UNIVERSITAS CAROLINA PRAGENSIS

Charles University in Prague - First Faculty of Medicine

Visual apparatus
Visual pathway
Cortical visual fields

Institute of Anatomy

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Subject: General Medicine and Dentistry - Anatomy 2

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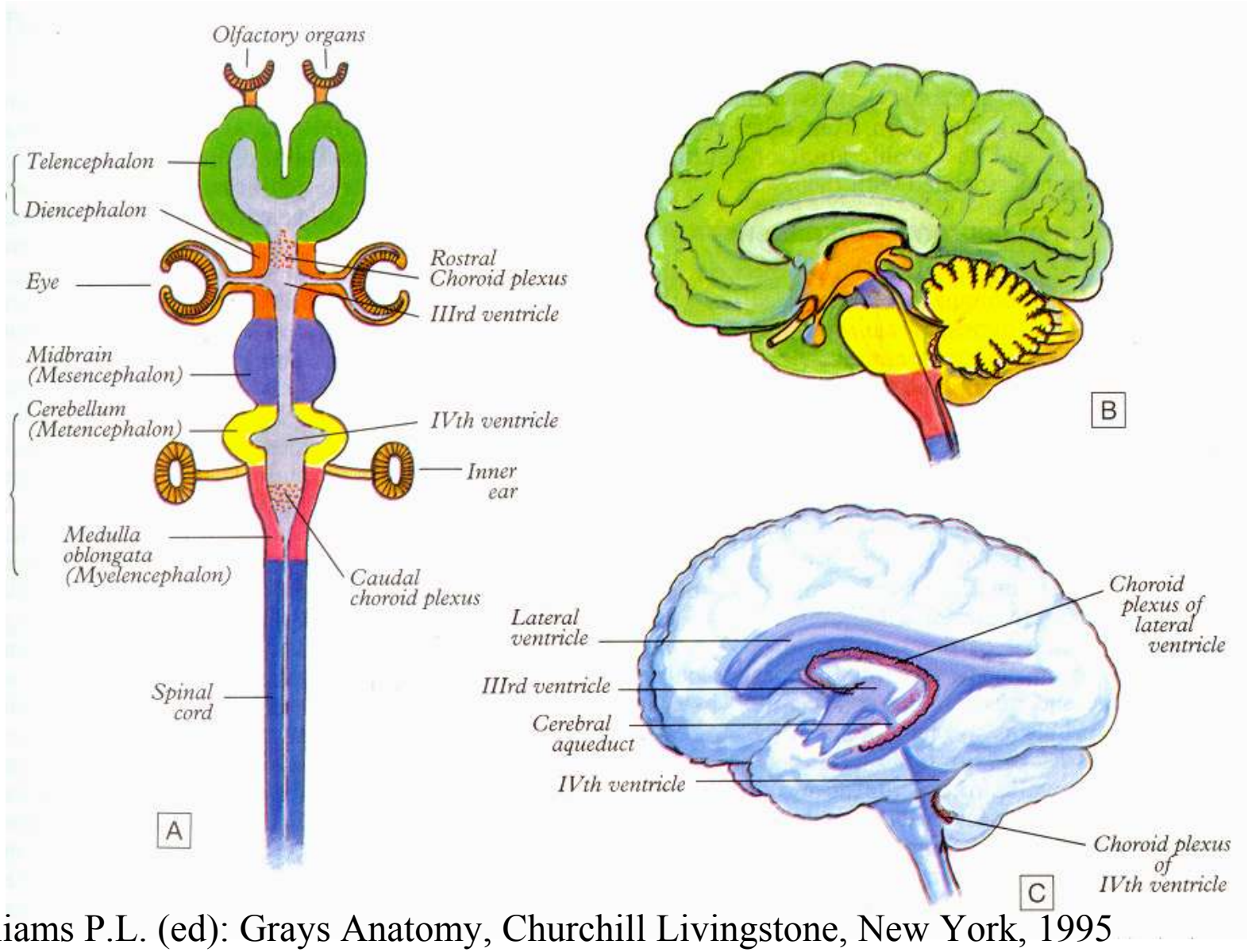
Structure of CNS

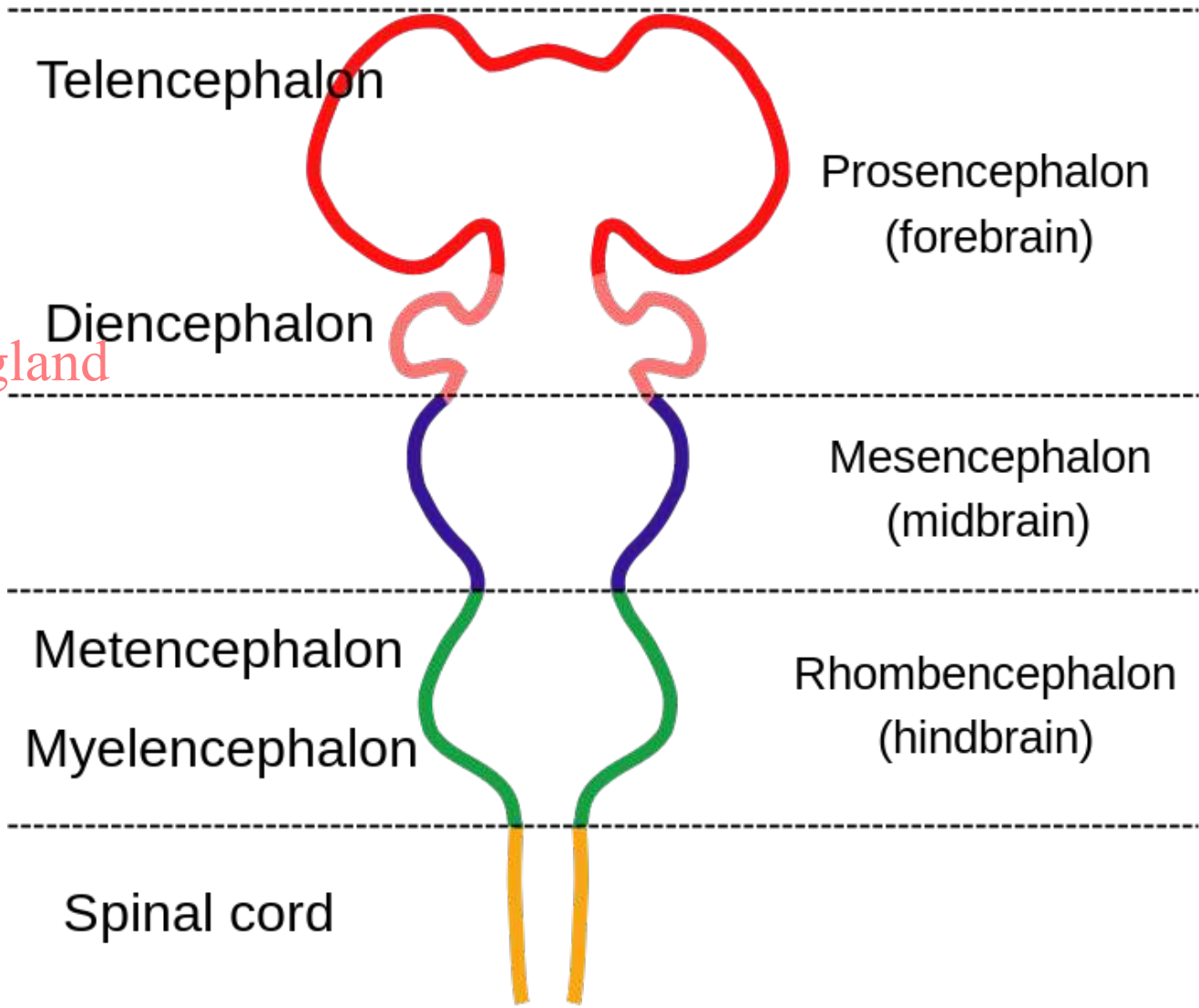


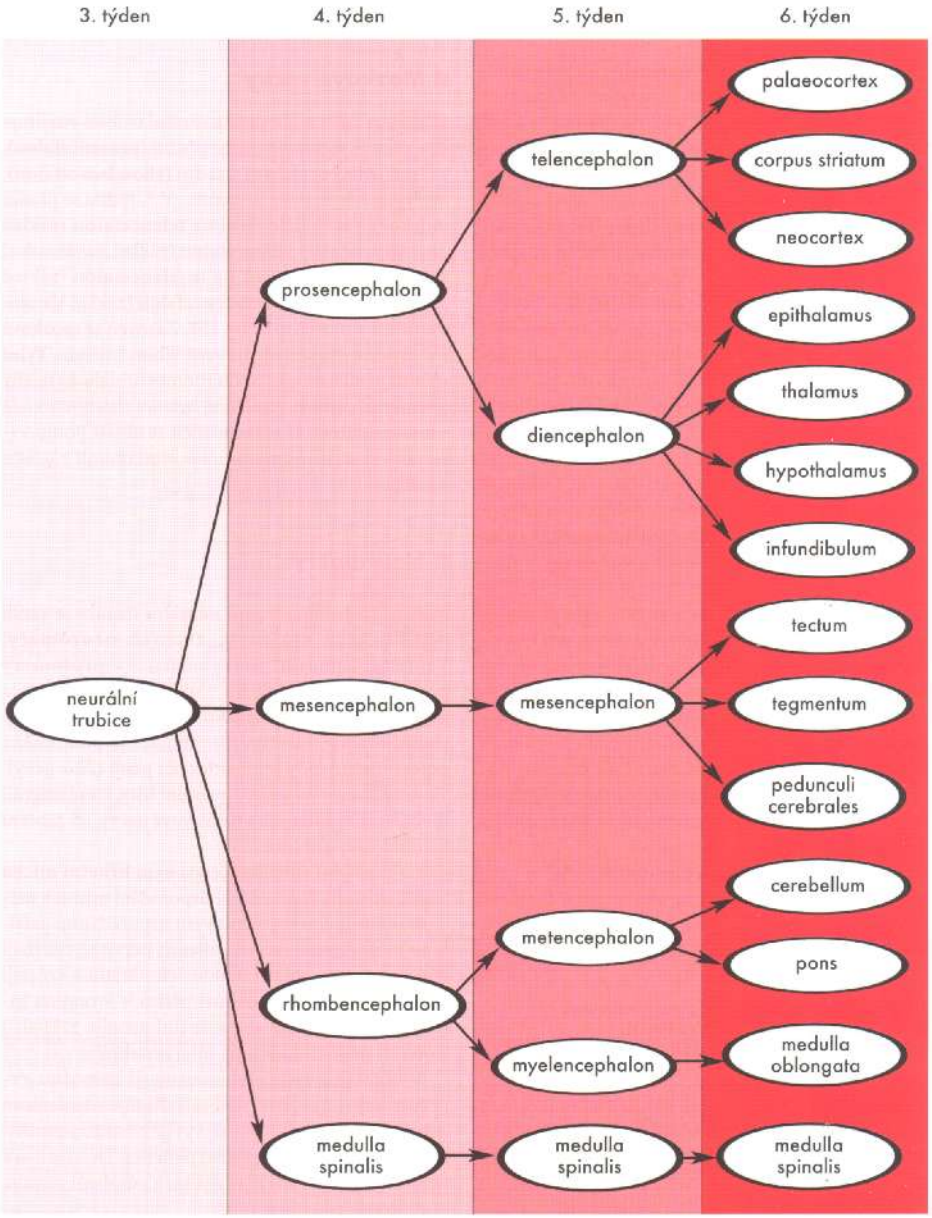
Williams P.L. (ed): Grays Anatomy, Churchill Livingstone, New York, 1995

Brain regions

cortex
basal ganglia

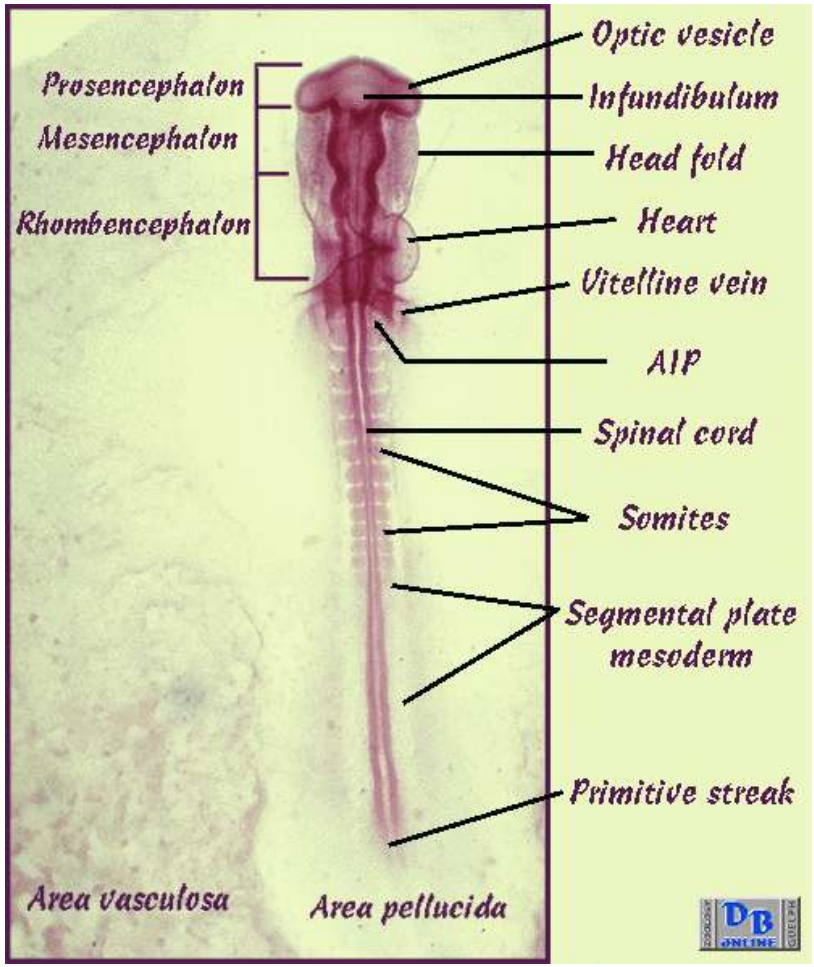
thalamus
hypothalamus
epithalamus - pineal gland
pretectum
metathalamus

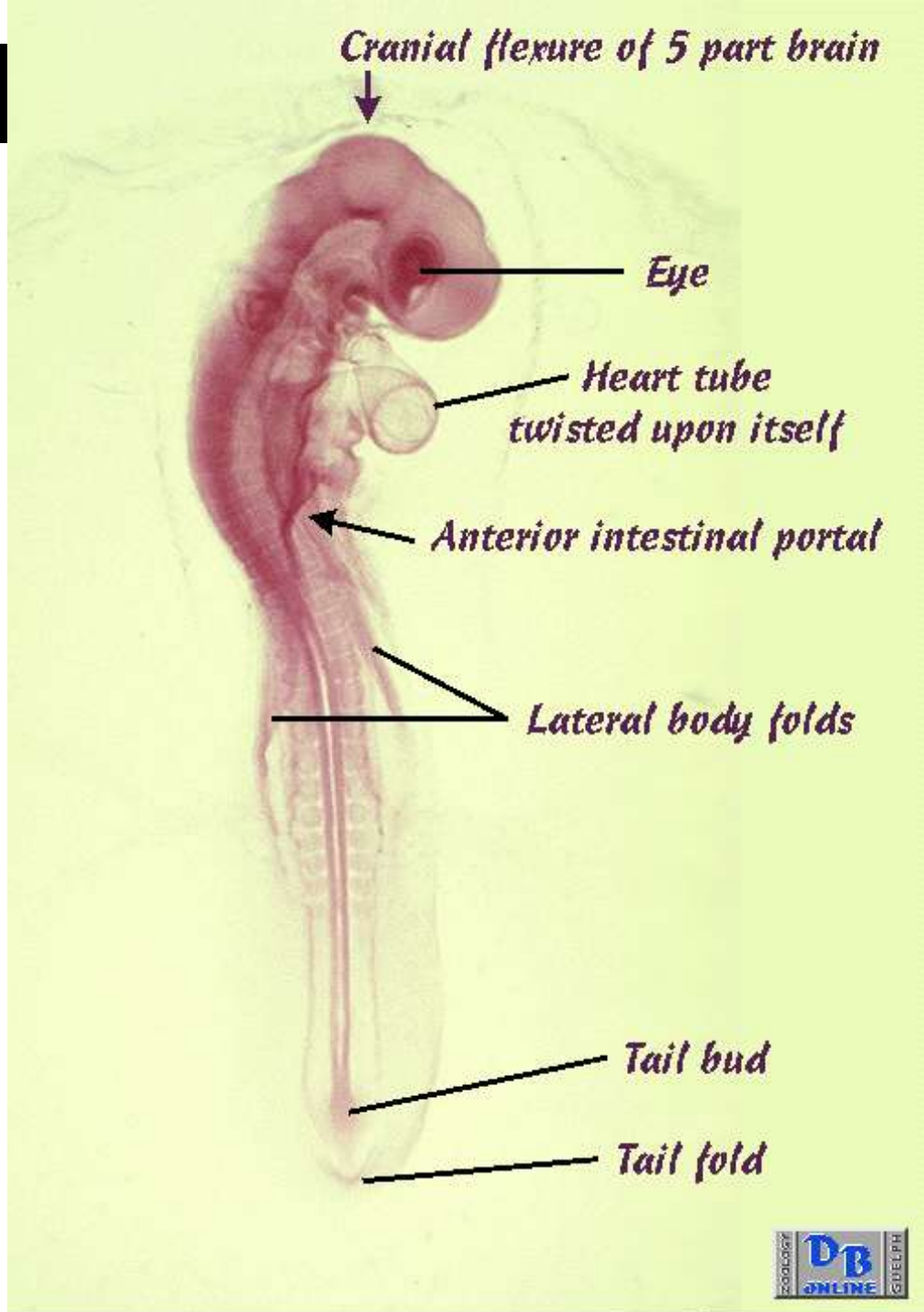




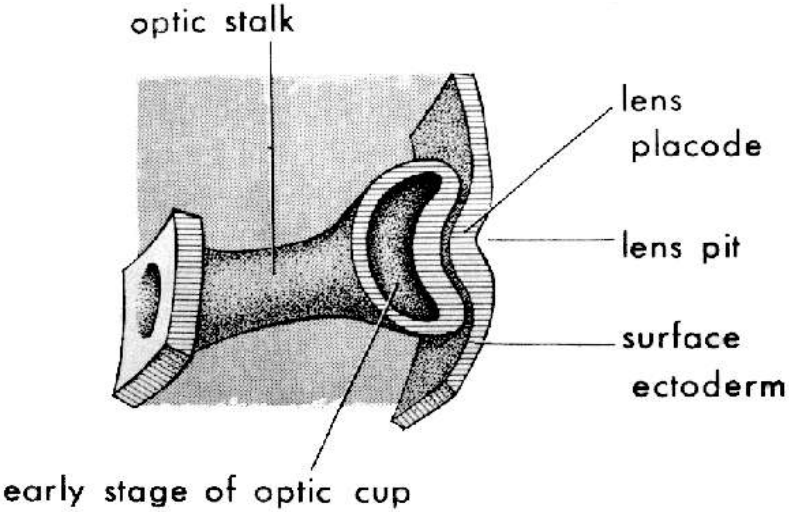
Obr. 157. Postup diferenciace neurální trubice v jednotlivé oddíly CNS v průběhu 3.–6. týdne embryonálního vývoje člověka

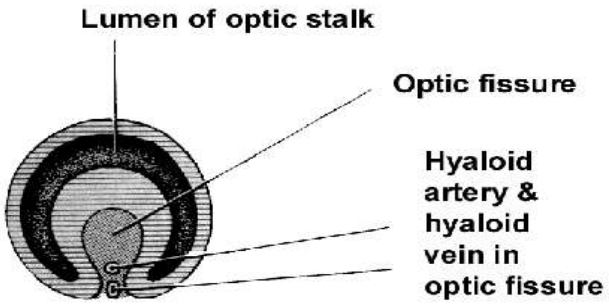
33 & 48 h chick embryo

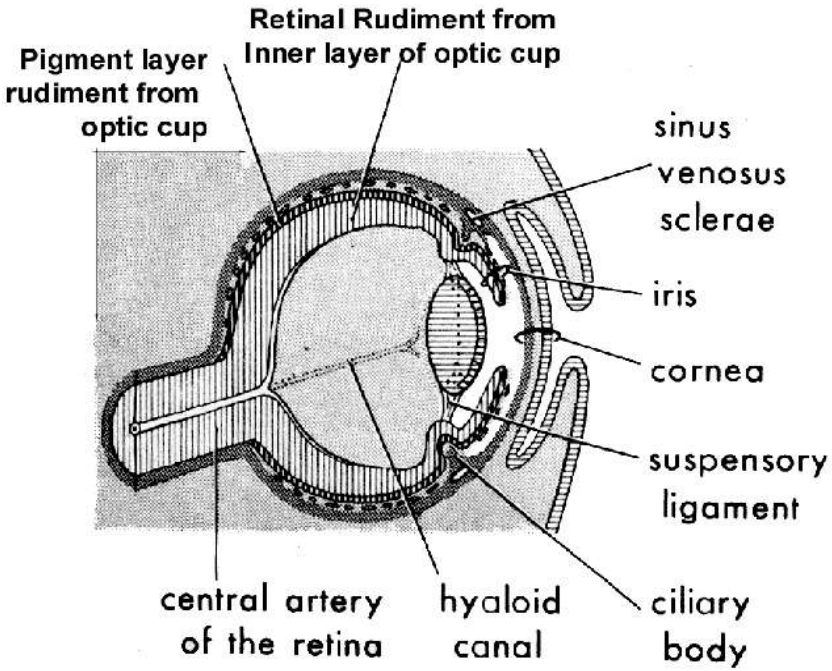


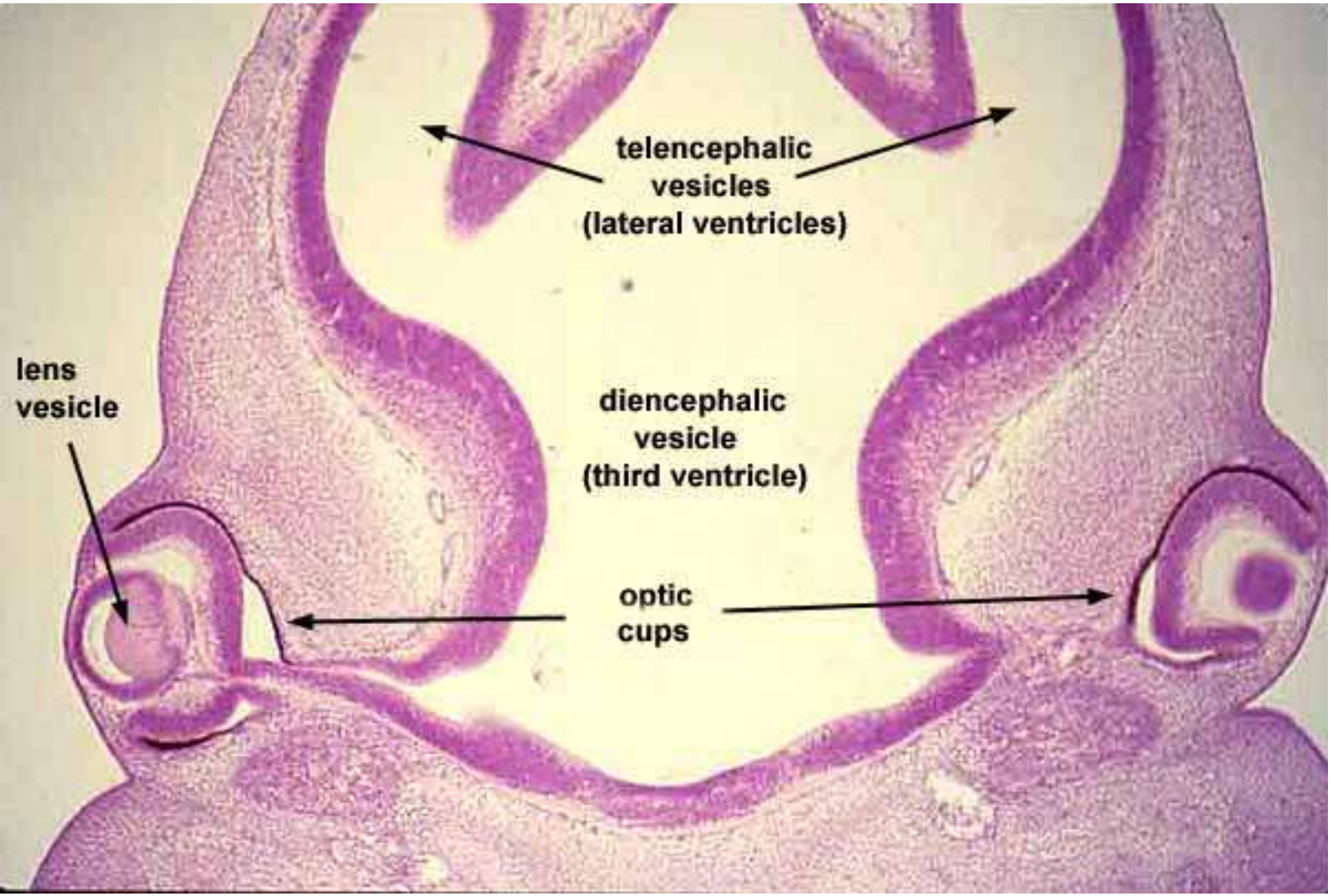


The development of the eye

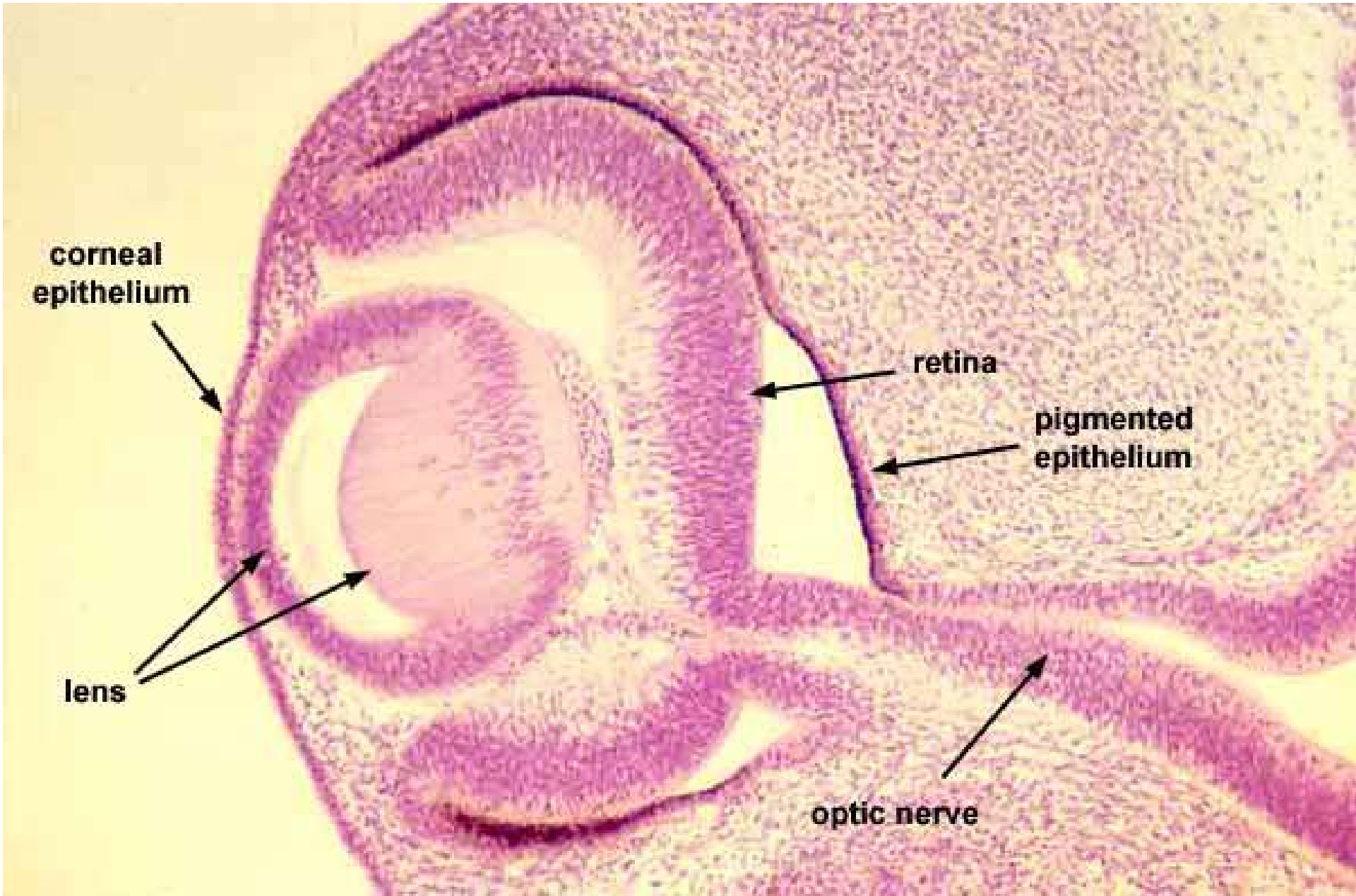




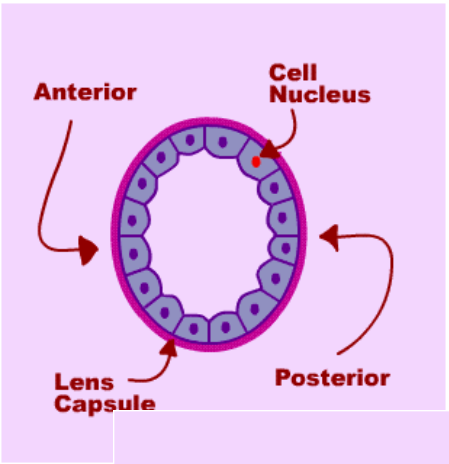


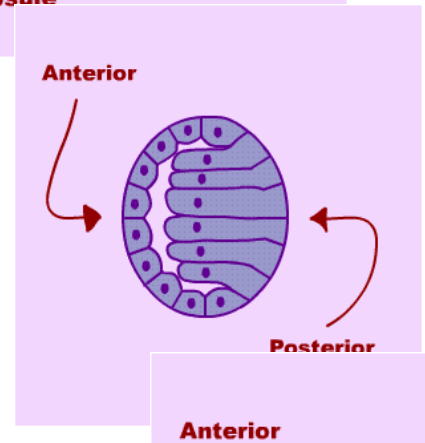


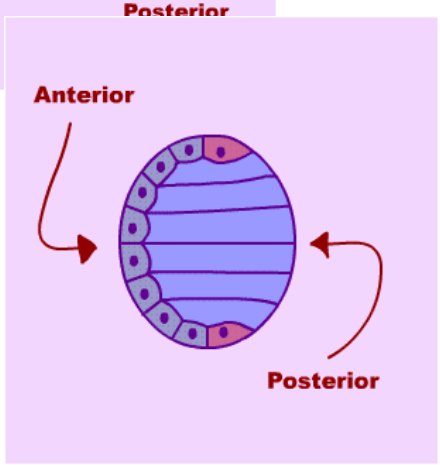
http://www.siumed.edu/~dking2/ssb/EE015b.htm

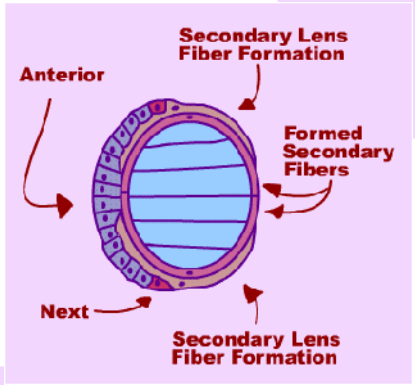

corneal
epithelium
retina
pigmented
epithelium
lens
optic nerve

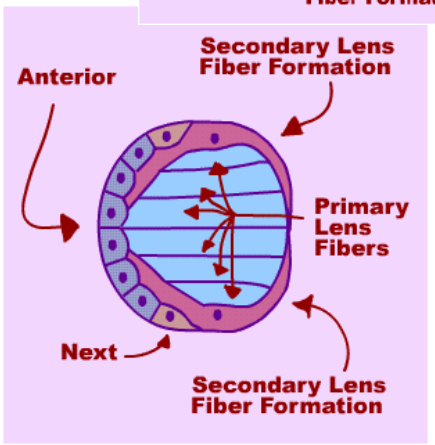
Lens development

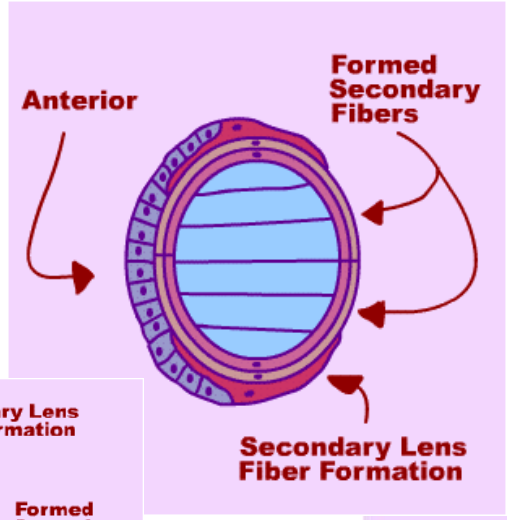


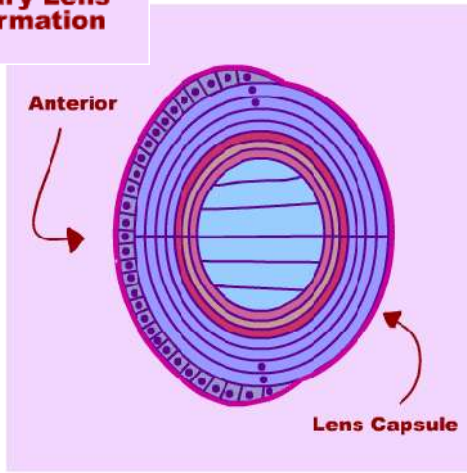






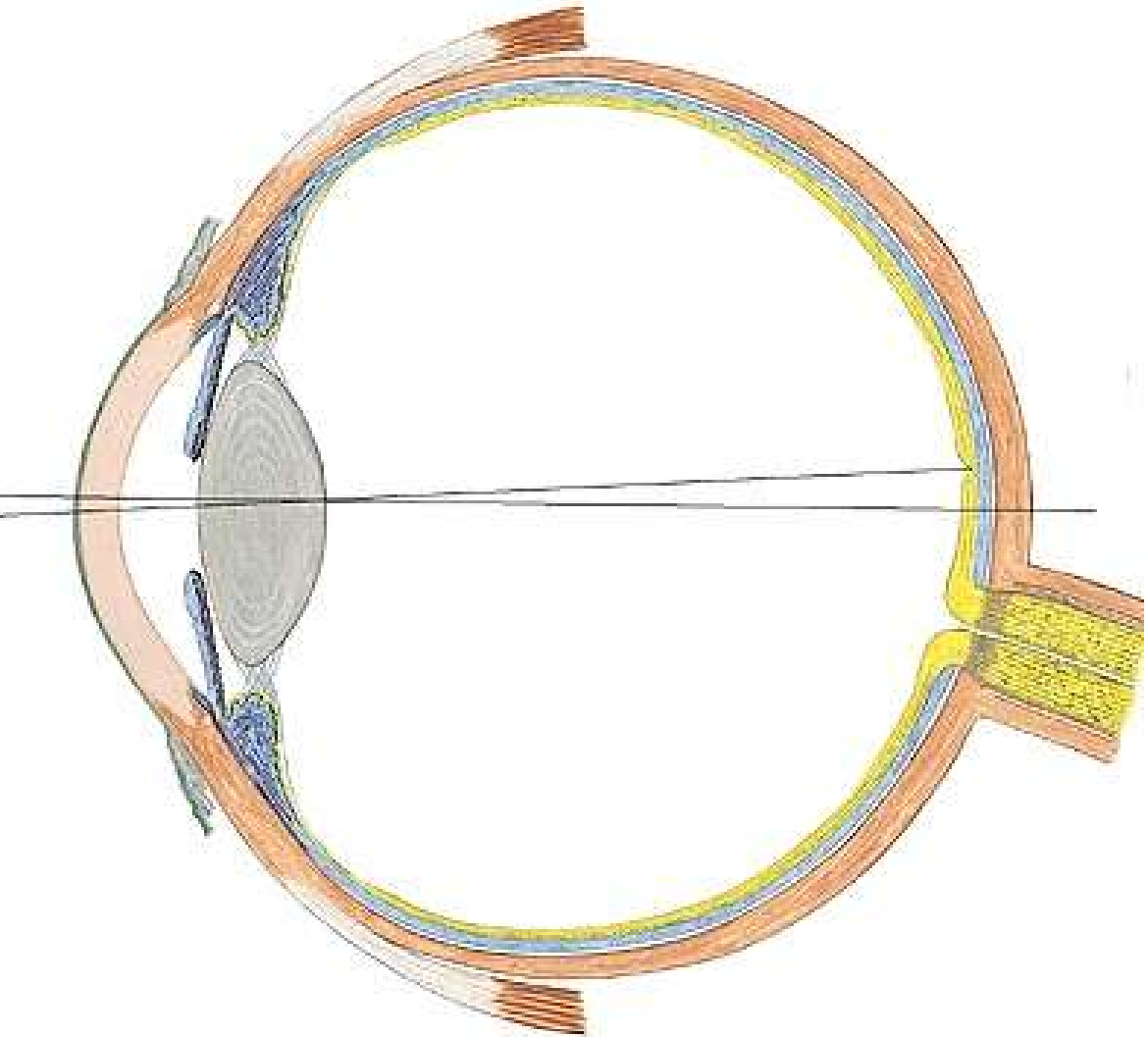






http://www.dogstuff.info/lens_development_kral.html

BULBUS OCULI



1. Tunica fibrosa
sclera; cornea

2. Tunica vasculosa
choroidea; corpus ciliare; iris

3. Tunica interna
pars optica retinae
pars ciliaris et iridica retinae

Vitreous humour, lens, chambers, extraocular muscles, eyelids, lacrimal apparatus

The Fibrous Tunic

- Most **EXTERNAL layer** of the eyeball
  - Composed of two regions of connective tissue
    - **Sclera** – posterior five-sixths of the tunic
      - White, opaque region
      - Provides shape and an anchor for 6 eye muscles
    - **Cornea** – anterior one-sixth of the fibrous tunic
    - Limbus – junction between sclera and cornea (stem cells)
    - Scleral venous sinus – allows aqueous humor to drain (Glaucoma! High eyeball pressure)

The Vascular Tunic

- The **MIDDLE layer** of the eyeball
- Composed of **choroid, ciliary body, and iris**
- **1. Choroid** – vascular, darkly pigmented membrane
  - Forms posterior five-sixths of the vascular tunic
  - Brown color – from melanocytes
  - Prevents scattering of light rays within the eye
- Choroid corresponds to the arachnoid and pia maters (**therefore sclera corresponds to …**)

Eyelid development

Eyelids fused by 9 weeks of development.
Week 20 – opening begins.

http://onlinelibrary.wiley.com/doi/10.1002/ar.21366/pdf

VISUAL PATHWAY

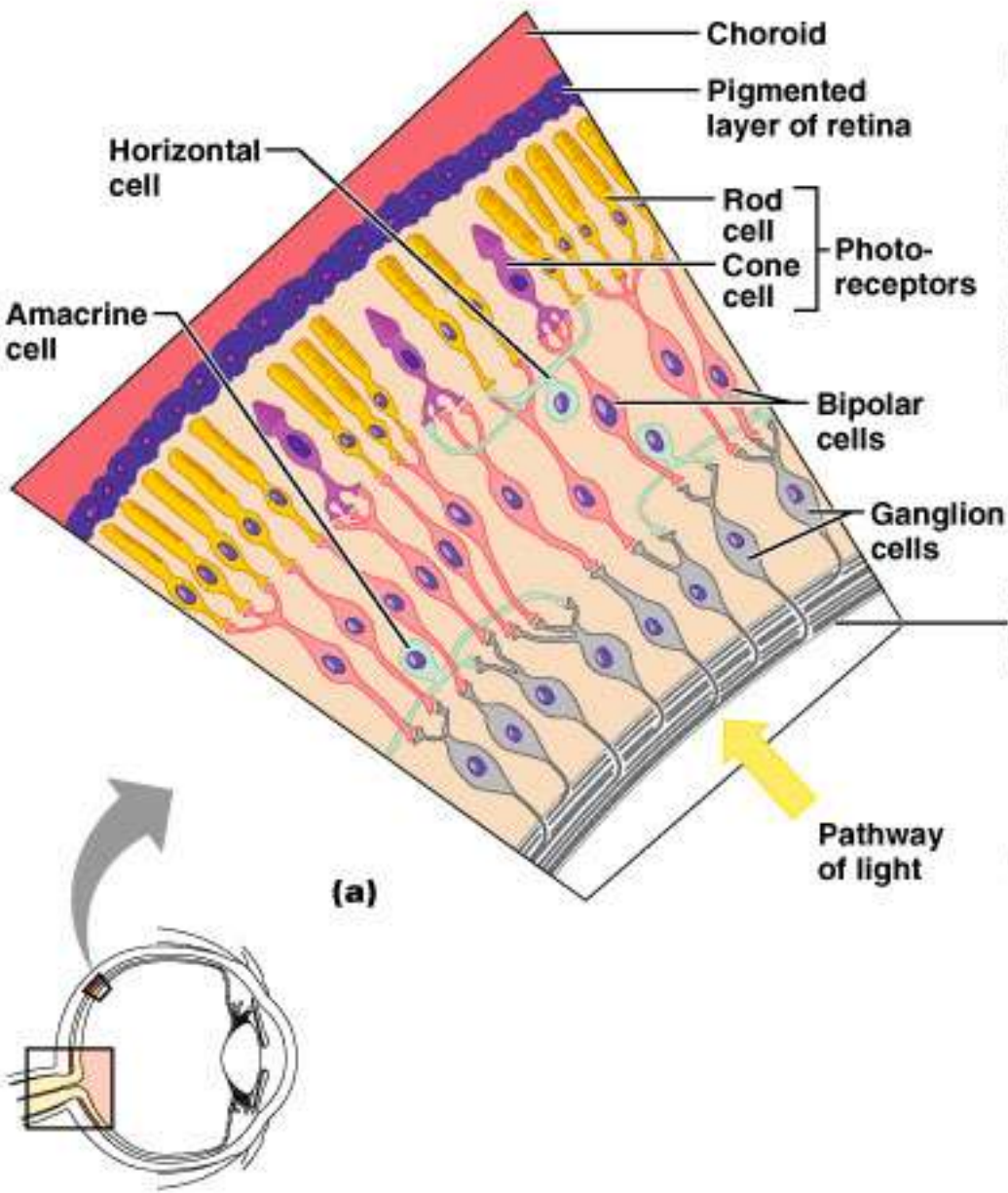
1.,2.,3. N – rods and cones, bipolar cells, ganglion cells (+ horizontal and amacrine).

4. N – corpus geniculatum laterale, tr. geniculo-corticalis (radiatio optica) to area 17

5. N – cell in area 17 (V_1)

The Sensory Tunic - RETINA

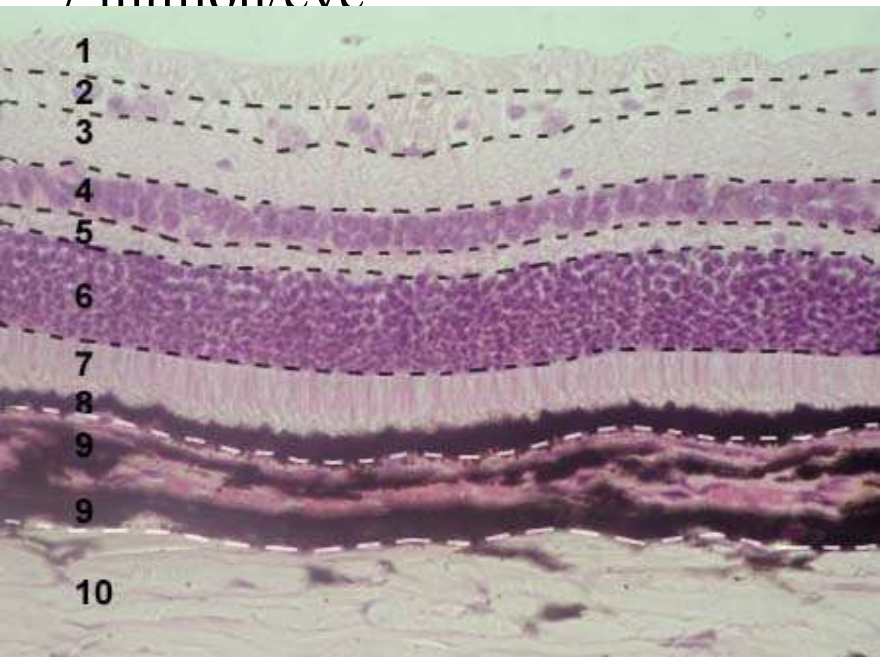
- the <u>DEEPEST layer</u>
- Composed of two layers
  - Pigmented layer – single layer of melanocytes
  - Neural layer – sheet of nervous tissue
    - Contains three main types of neurons
      - Photoreceptor cells
      - Bipolar cells
      - Ganglion cells

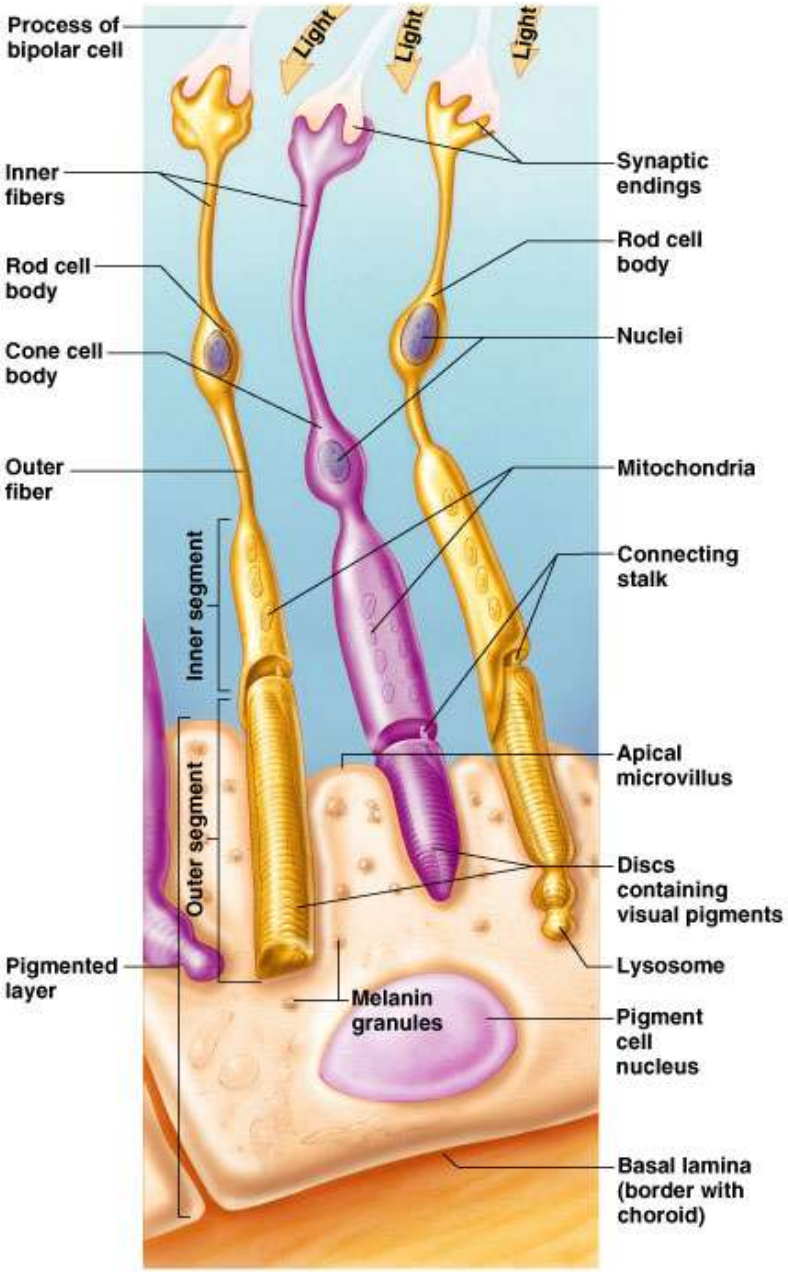


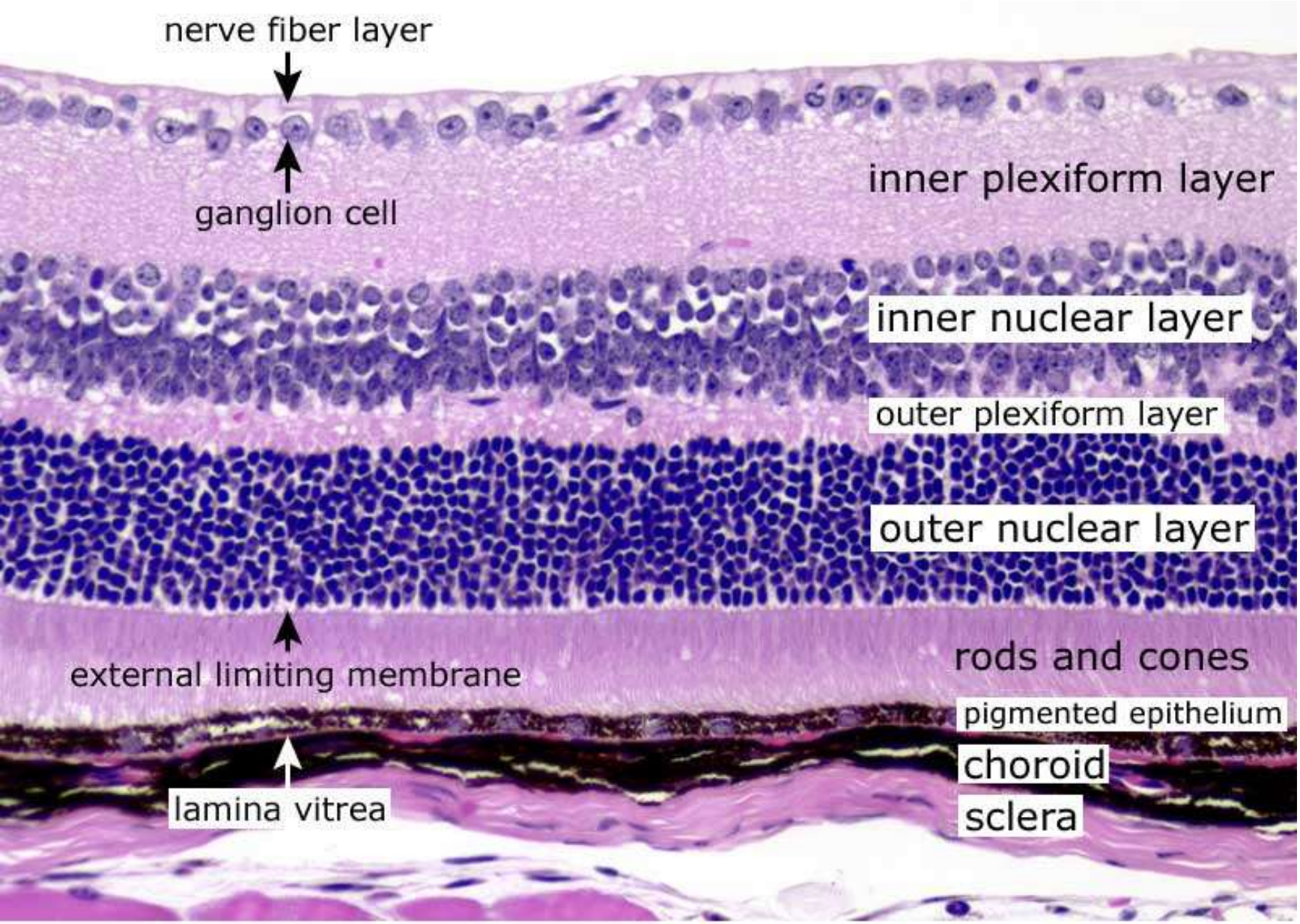
RETINA - Photoreceptors

- **Rod cells** – more sensitive to light
  - vision in dim light
  - 120million/eye
- **Cone cells** – operate best in bright light

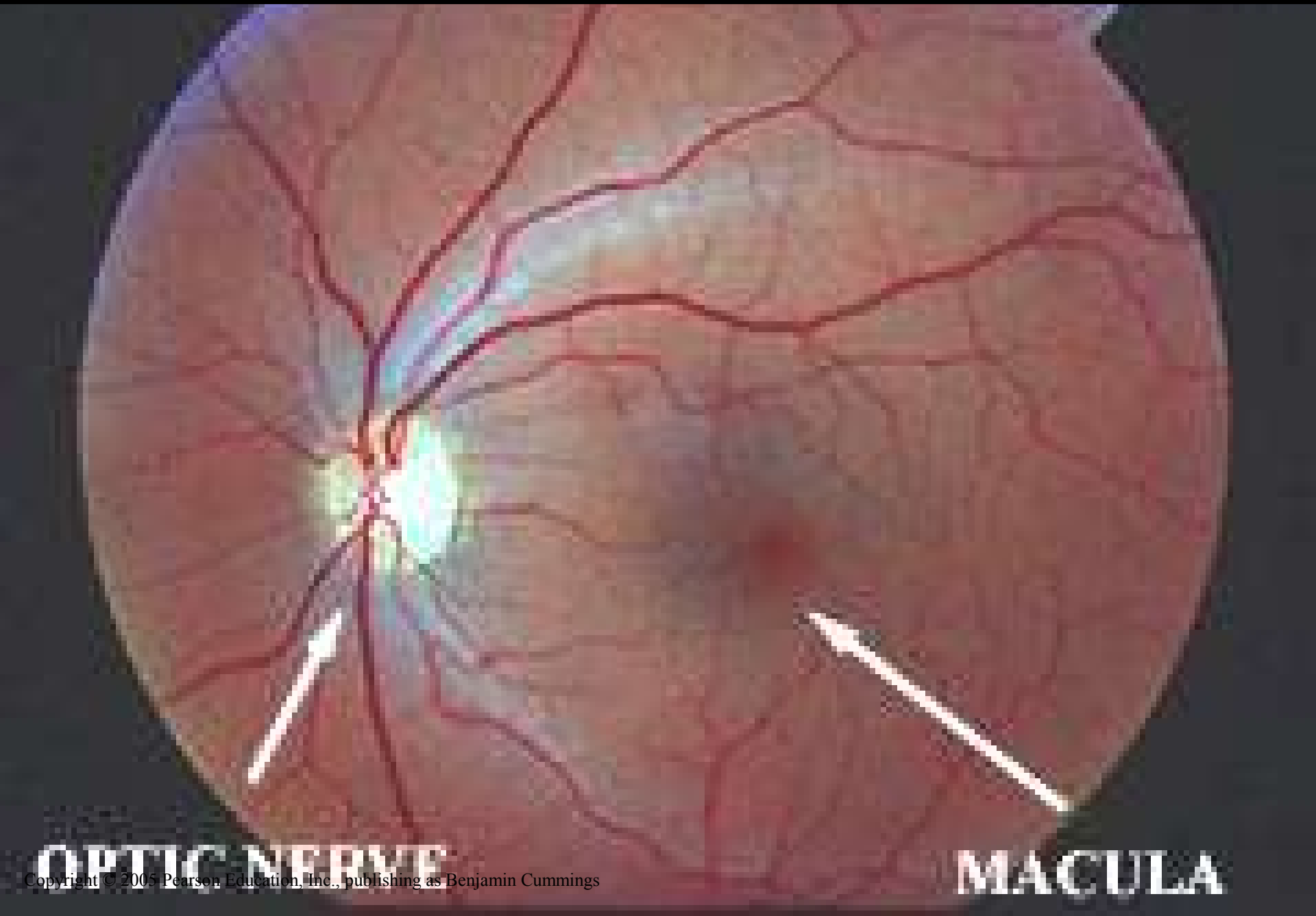
- high-acuity color vision
- 7 million/eye

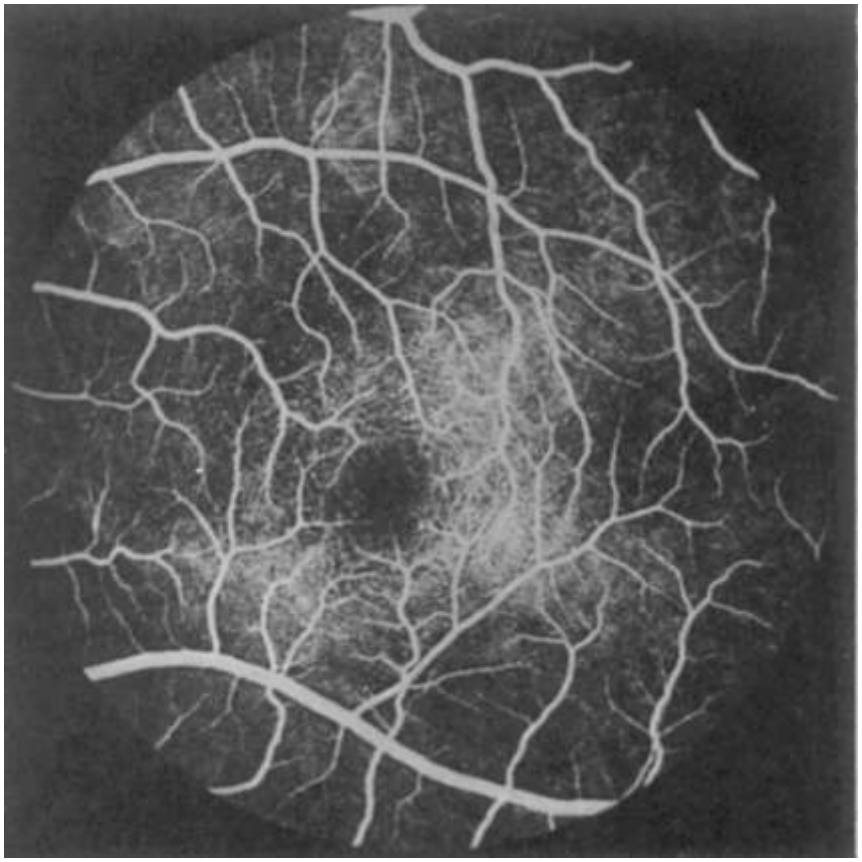






Normal Opthalmoscopic View of Eye

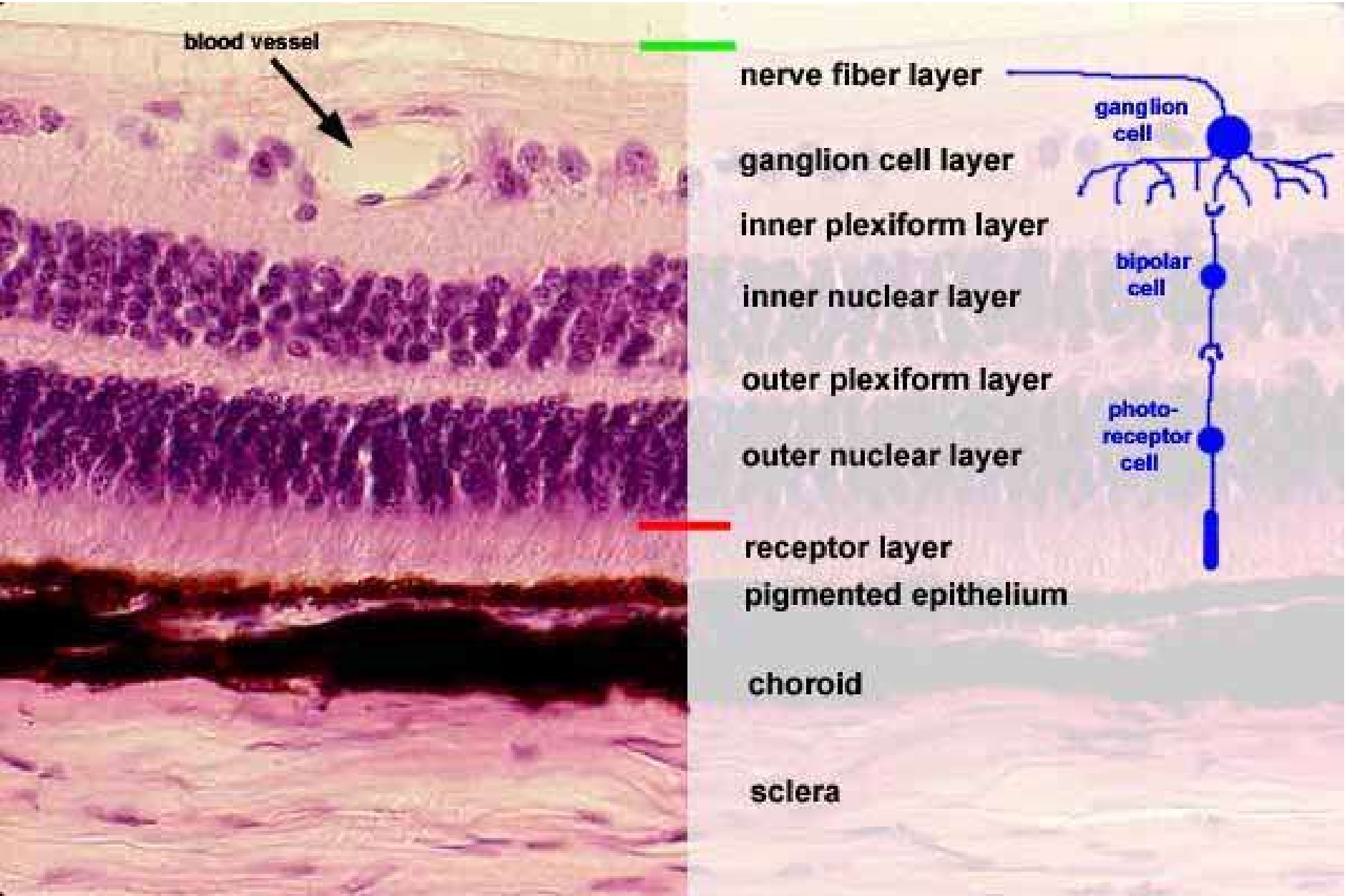




Macula lutea

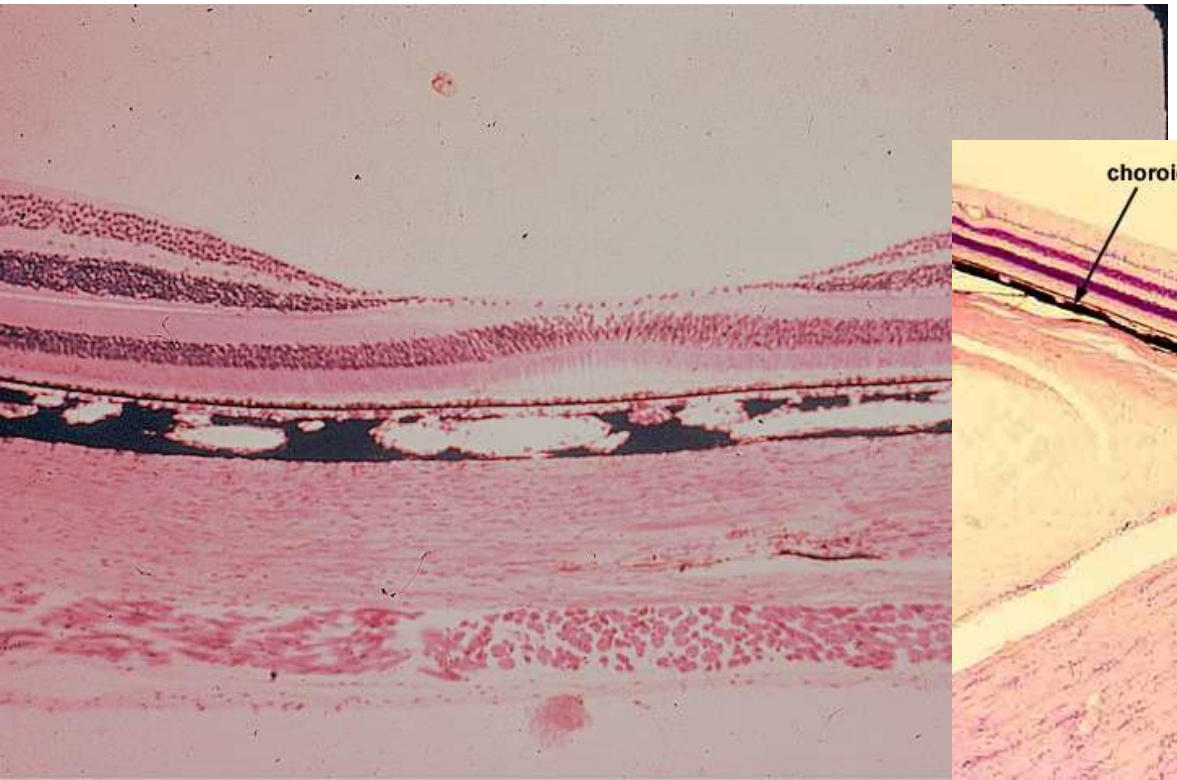
Wiliams P.L. (Ed) Gray´s Anatomy. Churchill Livingstone, New York, 1995

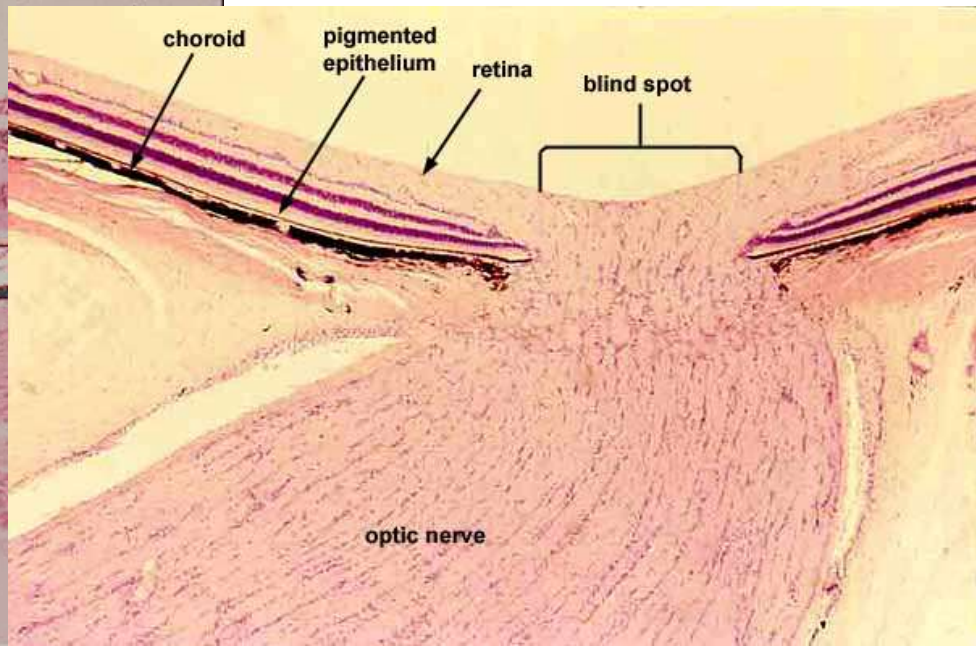
a.+v. centralis retinae



RETINA – macula lutea

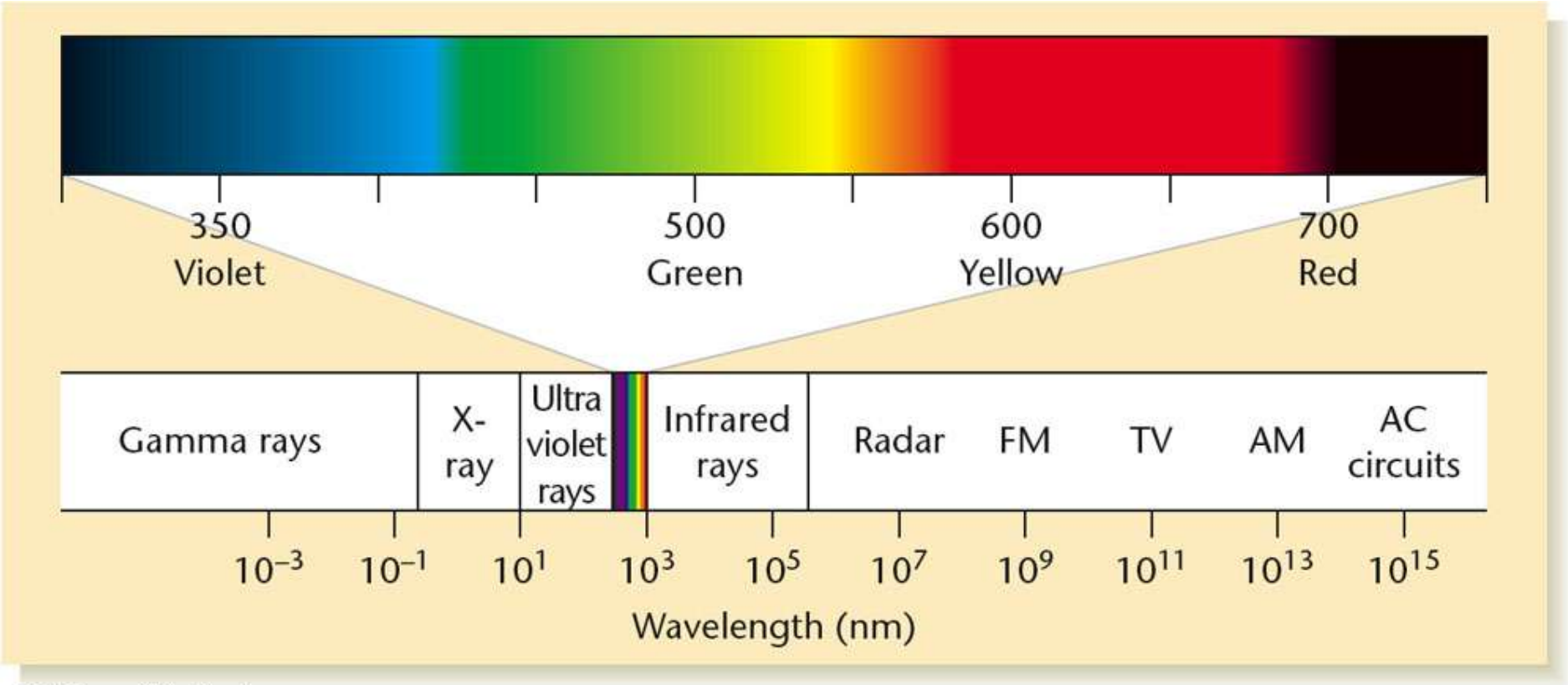
- **Macula lutea** – very few blood vessels, contains *mostly* cones
- Its center - **fovea centralis** – contains only cones
    - Region of highest visual acuity
- **Optic disc** – blind spot, where optic nerve leaves.





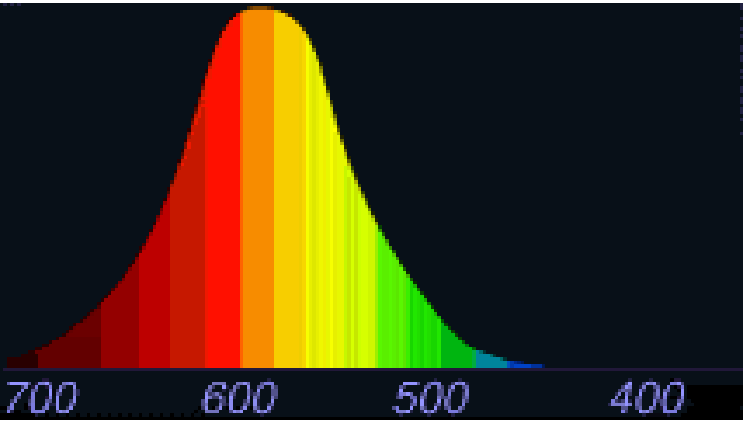
BLIND SPOT

400-700nm

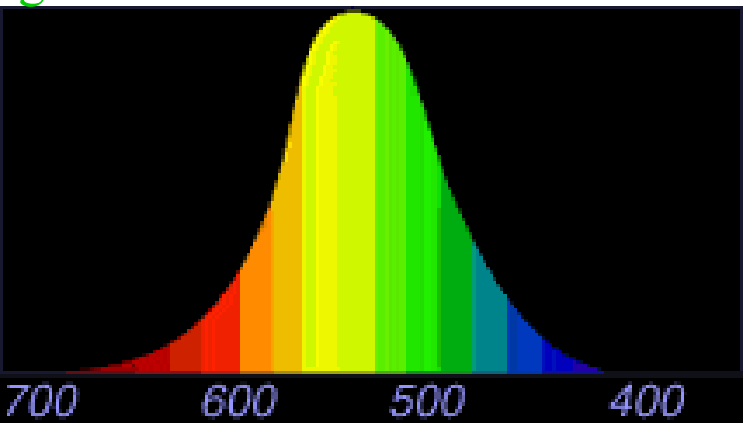


CONES – colour vision

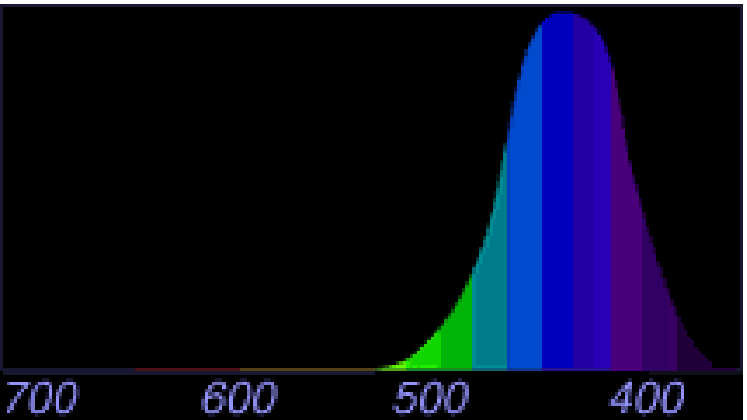
"red" or "L" cones long wavelength light



"green" or "M" medium



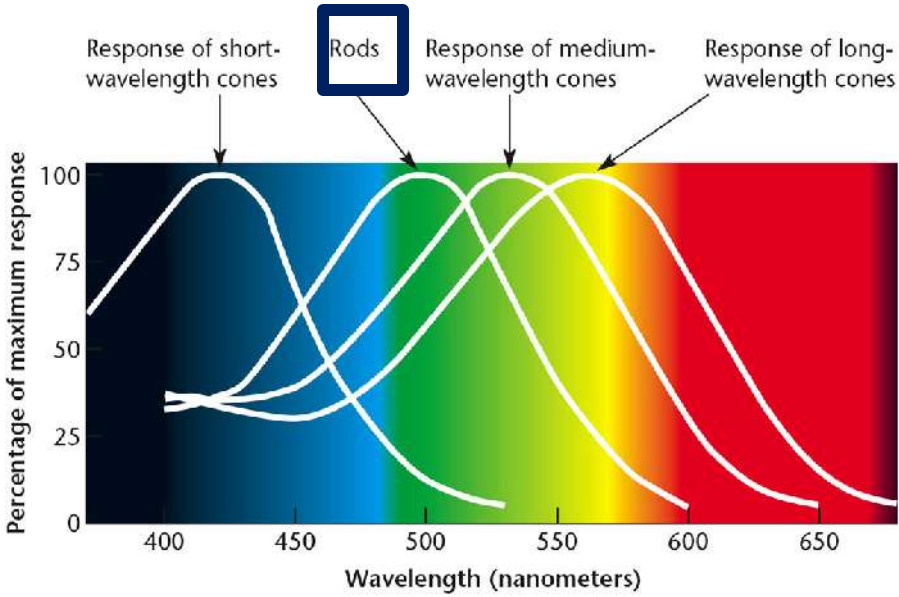
"blue" or "S" cones short

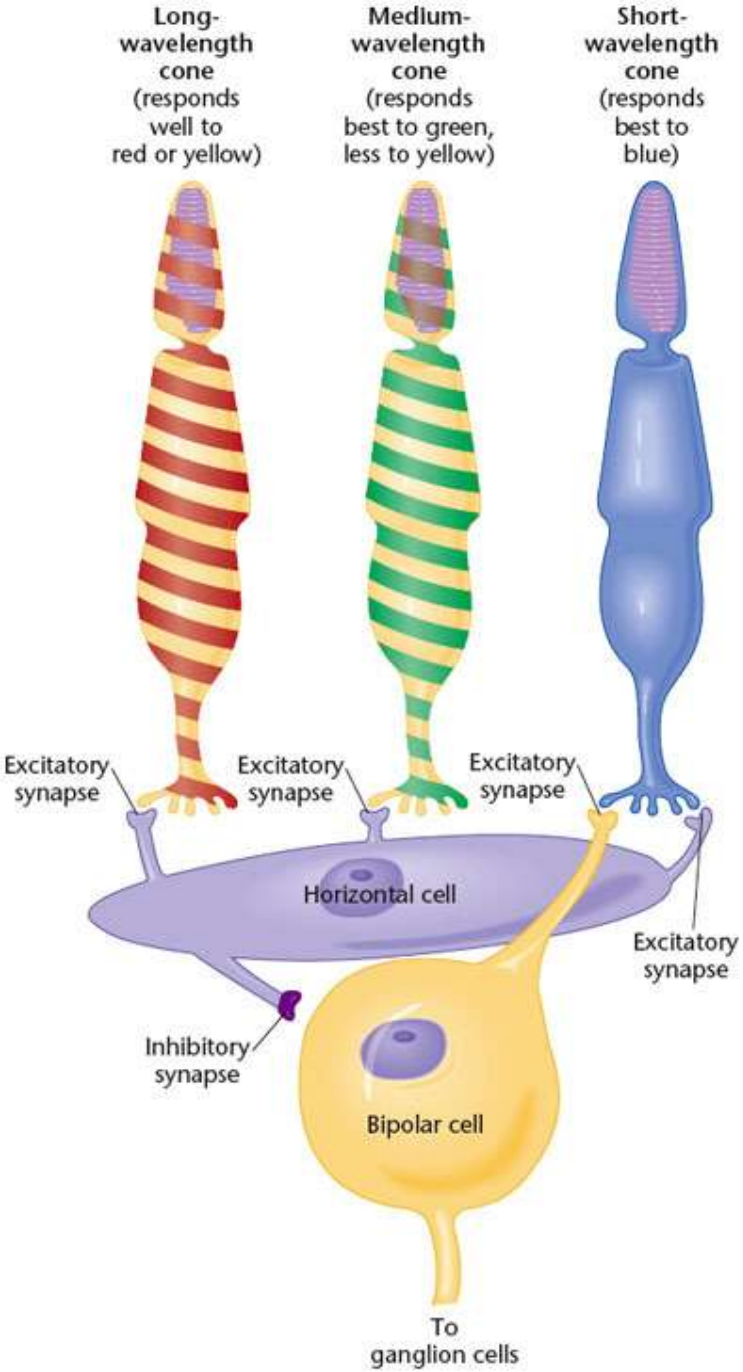


Trichromatic theory - the comparison begins in the retina ((optic nerve has only 1million axons)), where signals from "red" and "green" cones are compared by specialized red-green cells "opponent-process theory".

- compute the balance between red and green light coming from a particular part of the visual field

Defect of one or more types of cones - COLOURBLINDNESS





- Lateral inhibition is the reduction of activity in one neuron by activity in neighboring neurons.
- responsible for heightening contrast in vision

The Photoreceptors: PHOTOTRANSDUCTION

- Rods and cones contain photopigments- chemicals that release energy when struck by light.

  Photopigments consist of 11-*cis*-retinal (derivative of Vitamin A) which is bound to opsin (a protein).

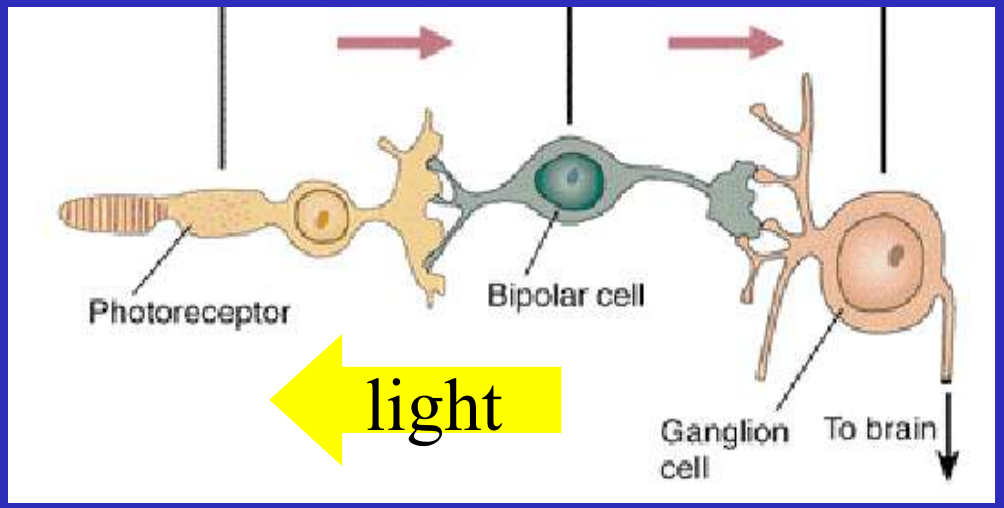
  Light converts 11-*cis*-retinal to all-*trans*-retinal, which ultimately activates 2nd messenger systems that work to close Na+ channels, hyperpolarizing the receptor.

  More light = hyperpolarization

The Photoreceptors: PHOTOTRANSDUCTION

Photoreceptors input to retinal bipolar cells, which input to retinal ganglion cells.

Photoreceptors and bipolar cells do not produce action potentials. They produce graded potentials.

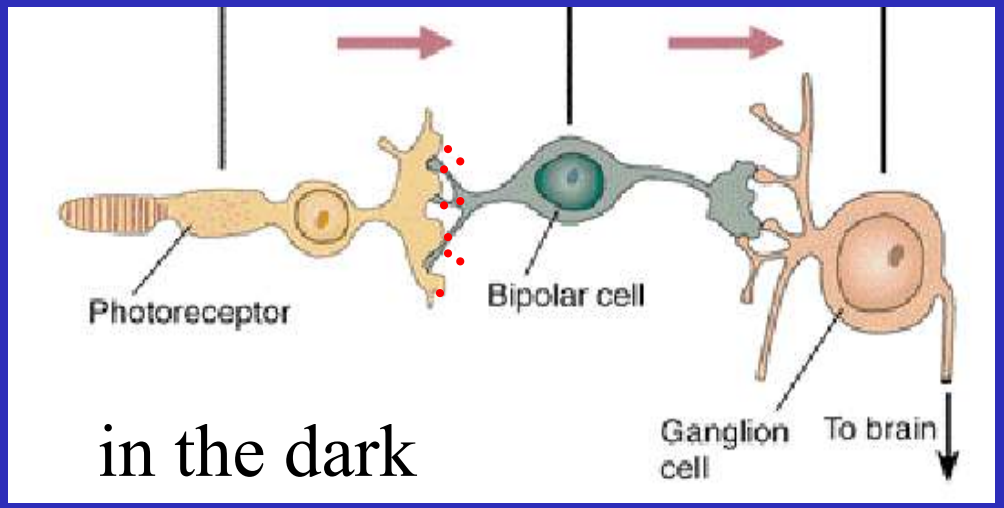


Retinal ganglion cells produce action potentials.

The Photoreceptors: PHOTOTRANSDUCTION

At rest, (i.e. in the dark) photoreceptors continuously release neurotransmitter (glutamate).

Glutamate hyperpolarizes some bipolar cells, and depolarizes other bipolar cells.



Some bipolar cells provide hyperpolarizing input to ganglion cells, and some bipolar cells provide depolarizing input.

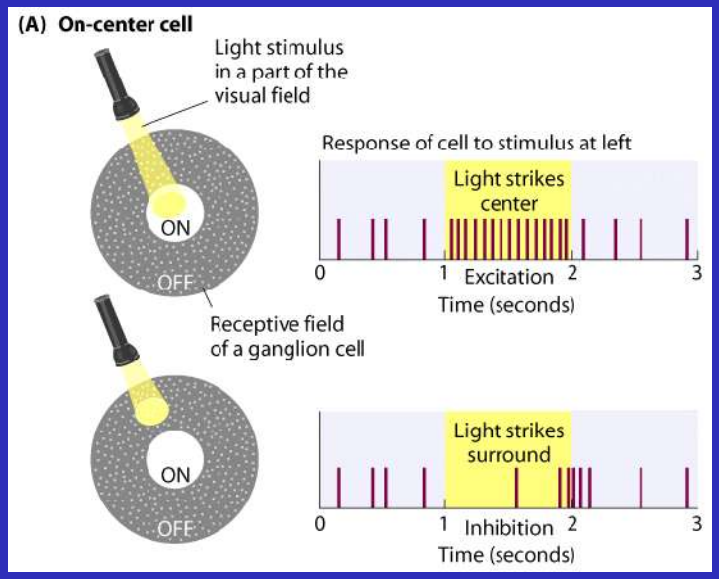
Processing in the Retinal Ganglion Cell

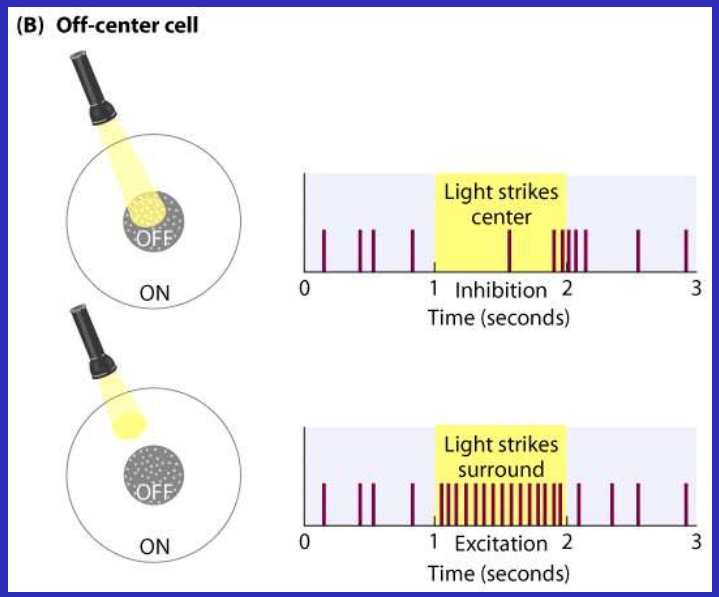
Each ganglion cell ONLY responds to the presence or absence of light in its receptive field

Receptive field is the area of visual space to which a given cell responds
•GGanglion cell receptive fields are circular.

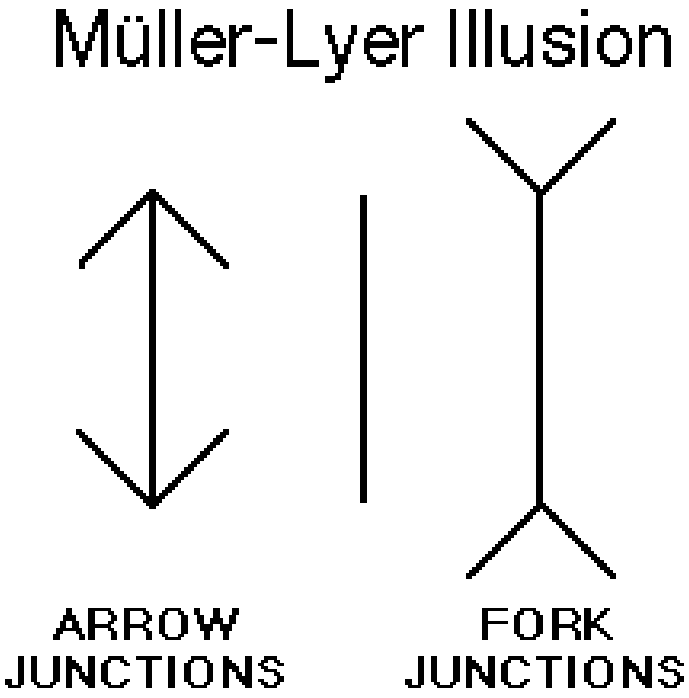
Ganglion cell receptive fields have a concentric antagonistic surround.

on-center cells→ mostly excited by light falling on the center of the receptive field
off-center cell → mostly excited by light in the surround.

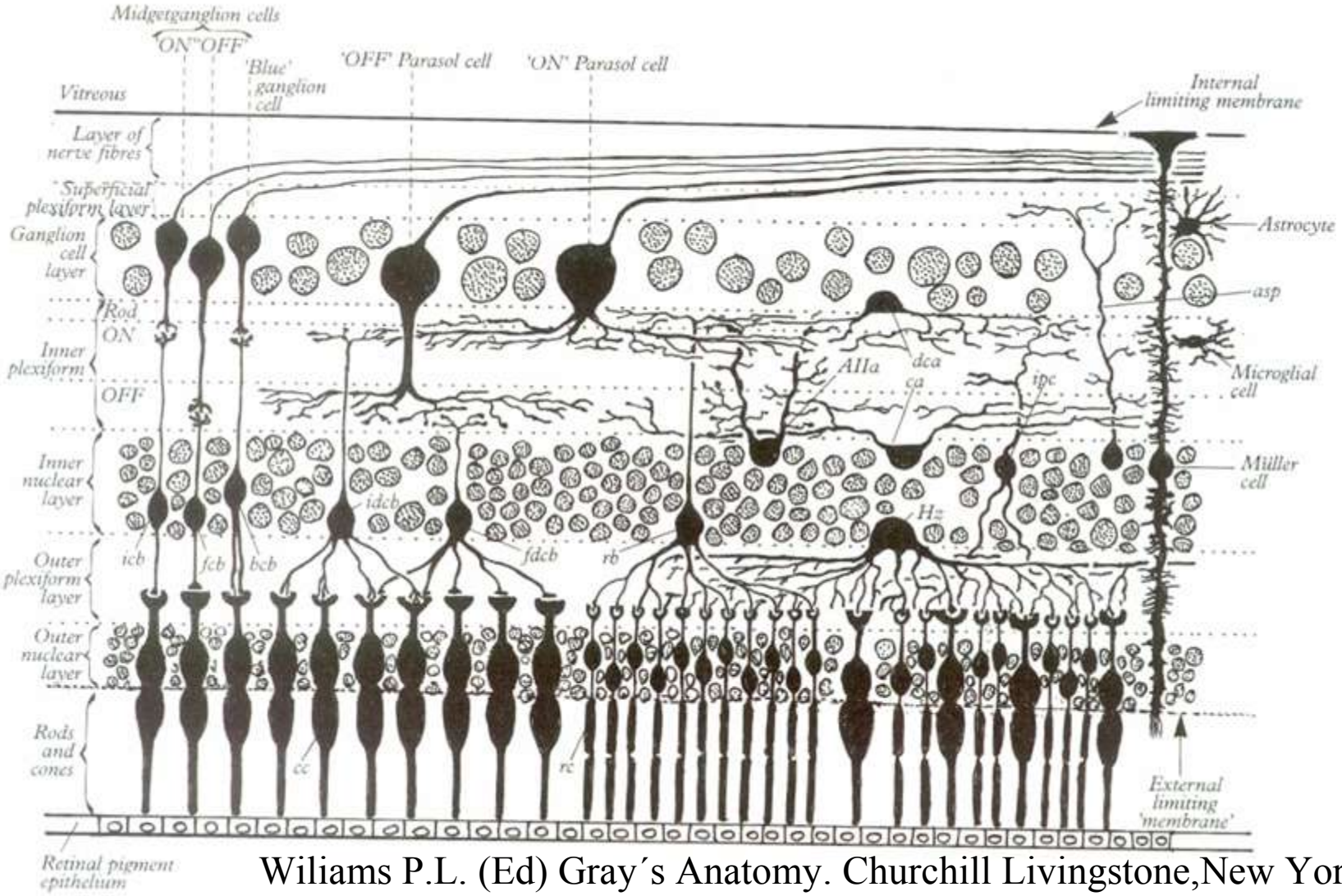




Geometric illusions



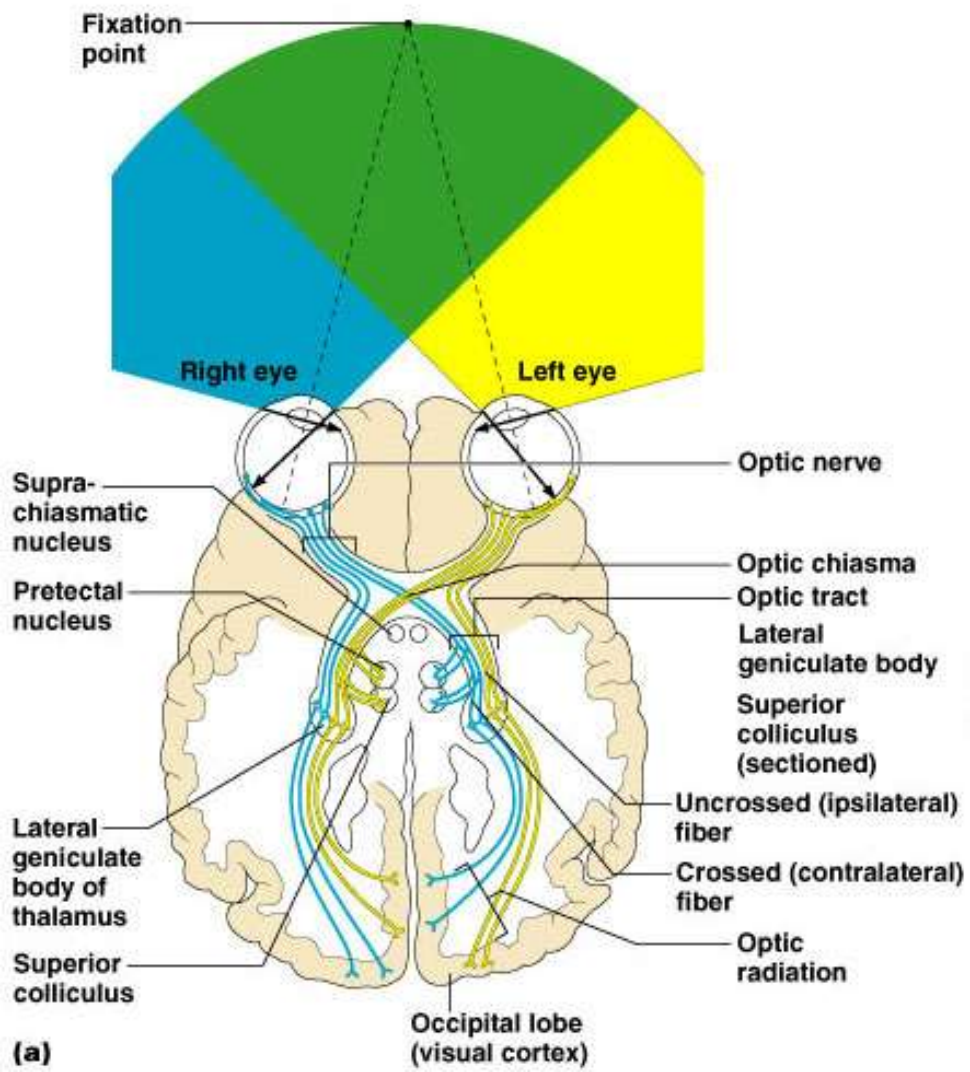
Retina-schema



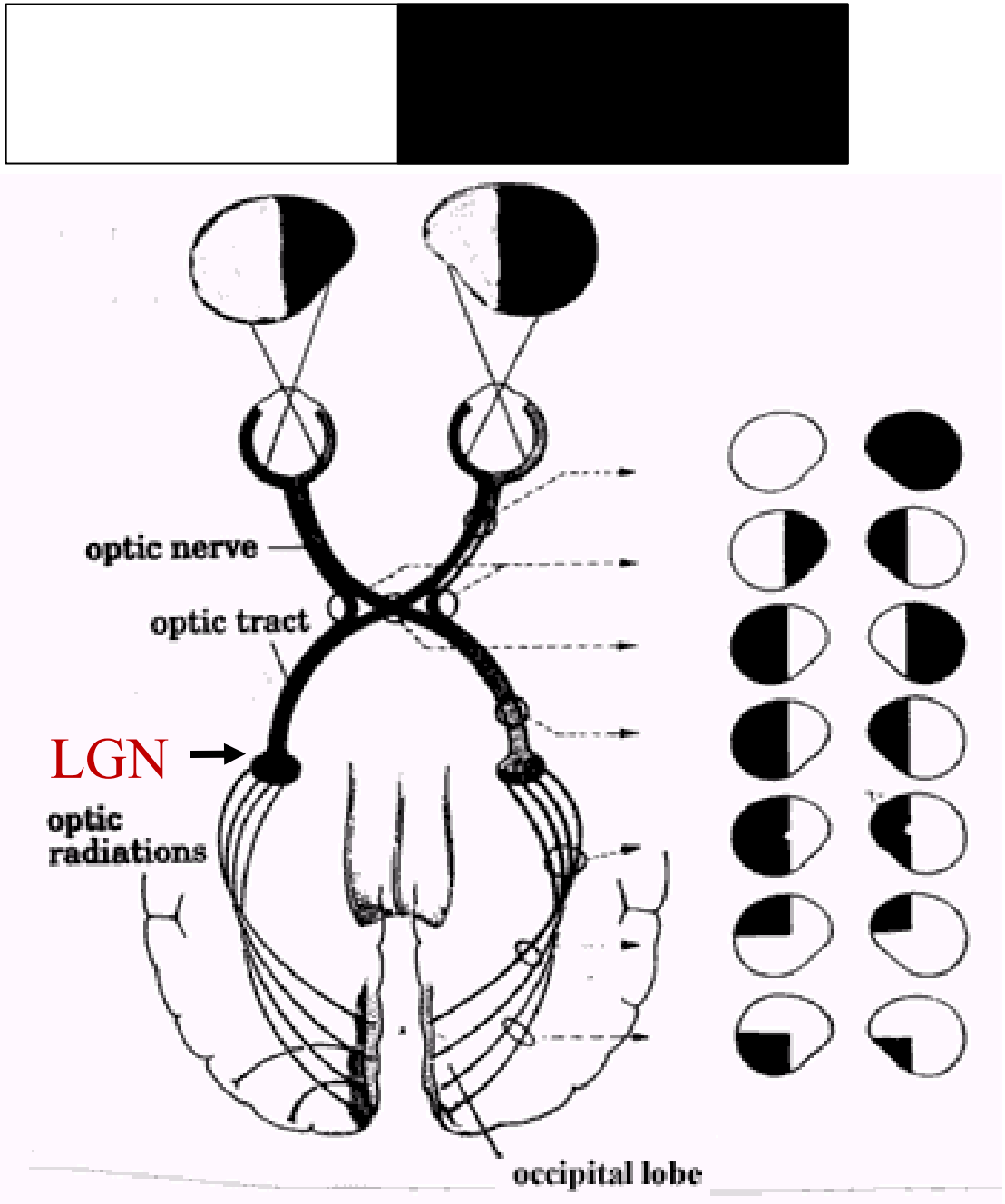
Wiliams P.L. (Ed) Gray´s Anatomy. Churchill Livingstone,New York, 1995

Visual Pathways to the Cerebral Cortex

- Light activates **photoreceptors**
- Photoreceptors signal **bipolar cells**
- Bipolar cells signal **ganglion cells**
- Axons of ganglion cells exit eye as the **optic nerve**
- Optic nerve **decussates at chiasma**
- **Optic tract** goes to **lateral geniculate nucleus** of the thalamus (but some fibers to midbrain for pupillary reflex, position and movements of the eye – unconscious)
- **Optic radiation** reaches the primary visual cortex (conscious seeing)



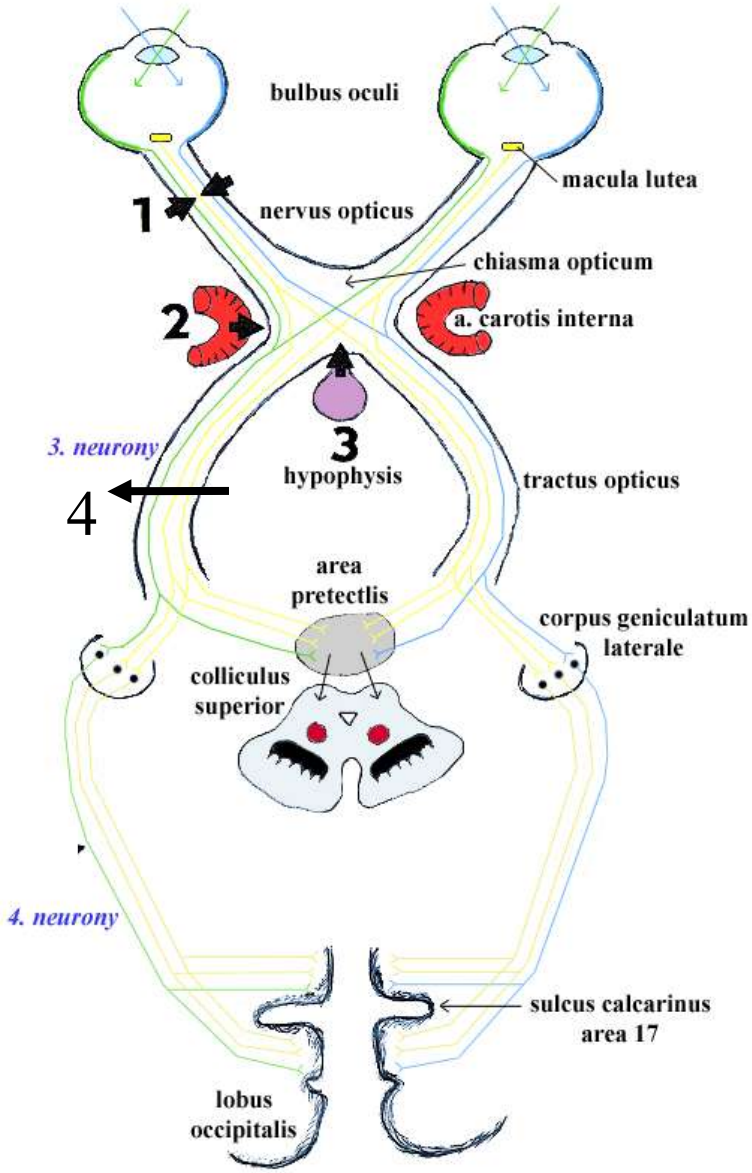
Visual Pathways to the Brain and Visual Fields - DEFECTS



The primary visual cortex (area V1) receives information from the lateral geniculate nucleus and is the area responsible for the first stage of visual processing.

Some people with damage to V1 show blindsight, an ability to respond to visual stimuli that they report not seeing.

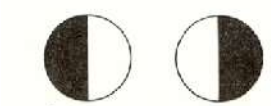
Visual fields



1 – amaurosis

2 – nasal hemianopia (a.carotis interna)

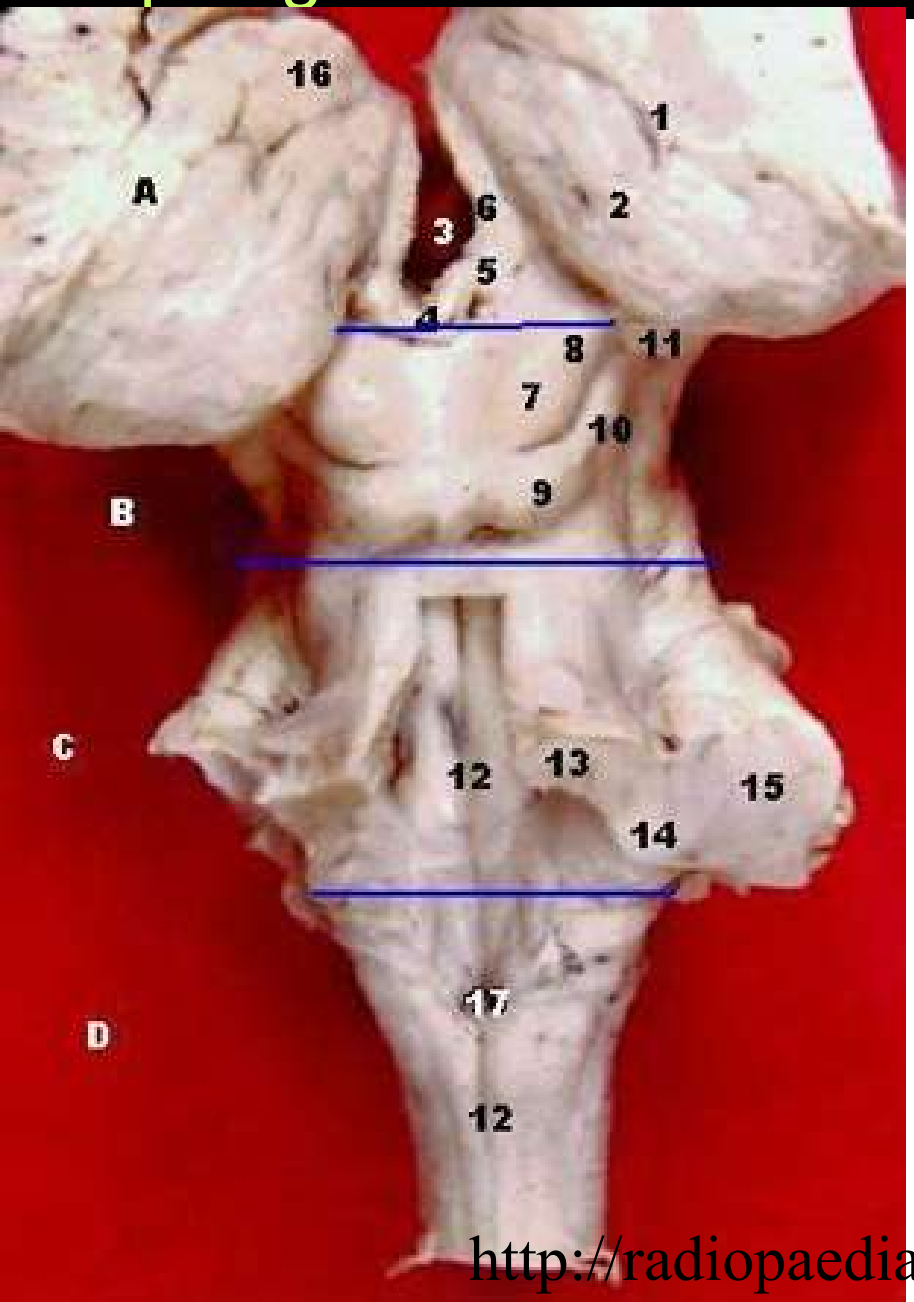
3 – bitemporal hemianopia (hypophysis)



4 – homonymous hemianopia

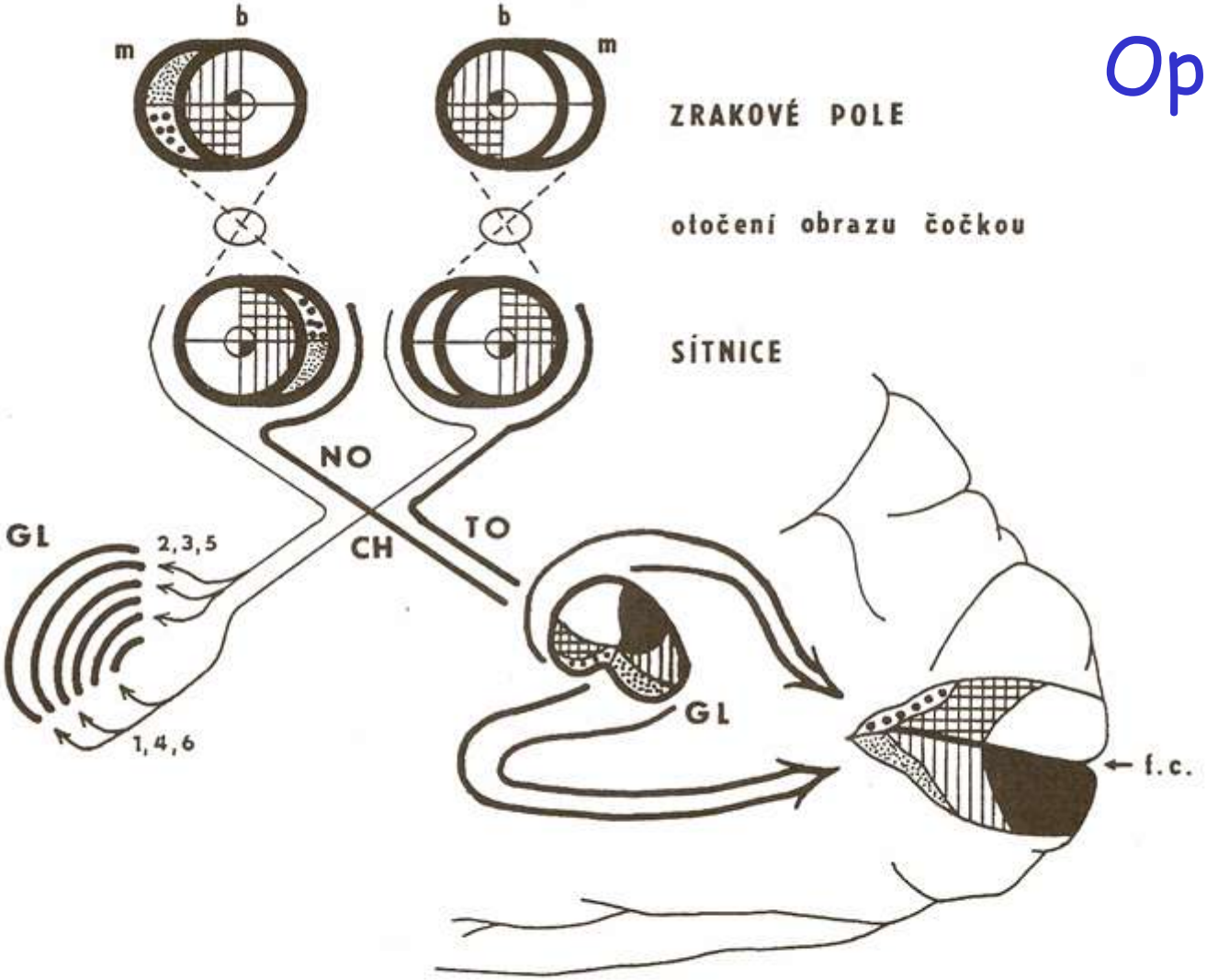
Cortex - quadrantanopia (ischaemia in a.cerebri post.), cortical blindess, optical agnosia, dysmorfopsia, fosfens, halucinations

Corpus geniculatum lateral



http://radiopaedia.org/articles/corpora-quadreigemina

Optical tract

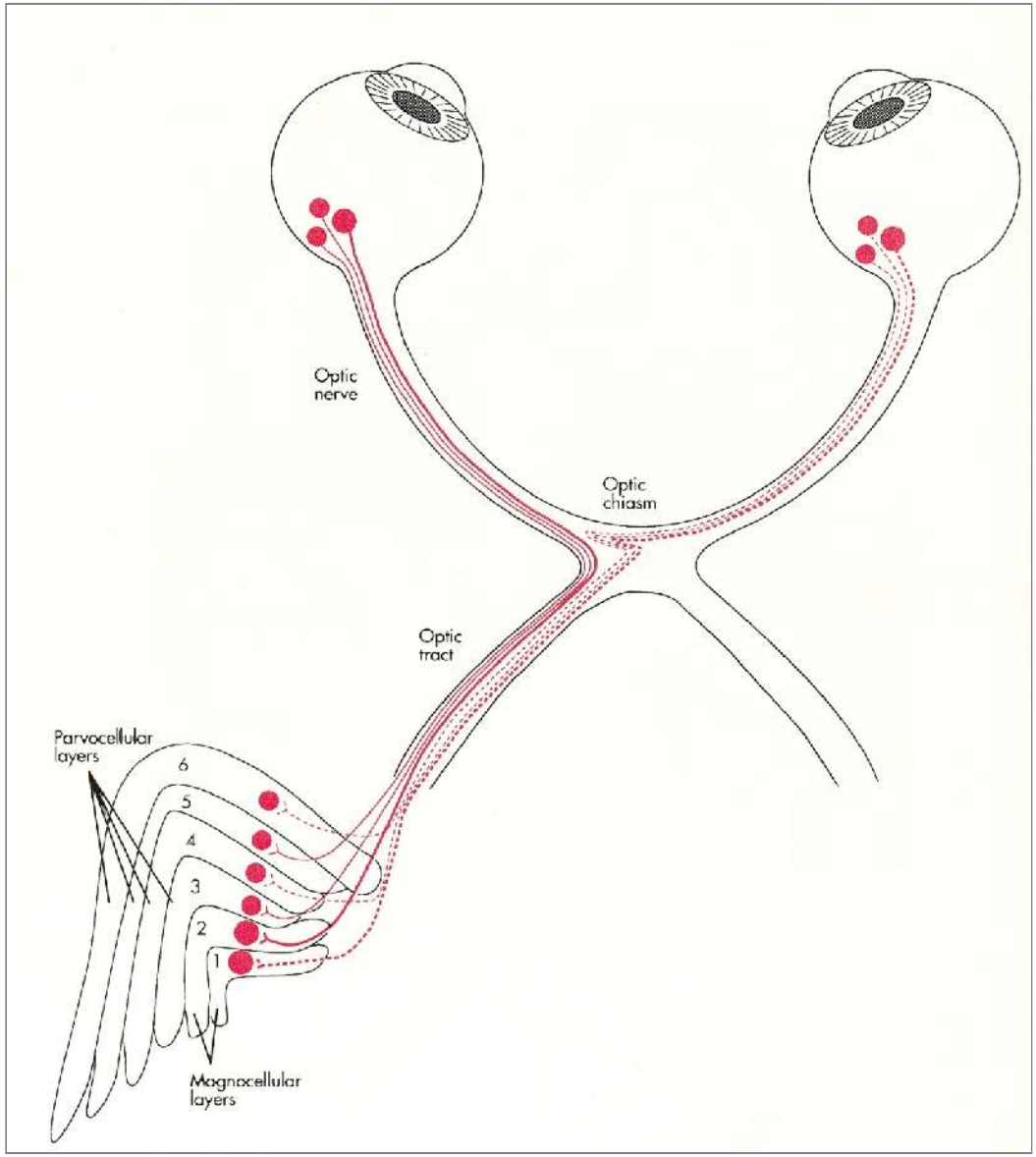


Obr. 102.: Schema zrakové dráhy od zrakového pole po fissura calcarina s vyznačením topografie (retinotopiky).

b – oblast binokulárního vidění,
f.c. – fissura calcarina,
GL – corpus geniculatum laterale (arabská čísla = jeho vrstvy),
CH – chiasma opticum,
m – monokulární vidění,
NO – nervus opticus,
TO – tr. opticus.

Petrovický et al.: Anatomie, IX Centrální nervový systém, Karolinum, Praha, 1995

4. N, section of corpus geniculatum laterale



Crossed fibers to 1., 4., 6.

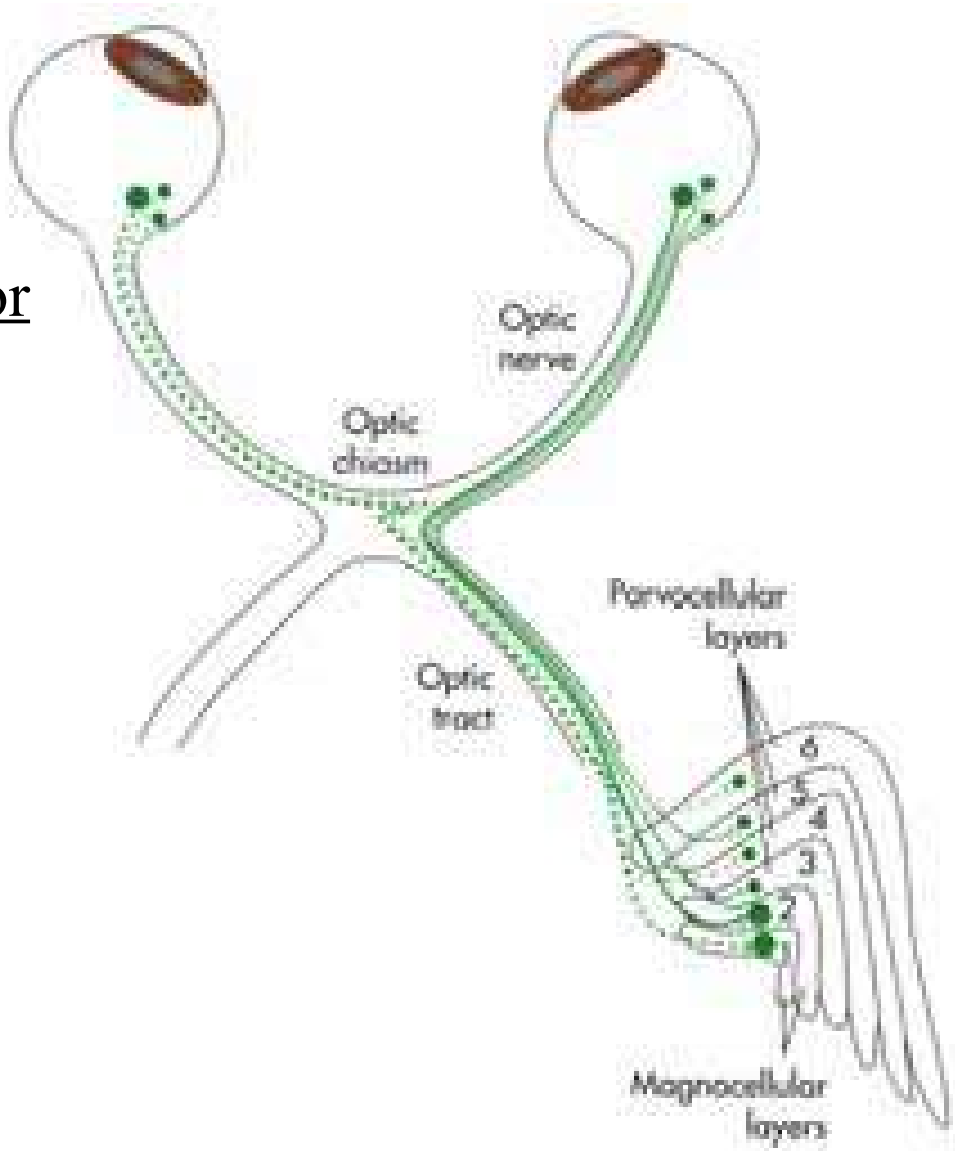
Uncrossed fibres to 2., 3., 5.

Lateral Geniculate Nucleus

•(LGN) in the thalamus is the major target of the retinal ganglion cells.

•It receives inputs from both eyes and relays these messages to the primary visual cortex via the optic radiation.

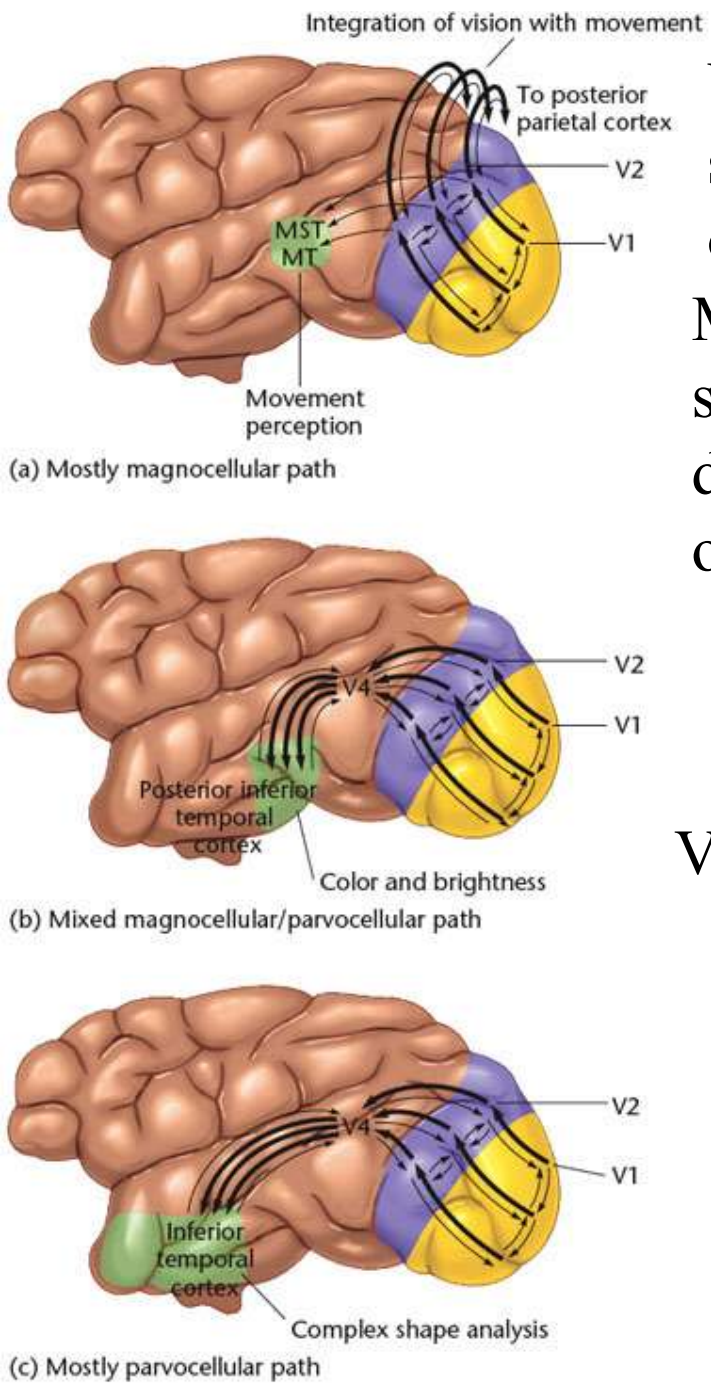
•Topographically organised.



Analysis of vision shape, colours, movement and position in space. Occipital, temporal and parietal lobes.. Ca. 20 retinotopical maps.

System of magnocellular tracts for analysis of movement in space, rough shape and contrast. Not colour sensitive.

System of parvocellular tracts specializes on detection of details and exact shape and colours.



V1(Br17) – primary visual cortex, simple, retinotopic, perception of object orientation and movement

MST – V5, movement of objects, stereovision (binocular +monocular – decreasing size, loss of detail)… movement of eyes

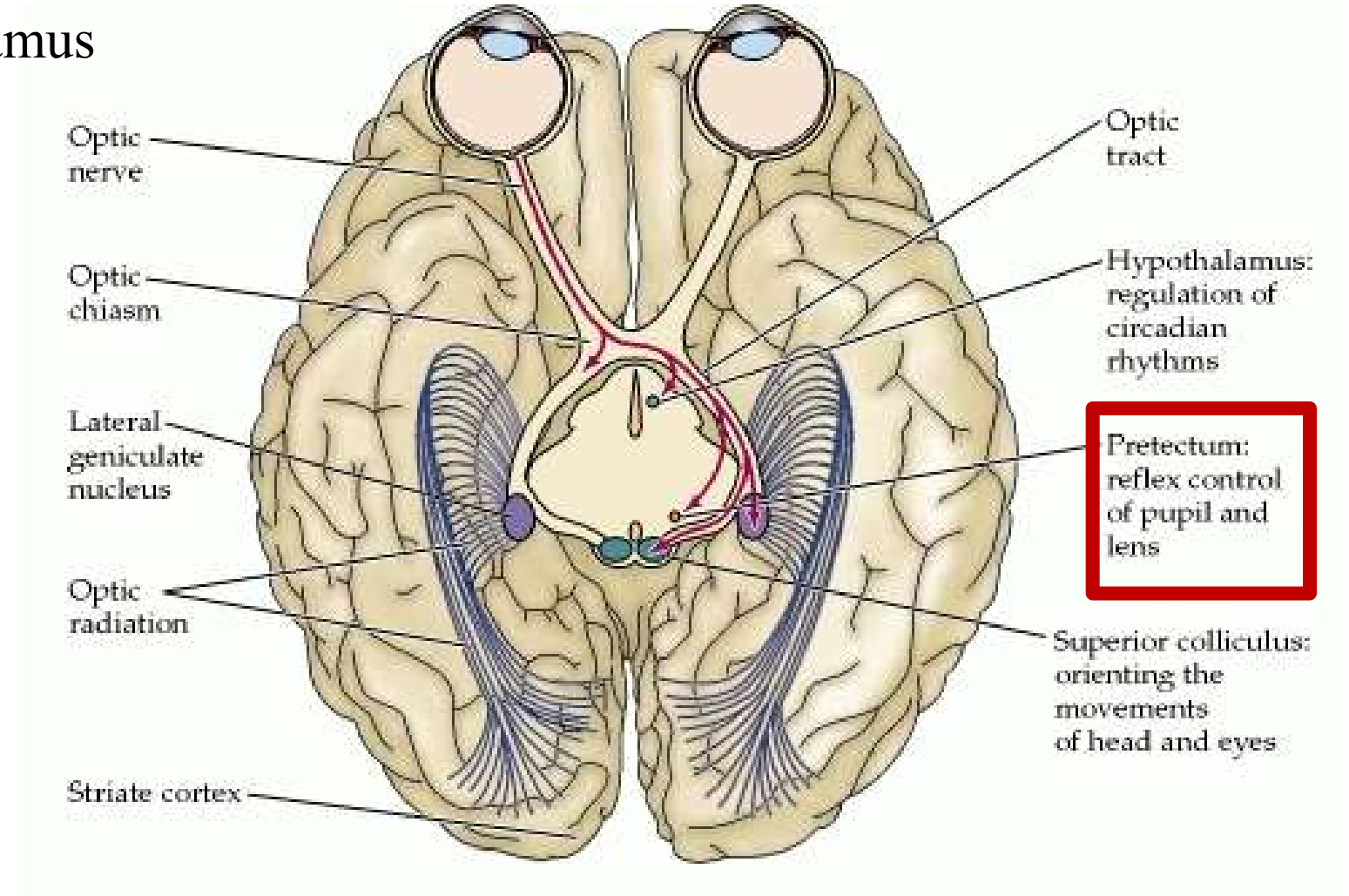
V2 - orientation, spatial frequency, and colour

V4 – colour perception

Central Projections of the Retina

The retina projects to *four subcortical regions in the brain:*

1) Lateral Geniculate nucleus
2) Superior Colliculus
3) Hypothalamus
4) Pretectum



Branches of the visual pathway (all start from the 3.N.)

~ To hypothalamus: optical input to vegetative system (circadian, season cycle)

~ Pupillary reflexes:

Miosis : via area pretectalis (AP=pretectum) to n. III (*EW)* - ganglion ciliare - nn. ciliares breves - m. ciliaris et m. sphincter pupillae (accommodation = same, but from AP via ncl. interstitialis Cajali)

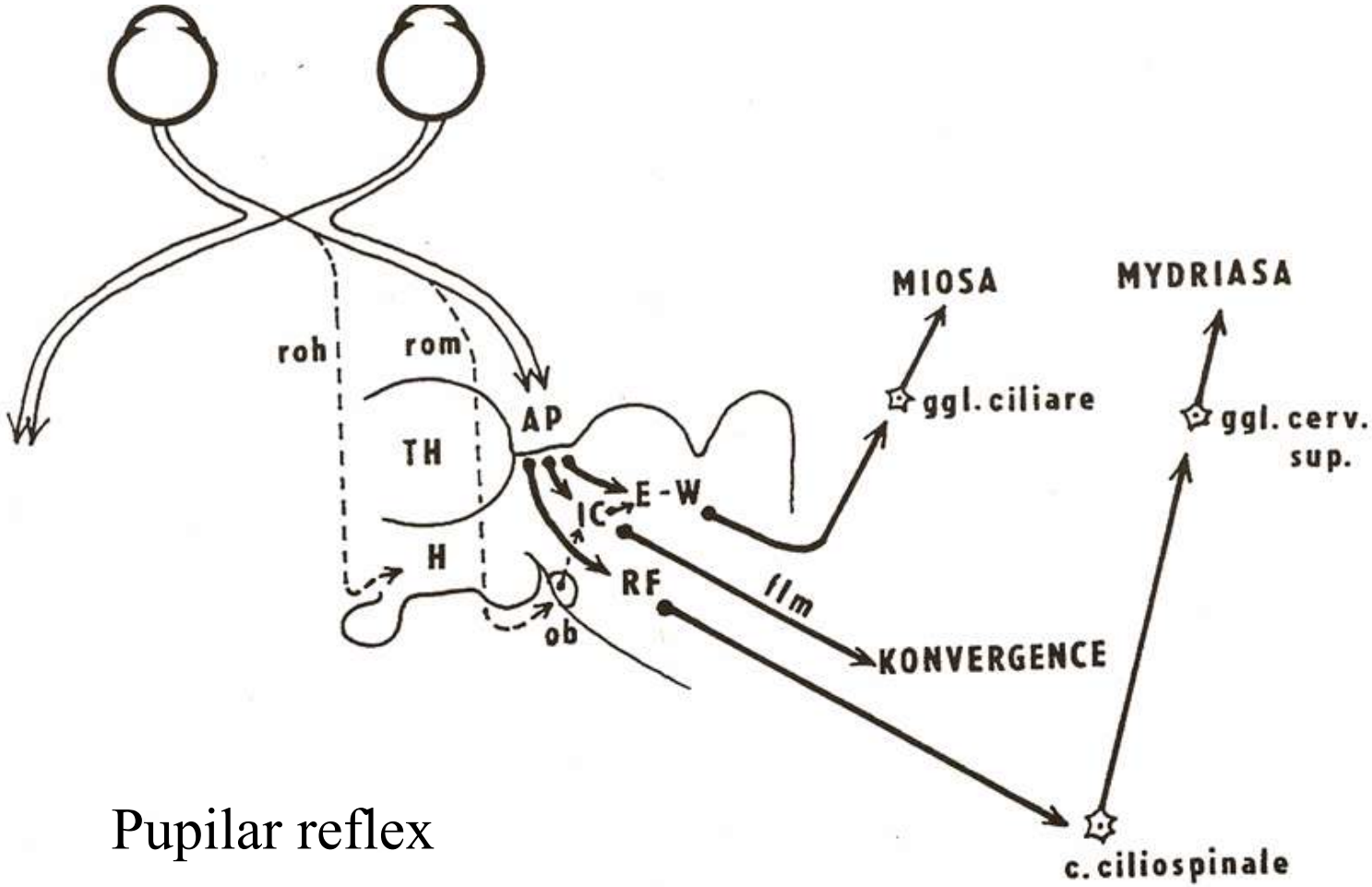
Mydriasis: via AP to reticular formation: tractus reticulospinalis - centrum ciliospinale C8-Th1 - ganglion cervicale superius - plexus caroticus internus et ophtalmicus - nn. ciliares breves - m. dilatator pupillae

Convergence: via AP to ncl. Cajali - FLM - nuclei of extraocular muscles nerves

~ Tectal visual circuit – tr. tectospin., - nuclearis, - interstitialis, crbl (coordination of the movements of the eye, head, neck (body) towards a visual stimulus)

~ To pulvinar Th: coordination of visual and sensory inputs

Pupilární reflex

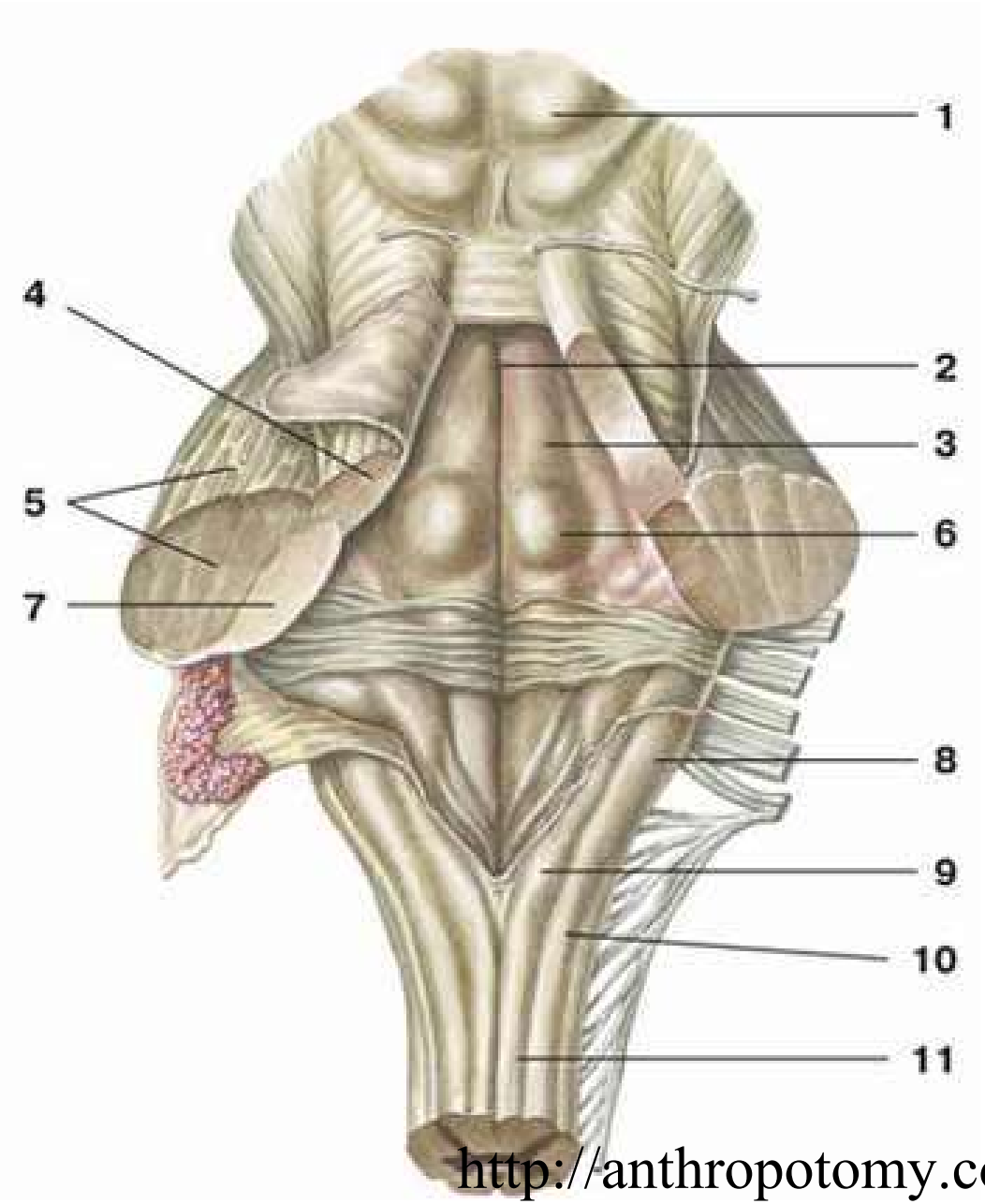


Pupilar reflex

Obr. 104.: Schema drah pupillárního reflexu.

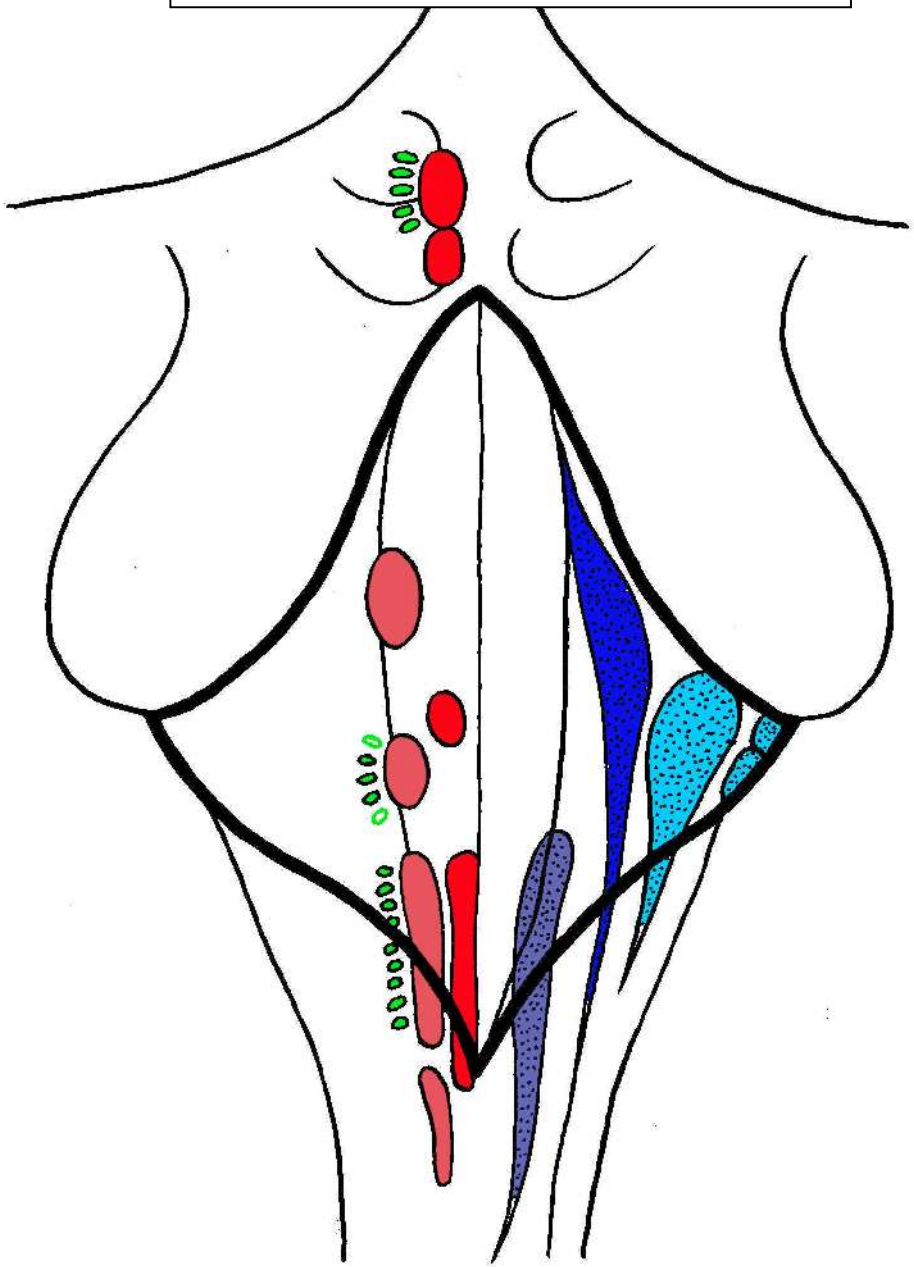
AP – area pretectalis,
E-W – Edinger-Westphalovo jádro (III.),
flm – fasc. longitudinalis medialis,
H – hypothalamus,
IC – ncl. interstitialis Cajali,
ob – ncl. opticus basalis,
RF – retikulární formace,
roh – radix optica hypothalamica,
rom – radix optica mesencephalica,
TH – thalamus.

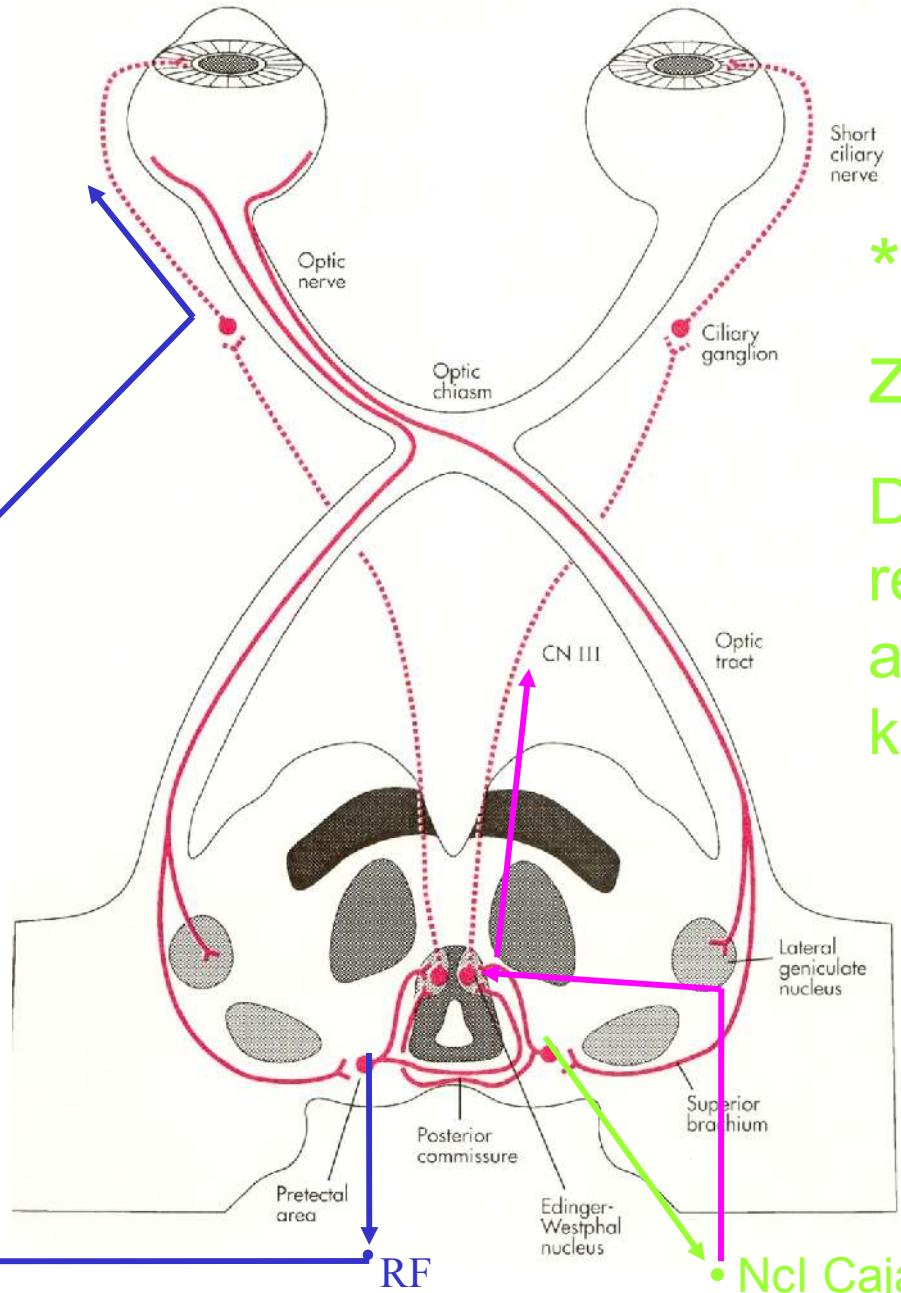
Petrovický et al.: Anatomie, IX Centrální nervový systém, Karolinum, Praha, 1995



http://anthropotomy.com/assets/images/part3/116.jpg

Cranial nerve nuclei





nn. ciliares breves

*Odbočky ze zrakové dráhy

Dráhy pupilárního reflexu, dráhy pro akomodaci a konvergenci

gangl. cervicale superius

C8 – Th1

RF

akomodace

Ncl Cajali → fasc.longit.med., konvergence

Corneal reflex

Nasociliary branch of the ophthalmic branch (V1) of the 5th cranial nerve (trigeminal nerve) sensing the stimulus on the cornea, lid, or conjunctiva

7th cranial nerve (Facial nerve) initiating the motor response (i.e. it is the efferent)

Onion and contact lenses

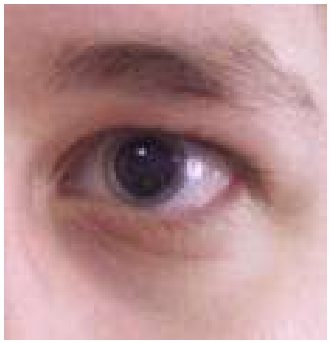
Pupillary light reflex + accommodation reflex

And accommodation

The Vascular Tunic - IRIS

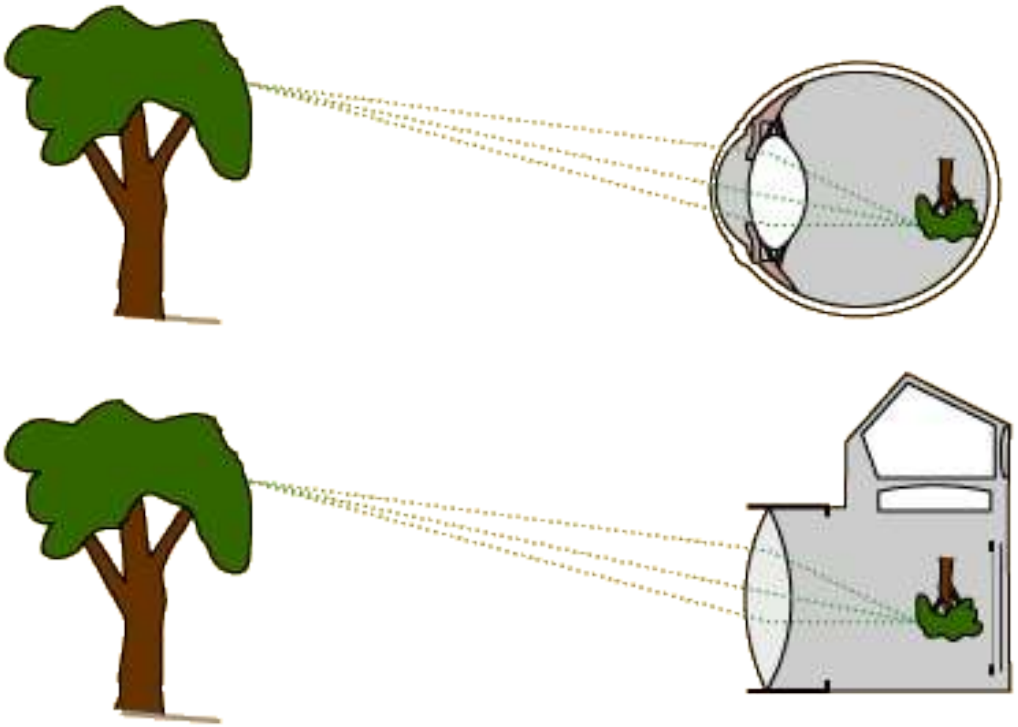
- Visible colored part of the eye
- Attached to the ciliary body
- Composed of smooth muscle
- Pupil – the round, central opening
  - Sphincter pupillae muscle (constrictor or circular) PARASYMPATHETIC
  - Dilator pupillae muscle (dilator or radial) SYMPATHETIC (atropin – atropa bella-donna – mandragora)

Pupillary dilation and constriction

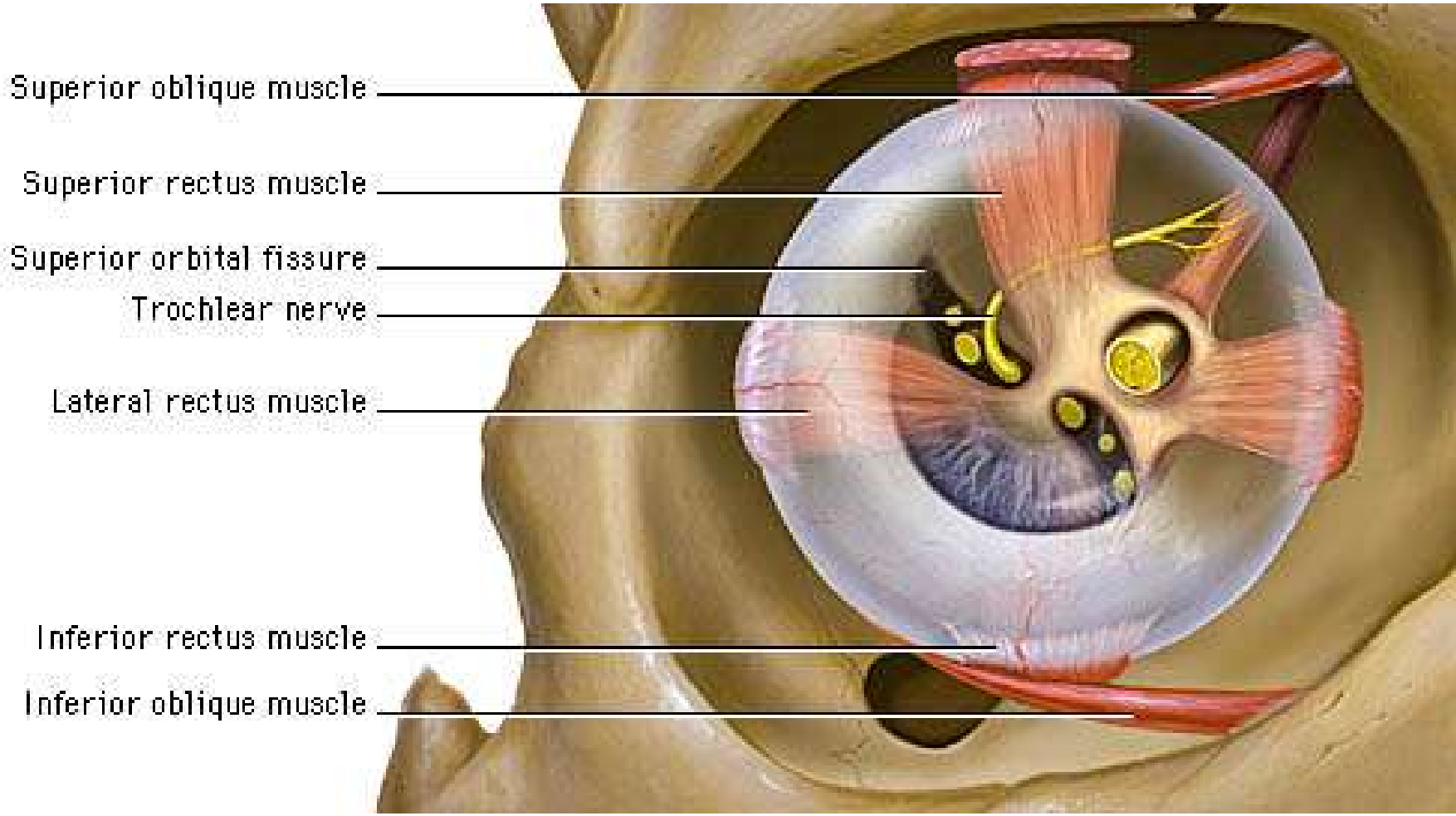


The Eye as an Optical Device

- Structures in the eye (lens, cornea, and humors) bend light rays
- Light rays converge on the retina at a single focal point
- Accommodation – curvature of the lens is adjustable - for focusing on nearby objects (**blur-driven**)



?????????-ocular reflex - the Extraocular muscles

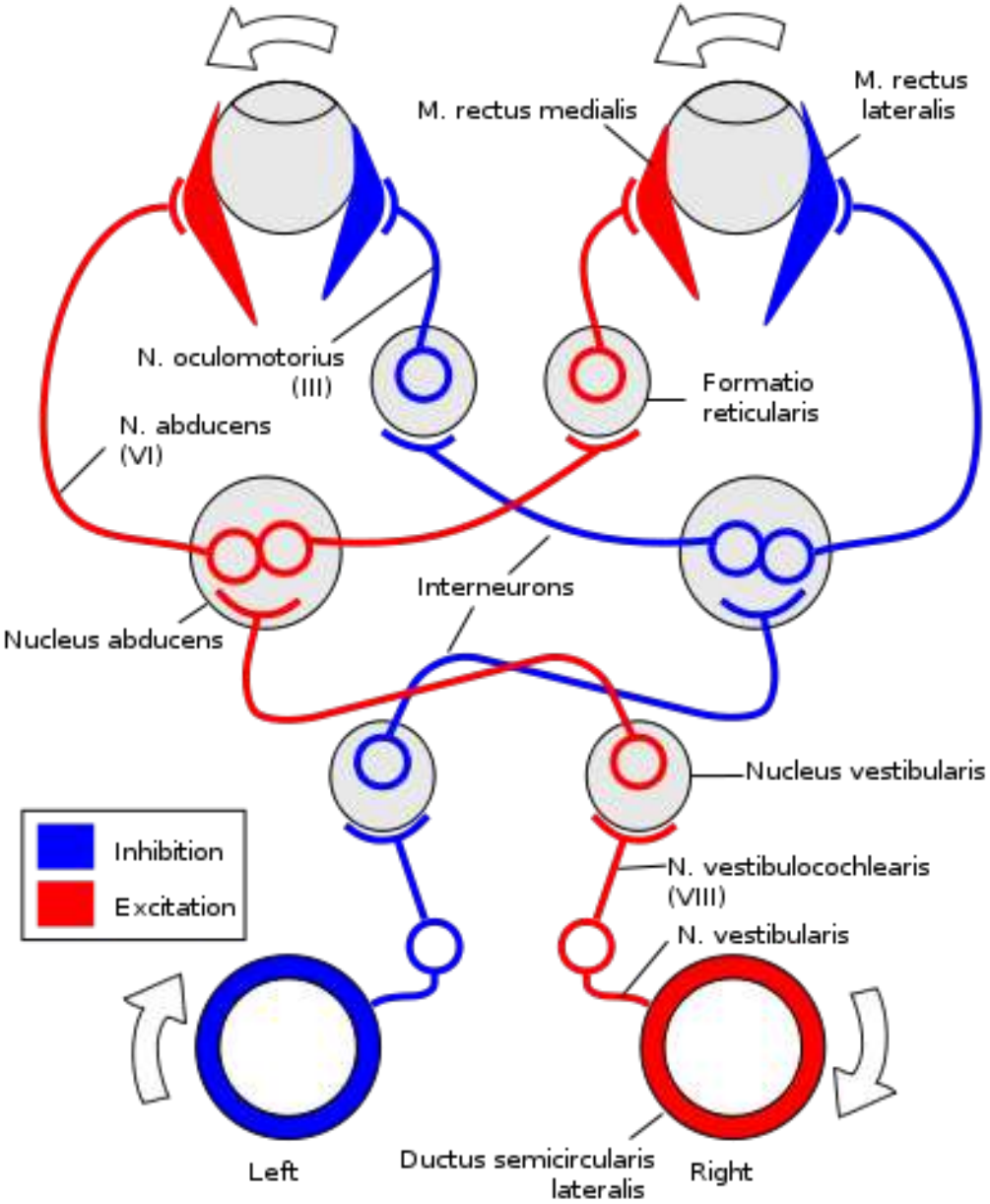


3 cranial nerves…

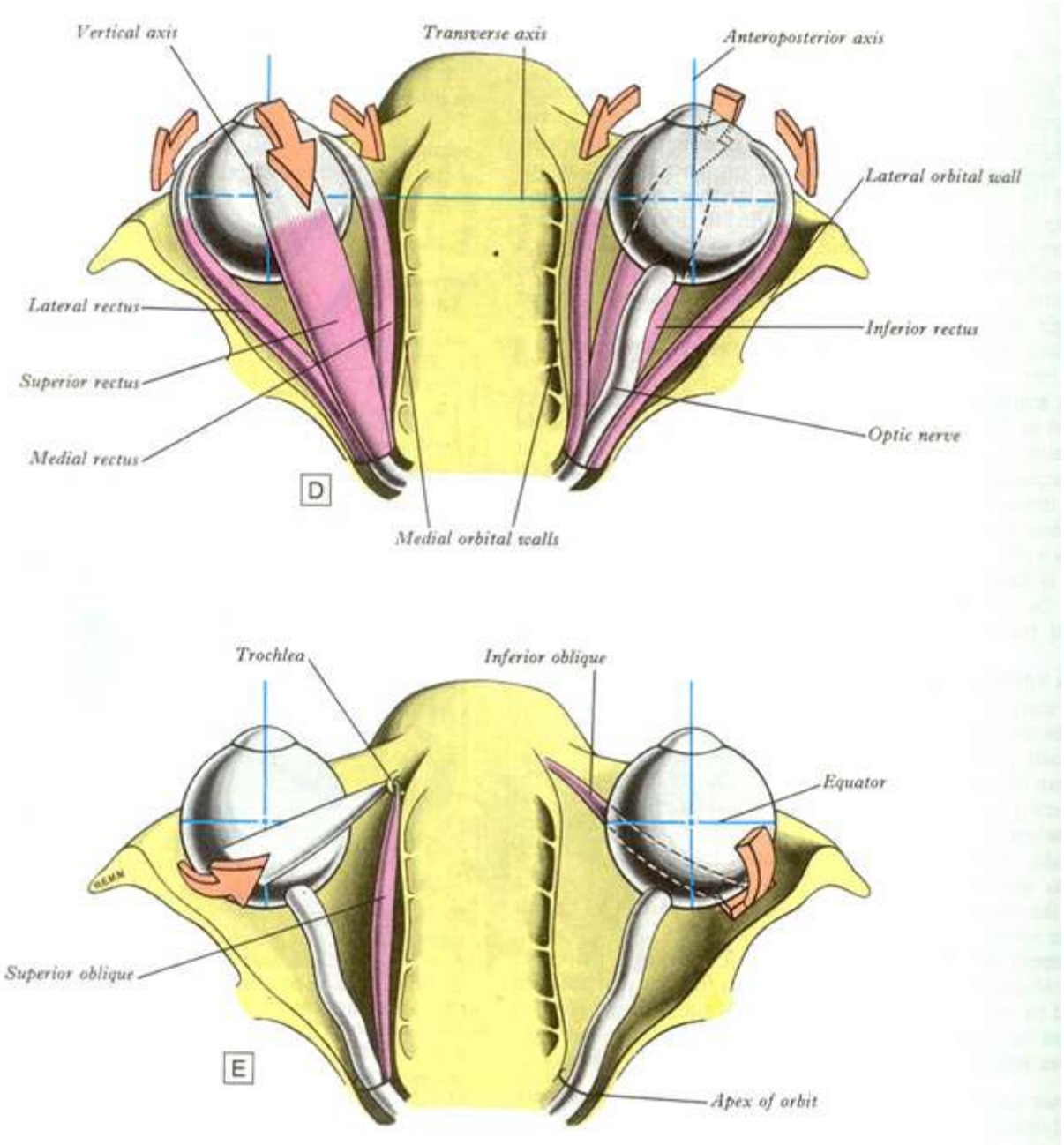
smooth pursuit - track image

saccadic - not apparent; move image to different receptors

Vestibulo-ocular reflex - the Extraocular muscles

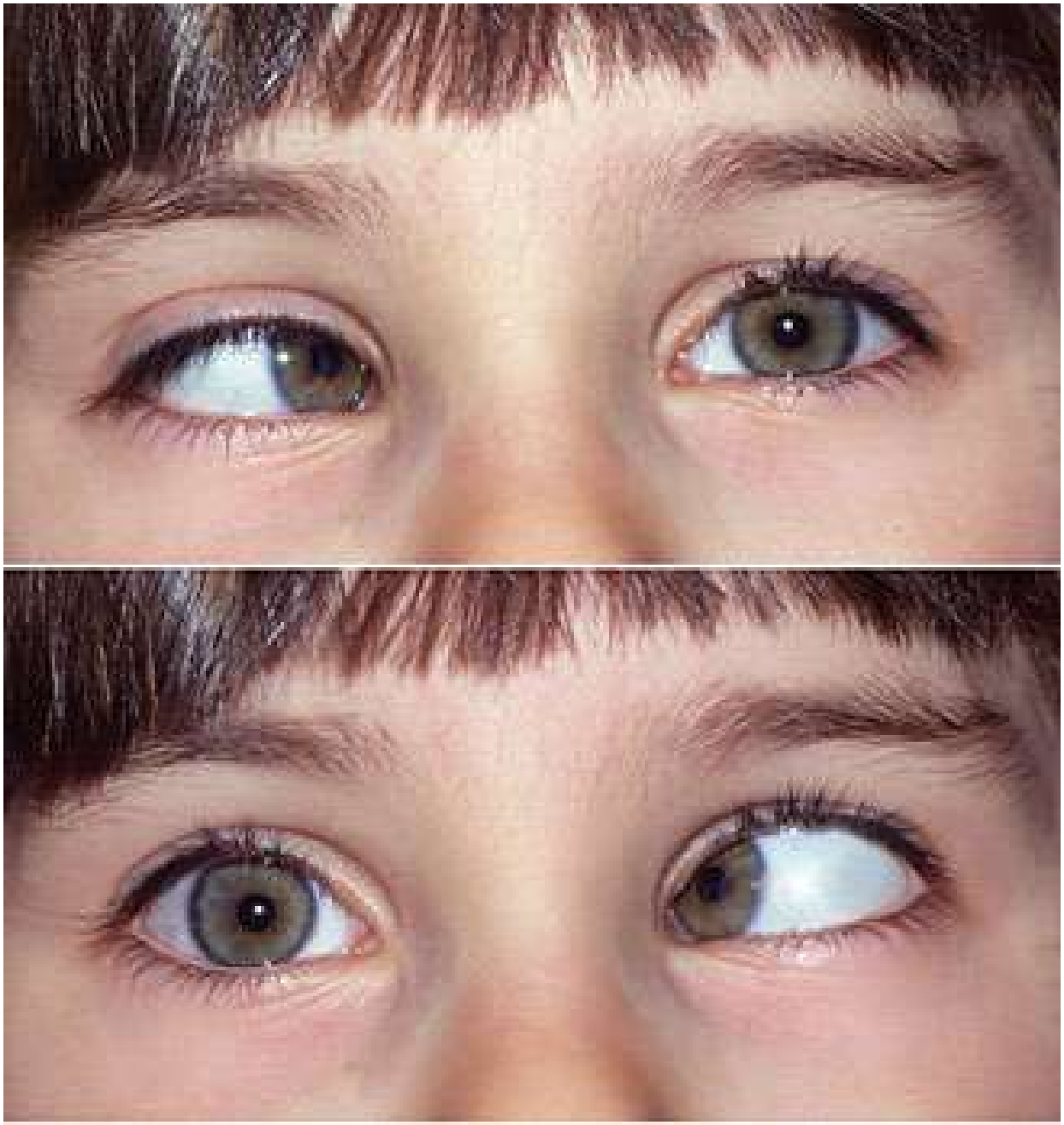


Extraocular muscles



Wiliams P.L. (Ed) Gray´s Anatomy. Churchill Livingstone, New York, 1995

Strabismus



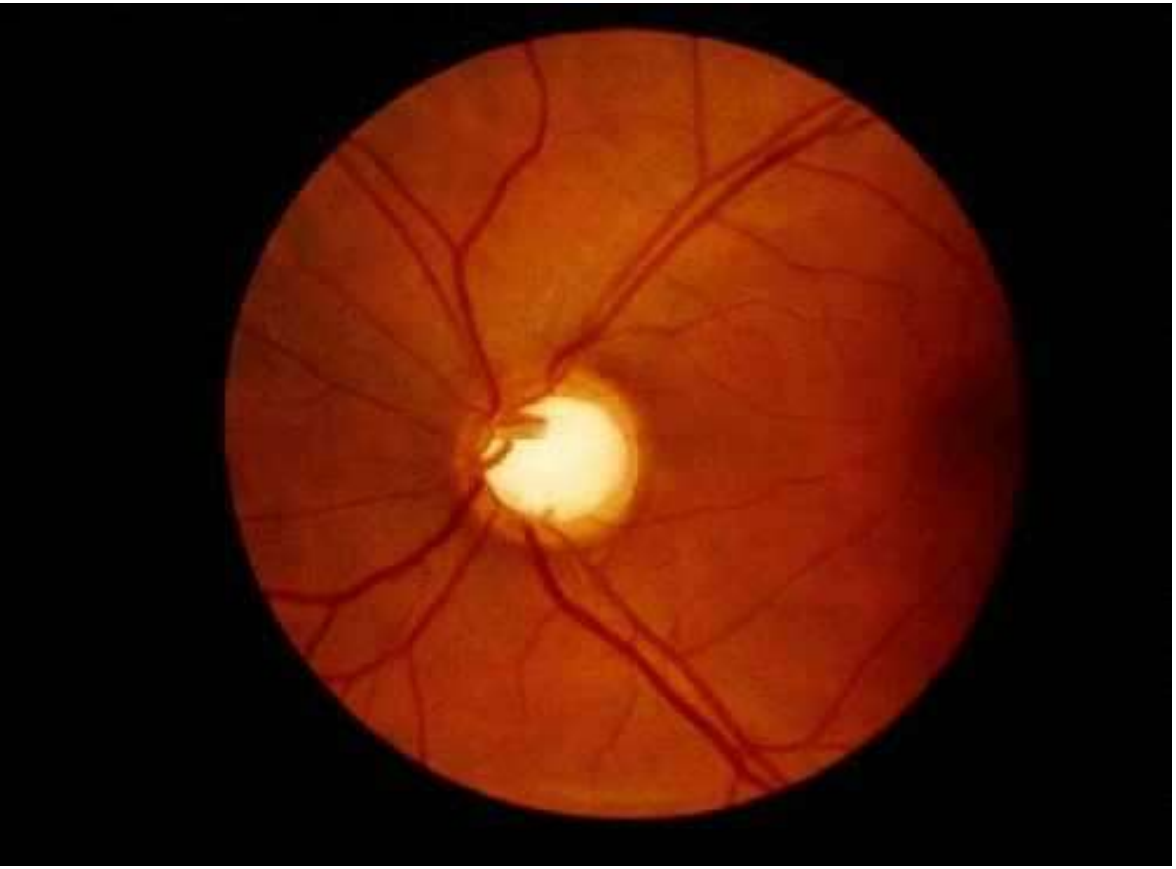
http://e-learning.studmed.unibe.ch

Senile macular degeneration

http://www.medrounds.org

http://www.lowvisionclub.com

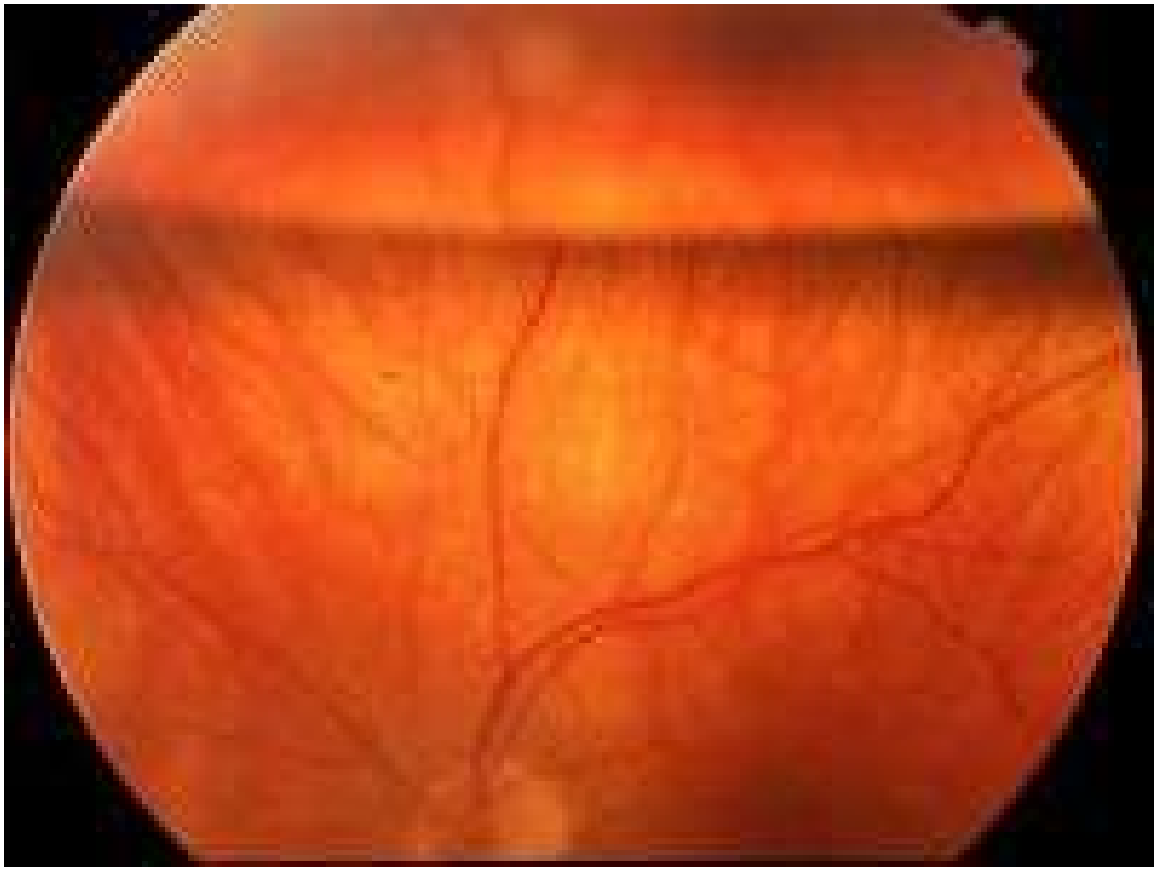
Glaucoma



http://137.222.110.150/calnet/Visual1/image/glaucoma-opthalmoscopic%20photo.jpg

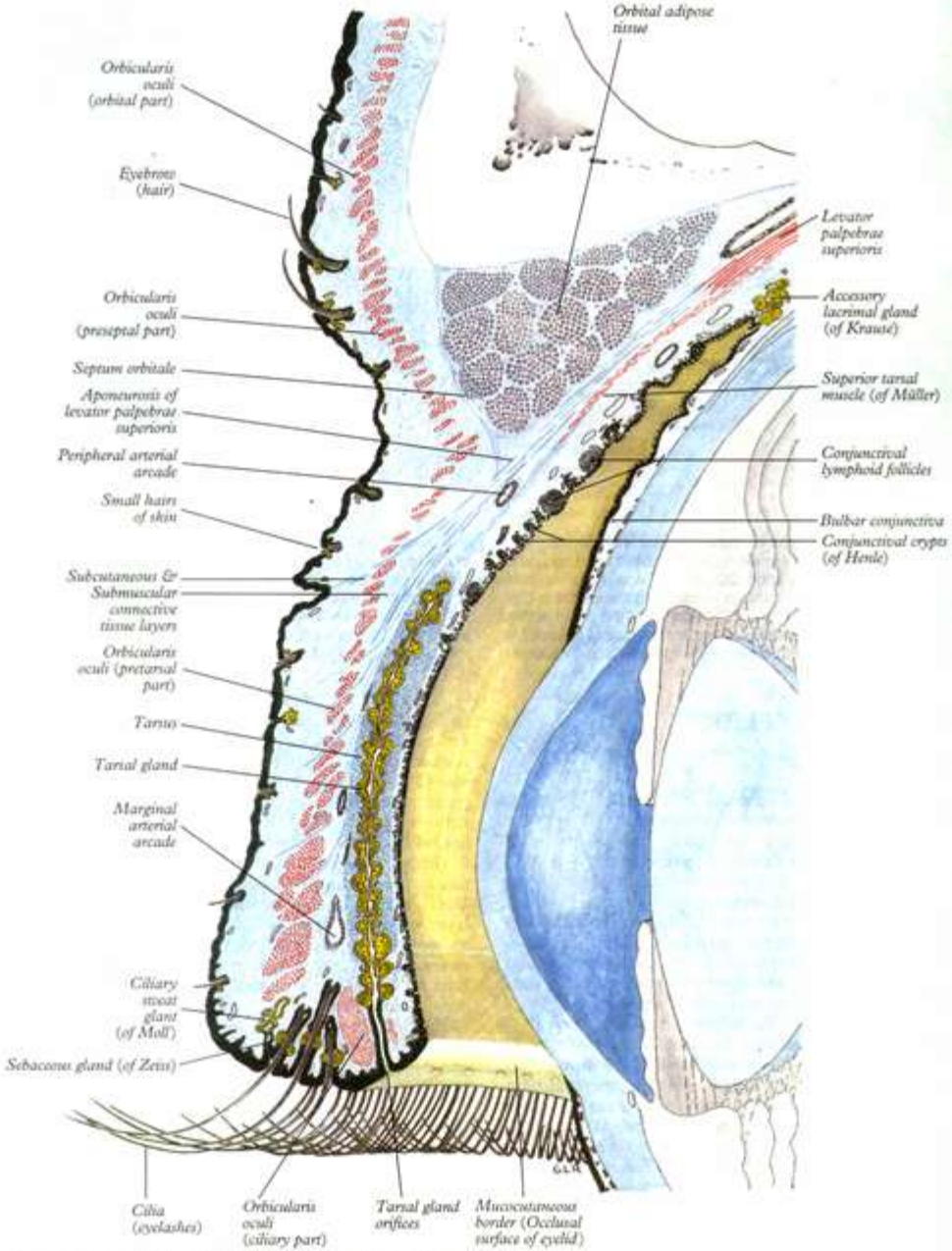
http://www.lowvisionclub.com

Retinal amotion



http://www.lexum.cz/vitroretinalni-choroby.php

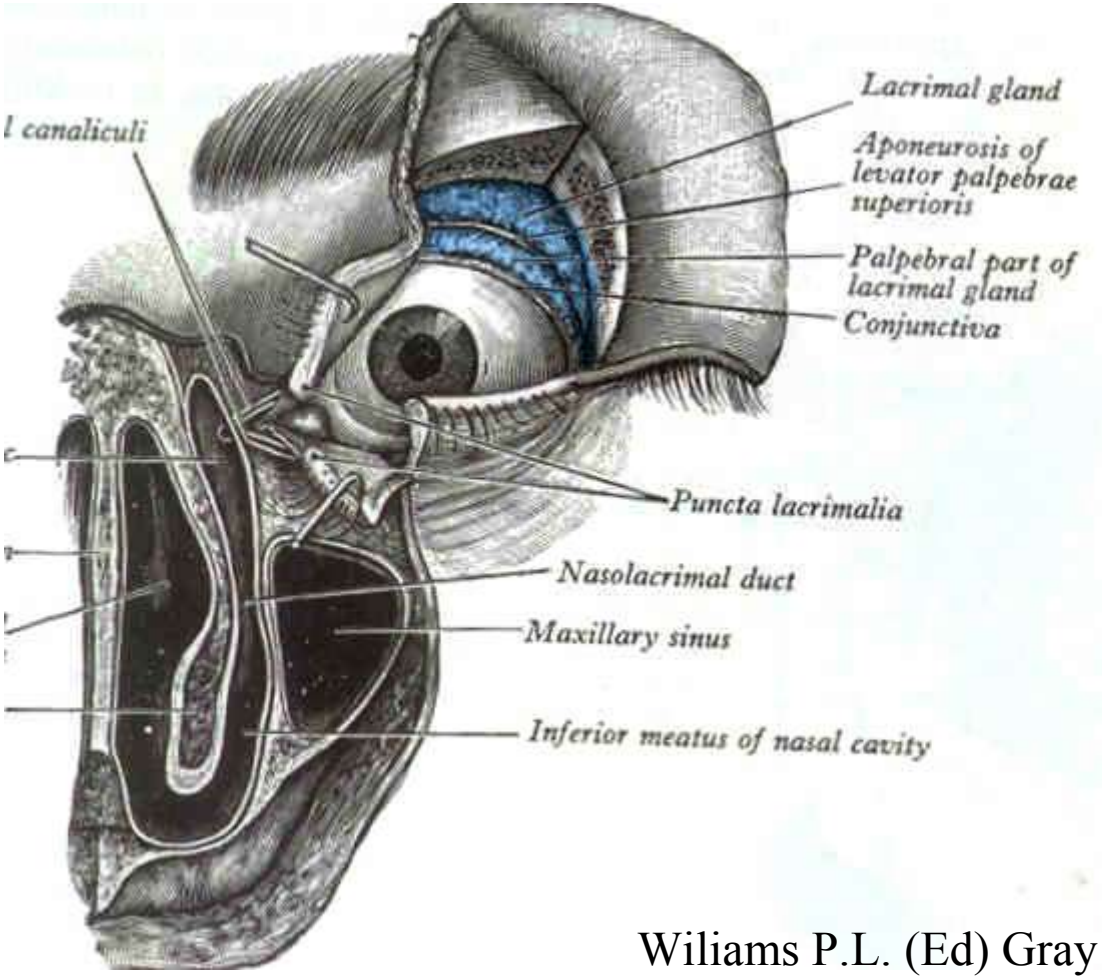
Eyelid and conjunctiva

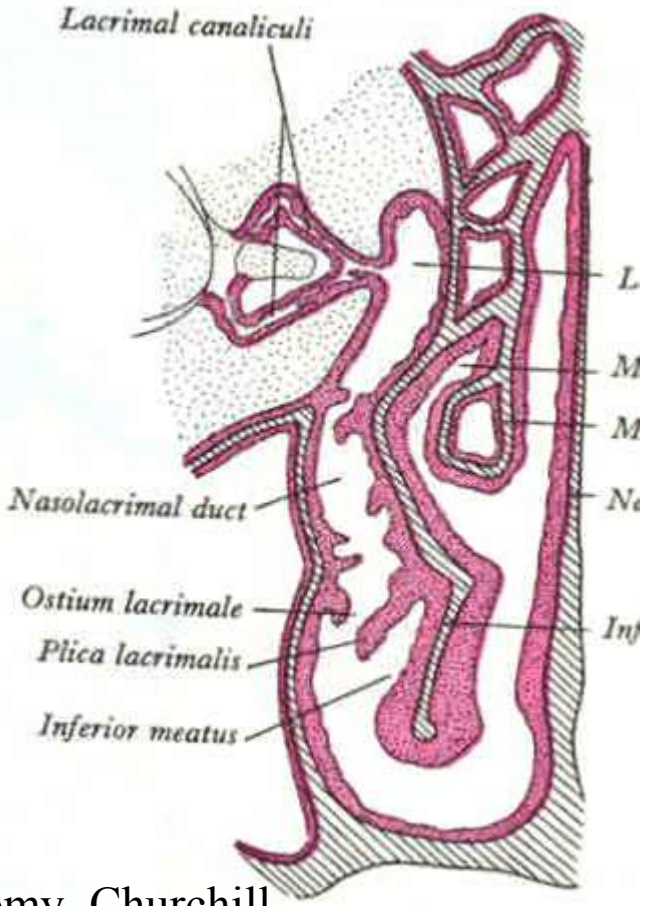


8.459 Illustration depicting the structure of the upper eyelid and anterior segment of the eye: sagittal section. (Provided by G L Ruskell, Department of Optometry and Visual Science, The City University, London.)

Wiliams P.L. (Ed) Gray´s Anatomy. Churchill Livingstone, New York, 1995

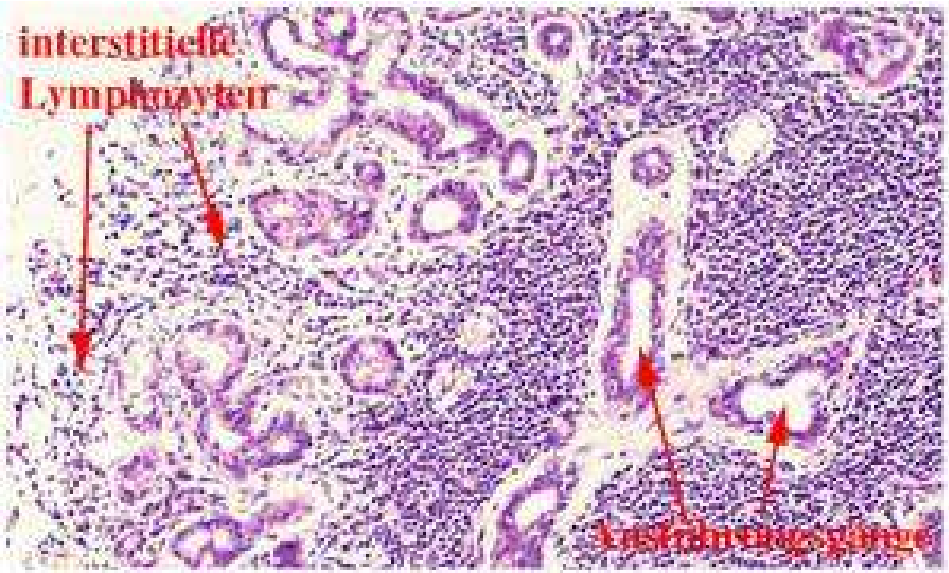
Lacrimal apparatus





Wiliams P.L. (Ed) Gray´s Anatomy. Churchill Livingstone, New York, 1995

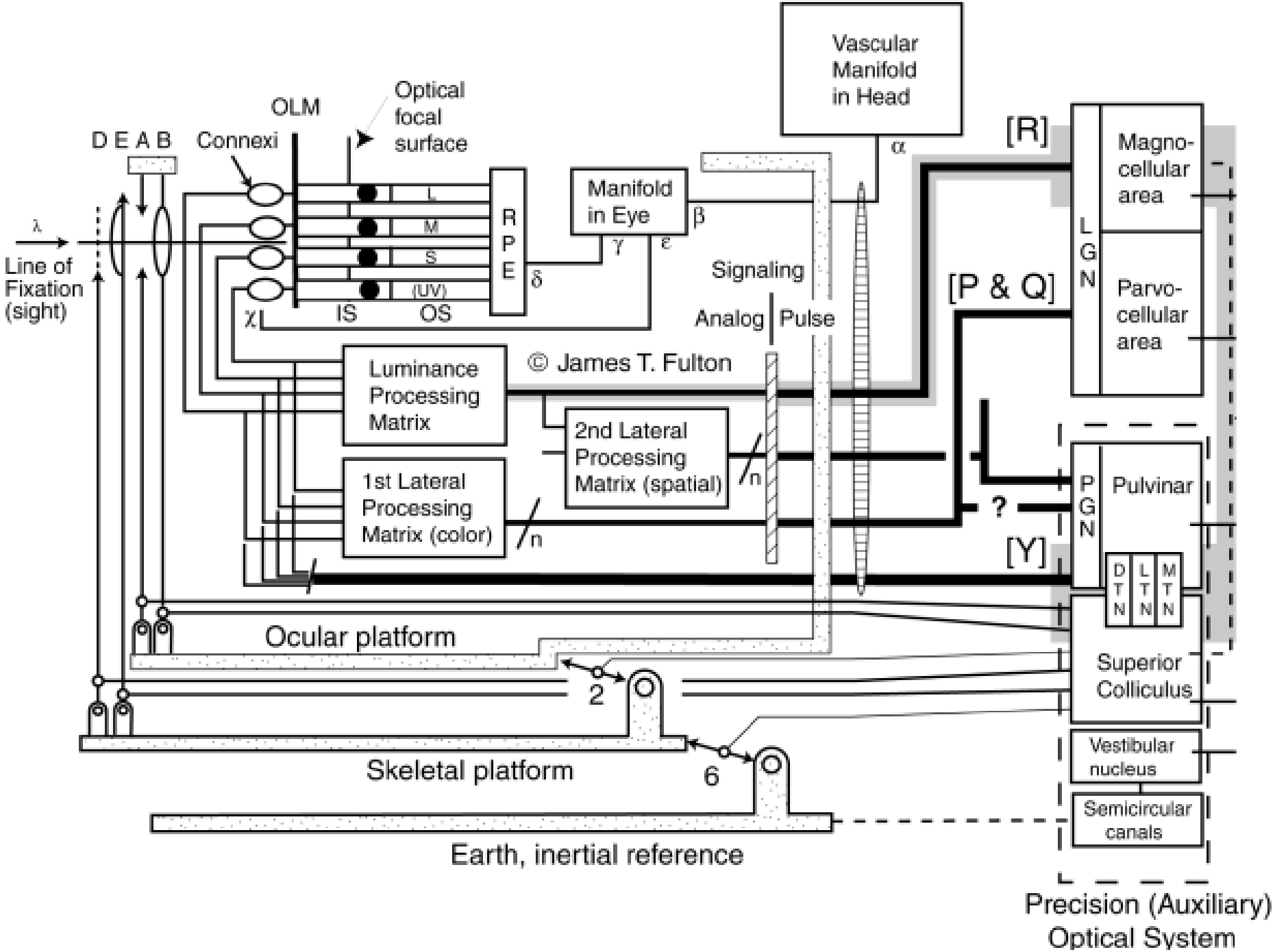
Sjögrenův syndrom



Lippenspeicheldrüse: Periduktale und interstitielle lymphozytäre Infiltrate bei Sjögren-Syndrom.

http://edoc.hu-berlin.de

http://www.dgrh.de


Vascular Manifold in Head
α
[R]
Magno-cellular area
L G N
Parvo-cellular area
OLM
Optical focal surface
D E A B
Connexi
λ
Line of Fixation (sight)
L
M
S
(UV)
IS
OS
χ
R P E
δ
Manifold in Eye
β
γ
ε
Signaling
Analog
Pulse
[P & Q]
© James T. Fulton
Luminance Processing Matrix
2nd Lateral Processing Matrix (spatial)
1st Lateral Processing Matrix (color)
n
n
?
[Y]
P G N
Pulvinar
D T N
L T N
M T N
Ocular platform
Superior Colliculus
2
6
Skeletal platform
Vestibular nucleus
Semicircular canals
Earth, inertial reference
Precision (Auxiliary) Optical System