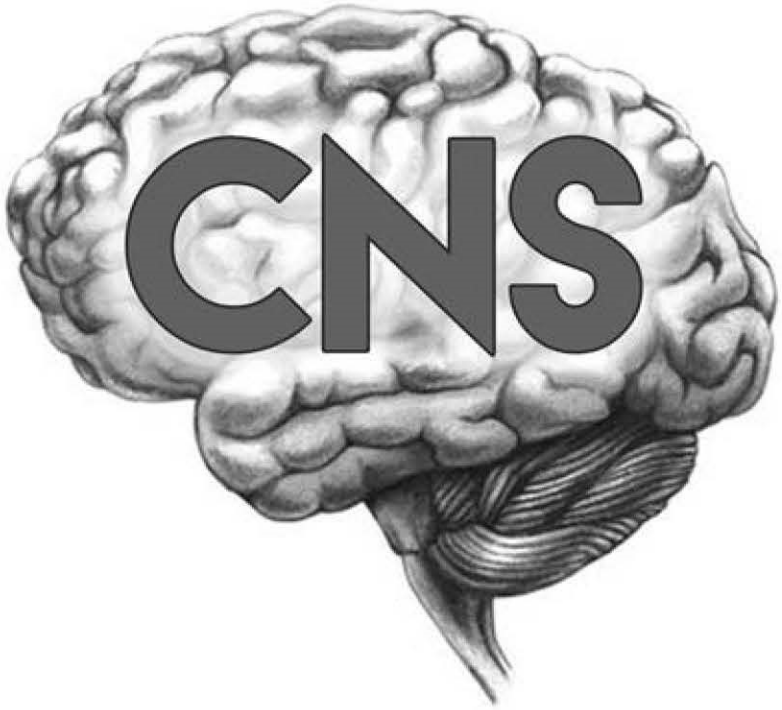

ANATOMY

○ Sheet ✓ Slide ✓ Handout

Number

6

Subject

.....

Doctor

RD .Faraj Al-Bustami

Date: **6/3/2017**

Price: **45**

EYEBALL

The eyeball is formed of three coats :

1. Fibrous coat : external.
2. Vascular and muscular coat : intermediate.
3. Nervous coat : internal.

Fibrous Coat

is formed of the cornea and sclera.

A. Cornea : transparent and forms the anterior sixth of the fibrous coat.

B. Sclera : is formed of dense white fibrous tissue (white of the eye). The optic nerve pierces the sclera about 3 mm. to the infero-medial side of the posterior pole of the eyeball.

The corneo-scleral junction (Limbus) presents a circular canal called the sinus venosus sclerae (*canal of Schlem*) into which the aquous humour is absorbed from the anterior chamber.

Vascular and Muscular Coat

is formed by the iris, ciliary body and choroid.

A. Iris : a circular diaphragm behind the cornea. It presents a central hole called the *pupil*. It contains the constrictor (sphincter) and dilator pupillae muscles.

The colour of the iris varies in different individuals due to presence of pigments. The space between the iris and cornea is called *anterior chamber*. The space between the iris and lens is called *posterior chamber*. The two chambers communicate through the pupil.

B. Ciliary body : composed of several parts :

a) *ciliary muscle* : which forms a muscular ring around the iris. It is formed of smooth muscle fibers arranged circularly and radially.

b) *ciliary processes* : which are irregular projections deep to the ciliary muscle. They lie lateral to the posterior chamber between the margins of the iris and lens. They secrete the aquous humour.

c) *ciliary ring* : which is a narrow vascular zone at the junction with the choroid.

N.B Aqueous humour is secreted into the posterior chamber from the capillaries of the ciliary processes & circulates into the anterior chamber through the pupil → from the anterior chamber it is drained into the anterior ciliary veins through the canal of Schlemm ⟹ Interference with drainage of the aqueous humour into the canal of Schlemm results in an increase of the intraocular pressure (glaucoma) → This produces pressure atrophy of the retina causing blindness

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C. **Choroid** : is the largest part of the middle coat, lying between the sclera and retina. The choroid is formed of delicate areolar tissue which is highly pigmented and rich in blood vessels. Posteriorly, it is pierced by the optic nerve.

Nervous Coat

This coat is mainly formed by the retina. (outer pigmented layer; inner nervous layer)

The retina is supplied by branches of the central artery of the retina which never anastomose together or with other arteries in the eyeball (i.e they are end-arteries)

The retinal veins collect into a central vein (its obstruction by embolism leads to sudden blindness)

Lens

— transparent, solid, elastic and bivonvex.

— lies between the iris and vitrious body.

— Its equator is blunt.

— The *suspensory ligament of the lens* is attached to the anterior surface of the capsule of the lens close to the the equator. Some fibers of the ligament are attached to the equator and posterior surface close to the equator.

The suspensory ligaments of the lens fixes the lens in position and connects it to the ciliary muscle. Therefore the curvature of the lens is affected by the contraction of the ciliary muscle and the degree of tension of the suspensory ligament. *

During looking to a near object the ciliary muscle reflexly contracts, the suspensory ligament gets loose and the curvature of the lens increase (accomodation).

— The elasticity of the lens begins to diminish after the age of fourty years → (Presbyopia)

— The transparency of the lens begins to diminish in old people, a condition known as *cataract.*

Vitreous Body

This is a transparent, structurelss, colourless gel-like substance which fills the concavity of the retina. It occupies about four-fifths of the eyeball and lies behind the lens.

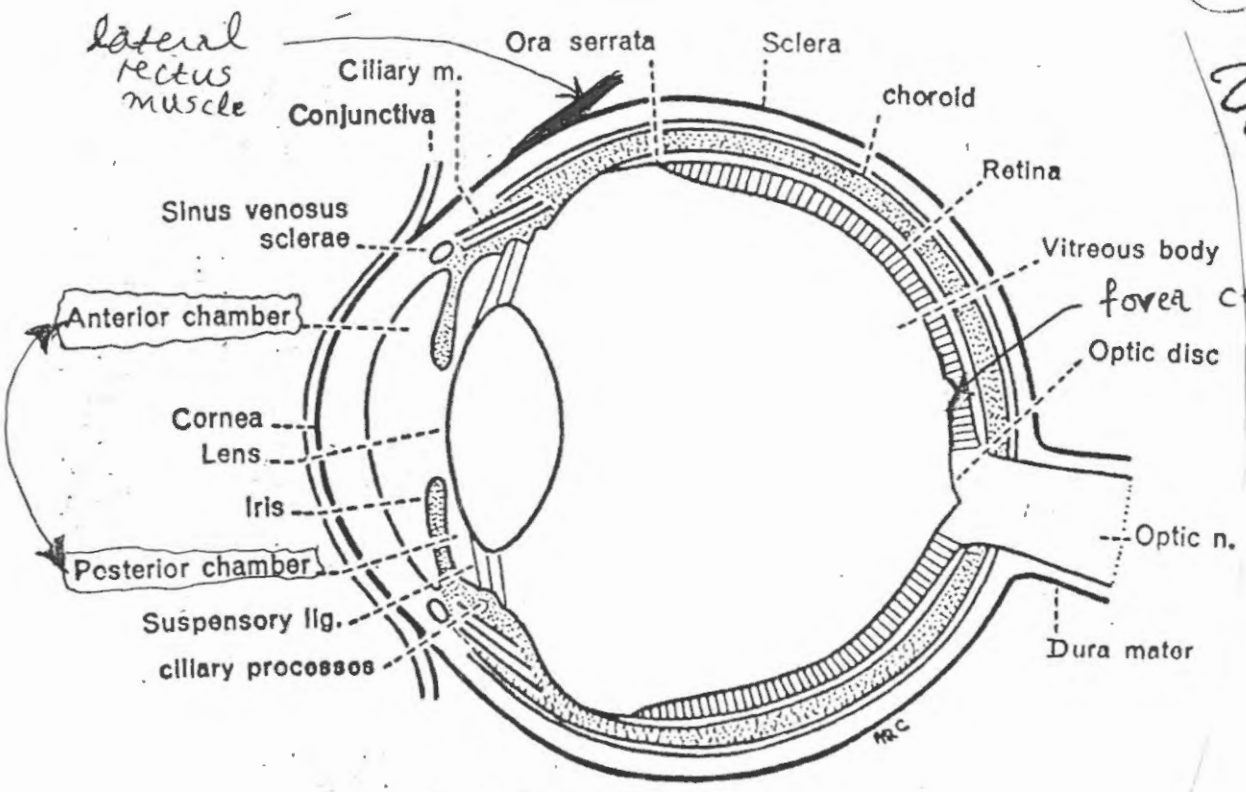
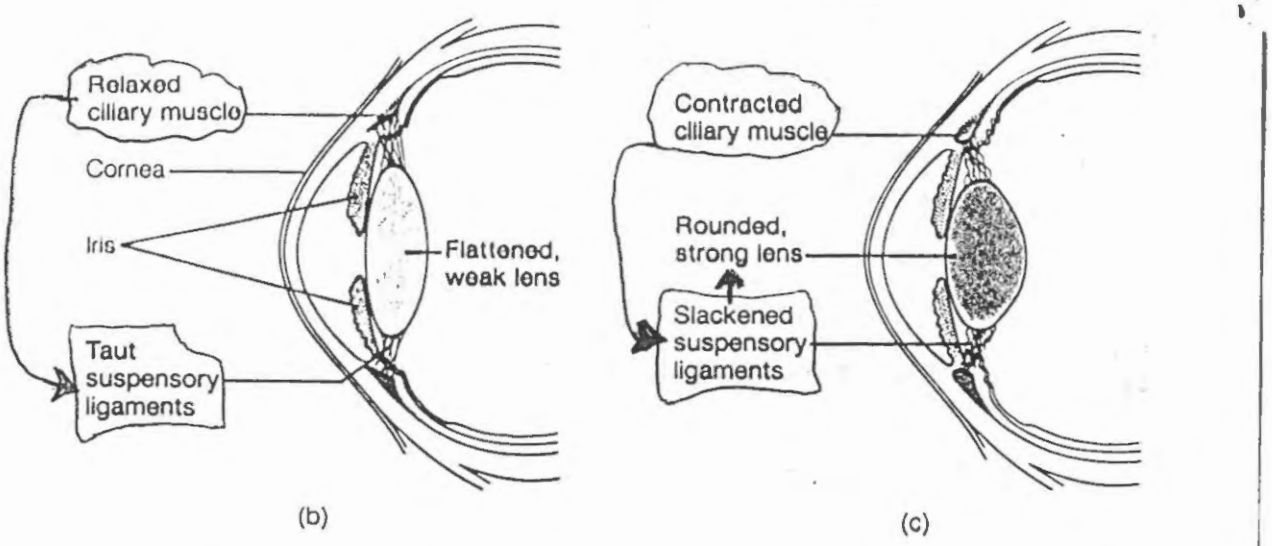


Fig. 174 Sagittal section of the eyeball.

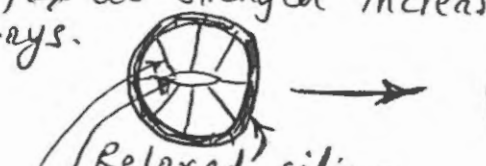
Retina: ① opposite the entrance of optic nerve (infero-medial to the posterior pole) the circular area of 1.5 mm diameter is known as optic disc → the depressed area of the optic disc is called the physiological cup → it contains no receptors (no rods or cones) & is therefore insensitive to light (physiological blind spot) ② At the posterior pole of the eye (3 mm lateral to the optic disc) → there is another depression of similar size called the macula lutea, it is avasc and yellow in colour → the centre of macula is further depressed to form the fovea centralis → This is the thinnest part of retina containing only cones & is the site of maximum acuity of vision ③ the retina consists of an outer pigmented layer & an inner nervous layer (its outer surface is in contact with the choroid & its inner surface is in contact with the vitreous body). In Retinal detachment انفصال الشبكية the outer pigmented layer remains attached to the choroid but the inner nervous layer separates out from the pigmented layer and displaced inward ⑤ the Retina is composed of 10 layers but ONLY 3 layers of major neurons →

Receptors (rods & cones) → ① 1st order neurons → bipolar cells → 2nd order neuron → ganglion cells → third order neurons, its axons form → optic nerve



Accomodation تكيّف العين → increases the strength of the lens for near vision

1. The strength of the lens depends on its shape, which in turn is regulated by the ciliary muscle.
2. The ciliary muscle is a circular ring of smooth muscle attached to the lens by suspensory ligaments.
3. When the ciliary muscle is relaxed → the suspensory ligaments are taut شدّ & pull the lens into a flattened weakly refractive shape ⇝ As the muscle contracts its circumference decreases, relaxing the tension in the suspensory ligaments → the lens becomes more spherical (more rounded) → its strength increases causing greater bending of light rays.



Relaxed ciliary muscle
↓
larger circumference
↓
Tense suspensory ligaments
↓
flattened lense
↓
weaker lense

Contracted ciliary muscle (by parasympathetic stimulation)
↓
Smaller circumference
↓
Slackened (relaxed) Suspensory ligaments
↓
more rounded lens
↓
Stronger lens

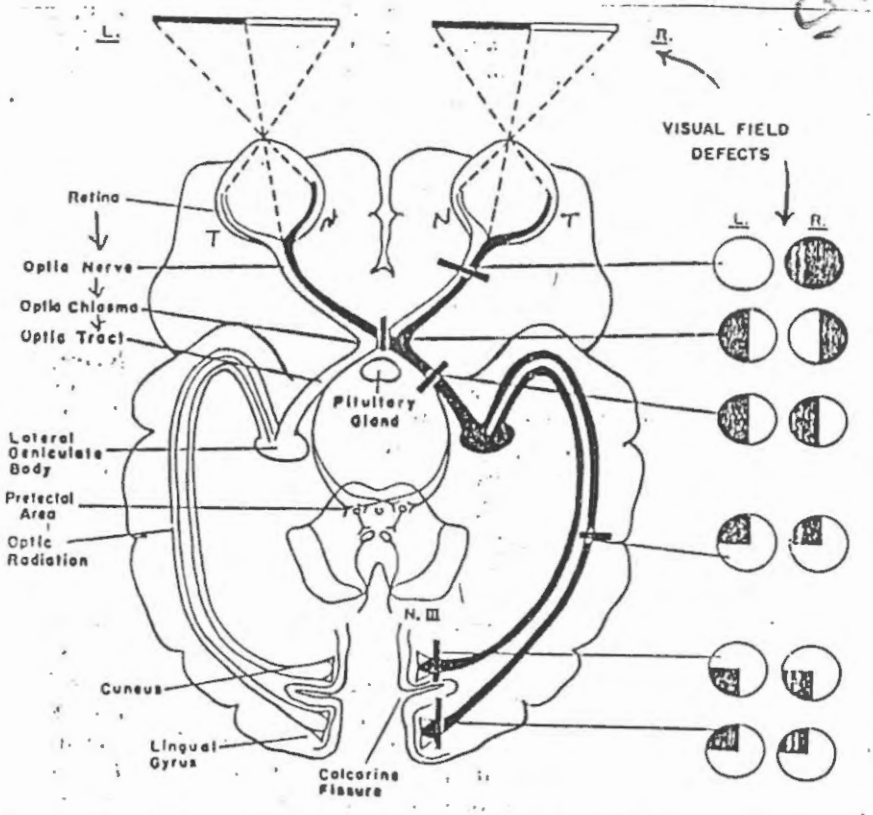


FIGURE 38. The visual pathway. On the right are maps of the visual fields with areas of blindness darkened to show the effects of injuries in various locations.

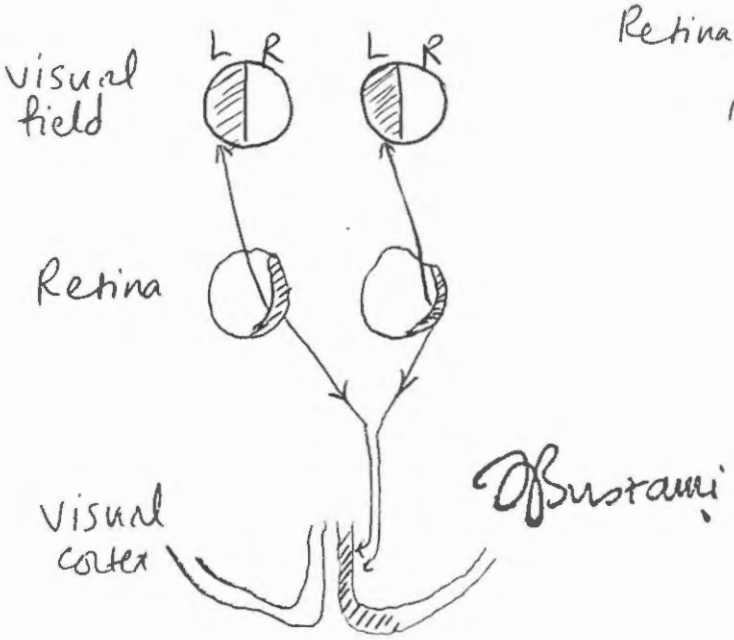
Lesion	Effect
optic Nerve	→ blinds the eye
optic chiasma	→ heteronomous bitemporal hemianopia
optic tract	→ contralateral homonymous hemianopia
optic radiation (lower part within temporal lobe) (cuneus) gyrus	→ contralateral superior homonymous quadrantiopia
(or) (superior part of optic radiation within parietal lobe)	→ contralateral inferior homonymous quadrantinopia

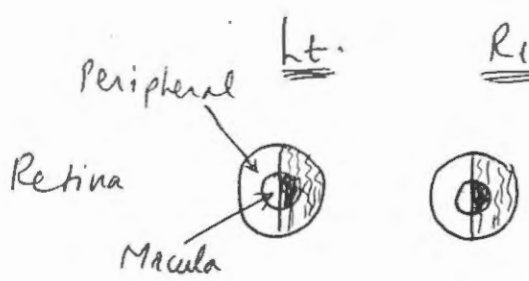
optic Principles ← Same as those of any camera

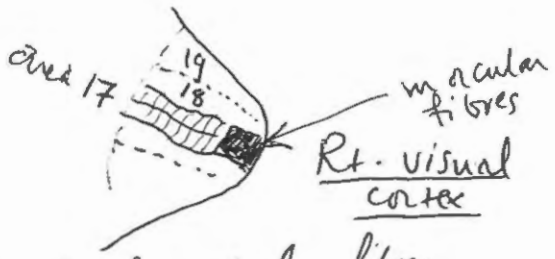
image (real) that is formed is upside down (inverted) + turned left to right (reversed)

Light falling on the rods & cones of the retina (1st order neurons of the visual pathway) triggers a photochemical reaction in these cells — initiates nerve impulses → bipolar cells of retina (2nd order neurons) → ganglion cells (3rd order neurons) → axons converge toward the optic disc to form the optic nerve → pierce the sclera of eyeball → optic chiasma (close to the pituitary gland) fibres from the nasal halves of each retina CROSS Crossing → optic tract → lateral geniculate body of thalamus (it is the thalamic centre for vision; fibres of optic tract Synapse here → Cells of the geniculate bodies give rise to fibres which form the geniculo-calcarine tract OR optic radiation which end on the visual cortex → (area 17) on either side of the calcarine fissure within the occipital cortex

Note from the diagram → The right visual cortex — area 17 — receive visual impulses from the Rt. half of each retina → Left half of each visual field







Peripheral retinal fibres occupy the anterior part while macular fibres occupy the posterior part

A lesion of the optic tract behind the chiasm disconnects fibers from one half of each retina. If the right optic tract is destroyed, visual function is lost in the right halves of both retinae. *The result, however, is not described in terms of the retinae, but with reference to the disturbance that is produced in the visual fields.* In this instance there is blindness for objects in the left half of each field of vision, a condition known as *left homonymous hemianopia.* Even though one optic tract has been completely interrupted, vision is sometimes preserved in a small area at the fixation center, the area of the macula. Macular sparing cannot be explained anatomically, and opinions differ as to its significance. Lesions which destroy the entire visual area of the right occipital lobe, or all of the fibers of the right optic radiation, will also produce left homonymous hemianopia. Visual acuity of the parts of the retinae whose functions remain is not affected, and the patient may not be aware of the presence of hemianopia.

The *cuneus,* which is the gyrus above the calcarine fissure, receives visual impulses from the dorsal, or upper halves, of the retinae; the *lingual gyrus* below the calcarine fissure, receives impulses that arise from the ventral, or lower halves. Thus a lesion that is confined to the right lingual gyrus cuts off visual impulses from the lower part of the right half of each retina. This produces a loss of vision in one quadrant, rather than hemianopia. Since the images which are focused on the lower part of the retina come from objects above the horizon line, there is, in this instance, an upper left quadrant defect (see Fig. 38). The visual impulses which go to the lingual gyrus travel in the ventral part of the optic radiation. Consequently, a lesion of the ventral fibers of the right optic radiation has the same effect as a lesion of the right lingual gyrus.

Lesions of the middle part of the optic chiasm are frequently produced by compression of these fibers from a tumor of the pituitary gland, or a craniopharyngioma which lies near the midline immediately behind the chiasm. The decussating fibers of the optic nerves are injured and visual impulses from the nasal halves of each retina are blocked. As a result, the left eye does not perceive images in the left half of its visual field, and the right eye does not record images in the right half of its field of vision. The defect is in the temporal field of each eye and is therefore called *heteronomous bitemporal hemianopia.*

areas 18, 19

↓

Secondary (association) visual area

↓ function

① Recognition of what is seen

② connected to the frontal eye field (area 8) as well as with sup. colliculus → plays a key role in conjugate eye movements induced by visual stimuli

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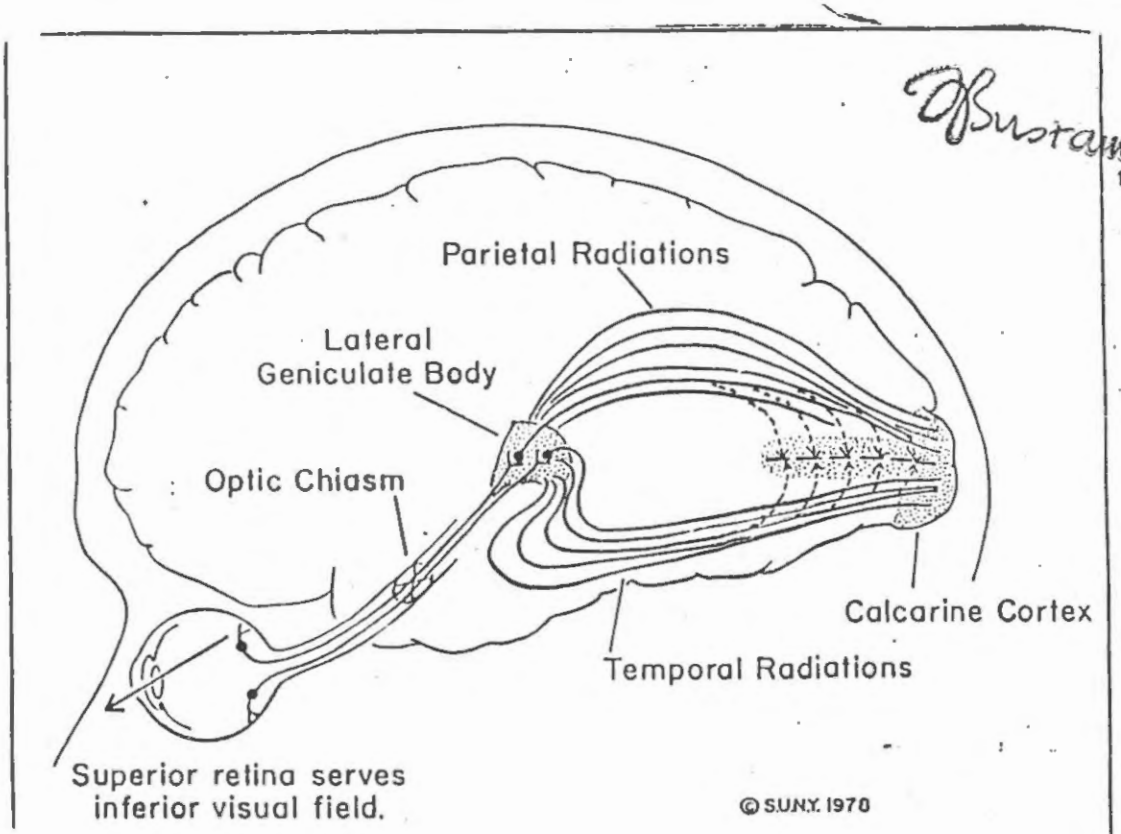
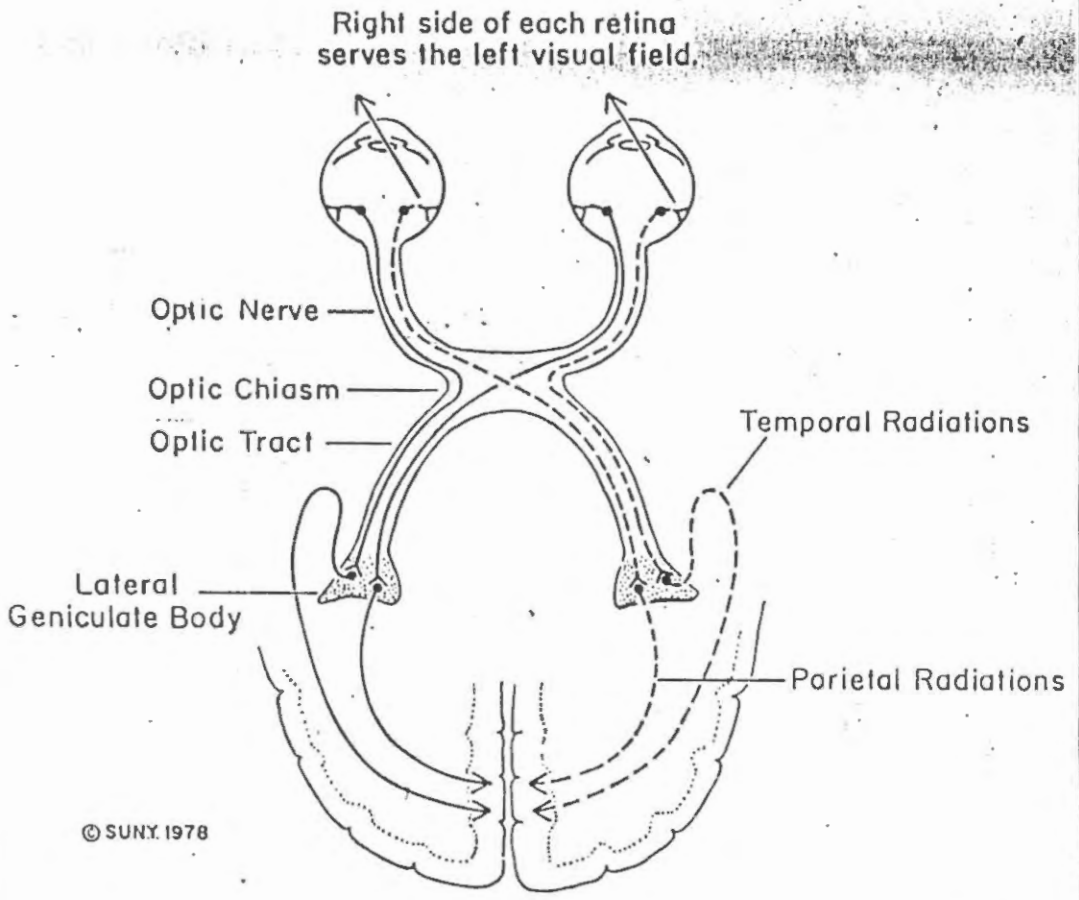
Stimulation of area 18, 19 → hallucination of formed image

---

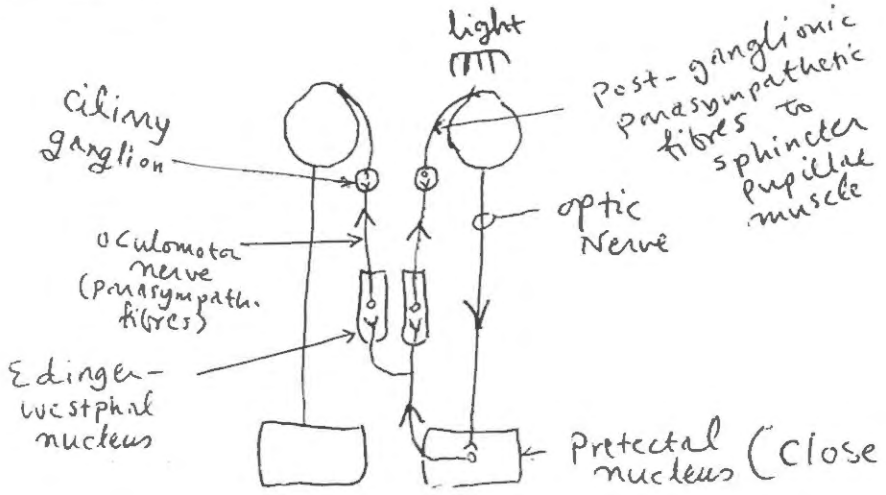
ablation (destruction) of area 18, 19 → visual agnosia (Patient is able to see objects but is unable to recognize them).

(7)


Parietal Radiations
Lateral Geniculate Body
Optic Chiasm
Calcarine Cortex
Temporal Radiations
Superior retina serves inferior visual field.
© SUNY 1970


Right side of each retina serves the left visual field.
Optic Nerve
Optic Chiasm
Optic Tract
Temporal Radiations
Lateral Geniculate Body
Parietal Radiations
© SUNY 1978

Light reflex



Afferent

optic Nerve → optic chiasma → optic tract → Pretectal nucleus (Close to superior colliculus)

Edinger-Westphal nucleus of BOTH sides → Preganglionic Parasympathetic fibres to Both ciliary ganglia → post-ganglionic parasympathetic fibres to sphincter pupillae of both eyes

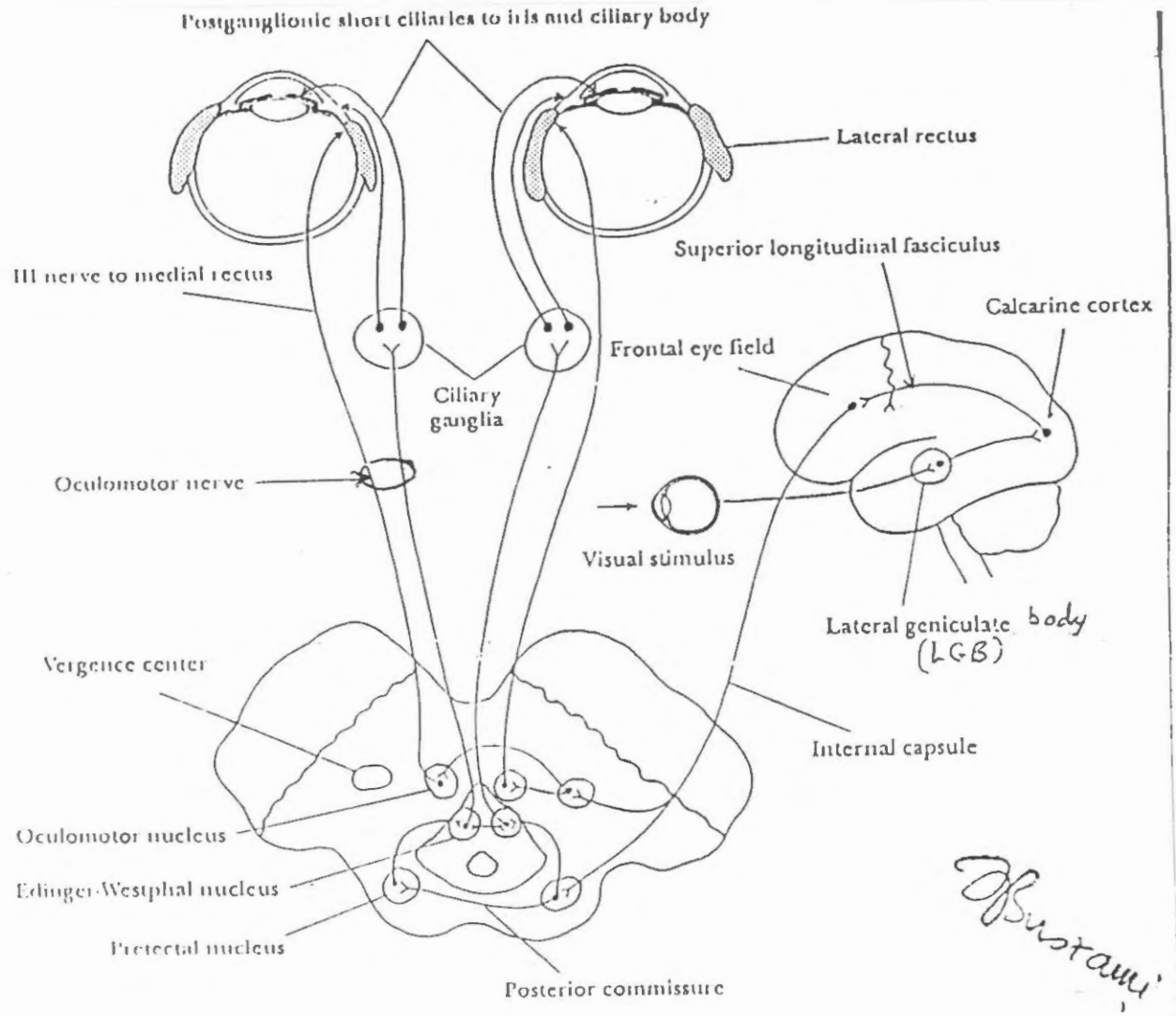
When light is thrown on one retina → BOTH Pupils.

respond by constriction < response of ipsilateral pupil → direct light reflex
" " contralateral " → consentual "

* Lesion of optic Nerve → loss of both < direct / consentual > light reflex
* " " oculomotor → loss of direct light reflex
consentual light reflex is normal

The pathway for the accommodation-convergence reflex is thus different from that of the light reflex. This is supported clinically by a condition known as the Argyll Robertson pupil, in which the light reflex is lost while the accommodation-convergence reflex persists. The site of the lesion in this condition has not been established with certainty, but its etiology is known to be syphilis of the nervous system.

L → L



ACCOMMODATION REFLEX

Requires thickening of the lens, narrowing of the pupil, and convergence in order to see near objects clearly. The visual cortical stimulus relayed to the frontal eyefields is sent via the internal capsule to the pretectal nuclei and a midbrain tegmental reticular "vergence center". The pretectum organizes the required parasympathetic stimulus to the smooth muscle of the ciliary body and the iris through the Edinger-Westphal nucleus. The vergence center orchestrates bilateral stimulation of the medial recti (and inhibition of the lateral recti) through its connections with the MLF yoking sytem.

When the eyes are directed to an object close at hand, three different reflex responses are brought into cooperative action (Near-Point reaction)

1. Convergence: The medial recti muscles contract to move the eyes into alignment so that images in each eye focus on the same part of the retina. Otherwise the two images cannot be fused and diplopia will result.
2. Accommodation: The lenses are thickened as a result of Contraction of ciliary muscles in order to maintain a sharply focused image.
3. Pupillary Constriction: The pupils are narrowed as an optical aid to regulate the depth of focus. The constriction does not depend on any change in illumination and is separate from the light reflex.

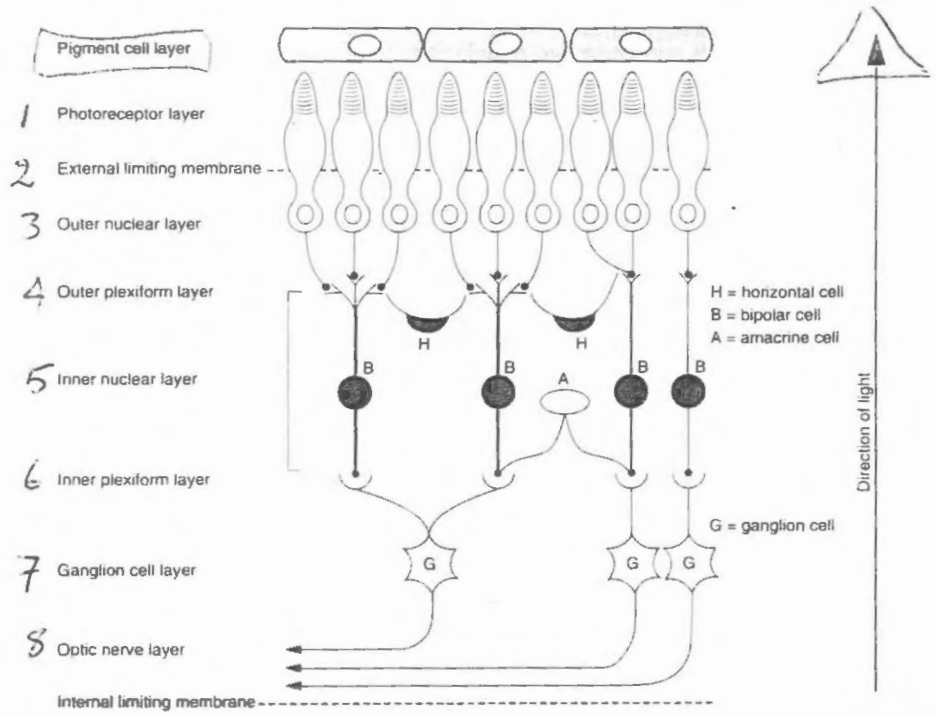


FIGURE 6-5. Organization of the retina. Photoreceptors converge on bipolar cells, which converge on ganglion cells. All of the receptors that convey information to a ganglion cell are part of that ganglion cell's receptive field.

1) Photoreceptors → outermost layer (light has to pass through other layers before reaching receptors Except at fovea centralis)

2) External limiting membrane

3) outer nuclear layer → nuclei of photoreceptors

4) outer plexiform layer → synaptic connections between photoreceptors, horizontal & bipolar cells

5) inner nuclear layer → nuclei of bipolar, horizontal & amacrine cells

6) inner plexiform layer → synaptic connections between ganglion & bipolar cells

7) Ganglion cell layer → their axons form optic nerve

8) internal limiting membrane

(Rods & cones)

1. **Morphology.** Both cell types consist of:
   a. An **inner segment containing the nucleus, abundant mitochondria,** and **synaptic vesicles**
   b. An **outer segment containing membranous disks**
      (1) The membranous disks are **continuously formed at the base of the outer segment and migrate toward the apex,** where they are sloughed off.
      (2) The membranous disks **contain a visual pigment,** called **rhodopsin,** which absorbs light rays.
         (a) **Rhodopsin** consists of a protein called **opsin** and a light-absorbing analogue of vitamin A (retinol) called **11-*cis* retinal** (Figure 6-4).
         (b) The amino acid composition of opsin determines the wavelength of light absorbed by the photopigment.
            (i) **Rods** contain a **single type of opsin**. The gene encoding for rod opsin is located on chromosome 3.
            (ii) **Cones** contain **three types of opsins** (**blue, green,** or **red,** depending on the portion of the visual spectrum they absorb best).

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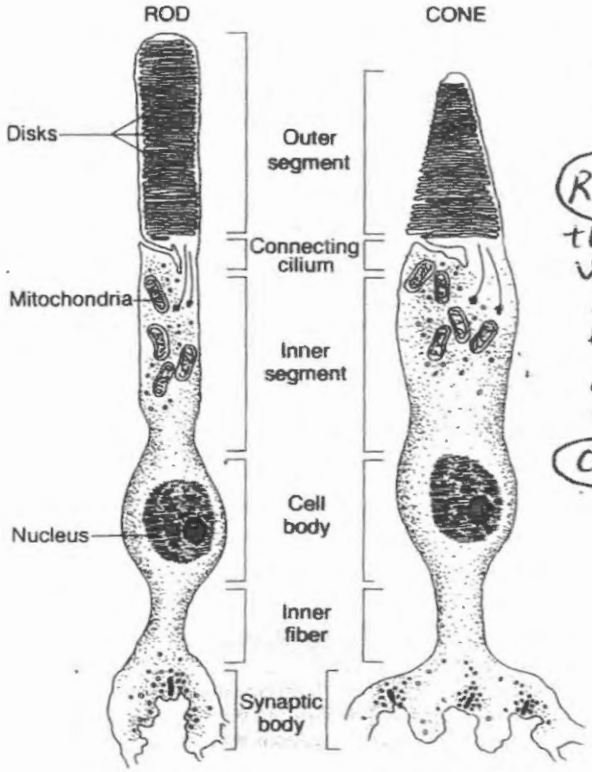


FIGURE 6-3. Morphology of rod and cone receptor cells. Cones, which are responsible for color perception and high visual acuity, are found in the fovea. Rods, which are responsible for night vision, are located in the peripheral retina.

Rods more sensitive to light than cones, Responsible for night vision. contain more rhodopsin in their outer segment. can detect light entering the eye from any direction whereas cones respond only to light directly along their axis

Cones – daylight
high acuity (Concentrated colour vision in centre of retina)
have 3 different Photopigment

Rods & cones are DEPOLARIZED in the DARK? & Hyperpolarized in the light. The only receptors that respond to their specific stimulus by hyperpolarization.

   a. **Darkness.** Rods and cones are **depolarized** in the dark. Their resting membrane potential is low, approximately −40 mV.
      (1) The low resting membrane potential results from the **high Na^+ conductance of the outer segment** (see Figure 6-4A).
         (a) Na^+ flows into the cell through Na^+ channels in the outer segment and is transported out of the inner segment by Na^+-K^+ pumps.
            (i) **Na^+ channels** are **maintained in the open state** by **cyclic guanosine monophosphate (cGMP),** which is synthesized from guanosine triphosphate (GTP) by guanylate cyclase. When cGMP binds to the Na^+ channel, the channel opens. That is, in this case, cGMP acts by activating the channel directly, not by activating a protein kinase.
            (ii) The numerous mitochondria in the inner segment provide the large quantities of adenosine triphosphate (ATP) required to maintain the high Na^+-K^+ pump activity.
         (b) The large flow of current into the cell through the outer segment and out of the cell through the inner segment is called the **dark current**.
      (2) The low resting membrane potential allows **continuous release of synaptic transmitter**.
   b. **Light.** The photoreceptors **hyperpolarize** when stimulated by light. Absorption of light ~~by rhodopsin~~ initiates a series of reactions resulting in the hydrolysis of cGMP,

→ Closing of Na^+ channels → hyperpolarization of the cell

- In the centre of the retina → yellowish region → macula lutea
- The fovea is a central depression in the macula lutea 0.3 mm diameter
- The fovea is the visual centre of the eye & the area of highest resolution !!!!
- optic disc → 3 mm to nasal side of fovea

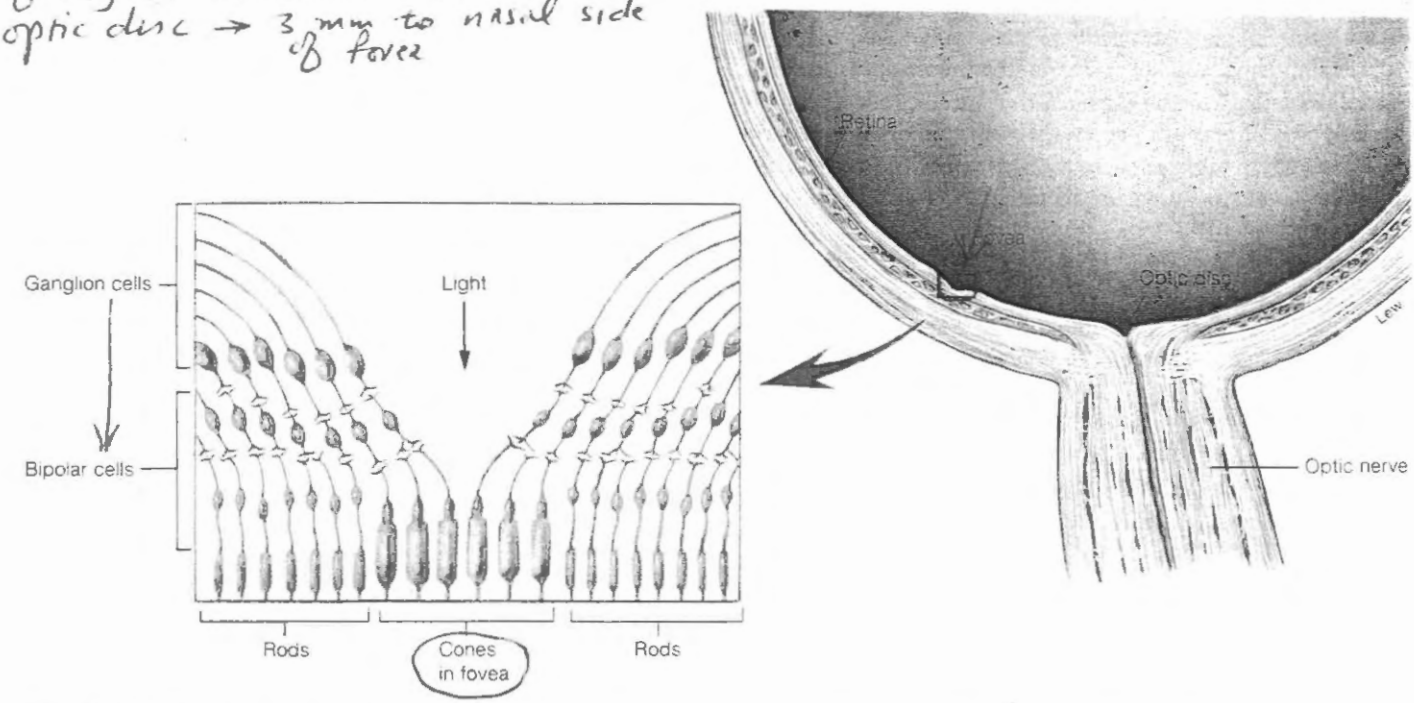


Figure 10.42 **The fovea centralis.** When the eyes "track" an object, the image is cast upon the fovea centralis of the retina. The fovea is literally a "pit" formed by parting of the neural layers. In this region, light thus falls directly on the photoreceptors (cones).

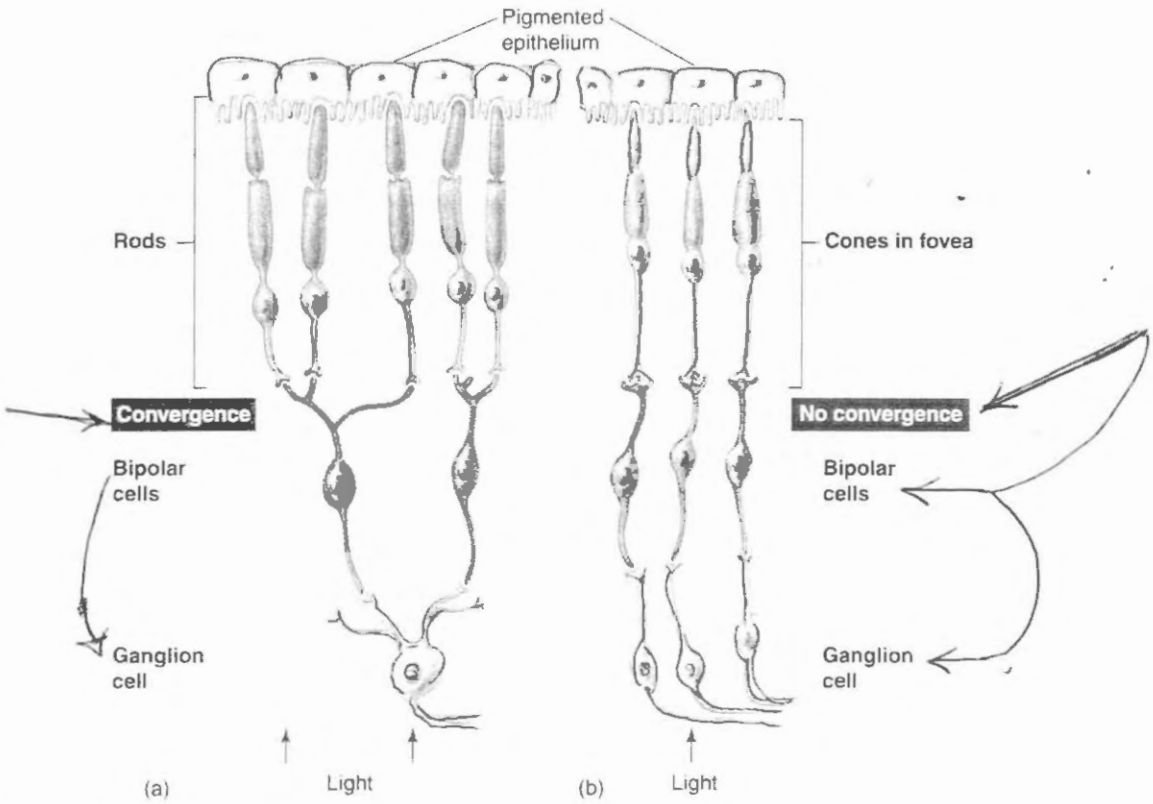
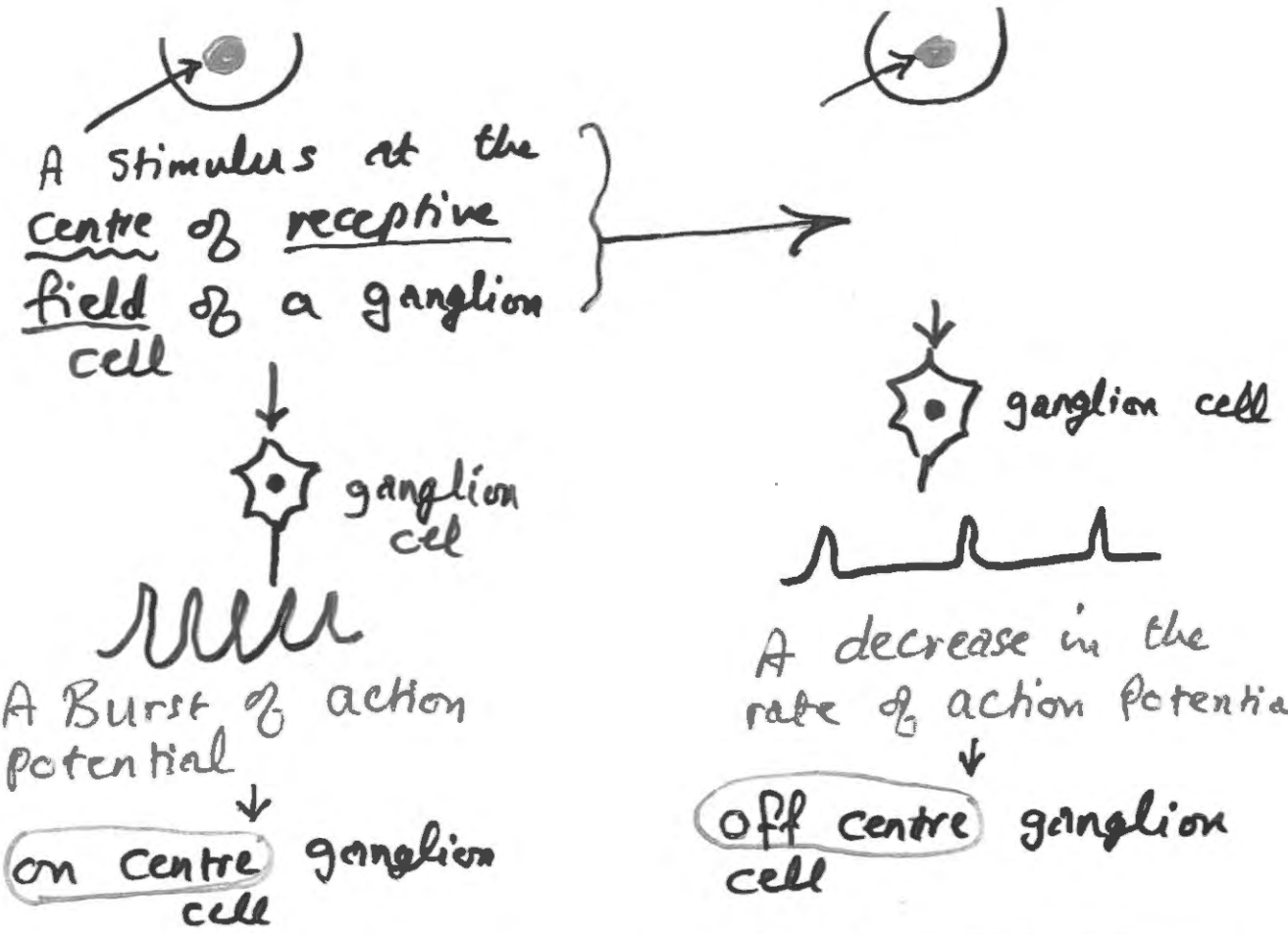
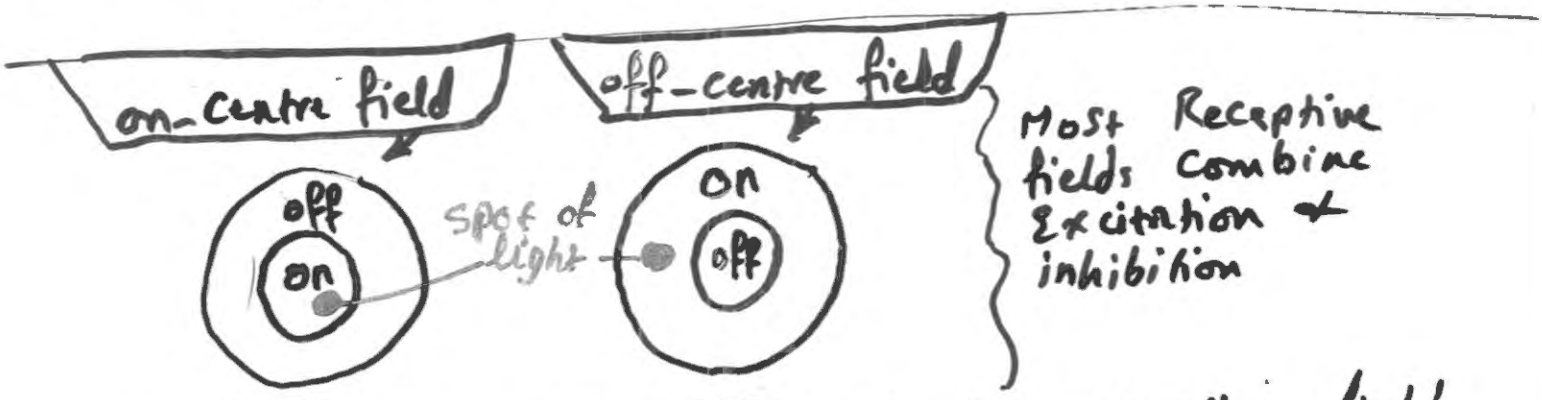


Figure 10.43 **Convergence in the retina and light sensitivity.** Since bipolar cells receive input from the convergence of many rods *(a)*, and since a number of such bipolar cells converge on a single ganglion cell, rods maximize sensitivity to low levels of light at the expense of visual acuity. By contrast, the 1:1:1 ratio of cones to bipolar cells to ganglion cells in the fovea *(b)* provides high visual acuity, but sensitivity to light is reduced.





* If light on the centre of the receptive field excites a ganglion cell → the same cell will be inhibited by light in a circular area around the centre (the surround) → these are ON centre / off surround cells

* In other ganglion cell → a spot of light falling on the centre is inhibitory while in the surrounding it is excitatory → these are off centre / on surround cells

The horizontal cell → Blocks output from the centre pathway when a contrasting illumination falls on the surround

Ganglion Cells of Retina

- Anatomically → Large alpha → in peripheral retina → mainly from rods
  Medium sized beta → in central retina → mainly from cones
- Location →
- input →
- Physiologically → correspond to Y cell (also called M cell) → connect to large cells in Magnocellular layers (layers 1+2) of LGB
  ..... to X-cell (also called P cell) → connect to smaller parvocellular layers (layers 3–6) of LGB

show On or off Centre–Surround pattern

responsive to Colour Stimuli

Centre responds to one colour & the surround responds to the colour opposite it on a colour wheel e.g. an X-cell may have a Yellow-responsive centre & a blue responsive surround

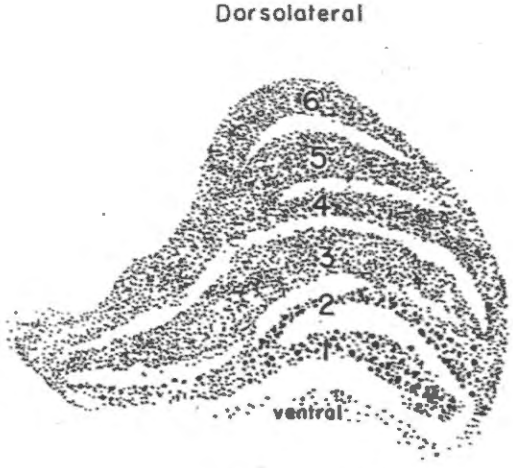


FIG. 9-16. Drawing of the cellular lamination of the lateral geniculate body. Laminae *1* and *2* constitute the magnocellular layers; the ventral nucleus is shown below. Crossed fibers of the optic tract terminate in laminae *1*, *4* and *6*; uncrossed fibers terminate in laminae *2*, *3* and *5*. (From Carpenter, *Human Neuroanatomy*, 1976; courtesy of The Williams & Wilkins Company.)

Ipsilateral and Contralateral Layers

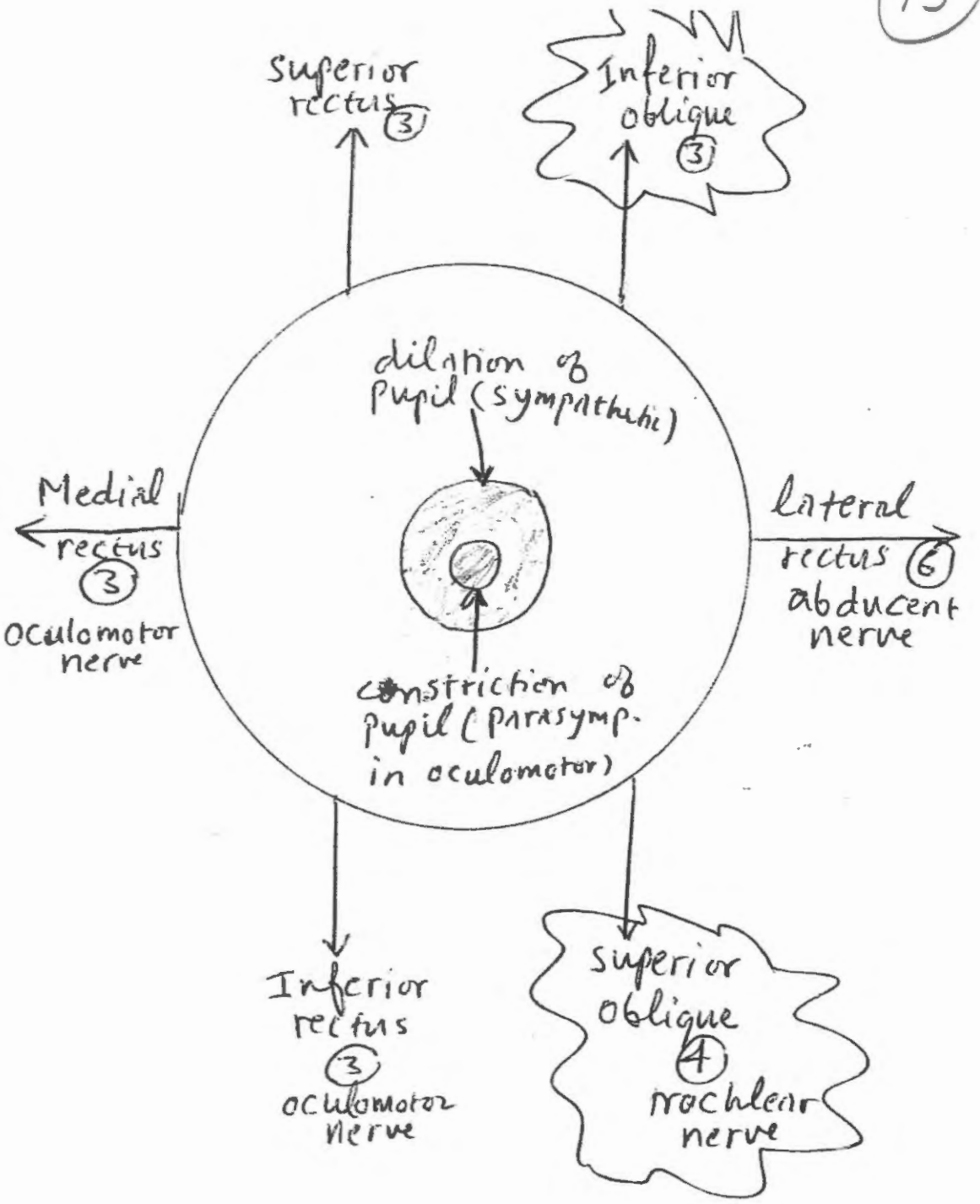
The ganglion cell axons that arise in the *temporal* retina remain uncrossed as they pass through the chiasm and terminate in layers 2, 3, and 5 of the *ipsilateral* lateral geniculate nucleus. On the other hand, the axons that arise in the *nasal* retina cross in the chiasm and terminate in layers 1, 4, and 6 of the *contralateral* lateral geniculate (Fig. 20-9).

Recall → the Y(M) ganglion cell:

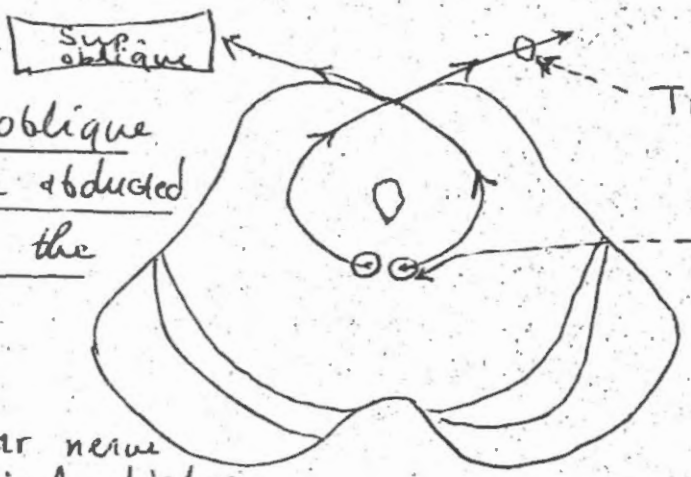
1. Receive their input mainly from RODS
2. have large receptive fields & thick rapidly conducting axons
3. particularly sensitive to MOVING STIMULI

the X(P) ganglion cells

1. Receive input mainly from Cones
2. have small receptive fields & slower-conducting axons
3. tonically responsive to stationary stimuli (fixed stimuli)
4. arise mainly in the central retina → Responsible for ... acuity Colour vision


Superior rectus (3)
Inferior oblique (3)
dilation of pupil (sympathetic)
Medial rectus (3)
oculomotor nerve
lateral rectus (6)
abducent nerve
constriction of pupil (parasymp. in oculomotor)
Inferior rectus (3)
oculomotor nerve
superior oblique (4)
trochlear nerve

* 2 important nuclei are seen at the level of the inferior colliculus:
  - (a) Mesencephalic nucleus of trigeminal nerve
  - (b) Nucleus of the trochlear nerve → lies within the central gray matter. Axons of this nerve arch around the central gray → cross in anterior medullary velum → Emerg FROM DORSAL ASPECT OF MIDBRAIN
* The trochlear nerve is thus unique in two respects:
  1. It is the only cranial nerve that emerges on the dorsal aspect of the brainstem
  2. It is the only cranial nerve that crosses before emerging from brainstem.
* Because of decussation → lesion of the trochlear nucleus result in paralysis of the contralateral superior oblique muscle, whereas lesion of the nerve after it emerges from the brainstem result in paralysis of the ipsilateral superior oblique



Remember the Sup. oblique acts by intorsion of the abducted eye & depression of the adducted eye

⇩

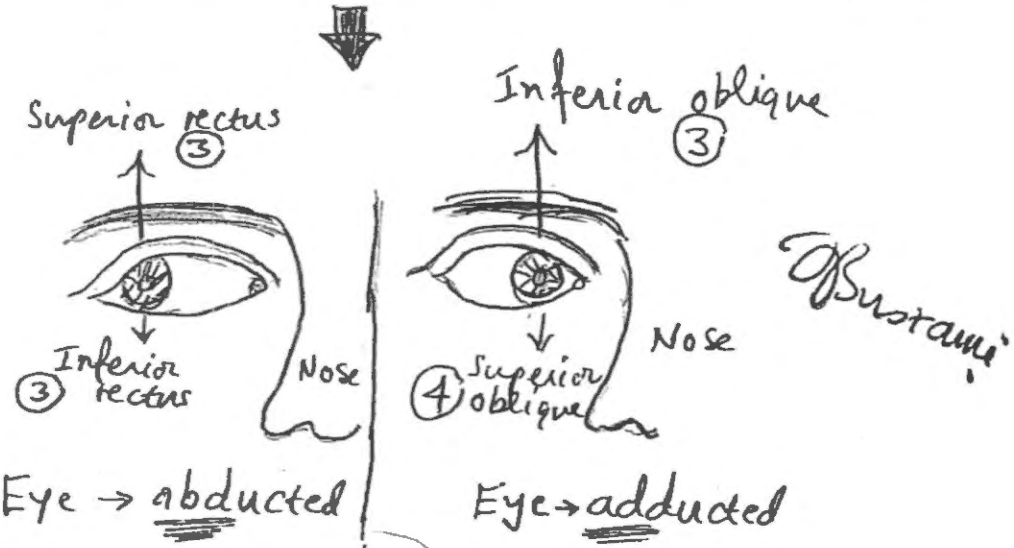
Patients with trochlear nerve lesion complain of Vertical diplopia especially when looking contralaterally down e.g descending stairs

* The trochlear nucleus receives
  - [redacted] corticonuclear fibres (Mostly)
  - Vestibular fibres from MLF concerned with coordination of eye movements

3rd cranial nerve **Oculomotor nerve**

① Supplies all extrinsic muscles of eye except: lateral rectus & superior oblique !!

② contains Parasympathetic fibres which supply the constrictor pupillae muscle (Smooth muscle inside the eyeball which constricts the pupil)



Extrinsic muscles of eye

→ Medial rectus ③ + lateral rectus (6 = abducent N.) adduct & abduct the eye

→ When the eye is **abducted** → superior rectus ③ elevates & inferior rectus ③ depresses the eyeball

→ When the eye is **adducted** → Inferior oblig ③ (= oculomotor N.) elevates and Superior oblique (4 = trochlear N.) depresses the eye ball

Lesion of RE: **oculomotor nerve** ③

① Downward & outward Deviation of the eye ball (External Squint) (due to paralysis of all extrinsic muscles of the eye Except lateral ⑥ rectus & superior ④ oblique

② Dilated pupil → the constrictor pupillae supplied by parasympathetic fibres is paralysed and the dilator pupillae supplied by sympathetic fibres takes over

③ Diplopia (double vision)

Lesion of **abducent nerve** ⑥ → patient cannot abduct the affected eye which remains adducted (internal Squint)

Lesion of **trochlear nerve** ④ → Diplopia on going downstairs

Oculomotor nucleus → located dorsal to MLF at the level of the sup. colliculus

composed of

lateral Somatic motor cell column → organized into subgroups for each of the extraocular muscles supplied by oculomotor nerve

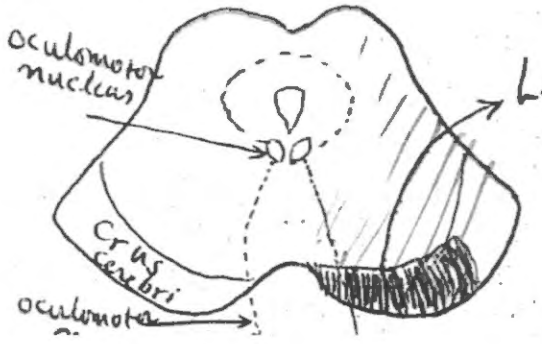
medial Visceral cell column → includes

- Edinger-Westphal nucleus → concerned with light reflex
- Nucleus of Perlia → concerned with accomodation → has not been identified in man

Axons course through the tegmentum and emerge through the interpeduncular fossa medial to crus cerebri & run between the superior cerebellar artery and the posterior cerebral artery (important in relation to aneurysm) and supply: Superior rectus, inferior rectus, medial rectus, inf. oblique, Levator palpebrae superioris

Lesion of this component

1. Downward & outward deviation of eyeball
+
2. Drooping (Ptosis) of the upper lid



Lesion → ipsilateral 1+2+3 + contralateral Upper motor neuron paralysis

* Alternating hemiplegia

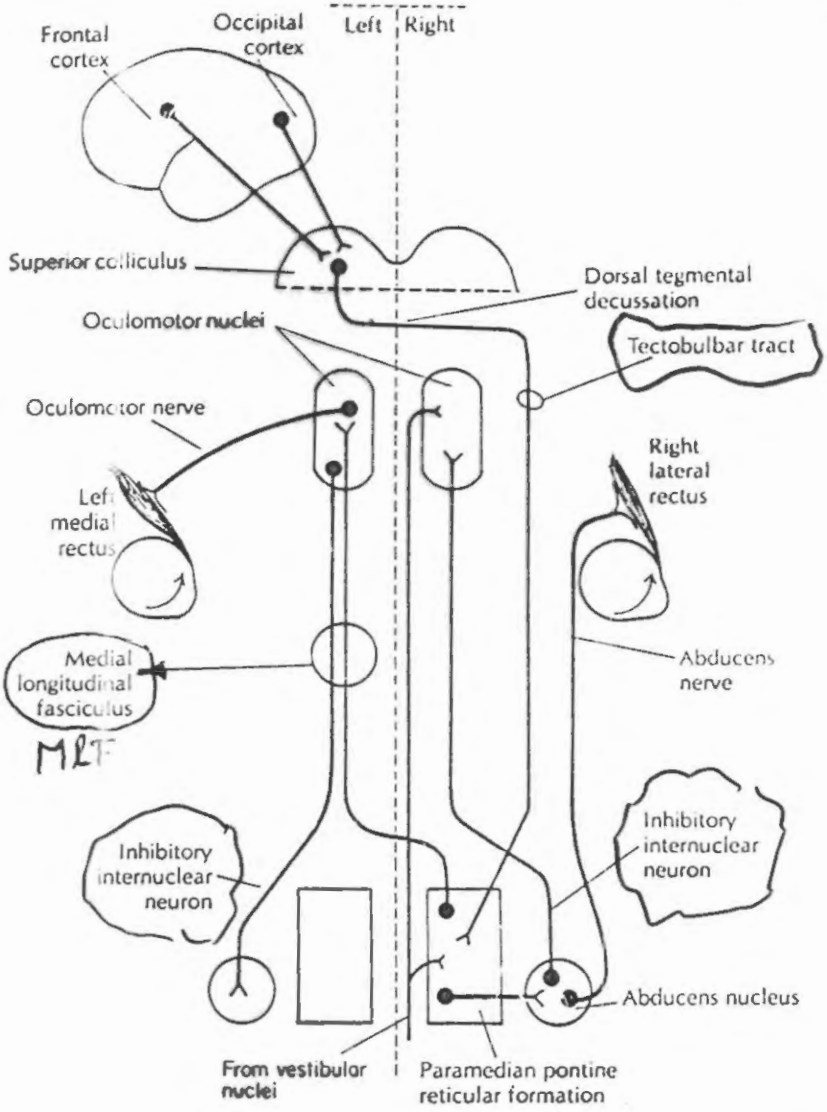
Axons of visceral cell column accompany those of somatic motor column as far as the orbit. In the orbit they part company and project to ciliary ganglion → Postganglionic fibres innervate
- Sphincter pupillae m.
- Ciliaris m.

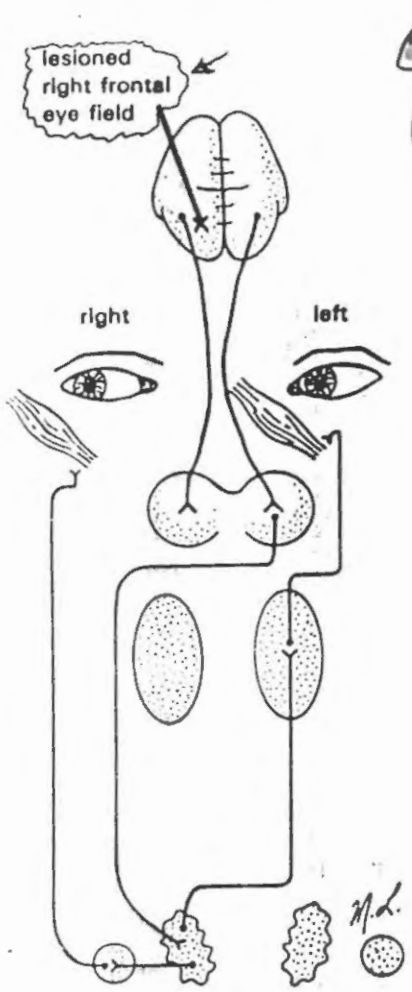
2. Smooth intraocular muscle

3. Dilated pupil unresponsive to light or accomodation

VOLUNTARY EYE MOVEMENTS

The area of the cerebral cortex that controls voluntary eye movements is the **frontal eye field**, located anterior to the motor cortex. Electrical stimulation of the frontal eye field results in conjugate deviation of the eyes to the opposite side. A destructive lesion there causes both eyes to deviate to the same side—looking away from the paralyzed side of the body if the motor cortex has been damaged by the same lesion. There are probably no direct corticobulbar fibers from any part of the cerebral cortex to the nuclei of cranial nerves III, IV, and VI. Instead, the voluntary control of eye movements is mediated by a polysynaptic pathway that involves the frontal cortex, superior colliculus, pretectal area, accessory oculomotor nuclei, and, finally, oculomotor, trochlear, and abducens nuclei (Fig. 8-4). (The





Right supranuclear ophthalmoplegia

PARALYSIS OF CONJUGATE LATERAL GAZE

Cortical Gaze Control

From frontal and occipital gaze control centers, the left side of the brain turns the eyes conjugately to the right. The frontal eye field initiates voluntary saccadic movements of the eyes ("Look to the right!"), while the occipital eye field initiates slower automatic pursuit movements ("Follow my finger!").

Ischemic stroke and cerebral hemorrhage are the most common causes for conjugate gaze paralysis because gaze paralysis from cerebral lesions only occurs immediately after acute lesions, disappears then, and can be revisualized only under special circumstances.

Internuclear Ophthalmoplegia

To understand so-called **internuclear ophthalmoplegia** one must recall certain information.

Three types of conjugate movement, i.e., convergent, parallel vertical, and parallel horizontal, were described previously.

The conjugate convergent as well as the vertical movements involve two pairs of nuclei that are situated close together, i.e., the oculomotor nuclei and the trochlear nuclei. The conjugate horizontal or lateral gaze movement involves a pair of nuclei which are far apart from each other, i.e., the abducens (right or left) and the oculomotor (left or right) (**Fig. 13-7**). It appears

1. that the cortical descending motor fibers stimulate the superior colliculus and that the superior colliculus sends fibers to a nucleus of the opposite side, i.e., **the parabducens nucleus,** which is located in the **paramedian pontine reticular formation (PPRF),** close to the abducens nucleus; and

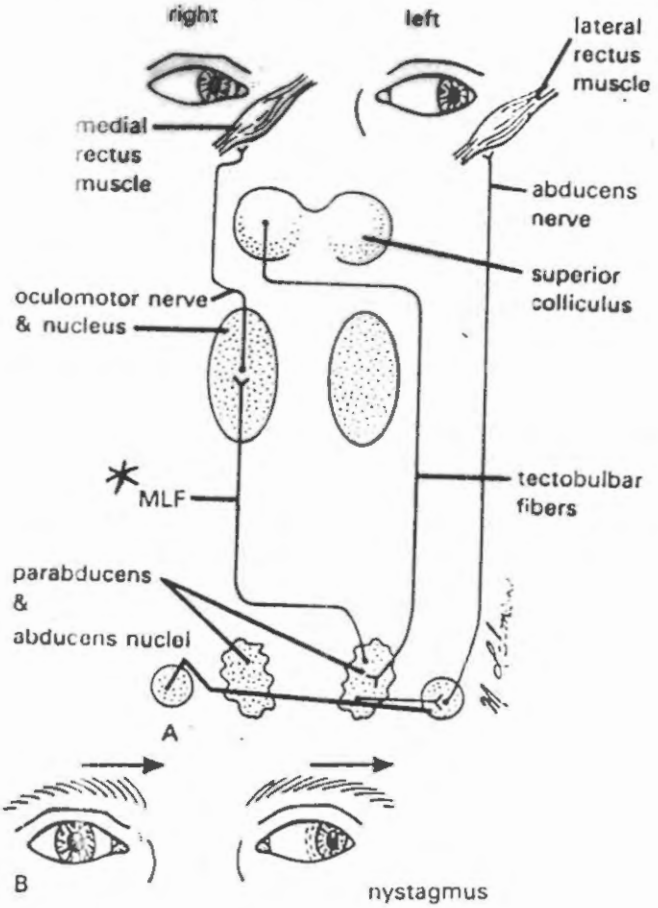


Fig. 13-7. (A) Pathway for lateral conjugate gaze; (B) right internuclear ophthalmoplegia.

2. that the parabducens nucleus stimulates the near-by abducens nucleus (concerned with the lateral rectus muscle) and also, through a path with other different fibers, the medial longitudinal fasciculus (MLF), the portion of the opposite oculomotor nucleus concerned with the medial rectus muscle.

A lesion of the MLF (affecting the path between the parabducens and oculomotor nuclei) produces internuclear ophthalmoplegia. The most common cause is multiple sclerosis.

If a lesion occurs in one MLF, e.g., the right MLF as in Figure 13-7, it is manifest when the patient tries to look laterally to the side opposite of the lesion. The medial rectus on the side of the lesion does not adduct; the abducting left eye moves laterally and displays **horizontal nystagmus** in **lateral gaze.** These signs of internuclear ophthalmoplegia are also known as **medial longitudinal fasciculus syndrome,** which usually is bilateral, affecting both MLF. This is an important syndrome as its verification pinpoints the causal lesion very precisely in a specific region of the brain stem, i.e., the region of the MLF in the upper pons between the abducens and oculomotor nuclei.

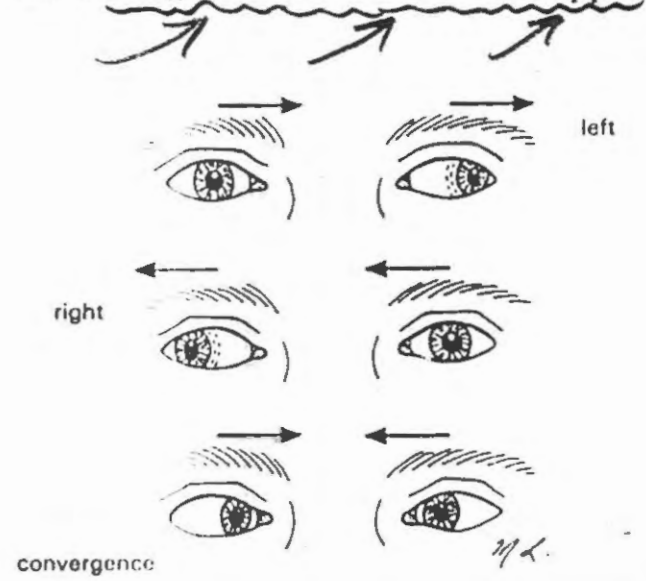
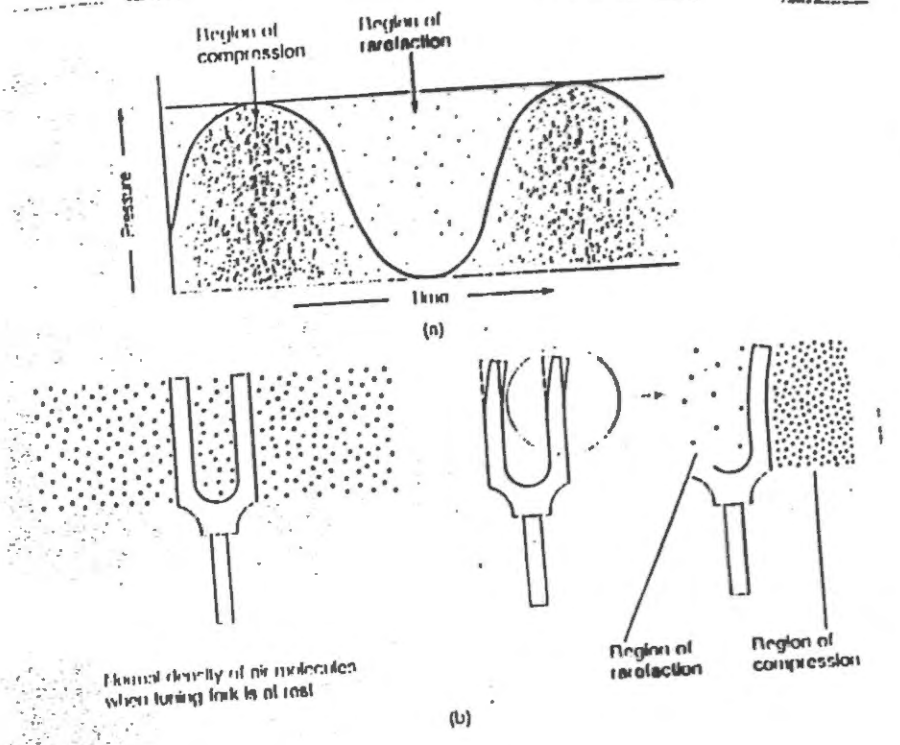
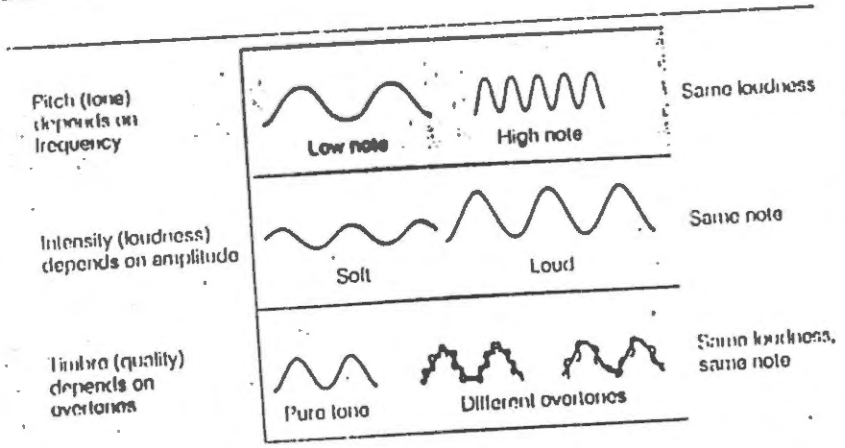


Fig. 13-8. Bilateral internuclear ophthalmoplegia.

A test to substantiate the diagnosis of internuclear ophthalmoplegia, when the described signs have appeared, consists in verifying that the patient is able to converge the eyes and make vertical movements of the eyes. A case of internuclear ophthalmoplegia affecting both MLF is illustrated in Figure 13-8.



• FIGURE 6–34 Properties of Sound Waves



تتكون الأمواج الصوتية من مناطق ضغط تتبادل مع مناطق تخلخل لجزيئات الهواء

↓

أي جسم تصدر عن إهتزازات إضطراب في جزيئات الهواء بالشكل السابق يكون مصدراً للصوت

↓

اهتزاز الشوكة الرنانة يولد مناطق ضغط لجزيئات الهواء أمام الشوكة ومناطق تخلخل لجزيئات الهواء خلف الشوكة وبالتالي تحدث اهتزازات الصوت

↓

يمكن لأمواج الصوت أن تنتقل في أوساط غير الهواء (مثل الماء)

⇩

يتميز الصوت بخصائص:

(١) نبرة أو نغمة الصوت (لحن الصوت)
Pitch (tone)

(٢) علو الصوت
intensity (loudness)

(٣) طابع (رنة) الصوت
Timbre (quality)

---

(١) Pitch نغمة الصوت وتعتمد على تردد الاهتزازات Frequency of vibrations فكلما زاد التردد زادت نغمة الصوت (إرتفعت)

تستطيع أذن الإنسان أن تميز أنواع صوتية ذات تردد يتراوح بين ٢٠ - ٢٠,٠٠٠ دورة في الثانية ولكنها تكون أكثر حساسية للترددات التي تتراوح بين ١,٠٠٠ - ٤,٠٠٠ دورة في الثانية

(٢) علو الصوت أو شدة الصوت
intensity or loudness

تعتمد على حجم Amplitude أمواج الصوت أو الفرق في الضغط بين منطقة ضغط عالي لجزيئات الهواء ومنطقة تخلخل يقل فيها ضغط جزيئات الهواء

← وضمن مدى السمع لأذن الإنسان كلما ازداد حجم أمواج الصوت كلما ازداد الصوت علواً

← تستطيع أذن الإنسان أن تميز بين مدى واسع لشدة علو الصوت من درجة الهمس الى صوت اقلاع الطائرة النفاثة.

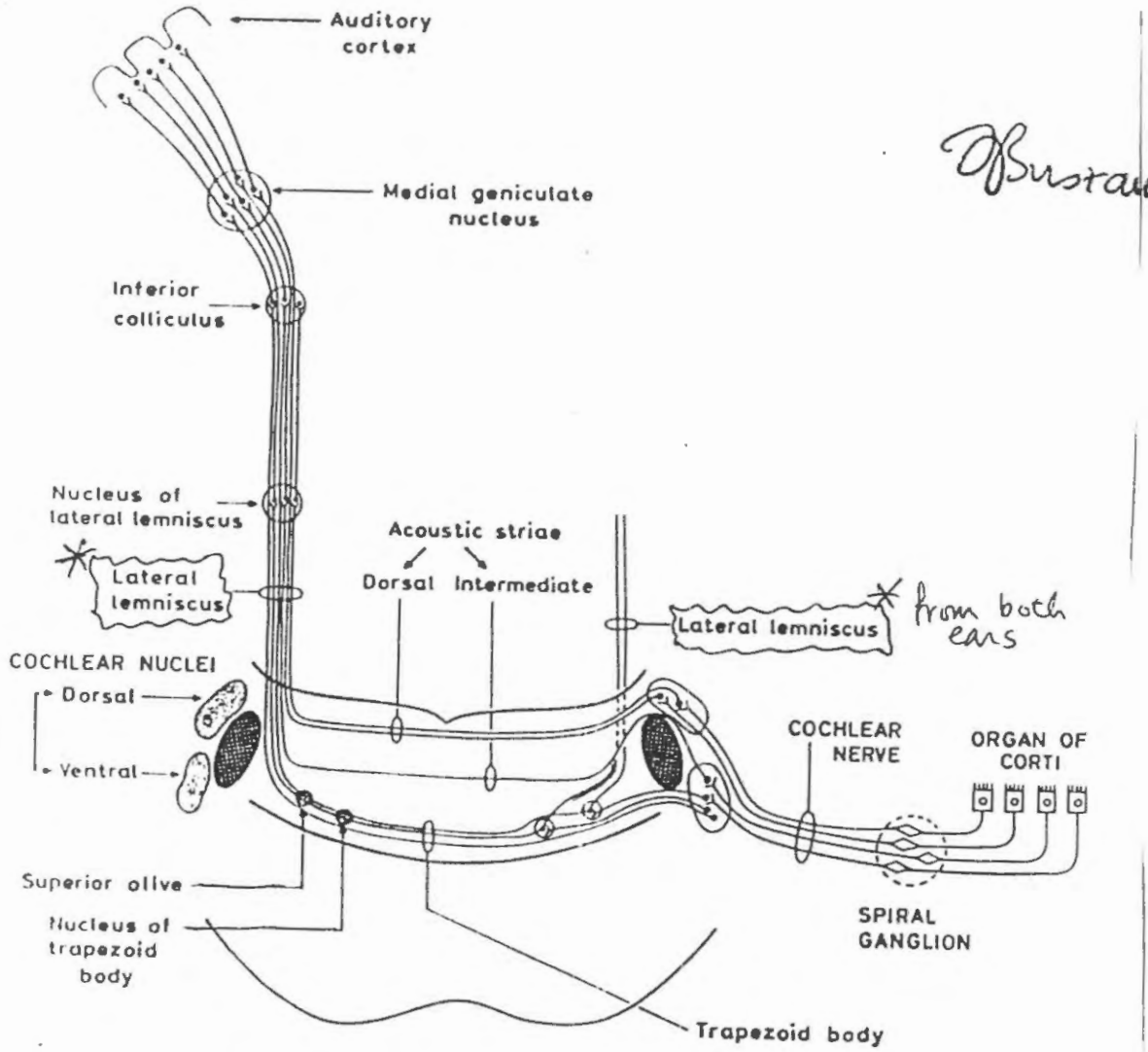


Figure 7.6. Schematic diagram of the auditory pathways.

Nerve fibres in the cochlear nerve (NI) → central processes of bipolar neurons in the SPIRAL ganglion located in the modiolus of the inner ear. The peripheral processes are linked to the hair cells of the auditory end organ in the organ of Corti.

cochlear nerve fibres Synapse on the cells of → dorsal / ventral cochlear nuclei (NII)

dorsal cochlear nuc. Receive fibres coming from basal turns of the cochlea mediating High frequency sounds whereas the ventral cochlear nucleus receive fibres from the apical turns of the cochlea mediating low frequency sound

Second order neurons (NII) from the cochlear nuclei run through the tegmentum of the pons forming the acoustic stride → dorsal / intermediate / ventral (trapezoid body)

* DORSAL acoustic stria → formed by axons of neurons in the dorsal cochlear nucleus
* Intermediate " " } → " " " " "
Ventral " " } → " " ventral " "

Acoustic Striae (Obustrauni) → Synapse on → Superior olivary nucleus / nucleus of the trapezoid body } 3rd order neuron N_{III}

Their axons form * mainly the contralateral lateral lemniscus with some projection to the * homolateral lateral lemniscus.

Both ears

↓

Nucleus of lateral lemniscus (synapse) N_{IV}

↓

Inferior colliculus N_{I}

↓

medial geniculate body (MGB) → thalamic centre for hearing

↓

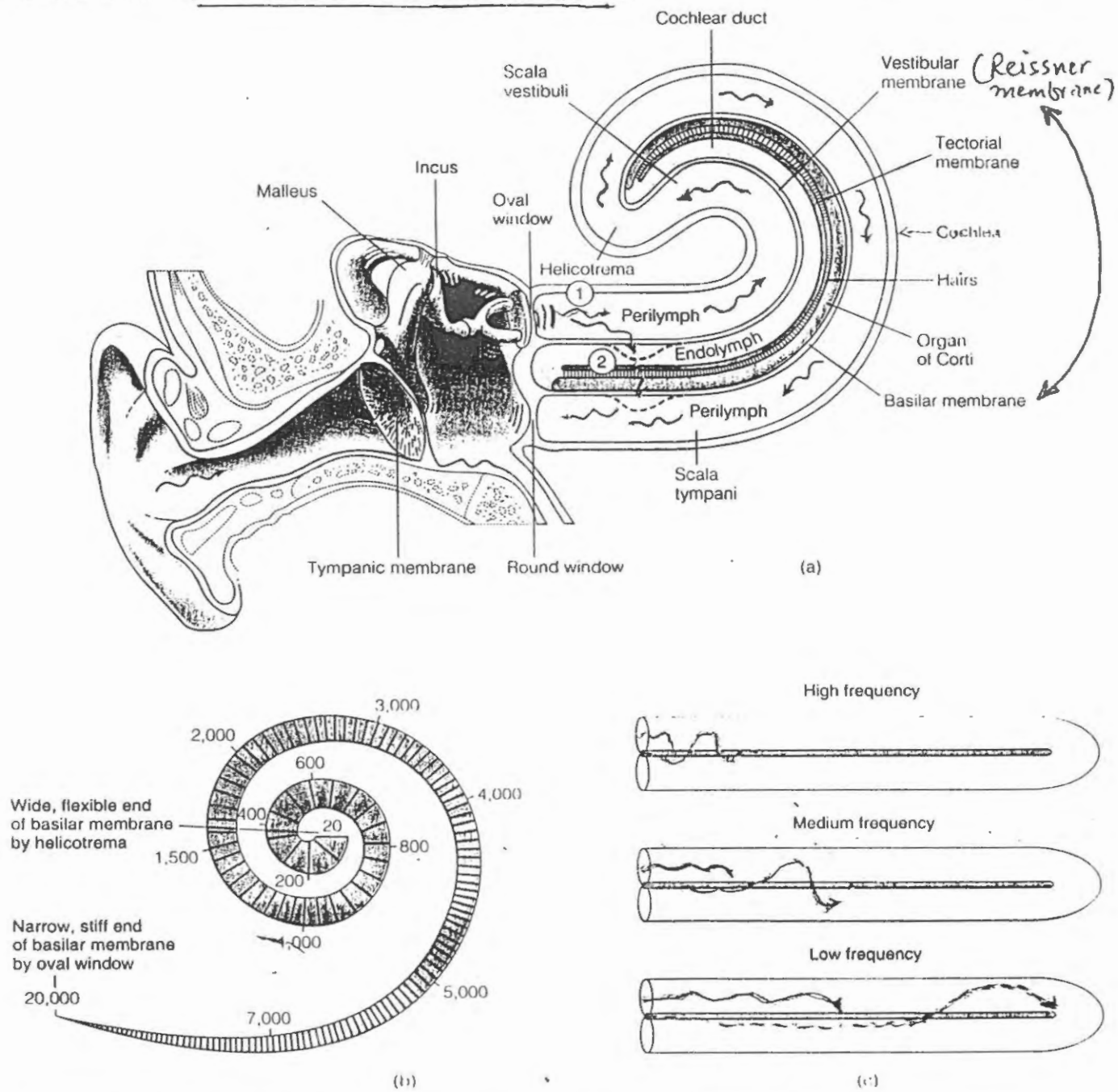
Final station → Primary auditory cortex (41, 42) (transverse gyri of Heschl) in Temporal lobe

Notice: Just as the various regions of the basilar membrane are associated with particular tones → the auditory cortex is also TONOTOPICALLY organized ⇒ Each region of the basilar membrane is linked to a specific region of the auditory cortex in the temporal lobe

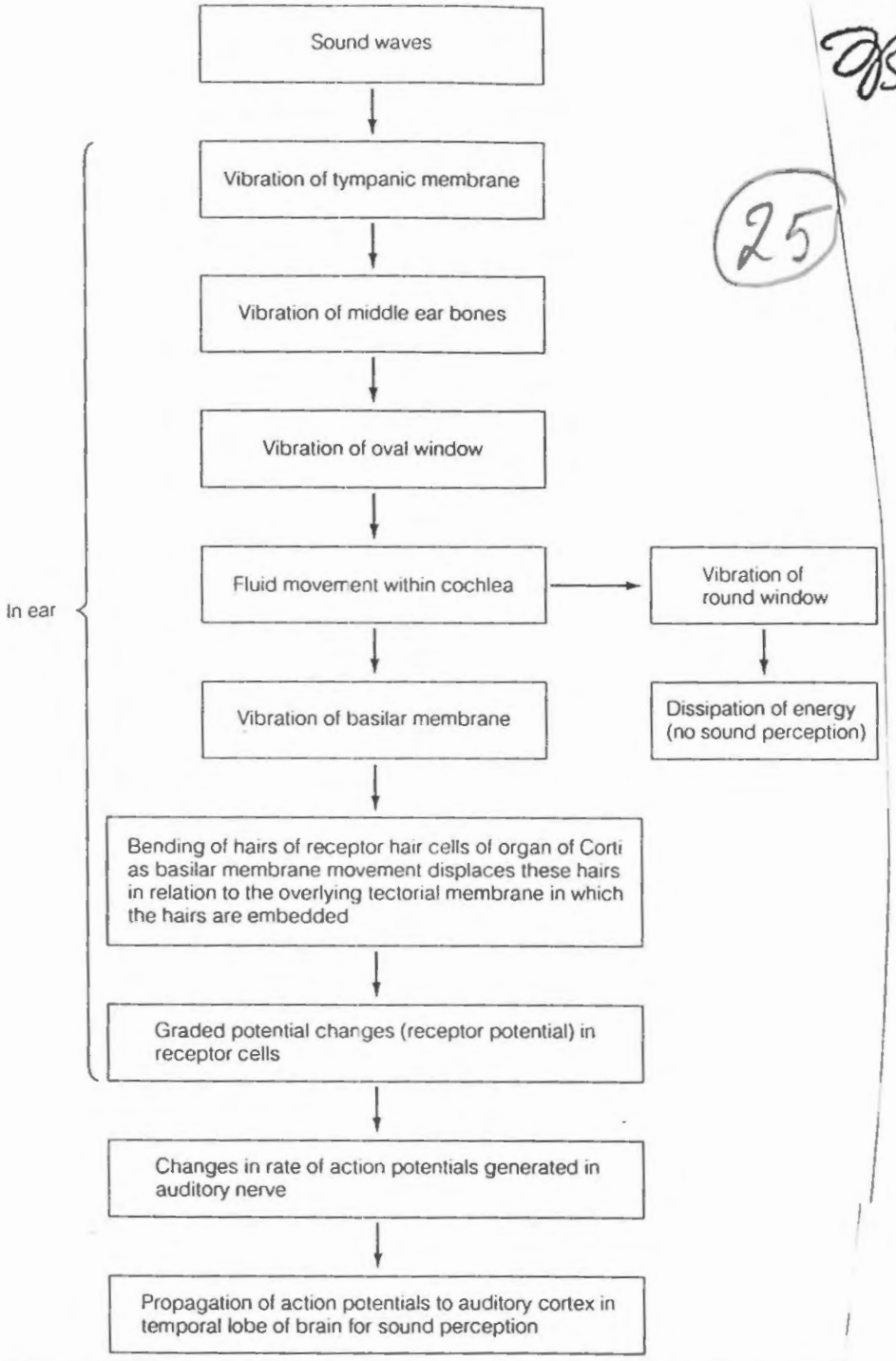
↓

The Primary auditory cortex appears to perceive DISCRETE SOUNDS while the surrounding auditory association cortex (area 22) → INTEGRATES the SEPARATE SOUNDS INTO A COHERENT MEANINGFUL PATTERN

• **FIGURE 6–36 Transmission of Sound Waves** (a) Fluid movement within the perilymph set up by vibration of the oval window follows two pathways: (1) through the scala vestibuli, around the helicotrema, and through the scala tympani, causing the round window to vibrate; and (2) a "shortcut" from the scala vestibuli through the basilar membrane to the scala tympani. The first pathway just dissipates sound energy, but the second pathway triggers activation of the receptors for sound by bending the hairs of the hair cells as the organ of Corti on top of the vibrating basilar membrane is displaced in relation to the overlying tectorial membrane. (b) Different regions of the basilar membrane vibrate maximally at different frequencies. (c) The narrow, stiff end of the basilar membrane nearest the oval window vibrates best with high-frequency pitches. The wide, flexible end of the basilar membrane by the helicotrema vibrates best with low-frequency pitches.



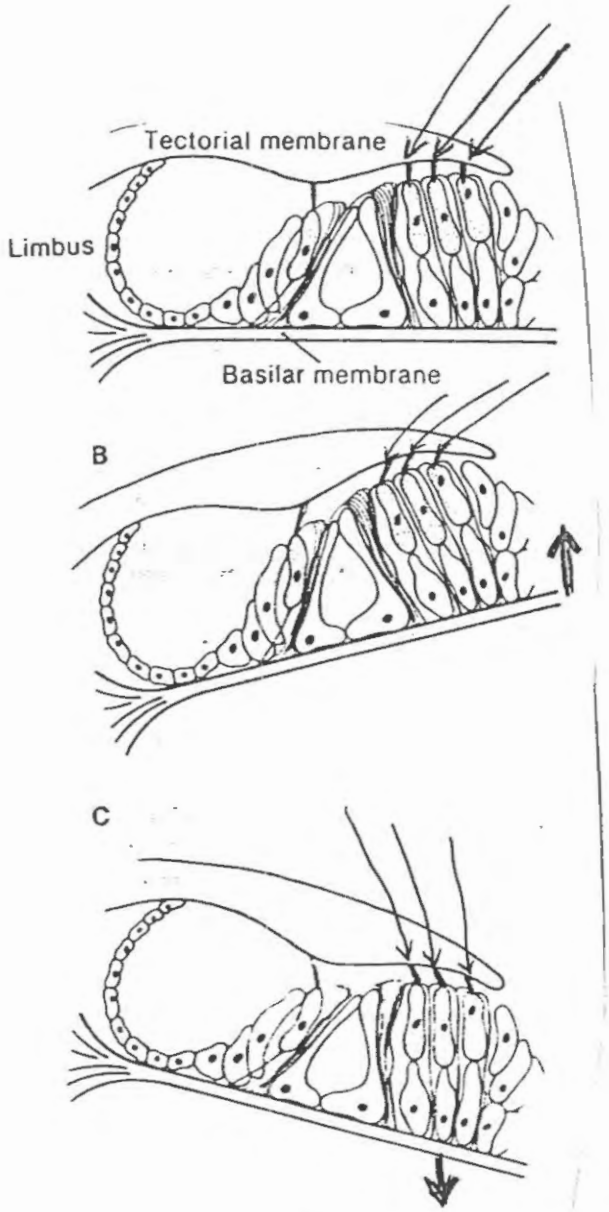
The numbers indicate the frequencies with which different regions of the basilar membrane maximally vibrate.



Pressure waves of frequencies associated with sound reception take a "shortcut." Pressure waves in the upper compartment are transferred through the thin vestibular membrane, into the cochlear duct, and then through the basilar membrane into the lower compartment, where they cause the round window to alternately bulge outward and inward. The main difference in this pathway is that transmission of pressure waves through the basilar membrane causes this membrane to move up and down, or vibrate, in synchrony with the pressure wave. Since the organ of Corti rides on the basilar membrane, the hair cells also move up and down as the basilar membrane oscillates. Because the hairs of the receptor cells are embedded in the stiff, stationary tectorial membrane, they are bent back and forth when the oscillating basilar membrane shifts their position in relationship to the tectorial membrane (= Fig. 6–37). This back-and-forth mechanical deformation of the hairs alternately opens and closes mechanically gated ion channels (see p. 81) in the hair cell, resulting in alternating depolarizing and hyperpolarizing potential changes—the receptor potential—at the same frequency as the original sound stimulus.

Thus, the ear converts sound waves in the air into oscillating movements of the basilar membrane that bend the hairs of the receptor cells back and forth. This shifting mechanical deformation of the hairs alternately opens and closes the receptor cells' channels, which bring about graded potential changes in the receptor that lead to changes in the rate of action potentials propagated to the brain. In this way, sound waves are translated into neural signals that can be perceived by the brain as sound sensations (= Fig. 6–38).

Up-and-down movement of the basilar membrane & tectorial membrane causes the stereocilia extending from the hair cells to bend BACK & FORTH



Depolarize

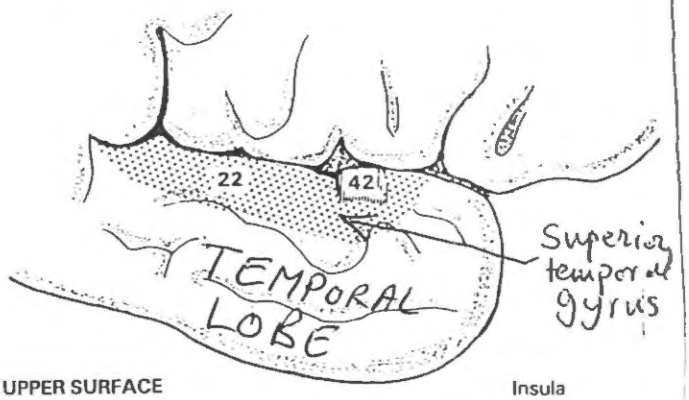
hyperpolarize

B - When the organ of corti moves upward (with the basilar membrane) → the stercocilia bend AWAY from the limbus & depolarize

C - When the organ of corti moves downward the stercocilia bend toward the limbus & they hyperpolarize

"Upsustaini

LATERAL SURFACE



UPPER SURFACE

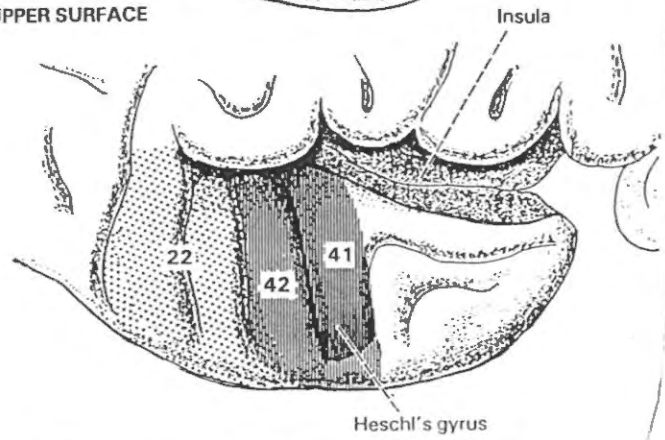


Fig. 30-9 Two views of the primary (41, 42) and secondary (22) auditory cortex.

Auditory cortex (Fig. 30-9)

The *primary auditory cortex* (areas 41 and 42 of Brodmann) includes the gyrus of Heschl on the upper surface of the superior temporal gyrus, and the adjoining part of the temporal operculum of the insula. 'Columnar organization' is obvious, the 'columns' being in fact stripes disposed mediolaterally. Each stripe is an isofrequency band, and the cortical arrangement is tonotopic: high tones excite the posterior stripes and low tones excite the anterior ones. The stripes are maximally excited from the *contralateral sound field*. Virtually all of the neurons are binaural.

Auditory association cortex (area 22)

* occupies the lateral surface of the superior temporal gyrus
* It receives short association fibres from the primary cortex & INTEGRATES INCOMING SOUNDS WITH AUDITORY MEMORY STORES

* Area (22) → has been subdivided into six cyto architectural areas → The most important is Wernicke's sensory speech area

* Lesion of the ① Cochlea ② Cochlear Nerve Cochlear nuclei → Complete ipsilateral deafness
* Lesion of the lateral lemniscus → up to 1ry auditory cortex → Bilateral partial deafness greatest in the contralateral ear
* Lesion of the auditory association cortex → Word deafness ?

the person fails to understand sounds or spoken words even though they are heard

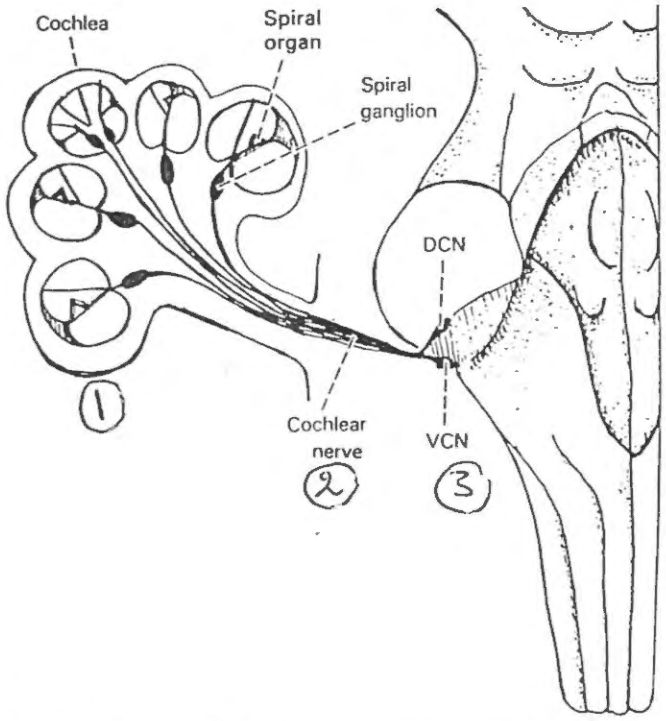


Fig. 30-2 Spiral ganglion and cochlear nerve. The nerve terminates in dorsal (DCN) and ventral (VCN) cochlear nuclei.

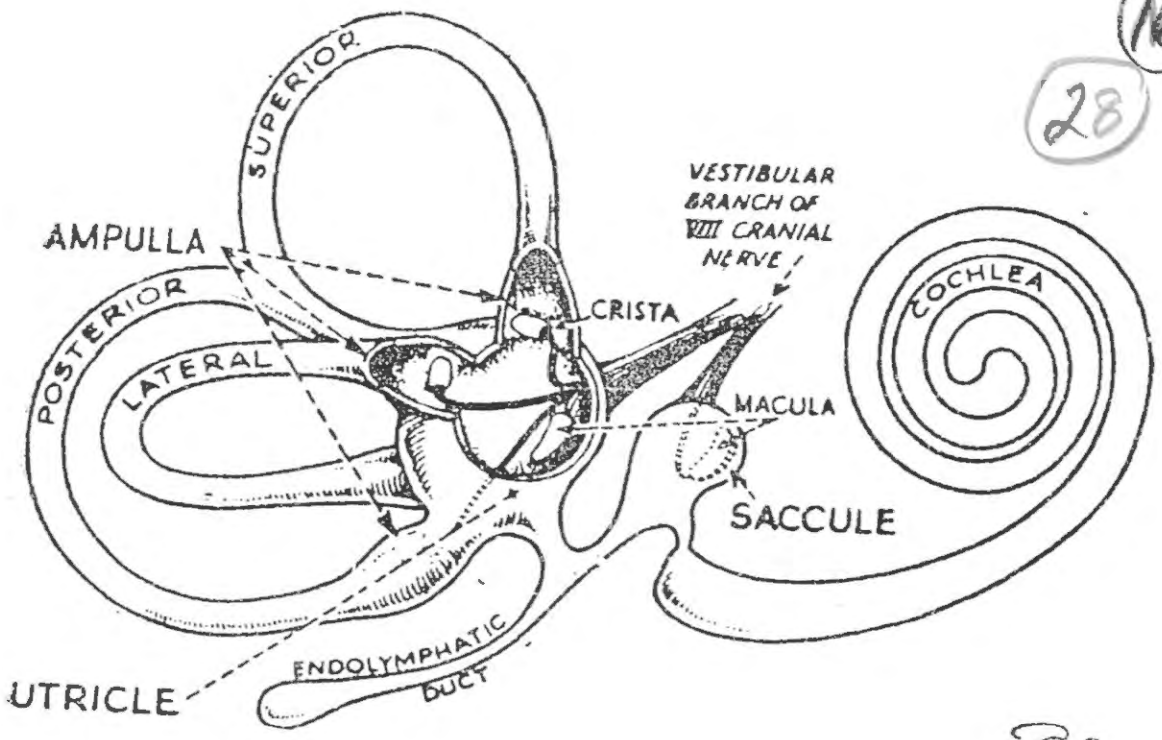
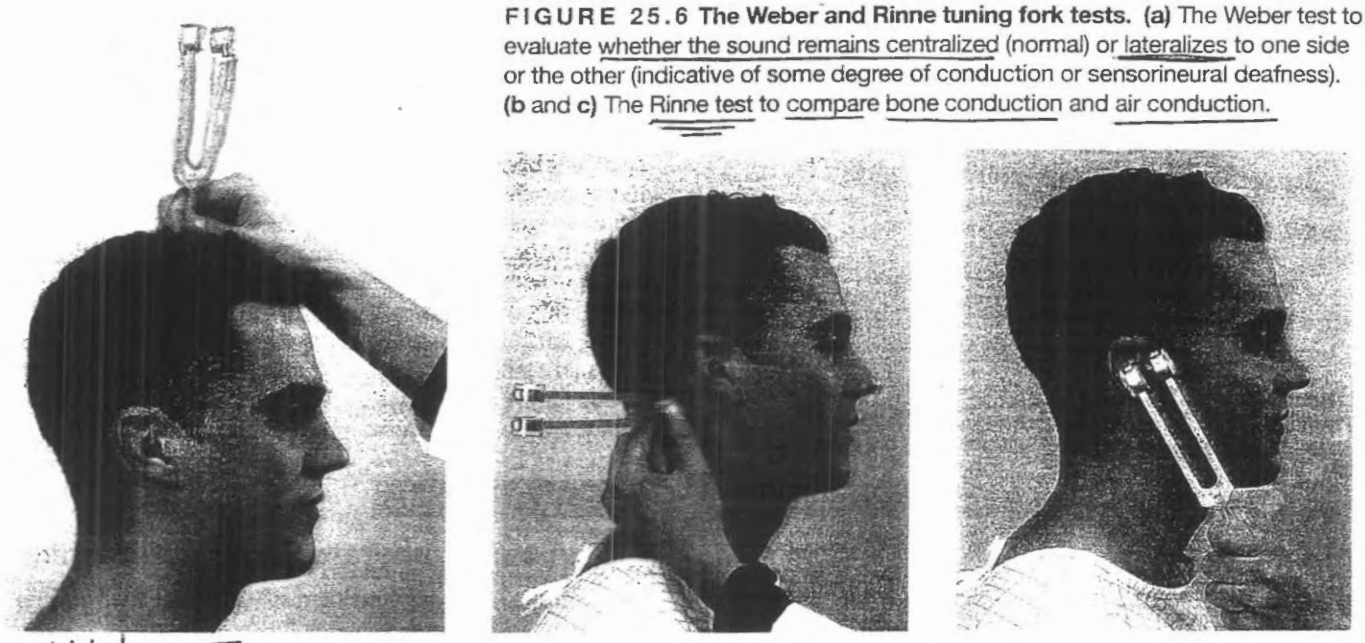


Figure 70 : The membraneous labyrinth.



(a) Weber Test (b) Rinne test (c)

FIGURE 25.6 The Weber and Rinne tuning fork tests. **(a)** The Weber test to evaluate whether the sound remains centralized (normal) or lateralizes to one side or the other (indicative of some degree of conduction or sensorineural deafness). **(b and c)** The Rinne test to compare bone conduction and air conduction.

Weber Test to Determine Conduction and Sensorineural Deafness (Nerve deafness)

Strike a tuning fork and place the handle of the tuning fork medially on your partner's head (see Figure 25.6a). Is the tone equally loud in both ears, or is it louder in one ear?

* If it is equally loud in both ears → you have EQUAL HEARING or EQUAL LOSS OF HEARING in both ears
* If nerve deafness is present in the Rt. ear → the tone will be heard in the Lt. ear but not the Rt. ear
* If conduction deafness is present in the Rt. ear (ear wax in ext. ear, disease of middle ear) → the sound will be heard more strongly in Rt. ear due to sound conduction by the bone of skull.

* Rinne test for comparing Bone- and Air- conduction hearing

1. Strike the tuning fork, and place its handle on your partner's mastoid process (Figure 25.6b).

2. When your partner indicates that the sound is no longer audible, hold the still-vibrating prongs close to his auditory canal (Figure 25.6c). If your partner hears the fork again (by air conduction) when it is moved to that position, hearing is not impaired and the test result is to be recorded as positive (+). (Record below step 5.)

3. Repeat the test on the same ear, but this time test air-conduction hearing first.

4. After the tone is no longer heard by air conduction, hold the handle of the tuning fork on the bony mastoid process. If the subject hears the tone again by bone conduction after hearing by air conduction is lost, there is some conduction deafness and the result is recorded as negative (−).

5. Repeat the sequence for the opposite ear.

Right ear: _____ Left ear: _____

Does the subject hear better by bone or by air conduction?

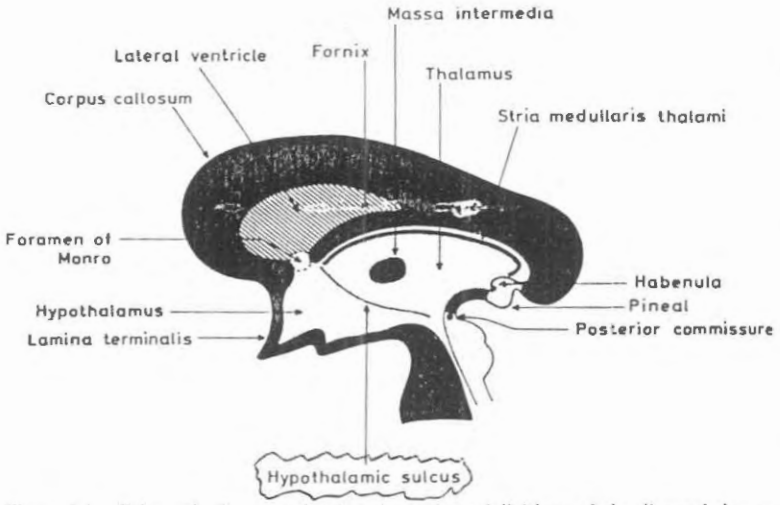


Figure 9.1. Schematic diagram showing the major subdivisions of the diencephalon as seen in a midsagittal view.

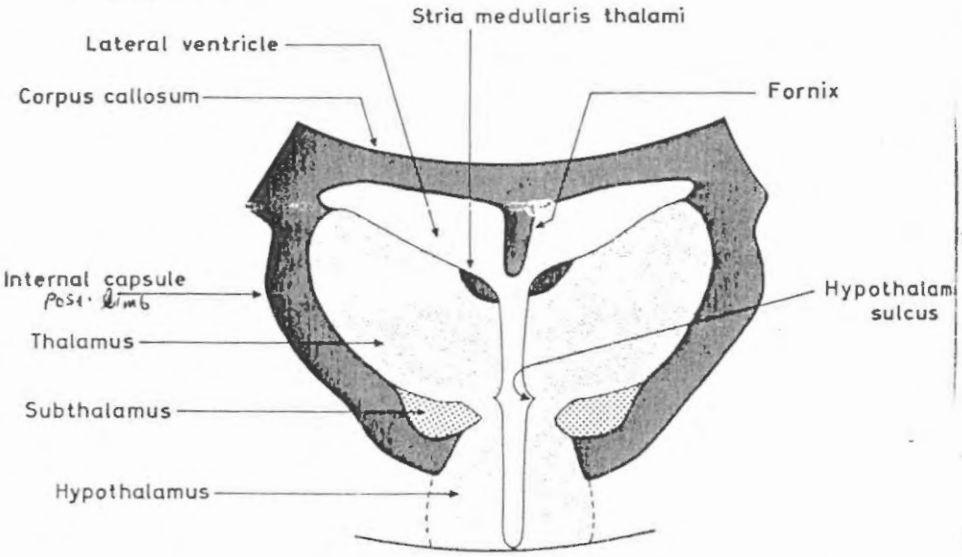


Figure 9.2. Schematic diagram showing the subdivisions of the diencephalon as seen in a composite coronal section.

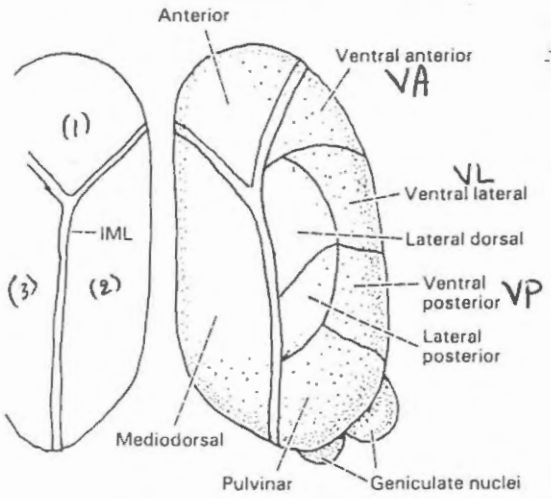


Fig. 17-1 Thalamus from above, with nuclear subdivisions. IML, internal medullary lamina.

Anatomical Subdivisions of thalamus:

The Y-shaped *internal medullary lamina* divides the thalamus into (1) anterior, (2) mediodorsal, and (3) lateral cell groups. The lateral group has dorsal and ventral tiers, each containing three nuclei. Below the hindmost member of the dorsal tier (the pulvinar) lie the medial and lateral geniculate nuclei.

Functional subdivisions of thalamus

1 *Specific nuclei* are reciprocally connected to localized areas of the cerebral cortex. They are said to be 'cortically dependent', because they degenerate when the target area of cortex is removed.

Anterior, VA, VL, VP, MGB, LGB

2 *Non-specific nuclei* project to wide areas of the cortex and influence their level of activity. They are not cortically dependent because they give abundant sustaining collaterals to one another.

Intralaminar, Reticular

3 *Association nuclei* have reciprocal linkages with association areas of the cerebral cortex (Table 17-1).

Mediodorsal, lateral dorsal, lateral posterior

Pulvinar

Bustami

* A groove extending between the foramen of Monro and the cerebral aqueduct → the hypothalamic sulcus divides the diencephalon into a dorsal portion the thalamus and a ventral portion, the hypothalamus.

"Diencephalon "inbetween brain" is completely surrounded by the cerebral hemispheres Except at its ventral surface.

- *Medially → 3rd ventricle
- *laterally → post. limb of internal capsule
- * dorsal surface → forms the floor of the lateral ventricle

Subthalamus: Medially → hypoth. / lat. → int. capsule / dorsally → thalamus / Ventrally → int. capsule

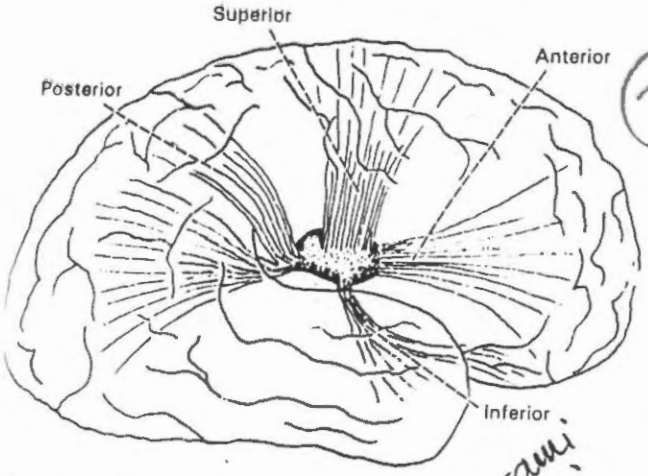


Fig. 17-6 Thalamic peduncles.

Mustansiriyah

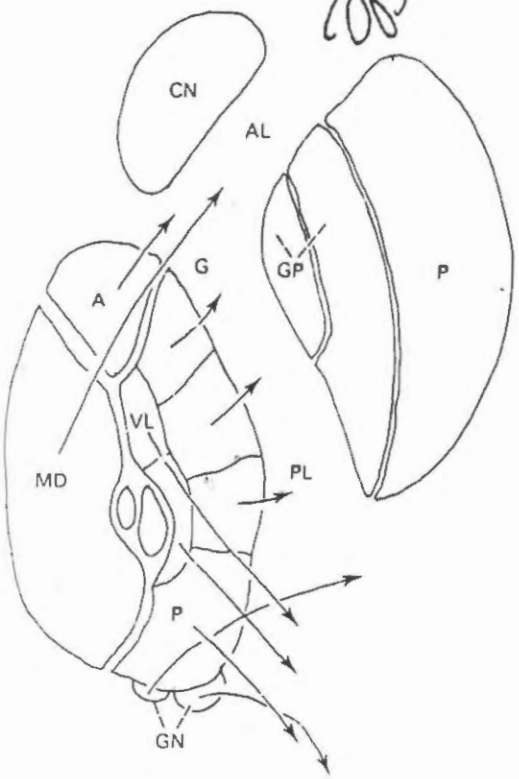
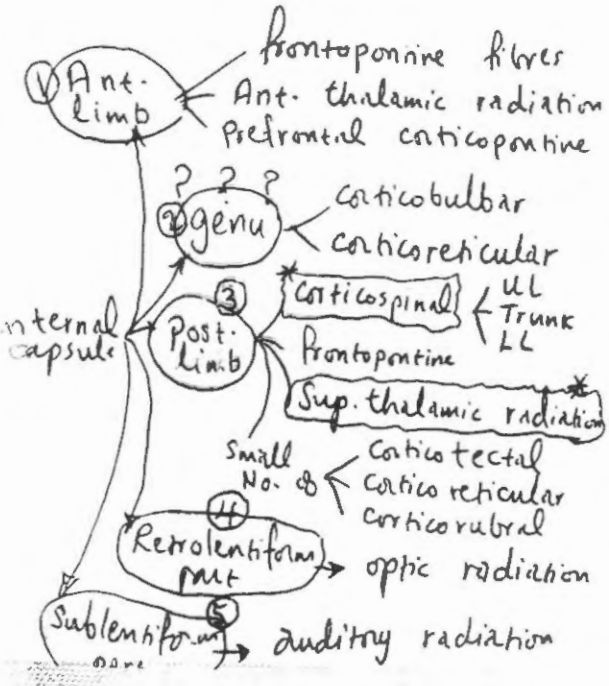


Fig. 17-7 Horizontal section through internal capsule. AL, anterior limb; G, genu; PL, posterior limb. Caudate nucleus (CN) and lentiform nuclei (P, putamen; GP, globus pallidus) are shown. A, anterior nucleus; MD, mediodorsal nucleus; VL, ventral lateral nucleus; GN, geniculate nuclei. Arrows indicate thalamic radiations.



Thalamic radiations (Peduncles)

(31)

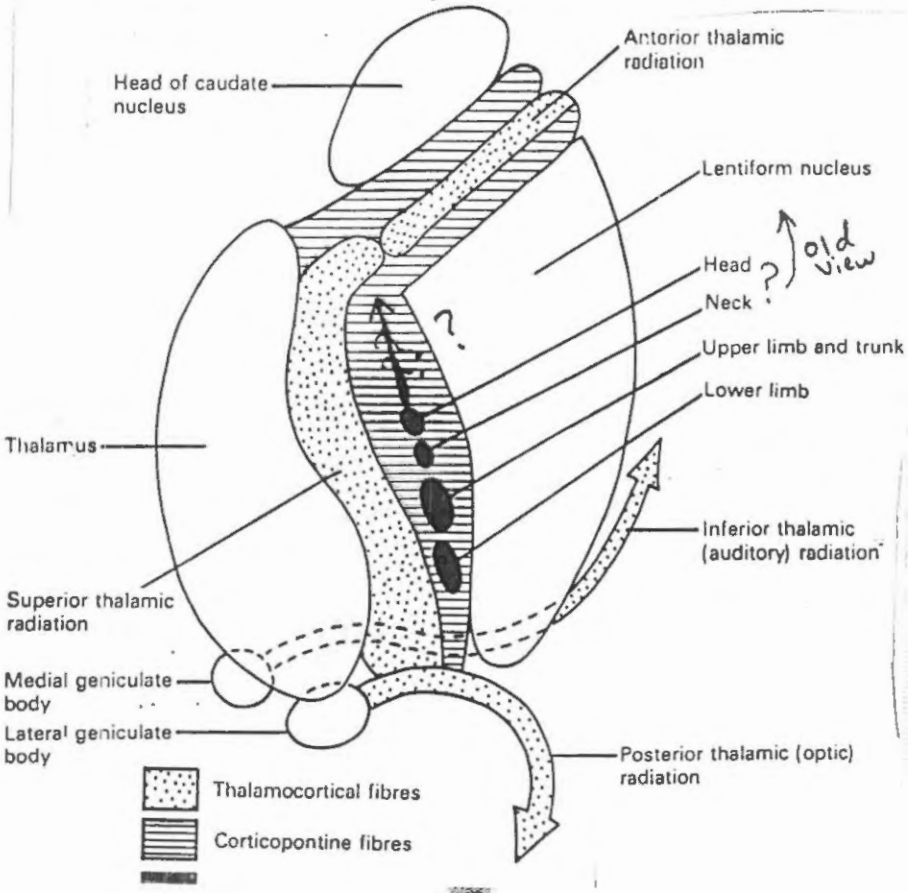
Fibres that RECIPROCALLY (i.e Aff. & Eff.) connect the thalamus & cerebral cortex

1. Anterior (frontal) peduncle : passes through the anterior limb of the internal capsule and connects the frontal lobe with the medial and anterior thalamic nuclei

2. Superior peduncle : passes through the posterior limb of the int. capsule and connects { Pre → 4,6 / post central → 3,1,2 gyri } with the ventral thalamic nuclei { VA / VL / VP }

3. Posterior (occipital) peduncle passes through the retrolentiform part of int. capsule and connects occipital lobe and caudal portion of thalamus, includes also the optic radiation from LGB → Calcarine cortex

4. Inf. or temporal peduncle passes through the sublentiform part of int capsule. Includes auditory radiation from MGB → transverse temporal gyrus



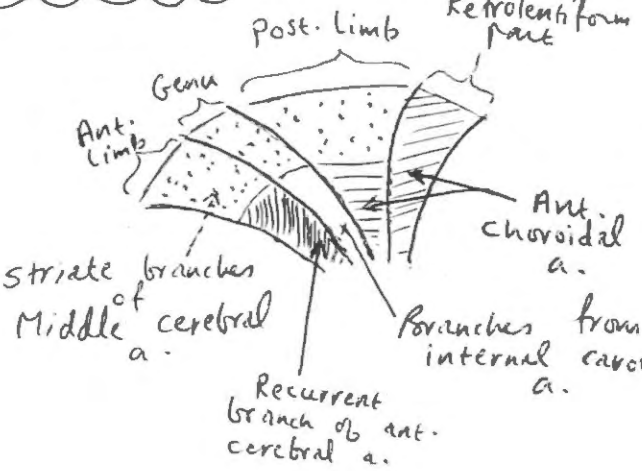
The internal capsule → Composed of all the fibres Afferent & Efferent which go to or come from the cerebral cortex. A large part of it is formed of thalamic radiations; the rest of it is formed of efferent fibres i.e corticofugal fibres which descend to lower portions of brainstem and spinal cord. These include corticospinal corticobulbar, corticoreticular and corticopontine tracts.

⇩

Thalamocortical & corticofugal fibres occupy a small compact area → lesion in this area produce more widespread disturbances than lesions in any other regio of the nervous system; and these include

(a) Contralateral Hemiplegia or Hemiparesis (corticospinal tract)
(b) Contralateral weakness of lower face (corticobulbar)
(c) Temporary Contralateral Hemianaesthesia (Sensory radiation)
(After some time there will be return of pain, temp. and simple touch → perceived at thalamus i.e Sensory cortex → is not needed to feel pain, temp. or simple touch; it is needed to feel Stereognosis + discriminative touch (2 point discrimination) It is also needed to tell where the pain is -localization-, the intensity and quality of stimulus)
(d) contralateral Hemianopia (optic radiation at retrolentiform part)

Blood supply:



(1) Both ant. & post. limbs are supplied primarily by the lateral striate branches of the middle cerebral a.
(2) The medial striate a. (recurrent a. of Heubner) supplies a rostromedial part of ant. limb
(3) genu of int. capsule → receives some direct branches from int. carotid a.
(4) the ventral part of post. limb + its entire retrolentiform part are supplied by branches of the anterior choroidal artery