8

Accommodation & the light pathways and effects of lesions

PHYSIOLOGY
CNS BLOCK
TEAM 443

MED 443
King Saud University

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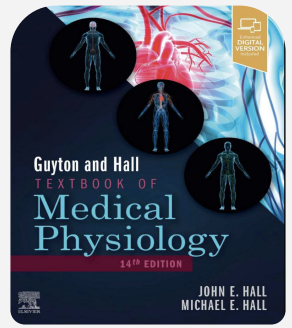
Editing File

Objectives :

1. Describe visual acuity & depth perception.
2. Contrast photopic and scotopic vision
3. To know visual pathway and field of vision
4. Describe the process of accommodation reflex and its pathway, contrasting the refraction of light by the lens in near vision and in far vision
5. identify and describe pupillary light reflex , its pathway and relate these to clinical situations as argyll Robertson pupil
6. identify the lateral geniculate body and visual cortex functions

Click me!



Highly recommended!

helpful video

Visual acuity

Definition The degree to which the details and contours of objects are perceived

- It is usually defined in terms of the **shortest distance** by which two lines can be separated and still be seen as 2 lines
- Person can normally distinguish two separate points if their centers lie up to 2 micrometers apart on the retina, which is slightly greater than the width of a foveal cone

which is approximately I.5 to 2 micrometers

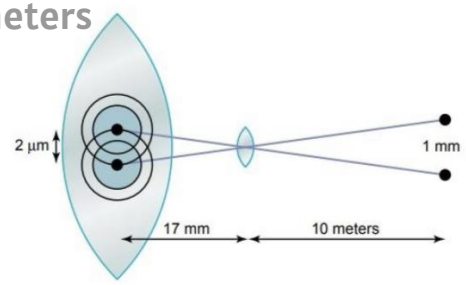
Visual acuity measure by Snellen chart*

- **Normal acuity = (d/D) = (6/6).**

d distance of Patient / D distance of normal person

- A person of 6/I2 has less vision than normal vision

which mean you see 6 meter apart what the normal person able to see it I2 meter apart



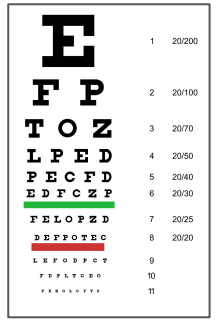
Maximum visual acuity for two point sources of light.

Visual threshold Is minimal amount of light that elicit sensation of light

اقل كميه ضوء تشوف فيها، تستفز العين وتعمل لها
(excitement to see the object)

IMP note : fovea has the maximum acuity for the following reasons:
I- it has cones rather than rods
2- cons in fovea are small in diameter so they're packed
3- fovea represents a large area in the primary visual cortex (areaI7)
4- cons has I to I representation meaning that each cone synapse with one bipolar neuron and each bipolar neuron synapse with I ganglion cell
5- the fibers around cons are pushed aside in fovea so that the light goes directly to the cons

*Snellen Chart:



Duplicity Theory of Vision

Q.Differentiate between cones & rods vision.

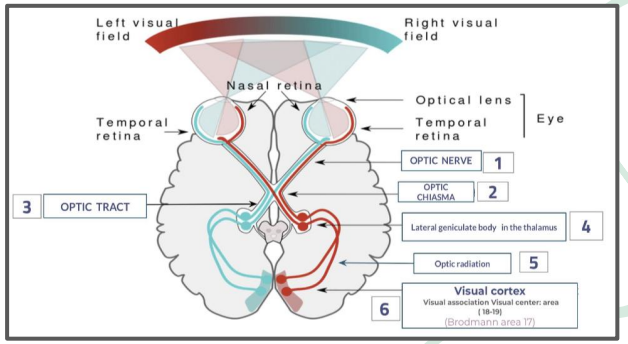
2 kinds of vision under Different conditions العين تقدر تشوف عن طريق:	
SCOTOPIC VISION (night vision, dim light vision)	- Served by rodes - Low visual acuity = no colors or details - Great sensitivity to light = low visual threshold (تحتاج كمية اقل من النور عشان تتحفز)
PHOTOPIC VISION (bright light vision)	- Served by cones -High visual acuity = colors & details - Low sensitivity to light = needs high visual threshold to be stimulated

Visual Pathway

- Pathway from **Retina** to the **Visual Centers** in the Brain
- **Photoreceptors** : Rods and Cones synapse on Bipolar Cells , which in turn , synapse on Ganglion Cells .
- Axons of **Ganglion Cells** constitute the Optic Nerve .
- These axons converge at the Optic disc ,which is also called Blind Spot (Why ?) ... Because there are no photoreceptor only way for optic nerve to pass through
- Passing through the Blind Spot they leave the eye , constituting the Optic Nerve .

1. Optic nerve
2. Optic chiasm
3. Optic tract
4. Lateral geniculate body (nucleus)
5. Optic radiation (geniculocalcarine tract)
6. Visual cortex

Optic tract send impulses to →lateral geniculate body in thalamus → its axons form geniculocalcarine tract that send to optic radiation → visual cortex in occipital cortex (**Brodmann area 17**)



Visual Pathway

- Optic nerve fibers from the medial (nasal) side of retinae decussate in the **Optic Chiasma.**
- Therefore an Optic Chiasm lesion (e,g, Pituitary Tumor) will cause vision loss from the both lateral(temporal) halves of the Field of Vision (bitemporal hemianopia)
- Optic nerve fibers from the lateral (temporal) parts of the retinae do not decussate.
- Therefore , each optic tract carries fibers from the both the temporal side of the ipsilateral retina (nasal field of vision of ipsilateral retina)+ nasal side of the contralateral retina(temporal field of vision of the contralateral retina)
- Therefore , a lesion in optic tract will cause loss of vision from the ipsilateral nasal field of vision + contralateral temporal field of vision (homonymous hemianopia).

1. Some ganglion cells axons pass from optic tract to pretectal region of midbrain for pupillary reflexes & eye movement

راح midbrain أيضا لكن عشان pretectal nucleus (جنب ال superior colliculus) مسؤولة عن :
تتوسع العين أو تتضيق حسب الضوء زي إذا كان الضوء ضعيف مرة تتوسع عشان تجمع أكثر قدر ممكن من الضوء بعكس لو كان الضوء كثير مرة (Reflex light pupillary)

2. Some axons of ganglion cells from optic chiasma pass directly to hypothalamus for circadian rhythm (light-dark cycle)

الساعة البيولوجية

النوع الثاني directly to hypothalamus
مسؤولة عن rhythm circadian بيروح
و تخلينا ننام بالليل و نصحى بالنهار

3. Some axons from lateral geniculate body in thalamus to superior colliculus in midbrain to control rapid directional movement of the two eyes and for accomodation. R & its miosis component

راح midbrain تحديداً superior colliculus
مسؤول عن أيش؟
accommodation reflex and miosis of pupil
(constriction of the pupil)

Dr.Faten important Note:
طيب لو صار في chiasm مشكلة؟ خاصة مشاكل pituitary gland
.Because the pituitary gland located beneath the chiasm
> So pituitary tumor for example will cause injury for optic chiasm
> cause injury to nasal fibers أي طيب field أكيد ماعاد راح ينشاف؟ outer (lateral) part of each field
(Pts loss of each half of the eye)

Do not worry More explanation in the next slides

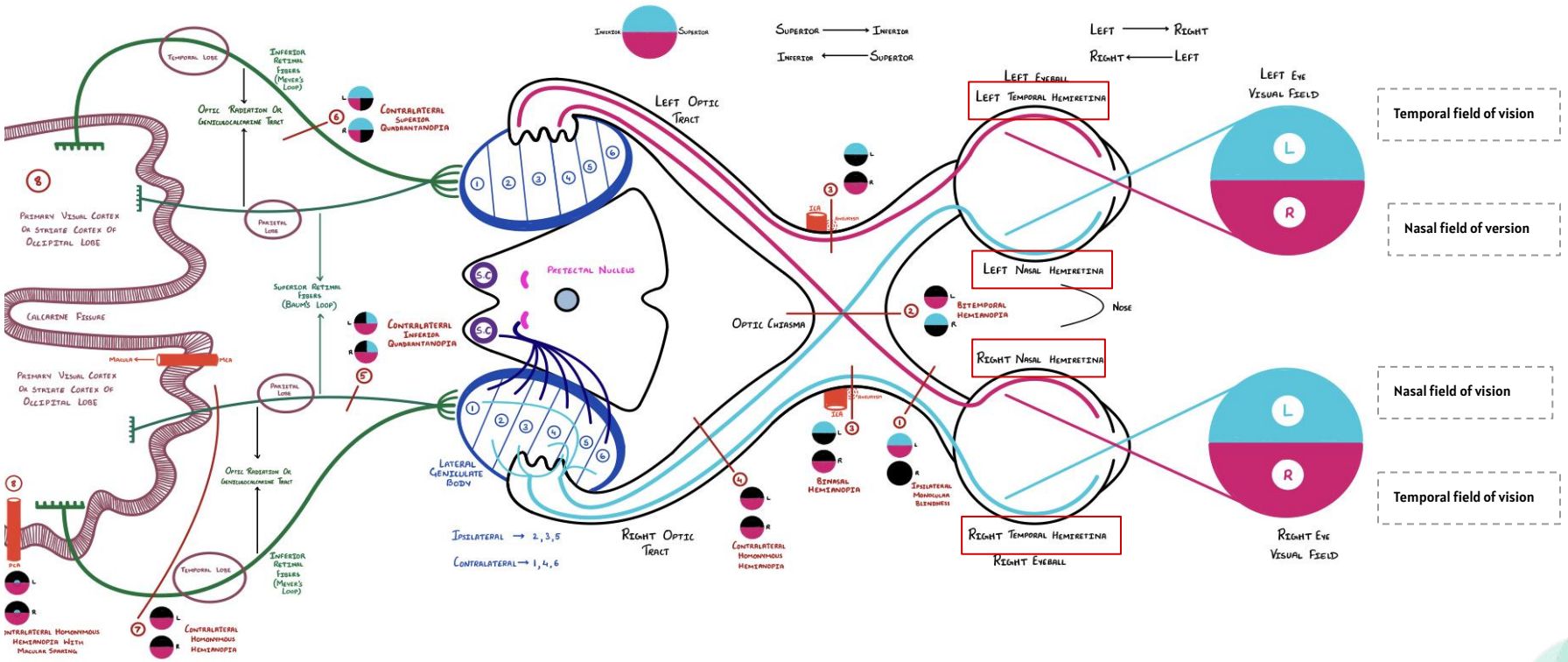
Extra.....

Important

There are two vision fields I-temporal 2-nasal, the temporal visual field is represented on the nasal hemiretina(half), while the nasal visual field is represented on the temporal hemiretina(half).
the **nasal hemiretina** (temporal visual field) decussate in the optic chiasm -> a lesion here can cause loss of the temporal visual field called bitemporal hemianopia (tubal vision)(number 2 in the picture),
the **temporal hemiretina** (nasal visual field) doesn't decussate so a lesion in the optic tract can cause problems with both fields called homonymous hemianopia. (Number 4 in the picture)

Check the picture for better understanding !!

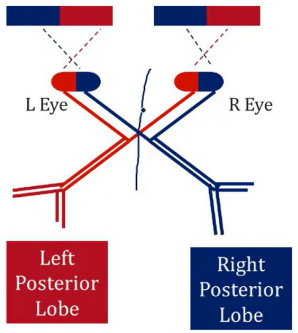
hemiretinaنسمي المشكلة حسب اللي يشوفها المريض وليس حسب ال

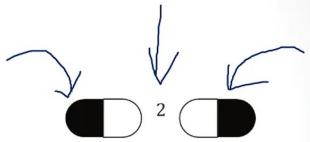


credit to lama alotaibi
Further examples in the next slide...

Extra.....

Bitemporal Hemianopsia



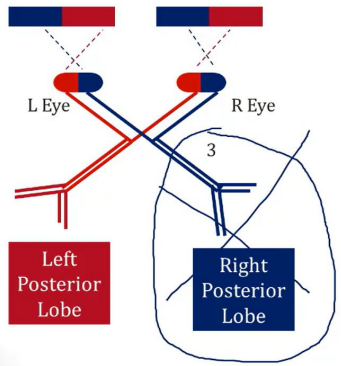


Optic Chiasm Compression
Pituitary Tumor/Aneurysm

Bitemporal Hemianopsia

Nunh-huh /Wikipedia

Homonymous Hemianopsia



Left PCA Stroke
Left **Optic Tract** Lesion
Right visual loss

Right PCA Stroke
Right **Optic Tract** Lesion
Left visual loss

Homonymous Hemianopsia

Nunh-huh /Wikipedia

VISUAL PATHWAY & FIELD

Female slides

- The nasal fibers (medial) cross to opposite side at optic chiasma
- The temporal fibers (lateral) do not cross
- Nasal fibers conveys temporal field (outer)of vision
- Temporal fibers conveys nasal field (inner)of vision

OPTIC TRACT :

- The left optic tract corresponds to the right medial ½ of the visual field
- The right optic tract corresponds to the left medial ½ of the visual field

Accommodation

Definition

Modification of the refractive power of the eye **(by increasing curvature of the lens)**
(LENSتزيد قوة الانكسار عن طريق زيادة تحدب ال) → the goal: clearing the vision view of **a nearby object.**

Part of the near response: 1 **Lens change**(increase the curvature) 2 **Constriction on pupil**(myosis) 3 **Convergence of the eyes**

- Ciliary muscle has two separate sets of smooth muscle fibers longitudinal fibers and circular fibers
- Contraction of either set in the ciliary muscle relaxes the ligaments to the lens capsule, and the lens assumes a more spherical shape, because of the natural elasticity of the lens capsule & **and increase its refractive power.** up to 12 diopter.
- The ciliary muscle of accommodation is Controlled by Parasympathetic Nerves transmitted to the eye through **Oculomotor nerve.**

Mechanism of Accommodation

Near object

1. Ciliary muscle Contraction
2. Relaxation of the suspensory ligament
3. Lens more convex
4. Increase diopteric power of the eye
5. Near object focused on the retina

Far object

Contraction of the suspensory ligament

↓

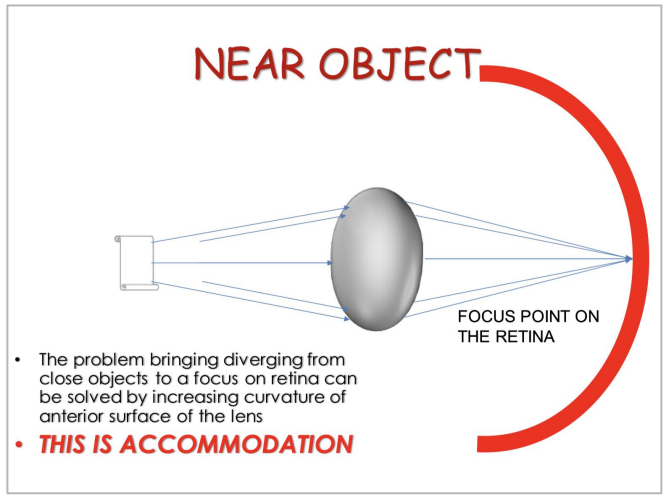
Lens less convex (Flat)

↓

Decrease diopteric power of the eye

↓

Far object focussed on the retina

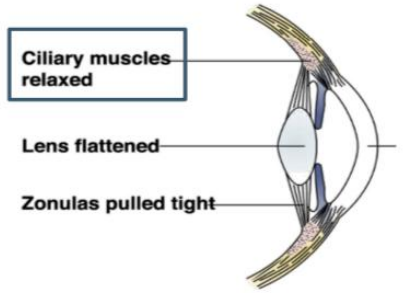


Accommodation

Distance Vision	Accommodation (during **near** vision)
Ciliary Muscle **Relaxed**	Ciliary Muscle **Contracts**
Suspensory Ligaments Under **↑Tension** Ligaments become tensed/taut	Reduced Tension on/Relaxation of Suspensory Ligaments (**↓Tension**) Ligaments become lax
Lens is Flattened (**↓round**)	Lens becomes Round (**↑round**/more convex) To increase dioptric power
Focus on **Distant** Objects	Focus on **Near** Objects on the retina

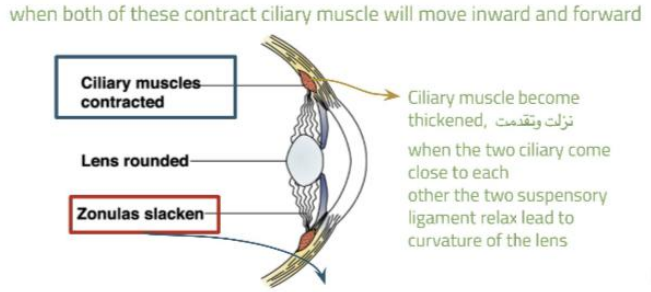
1
2
3
4

○ When the cilary muscles are relaxed, the zonalus pulls tight and keeps the lens flattened for distant vision

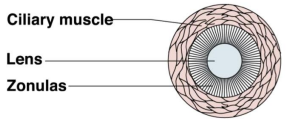


zonulas = Suspensory Ligaments

○ When the ciliary muscles contract, it releases the tension on the zonulas and the elastic lens returns to a more rounded shape suitable for near vision



Slack or Slacken or LAX all of them mean relaxation of suspensory ligament



The elastic lens is attached to the circular cilliary muscles by the zonalus

At rest (looking at far objects):-
Ciliary muscles are relaxed + taut (tense) ligaments + flat lens
looking at near objects:-
- ❖ from near (close) objects parallel rays focus behind retina (if ciliary muscles remain relaxed) Cause blurred vision
- ❖ Solution is to increase curvature & refractive power of lens by accomodation to bring focus on retina.

Dioptric power of the eye (كل ما زادت كل ما زاد قوة الانكسار→more accommodation)(measurement for strength of lens focusing)
Diopter= I/focal length
- ○ Cornea → 40-45D
- ○ Lens → I5-20 D
- ○ Accomodation → +I2D (→ ↑refractive power → focus on near objects)

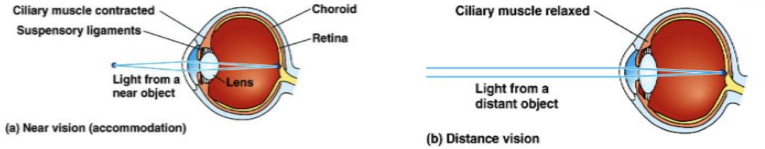
Amplitude of Accommodation:Additional diopters added by increasing the convexity of the lens.(this is the +I2D)

Near response

convergence of both visual axis. WHY ?	لما ننظر للشيء القريب كل العينين يشوف **medial side** ، ناحية الأنف س : ليه العينين كلهم يناظرون لنفس المكان ؟ اللي نسميه **convergence** ج : عشان نجيب **corresponding points of the image on same focus for both eye** يعني العينين يجيبون ال **focus** لنفس المكان
pupil constriction. Why?	protection from excess light
Accomodation. Why?	To increase the refractive power and bring the focus on the retina

Accommodation reflex

Female slides



- Focusing at near object by increased anterior surface curvature of lens by ciliary muscles contraction slack = relaxed ligaments & increased anterior surface curvature of lens . why? to add I2D to refractive power of lens

- both circular & longitudinal ciliary muscles contract to pull ciliary muscle forwards & inwards ciliary muscles edges come close to each other to increase anterior surface curvature of lens. Test sanson purkinje image

اختبار كانوا يسوونه زمان، يجيبون شموع ويحطونها قدام العين ويشوفون ثلاث صور تبع ال **accommodation** ←

1-cornea image
2-anterior surface of the lens
3-posterior surface of the lens

Male slides

Age (yrs)	Near point (cm)	Amplitude of Accommodation
10	9.0	11.0
20	10.0	10.0
30	12.5	8.0
40	18	5.5
60	83	1.2
70	100	1.0

Near Point

Definition Nearest point to eye at which object can brought into focus on retina by ACCOMODATION

10 years 9 cm
60 years 80 -100 cm, due to hardness of lens & loss of accommodation

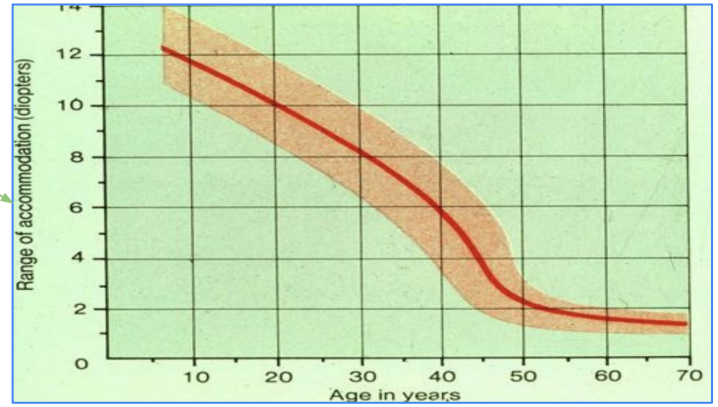
للي عمره ١٠ سنوات يشوف حتى لو الاوبجيكت قريب منه الي حدود 9cm

أما كبار السن يحتاجون يبعدون عن الاوبجكت 100cm عشان يشوفو

Presbyopia

قطر النظر الشيخوخي

نلاحظ هنا ان ال accommodation يقل مع التقدم بالعمر, لانك بتخسر ال Lens elasticity



Presbyopia triade:

1- loss of accommodation & focus behind retina

dr.faten : weakness not loss

2- loss of lens elasticity

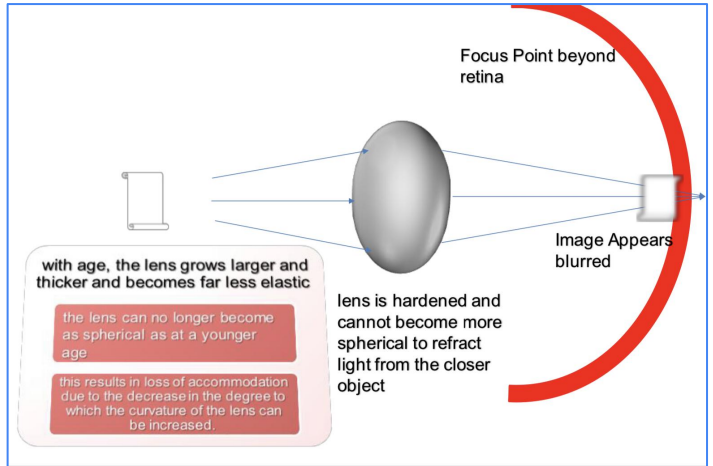
Hardness of lens, lens loses flexibility and begins to stiffen CAN NOT increase the convexity; cannot increase the dioptric power

نرجّع الاوبجكت ، لان و هو قريب ال focus ورا الretina
فنبعد الاوبجكت عشان الفوكس ترجع مكانها الطبيعي

3- near point recede

-correction by biconvex lens

To decrease the focal distance by increase the convexity of lens

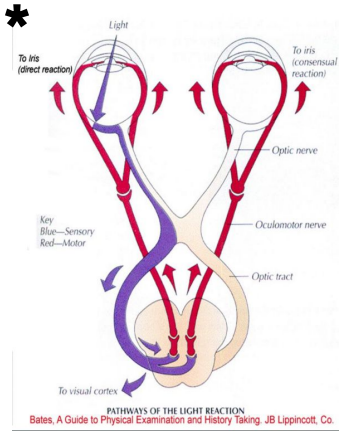


Pathway of accommodation

Do not worry More explanation in the next slide

Afferent:	Efferent:
• Light on eye • Retina • Optic nerve • (→optic chiasm→optic tract) • Lateral geniculate body in thalamus • Superior colliculus in midbrain	• Both Edinger Westphal nucleus (oculomotor parasympathetic) • Both Ciliary ganglia • Both Oculomotor nerves ■ bilateral ciliary muscle contraction (accomodation. R) ■ contraction of iris (sphincter pupillae) circular muscles for miosis of near response.

*



pupillary light reflex

Light fall on one pupil → a direct light reflex occurse (constriction of this pupil) (direct pupillary reflex) + other pupil (indirect/consensual) reflex (the non stimulated eye also get the reflex)

❖ Diameter of pupil: varies from 1.5mm to 8mm
(Quantity of light changes X30 fold)

Pathway of pupillary light reflex (indirect) * :

Light on eye → retina → optic nerve → optic chiasm → optic tract pass through **superior colliculus** to end in **pretectal nucleus** → both **oculomotor nerve nuclei** (EWN) → both **ciliary ganglia** → supply both eyes by **oculomotor nerves** (short ciliary nerve to **constrictor pupillae**) miosis in both eyes.
Conversely, in darkness, the reflex becomes inhibited, which results in dilation of the pupil.

The pupil constricts in response to:

1. The accommodation reflex
2. The light reflex

Argyll Robertson pupils (Neurosyphilis)

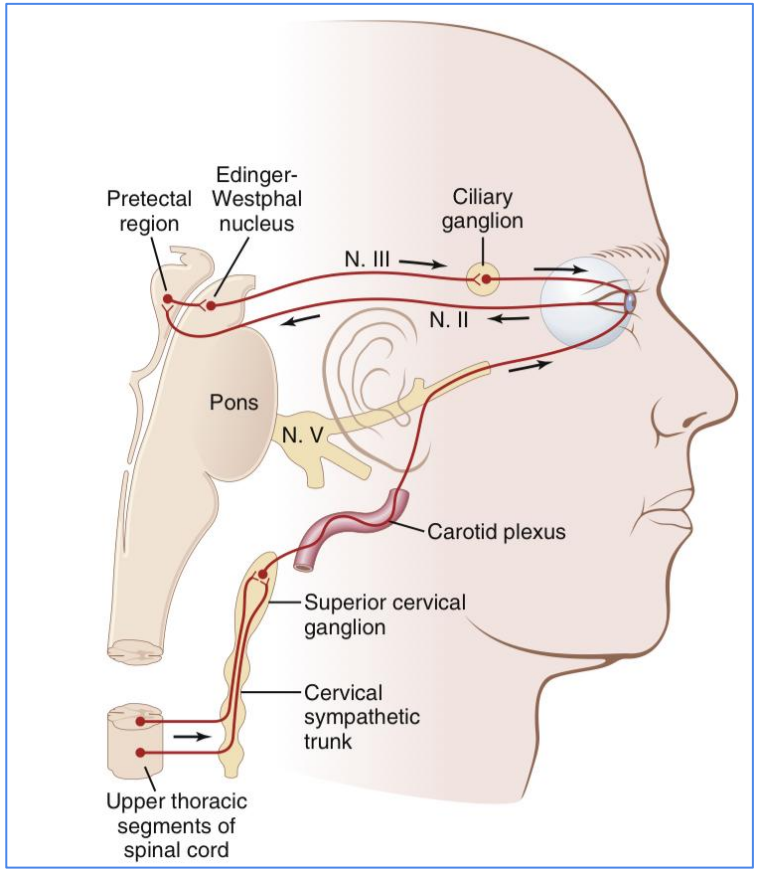
1. Pupils constrict in response to accommodation reflex, but **not to the light reflex** because of different pathways
2. In syphilis tabes dorsalis which destroy pretectal nucleus only, away from superior colliculus & fibers of accomodation
3. light R is lost but accommodation R remains

Male slides

Important

Direct Reflex on Right, Consensual Reflex on Left

From Guyton : The eye is innervated by both parasympathetic and sympathetic nerve fibers, as shown in Figure.
The parasympathetic preganglionic fibers arise in the Edinger Westphal nucleus—the visceral nucleus portion of the third cranial nerve—and then pass in the third nerve to the ciliary ganglion, which lies immediately behind the eye. There, the preganglionic fibers synapse with postganglionic parasympathetic neurons, which in turn send fibers through ciliary nerves into the eyeball. These nerves excite the following:
(1) the ciliary muscle that controls focusing of the eye lens
(2) the sphincter of the iris that constricts the pupil.



بكل اختصار لما يصير فيه light على العين، ال optic nerve بيستقبل الاشارة ويرسلها، وحتستقبلها ال Edinger Westphal nucleus, ثم ترسل الاشارة عن طريق الال3th cranial nerve ل ciliary ganglion، ثم منها الاشارة تروح لعضلات العين ويصير ال light reflex

Retinal Ganglion Cells & Their

Female slides

1. W cells: 40% with small diameter , sensitive or detecting directional movement in the field of vision, and they are probably important for much of our rod vision under dark. Mostly by rods

2. X Cells: 55% has a medium size diameter
Transmission of the Visual Image and Color Vision.
Mostly by cones

3. Y Cells: 5% only with large diameter to Transmit
Instantaneous & rapid Changes in the Visual Image , either rapid movement or rapid change in light intensity

Extra.....

GUYTON AND HALL

- W Cells: These cells have wide dendritic distribution along the retina, thus they are efficient in detecting the shift of focus in the visual field.
- X Cells: Their dendritic fields do not distribute widely within the retina, therefore they transmit signals from discrete, small areas of the retina. Consequently, it is mainly through X Cells that details regarding visual acuity and color are transmitted. Each X Cell receive input from at least one cone, therefore it is most probably responsible for transmitting all color vision.
- Y Cells: Much like W cells these cells have wide dendritic distribution along the retina, Y and W cells make synaptic connections with the superior colliculus and mediate their functions through transmitting information about rapid changes in the visual field.

Lateral geniculate body LGB

- ❖ Left LGB (similar to left optic tract) has all layers receive from RIGHT 1/2 of visual field.
- ❖ Right LGB (similar to right optic tract) has all layers receive from LEFT 1/2 of visual field.
- ❖ LGB has 6 layers.
- ❖ In primates a different classification is used:

➢ Parvocellular (P) cells which project to parvocellular layer of LGB, conducting signal of fine details & colors.

➢ Magnocellular (M) cells , which project to magnocellular layer of LGB, and they are high sensitive to low contrast stimuli and to rapid movement visual signals.

Function of LGB:

1. acts as a relay station for visual information from optic tract to cortex.
2. It has point to point transmission with high degree of (spatial fidelity يحدد المكان بدقة)
3. Acts as a gate which controls signal transmission to visual cortex i.e control how much signals reach visual cortex
4. color vision & detect shapes & texture
5. N.B: - It receives gating control signals from two major sources:
   ◗ Corticofugal fibers returning in a backward direction from the primary visual cortex to the lateral geniculate nucleus ◗ Reticular areas of the mesencephalon. Both of these are inhibitory and, when stimulated, can turn off transmission through selected portions of the dorsal lateral Footnotes geniculate nucleus

LGB pathways to visual cortex

The magnocellular pathway (Mainly Rods)	The parvocellular pathway (Mainly Cones)
• From layers **1 and 2** which have large cells and are called **magnocellular**, carries signals for detection of: **movement, depth, and flicker.** • These receive their input almost entirely from the large type M retinal ganglion cells. • A rapidly conducting pathway to the visual cortex. • This system is color blind, transmitting only black- and-white information.	• From layers **3,4,5,6** which have small cells and are called parvocellular, carries signals for: **color vision, texture, shape, and fine detail.** • Moderate velocity of conduction. • These neurons receive their input almost entirely from the type P retinal ganglion cells that transmit color and convey accurate point to point spatial information

Cortical Visual areas: 1 Primary (area 17) 2 Secondary association area, (areas 18, 19)

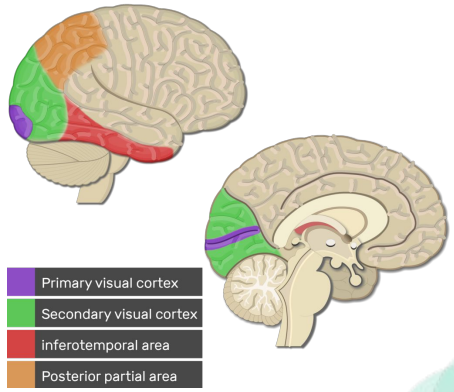
Visual cortex:

• The Primary Visual Cortex Has **Six Major Layers of cells** arranged vertically each act as a separate unit for processing of informations.

• The fovea is responsible for the highest degree of visual acuity, so it has larger representation in the primary visual cortex than the most peripheral portions of the retina.

• Signals from the retinal fovea transmits its signals terminate near the occipital pole, whereas signals from the more peripheral retina terminate in concentric half circles anterior to the pole on the medial occipital lobe.

• The upper portion of the retina is represented superiorly and the lower portion inferiorly.



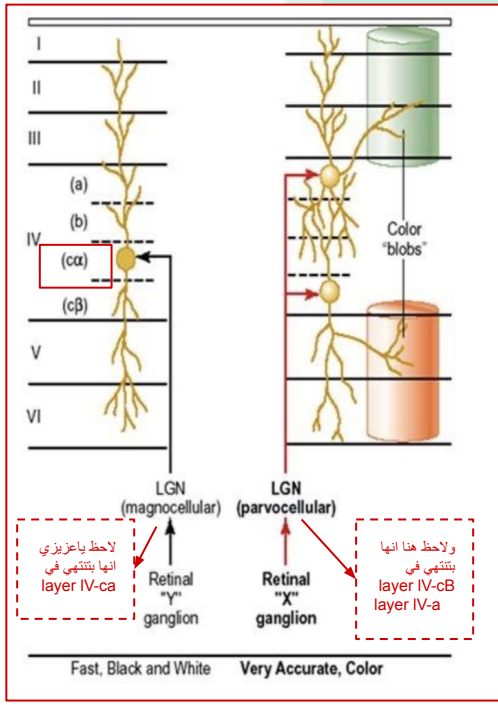
Primary and Association visual cortex

pictures are in the next slide

Primary visual cortex (braodmann area 17):		Association visual cortex (area 18&19) (secondary visual areas):
Medial aspect of each occipital lobe Its neurons arranged in the form of columns forming 6 distinct layers	1	Located anterior, lateral, inferior and superior to primary visual area extend to parietal and temporal lobe
Perceive sensation of vision (movement + shapes + stereoscopic vision + brightness) and has blobs for color detection	2	Interpretation of visual stimuli (هل الصوره بعيده او قريبه, وماهي ابعادها)
Perception of visible objects without knowing the meaning of these objects.	3	Dealing with complex perception of patterns & forms & responsible for object recognition
removal of the primary visual cortex causes loss of conscious vision, (blindness) (but patient react subconsciously to changes in light intensity, to movement in the visual scene). These reactions include turning the eyes, turning the head, and avoidance. This vision is believed to be subserved by neuronal pathways that pass from the optic tracts mainly into the superior colliculi.	4	When this fixation area is destroyed bilaterally , causes difficulty keeping its eyes directed toward a given fixation point.
	5	The fixation mechanism that causes the eyes to "lock" on the object of attention is controlled by **secondary visual center.**

Visual projection to area 17

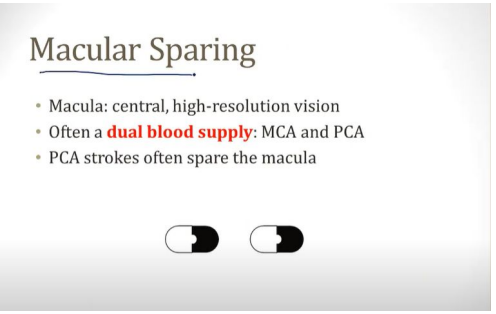
Color Blobs are in the Visual Cortex. Interspersed among the primary visual columns & among the columns of the secondary visual areas.
Column-like areas called colour blobs.Clusters of cells responsible for **color detection.**
Two types of cortical neurons:
1. **Simple cells** detect color contrast details, bars of **light, lines, borders and edges**
2. **Complex cells** detect Line Orientation When a Line Is Displaced Laterally or Vertically in the Visual Field (**linear movements of a stimulus**)



Macular sparing:

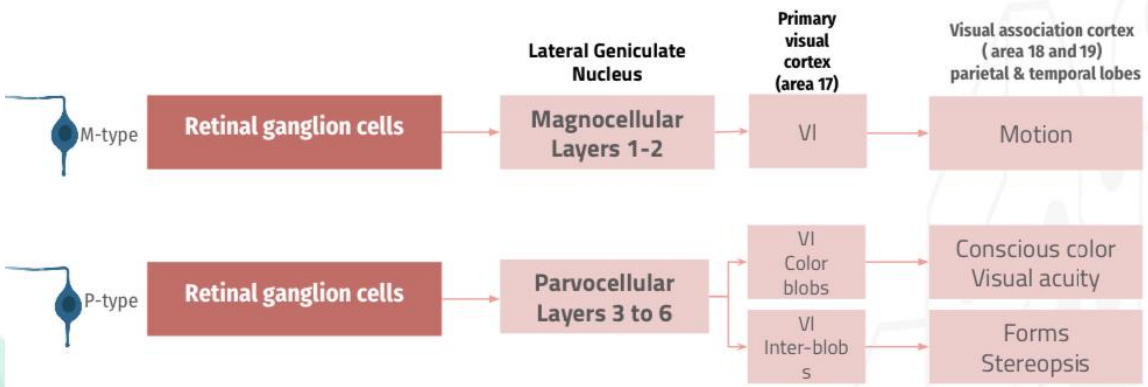
لاحظو الاماكن تبع **periphery** صغيرة لذلك فالنيورونز حقتها شويه و صغيره ف أي **trauma or tumor** بيسببون فقدان وظيفتهم ، بعكس **fovea** او الماكيو لا كبار جدا و النيورونز حقتها كثيرة لذلك حتى لو صار **trauma** ماراح تفقد كل وظيفتها الكونسبت اللي شرحناه هذا هو ال **Macular sparing**

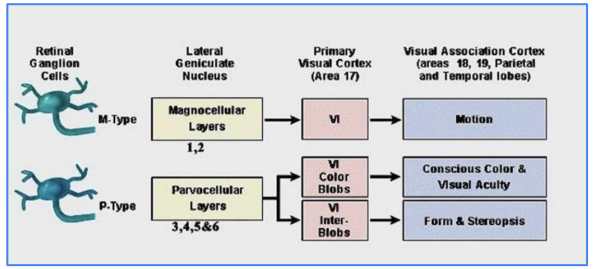
Macular sparing = loss of peripheral vision with intact macular vision because the macular representation is separate from that of the peripheral fields and is very large relative to that of the peripheral fields.

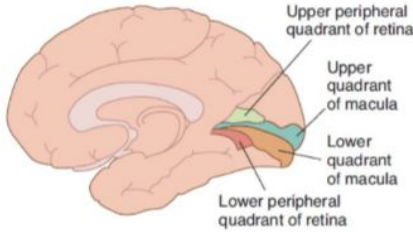


Retinotopic Organization & Process of Visual Info

ganglion fibers (axon) يطلع من to the LGB nucleus







Depth Perception

helpful video

(Determination of an Object Distance from the Eye)

1. **The sizes of the images of known objects on the retina** البعيد نشوفه صغير و القريب نشوفه كبير

2. **The phenomenon of moving parallax :**

   when the person moves his head to one side or the other, the images of close-by objects move rapidly across the retinas, while the images of distant objects remain almost completely stationary like when ur inside a car and ur trying to see treas or any thing beside the road

   تخيلوا إننا نمشي في الطريق وقدامنا مزرعة، اشجارها ممتدة كل الطريق، فطبعا فيه شجر قريب من عيوننا وفيه شجر بعيد
   تقولك الشجر القريب بتشوفينه وبتعدينه فيقولون **move rapidly across the retina** ويجي اللي بعدوا و هكذا
   لكن الاجسام البعيدة طول وقتها منعكسة على عيوننا لذلك يوصفونها **Remain almost completely stationary**

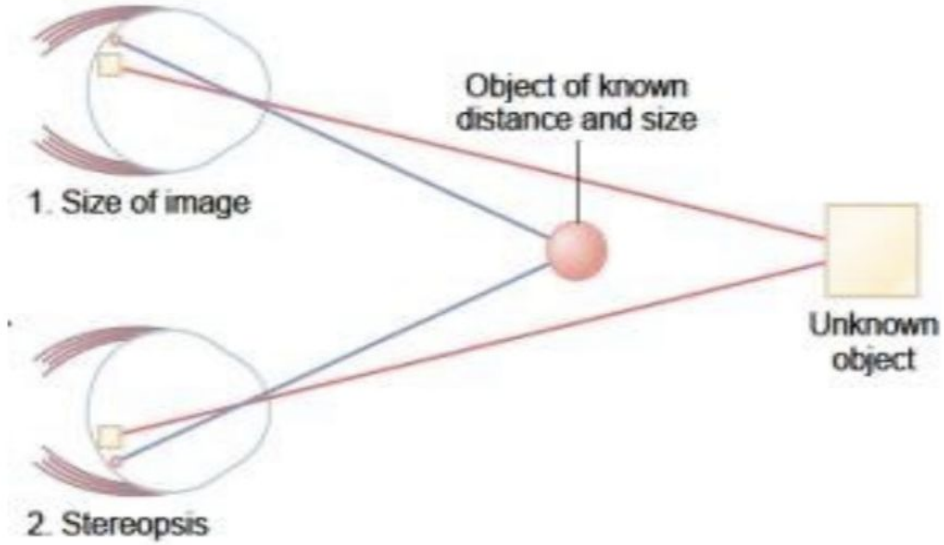
3. **The phenomenon of stereopsis or Binocular** لما نشوف شي قريب نقدر نحدد ابعاده

   The perception of depth and 3-dimensional structure obtained on the basis of visual information deriving from two eyes by individuals with normally developed binocular vision

Extra.....

GUYTON AND HALL

- The retina can distinguish the distance of objects if the object's size is known by the brain, since the size of the object is known, and the image size on the retina is known, the brain computes this set of information to calculate the relative distance of the object.
- Binocular vision can also help detect depth and relative distance of objects, that is, each eye sees objects at a slightly different angle, this causes each eye to see different aspects of a certain object. This gives the perception of three dimensions and depth. This can be demonstrated by closing one eye or the other alternatively and observing how the object will appear slightly different.



TEST YOURSELF !

1- Hassan visited an ophthalmologist and was diagnosed with Argyll Robertson pupil, which reflex will be absent in this case ?

A) Accommodation reflex

B) Light reflex

C) Miosis

D) Accommodation and Light reflexes

2- Which of the following is a characteristic of presbyopia ?

A) Corrected by cylindrical

B) Occur in young

C) Hard and weak lens

D) Focus in front of retina

3- Damage of which of the following nuclei causes loss of both pupillary and accommodation reflexes?

A) Main oculomotor nucleus

B) Edinger Westphal nucleus

C) Lateral geniculate body

D) Nucleus Ambiguus

4- which one of the following processes is required in the accommodation of near vision?

A) Dilation of the pupil

B) Increase curvature of the lens

C) Relaxation of ciliary muscle

D) Stiff suspensory ligament

Answers : B, C, B, B

SAQ

Mention the cortical visual areas.

- primary (braodmann area 17)
- secondary association (areas 18 , 19)

The pupil contracts in response to?

- the accommodation reflex
- the light reflex

Define the near point.

Nearest point to eye at which object can brought into focus on retina by accomodation

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