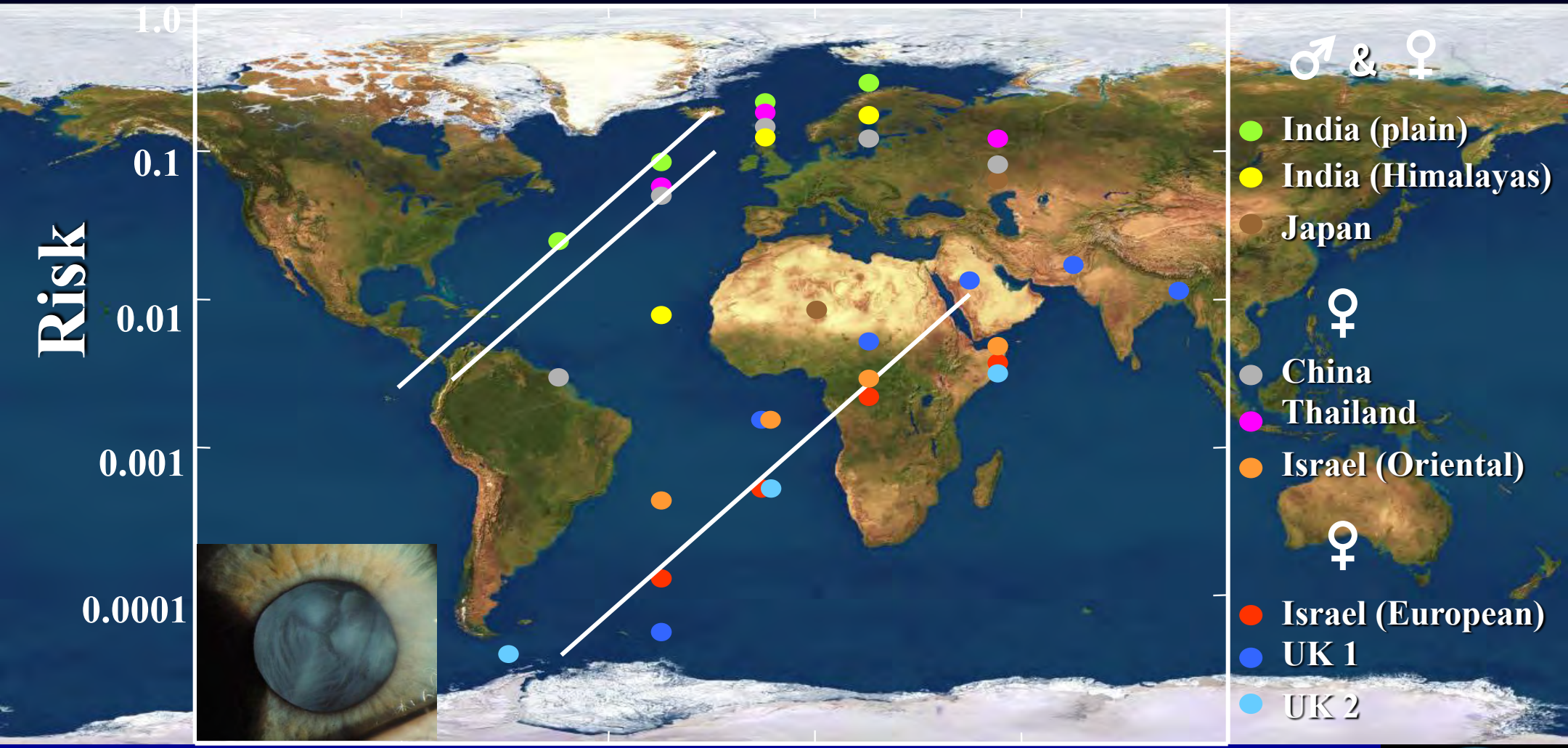
Taylor Tr. Am. Ophthal. Soc. 87 802 (1989)



CATARACT PREVELANCE IN ABORIGINES BY ULTRAVIOLET ZONE

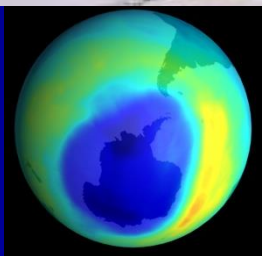
	Age		
UV Zone	0 - 39	40 – 50	60 +
1	0%	1.7%	13.6%
2	0%	2.6%	24.2%
3	0.1%	3.7%	29.5%
4	0.1%	3.8%	30.5%
5	0.2%	5.1%	29.8%

Variation in onset of Age Related Cataract with Latitude

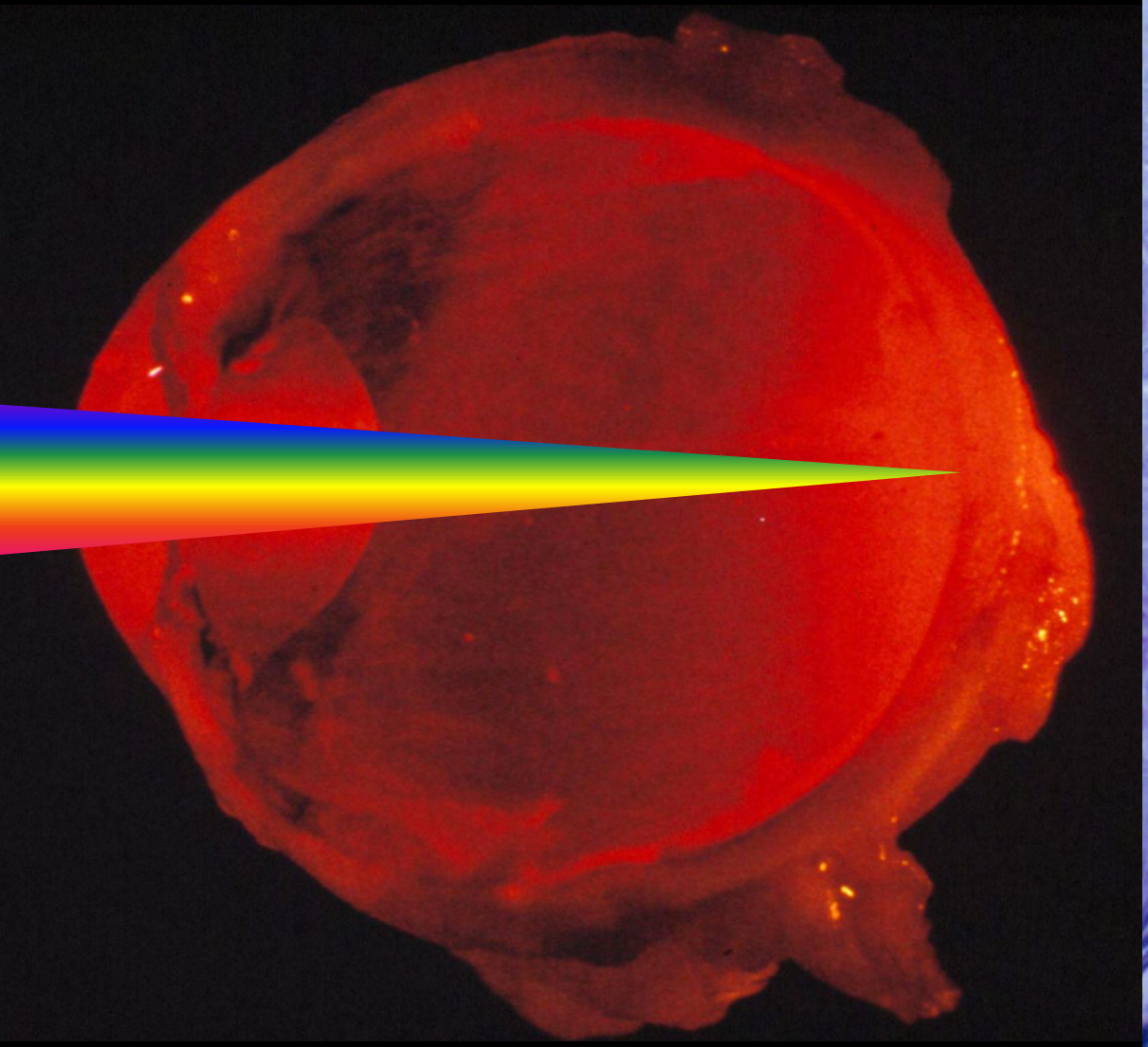


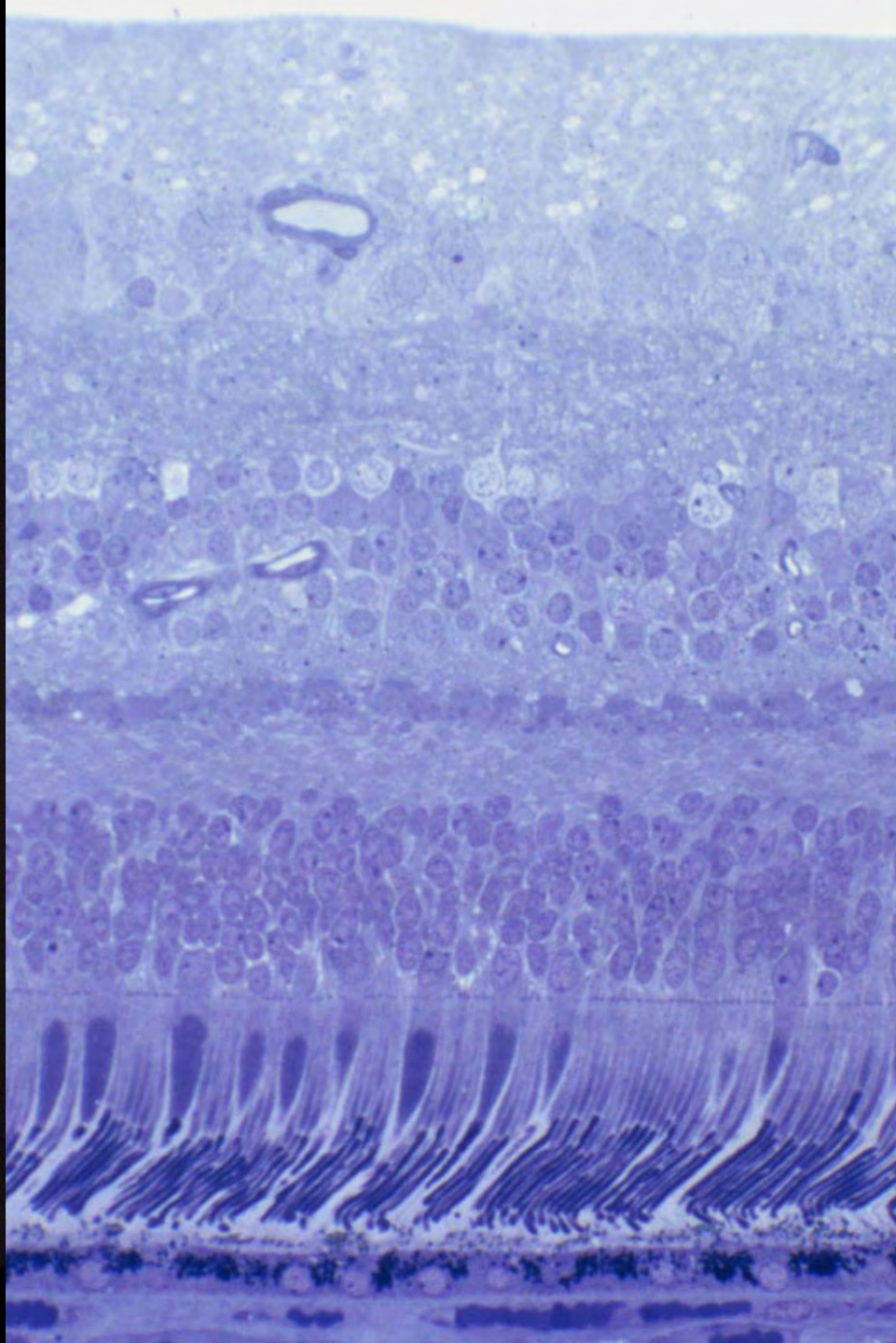
RA Weale, Br.J. Ophthalmology Jan 1982

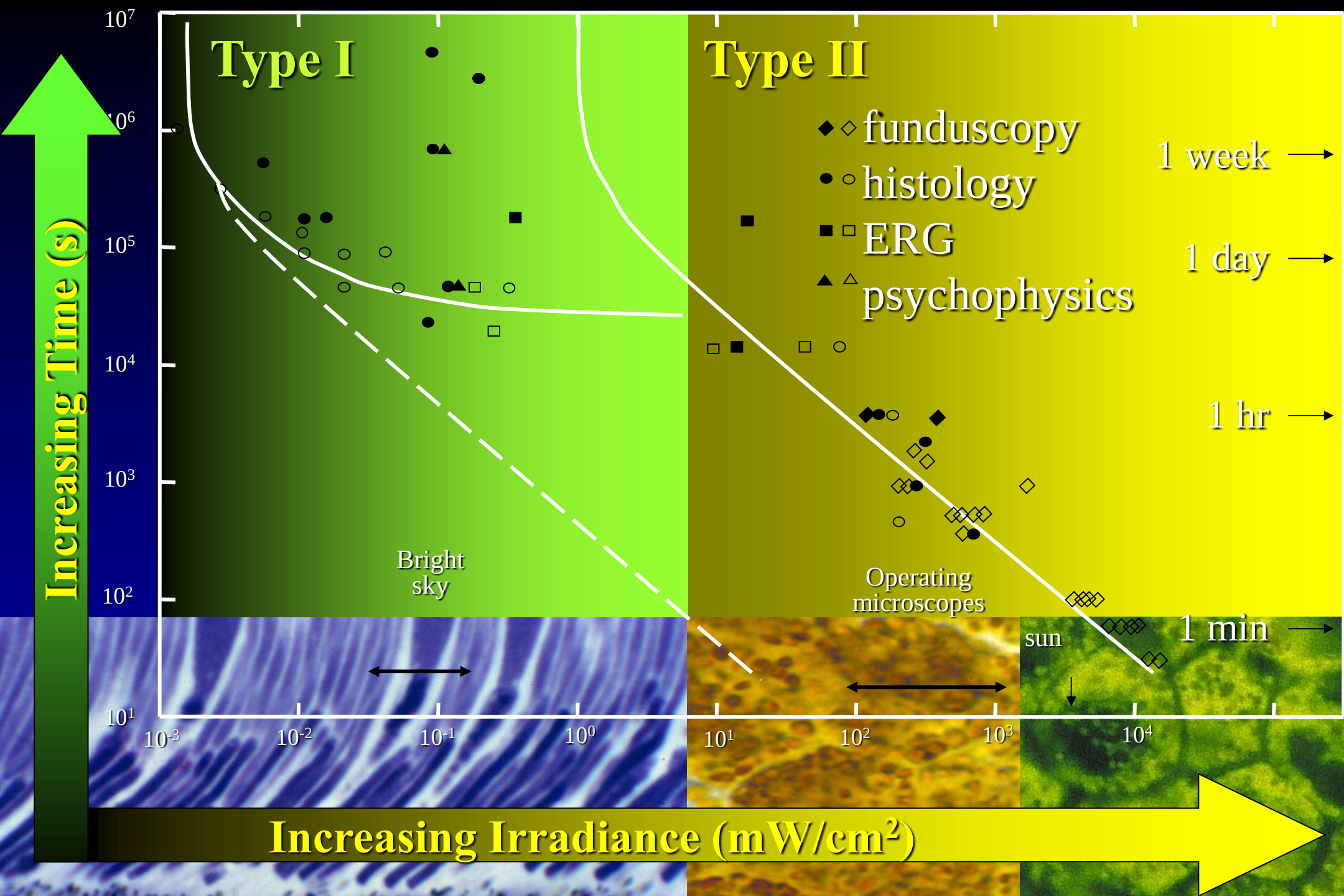
Hole in Ozone Layer over Antarctica 11.4 million sq miles

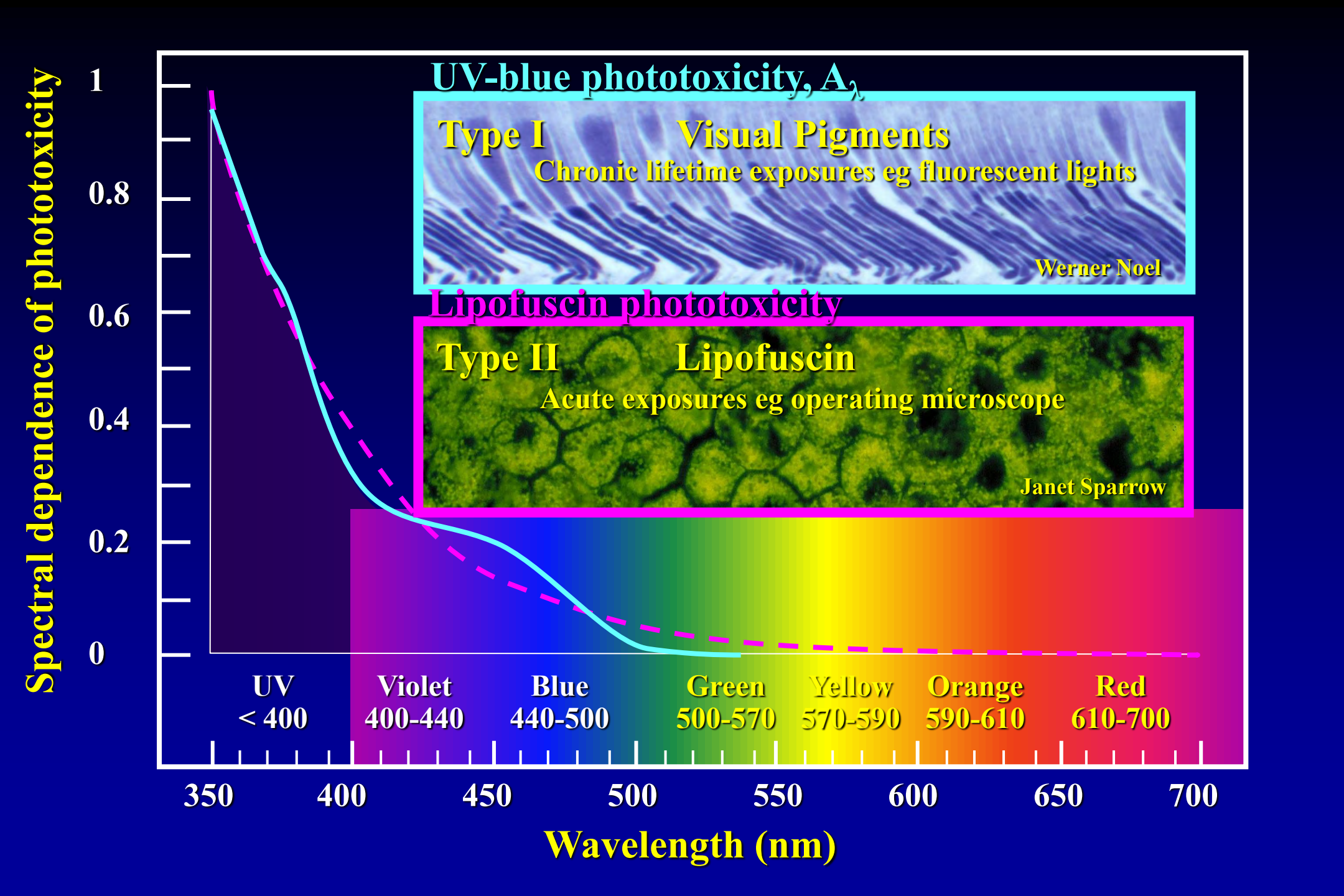


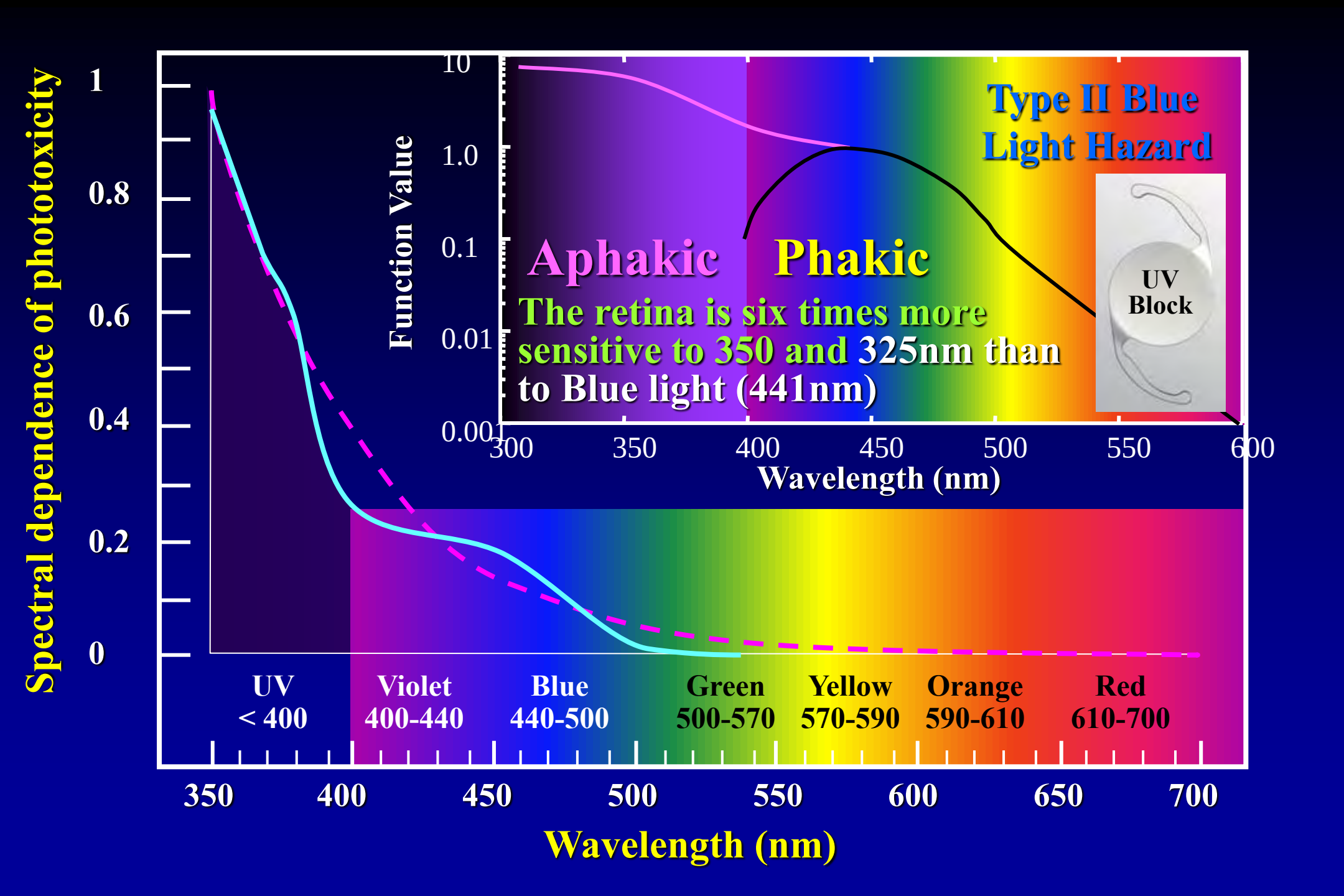
Retinal Hazard Zone
400 – 1400nm






Type I
Type II
funduscopy
histology
ERG
psychophysics
1 week
1 day
1 hr
1 min
Bright sky
Operating microscopes
sun
Increasing Time (s)
Increasing Irradiance (mW/cm²)
10⁷
10⁶
10⁵
10⁴
10³
10²
10¹
10⁻³
10⁻²
10⁻¹
10⁰
10¹
10²
10³
10⁴


UV-blue phototoxicity, A_λ
Type I Visual Pigments
Chronic lifetime exposures eg fluorescent lights
Werner Noel
Lipofuscin phototoxicity
Type II Lipofuscin
Acute exposures eg operating microscope
Janet Sparrow
Spectral dependence of phototoxicity
1
0.8
0.6
0.4
0.2
0
UV
< 400
Violet
400-440
Blue
440-500
Green
500-570
Yellow
570-590
Orange
590-610
Red
610-700
350
400
450
500
550
600
650
700
Wavelength (nm)


Spectral dependence of phototoxicity
1
0.8
0.6
0.4
0.2
0
UV
< 400
Violet
400-440
Blue
440-500
Green
500-570
Yellow
570-590
Orange
590-610
Red
610-700
350
400
450
500
550
600
650
700
Wavelength (nm)
Function Value
10
1.0
0.1
0.01
0.001
300
350
400
450
500
550
600
Wavelength (nm)
Type II Blue
Light Hazard
Aphakic
Phakic
The retina is six times more
sensitive to 350 and 325nm than
to Blue light (441nm)
UV
Block

Light Off

Melanopsin 470nm

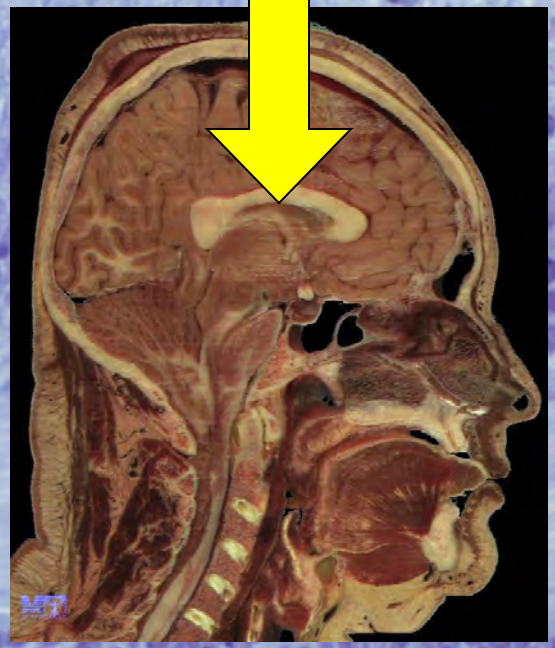
1% Ganglion Cells

"photoreceptors"

Light On

Melatonin Increase

Melatonin Suppression



suprachiasmatic nuclei
anterior hypothalamus

Master Clock

Go to sleep

Wake up

Berson et al, Science 295,2002

Fashion Tints

Sunglasses

High Performance Filters