FAV, Talk no. 8,
Retina and visual pathway

http://nemo.lf1.cuni.cz/mlab/ftp/PPT-CVUT/

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Outline 8 – Retina and Subcortical Visual Pathway

- Retina, Point Spread Function
- Adaptation, Acomodation
- Visual Acuity, Optical Eye Media, Lens
- Rods, Cones, Illumination, Black and White and Color Vision
- Ten Neural Layers in Retina, Functional Aspects
- Binocular Vision and Its Disorders, Vergence, Strabism
- Saccades, Visual Following, Nystagmus
- Visuomotor Eye Movement Control, Basic Concepts
- Optical nerve, Perimeter, Objective Perimeter
- Color Opponent System in the Visual Pathway

Snellen (N/36)

Optotypes have (N/32)

letters with defined (N/28)

letter size, or number of points(N/26)

seen from a calibrated distance. (N/24)

This is written as fraction. (N/22)

The best vision is: 6/6 (N/20)

From distance six meters/ (N/18)

we see six points (B/16)

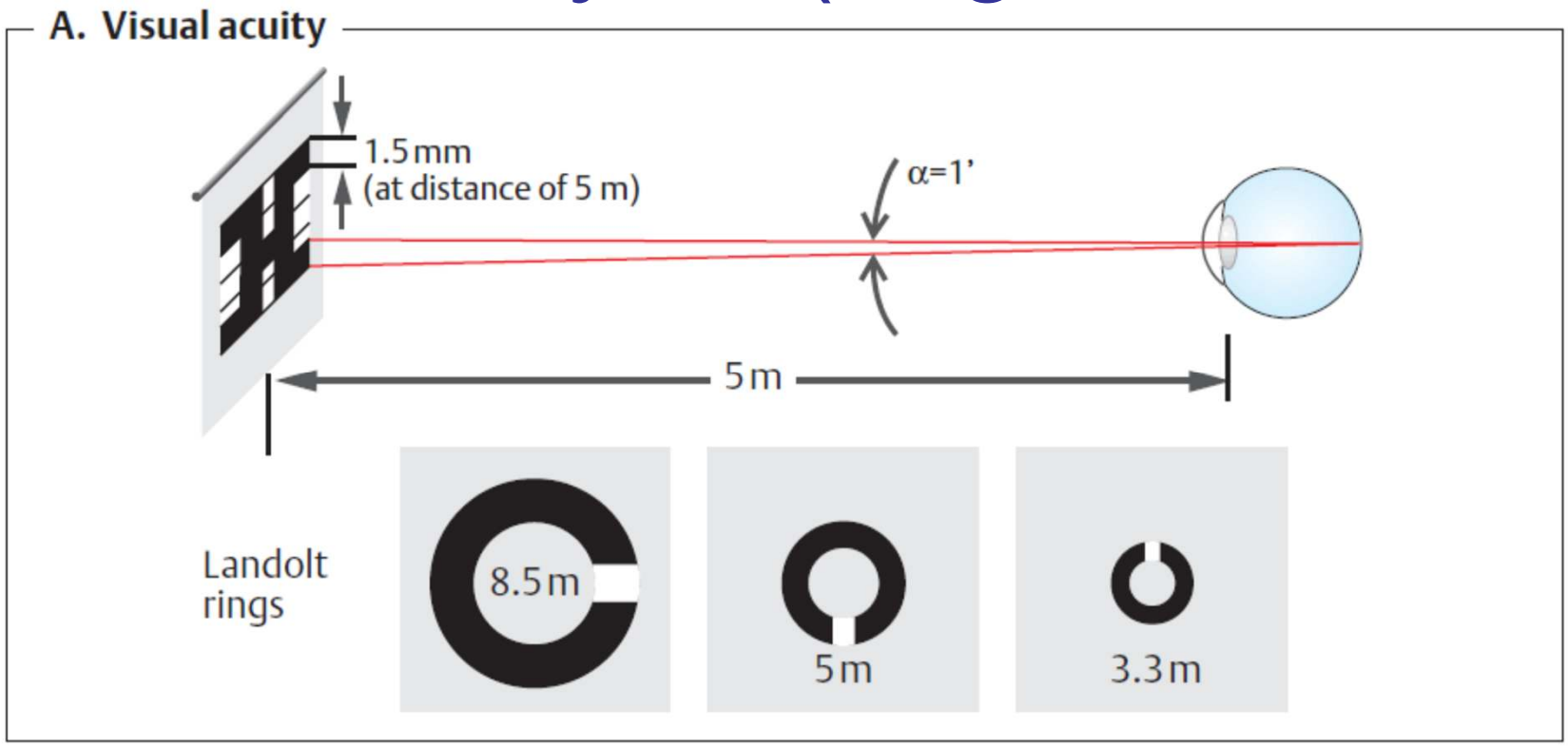
(one arch minute each). (B/14)

Functional classification of vision impairment

Fraction denotes: we see 6 points/ from 6 m distance.
Geometry of 2D angle is simplified to a square patch.

1 normal vision		6/6
2 low vision	worse than	(<) 6/18
(on the best eye with corrective lenses)		
3 (practical) blindness		< 3/60
or narrowing of visual angle	less than	< 10*10^{o}
other norm	< 6/60,	< 20*20^{o}
4 *amblyopia*		

Visual Acuity: 1’ (angular minute)



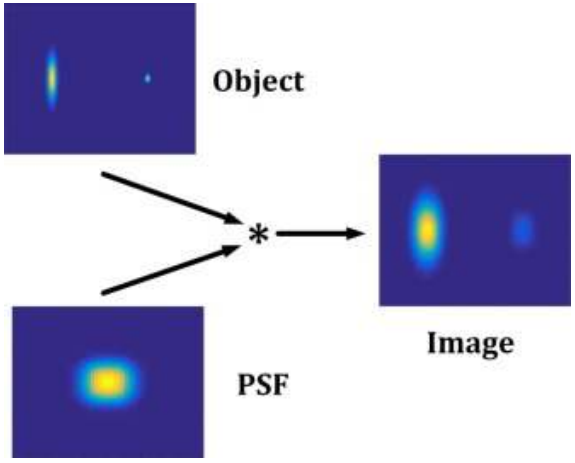
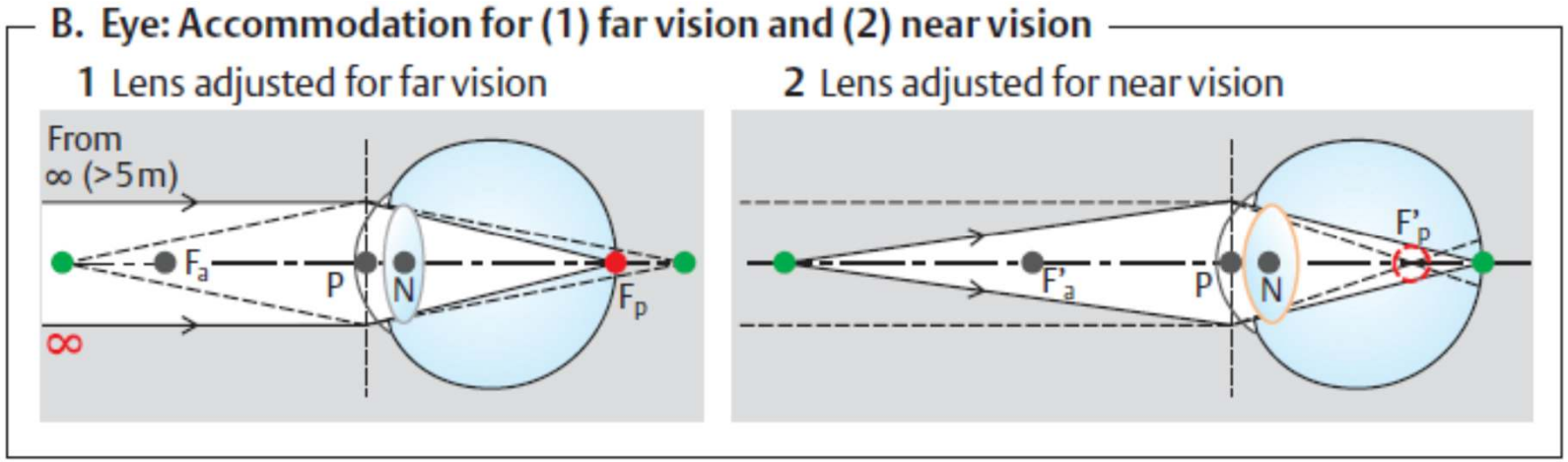
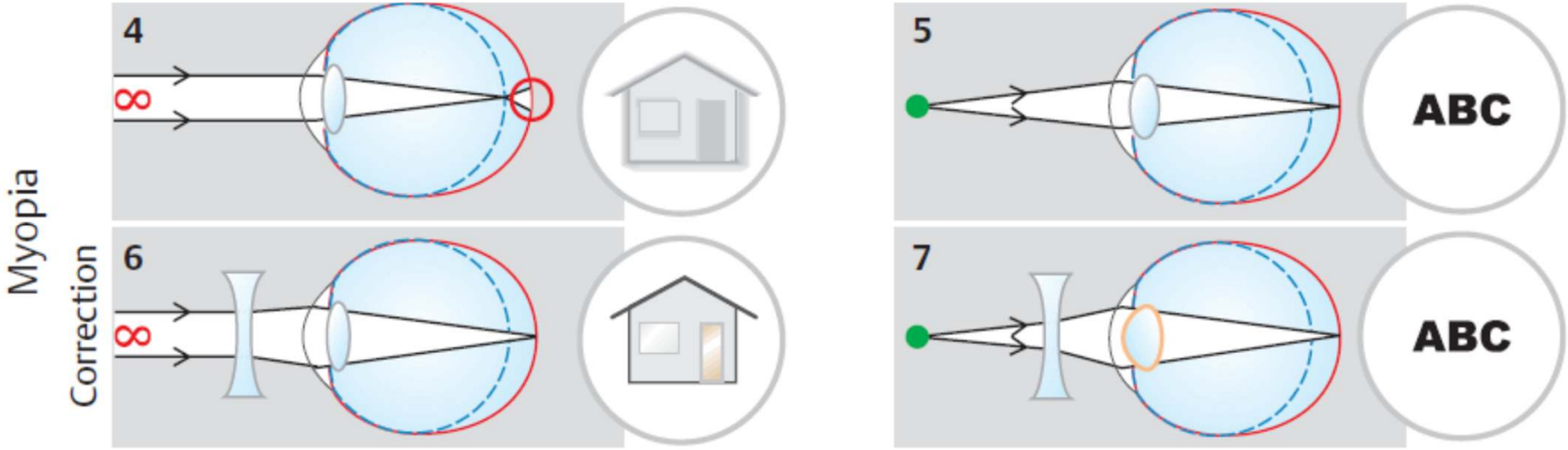


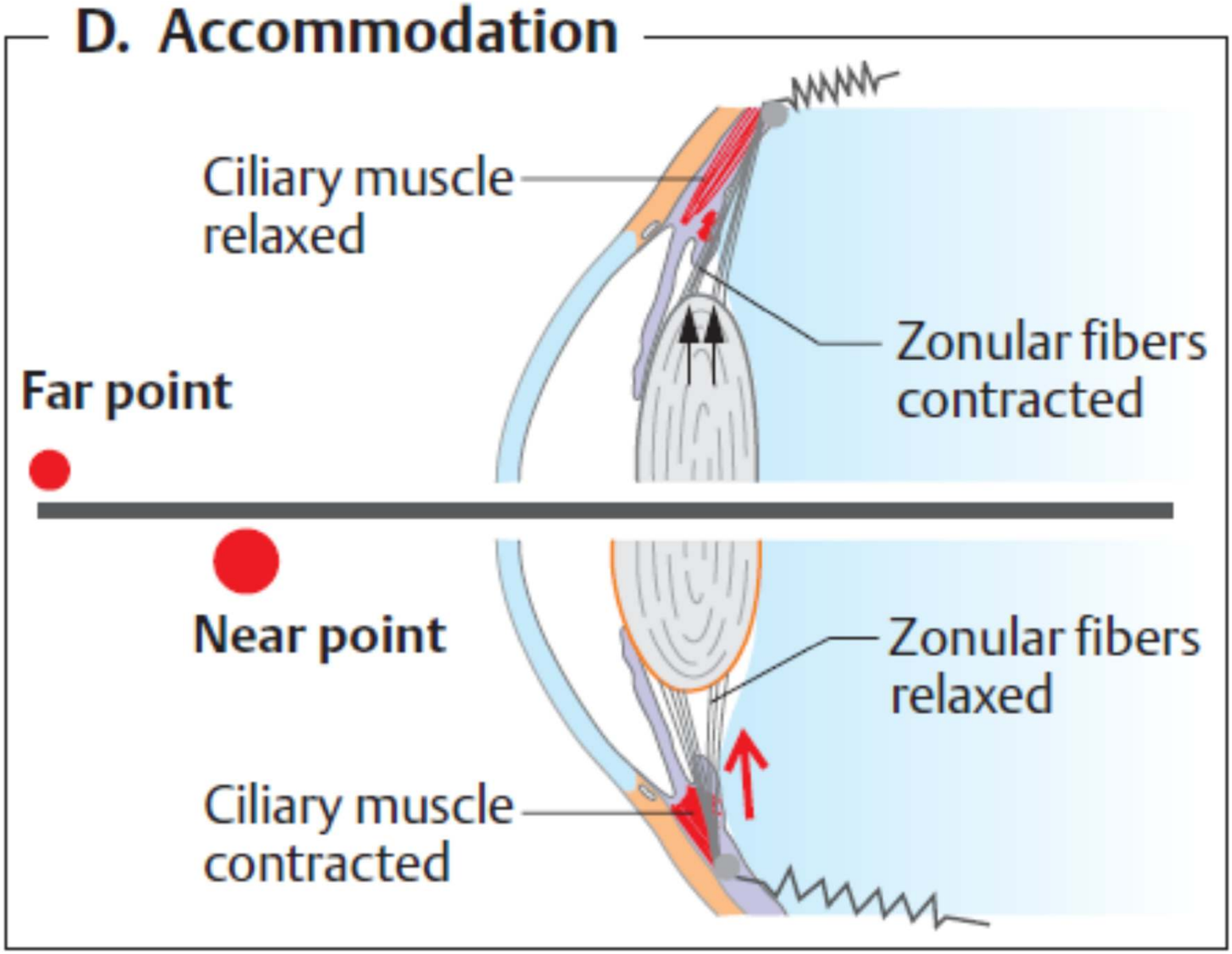
Image results from convolution of object and point spread function

Far and Near Point





Accomodation = Focusing to Get Sharp Image



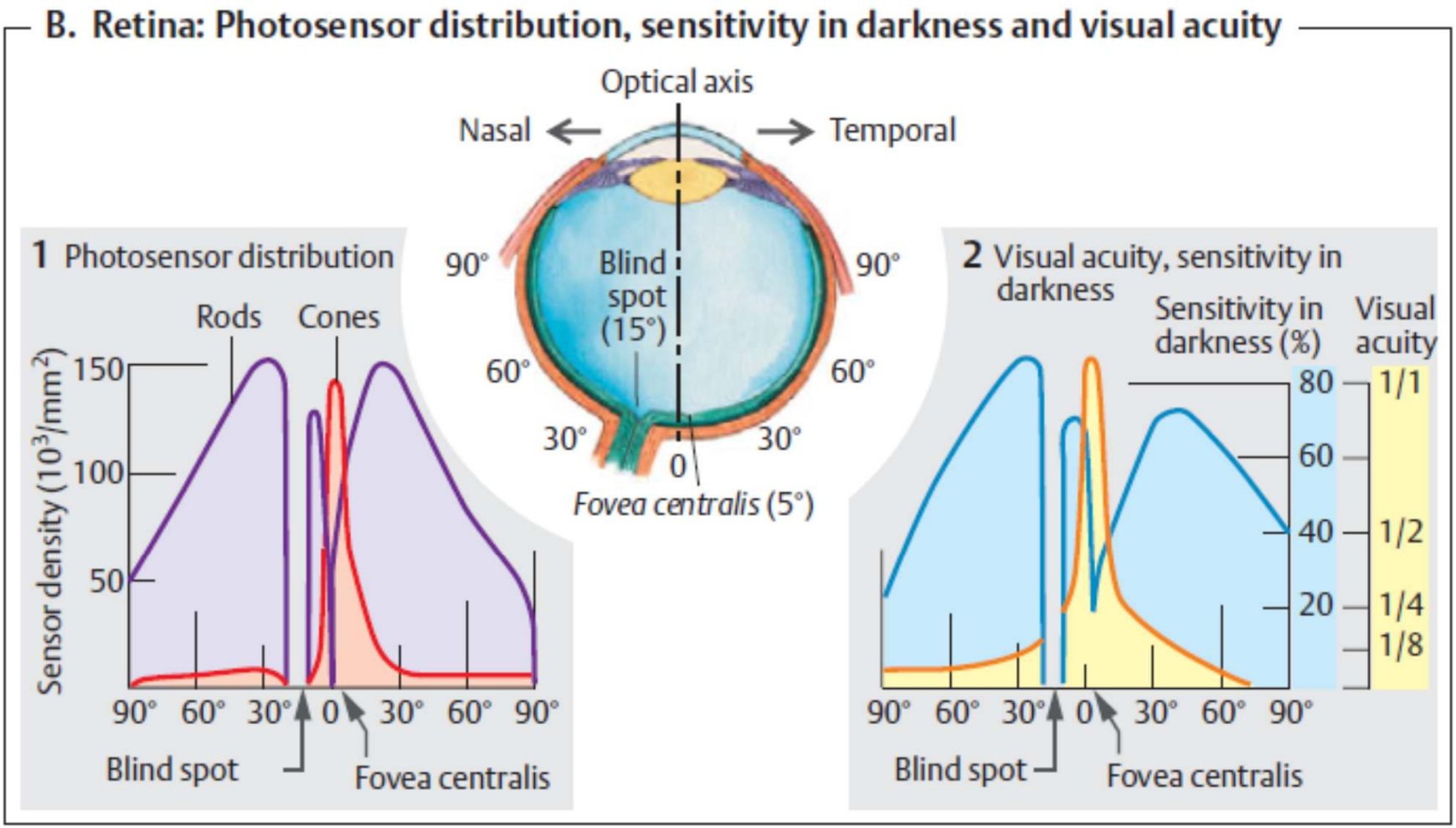
Accomodation = Focusing to Get Sharp Image

In individual development and ageing, far and near point positions change.

Around age of 50, elasticity of lens drops to the point that the near point is far enough that practically merges with the far point.

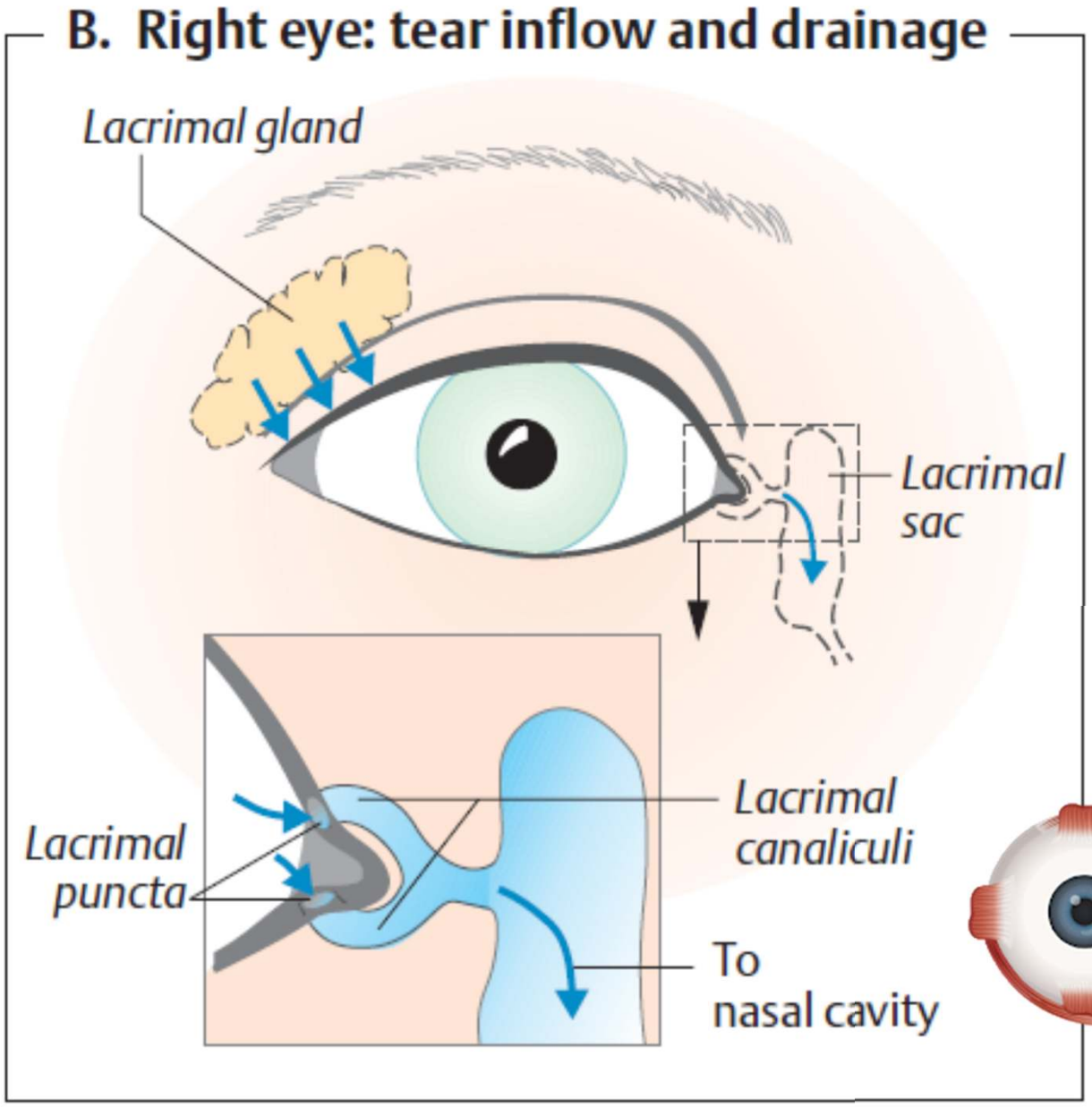
(As next stage, with the use of current eye treatment, patients with cataract have implanted artificial lenses…)

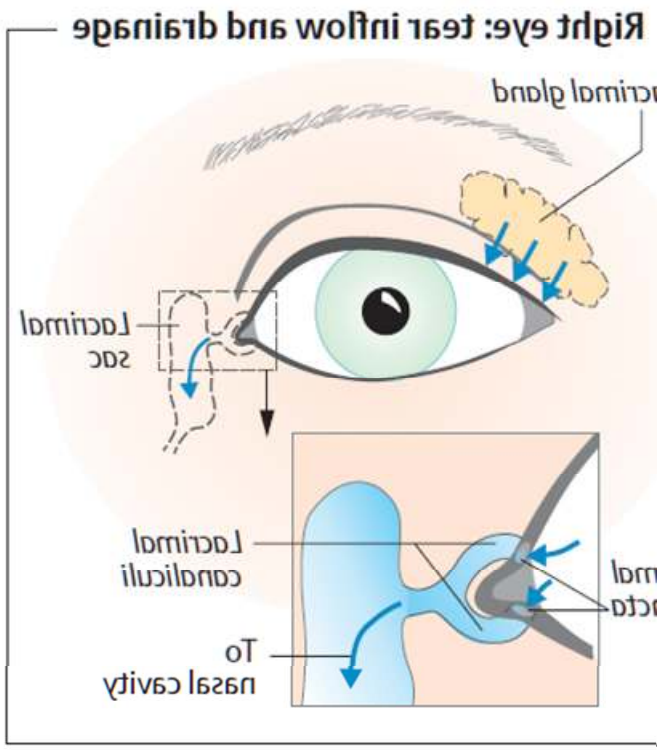
Visual Acuity, Day and Night Acuity



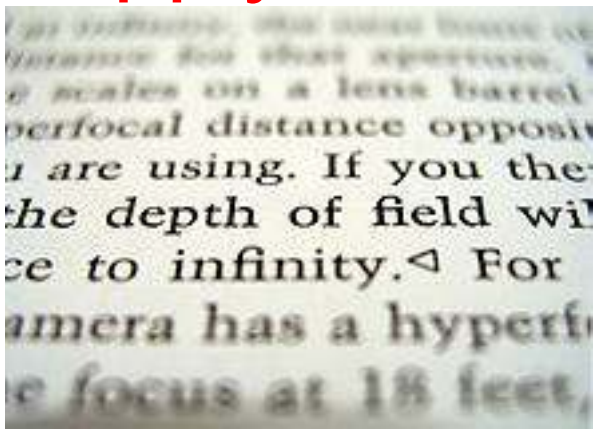
Perimeter investigation

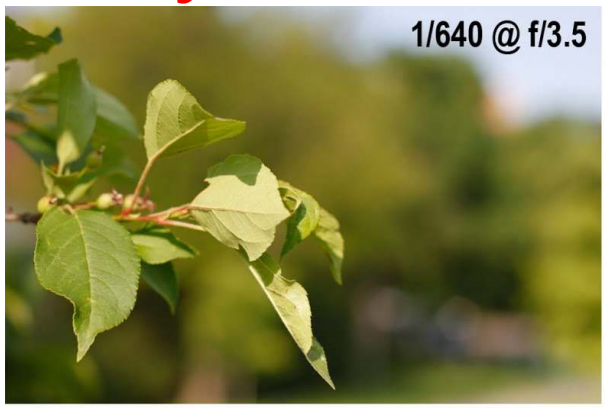
Lacrimal Gland and Duct, Eye Muscles

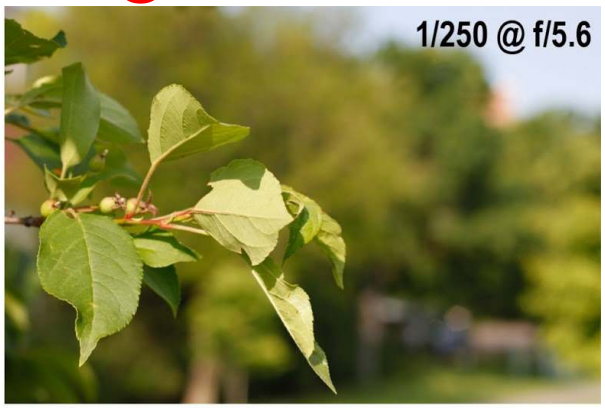


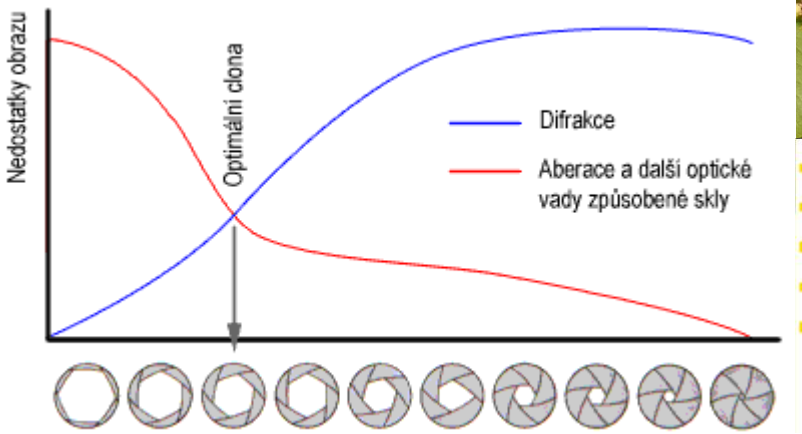


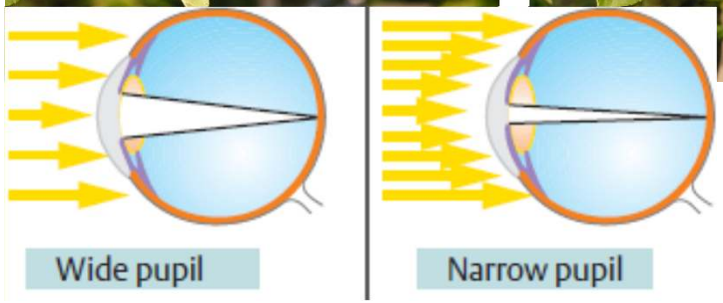
Aperture Versus Depth of Field (světelnost/ clona, hloubka ostrosti) Apply to Human Eye Functioning as Well





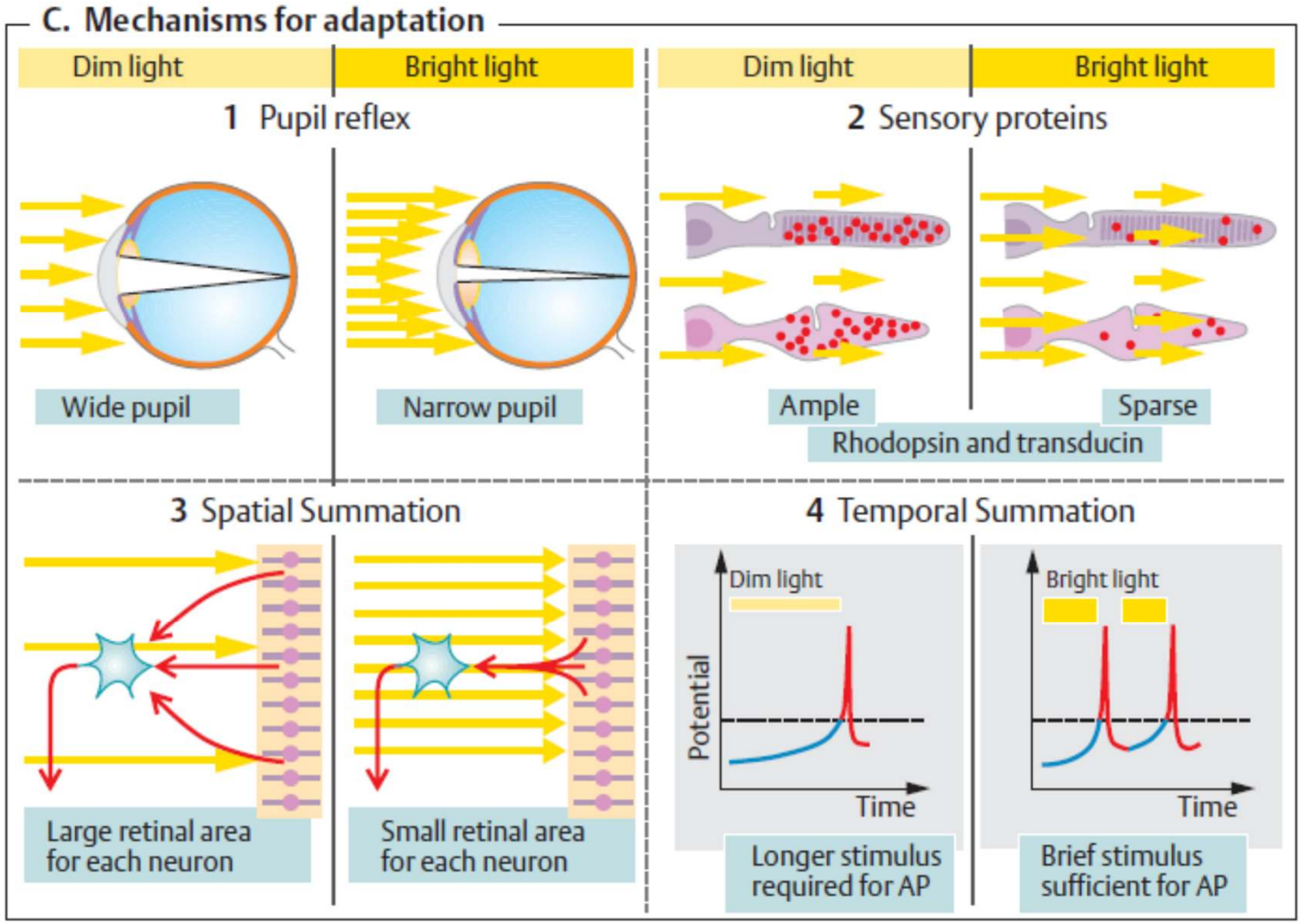




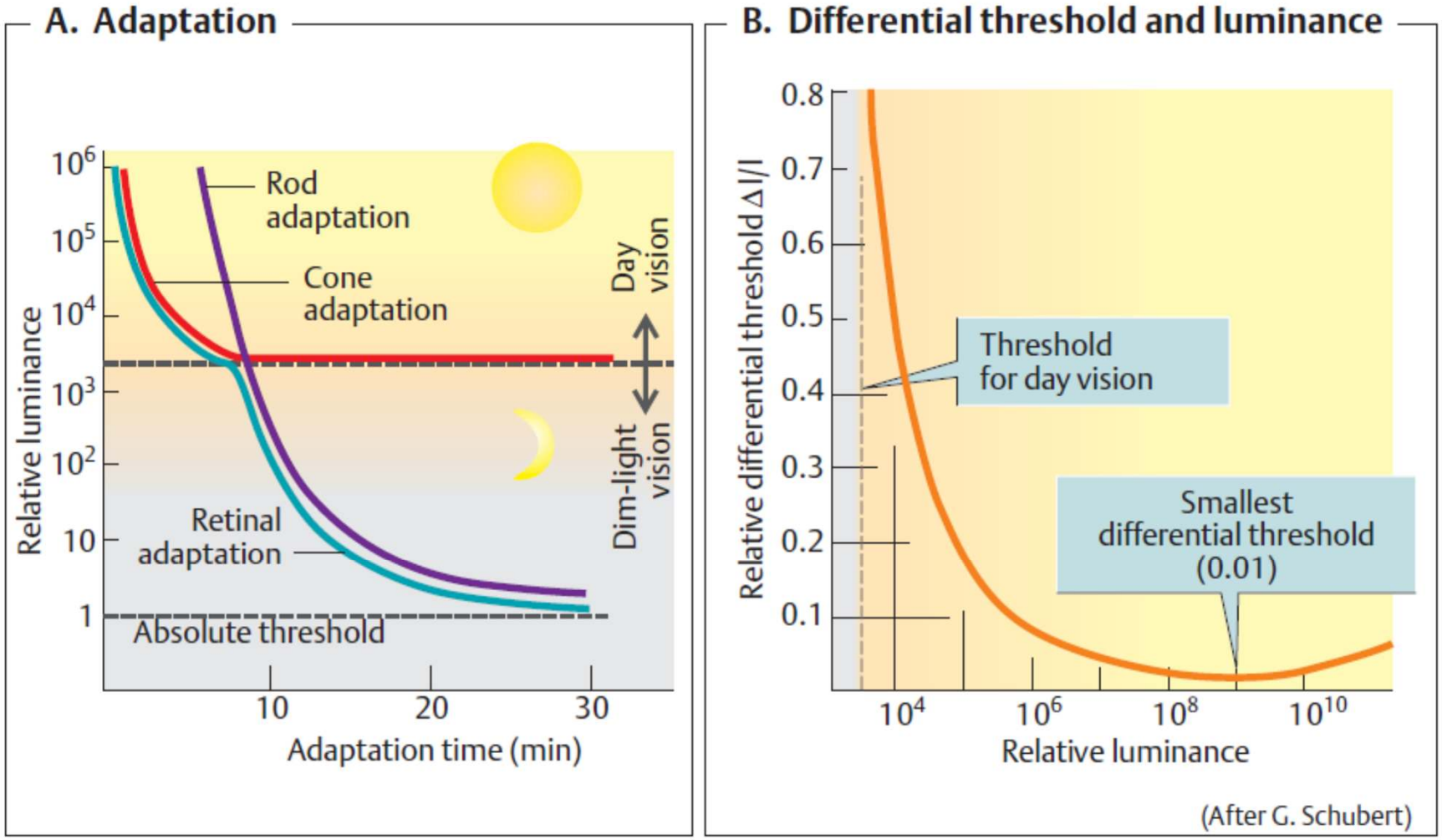


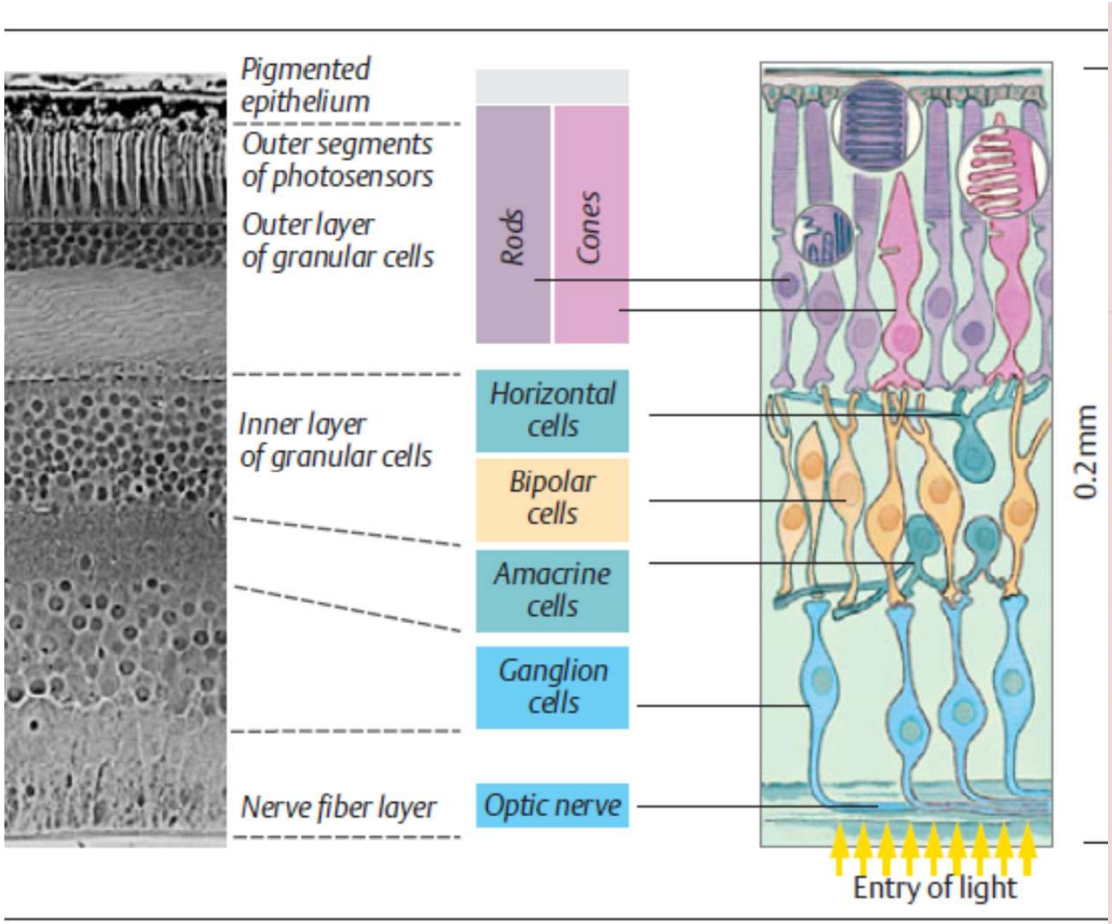
Aperture Versus Depth of Field

Apply to Human Eye Functioning as Well



Adaptation to Day and Night Illumination Conditions





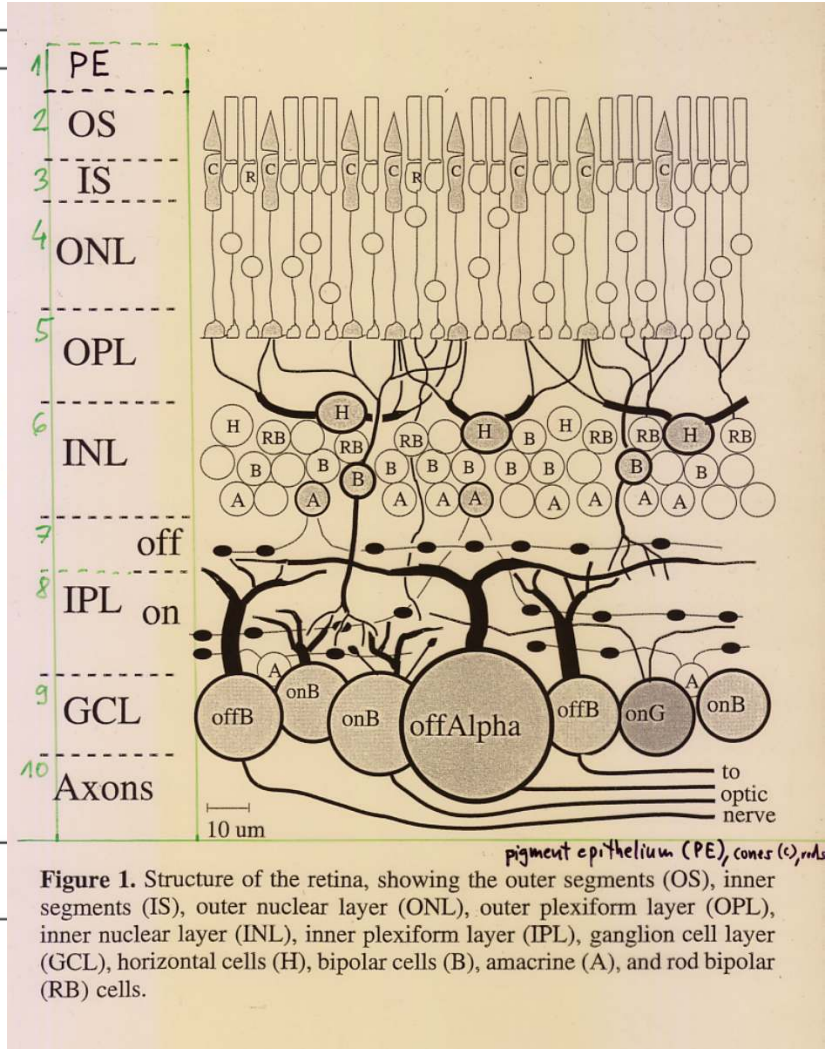
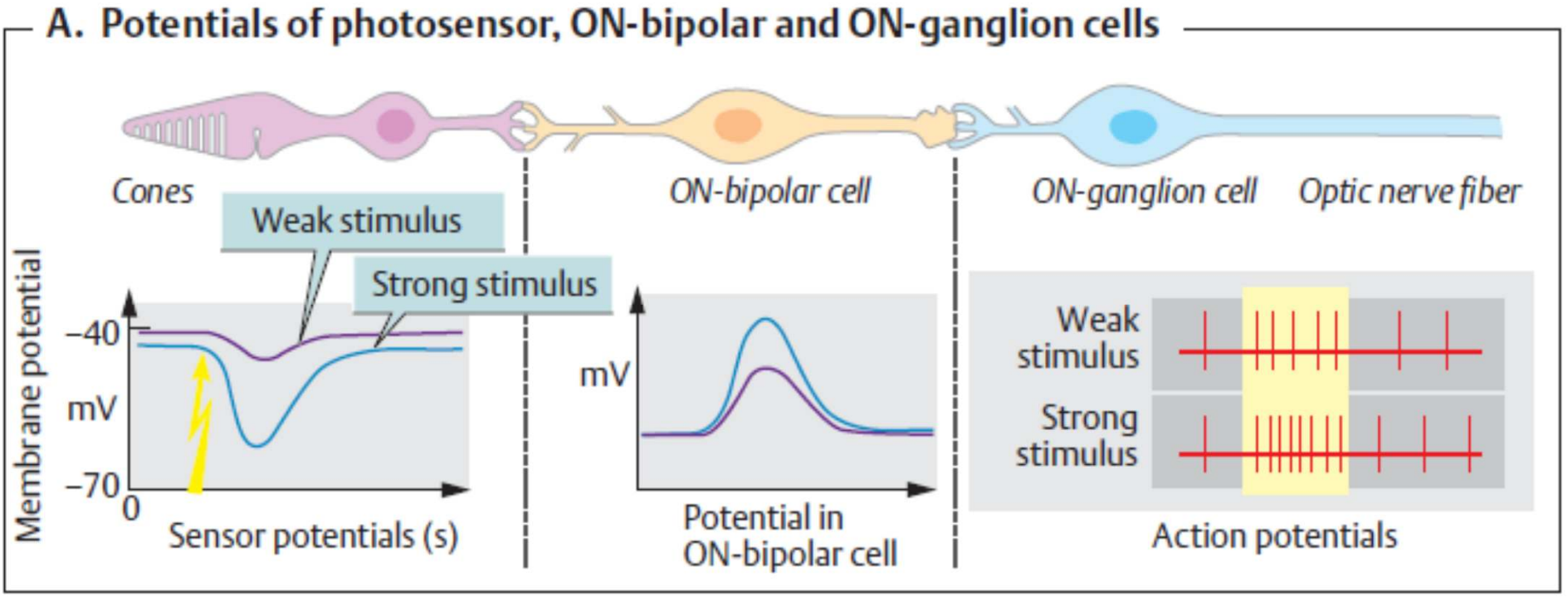


Figure 1. Structure of the retina, showing the outer segments (OS), inner segments (IS), outer nuclear layer (ONL), outer plexiform layer (OPL), inner nuclear layer (INL), inner plexiform layer (IPL), ganglion cell layer (GCL), horizontal cells (H), bipolar cells (B), amacrine (A), and rod bipolar (RB) cells.

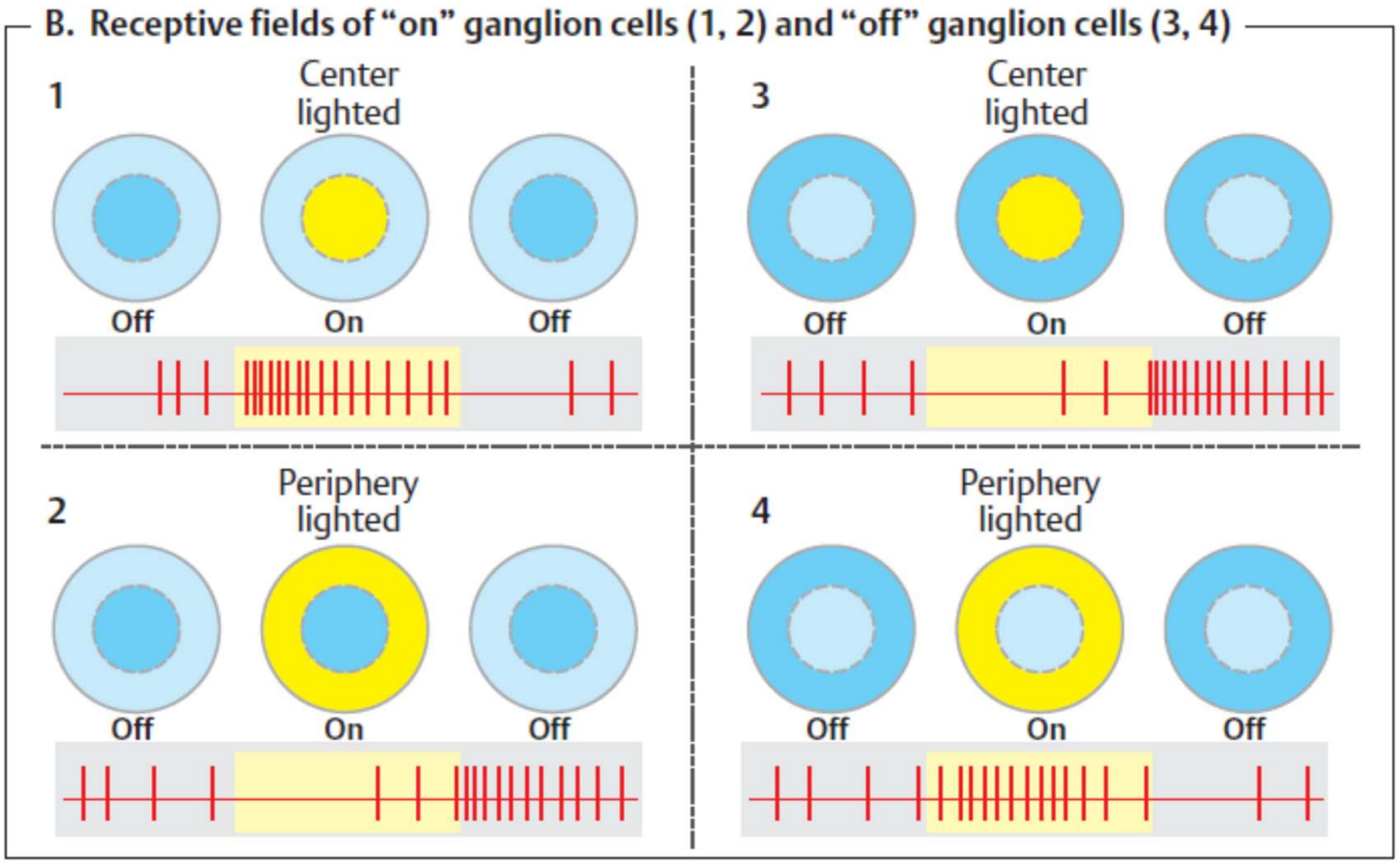
Ten Layers of Retina

Optic nerve is output of retina.
Retina is unique neural network of immense size of one million output lines (patch of = 10^3*10^3).
It is poorly understood…

Od světla přes receptorový potenciál k akčním potenciálům a kódování ve zrakovém nervu



From Light Through Receptor Potential to Action Potentials and Coding in Optical Nerve



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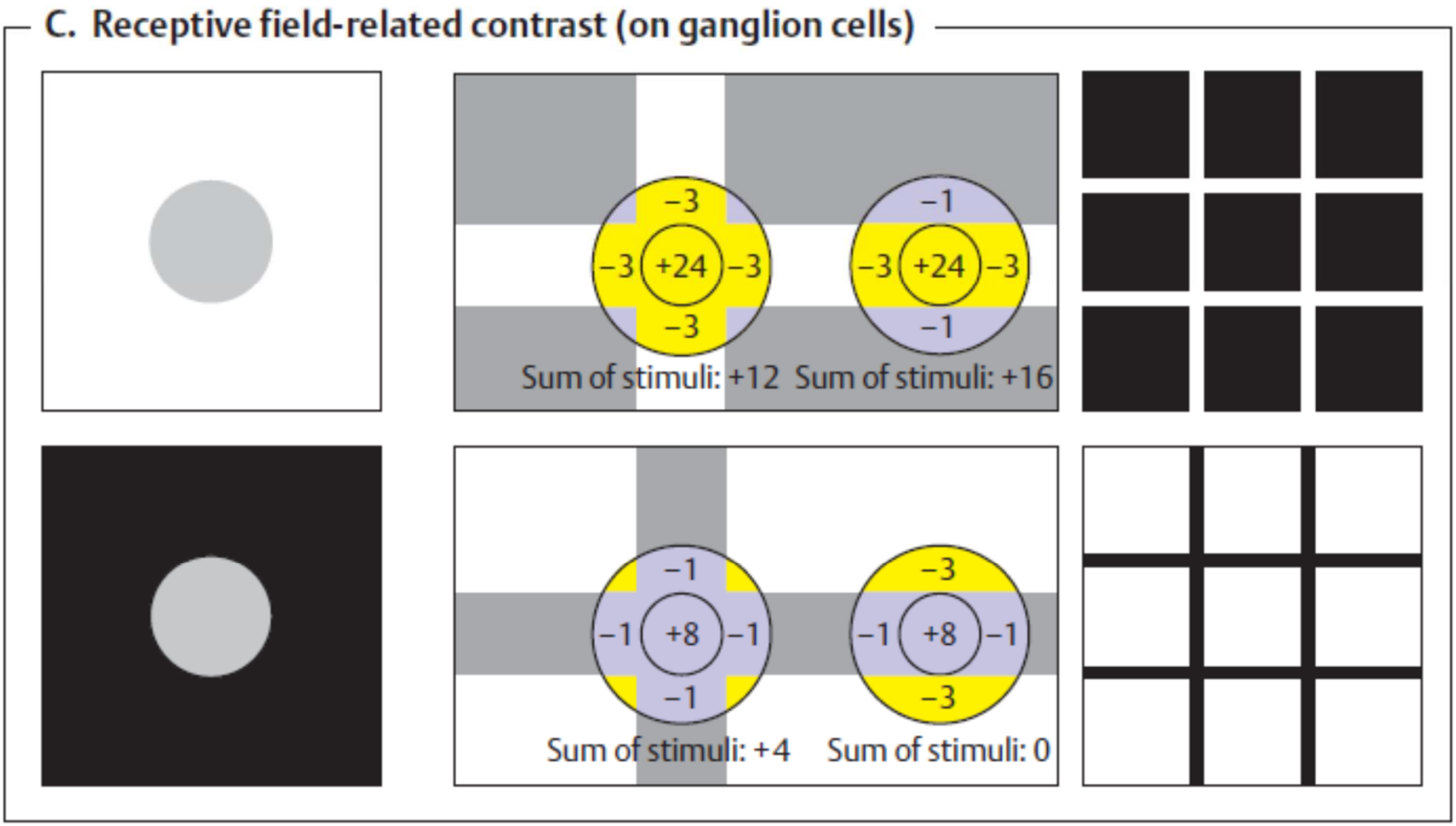
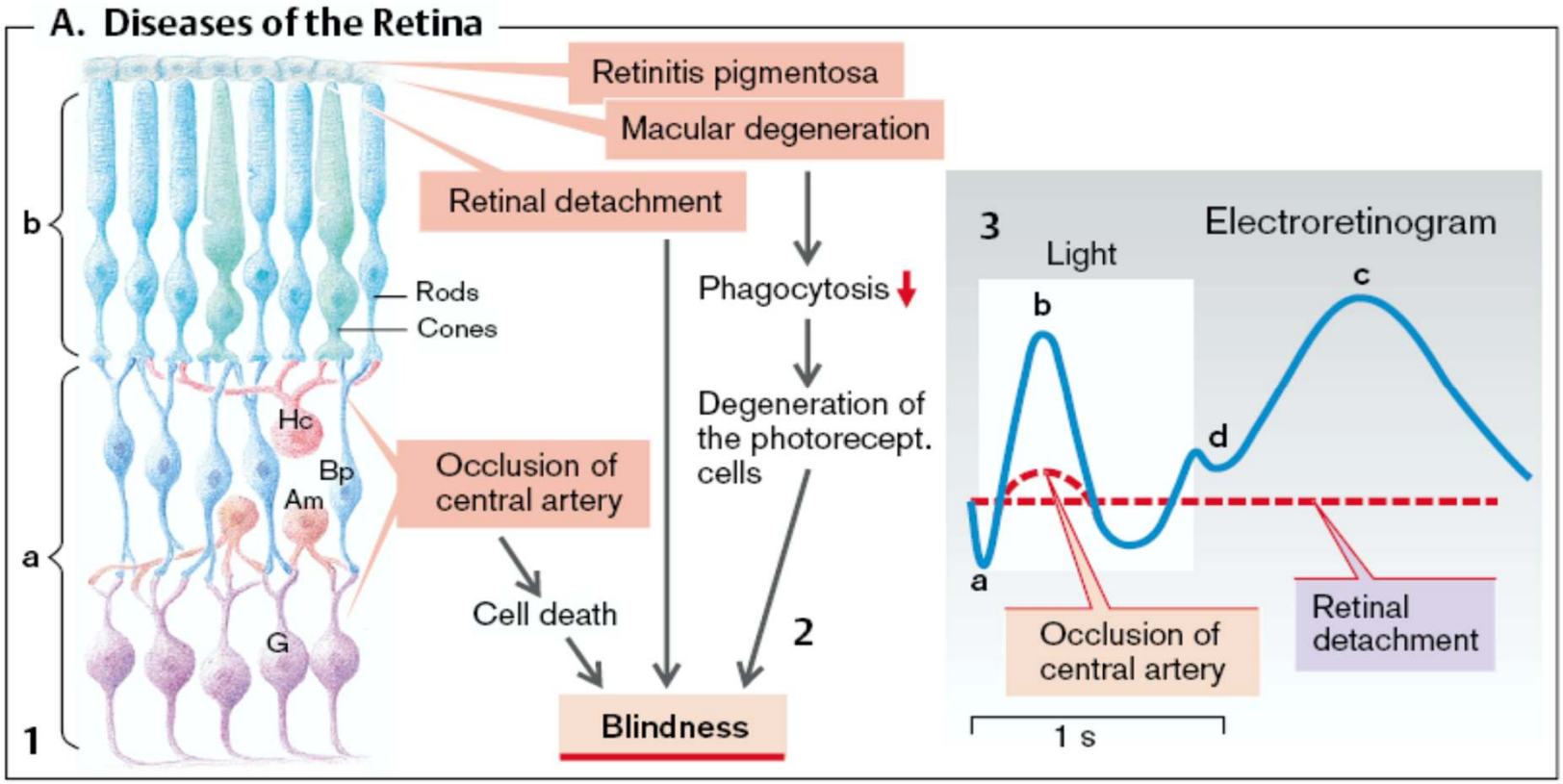
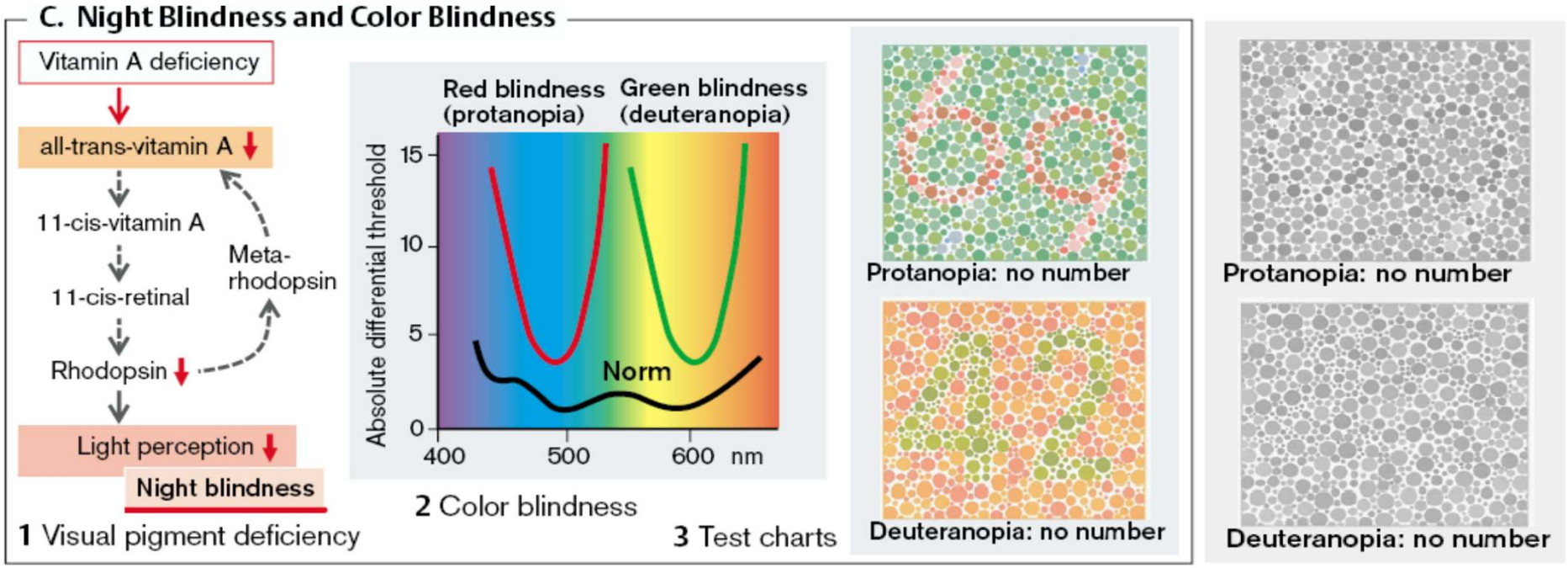


Electric Potentials of Retina



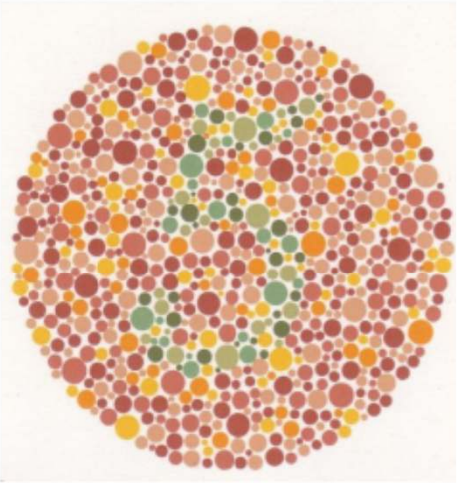
Day and Night Vision, with Rods and Three Cone Types

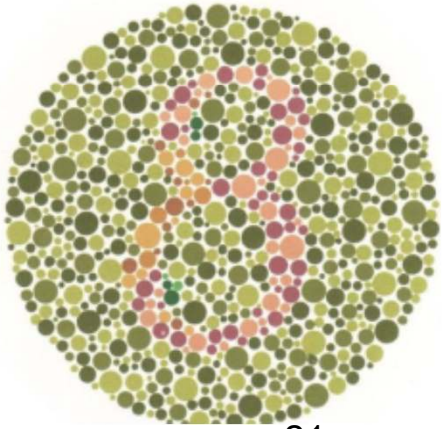


Color Blindness is manifested in men (XY) only, as it is located to X chromosome, which have women in duplicate (XX). It also includes visual acuity impairment due to different densities of cones.

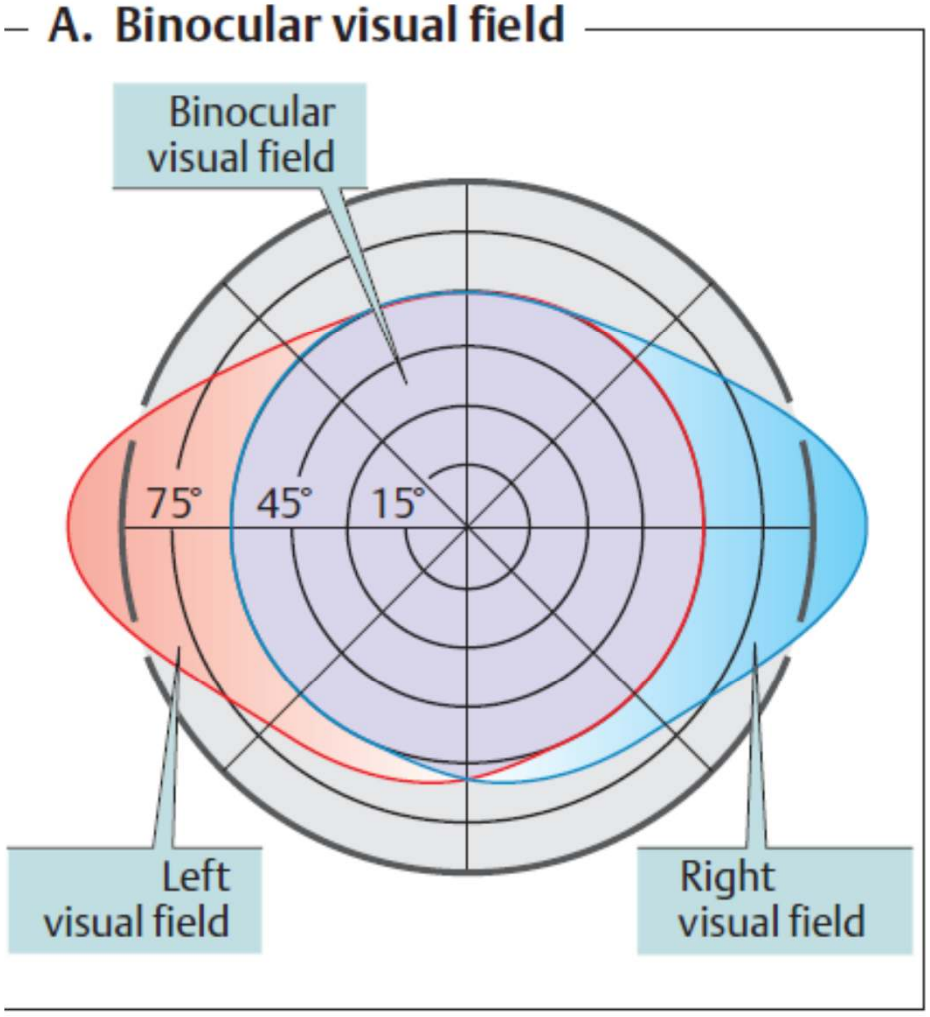
Protanopia and Deuteranopia and How They (May) See Colors

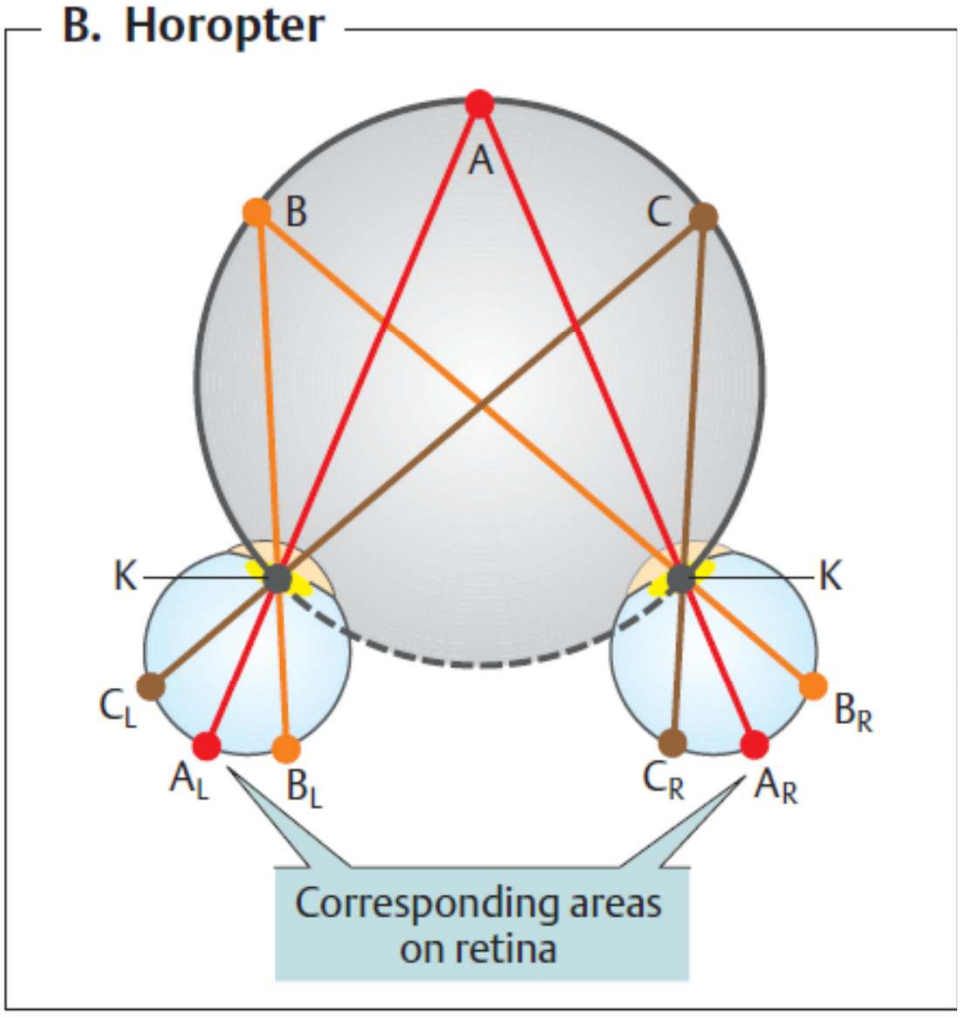
Viděné barvy	Normální oko	Barvoslepé oko	
		na červenou barvu	na zelenou barvu
	červená	špinavě zelená	žlutočervená
	oranžová	žlutá	žlutá
	žlutá	světle žlutá	žlutá
	žlutozelená	šedožlutá až bílá	žlutá
	zelená	šedá	šedožlutá až bílá
	modrá	světle modrá	světle modrá
	fialová	modrá	modrá





Binocular/ Stereoscopic Vision





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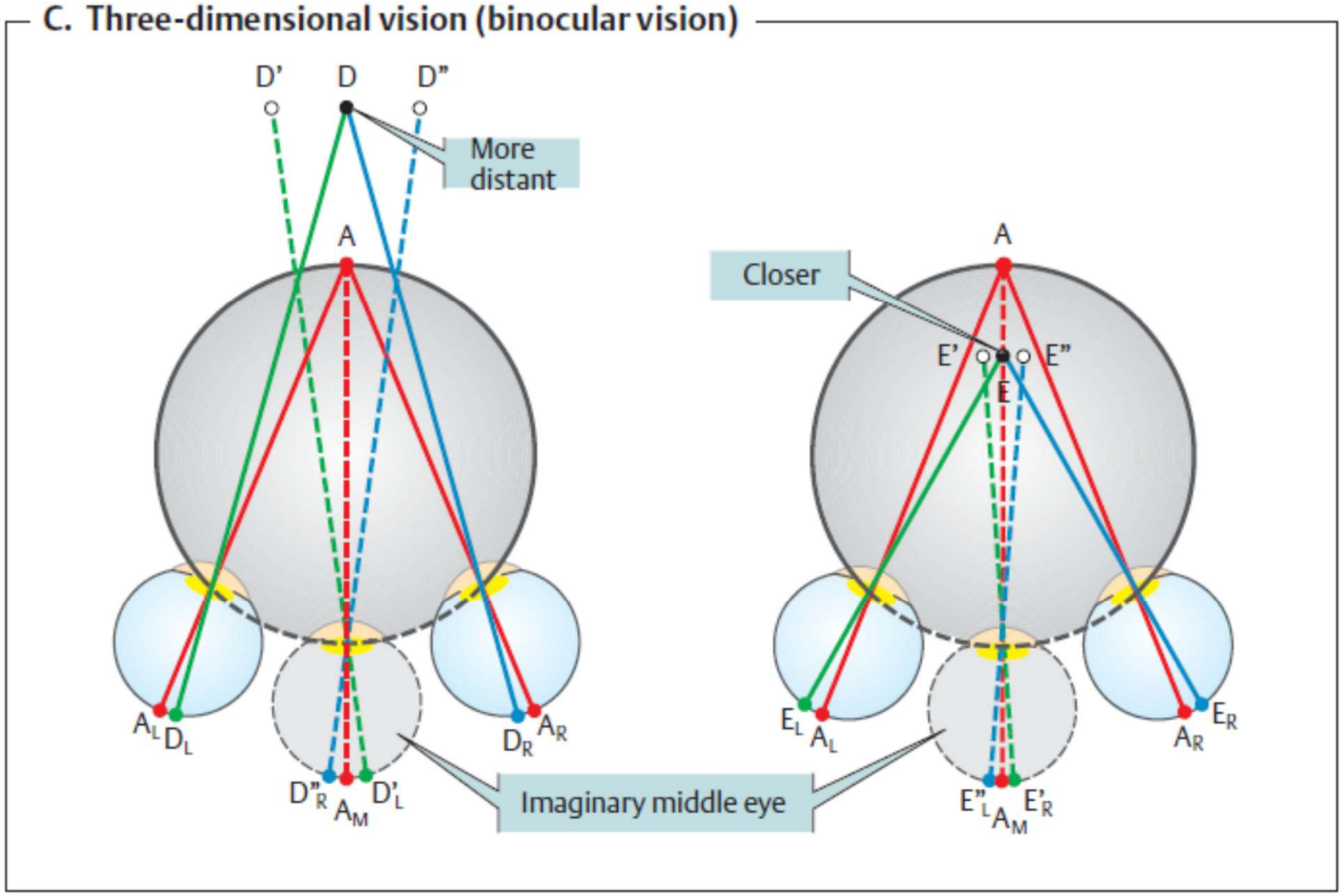


Geometry of disparities using the Cyclopean Eye

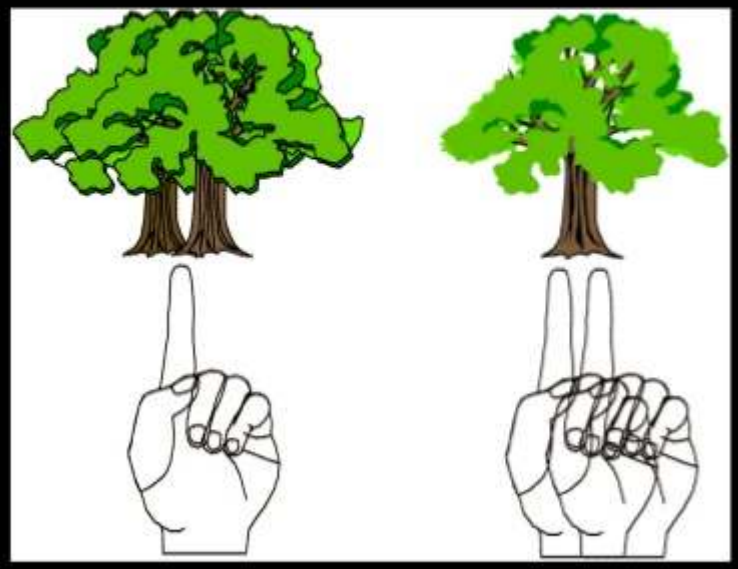
Binocular Focusing is Realized by Eye Con- and Di-Vergence

Vergence eye movements

Either blur or retina disparity will generate vergence.

Latency for vergence movements is ~160 ms.

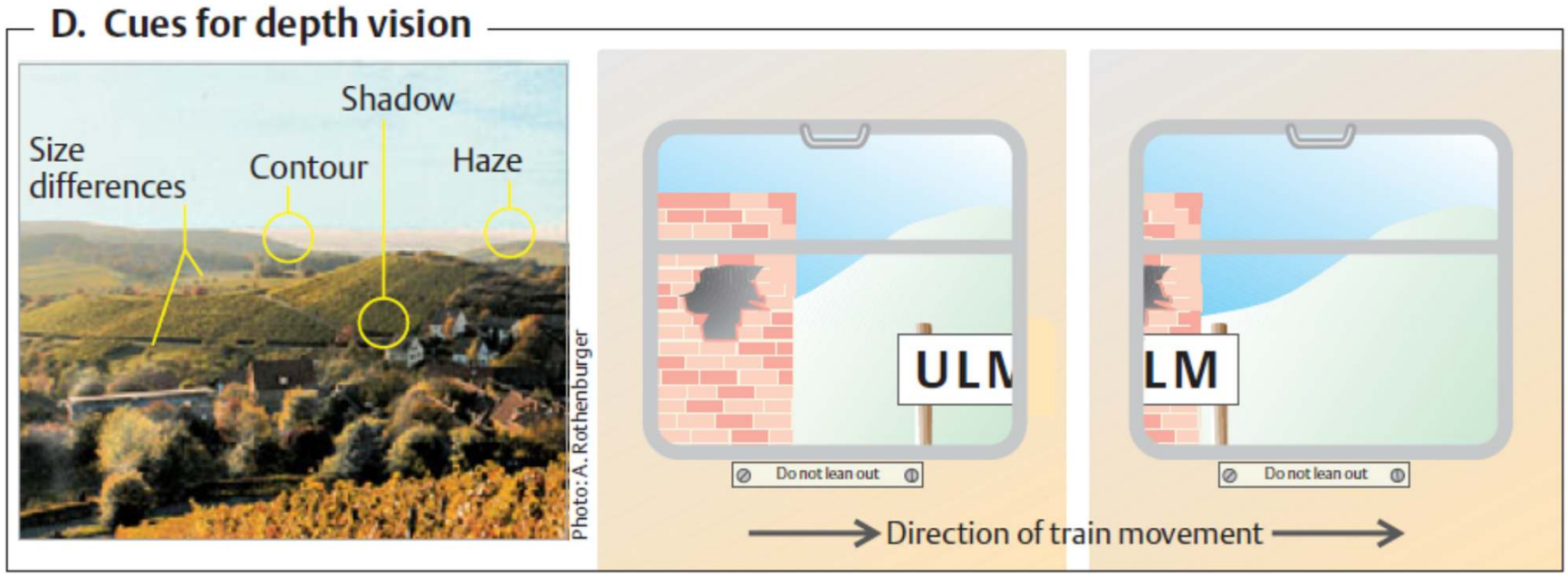
Maximum velocity is 20°/sec.



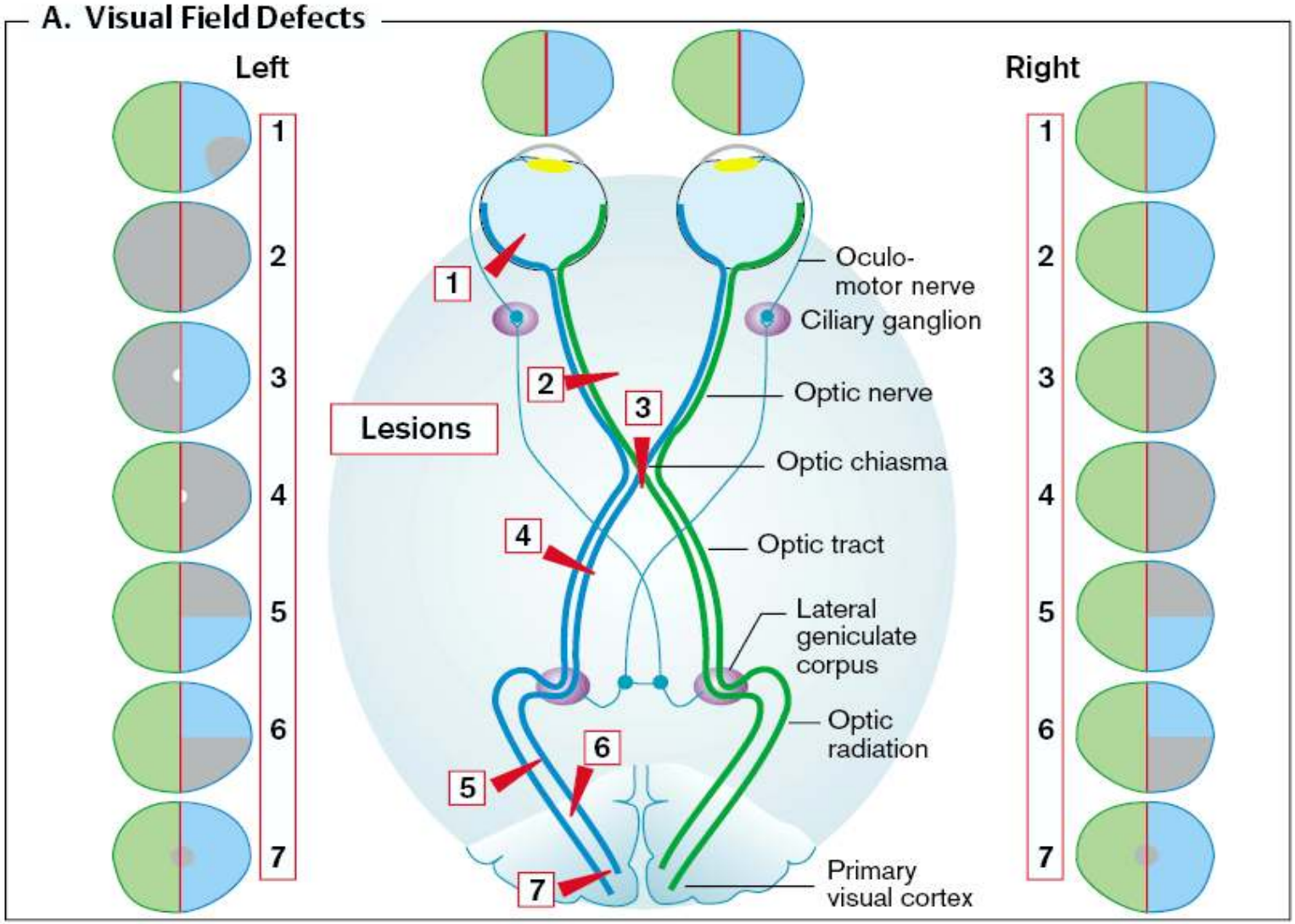
(Con)vergence disorder is called strabism.

Stereoscopic Vision

Binocular: Stereo Disparity, in Near Field Scene Only
Monocular: - By Perspective
- By Known Object Sizes
- By Parallax (in Disparity and Relative Motion)



Visual Fields in Nerve and their Defects

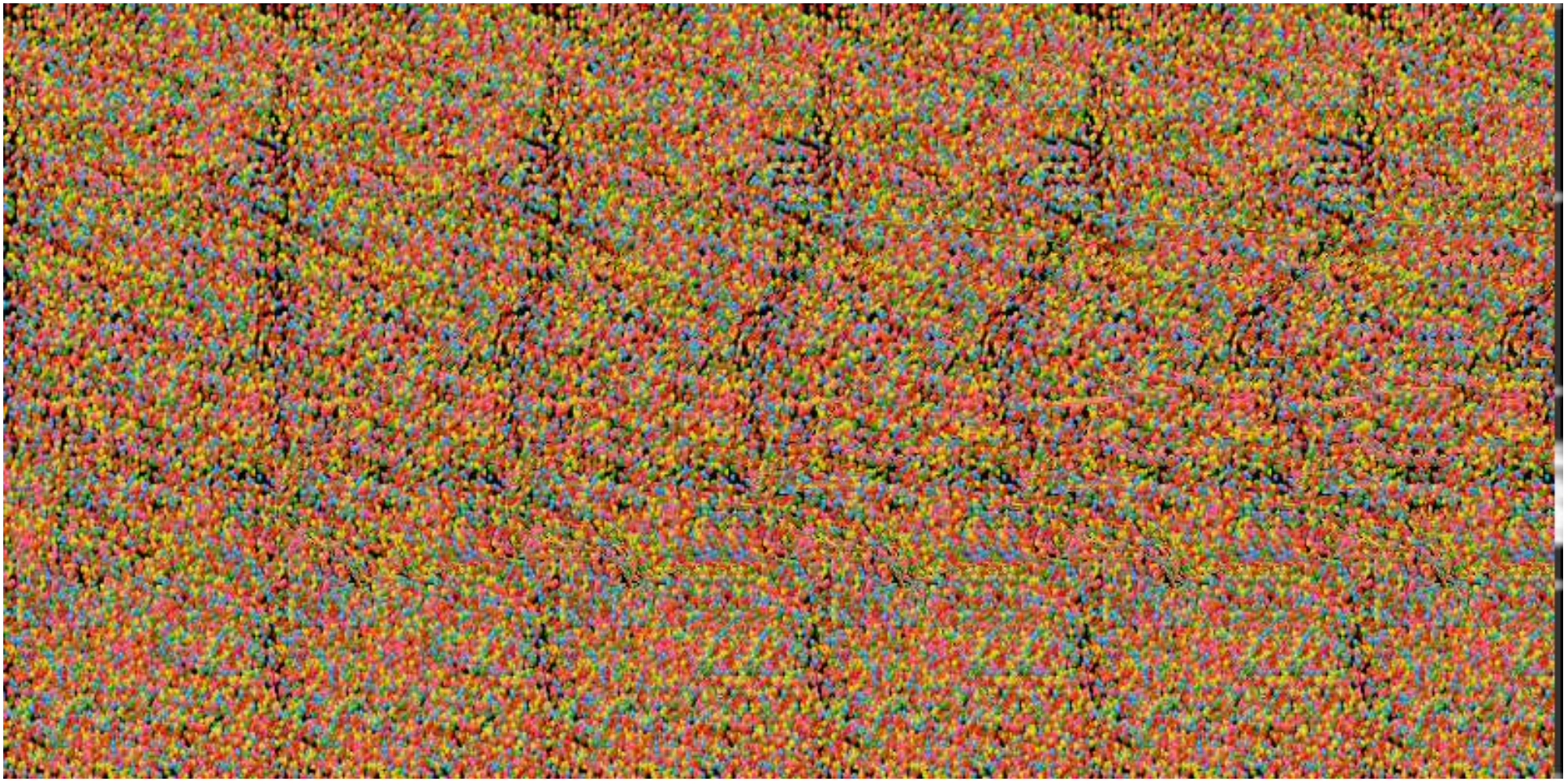


Literary references

[Despopoulos, Silbernagl,
Color Atlas of Physiology, 1991],
etc

[Marsalek, Hajny, Vokurka,
Pathological physiology of visual pathway. 2017]

Random dot stereogram (autostereogram)



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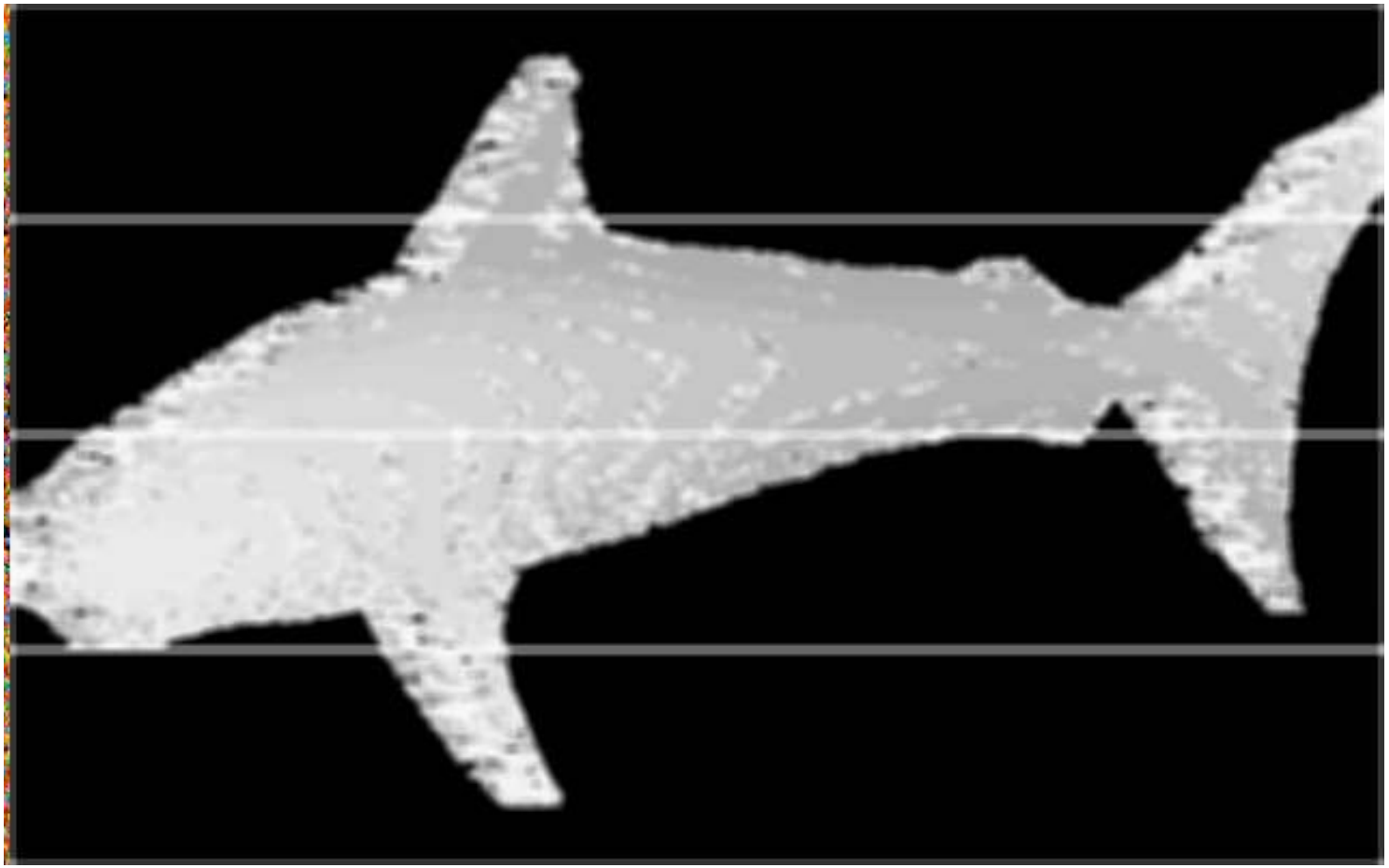

Other stere-scopic perception can be obtained using red and blue anaglyphs. This will be also subject in next two lectures:

- Visual cortex
- Vision/ hearing cross, also about space perception

Conclusionc

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Thanks for your attention

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END
OF THE LECTURE