

FAV, Talk no. 8, Retina and visual pathway

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November 2020

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



1 20/200

2 20/100

3 20/70

4 20/50

5 20/40

6 20/30

7 20/25

8 20/20

9

10

11

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		$< 10^{\circ} \times 10^{\circ}$
other norm	$< 6/60,$	$< 20^{\circ} \times 20^{\circ}$
4 <i>amblyopia</i>		

Visual Acuity: 1' (angular minute)

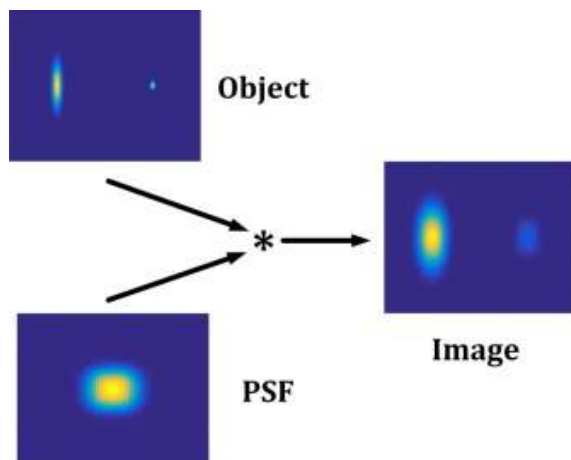
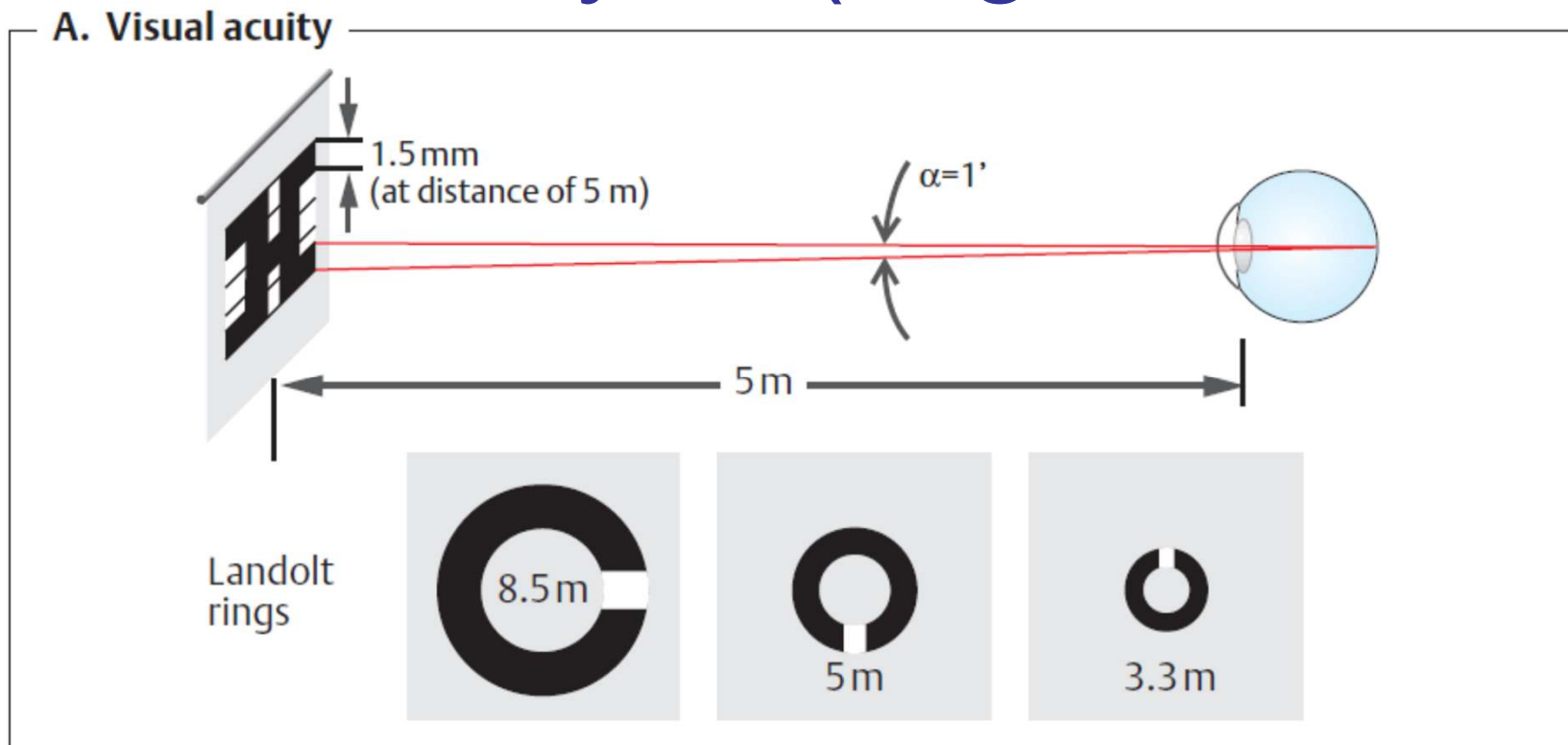
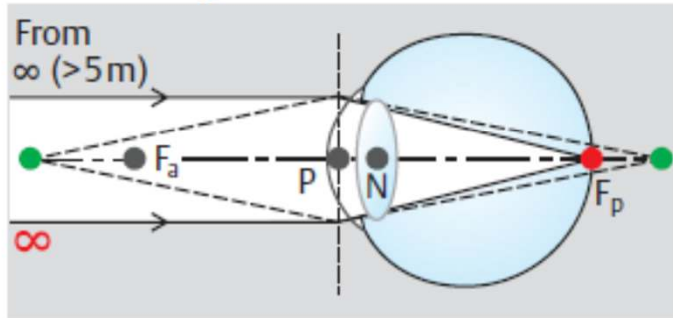


Image results
from convolution
of object and point
spread function

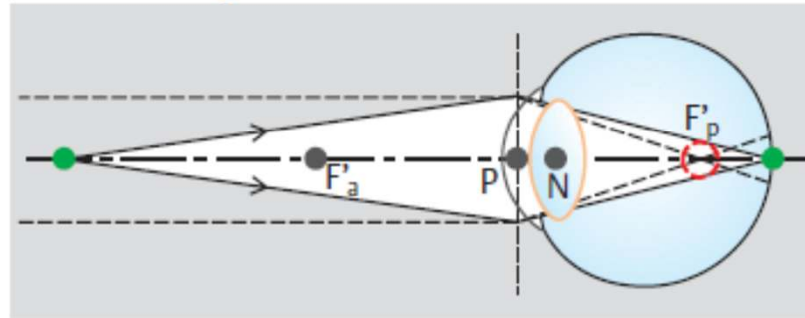
Far and Near Point

B. Eye: Accommodation for (1) far vision and (2) near vision

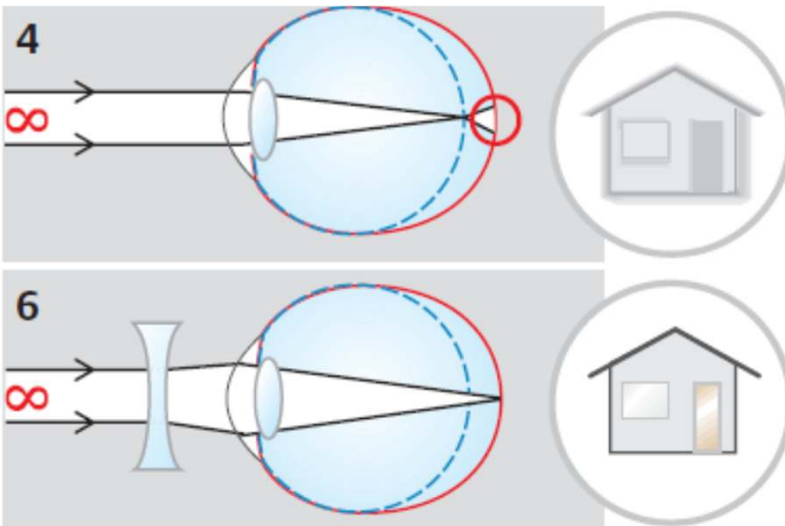
1 Lens adjusted for far vision



2 Lens adjusted for near vision

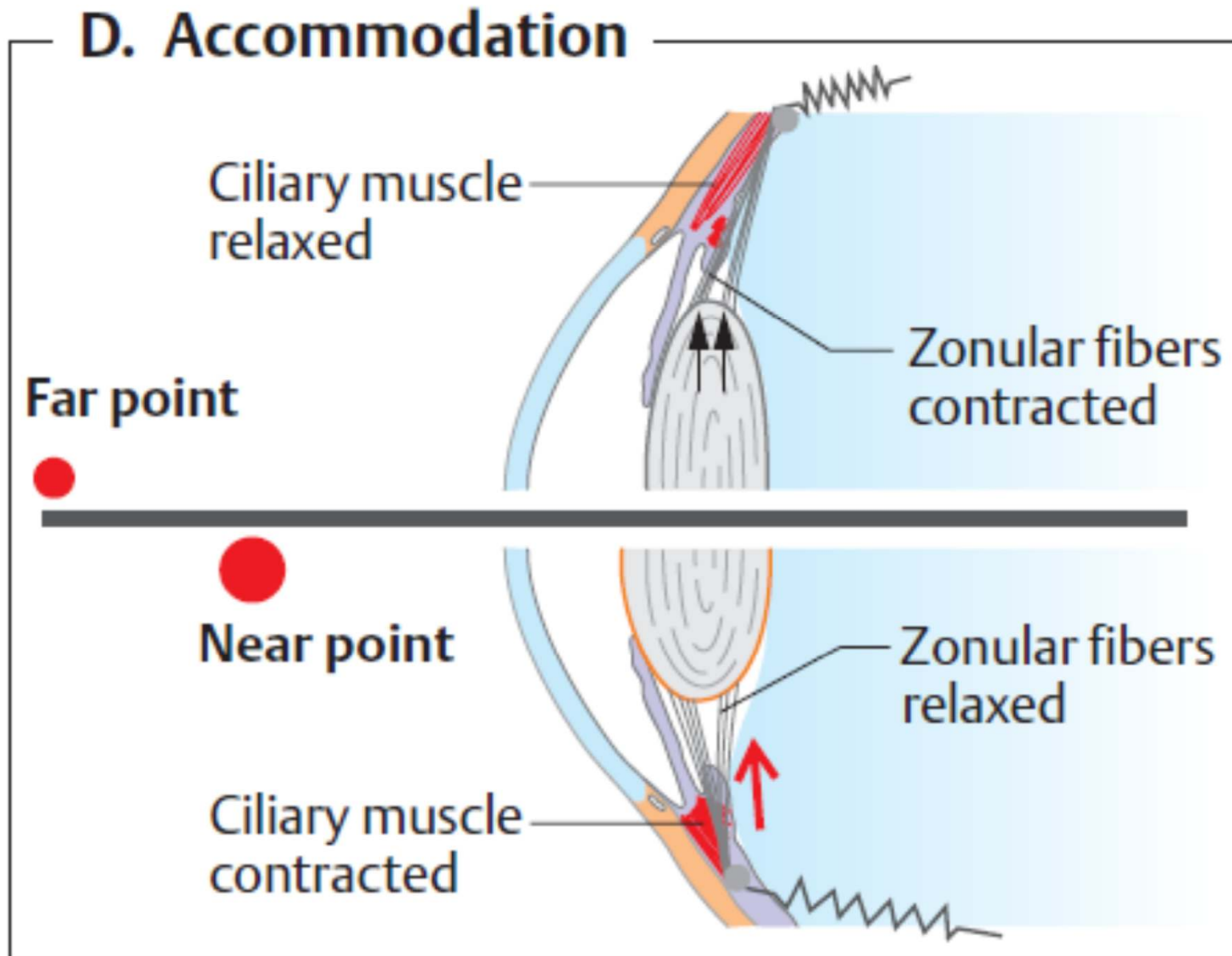


Myopia



Correction

Accommodation = Focusing to Get Sharp Image



Accommodation = Focusing to Get Sharp Image

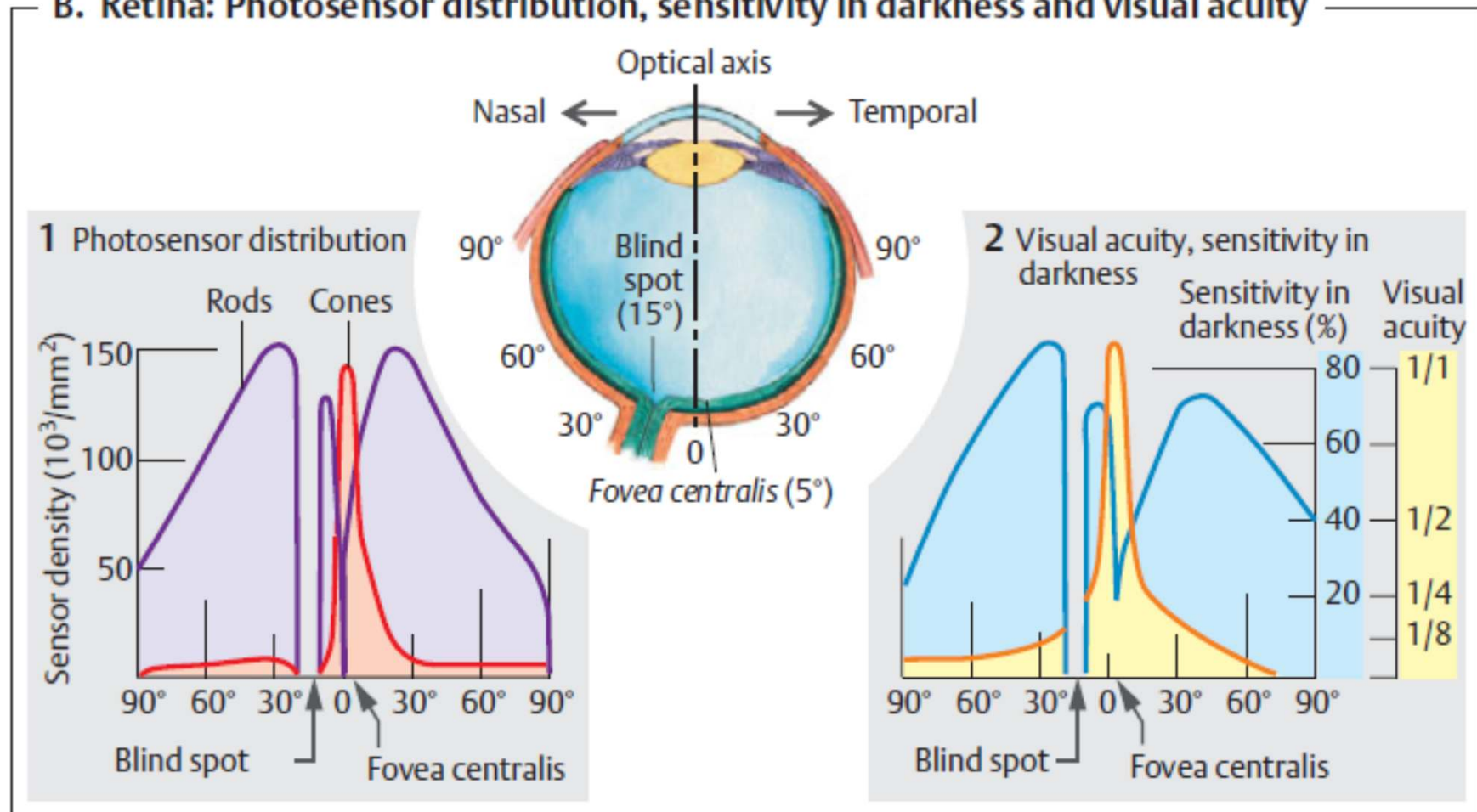
In individual development and ageing, far and near point positions change.

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

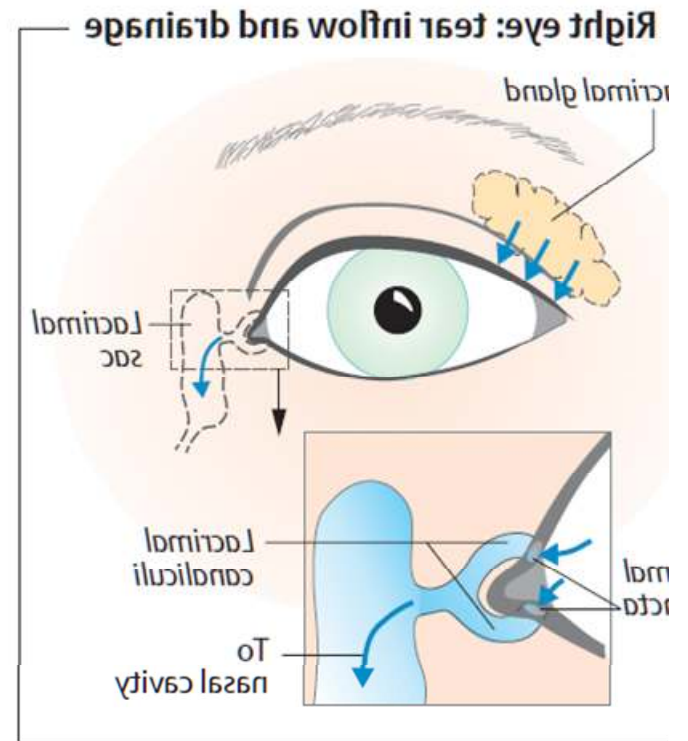
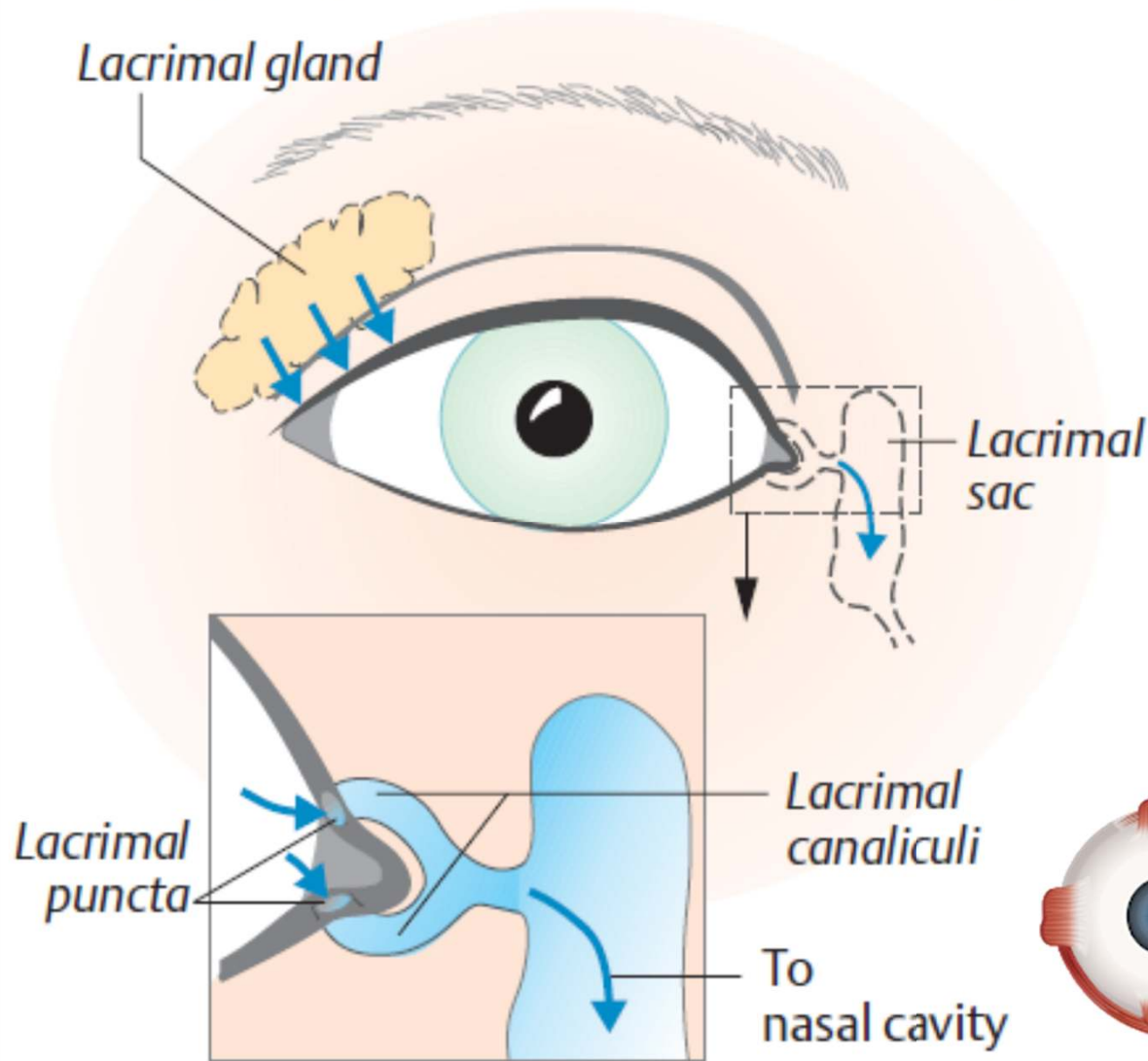
B. Retina: Photosensor distribution, sensitivity in darkness and visual acuity



Perimeter investigation

Lacrimal Gland and Duct, Eye Muscles

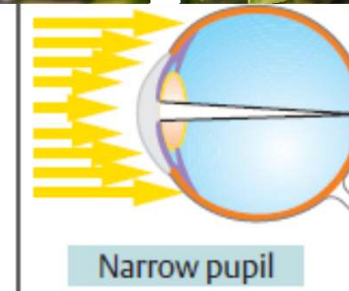
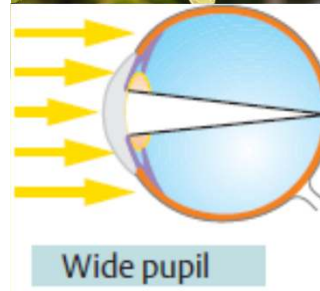
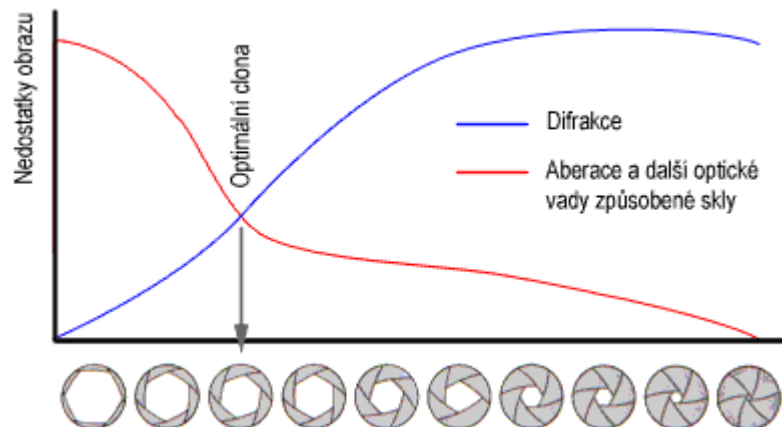
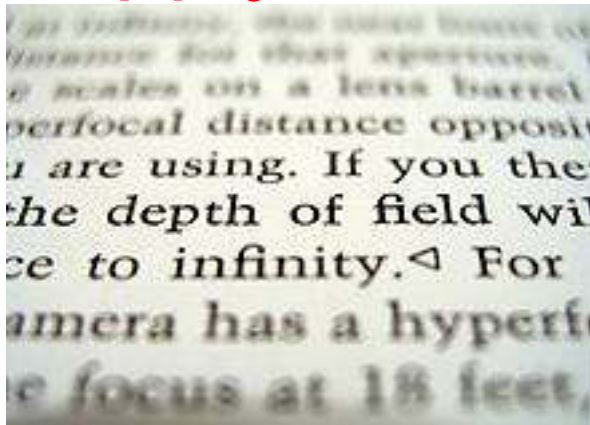
B. Right eye: tear inflow and drainage



Aperture Versus Depth of Field

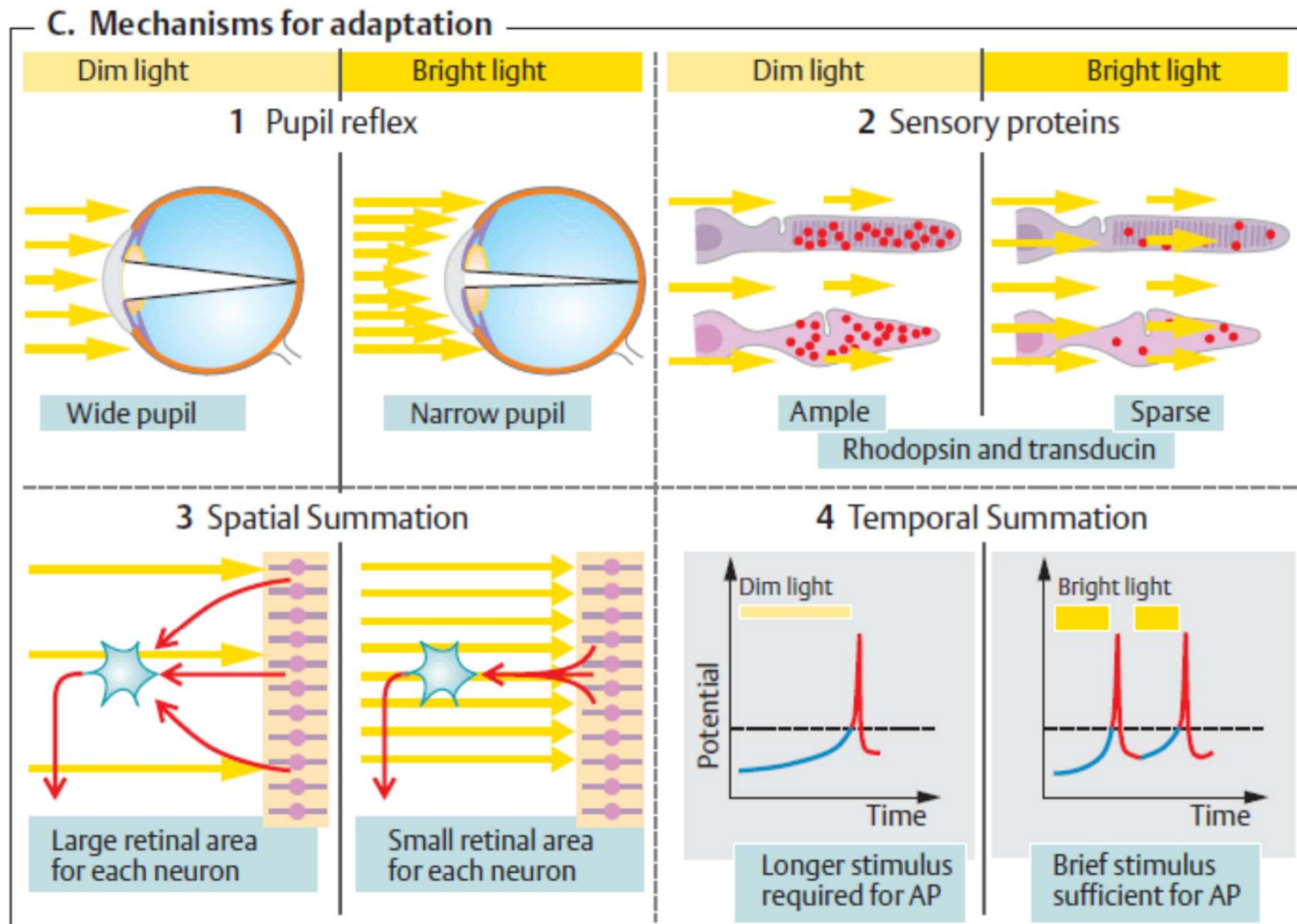
(světelnost/ clona, hloubka ostrosti)

Apply to Human Eye Functioning as Well

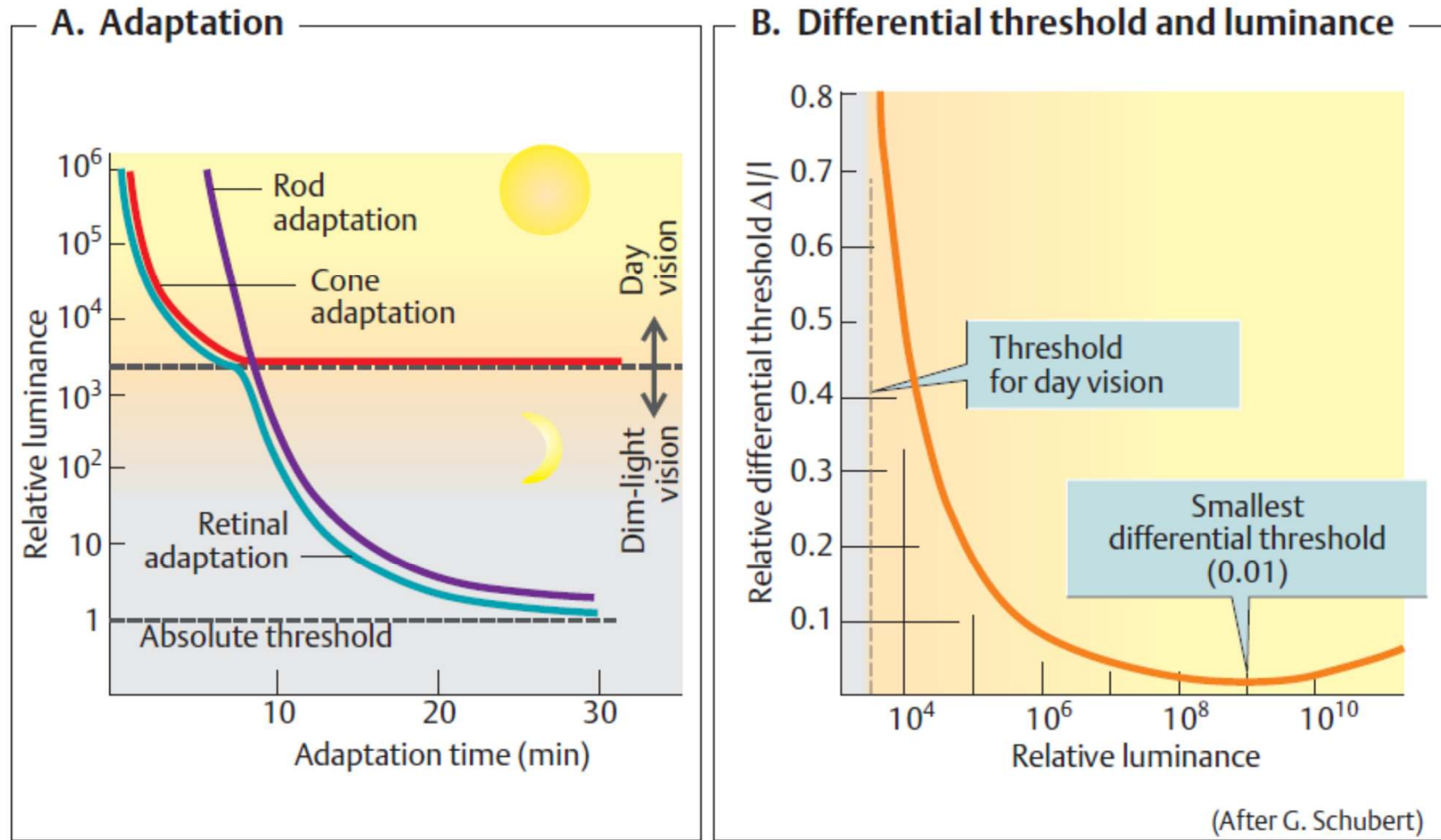


Aperture Versus Depth of Field

Apply to Human Eye Functioning as Well



Adaptation to Day and Night Illumination Conditions



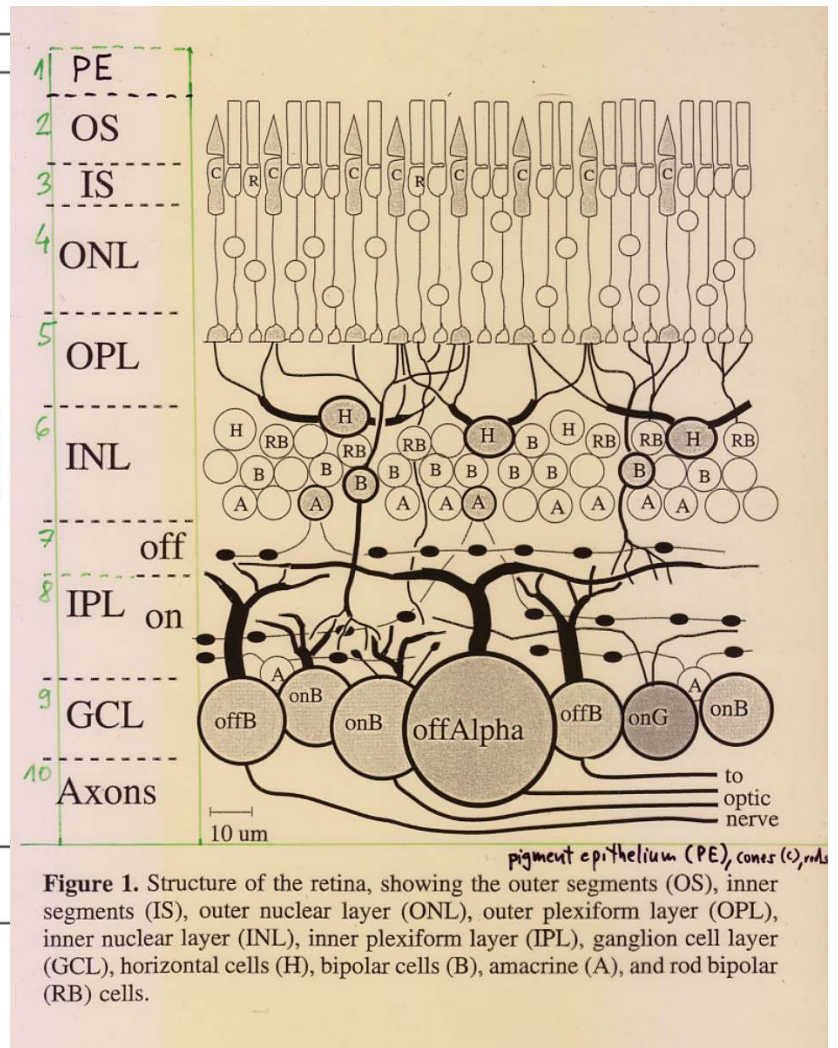
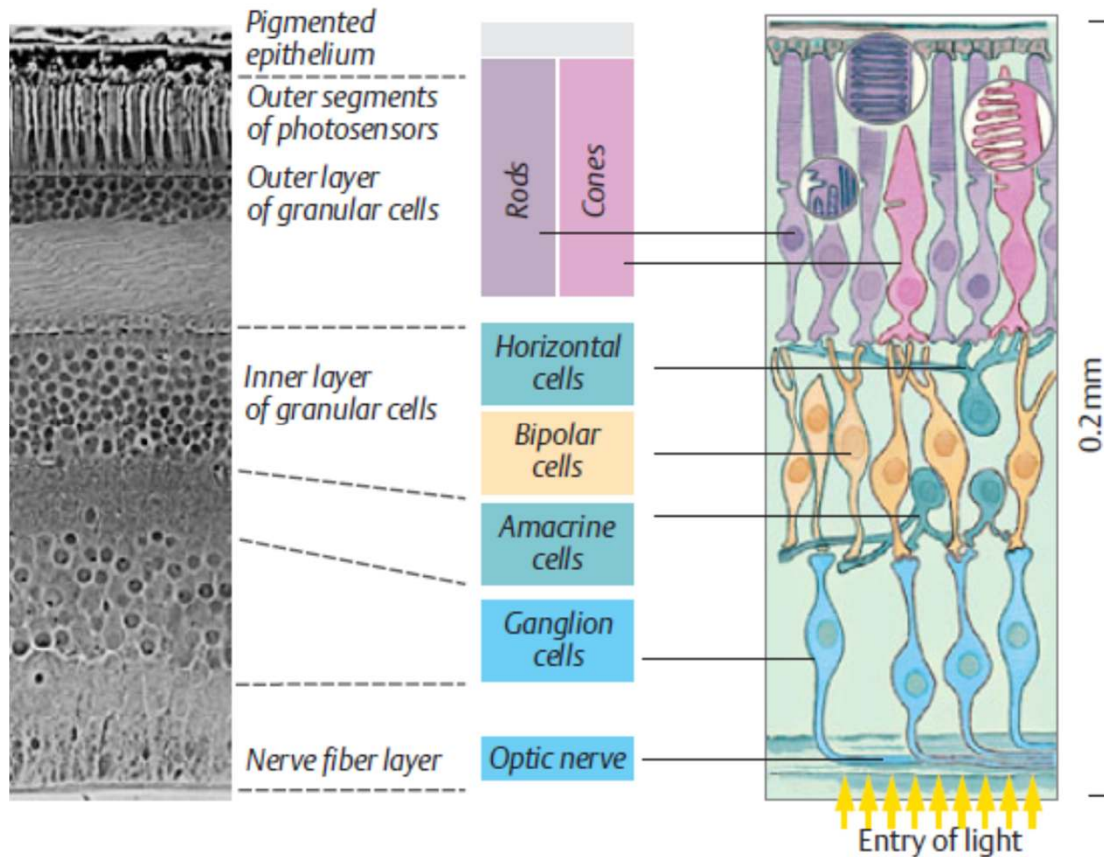


Figure 1. Structure of the retina, showing the outer segments (OS), inner segments (IS), outer nuclear layer (ONL), outer plexiform layer (OPL), inner nuclear layer (INL), inner plexiform layer (IPL), ganglion cell layer (GCL), horizontal cells (H), bipolar cells (B), amacrine (A), and rod bipolar (RB)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

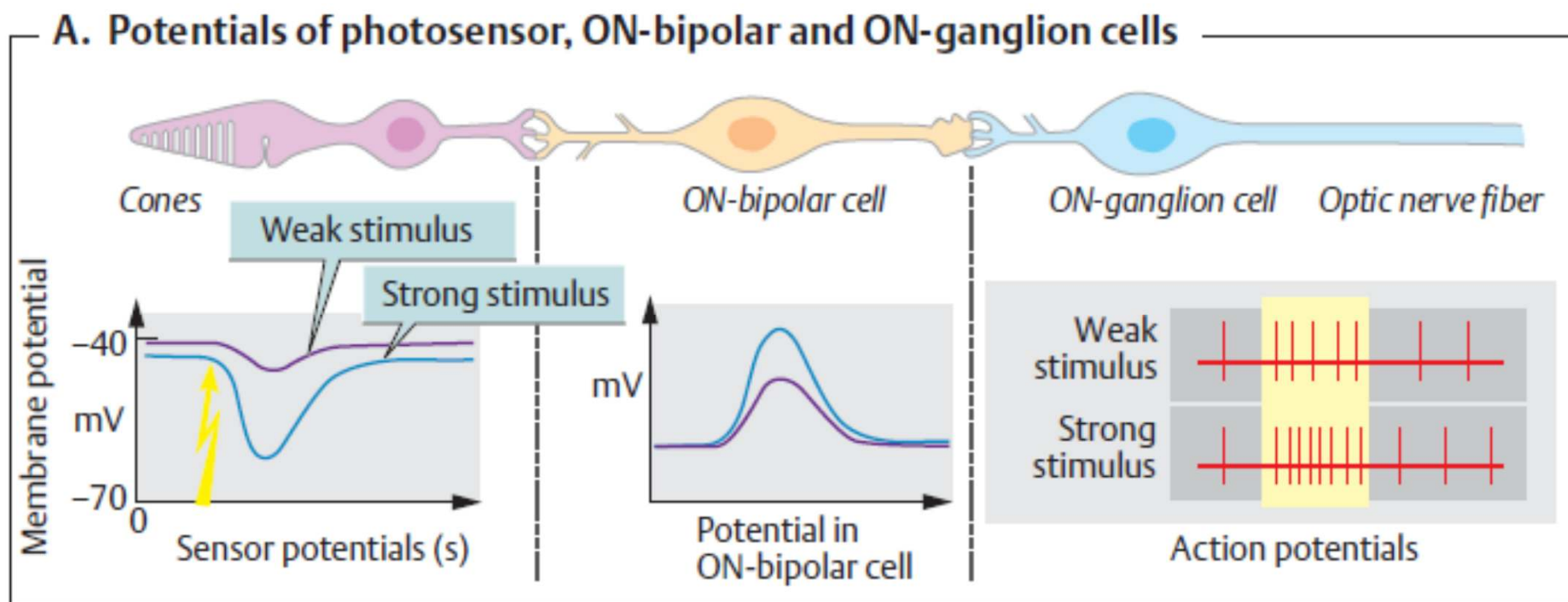
Ten Layers of Retina

Optic nerve is output of retina.

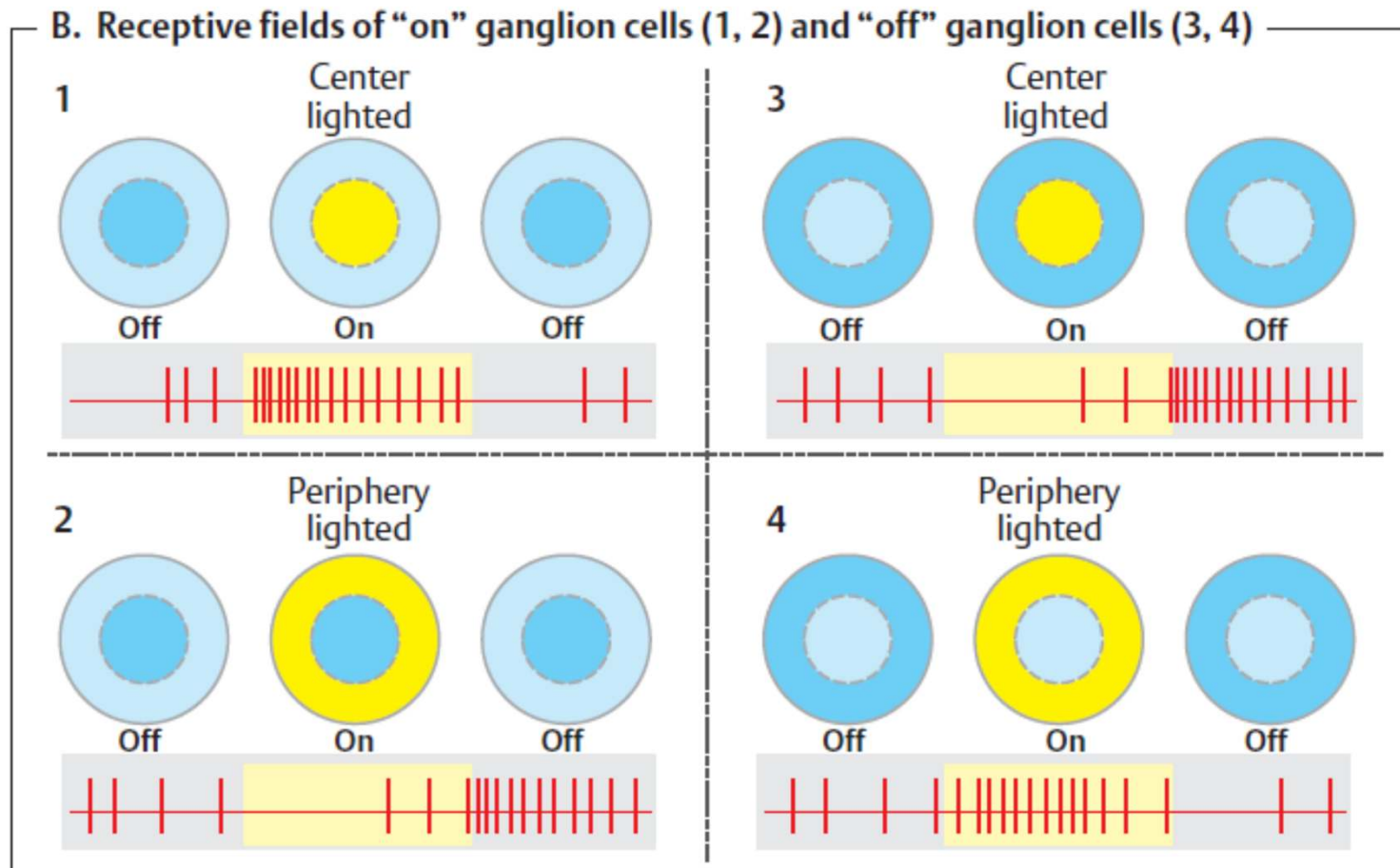
Retina is unique neural network of immense size of one million output lines (patch of = $10^3 \times 10^3$).

It is poorly understood...

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

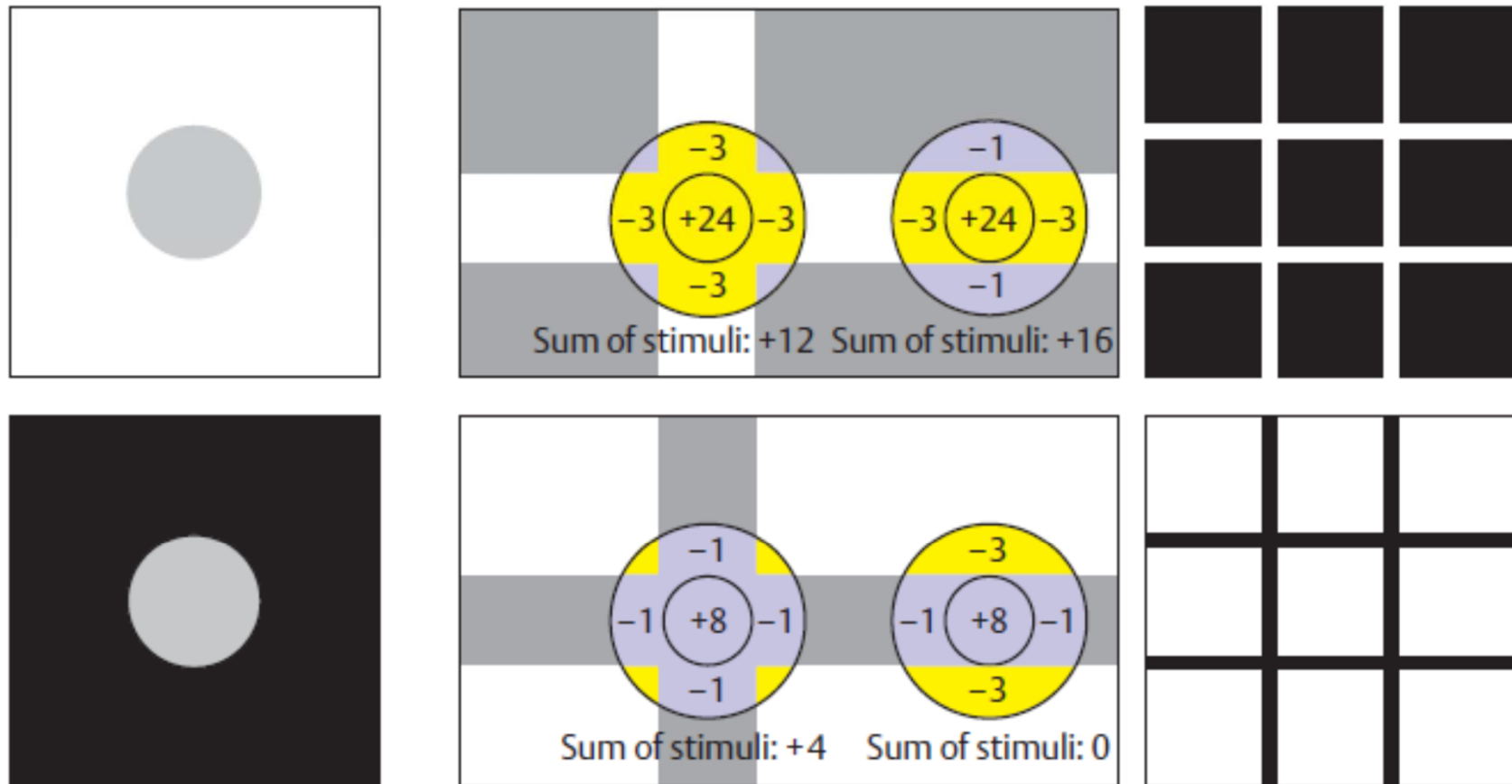


From Light Through Receptor Potential to Action Potentials and Coding in Optical Nerve

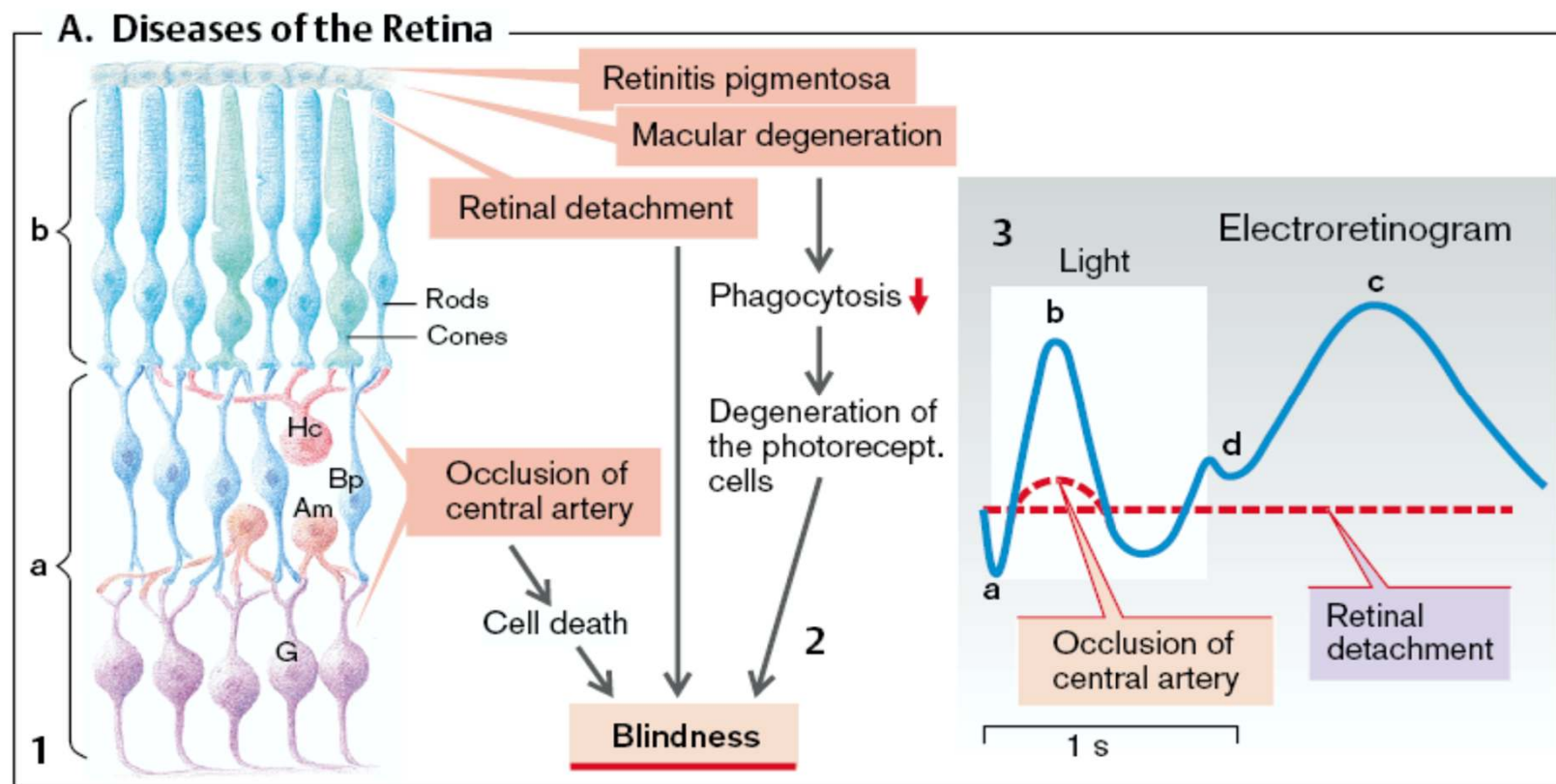


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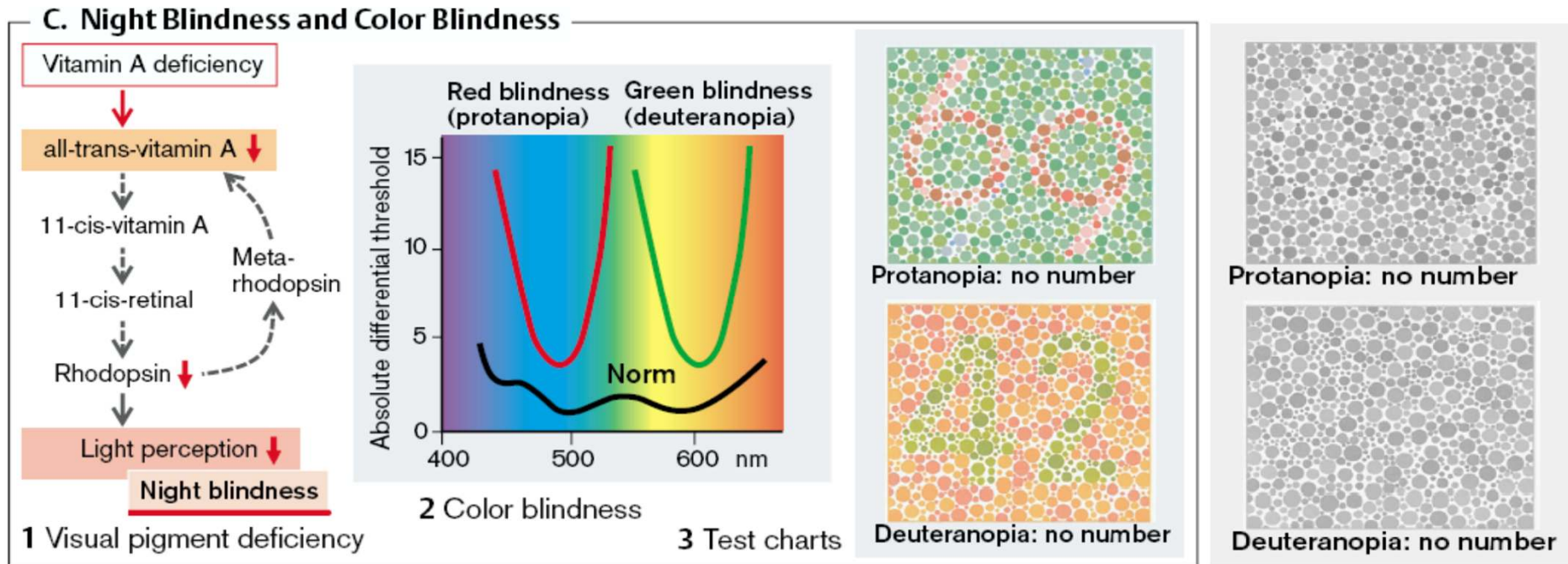
C. Receptive field-related contrast (on ganglion cells)



Electric Potentials of Retina



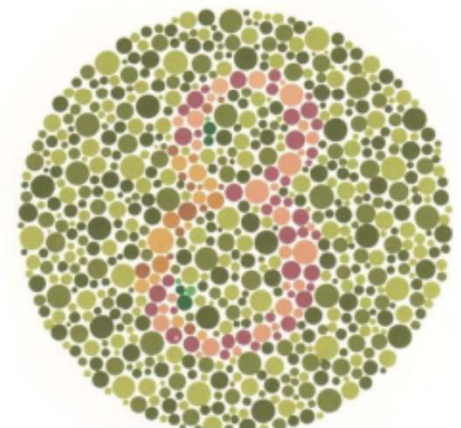
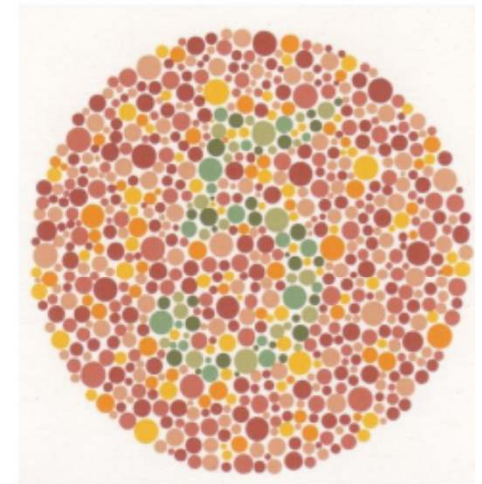
Day and Night Vision, with Rods and Three Cone Types



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.

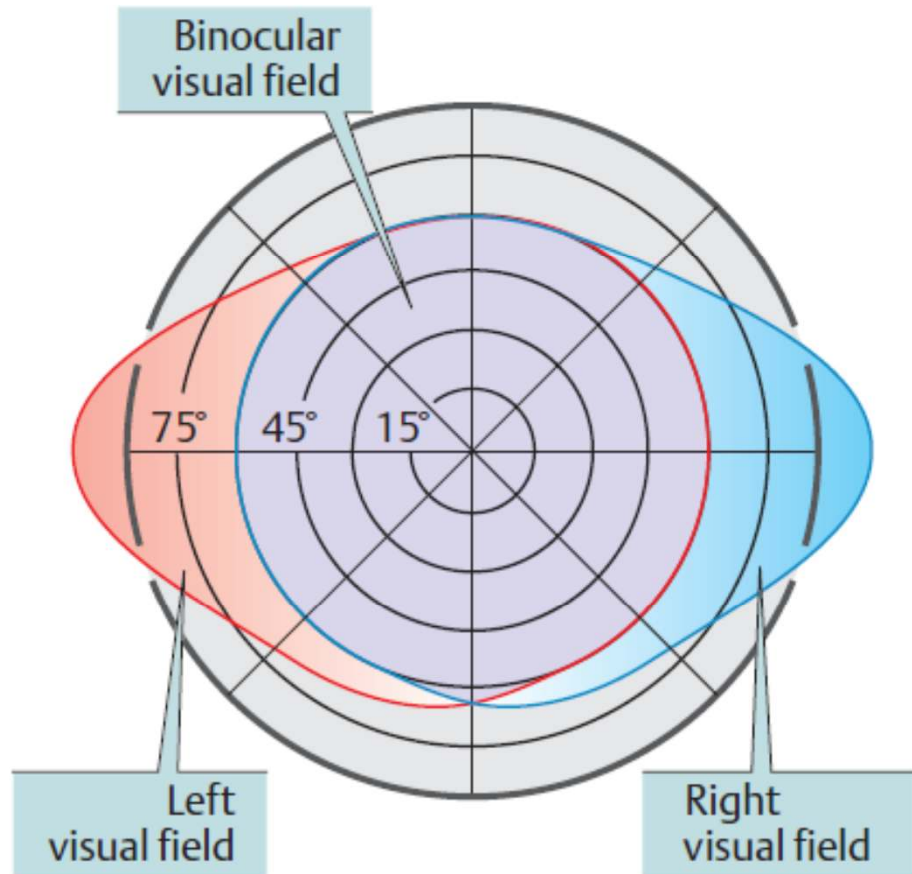
Protanopia and Deuteranopia and How They (May) See Colors

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

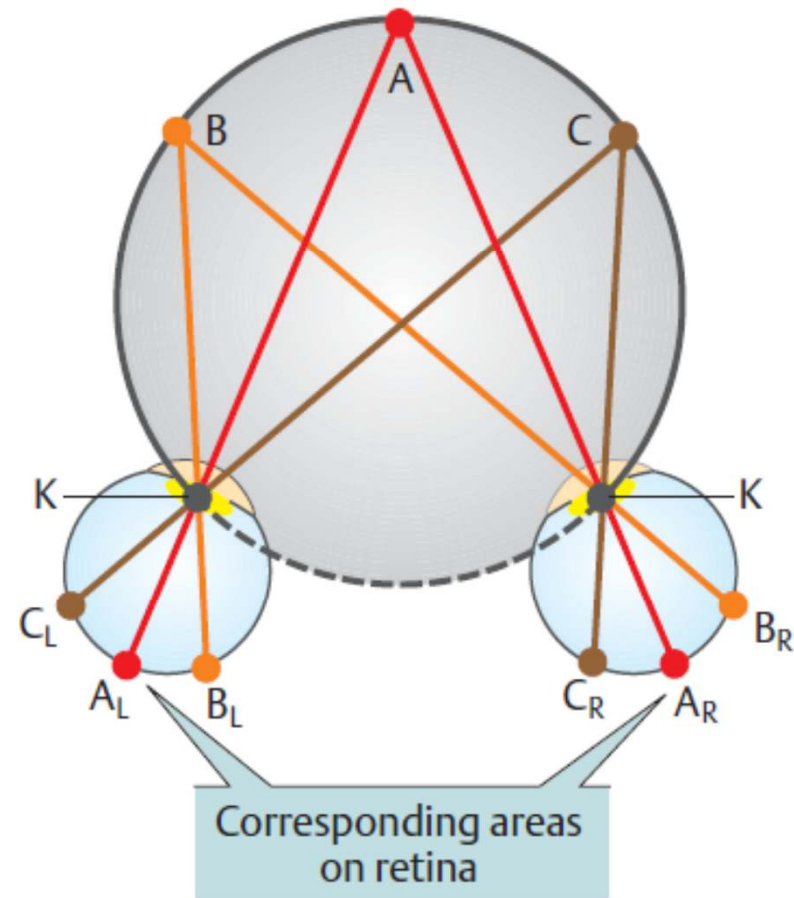


Binocular/ Stereoscopic Vision

A. Binocular visual field

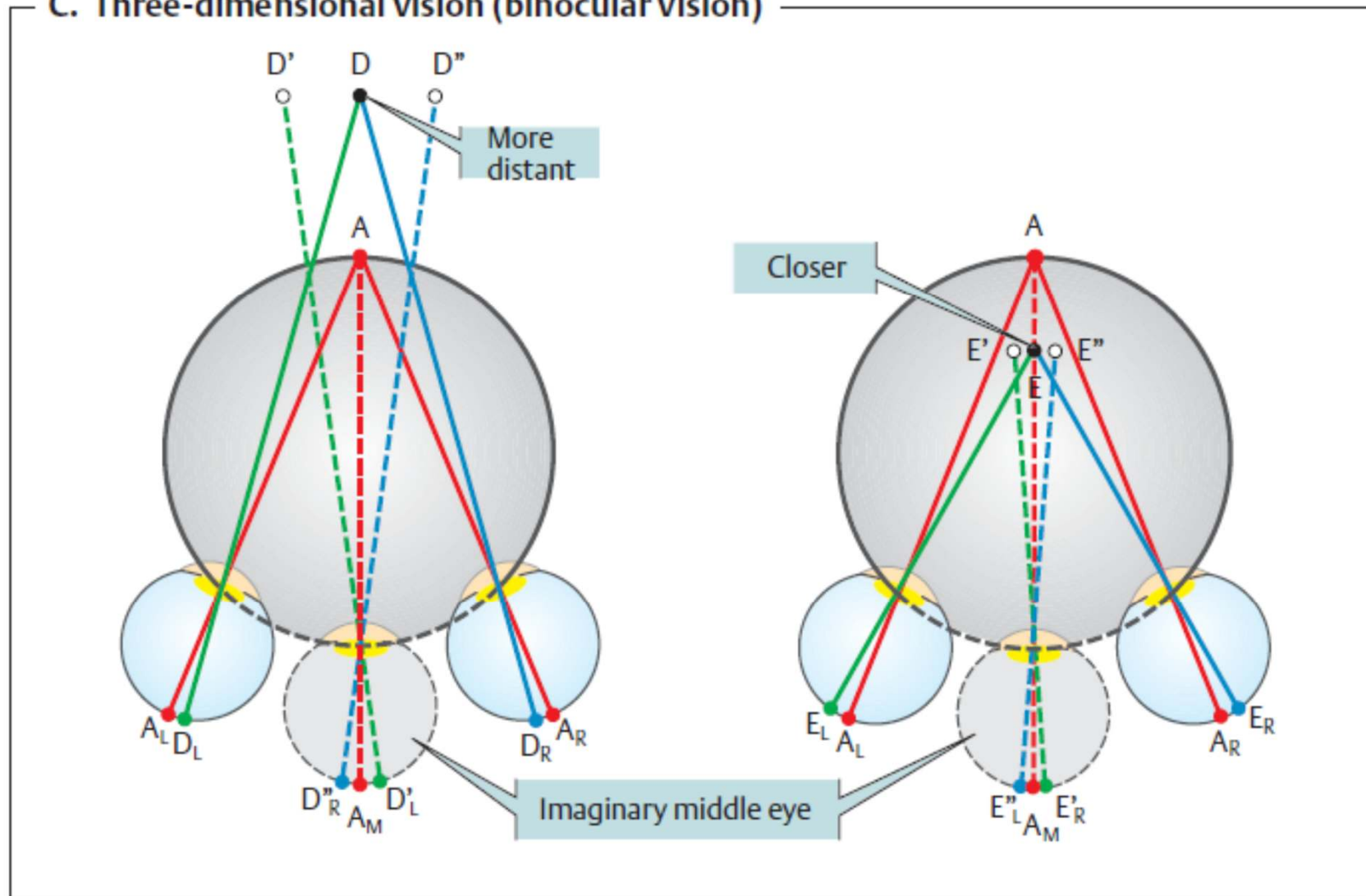


B. Horopter



Binocular/ Stereoscopic Vision

C. Three-dimensional vision (binocular vision)



Geometry of disparities using the Cyclopean Eye

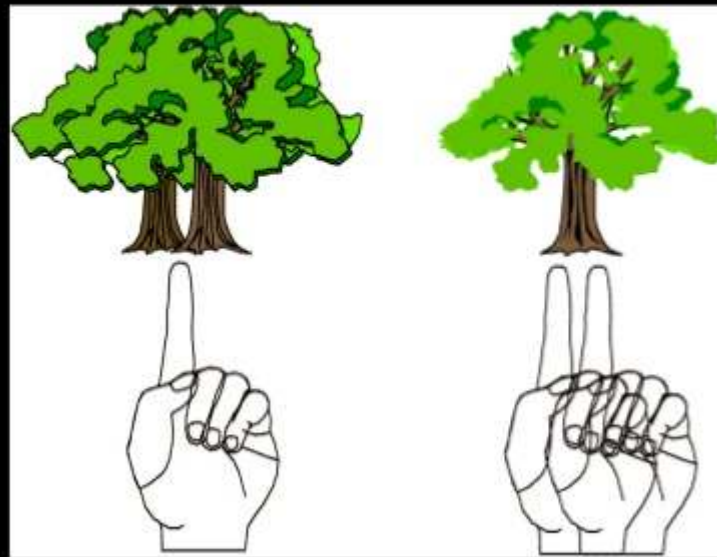
Binocular Focusing is Realized by Eye Con- and Di-Vergence

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 strabismus.

Stereoscopic Vision

Binocular: Stereo Disparity, in Near Field Scene Only

Monocular: - By Perspective

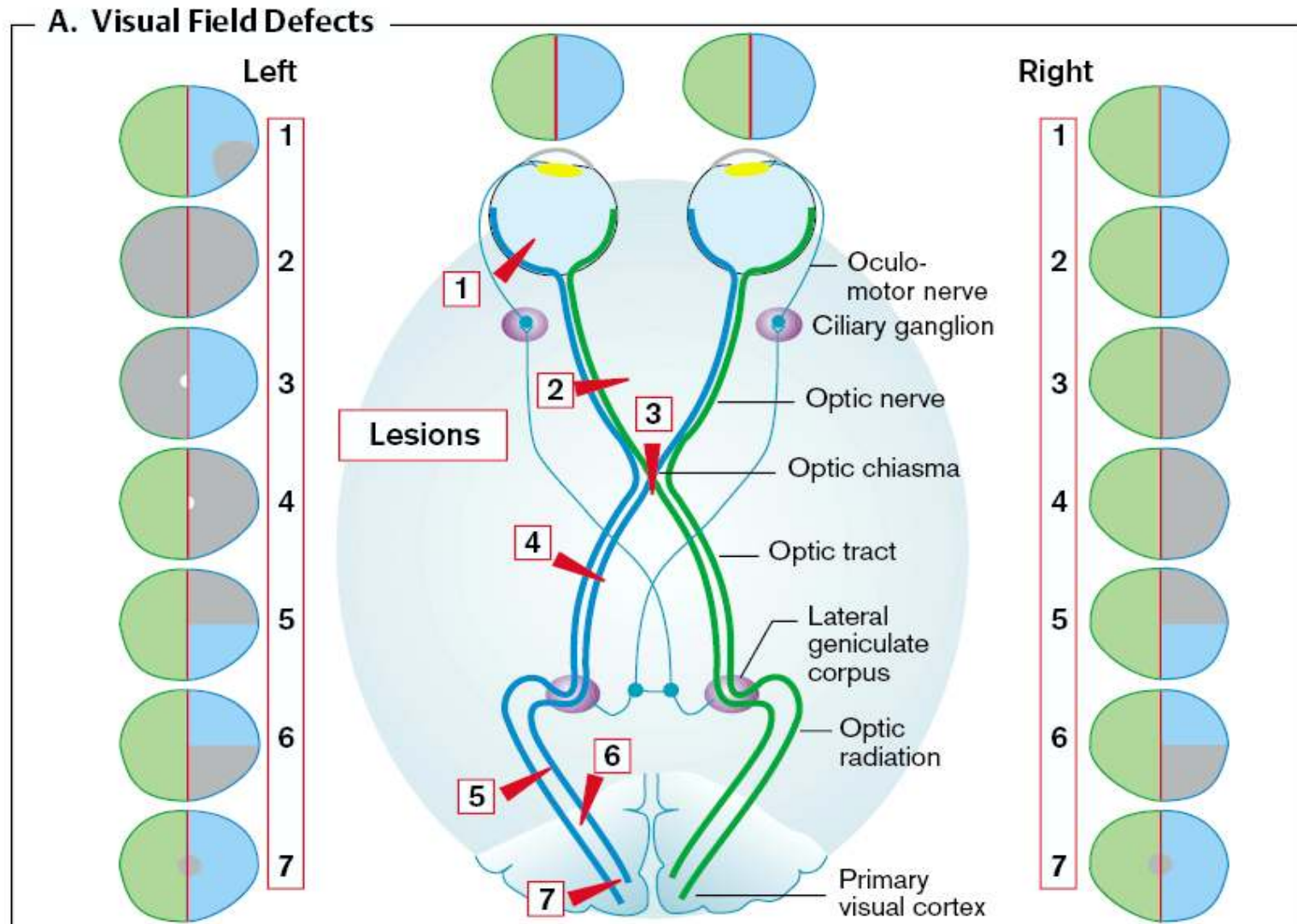
- By Known Object Sizes

- By Parallax (in Disparity and Relative Motion)

D. Cues for depth vision



Visual Fields in Nerve and their Defects

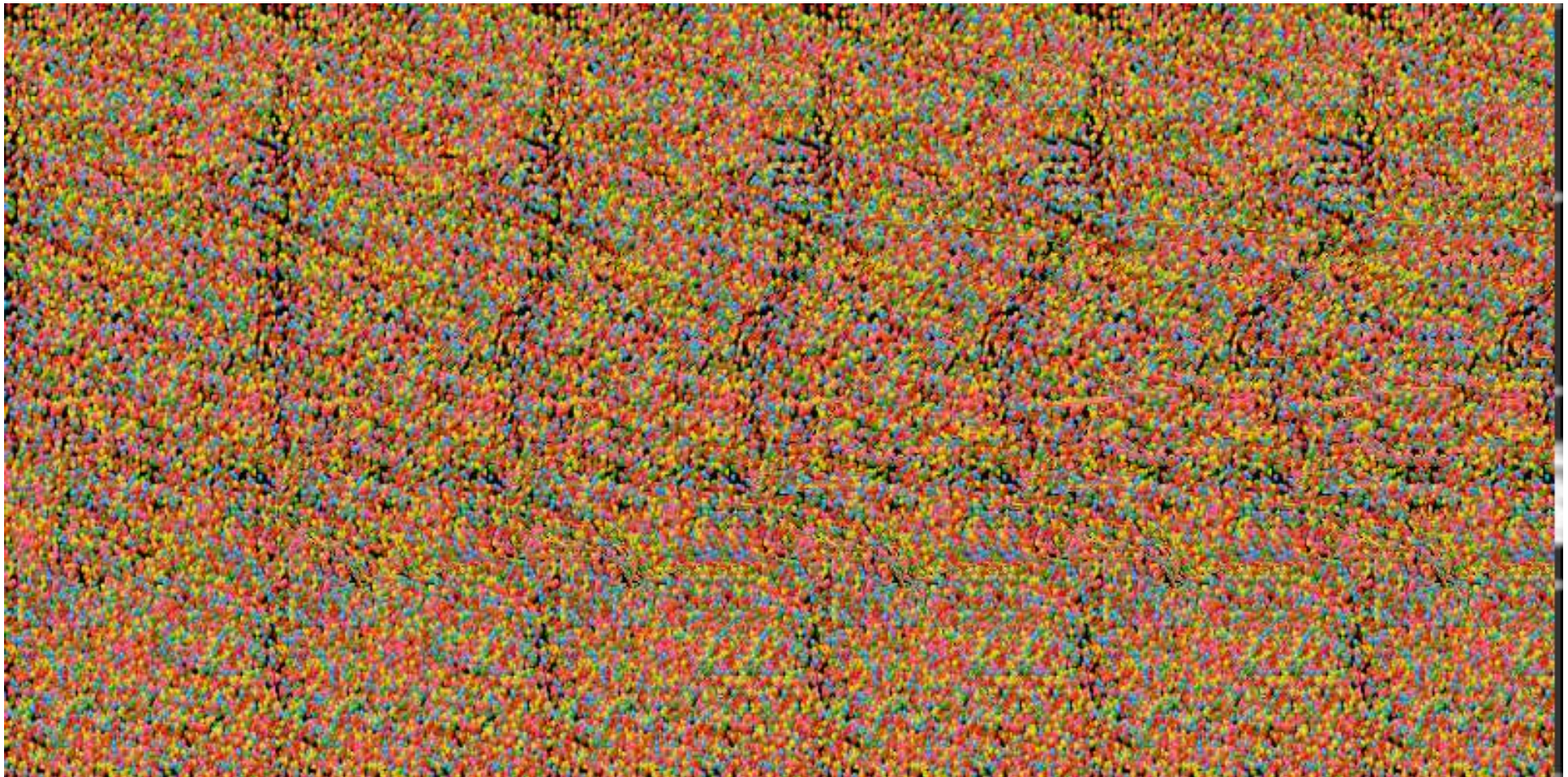


Literary references

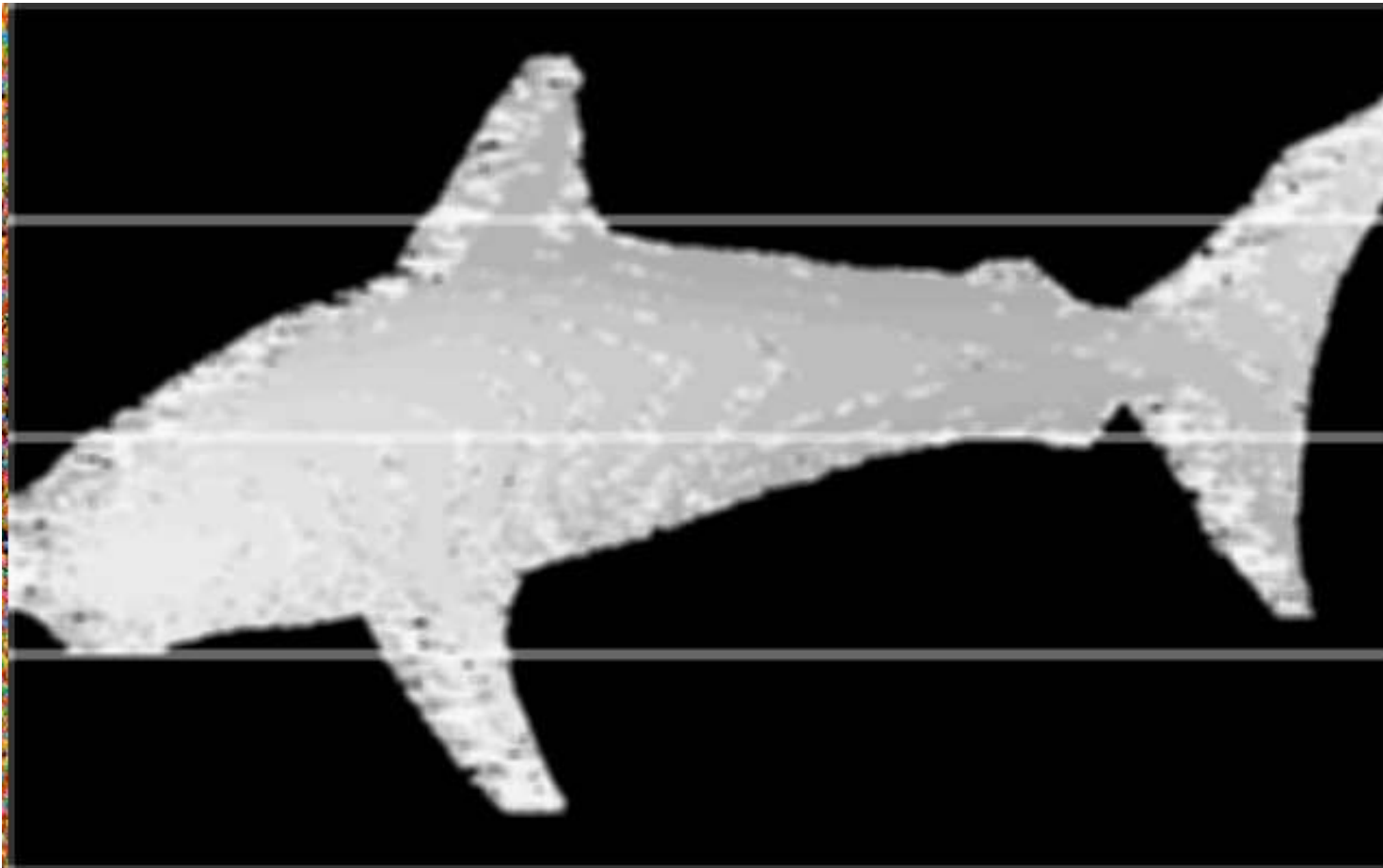
[Despopoulos, Silbernagl,
Color Atlas of Physiology, 1991],
etc

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

Random dot stereogram (autostereogram)



Random dot stereogram (autostereogram)



Other stereoscopic 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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