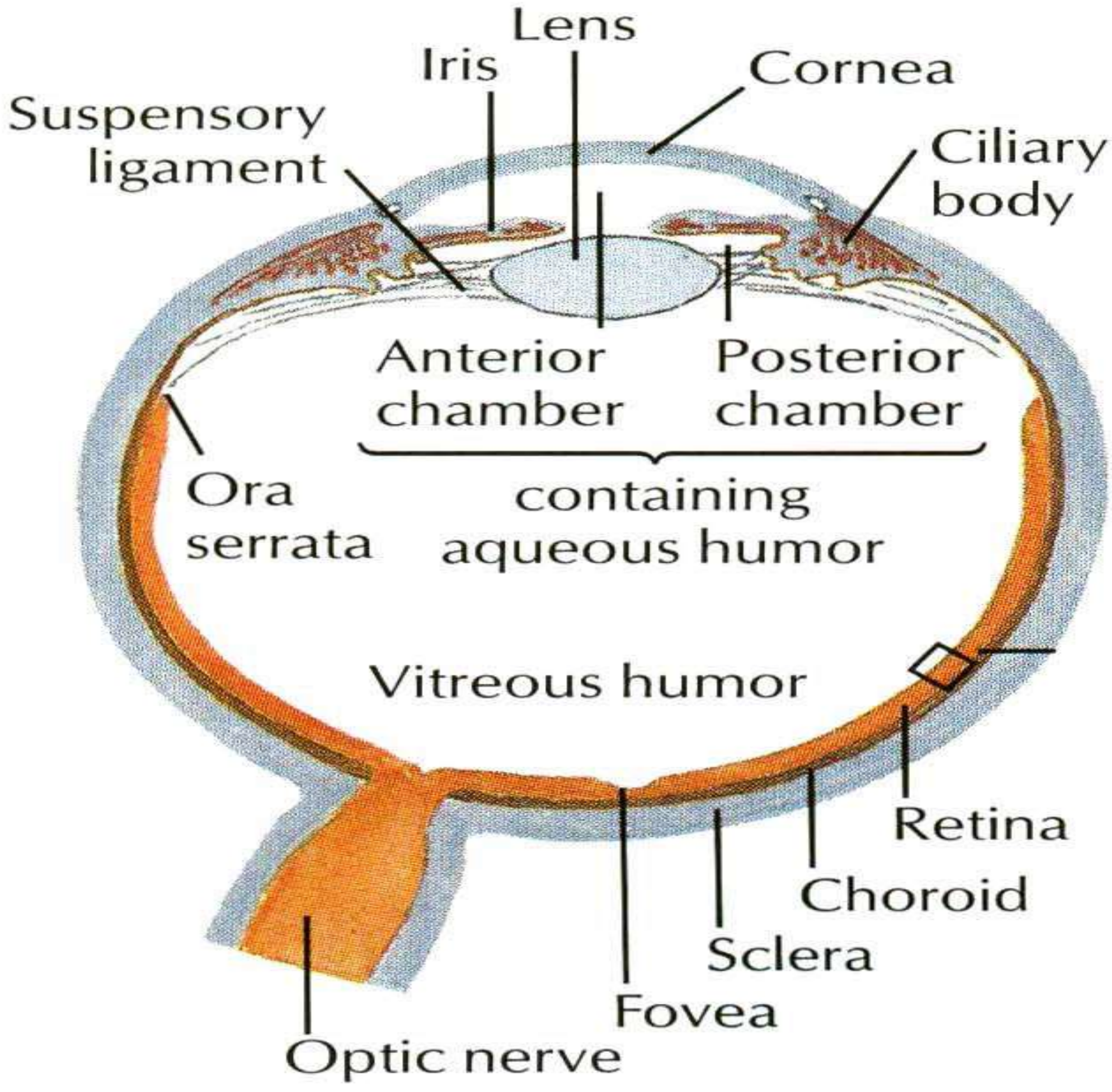
- **Lecture 12. Visual system. Auditory system**

A. Eyeball


Lens
Iris
Cornea
Suspensory ligament
Ciliary body
Anterior chamber
Posterior chamber
containing aqueous humor
Ora serrata
Vitreous humor
Retina
Choroid
Sclera
Fovea
Optic nerve

Physiological abnormalities of refraction

- Spherical abberation
- Chromatic abberation
- Astigmatism

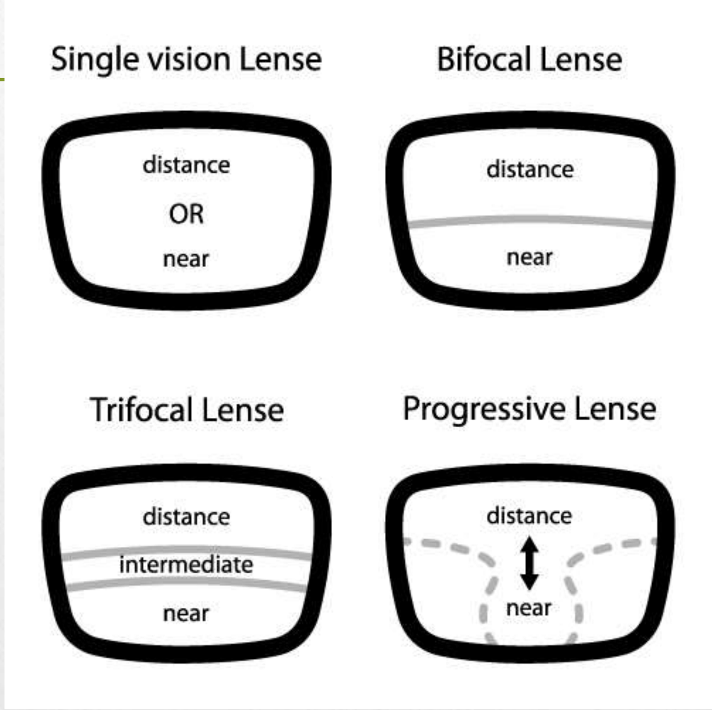
Pupillary reflex

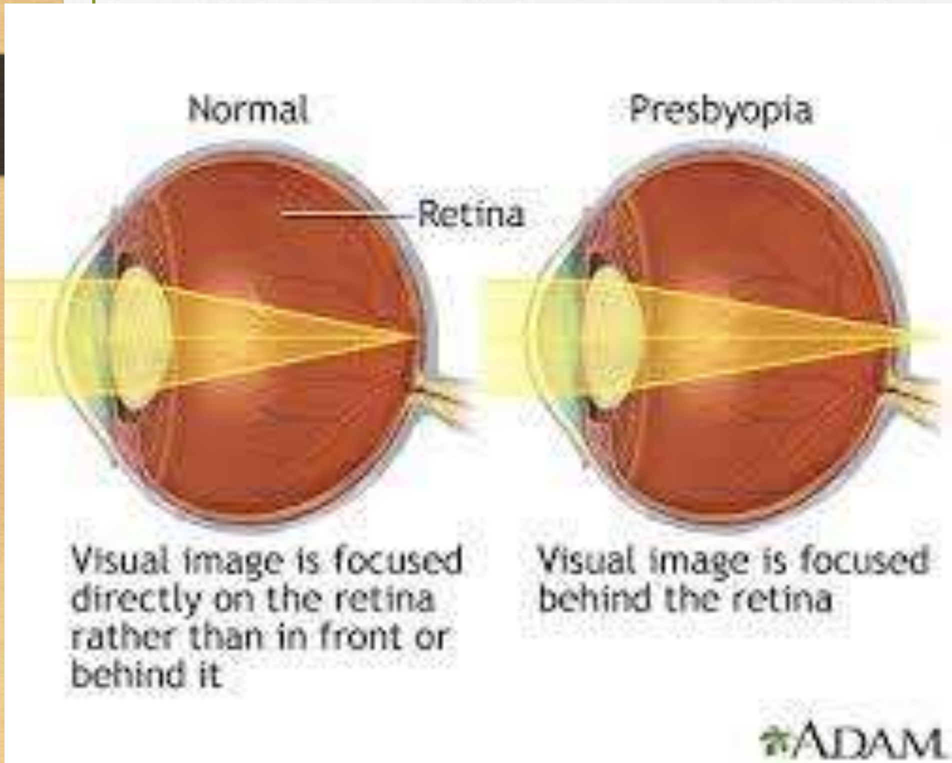
- Pupil constriction under the influence of light
- Midbrain reflex
- Parasympathetic nucleus of n.oculomotorius

Accomodation reflex

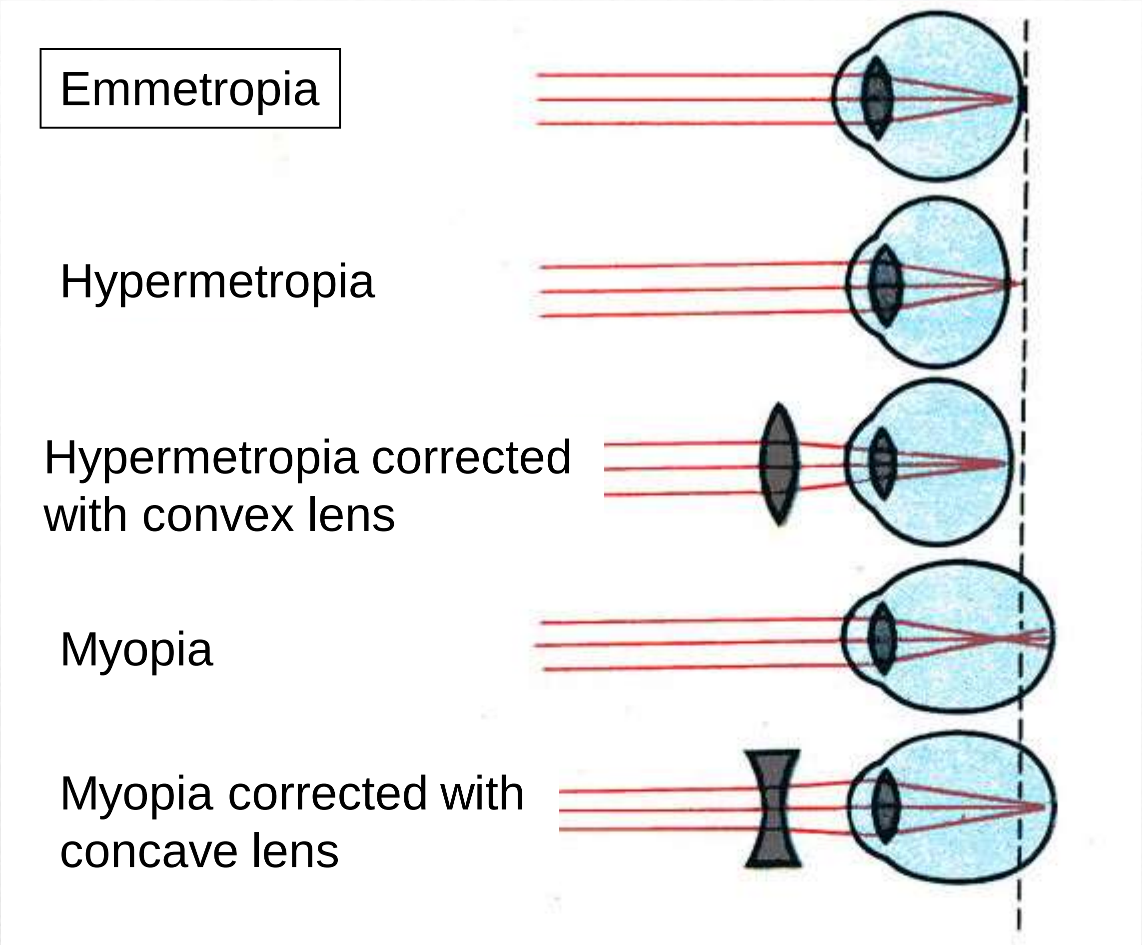
- Changing the curvature of crystaline lens for better refraction at close vision
- Common pathways with pupillary reflex

presbyopia


Single vision Lense
distance
OR
near
Bifocal Lense
distance
near
Trifocal Lense
distance
intermediate
near
Progressive Lense
distance
near


Normal
Presbyopia
Retina
Visual image is focused directly on the retina rather than in front or behind it
Visual image is focused behind the retina
ADAM

Cataract - clouded, blurred or


Emmetropia
Hypermetropia
Hypermetropia corrected with convex lens
Myopia
Myopia corrected with concave lens

Acuity of vision

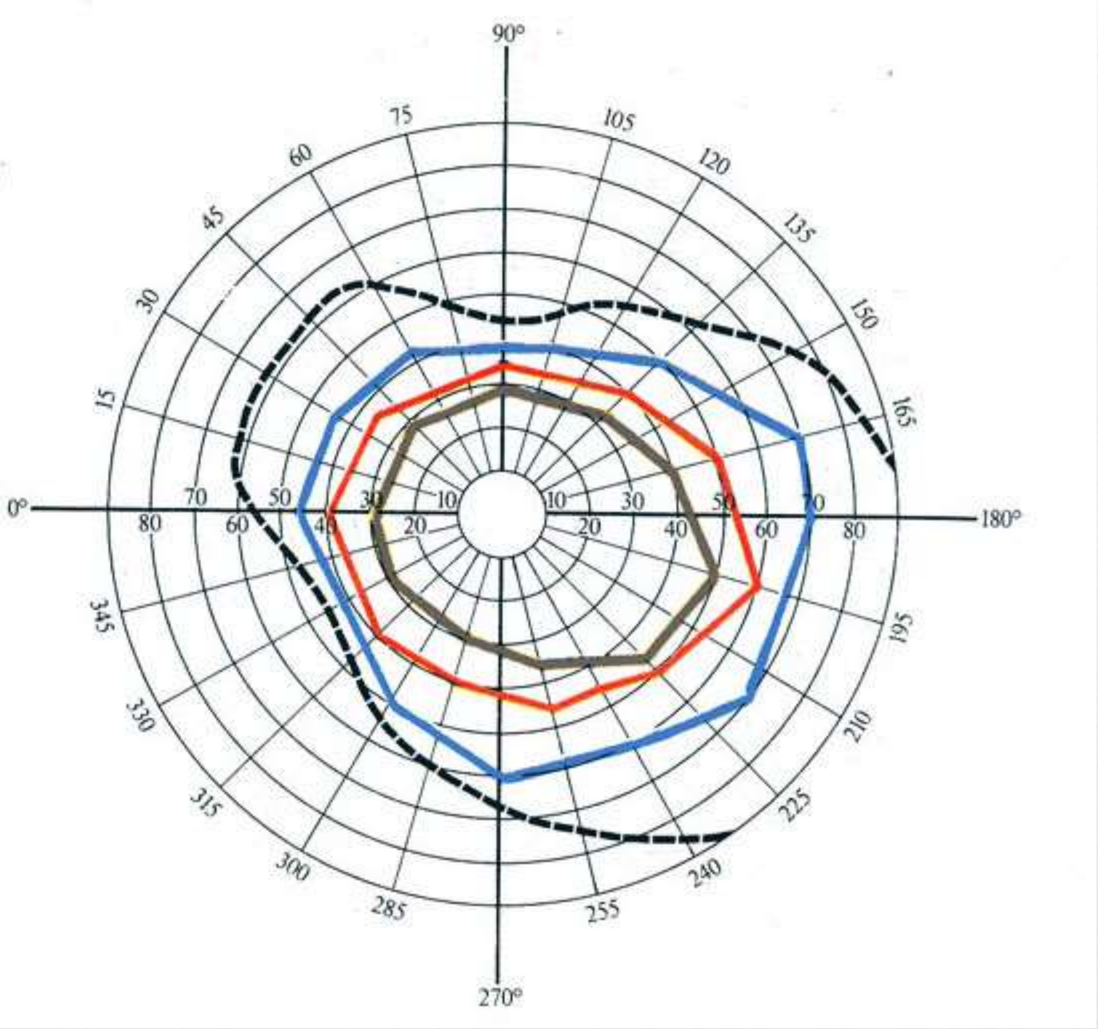
- Is determined by the least distance between two points that the eye can distinguish
- Normal eye can distinguish 2 points subtended by an angle of 60 seconds
- Measured by Snellen's types

Acuity of vision

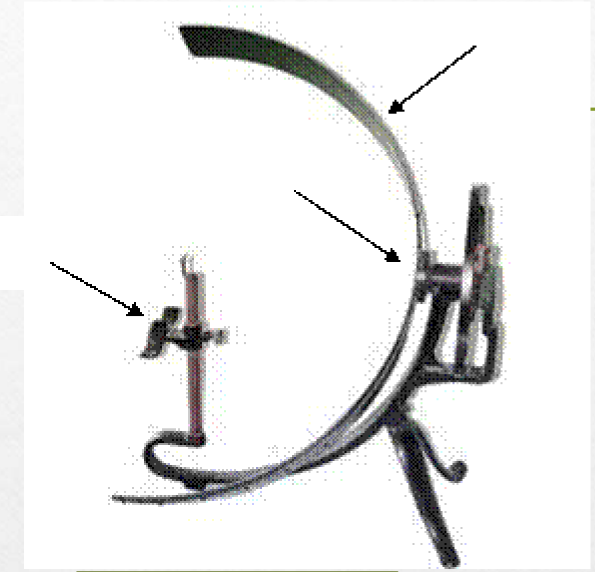
- Vis (OD)= $\frac{d}{D} = \frac{5{,}0}{5{,}0} = 1$
- Vis (OS)= $\frac{d}{D} = \frac{2{,}5}{5{,}0} = 0.5$

Field of vision

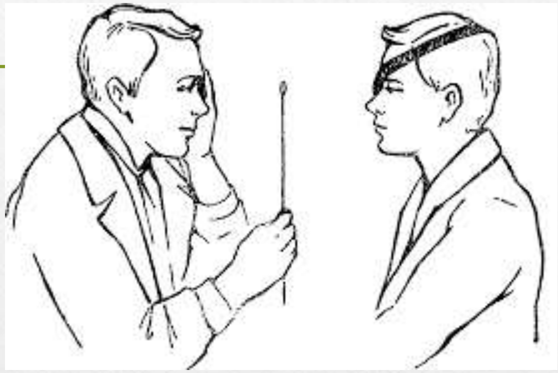
- Aggregate number of points seen simultaneously when the eye is fixed steadily on one point
- The extent of the field of vision is measured by *perimeter*


90°
75
105
60
120
45
135
30
150
15
165
0°
180°
345
195
330
210
315
225
300
240
285
255
270°
10
20
30
40
50
60
70
80

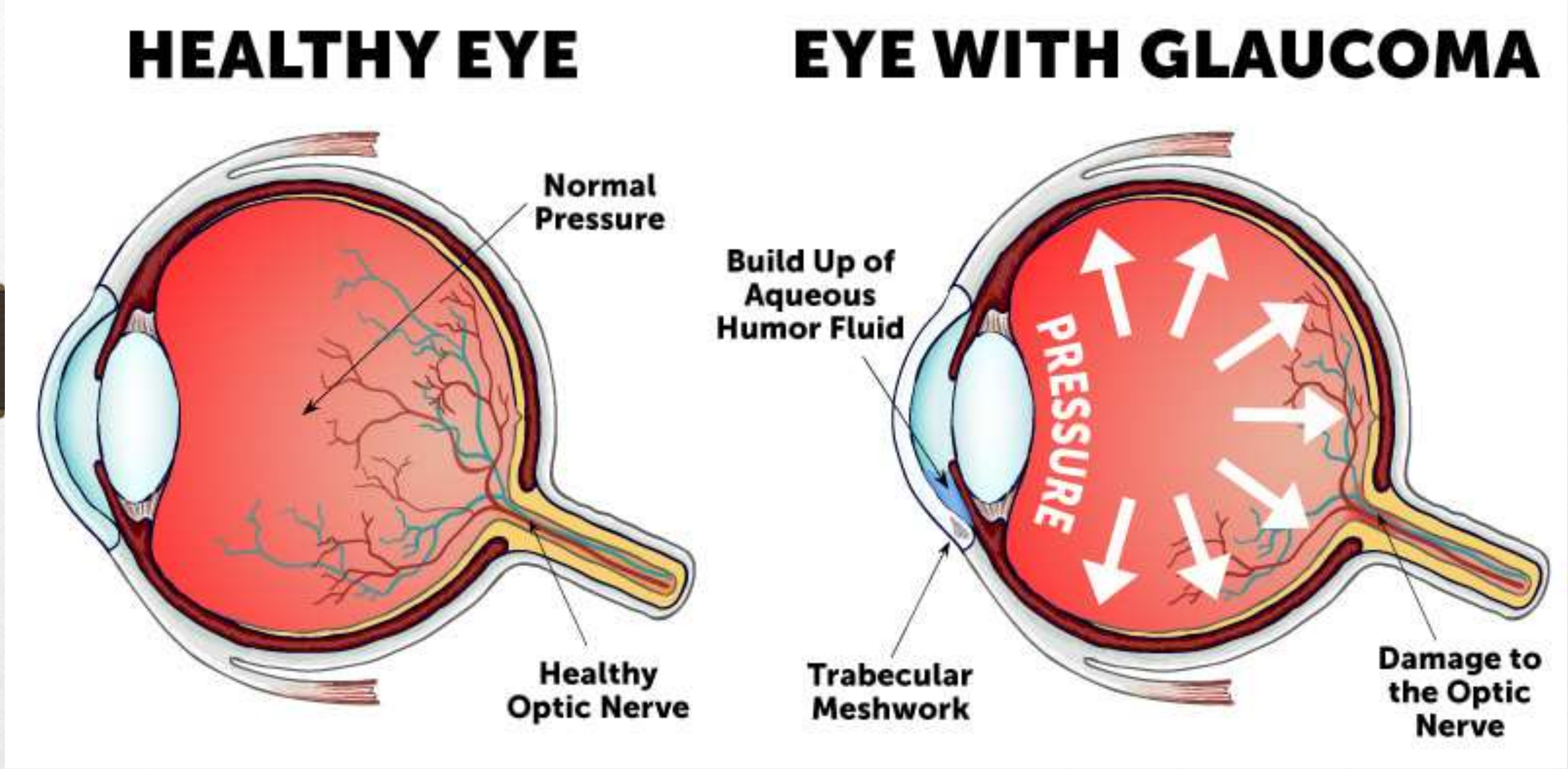
Examination of fields of vision



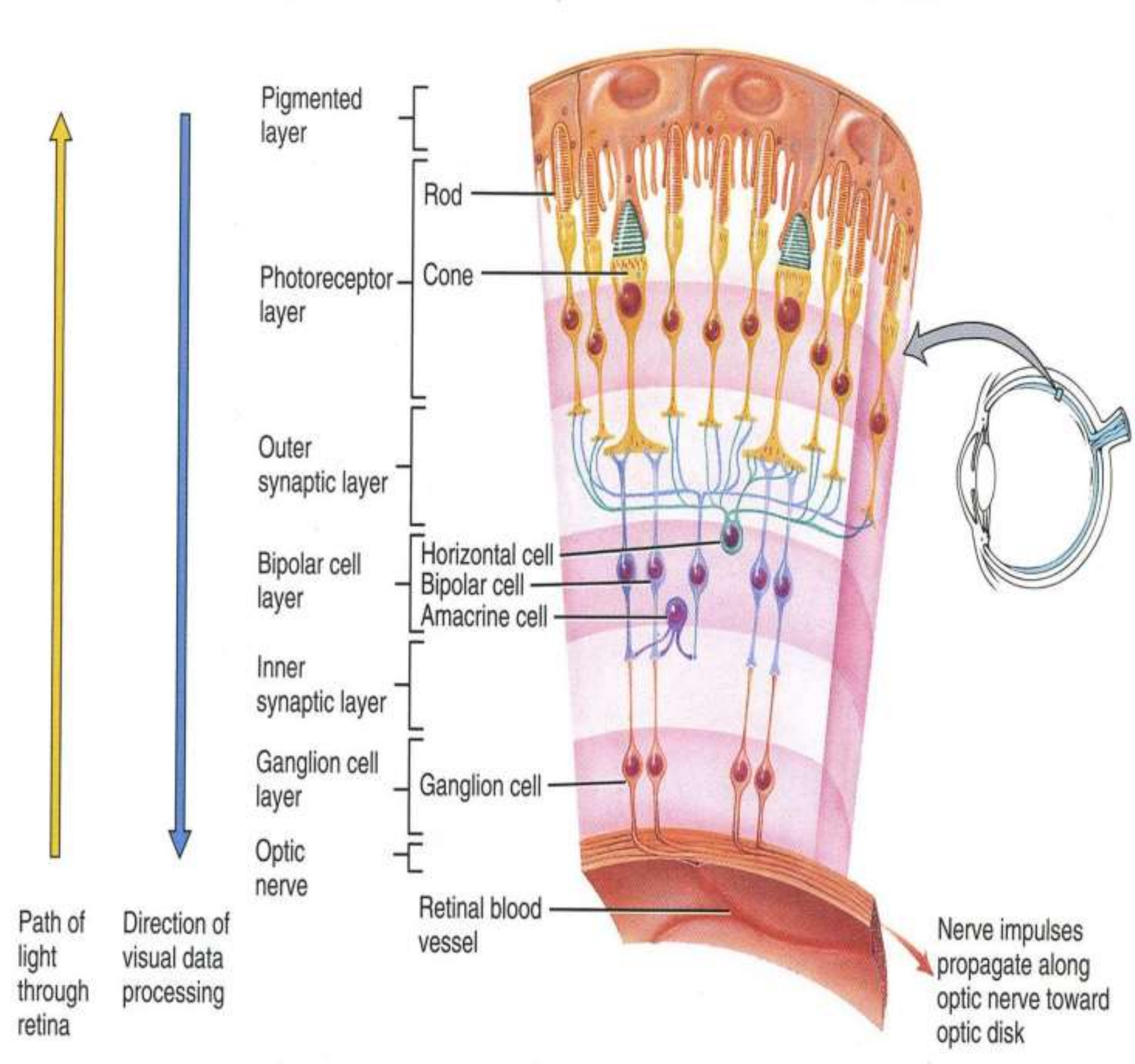
Perimeter

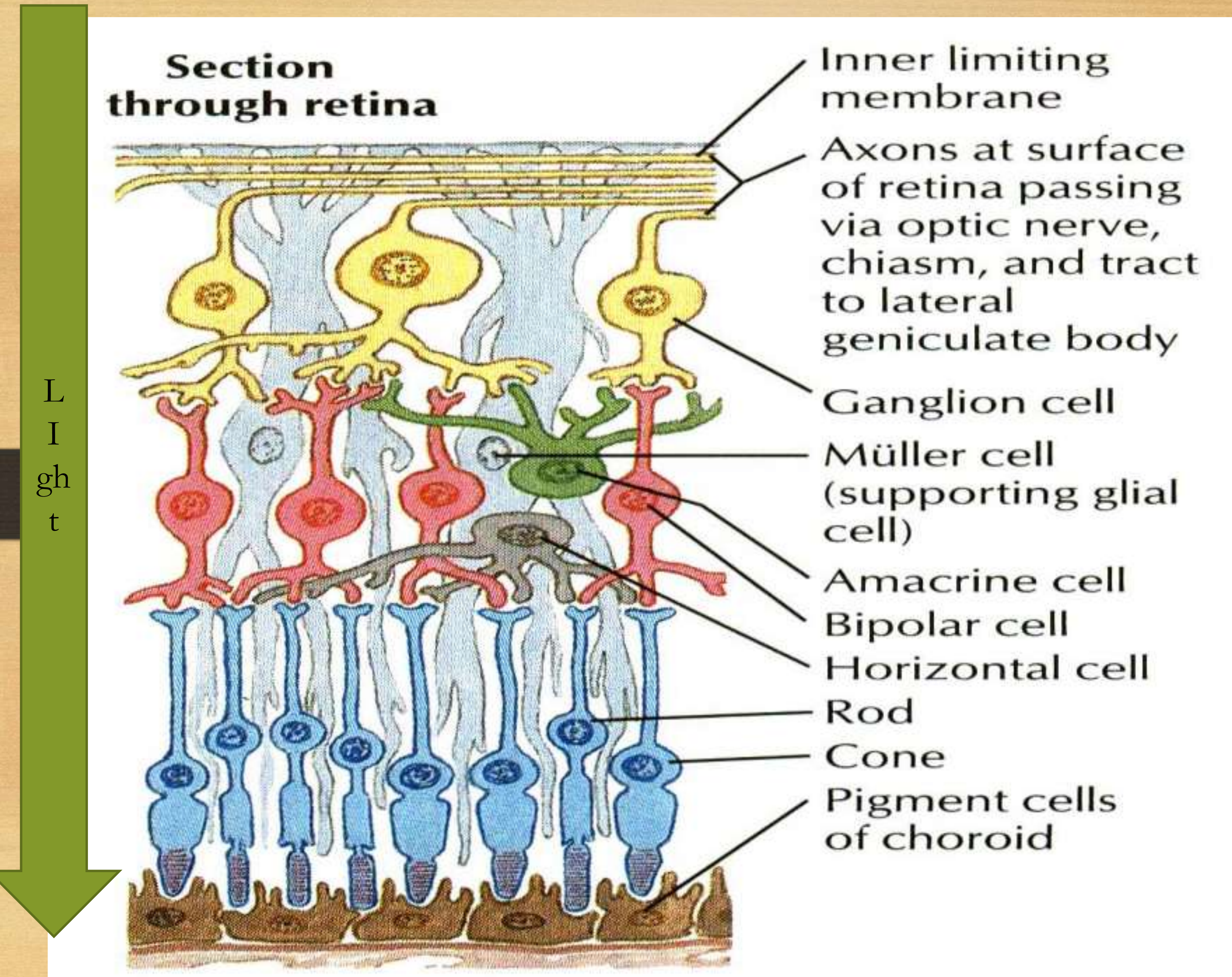


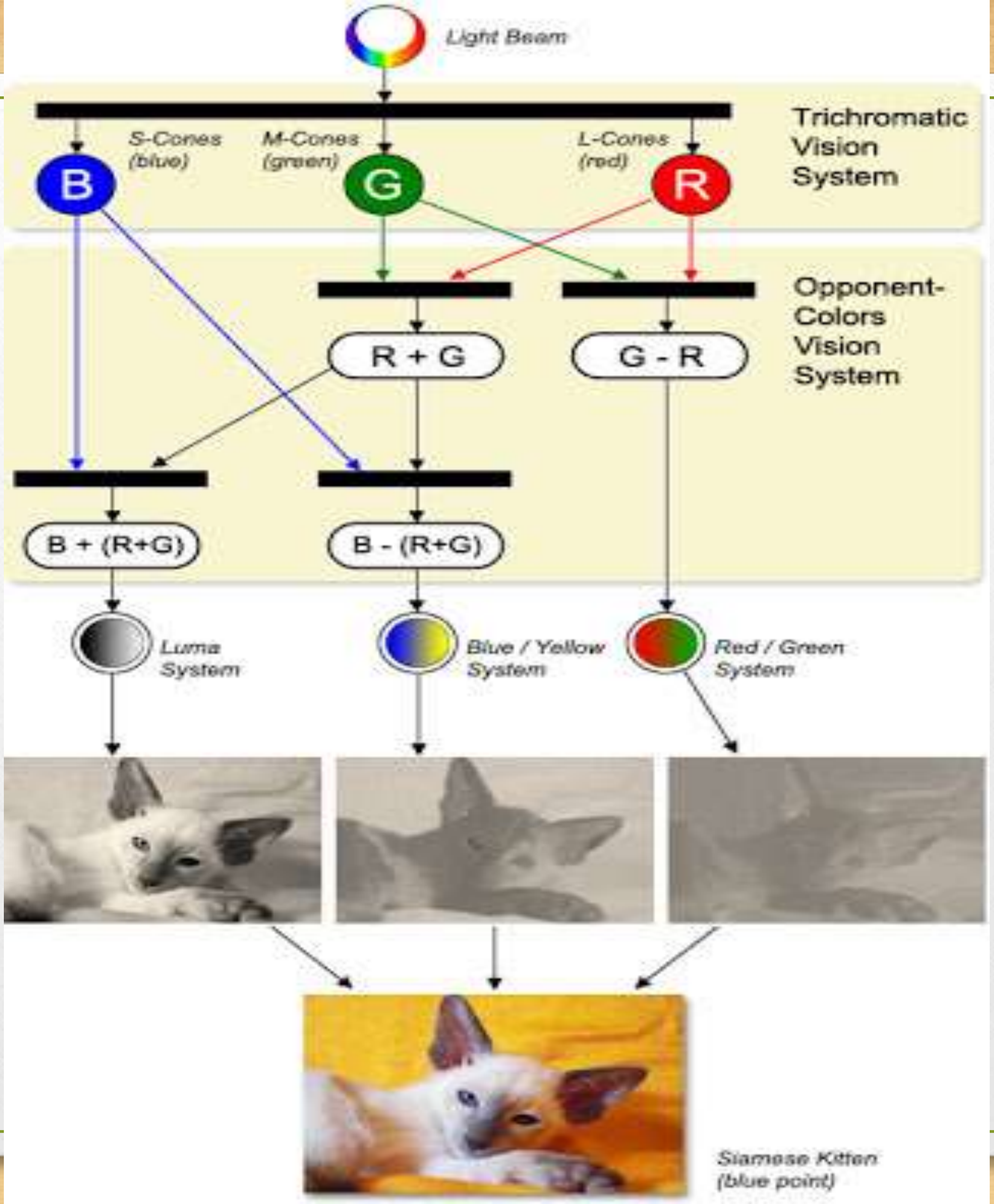
glaucoma



HEALTHY EYE
EYE WITH GLAUCOMA
Normal Pressure
Healthy Optic Nerve
Build Up of Aqueous Humor Fluid
PRESSURE
Trabecular Meshwork
Damage to the Optic Nerve

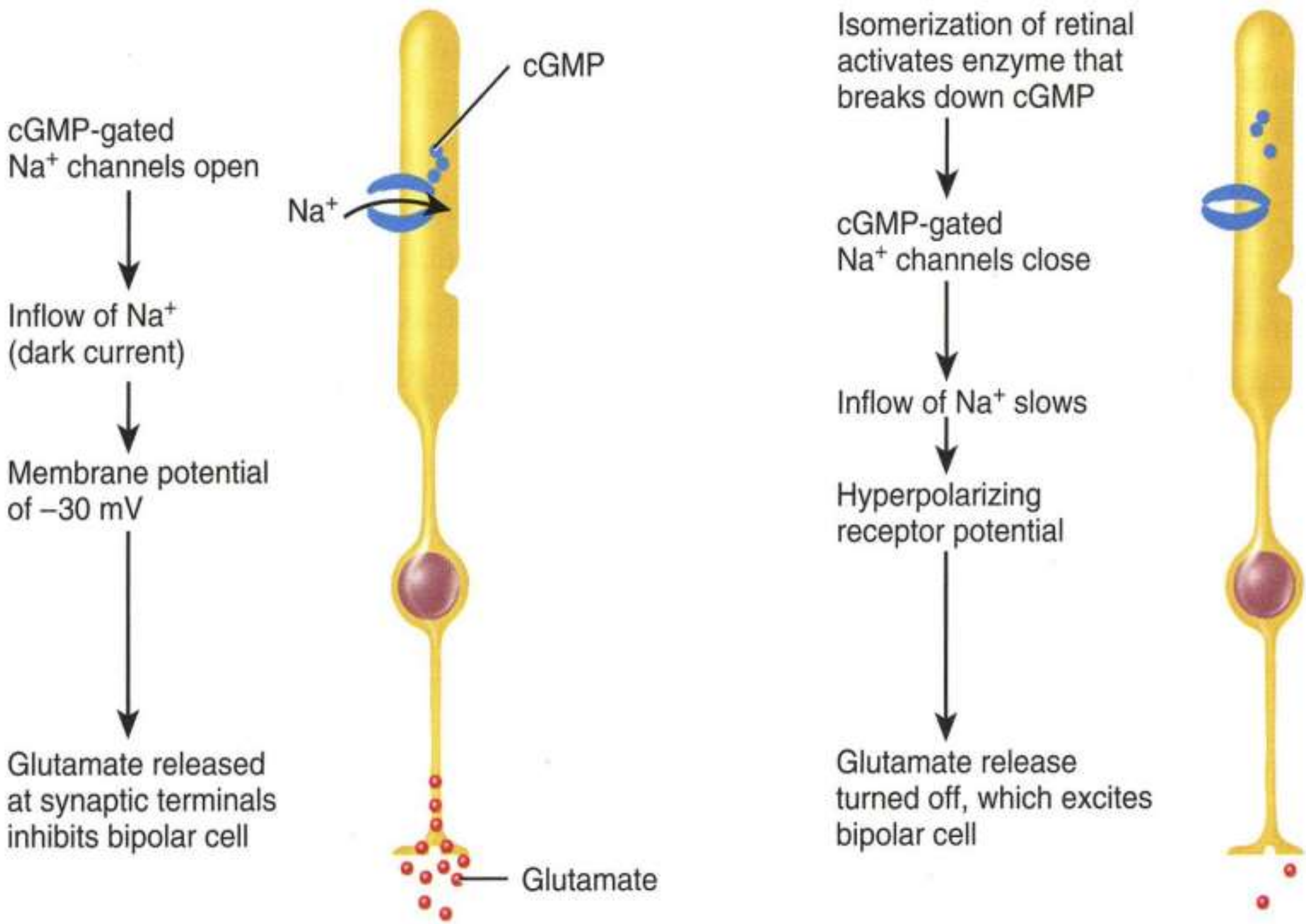

Pigmented layer
Photoreceptor layer
Outer synaptic layer
Bipolar cell layer
Inner synaptic layer
Ganglion cell layer
Optic nerve
Rod
Cone
Horizontal cell
Bipolar cell
Amacrine cell
Ganglion cell
Retinal blood vessel
Path of light through retina
Direction of visual data processing
Nerve impulses propagate along optic nerve toward optic disk


L
I
gh
t
Section
through retina
Inner limiting
membrane
Axons at surface
of retina passing
via optic nerve,
chiasm, and tract
to lateral
geniculate body
Ganglion cell
Müller cell
(supporting glial
cell)
Amacrine cell
Bipolar cell
Horizontal cell
Rod
Cone
Pigment cells
of choroid


Light Beam
Trichromatic
Vision
System
S-Cones
(blue)
M-Cones
(green)
L-Cones
(red)
B
G
R
Opponent-
Colors
Vision
System
R + G
G - R
B + (R+G)
B - (R+G)
Luma
System
Blue / Yellow
System
Red / Green
System
Siamese Kitten
(blue point)

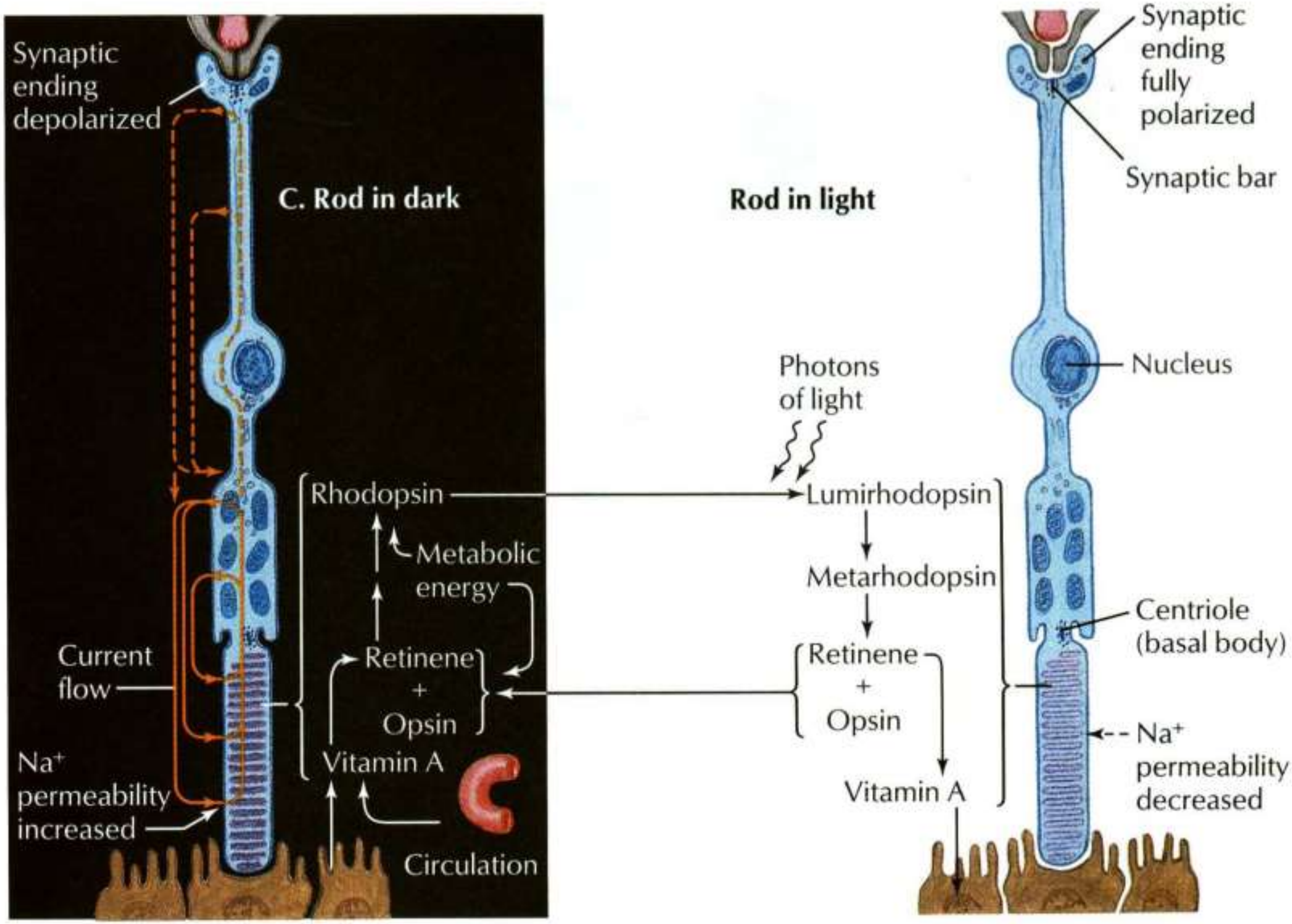
Operation of rod photoreceptors.

Light causes a hyperpolarizing receptor potential in photoreceptors, which decreases release of an inhibitory neurotransmitter (glutamate).



(a) In darkness

(b) In light



Synaptic ending depolarized
C. Rod in dark
Rhodopsin
Metabolic energy
Retinene + Opsin
Vitamin A
Circulation
Current flow
Na+ permeability increased
Rod in light
Synaptic ending fully polarized
Synaptic bar
Nucleus
Photons of light
Lumirhodopsin
Metarhodopsin
Retinene + Opsin
Vitamin A
Centriole (basal body)
Na+ permeability decreased

Ganglion Cell Receptor Fields

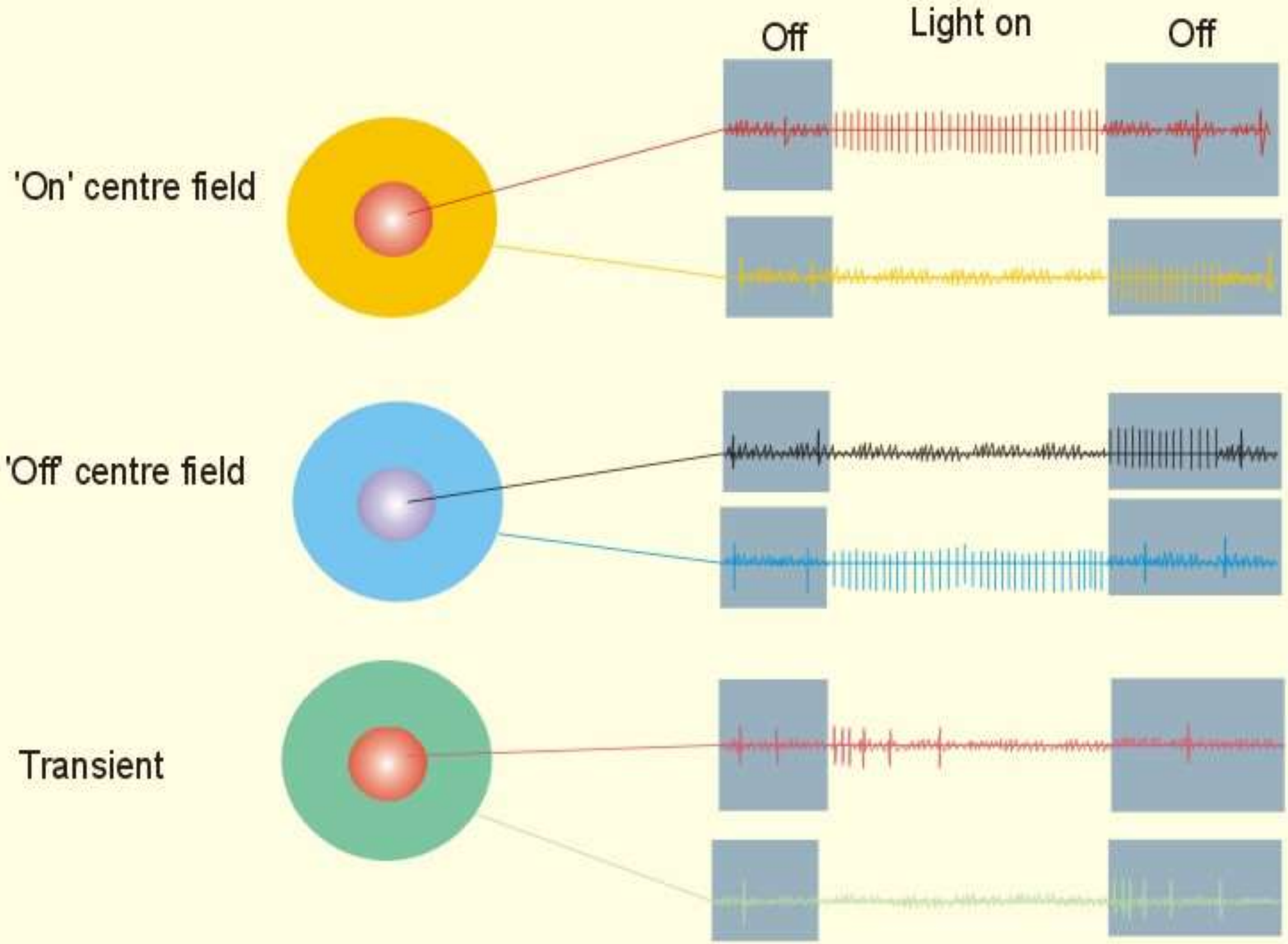
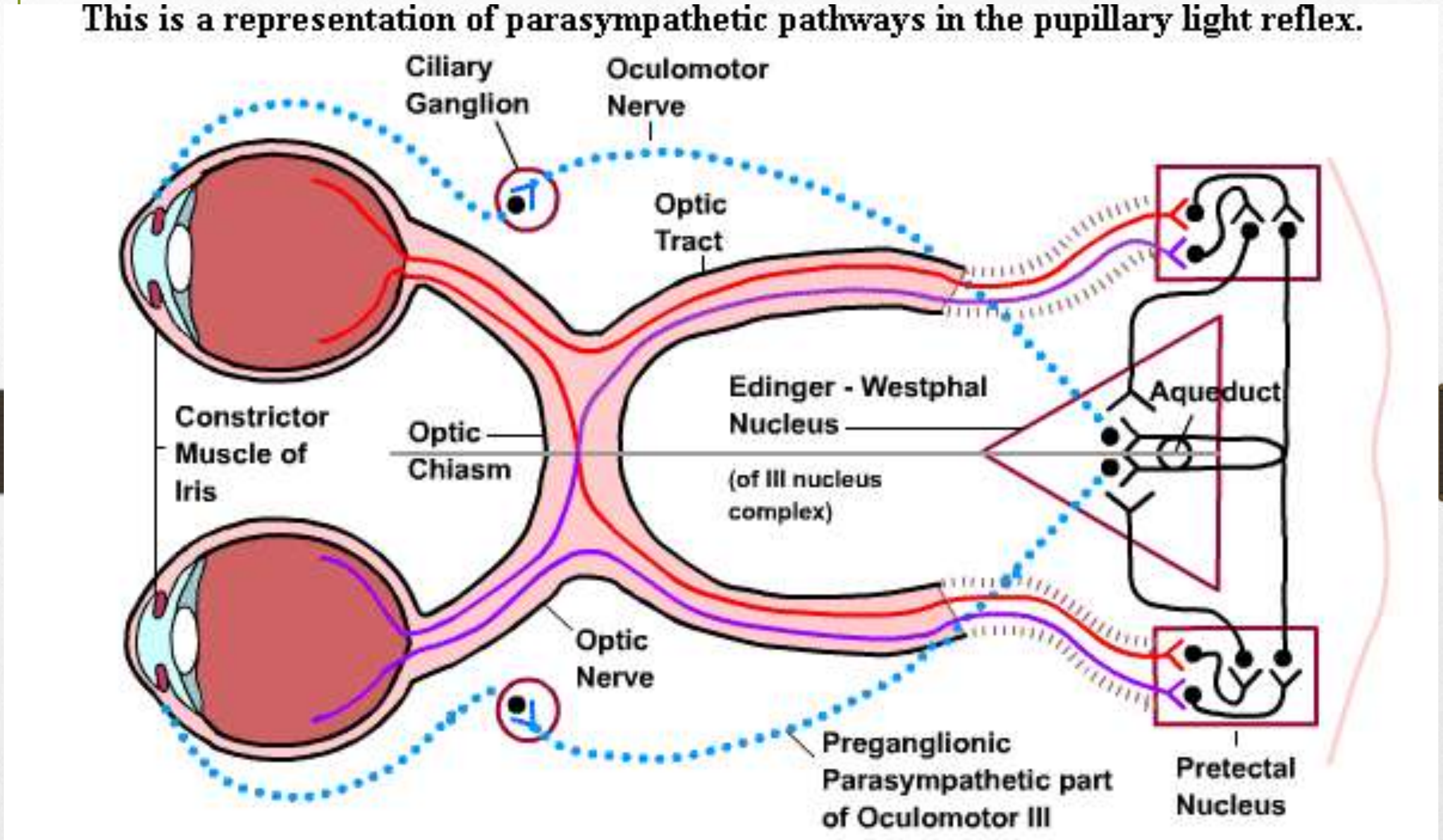
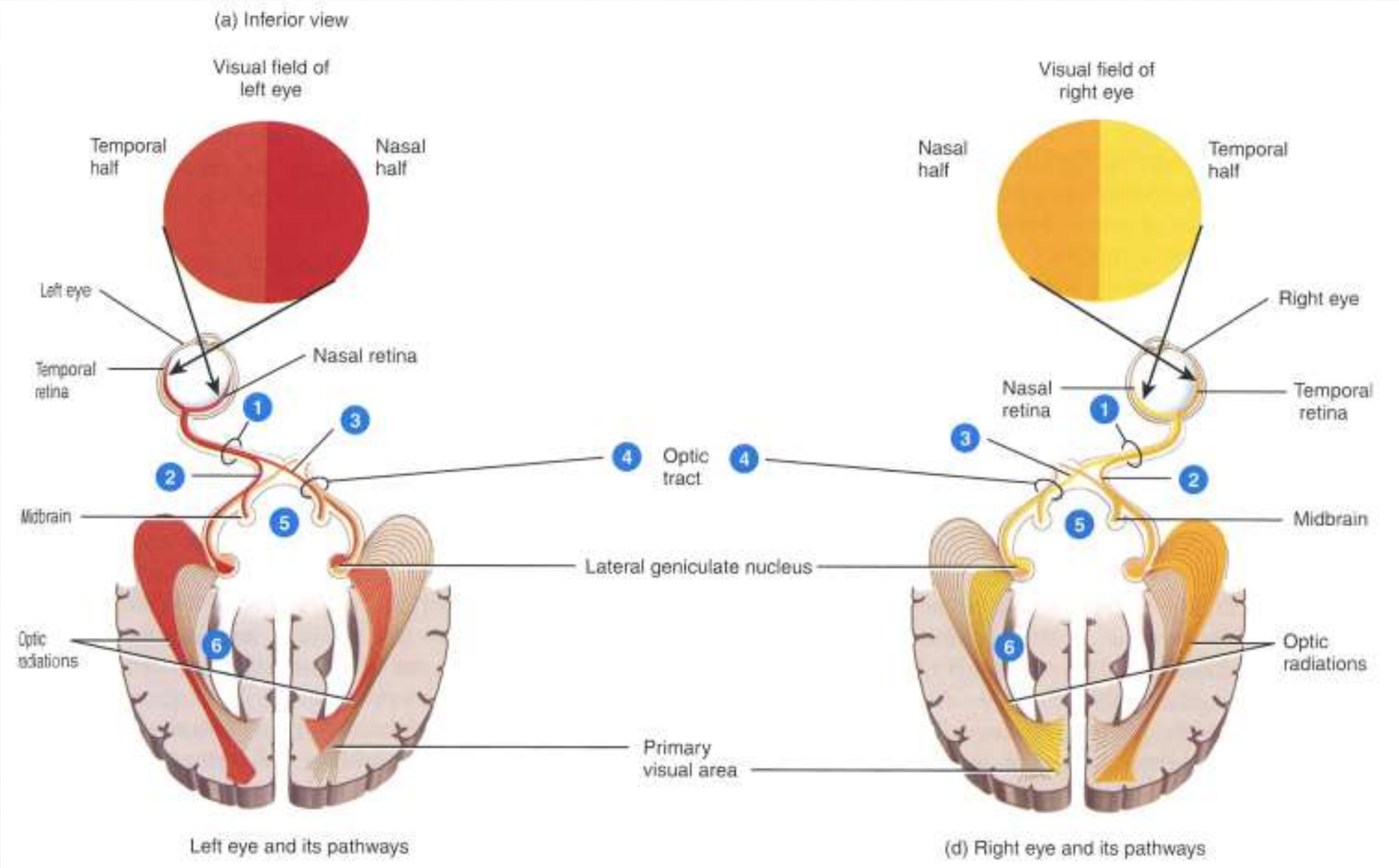


Fig. 5-2

KMc

pupillary reflex




(a) Inferior view
Visual field of left eye
Temporal half
Nasal half
Left eye
Temporal retina
Nasal retina
1
2
3
4
Optic tract
4
5
Midbrain
Lateral geniculate nucleus
Optic radiations
6
Primary visual area
Left eye and its pathways
Visual field of right eye
Nasal half
Temporal half
Right eye
Nasal retina
Temporal retina
1
2
3
5
Midbrain
6
Optic radiations
(d) Right eye and its pathways

Visual Field Defect

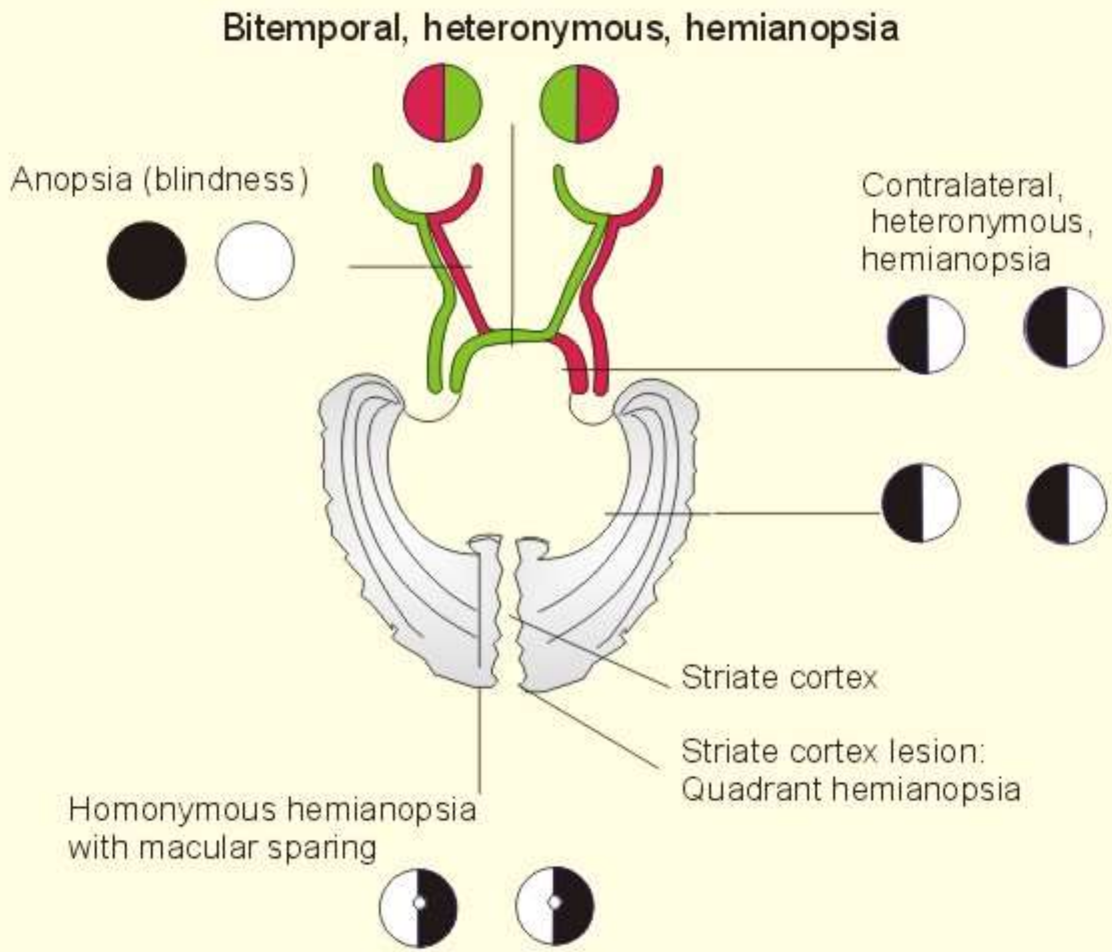
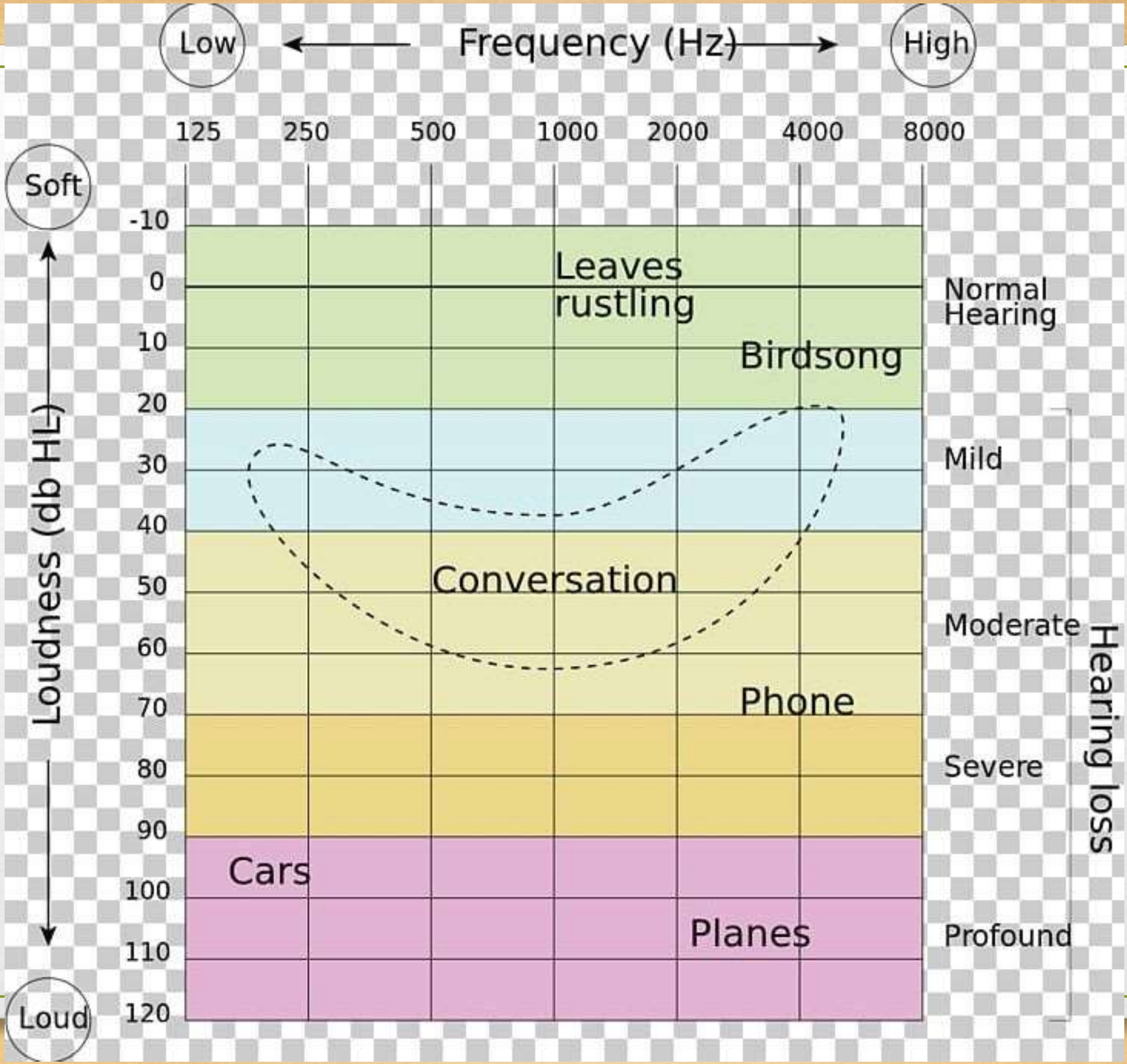


Fig. 5-6

KMc

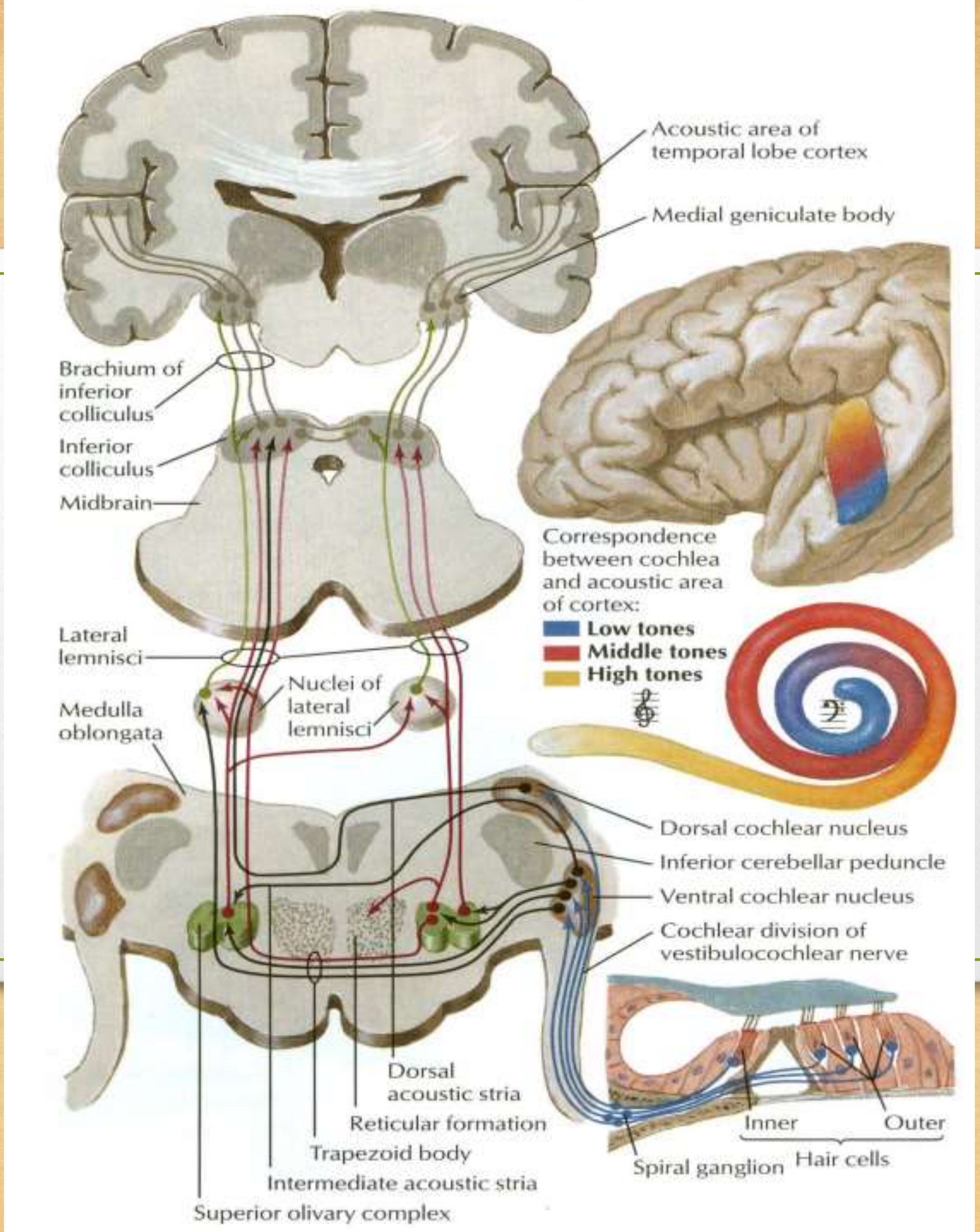
Physiology of hearing



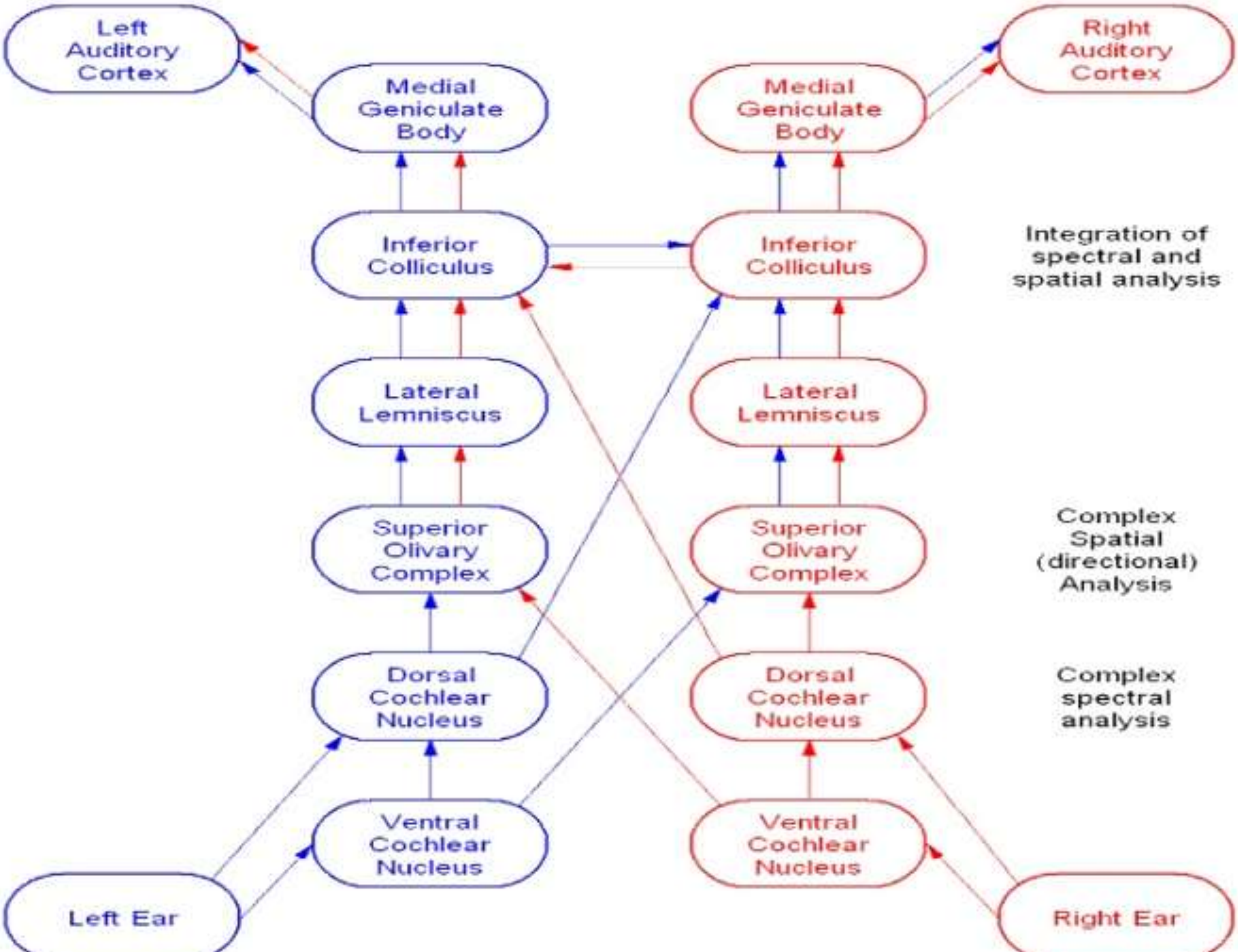
Low
Frequency (Hz)
High
125
250
500
1000
2000
4000
8000
Soft
Loudness (db HL)
Loud
-10
0
10
20
30
40
50
60
70
80
90
100
110
120
Leaves rustling
Birdsong
Conversation
Phone
Cars
Planes
Normal Hearing
Mild
Moderate
Severe
Profound
Hearing loss

Auditory analyzer

- Auditory pathway: Eighth nerve → Cochlear nuclei → Superior Olivary complex → Lateral Lemniscus → Inferior Colliculus → Medial Geniculate body → Auditory Cortex (ECOLI MA)
- Each ear is represented in both cerebral hemispheres
- Auditory cortex is situated in superior temporal gyrus (Brodmann's Area 41)



Acoustic area of temporal lobe cortex
Medial geniculate body
Brachium of inferior colliculus
Inferior colliculus
Midbrain
Correspondence between cochlea and acoustic area of cortex:
Low tones
Middle tones
High tones
Lateral lemnisci
Nuclei of lateral lemnisci
Medulla oblongata
Dorsal cochlear nucleus
Inferior cerebellar peduncle
Ventral cochlear nucleus
Cochlear division of vestibulocochlear nerve
Dorsal acoustic stria
Reticular formation
Trapezoid body
Intermediate acoustic stria
Superior olivary complex
Inner
Outer
Hair cells
Spiral ganglion

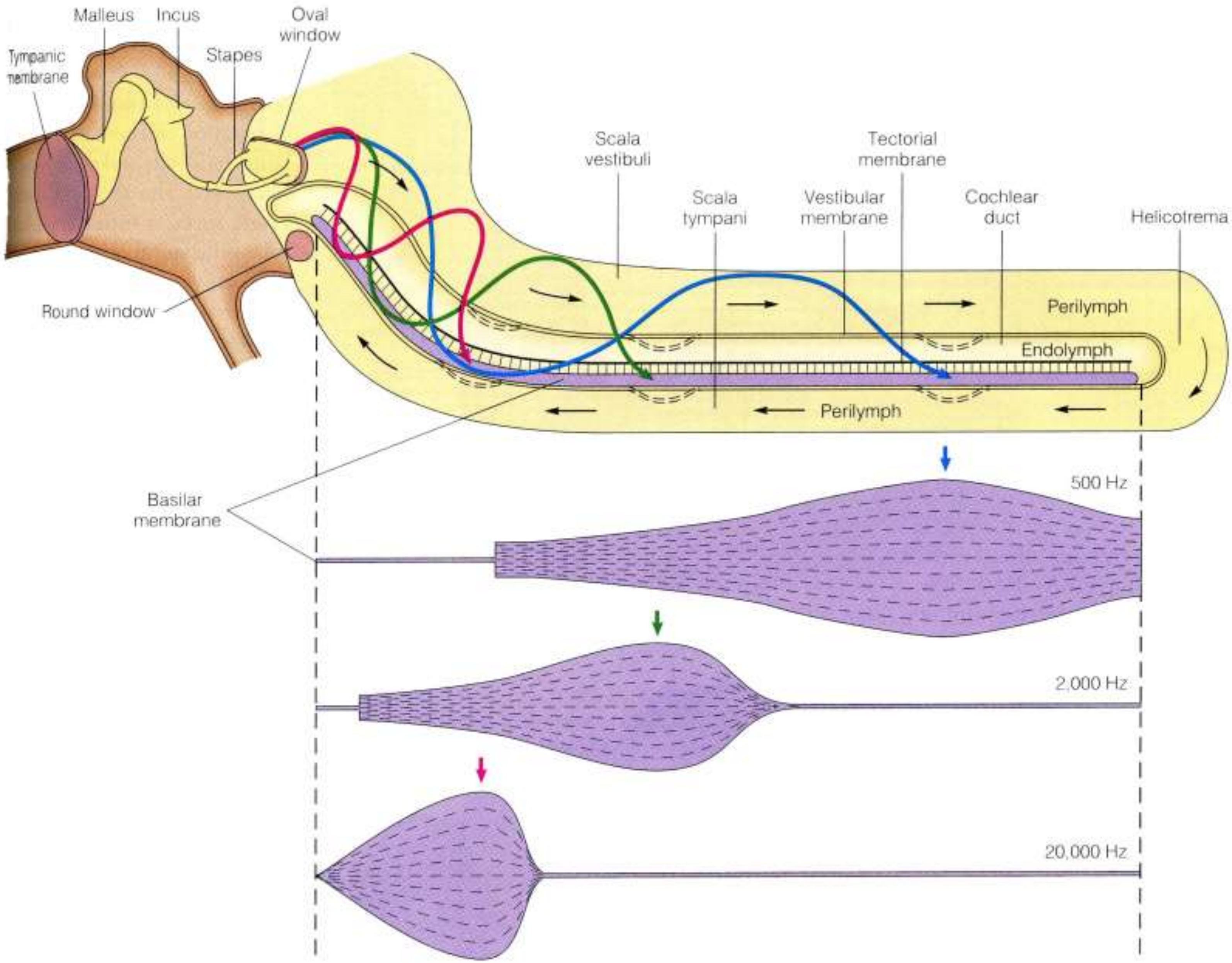

Left Auditory Cortex
Medial Geniculate Body
Right Auditory Cortex
Medial Geniculate Body
Inferior Colliculus
Inferior Colliculus
Integration of spectral and spatial analysis
Lateral Lemniscus
Lateral Lemniscus
Superior Olivary Complex
Superior Olivary Complex
Complex Spatial (directional) Analysis
Dorsal Cochlear Nucleus
Dorsal Cochlear Nucleus
Complex spectral analysis
Ventral Cochlear Nucleus
Ventral Cochlear Nucleus
Left Ear
Right Ear

Functions of the cortex in hearing

- The main function- formation of acoustic sensations
- Location-Heshle gyrus (superior temporal gyrus)
- Functions: 1. discrimination of sound frequences
- Psychic sensations of sound pitches
- Detection of the direction of the sounds
- Detection of special modulation of sounds, such as noise versus pure frequency sounds
- Function of association cortex: Recognition of sounds
- Associate sound information with information from other sensory areas of the cortex
- recognition of words (Wernike's area)

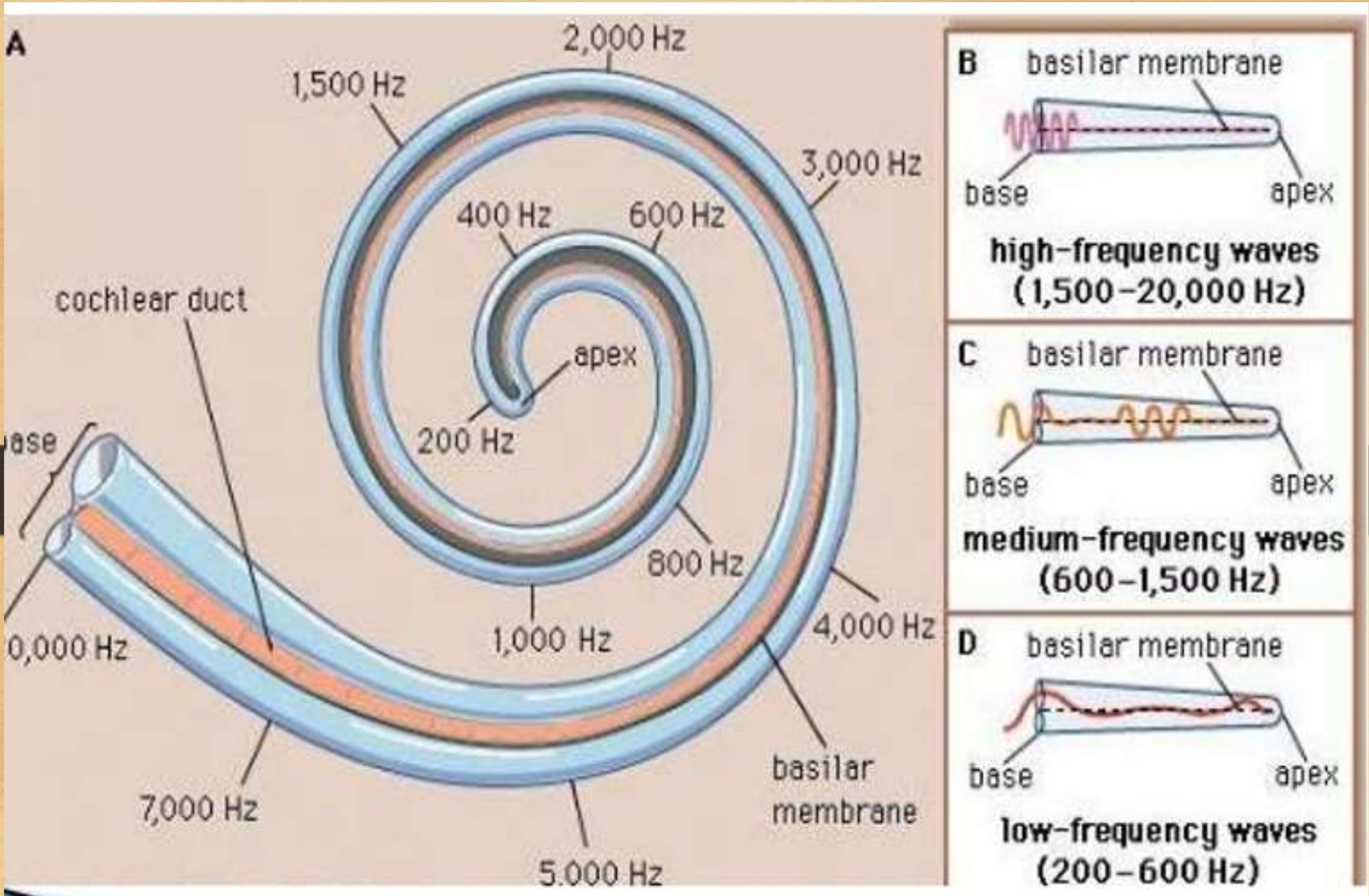
Determination of sound frequency

- Place principle for determination of sound frequency:
- Low frequency sounds cause maximal activation of the basilar membrane near the apex of the cochlea
- High frequency sounds cause maximal activation of the basilar membrane near the foramen oval of the cochlea
- Intermediate distances activate the basilar membrane between these two extremes
- Thus, there is spatial organization of the nerve fibers from the cochlea to the cerebral cortex. Specific brain neurons are activated by specific sound frequencies.



Sounds of low frequency cause pressure waves of perilymph to pass through the helicotrema. Sounds of higher frequency cause pressure waves to "shortcut" through the cochlear duct. This causes displacement of the basilar membrane, which is central to the transduction of sound waves into nerve impulses. (The frequency of sound waves is measured in cycles per second, or hertz [Hz].)

Sensory Organs


A
2,000 Hz
1,500 Hz
3,000 Hz
400 Hz
600 Hz
cochlear duct
apex
200 Hz
ase
800 Hz
1,000 Hz
4,000 Hz
0,000 Hz
basilar membrane
7,000 Hz
5.000 Hz
B basilar membrane
base
apex
high-frequency waves (1,500–20,000 Hz)
C basilar membrane
base
apex
medium-frequency waves (600–1,500 Hz)
D basilar membrane
base
apex
low-frequency waves (200–600 Hz)

The Travelling Wave Theory

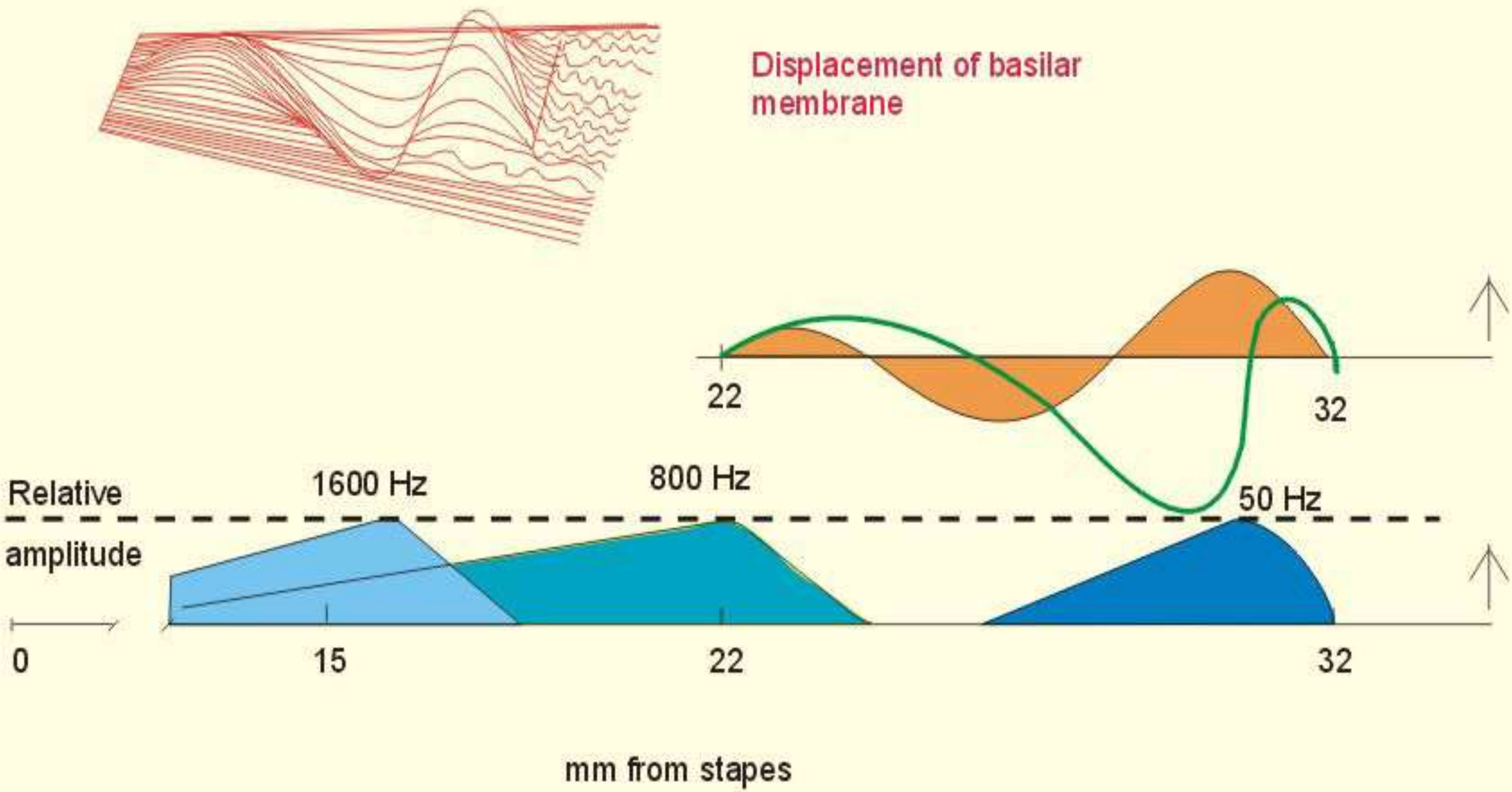


Fig. 5-4

KMc