Optimized Light Protection of the Eye

Why and How?

Siegfried Hünig

Why?

The Multifactorial Chronic Diseases of the Eye: Cataract and Age Related Macular Degeneration (AMD)

They develop undetectable and without any warning over 20 years and are triggered and accelerated by light.

AMD is the leading cause of blindness in the Western World:

65 years 19%   75 years 30%   85 years 35%

Germany/	2000:	2 mill.
AMD-patients	2020:	6 mill. (estim.)

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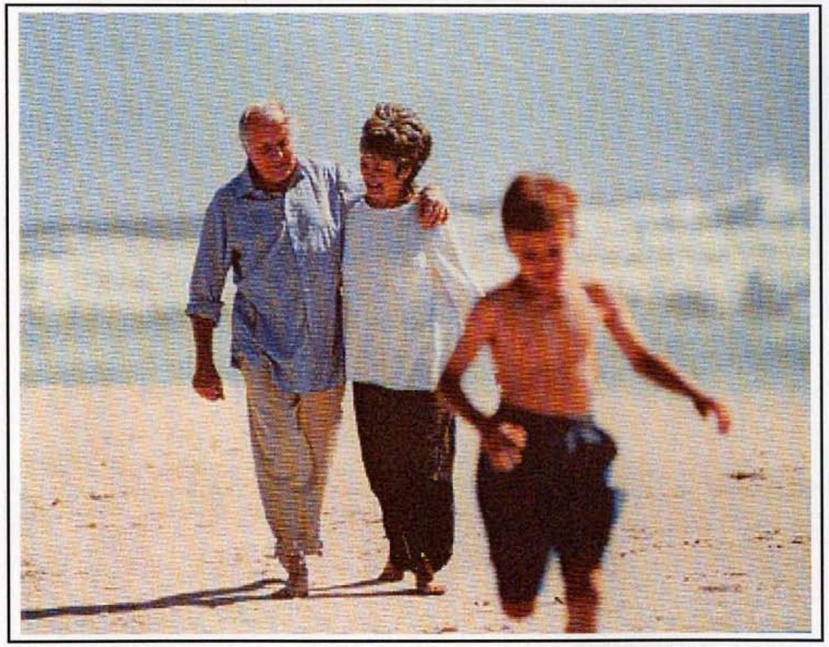
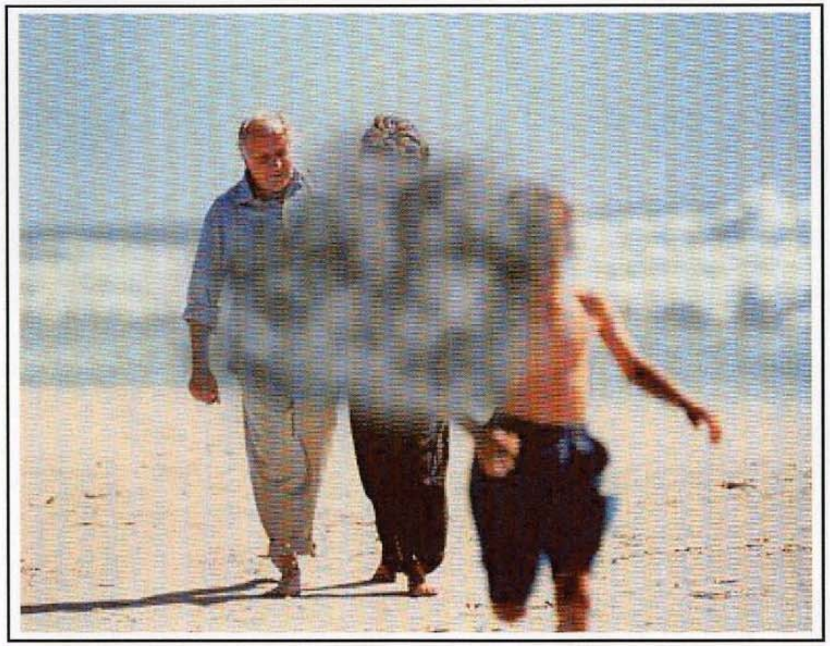
Normal vision

Age related macular degeneration (AMD)





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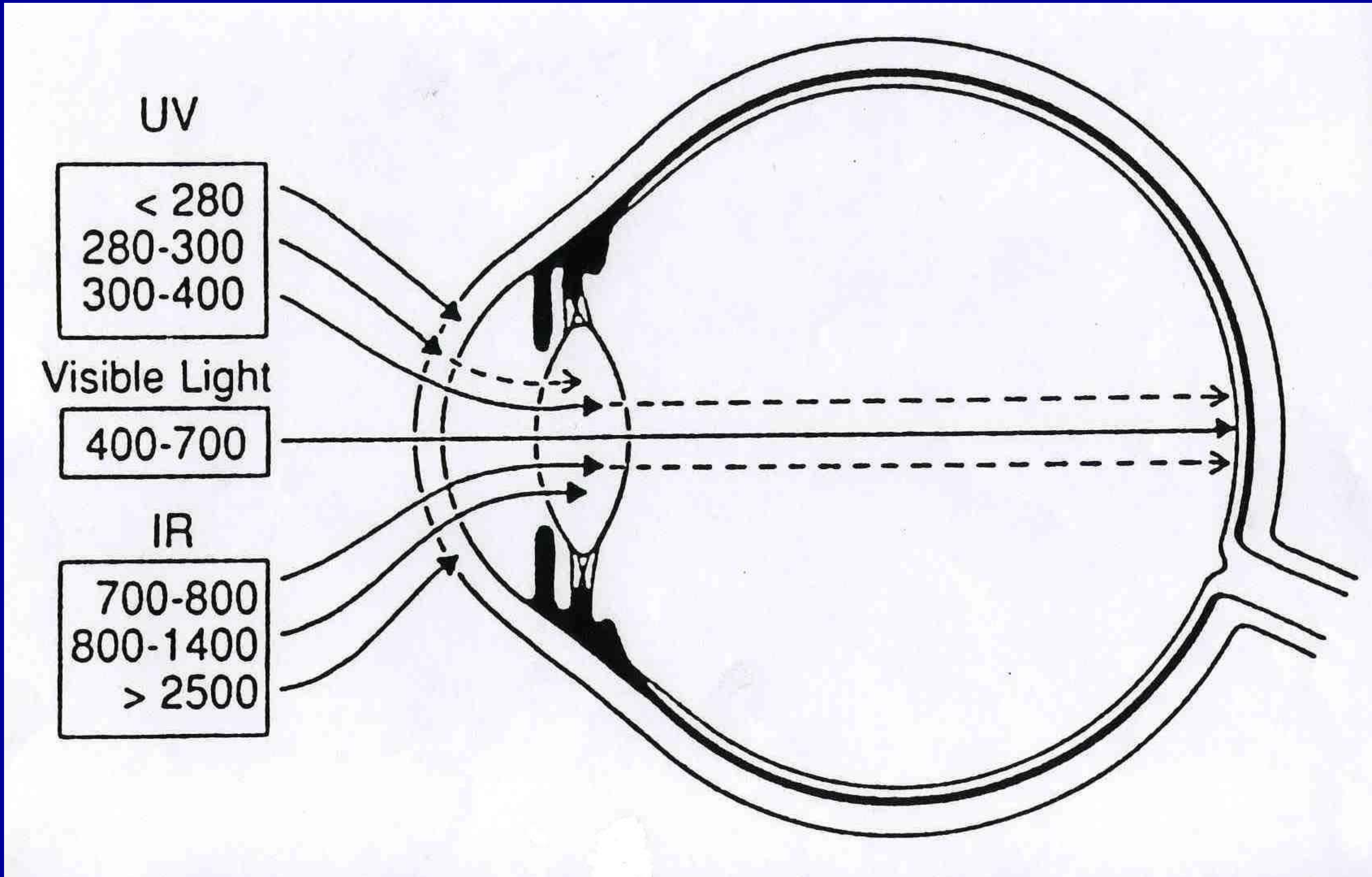
Why?

Dramatic increase of **cataract** and **AMD** over the last 50 years

Main reasons:

1. Increased life expactence
   Between 1930 and 2000 about 20 years were added!
2. Sun orientated life style, but protection no longer by brimmed hats
3. Artificial light has become increasingly brighter and whiter (i.e. more blue)
4. Dietary changes

1. – 3. call for optimized light protection of the eyes.


UV
< 280
280-300
300-400
Visible Light
400-700
IR
700-800
800-1400
> 2500

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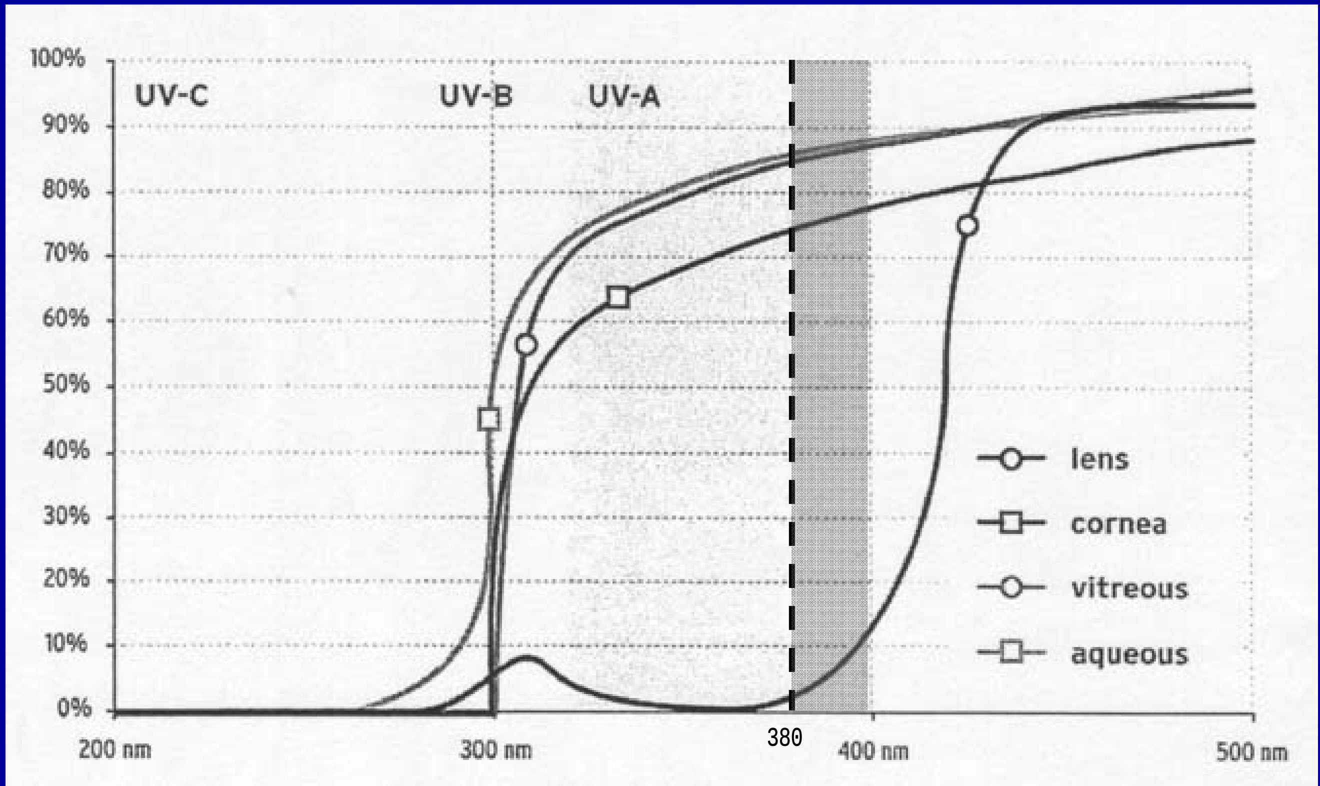
Why?

Out of the transparent Components of the Eye only the Human Lens is exposed completely to UV-A Radiation up to 400 nm

380 nm: UV Borderline according to EU-Norm 1836

Transmission (%)



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Ophthalmology **2004**, *11*, 880.

How?

Protection of the Lens

Transmission of the young lens 1-2% at 390 nm,
shifting to 410 nm on aging.
At 380 nm the lens still absorbes 70% of the UV energy.

Consequences:

UV 400 protection (50% transmission)

even with colourless glasses and contact lenses,

but definitely with all coloured glasses.

Technical problems are solved:

Colourless safety glasses worldwide used offer UV 400 protection!

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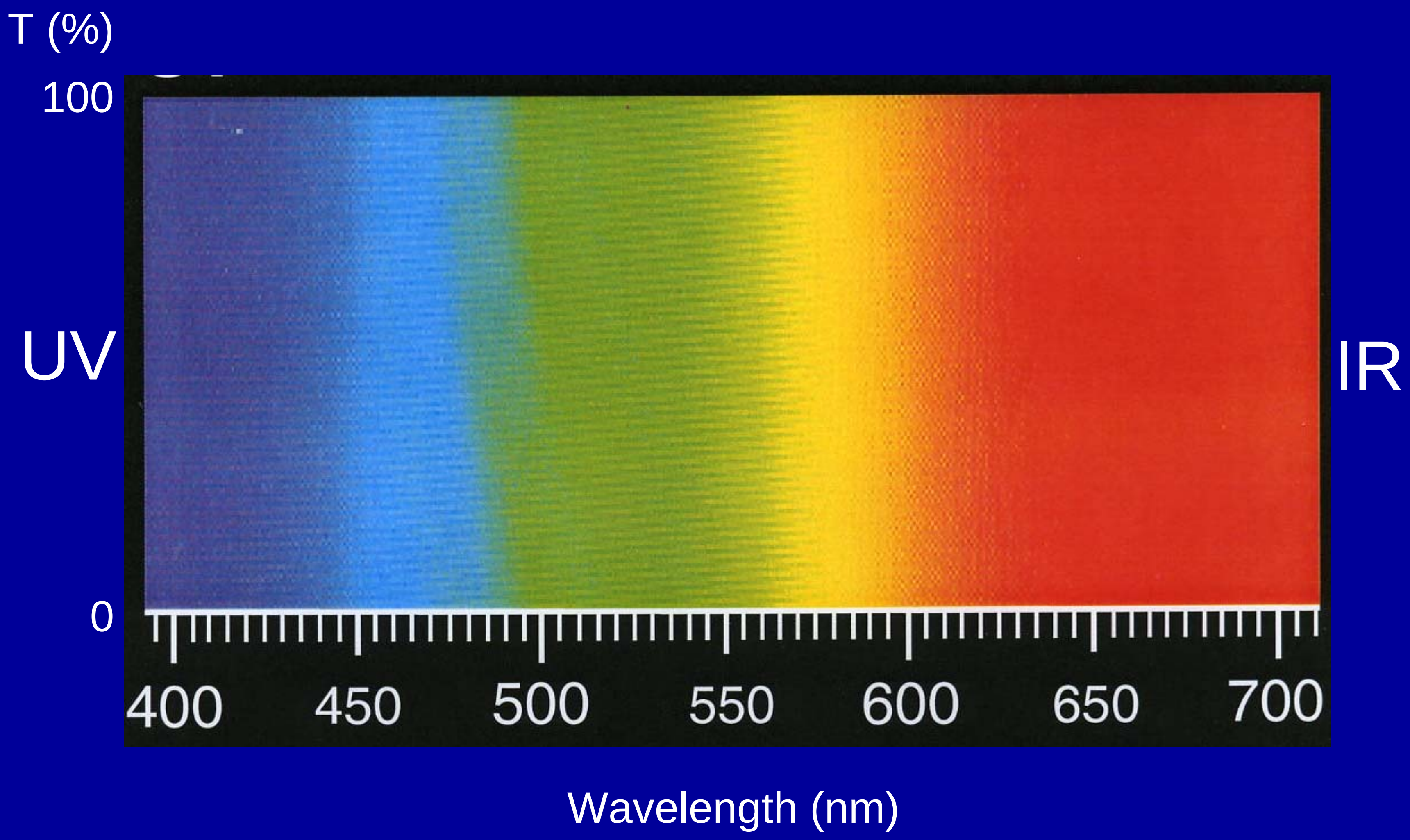

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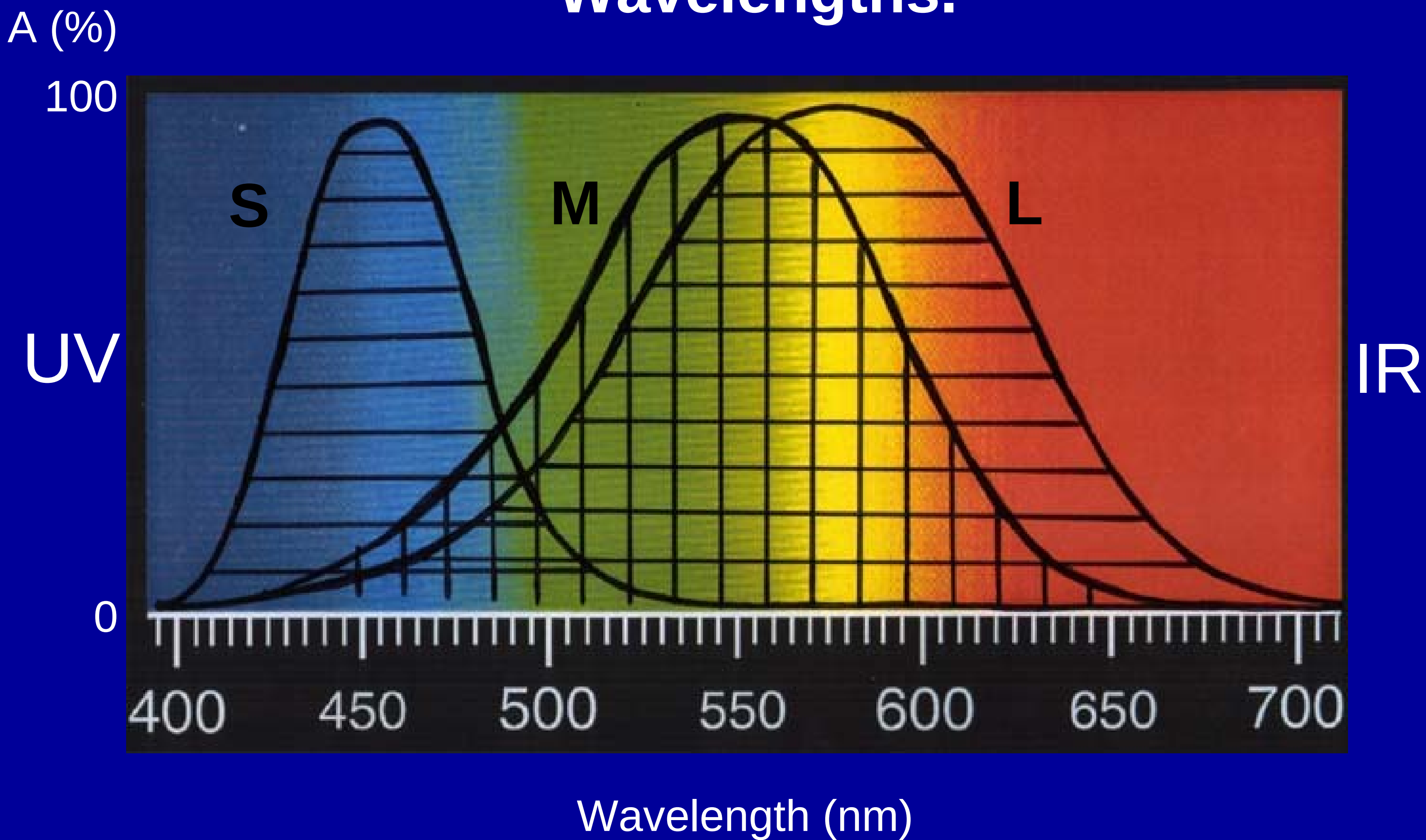
Absorption Range of Photoreceptors for Short (Blue), Middle (Green) and Long (Red) Wavelengths.



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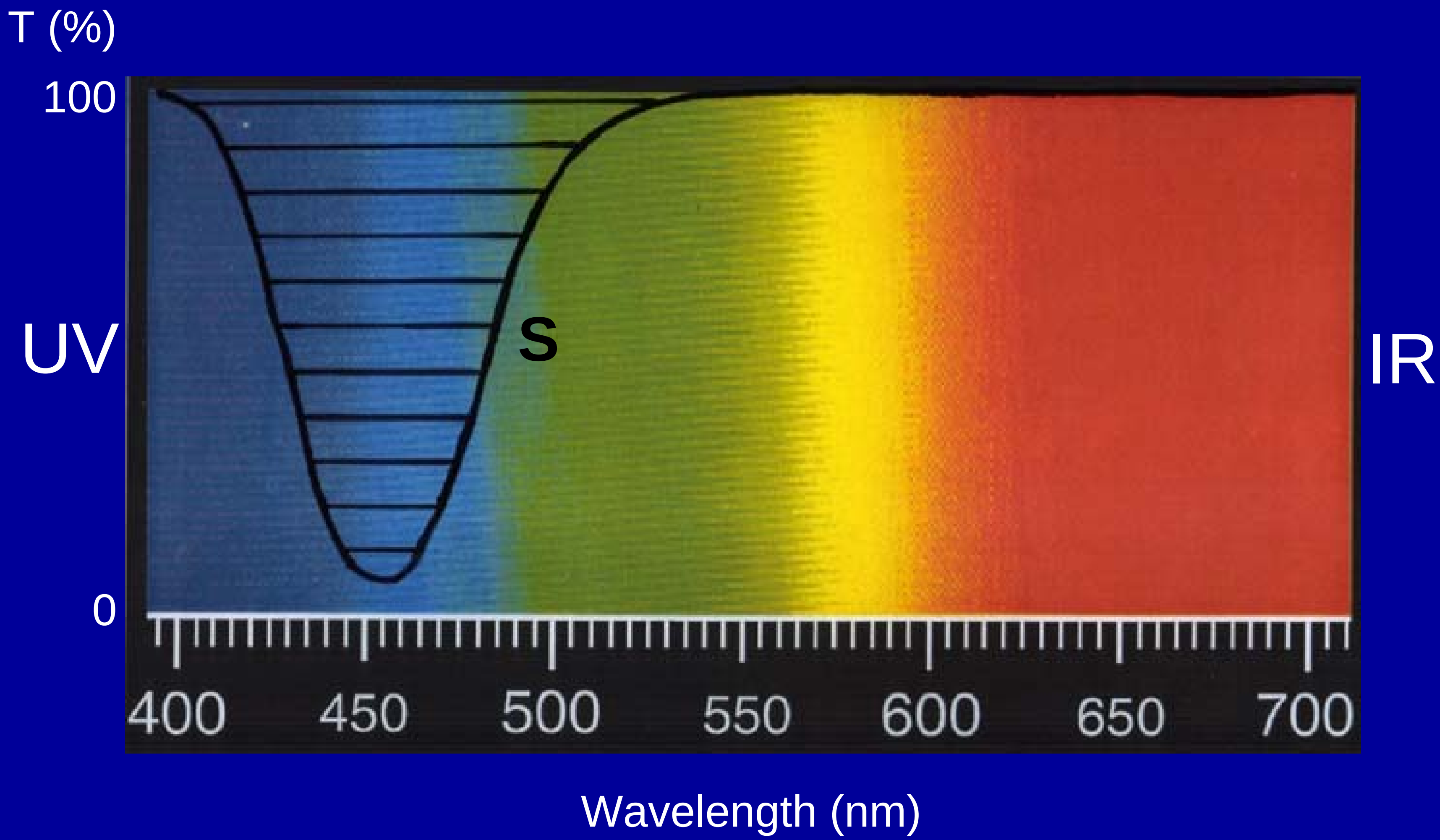
Short (Blue) Wavelength Photoreceptor. Transmission Plot.



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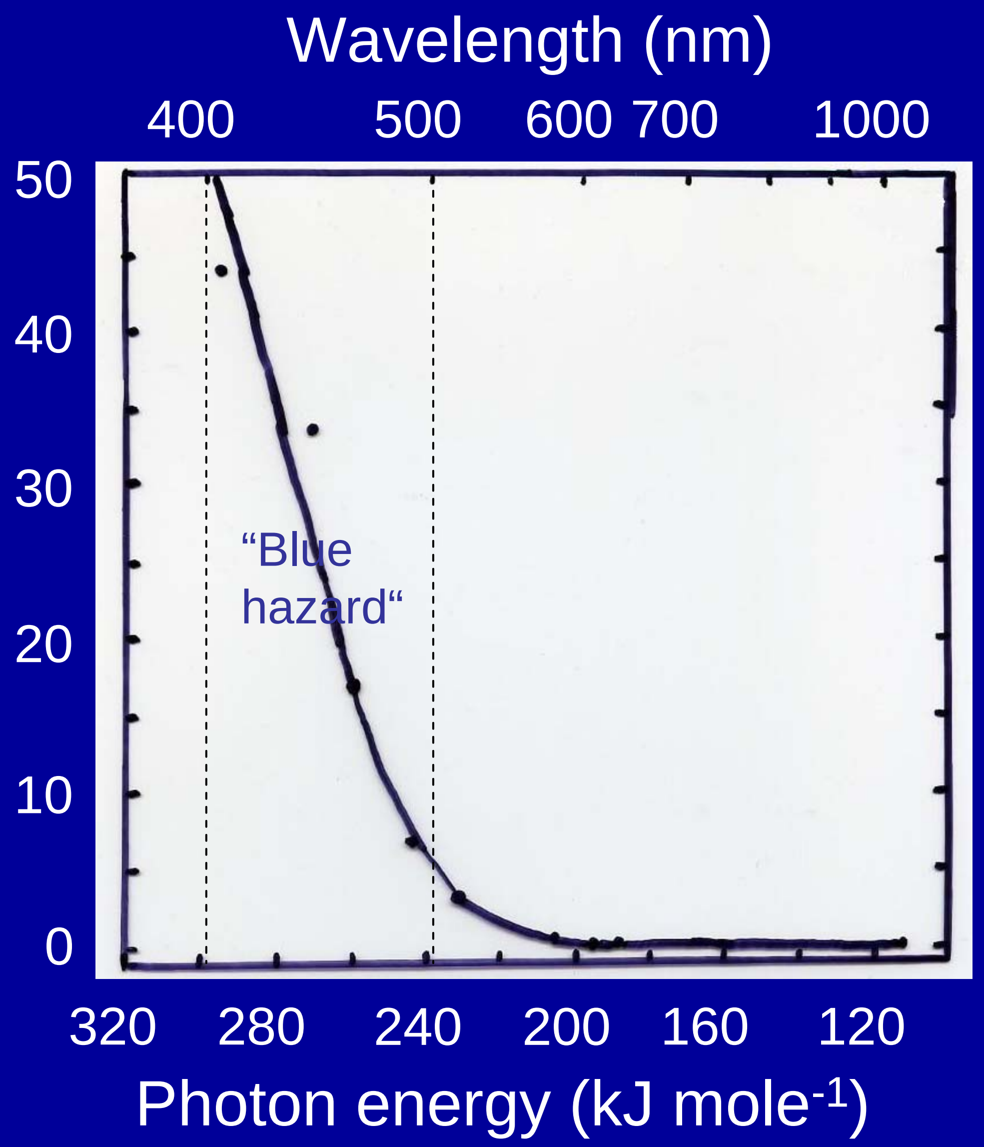
Why?



Retinal hazard rating [1/(kJ/cm²)]

W. T. Ham

1976

1979

1982

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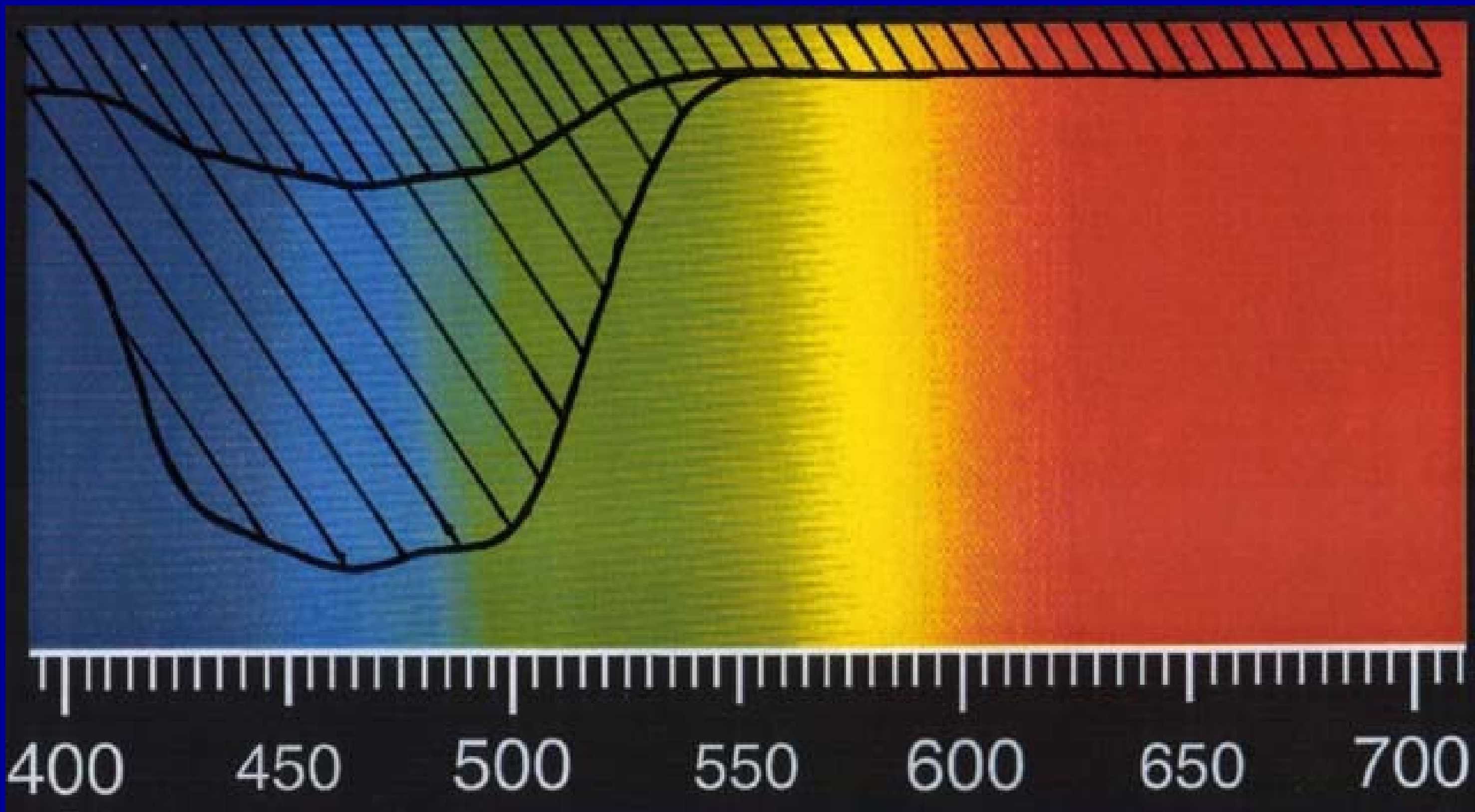
Transmission Spectra of the Macular Pigment (Yellow Spot) with low and high Density.

T (%)



Wavelength (nm)

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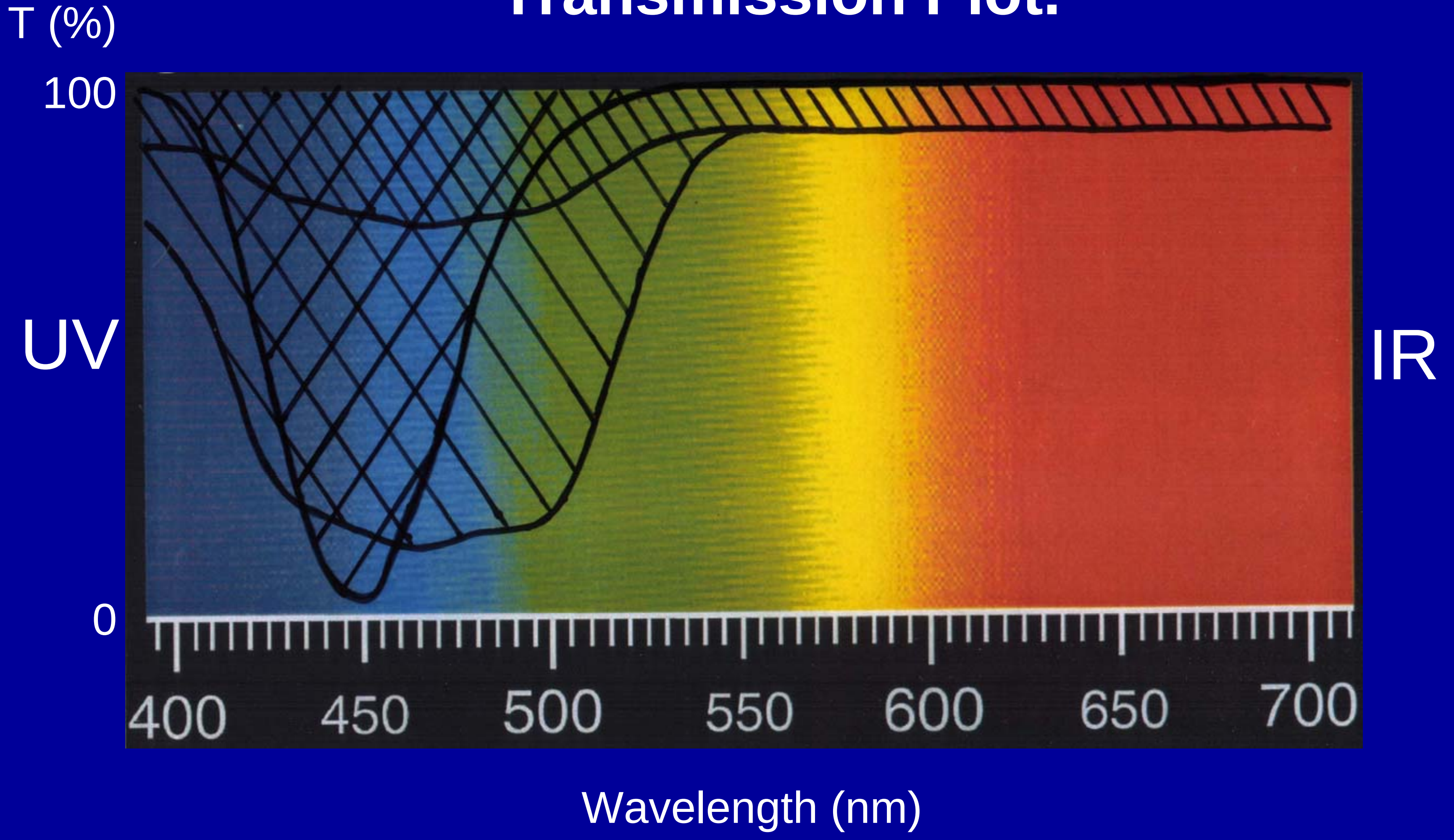
Light Sensitivity Spectrum of the Photoreceptor for Blue Light, Superposed by low and high Density Spectra of the Macular Pigment. Transmission Plot.



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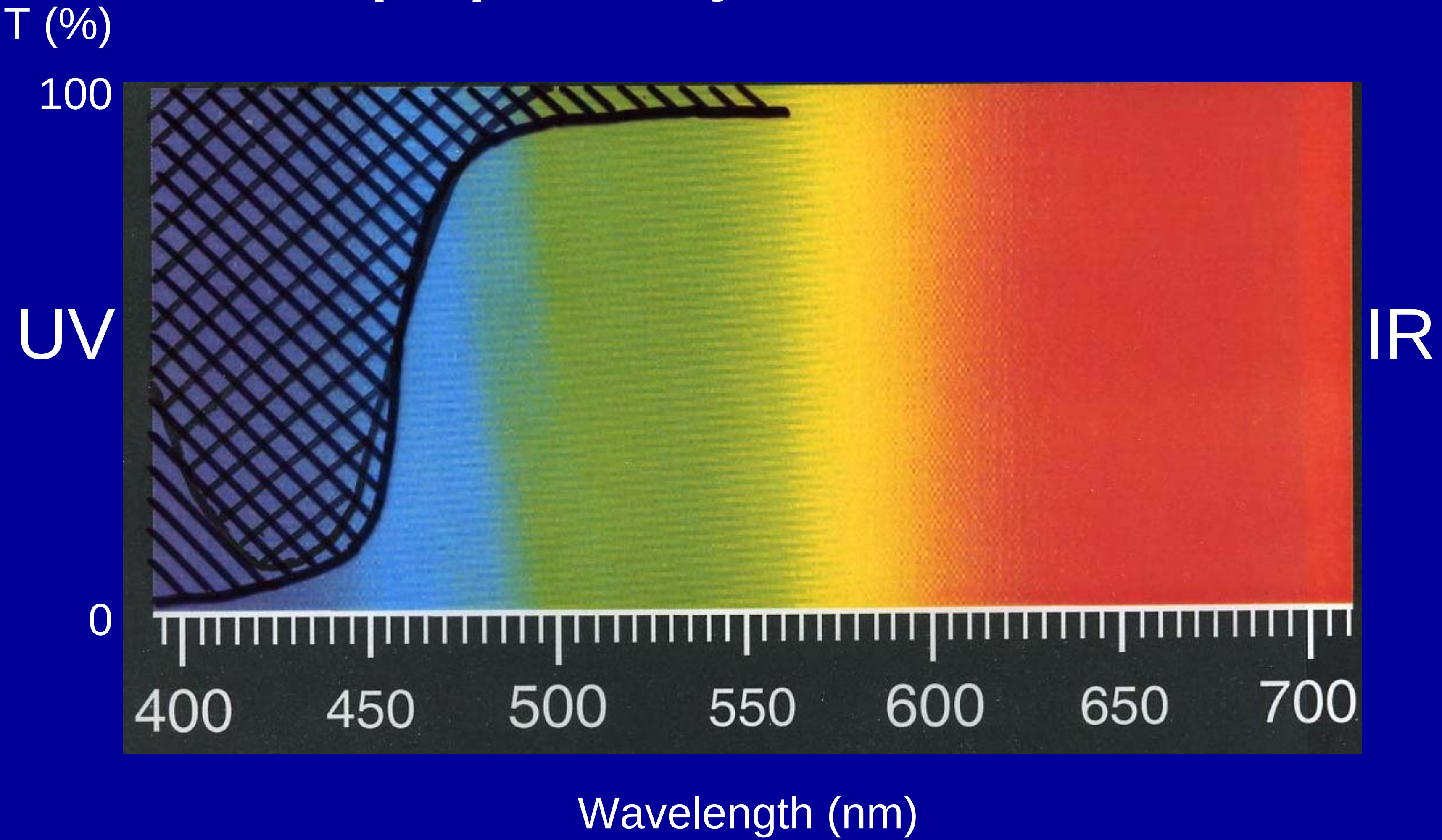
Light Sensitivity Spectrum of Photo Receptors for Blue Light, Plotted as Their Transmission, Superposed by a Yellow Filter.



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Why?

Special Protection of Blue Receptors

Blue receptors are destroyed by only 2% of the energy needed for the destruction of red receptors: “Blue hazard“.

How?

Consequences:	Blue receptors call for special protection by **yellow glasses**:
Transmission 400 - 450 nm 2 - 10%	• Increased contrast • Less glare, also from xenon head lights at night • Protection of the retina after cataract surgery with classic colourless lenses

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Why?

Formation of Lipofuscins (LFs)

Every day 10% of the antennae of our 126 million photoreceptors are destroyed by light. They must be cut off, digested and removed.
A small number cannot be digested and form yellowish deposits (lipofuscins) which accumulate during life and may then occupy up to 20% of the surface of the retina.
Absorbed light is transformed to fluorescent light which activates oxygen present. Thereby surrounding cells may be destroyed.

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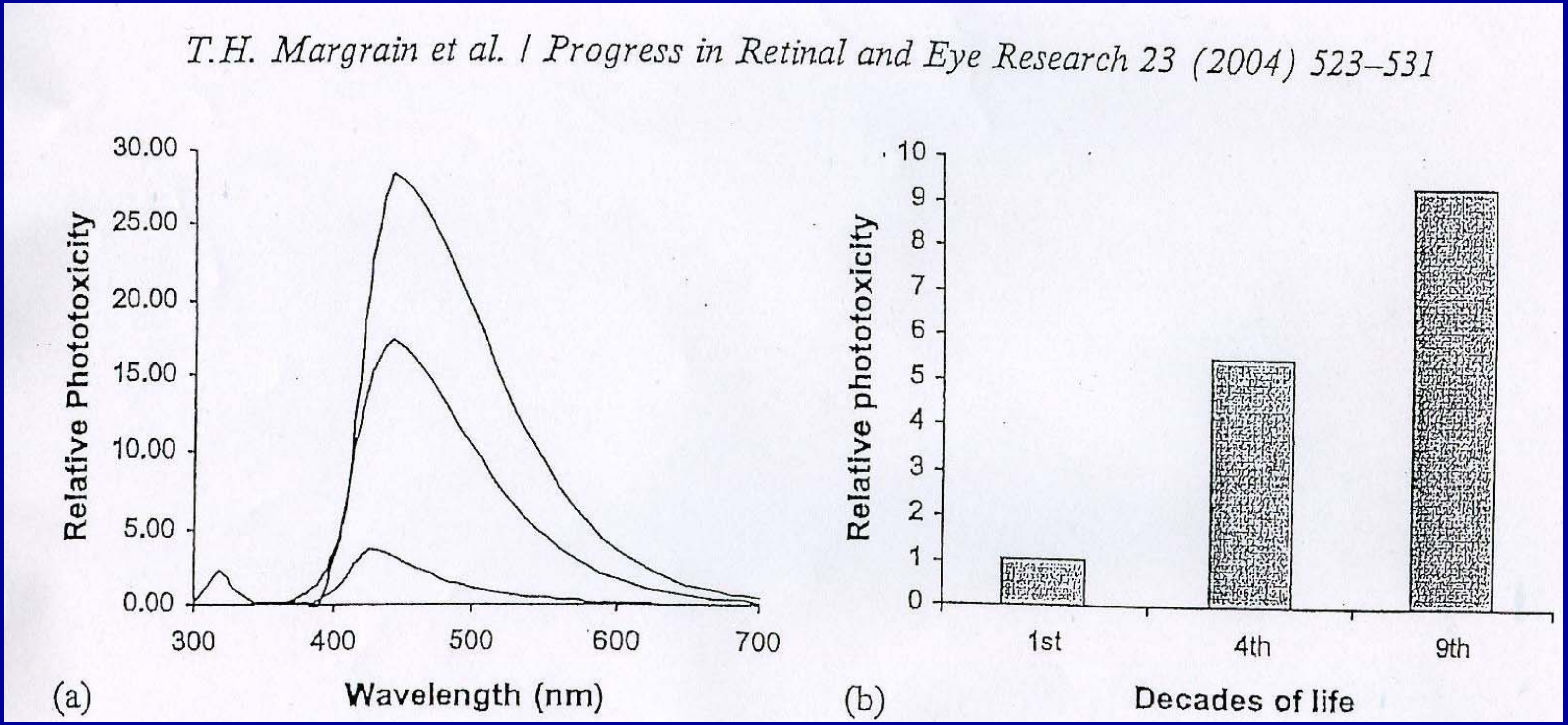

Phototoxicity action spectra for three different age groups (a) and their relative phototoxicity (b). The curves are based on the aerobic photoreactivity of lipofuscin, the age-related reduction in the characteristics of the human crystalline lens and the increase in lipofuscin content with age (Barker and Brainard, 1991: Delori et al. 2001; Rozanowska et al., 1995).

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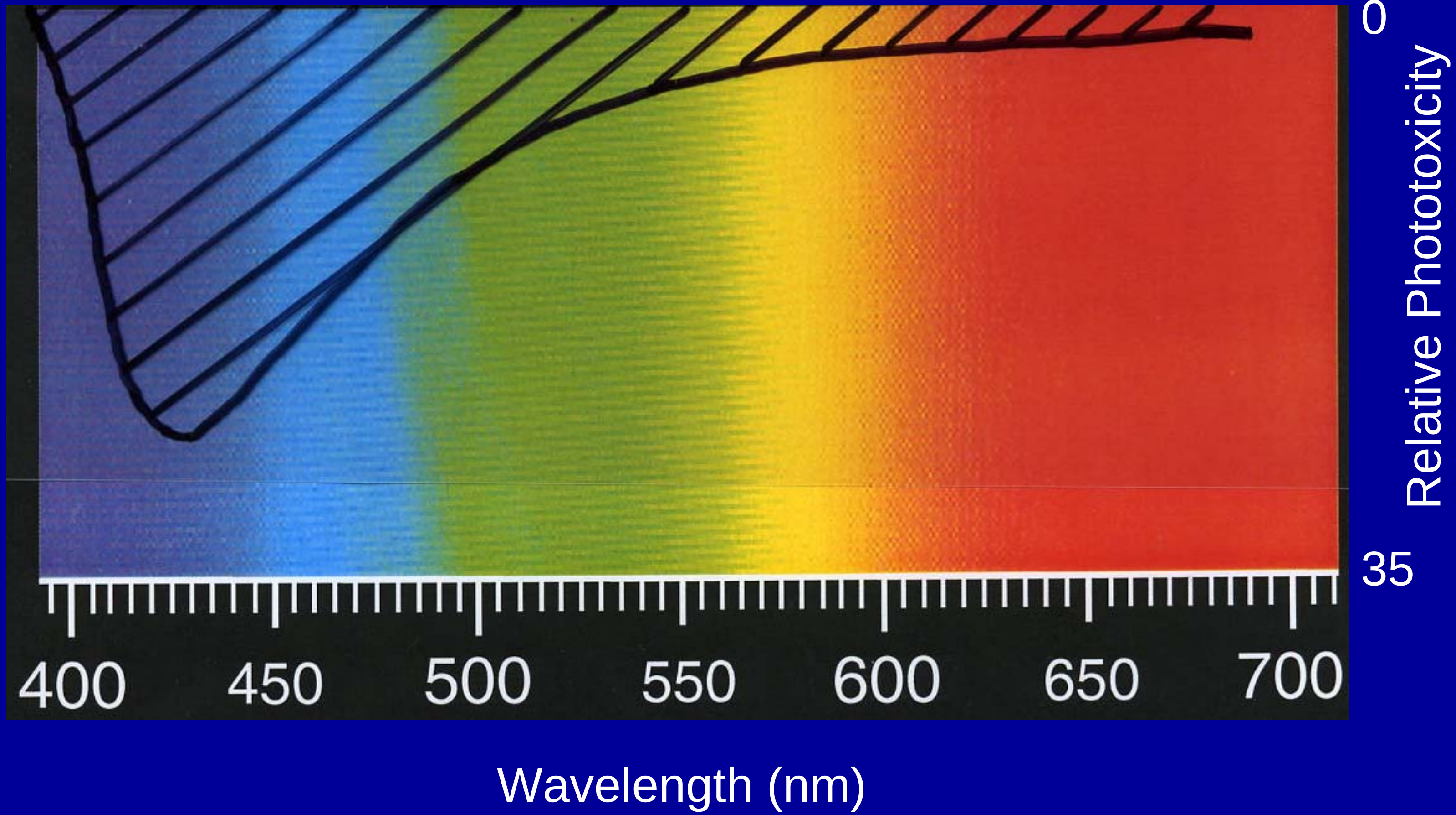
Phototoxicity Spectrum of Lipofuscins



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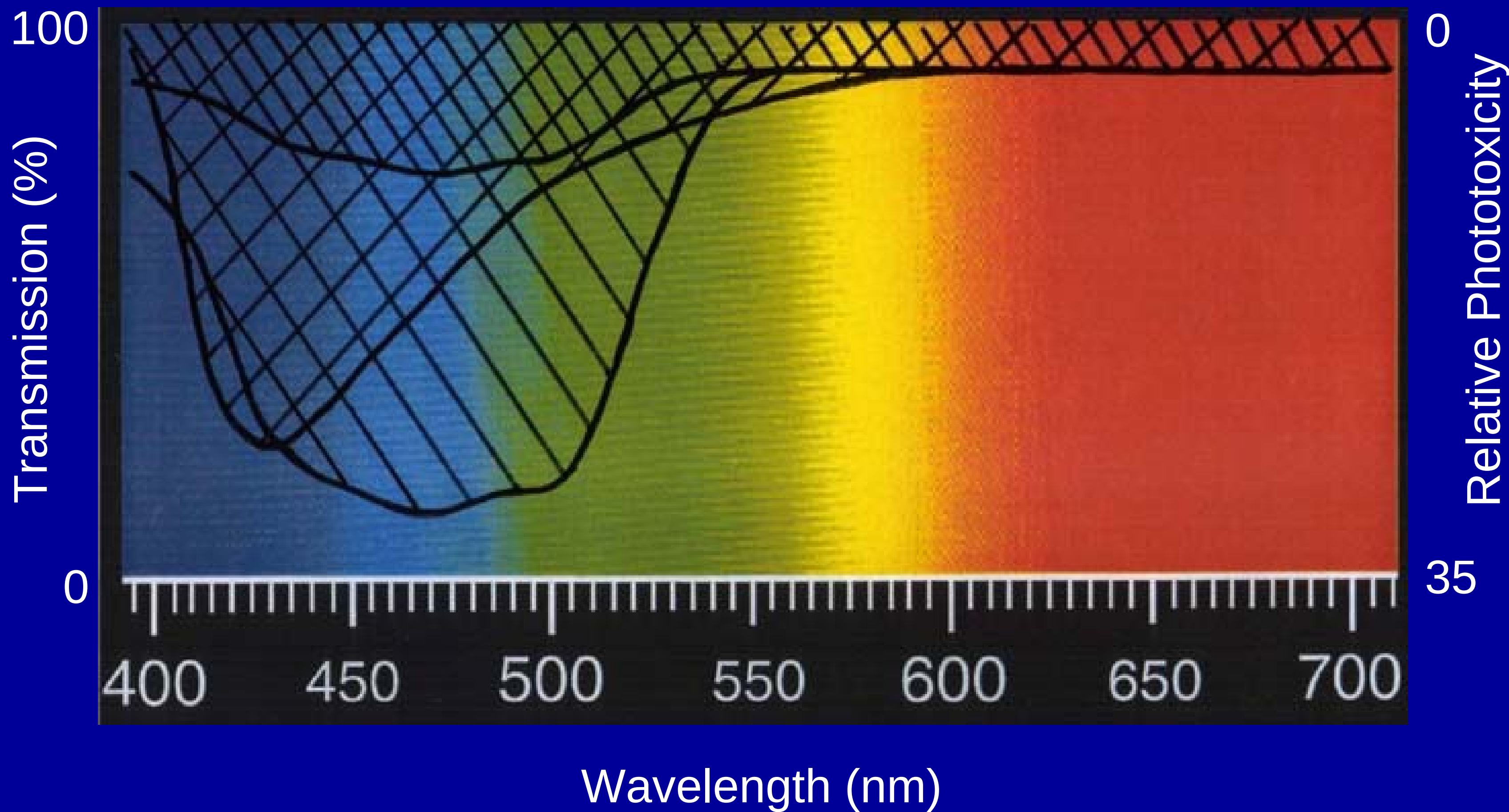
Phototoxicity Spectrum of Lipofuscins, Superposed by low and high Density Spectra of the Macular Pigment.



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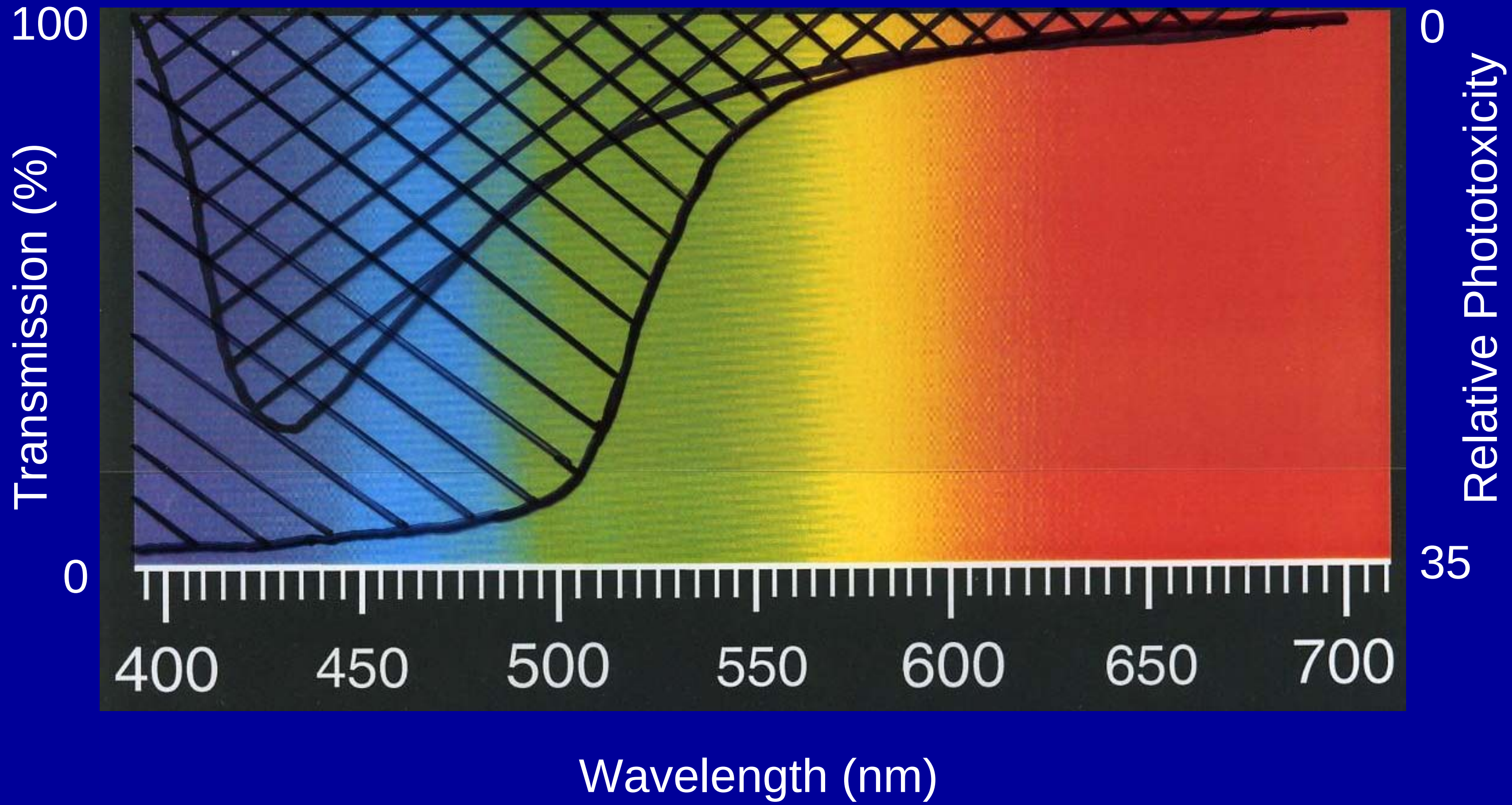
Phototoxicity Spectrum of Lipofuscins, Superposed by an Orange Filter



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How?

Suppression of Phototoxicity of LFs

Since most of phototoxicity of the LFs is observed between 400 and 500 (550) nm, adequate light filters will diminish or even fully suppress this dangerous toxicity.

Consequences: Orange glasses

Transmission
400 - 500 nm
2-10% or less

- High contrast, even with haze, less glare
- Full protection of the blue receptors
- Strong suppression of the activation of LFs
- Protection for patients with cataract or AMD

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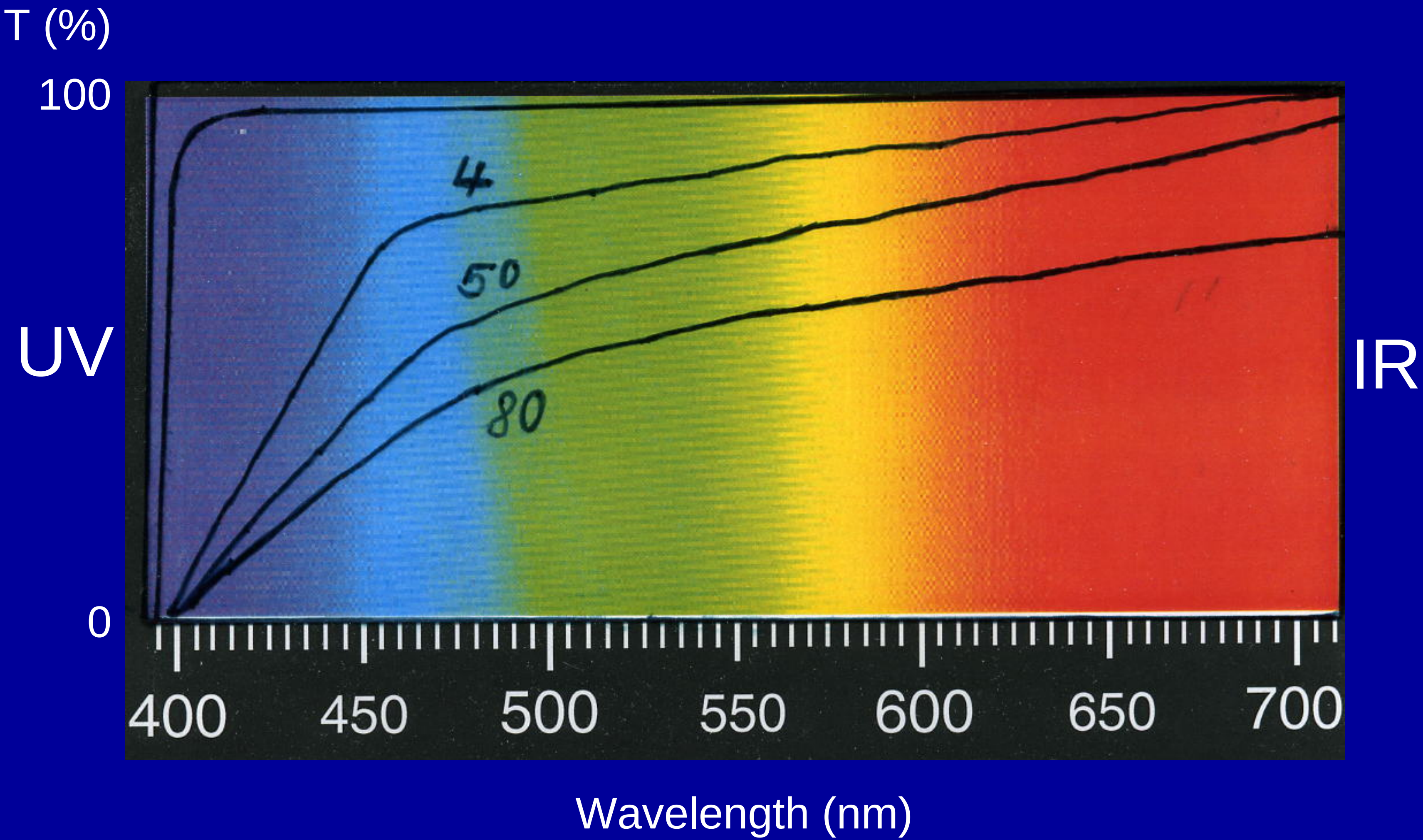
Transmission of Human Lenses (4, 50 and 80 Years) and of a Classic Artificial Lens



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How?

The Important Elements of Sunglasses

Sunglasses must meet the conditions for yellow and orange glasses combined with diminished transmission between 500 and 700 nm.

This is the essence of the Swiss SUVA standard (Prof. CH. Remé, ETH Zürich, 1994), realized in the SUVASOL® glasses, tinted with natural melanine (brownish colours).

<u>Transmission</u>:

UV (280 - 400 nm)	Blue (400 - 495 nm)	Green/Red (495 - 700 nm)	IR (700 - 1400 nm)
< 0.05%	2 - 8%	10 - 40%	< 50%

Gray and blue glasses cannot meet this standard.

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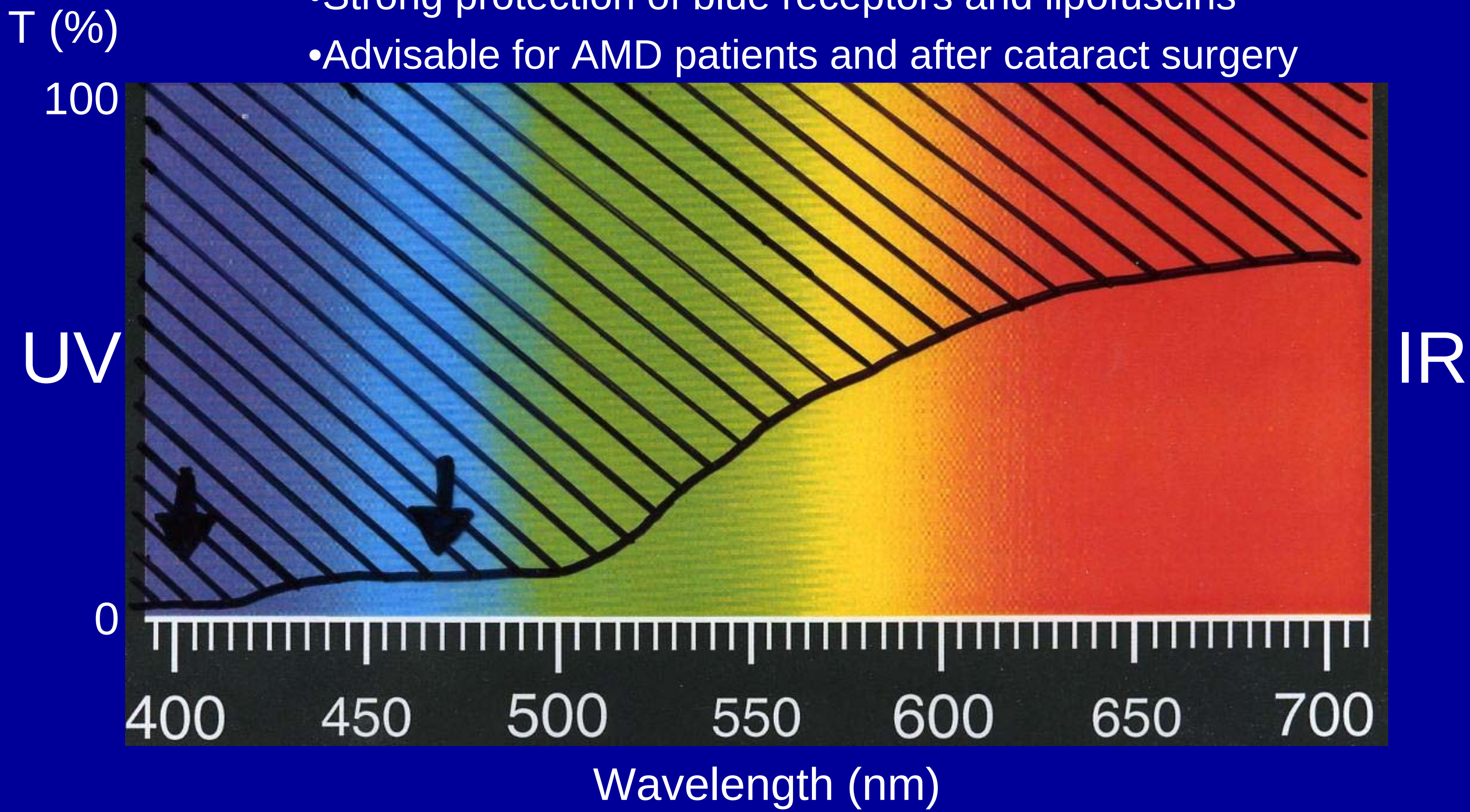
Typical Transmission of an Optimized Sunglass

- Full protection of the lens
- Strong protection of blue receptors and lipofuscins
- Advisable for AMD patients and after cataract surgery



• Less glare (cataract!) • Increased colour contrast • Improved acuity

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Why?

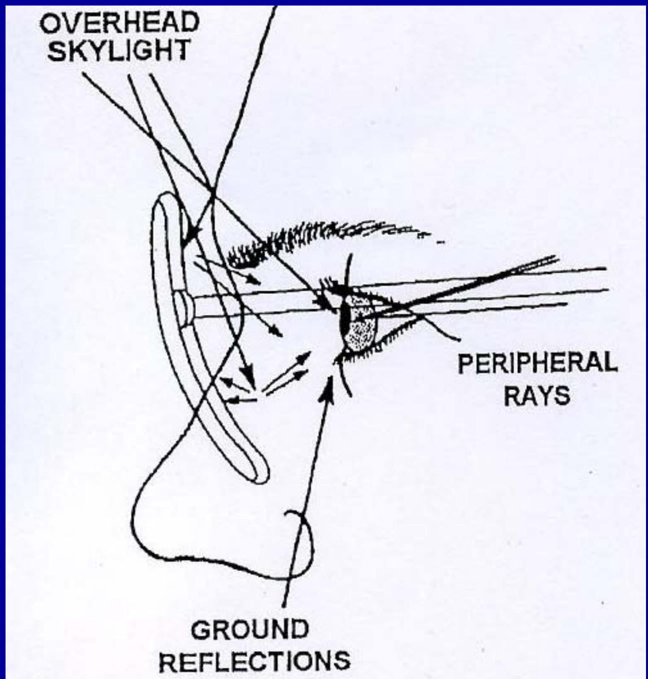
Size and Shape – Crucial Factors of Glasses and Frames

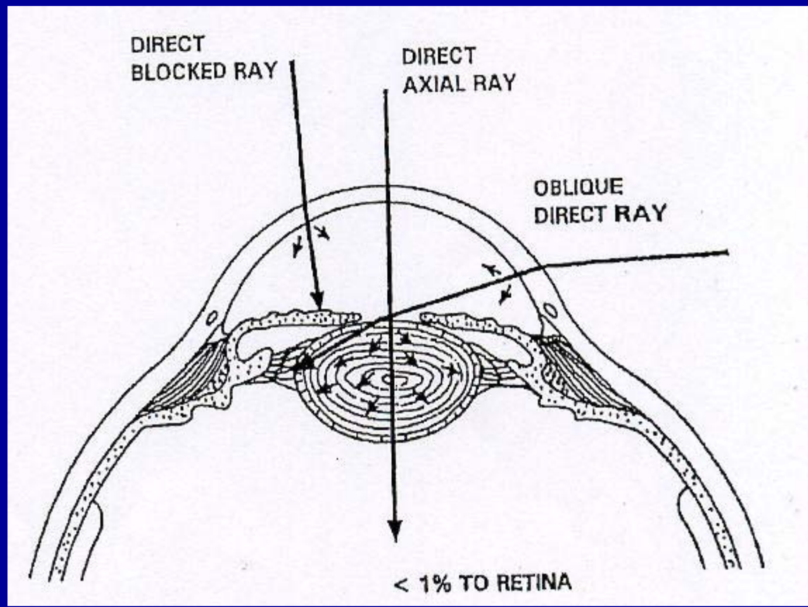
Unfiltered (UV, blue) direct and scattered light from above, below and from the sides hits the eye from unnatural directions.
It diminishes the protection even of optimal sunglasses and may become dangereous (30–50% s.l.) especially behind dark glasses because of widend pupiles.

Why?

Size and Shape – Crucial Factors in Glasses and Frames

Unfiltered (UV, blue) direct and scattered light hits the eye from above, below and the sides.
It reduces the protection even of best sunglasses and may become especially dangereous (30–50% s.l.) with dark glasses since they causes widening of the pupiles.





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D. H. Siliney, 1997, 2001, 2002

How?

Minimizing Scattered Light

For sunglasses of categories 2 and especially 3 and 4 minimizing of scattered light (< 10%) is essential.
There is still room for various fashionable designs of glasses and/or frames.




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No Check of Transmissions and Scattered Light!

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Why and How?

Conclusions

1. UV 400 nm protection for all glasses
2. Upper limit for transmissions

yellow	orange	sunglasses	
(400 - 450 nm)	(400 - 500 nm)	(400 - 500 nm)	above 500 nm
2 -10%	2 - 10%	2 - 10%	variable

3. Size and shape of glasses and frames should minimize scattered light

A quality label by ESA guarenteeing “Full Protection“ based on items 1-3 should convince users and help producers in Europe.

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