Anatomy & Physiology Of the Eye

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Acknowledgement:

This two-year curriculum was developed through a participatory and collaborative approach between the Academic faculty staff affiliated to Egyptian Universities as Alexandria University, Ain Shams University, Cairo University , Mansoura University, Al-Azhar University, Tanta University, Beni Souef University , Port Said University, Suez Canal University and MTI University and the Ministry of Health and Population(General Directorate of Technical Health Education (THE). The design of this course draws on rich discussions through workshops. The outcome of the workshop was course specification with Indented learning outcomes and the course contents, which served as a guide to the initial design.

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Contents

جامعة /أكاديمية : وزارة الصحة و السكان
كلية /معهد : الإدارة العامة للتعليم الفني الصحي
قسم : التشريح و الفسيولوجي

توصيف مقرر دراسى

1- بيانات المقرر		
الرمز الكودى :	اسم المقرر : الفسيولوجي	الفرقة /المستوى : الثاني
التخصص :	عدد الوحدات الدراسية : 2 نظرى 1 عملى	

2- هدف المقرر:	
The aim of this course is: 1. To introduce the basic structure and function of the visual system. 2. To provide the student with medical terminology. 3. To understand the structure and organization of human eye. 4. To acquire a detailed knowledge and understanding of the human eye in health and disease. 5. To develop basic concepts of neural processing of information as well as the skills to examine the eye.	

3- المستهدف من تدريس المقرر :	
By the end of this course the student should be able to: 1. Describe the general and basic structure of the orbit of the human body . 2. Describe the sequence of events taking place during early prenatal development of the human embryo or common causes of congenital malformations 3. Discuss the anatomical features of any structure (fascia, regions, muscles, vessels nerves,) of the orbit. 4. Describe the developmental process and/or congenital anomalies of the eye. 5. Explain the physiological basis of how the components of the visual system operate to set up conscious visual images. 6. Identify the various parts of the eye and outline the functions of each.	ا. المعلومات والمفاهيم :

7. Describe the pathophysiology of glaucoma, cataract, and errors of refraction. 8. Recognize how to assess the visual acuity, determine and correct errors of refraction. Evaluate the field of vision, eye movement, color vision, and fundus of the eye.	
By the end of this course the student should be able to: 1. Use reasoning in solving clinical problems related to the eye based on anatomical knowledge. 2. Predict the congenital anomalies that may be encountered based on given defects of development. 3. Enumerate the protective mechanisms of the eye. 4. Give a brief idea about corneal function, nutrition, hydration, transparency, and list causes of corneal opacity. 5. Demonstrate aqueous humor formation and drainage, and explain its role in maintaining intraocular pressure as well as in glaucoma. 6. Describe lens function and outline the causes of cataract. 7. Summarize how light rays are brought to a focus on the retina, and the role of accommodation in this process. 8. Differentiate hyperopia, myopia, astigmatism, and presbyopia. 9. Recognize the function of iris, and list causes of miosis and mydriasis. 10. Memorize retinal layers and write a brief idea about photoreceptors, retinal organization and function. 11. Explain dark and light adaptation. 12. Describe the visual pathways that convey visual signals from the retina to the visual cortex and recognize its lesion. 13. Identify the physiological and neurological basis of color vision. List causes and types of color blindness. 14. Demonstrate the field of vision, binocular vision and types of eye movement.	**ب- المهارات الذهنية :**
By the end of this course the student should be able to: 1. Identify marked bony features or attachments on real bones or projected pictures of bones of the skull. 2. Identify marked structures (e.g., muscles, vessels, nerves, ligaments, viscera … etc.) in the orbit in	**ج- المهارات المهنية الخاصة بالمقرر:**

dissected cadavers, plastic models or projected pictures. 3. Assess the visual acuity. 4. Perform fundus examination and determine myopia and hypermetropia. 5. Examine the field of vision and determine field defects. 6. Assess the integrity of accommodation and light neural pathways. 7. Evaluate color vision.	
By the end of this course the student should be able to: 1. Respect superiors and colleagues. 2. Gather and organize information including the use of information technology where applicable. 3. Present medical information in written or electronic forms. 4. Communicate ideas and arguments effectively. 5. Work constructively and cooperatively within a team. 6. Practice self evaluation. 7. Manage time effectively. 8. Create a dialogue and build trust with patient. 9. Deal with the patient complaints. 10. Interact with others to be positive and to show empathy and concern to patients.	**د- المهارات العامة :**
1. Skull and bony orbit. 2. Eye ball. 3. Orbital muscles and fascia 4. Nerves. 5. Vessels. 6. Visual pathway and reflexes. 7. Lacrimal apparatus. 8. Functional structure of the eye, ocular cavities, and nerve supply of the eye. 9. Protective mechanisms of the eye. 10. Behavior of light in nature and refraction. 11. Corneal transparency, hydration, nutrition, and function. Corneal reflex. 12. Aqueous humor formation, drainage, and function. 13. Intraocular pressure function and regulation. 14. Definition, types, and causes of glaucoma. 15. Lens function, nutrition, and optical properties. 16. Definition, and causes of cataract. 17. Vitreous humor structure and function. 18. Accommodation and errors of refraction. 19. Function of iris, light reflex, and causes of miosis and mydriasis.	**4- محتوى المقرر:**

20. Structural layers of retina and difference between rods and cones. 21. Retinal changes on exposure to light. 22. Dark and light adaptation. 23. Visual field and lesions in visual pathway. 24. Color vision. 25. Binocular vision and types of eye movements.	

1. **Lecture** 2. **Small group discussion** 3. **Practical sessions**	**5- أساليب التعليم والتعلم**
1- Revision lectures outside schedule 2- Tutorial classes.	**6- أساليب التعليم والتعلم للطلاب ذوى القدرات المحدودة**
7- تقويم الطلاب :	
1. Formative exams. 2. Final exam.	**أ- الأساليب المستخدمة**
1. Final written exam (15th week). 2. Final practical exam (15th week).	**ب- التوقيت**
1. Final written exam (30 marks for anatomy + 30 marks for physiology). 2. Practical exam (20 marks for anatomy + 20 marks for physiology)	**ج- توزيع الدرجات**
8- قائمة الكتب الدراسية والمراجع : **Ganong W.F.(2016). Review of Medical Physiology. 25th edition. McGraw-Hill. New York.** **Guyton and Hall (2016). Medical Physiology. 13th edition. El Sevier. China.** **Gray' s anatomy for students,2nd edition,2011,Darke R . et all** ***recomended books*:ATLAS OF HUMAN anatomy(Netter)**	
	أ- مذكرات

	• **Gray's Anatomy for students, 2nd edition, 2011, Drake R. et al** • **Ganong W.F.(2016). Review of Medical Physiology. 25th edition. McGraw-Hill. New York.** • **Guyton and Hall (2016). Medical Physiology. 13th edition. El Sevier. China.**	**ب- كتب ملزمة**

	▪ Clinical Anatomy by Regions, 9th edition, 2011, Snell RS ▪ -Last's Anatomy: Regional and Applied, 12th edition, 2011. Sinnatamby CS. ▪ Langman's Medical Embryology, 12th edition, Sadler T.W. ▪ Atlas of Human Anatomy, 6th edition, 2014, Netter F.H. ▪ Adler's Physiology of the eye (2003). 11th edition. Levin LA. El Sevier. China.	ج- كتب مقترحة
	• http://mic2.shams.edu.eg/ • http://www.zygotebody.com • http://www.wikilectures.eu/index.php/main_page • http://www.bestmedicallinks.com/anatomy-and-embriology-links • http://isc.temple.edu/marino/embryo/genitan.htm • http://embryology.med.unsw.edu.au/Movies/Movies.htm • http://www.onlinebiologynotes.com/physiology-of-vision/ • https://www.youtube.com/watch?v=kQjiO3tmk0w • https://www.youtube.com/watch?v=cG5ZuK0_qtc • http://www.ybu.edu.tr/sinancanan/contents/files/989Vision.pdf	د- دوريات علمية أو نشرات ..... الخ

Week	Theory	Practical
1st week	▪ Skull and bony orbit	Skull
2nd week	▪ Eye ball	Skull
3rd week	▪ Orbital muscles and fascia	Skull
4th week	▪ Nerves	Bony orbit
5th week	▪ Vessels	Bony orbit

6th week	▪ Visual pathway and reflexes	Bony orbit
7th week	▪ Lacrimal apparatus and anomalies of the eye	Bony orbit
8th week	▪ The protective mechanisms of the eye. ▪ Corneal function, nutrition, hydration, transparency, and causes of corneal opacity.	Field of vision
9th week	▪ Aqueous humor formation, drainage, and its role in maintaining intraocular pressure as well as in glaucoma. ▪ Lens function and causes of cataract.	Light reflex
10th week	▪ Accommodation Reflex. ▪ Errors of refraction.	Accommodation reflex
11th week	▪ Function of iris ▪ Causes of miosis and mydriasis. ▪ Retinal layers, photoreceptors, retinal organization and function.	Visual acuity and fundus examination
12th week	▪ Dark and light adaptation. ▪ Visual pathway and its lesions.	How to determine the site of lesion in visual pathway by using field examination and light reflex
13th week	▪ Color vision. ▪ Causes and types of color blindness. Field of vision, binocular vision and types of eye movement.	Color vision and eye movements

Core skills:

The purpose of the course is to acquaint the technical students with the structure of orbit of human body with special emphasis on eye ball parts in order that students will be able to:

1. Use reasoning in solving the clinical problems concerned with the size of the eyeball e.g. myopia, hypermetropia based on anatomical knowledge.
2. Recognize the interior of the eye:
    1. Anterior chamber
    2. Vitrous chamber
    3. Lens
3. Identify anatomical structures in normal (X-ray & CT scan) or cross section of the eye.
4. To know the origin, course and termination of visual pathway
5. Identify the location of tract as part of visual pathway inside the central nervous system.
6. Identify common congenital anomalies of the eye (photograph or museum jar).
7. Integrate, gather and organize information in written, oral and electronic form.
8. Construct and cooperate within a team

Core Knowledge By the end of this course, students should be able to:

1. Define the openings found in relation to the orbit e.g.
    1. Optic canal.
    2. The superior orbital fissure.
    3. The inferior orbital fissure.
    4. Canal for nasolacrimal duct.
2. Describe the ophthalmic artery and locate as many of the following branches as possible and note that they can divide into
    1. Ocular vessels: central artery and ciliary arteries.
    2. Orbital vessels e.g. lacrimal & supratrochlear
3. List branches of nerves e.g. oculomotor and realize that this nerves in addition to giving muscular branches provides parasympathetic innervation for sphincter pupillae (muscle of the iris) and the ciliary muscle of accommodation.
4. Discuss the eyelids and identify
    - Palpebral fissure
    - Layers
    - Composition
5. Identify anatomical structures in normal (X-ray & CT scan) or cross section of the eye.
6. To know the origin, course and termination of visual pathway
7. Identify the location of tract as part of visual pathway inside the central nervous system.
8. Identify common congenital anomalies of the eye (photograph or museum jar) medical.

Chapter 1

ANATOMY OF THE HEAD AND NECK (overview)

Head and Neck (Overview)

- The scalp (Fig1): is the soft tissue which covers the cranial vault of the skull.
- The face: extends from the hair line (superiorly)to the lower border of chin and the mandible (inferiorly) and auricle on each side.
- The skull and the cranial cavity: A) The skull is formed of separate bones. Many of these articulate with one another at serrated edges called ***sutures*** (Fig2). The skull is divided into two main parts (Cranium and Mandible). The exterior of the skull is studied in 5 views, each is called Norma. a. Norma verticals b. Norma frontalis c. Norma lateralis. d. Norma basalis e. Norma occipitalis.
  B). The cranial cavity (Fig3): is the interior of the skull that accommodates the brain and its associated structures.
- The eye.
- Arteries and veins of the head and neck:
  - Arterial supply of the head and neck: is derived from right and left common carotid arteries and left subclavian arteries.
  - Venous drainage of head and neck:
- The extra cranial regions and the neck: is drained by:
  - Internal jugular veins
  - External jugular veins
  - Anterior jugular vein
  - Subclavian vein.
- The intracranial regions: are drained by Dural venous sinuses.
- 6. Nerve supply to head and neck: from the following sources
- The 12 cranial nerves: 4 of these cranial nerves contain also parasympathetic fibers (the Oculomotor n, the Facial n, Glossopharyngeal n and the Vagus n.)
- Cervical nerves.
- Cervical part of right and left sympathetic chains.

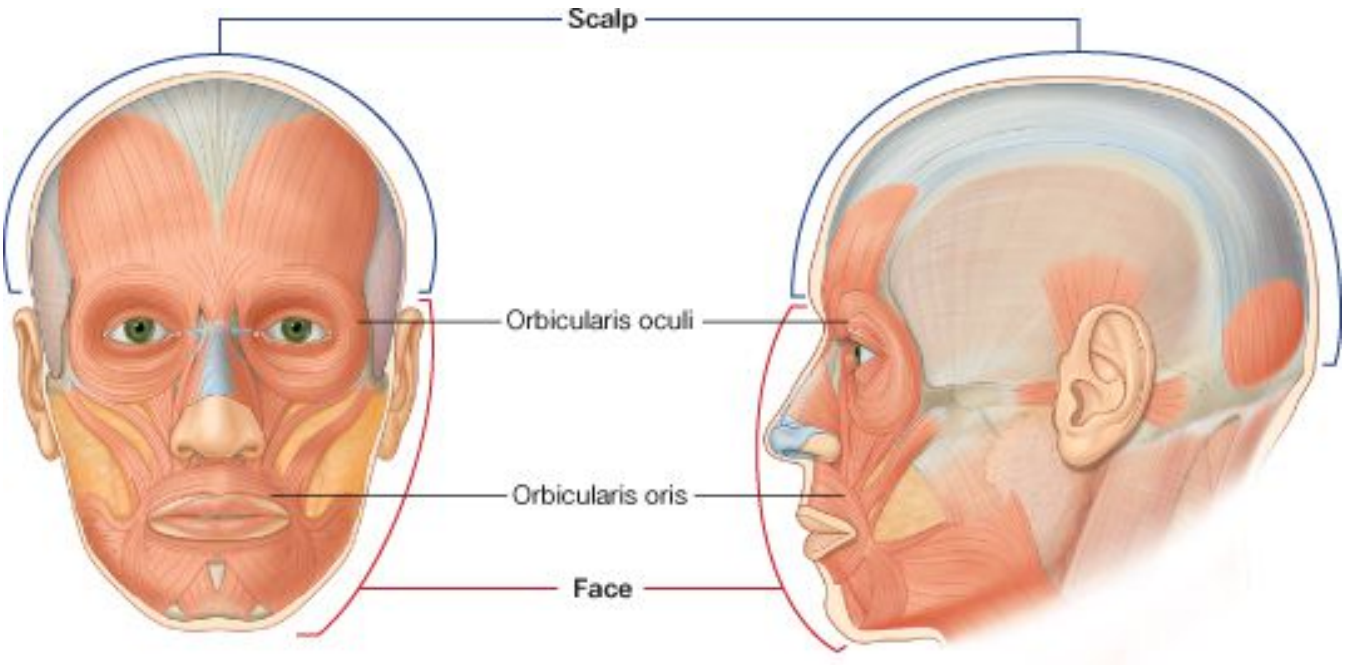


Figure 1: The scalp and face

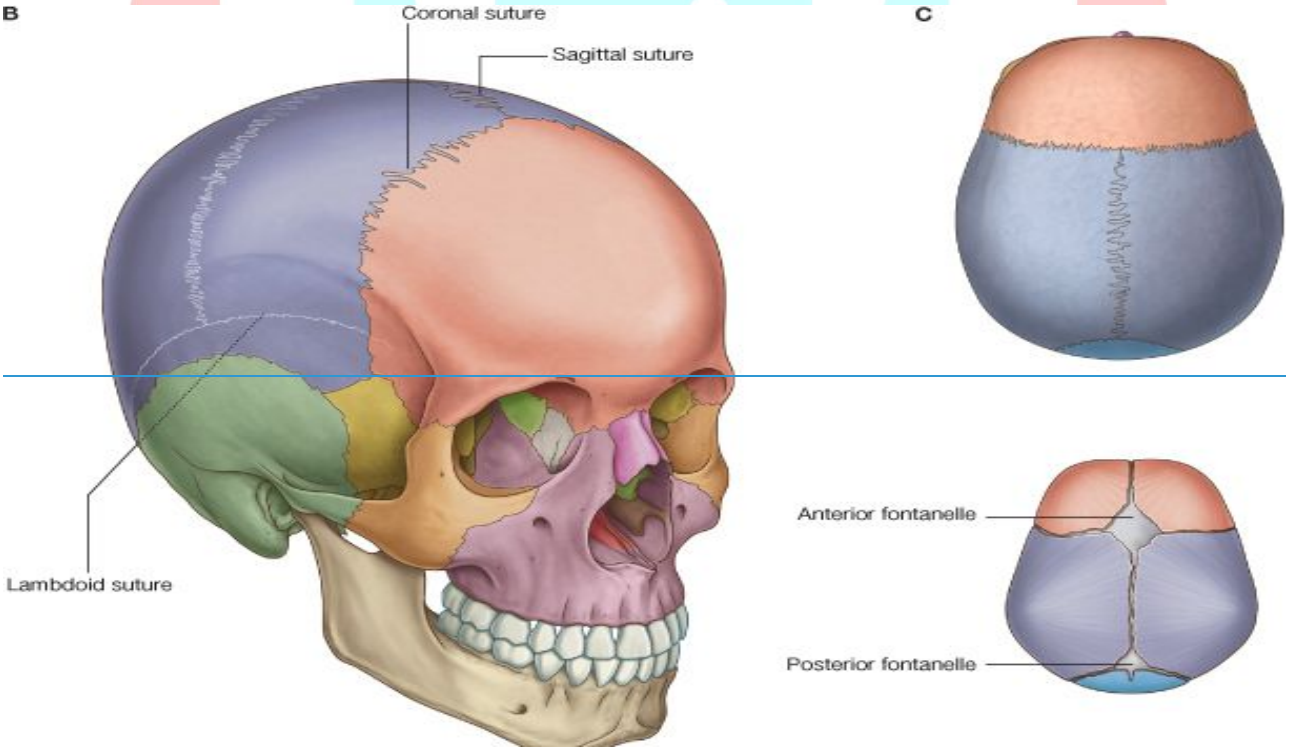
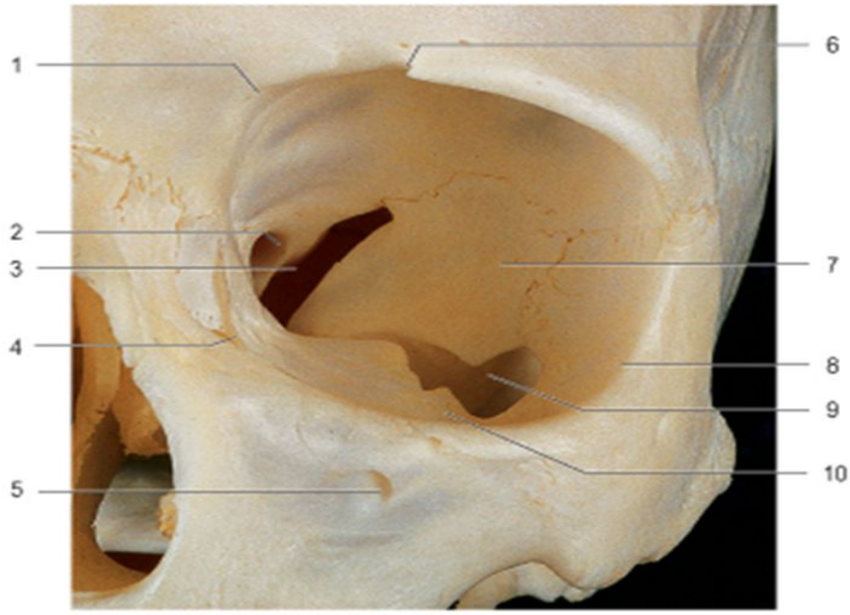


Figure 2: Sutures of the skull & Norma verticalis



1. Frontal notch.
2. Optic canal.
3. Superior orbital fissure.
4. Opening of nasolacrimal canal.
5. Infraorbital foramen.
6. Supraorbital notch.
7. Orbital surface of greater wing of sphenoid.
8. Orbital surface of zygomatic bone.
9. Inferior orbital fissure.
10. Infraorbital groove.

figure 3:The bony orbit

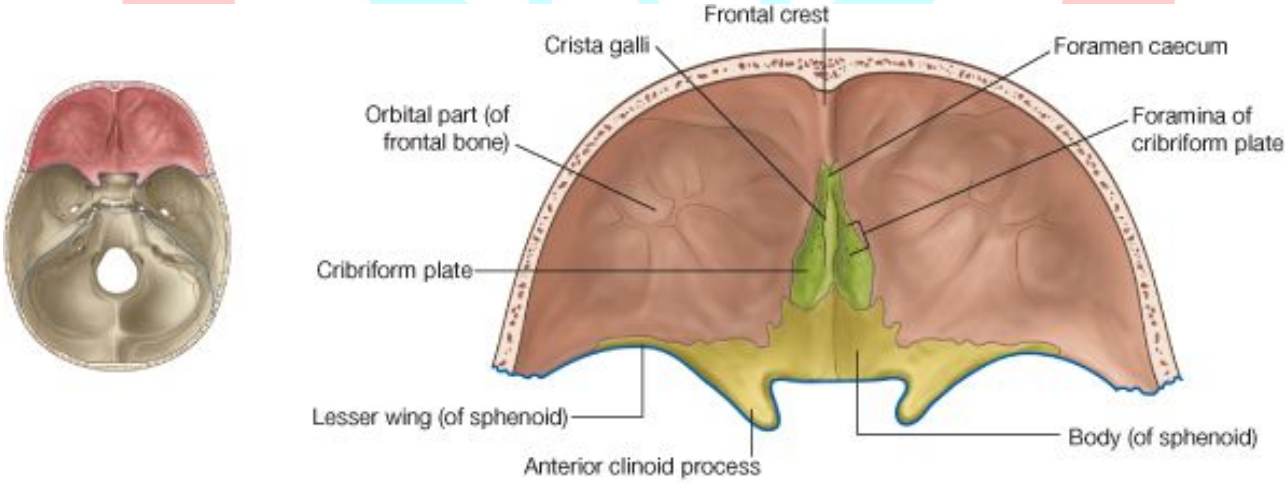


Figure 4 anterior cranial fossa

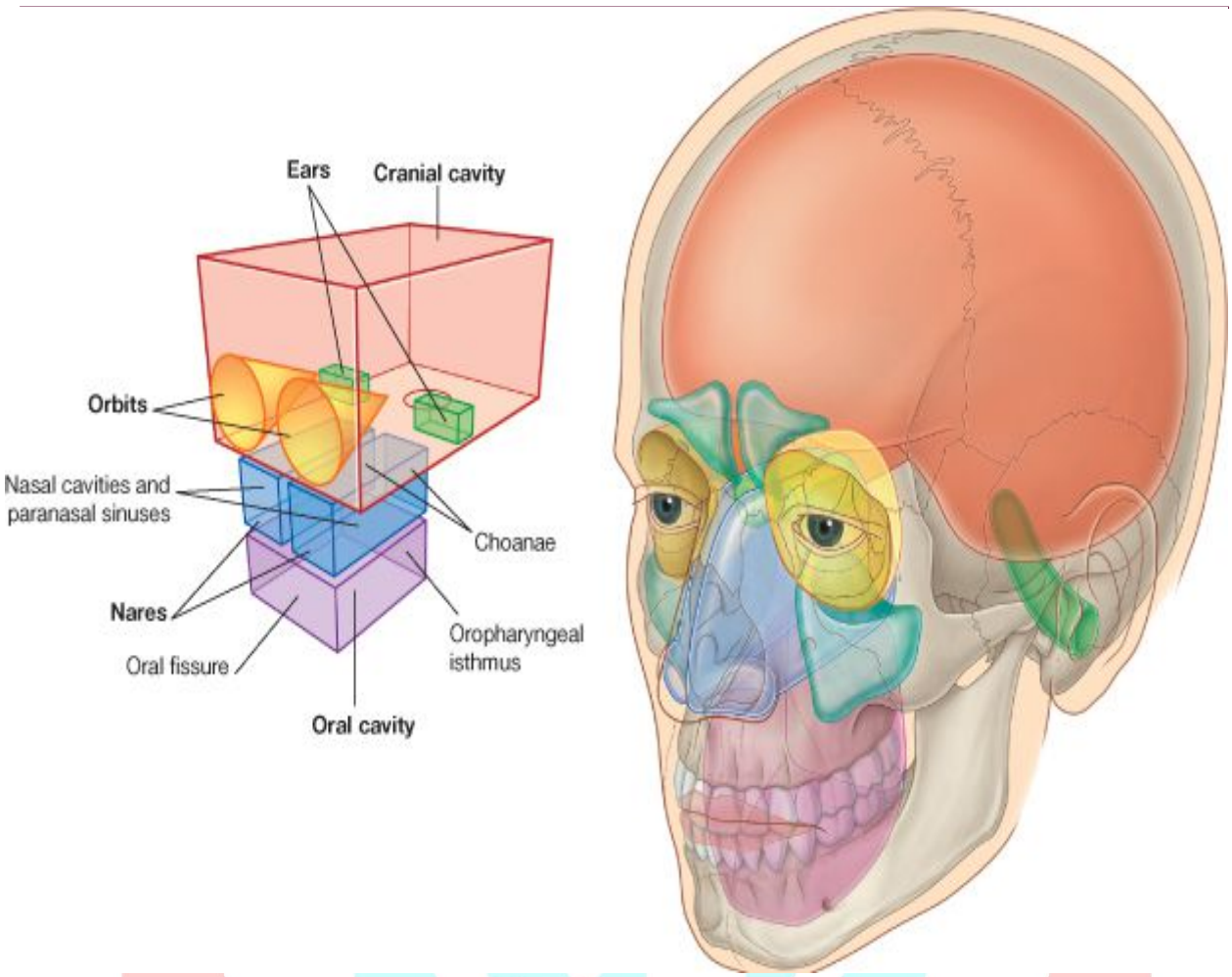


Figure 5 cavities of skull

Chapter 2

The orbit

Objectives

DISCUSS THE ANATOMY OF THE ORBIT

The Orbit

Each orbit resembles a four – sided pyramid having:

- **Apex**: directed backward.
- **Base**: (orbital opening, on face).
- **4 Walls:** Roof, floor, medial and lateral walls.

- Long axis (Fig6) of each orbit passes backwards and medially, so that the medial walls of the 2 orbits are parallel to each other and lateral walls are set at right angles to each other.

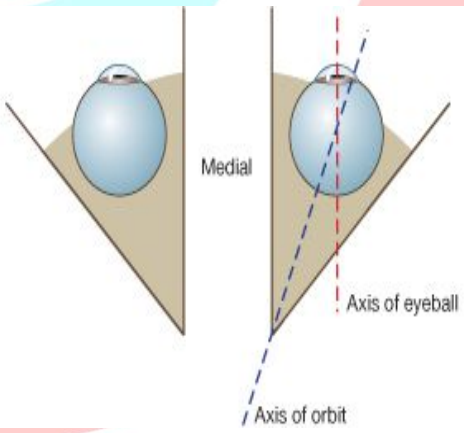


Figure 6: AXIS OF THE EYE BALL

BONY ORBIT

A) Orbital Opening**:**

- Represent the base of bony orbit, Quadrangular in shape.

- Bounded by 4 margins**:**

1-Superior margin: frontal bone. At the junction of medial 1/3 and lateral 2/3, it shows the **supraorbital notch (foramen)** which transmits the supraorbital nerve and vessels.

2-Inferior margin: the **zygomatic** bone (laterally) & **maxilla** (medially).

3-Lateral margin: frontal bone (above) & the **zygomatic** bone (below)

4-Medial margin: frontal bone (above) & **maxilla** (below).

B) WALLS OF THE ORBIT (Fig7)**:**

1. Roof**:** is related to the anterior cranial fossa & is formed by:

1. Orbital plate of frontal bone

2. Lesser wing of sphenoid

-**Features:**

1. Lacrimal fossa: lodges the lacrimal gland.

2. Optic canal: transmits optic nerve and ophthalmic artery.

3. Trochlear fossa: attachment to fibrous pulley (trochlea) for tendon of superior oblique muscle.

2. Lateral wall: Is formed by:

1. Frontal process of zygomatic bone (anteriorly).

2. Greater wing of sphenoid (posteriorly)

-**Features:**

Superior orbital fissure (see also the face): Lies at the junction of the roof and lateral wall posteriorly. Its lower border is marked by a small projection, which provides attachment to **"common tendinous ring"**. The ring divides the fissure into **3 parts,** which transmit the following structures**:**

a) Lateral part:

i) Lacrimal, frontal & trochlear nerves.

ii) Superior ophthalmic vein.

b) Middle part:

i) Superior division of the oculomotor nerve.

ii) Nasociliary nerve.

iii) Inferior division of the oculomotor nerve.

iv) Abducent nerve.

c) Medial part:

i) Inferior ophthalmic vein.

ii) Sympathetic nerves from plexus around ICA.

3. Floor: is related to the maxillary sinus & is formed by

1. Maxilla

2. Zygomatic bone (anterolaterally).

3. Orbital process of the palatine bone (at the posterior angle).

-Features:

1. Inferior orbital fissure: Lies at the junction of the floor and lateral wall. It transmits the following structures:

a) Continuation of maxillary nerve (infraorbital nerve).

b) Zygomatic nerve.

c) Orbital branches of the pterygopalatine ganglion.

d) Infraorbital vessels.

e) Communication between inferior ophthalmic v. & pterygoid plexus of vs.

2. Infraorbital groove, canal and foramen: transmit infraorbital nerve & vessels.

4. Medial wall: is related to the ethmoidal cells & is formed by the following bones arranged antero-posteriorly in order:

1. Maxilla.

2. Lacrimal bone.

3. Orbital plate of the ethmoid

4. Body of the sphenoid.

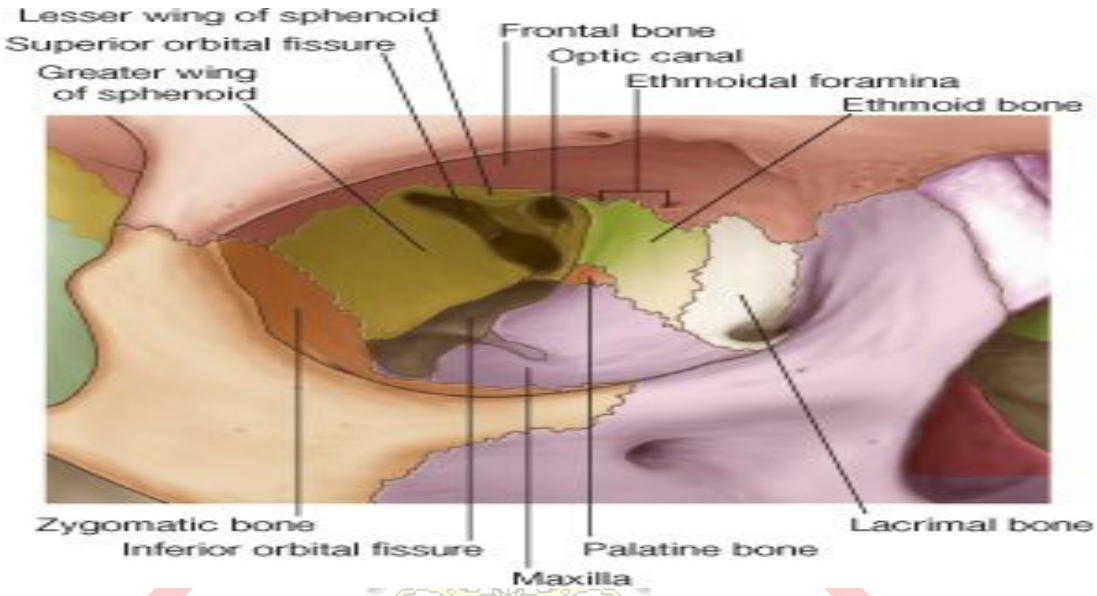


Figure 7: walls of orbit

II. CONTENTS OF THE ORBIT:

1) Fasciae, orbital and bulbar.

2) Muscles:

A) Intrinsic	**B) Extrinsic**
Constrictor papillae	**4** Recti muscles.
Dilator papillae	2 Oblique muscles.
Ciliary muscle	1 Levator palpebrae superioris

3) Blood vessels:

A. Ophthalmic artery.

B. Superior and inferior ophthalmic veins.

C. Infraorbital artery.

4) Nerves:

A. Sensory:

i. Optic nerve.

ii. Branches of ophthalmic nerve.

iii. Branches of maxillary nerve.

B. Motor:

i. Oculomotor nerve **(III)**

ii. Trochlear nerve **(IV)**

iii. Abducent nerve **(VI)**

C. Autonomic:

i. Sympathetic nerves.

ii. Parasympathetic (ciliary ganglion).

5)Eye ball.

6) Fat (orbital fat).

7) Lacrimal apparatus.

1.Orbital Fascia:

A. Orbital fascia (periorbital):

••Forms the periosteum of bony orbit.

••Expansions: At the margins of orbit, it sends off flap–like curtains into the eyelid, called the orbital septum

B. Bulbar Fascia (Fascial Sheath of the Eyeball):

••Forms a thin membranous loose sheath around the eyeball.

••It forms the following expansions:

1. Tubular sheaths covering each orbital muscle.

2. Medial check ligament

3. Lateral check ligament

4. Suspensory ligament of the eyeball: the lower part forms a hammock below the eyeball.

2. Muscles:

A- Extraocular (Fig8):

There are 7 voluntary muscles, 6 muscles that move the eyeball (4 recti +2 obliques) & one (levator) that acts on the upper eye lid.

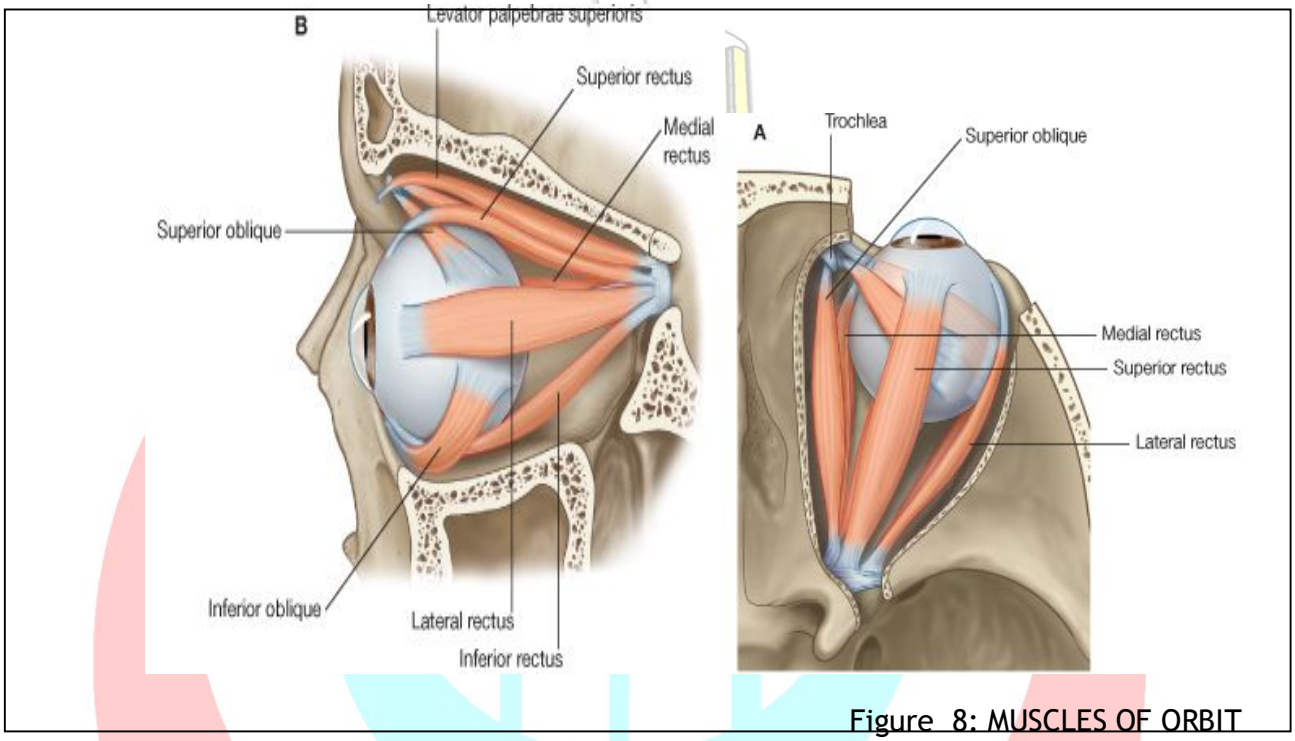


Figure 8: MUSCLES OF ORBIT

a. Recti muscles: Superior rectus (SR), Inferior rectus (IR), Medial rectus (MR) & Lateral rectus (LR).

9. **Origin:** The 4 recti arise from **the common annular tendon** **(common tendinous ring)**

••**Insertion:**

In the sclera in front of the equator of the eyeball, posterior to the limbus

(corneo-scleral junction), by the following average distances: SR, 7.7 mm; IR, 6.5 mm; MR, 5.5 mm; LR, 6.9 mm).

••All the recti form **a muscular cone** around the optic nerve, where the base of the cone is formed by their insertions & the apex is formed by the common tendinous ring.

b. Superior oblique (SO):

10. **Origin**: from the roof of orbit (lesser wing of sphenoid).
11. **Insertion:** into the sclera behind the equator of eyeball.

c. Inferior oblique (IO):

12. **Origin:** from floor of orbit.
13. **Insertion:** into the sclera behind the equator of eyeball.

d. Levator palpebrae superioris (LPS):

14. **Origin**: from orbital surface of lesser wing of sphenoid.
15. **Insertion:** its flat tendon splits into lamella inserted into:
    i. Skin of upper eyelid.
    ii. Superior tarsus (this part is the strongest part & is formed of smooth involuntary muscles & called **Müller's muscle**).
    iii. Superior fornix of conjunctiva.

Nerve Supply of extraocular muscles: (SO4, LR6, otherwise3)

••All the extraocular muscles are supplied by the oculomotor nerve except the superior oblique and lateral rectus where:

A) SR and **LPS** are supplied by the superior division of oculomotor.

B) MR, **IR** and **IO** by the inferior division of oculomotor

••**SO**: by trochlear nerve.

••**LR:** by abducent nerve

••**Note:** Sympathetic fibers supply the **Müller's muscle** (the smooth muscular part of LPS), thus, LPS has **double** nerve supply.

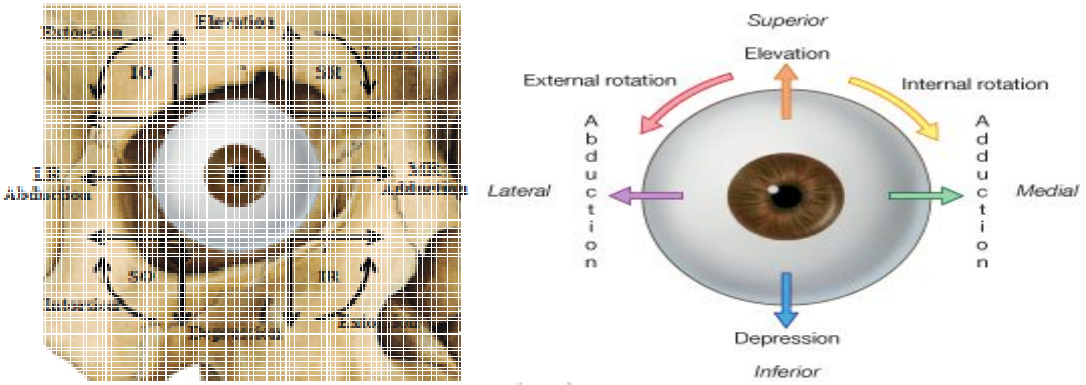


Figure 9: muscles of orbit(actions)

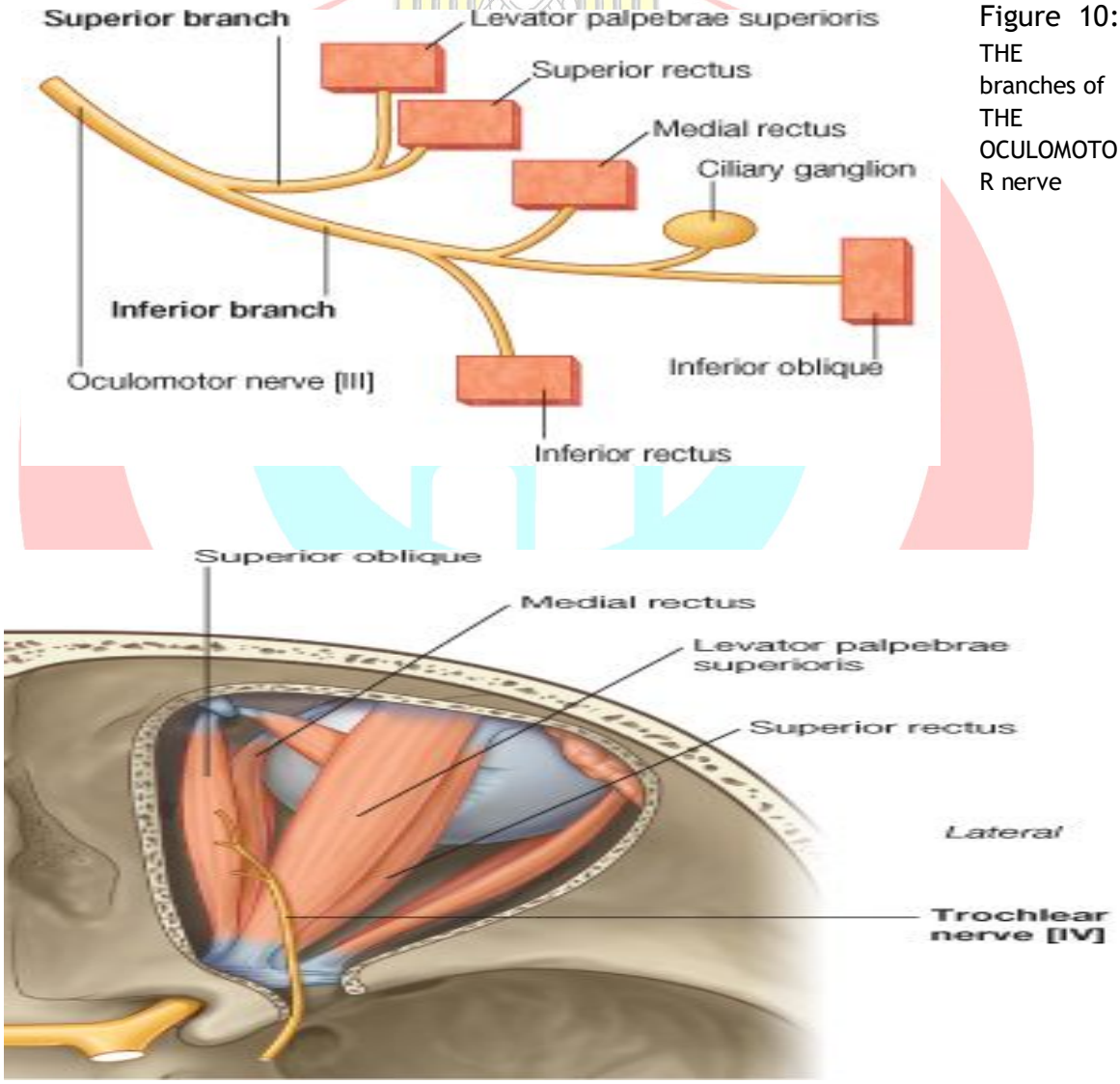


Figure 10: THE branches of THE OCULOMOTOR nerve

Figure 11: Trochlear nerve

Function:

A. Possible movements of the eyeball occur: either in combined or single movements.

B. Actions of each muscle (Fig9):

1. **LPS••**Elevation of the upper eyelid.
2. **MR••**Adduction.
3. **LR••**Abduction.
4. **SR••**Elevation, adduction and intorsion.
5. **IR••**Depression, adduction and extorsion.
6. **SO••**Depression, abduction and intorsion.
7. **IO••**Elevation, abduction and extorsion.

C. Movements of eyeball: (the cornea)

1. Elevation ••combined action of **SR** and **IO**.
2. Depression ••combined action of **IR** and **SO**.
3. Adduction ••**MR alone;** combined action of **SR** and **IR**.
4. Abduction •**LR alone;** combined action of **SO** and **IO**.
5. Intorsion ••combined action of **SO** and **SR**.
6. Extorsion ••combined action of **IO** and **IR**.

B- Intraocular Muscles:

-These muscles are formed of smooth muscle fibers, have involuntary actions and are supplied by autonomic nerves (sympathetic and parasympathetic).

- Include 3 muscles:

1) Constrictor pupillae (parasympathetic)

2) Dilator pupillae (sympathetic)

3) Ciliaris (parasympathetic): Ciliary muscle contraction renders the lens of the eye more convex, thus accommodating for near vision.

3. Vessels of the Orbit (Fig12)

A) Ophthalmic artery:

••**Origin:** a branch of cerebral part of ICA as it emerges from the roof of cavernous sinus.

••**Course & Relations:** It enters the orbit through optic canal, inferolateral to optic nerve (both are enclosed within a common dural sheath).

••**Termination**: Near medial angle of the eye by dividing into supratrochlear & dorsal nasal

••**Branches:**

i. **Central artery of the retina**

- o It arises from ophthalmic artery near optic canal.
- o It divides dichotomously into superior & inferior branches; each divides into temporal & nasal branches to supply retina.
- o The central artery of retina is an example of an end artery, so its occlusion causes complete blindness.
- o It is the only artery that can be seen by the naked eye (during fundus examination).

ii. **Posterior ciliary arteries**: pierce the sclera and supply choroid and iris.

iii. **Muscular branches**, to ocular muscles. They give **anterior ciliary arteries.**

iv. **Lacrimal branch:** to the lacrimal gland.

v. **Medial palpebral arteries:** To the upper and lower eyelids.

vi. **Posterior ethmoidal artery:** supply ethmoidal air sinuses and nasal cavity.

vii. **Anterior ethmoidal artery:** passes through the anterior ethmoidal canal.

viii. **Supraorbital artery:** to reach the forehead and scalp.

ix. **Supratrochlear artery** trochlea to ascend into the forehead and scalp.

x. **Dorsal nasal artery:** other terminal branch, reach the dorsum of the nose to anastomose with the facial artery (anastomoses between the internal & external carotids). supplies the side of the nose and the lacrimal sac.

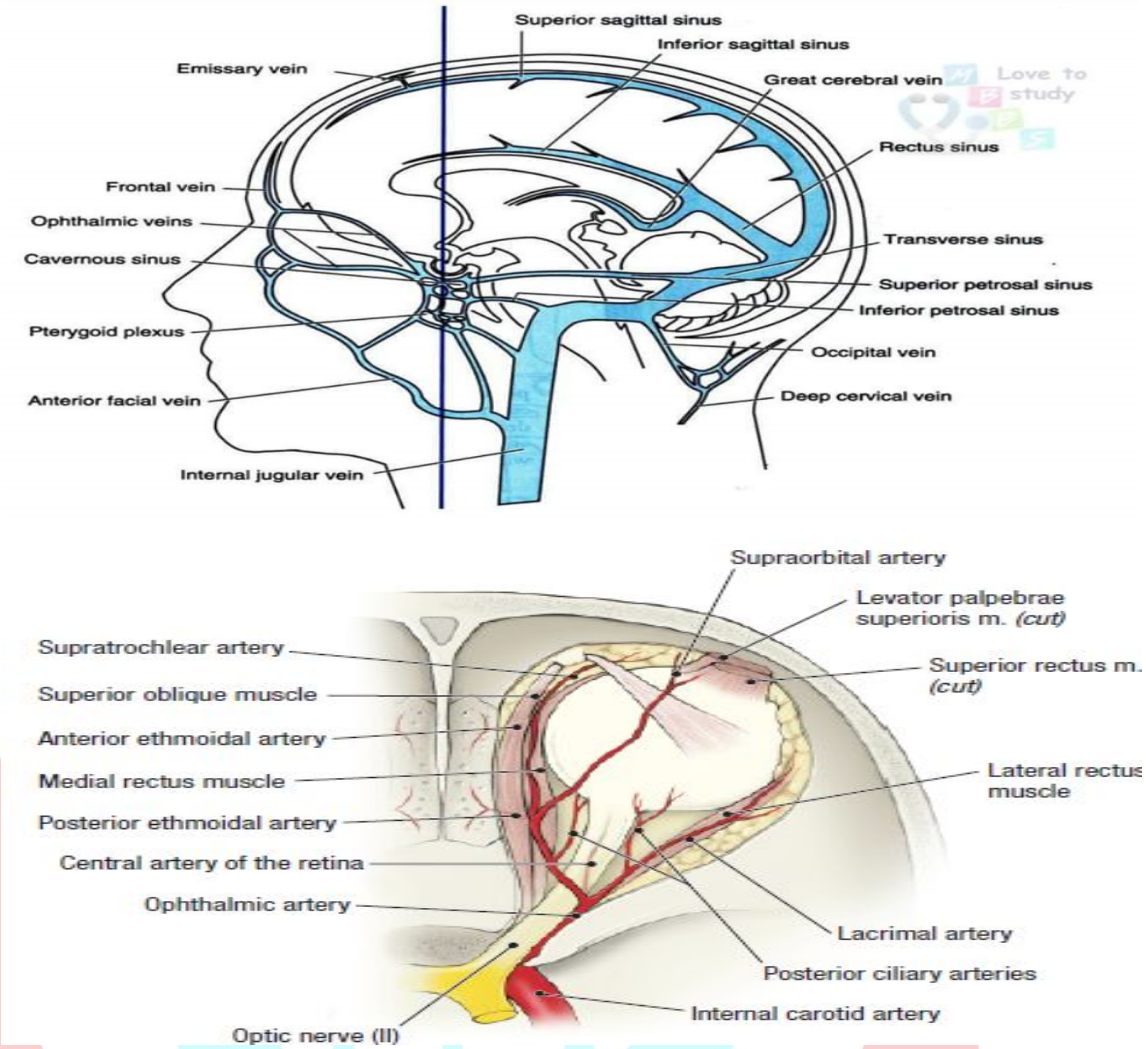


Figure12: vessels of orbit

B. Ophthalmic Veins:

1-Superior ophthalmic vein:

-It accompanies the ophthalmic artery above the optic nerve.

-It receives tributaries corresponding to branches of ophthalmic artery.

-It passes through the superior orbital fissure and drains into the cavernous sinus.

2-Inferior ophthalmic vein:

-It begins from veins in the anterior part of the floor of the orbit.

-It ends either by joining superior ophthalmic vein, or by draining directly into cavernous sinus.

-It communicates with pterygoid plexus of veins by a small vein passing through inferior orbital fissure. ***N.B:*** ***Applied anatomy***: thrombosis of cavernous sinus: It affects Cranial nerves 3,4 and6.

c. Lymphatics of orbit: drain into the pre-auricular (parotid) LN.

4. Nerves of the Orbit:

A- Sensory Nerves of the Orbit:

A. Optic Nerve:

- Course:

••It is the nerve of vision it is made up of axons of cells of the ganglionic

layer of the retina &passes through the optic canal to enter the middle cranial fossa, where it forms the optic chiasma.

••The whole nerve is enclosed in the 3 meningeal sheaths.

- Parts of the optic nerve: Optic nerve is about 40 mm long

i. Intra-orbital part: 25 mm (from the eyeball to the optic canal).

ii. Intra-canalicular part: 5 mm (in the optic canal).

iii. Intra-cranial part: 10 mm (from the optic canal to the optic chiasma).

- Relations:

i. In the orbit:

••Tortuous; to allow free movement of the eyeball.

••Ciliary ganglion lies between the nerve and the tendon of lateral rectus.

ii. In the optic canal.

iii. In the cranial cavity (Fig13)**:** Internal carotid artery lies on its lateral side.

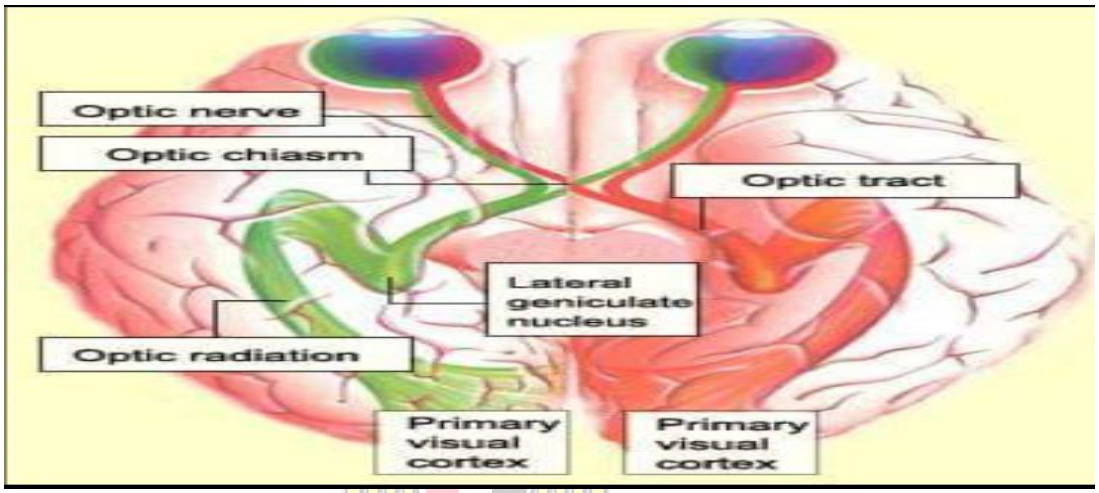


Figure 13: VISUAL PATHWAY

B. Ophthalmic Nerve (V Cranial Nerve: trigeminal nerve)

-It is the **smallest** division of the trigeminal nerve (purely sensory) enter the orbit through the **superior orbital fissure**.

i. Lacrimal nerve:

••The **smallest** branch of ophthalmic nerve.

(this branch contains postganglionic secretomotor fibers to the lacrimal gland, derived from the pterygopalatine ganglion)

••It supplies the lacrimal gland and the lateral part of the upper eyelid.

ii. Frontal nerve:

••The **largest** branch of ophthalmic nerve, branches:

1- Supratrochlear nerve: supplies skin of forehead & upper eye lid

2- Supraorbital nerve: It supplies frontal air sinus and the skin of the forehead and scalp up to the vertex.

iii. Nasociliary nerve:

••The **intermediate** branch of the ophthalmic nerve.

Branches:

1) **Communicating branch to the ciliary ganglion.**

2) **Long ciliary nerves**, (2 or 3 in number), supply sensory nerves to the cornea, iris & ciliary body. They contain motor sympathetic fibers to the dilator pupillae.

3) **Posterior ethmoidal nerve:** supply the ethmoidal and sphenoidal air sinuses.

4) **Anterior ethmoidal nerve:** passes through the anterior ethmoidal foramen to the cranial cavity, it leaves the nasal cavity to supply the skin of the nose as external nasal nerve.

5) **Infratrochlear nerve:** supplies skin of the upper eyelid and the side of nose.

B- Motor Nerves of the Orbit:

A. Oculomotor Nerve (Fig10)**:**

-Intracranial course:

••It runs in the lateral wall of cavernous sinus.

••the nerve divides into superior and inferior divisions.

-Intraorbital course: The two divisions of the nerve enter the orbit through the superior orbital fissure within the common tendinous ring.

i. Superior division, (smaller division) supplies the SR & LPS.

ii. Inferior division, (larger division) supplies MR, IR & IO.

••**N.B.:** Nerve to IO gives a motor (parasympathetic) root to ciliary ganglion supplying sphincter pupillae and ciliaris muscles.

••All branches enter the muscles on their ocular surfaces.

Applied Anatomy: Complete paralysis of the 3rd nerve results in:
(a) Ptosis and lateral squint (b) Loss of accommodation;
(c) Dilatation of the pupil (d) Slight proptosis & diplopia.

B. Trochlear Nerve (Fig11):

-Intracranial course:•It runs forwards in the lateral wall of cavernous sinus.

-Intraorbital course: The nerve enters the orbit through the superior orbital fissure outside the common tendinous ring and passes medially to supply SO muscle, on its upper border.

Applied anatomy: When trochlear n. is damaged, diplopia (double vision) occurs on looking Downwards

-Intracranial course: it runs forwards in the floor of the cavernous sinus.

-Intraorbital course: It enters the orbit through the superior orbital fissure within the common tendinous ring to supply the LR muscle through its ocular surface.

Applied Anatomy: Paralysis of the abducent nerve results in:

(i) Medial (internal) squint. (ii) Diplopia.

C- Autonomic Nerves in the Orbit:

a. Parasympathetic to sphincter pupillae & ciliaris muscle

b. Sympathetic fibers to dilator pupillae and levator palpebrae superior

c. Secretomotor fibers to lacrimal gland.

Ciliary Ganglion (Fig14)**:**

-A peripheral parasympathetic ganglion Situated behind the eye ball.

-Site: Near the apex of the orbit, between optic nerve and LR muscle.

- 3 Roots:

i. Motor (parasympathetic) root (arises from the nerve to the IO muscle)**:**

to supply the sphincter pupillae and ciliaris muscles.

ii. Sensory root: a branch from the nasociliary nerve.

iii. Sympathetic root (A branch from the internal carotid plexus):

supply blood vessels of the eyeball and may also supply dilator pupillae muscle.

NB: the 2 long ciliary nerves (of nasociliary) carry sympathetic fibers to the dilator pupillae.

-Branches:

8-10 Short ciliary nerves

i. Efferent postganglionic parasympathetic fibers to sphincter pupillae and ciliaris.

ii. Efferent postganglionic sympathetic fibers to the blood vessels of the eyeball.

iii. Afferent sensory fibers from eyeball.

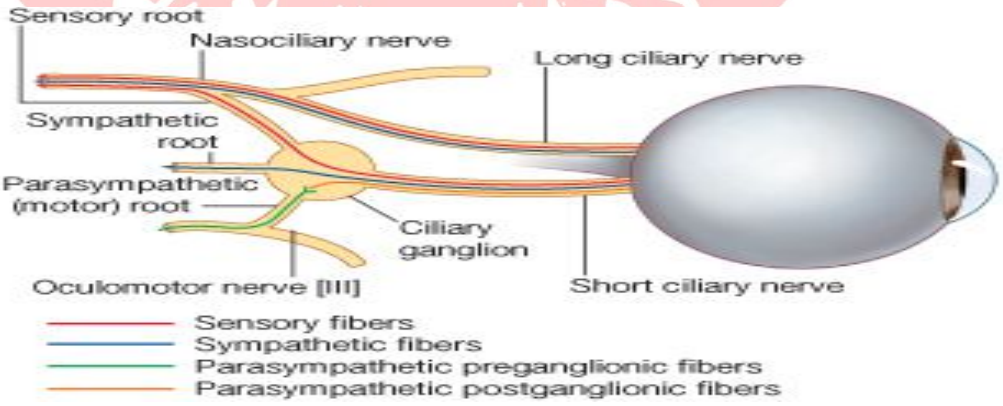


Figure 14: CILIARY ganglion

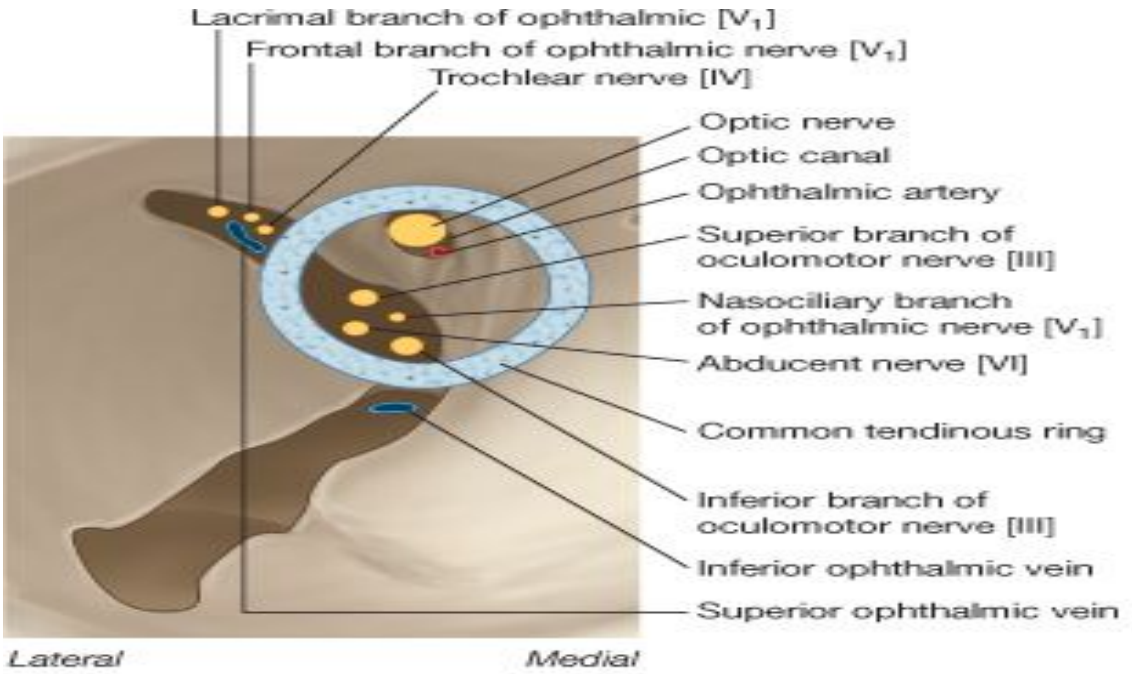


Figure 15: Common Tendinous ring

N.B: 1. NAME STUCTURES inside and outside COMMON TENDINOUS RING.

2.list Muscles in the orbit and its nerve supply.

3.Discuss the orbital and ocular vessels in the orbit.

5. The Eyeball: Its Wall has three layers

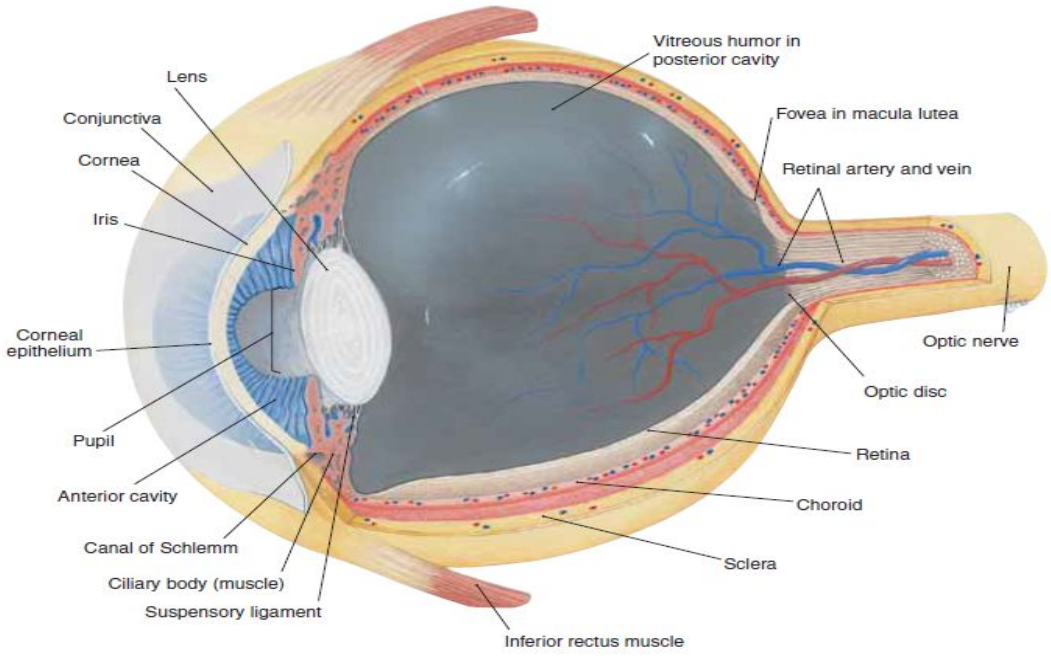


Figure 16: eyeball

External white fibrous coat (Fig16)**:**

1. **Sclera:** is a tough white fibrous tunic enveloping the posterior five_six of the eye.
2. **Cornea**: It is a transparent structure forming the anterior one_six of the external coat. The cornea has no capillaries, covers the iris and pupil inside the eye.

Middle vascular pigmented coat: consists of the choroid, ciliary body and iris.

Specialized structures:

1. **Choroid**
2. **Ciliary body**: (muscle) is a circular muscle that surrounds the edge of the lens and is connected to the lens by **suspensory ligaments**. The **lens** is made of a transparent, elastic protein
3. **Iris:** the colored part of the eye, it is formed of smooth muscle fibers in the iris change the diameter of the **pupil**, the central opening. Contraction of the radial fibers dilates the pupil; this is a sympathetic response. Contraction of the circular fibers constricts the pupil; this is a parasympathetic response (oculomotor nerves). Pupillary constriction is a reflex that protects the retina from intense light or that permits more acute near vision, as when reading.

Internal nervous coat: the posterior two-thirds of the eyeball and contains the visual receptors, the rods and cones. The **fovea centralis**, which contains only cones, is a small depression in the Macula

(yellow spot or macula lutea)) and is the area for best color vision. N.B. **OPTIC DISK (BLIND SPOT**): consists of optic nerve fibers formed by axons of the ganglionic cells.

Cavities of the Eyeball

There are two cavities within the eye:

The **posterior cavity** is found between the lens and retina and contains **vitreous humor** (or vitreous body). This semisolid substance keeps the retina in place. If the eyeball is punctured and vitreous humor is lost, the retina may fall away from the choroid; this is one possible cause of a **detached retina**.

The **anterior cavity** is found between the back of the cornea and the front of the lens, and contains **aqueous humor**, the tissue fluid of the eyeball. the lens and cornea have no capillaries; they are nourished by the continuous flow of aqueous humor.

N.B: 1.Compare between anterior chamber and posterior chamber of the Eye.
2.Name layers of the Eye ball. ***3.list contents of the Eye ball.***

Chapter 3

Lacrimal Apparatus and Eye lid

Objectives

AT THE END OF THE COURSE STUDENTS SHOULD BE ABLE TO:

1. DESCRIBE THE LAYERS COMPOSING THE EYE LID.

2. Define the Nerve supply of the lacrimal gland.

3. Discuss the anatomy of the lacrimal apparatus.

Lacrimal Apparatus

It is made up of the following **parts:**

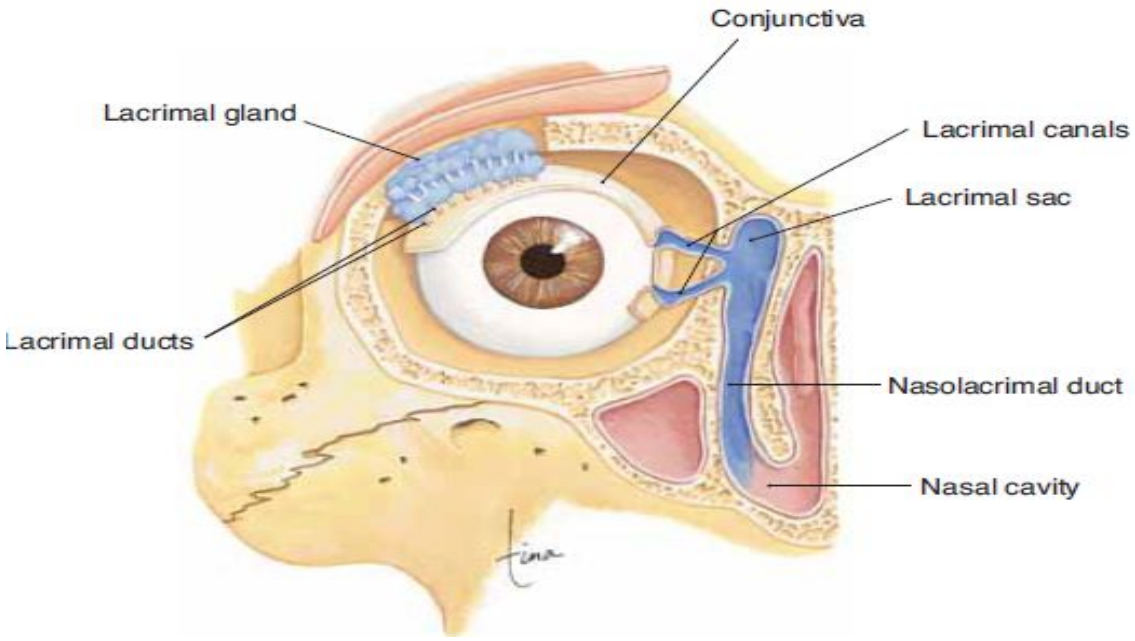


Figure17: lacrimal Apparatus

3. Lacrimal gland (Fig17-18):

••**Site**: mainly in the lacrimal fossa.

••**2 Parts:**

i. **Orbital part** ••larger and deeper, in lacrimal fossa.

ii. **Palpebral part** ••smaller and superficial, in the upper eyelid.

••**N.B.:** Small **accessory lacrimal glands** are found in conjunctival fornices.

••**Ducts**: About 12 of its ducts pierce conjunctiva of upper lid and open into conjunctival sac near its upper fornix.

••**Arterial supply**: by lacrimal branch of ophthalmic artery.

••**Nerve supply**:

i. The lacrimal nerve contains both sensory and secretomotor fibers.

ii. **Secretomotor fibers** begins in the special lacrimatory nucleus ••Preganglionic parasympathetic fibers ••**relay** in pterygopalatine ganglion ••Postganglionic parasympathetic fibers ••zygomatico-temporal nerve •• to lacrimal nerve ••lacrimal gland.

••**Function**: Lacrimal fluid flows into the conjunctival sac where it lubricates the front of the eye and deep surface of lids, helped by blinking (orbicularis oculi). When excessive, it overflows as **tears** from the medial angle of the palpebral fissure.

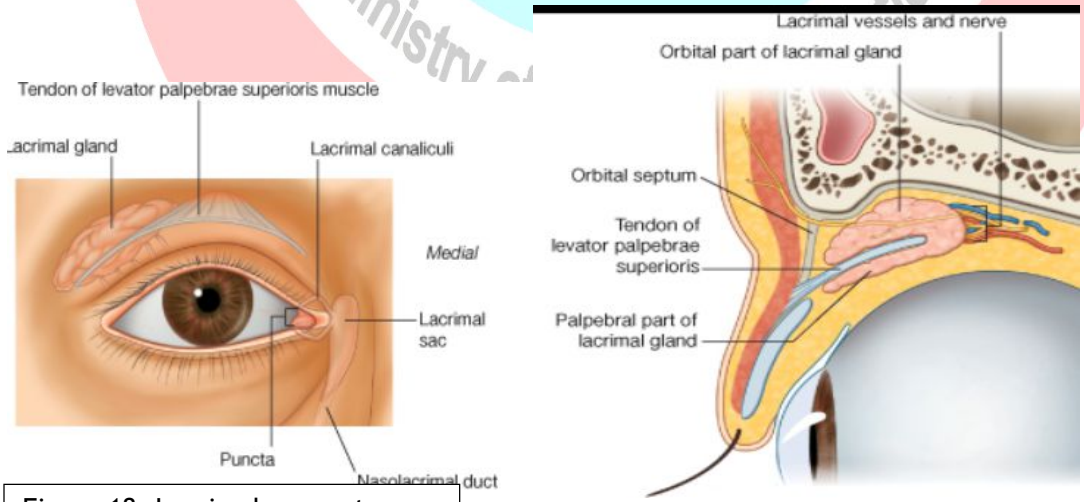


Figure 18: Lacrimal apparatus

B. Conjunctival sac:

••Conjunctiva is a mucous membrane that lines the deep surface of eyelids (**palpebral conjunctiva**) and the front of eyeball (**bulbar conjunctiva**).

••The potential space between the palpebral and bulbar parts is the **conjunctival sac** that opens out at the **palpebral fissure**.

••The line of reflection between the two parts forms the **superior** and **inferior fornices**.

••It forms a closed sac when both eyelids are closed.

C. Lacrimal puncti and canaliculi:

They are minute openings present on the medial end of the lid margin. Each punctum leads to a lacrimal canaliculus that opens into lacrimal sac.

D. Lacrimal sac: is the upper dilated end of the nasolacrimal duct.

4. **Nasolacrimal duct:** at the lower end of the lacrimal sac and runs downward in a bone canal to open into the inferior meatus of the nose.

Eyelids

••**Structure:** Each eyelid is made up of the following layers

A. **Skin** is thin.

B. **Superficial fascia:** loose areolar connective tissue containing the palpebral part of orbicularis oculi without fat.

C. **Palpebral fascia** of the two lids forms **orbital septum**. Its thickenings form tarsal plates (tarsi) in the lids and palpebral ligaments at the angles. Tarsi are thin plates near the lid margins that stiffen them. They contain tarsal (sebaceous) glands.

D. **Conjunctiva** lines the posterior surface of the tarsus.

••**Special features of the upper eyelid:**

A. It is larger and more movable.

B. Upper tarsal plate is larger and more rigid than lower one.

••**Blood supply:**

A. **Arterial supply by:**

i) Medial palpebral branches of ophthalmic artery.

ii) Lateral palpebral branch of lacrimal artery

B. **Venous drainage into:** ophthalmic and facial veins.

••**Nerve supply:**

A. **Upper eyelid** by**:** branches of ophthalmic nerve.

B. **Lower eyelid** by**:** branches of infraorbital nerve.

••**Lymphatic drainage:**

A. Medial halves of lids drain into the submandibular nodes.

B. Lateral halves into the preauricular nodes.

Chapter 4

Congenital anomalies

Objectives

At the end of the course the student will be able to identify congenital anomalies.

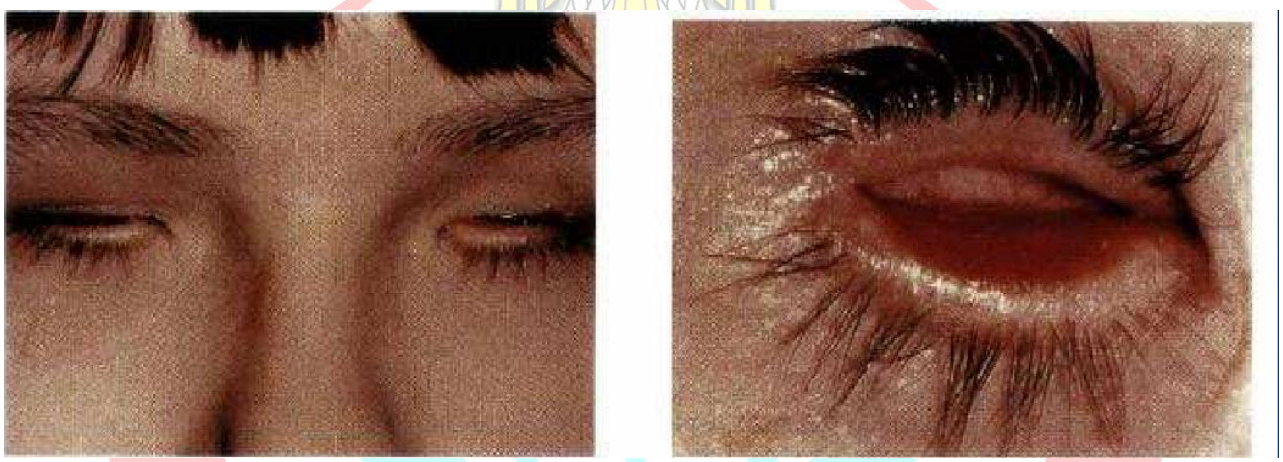


Figure 19: ANOPTHALMOS

Figure 20: Cystic Eye

Figure 21: Micropthalmos

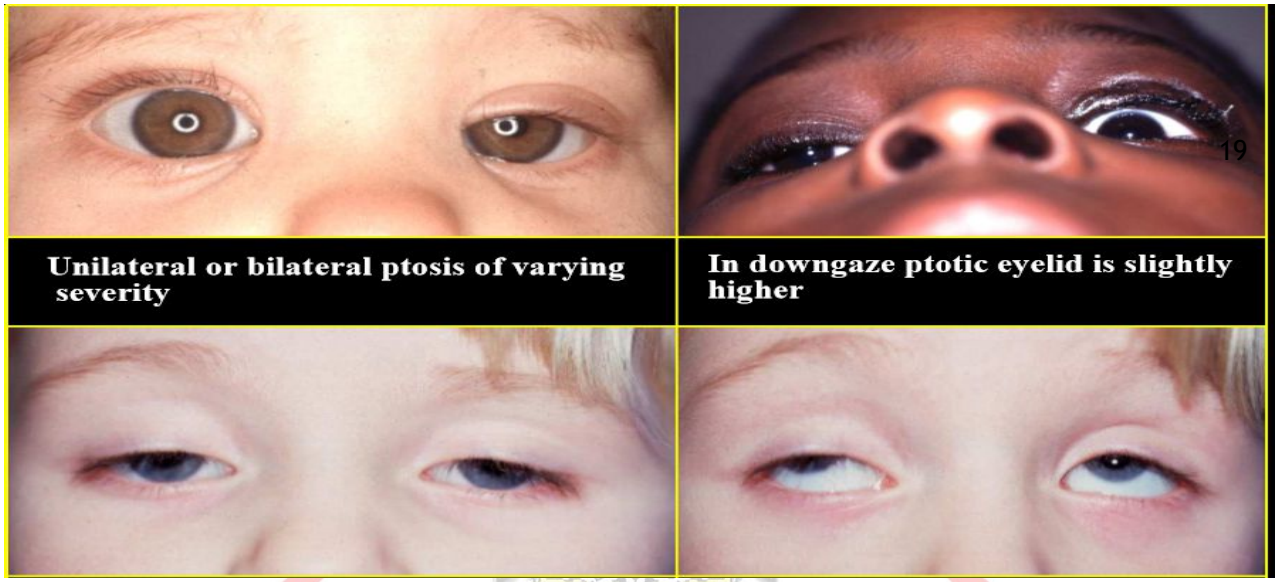


Figure 22 Congenital ptosis

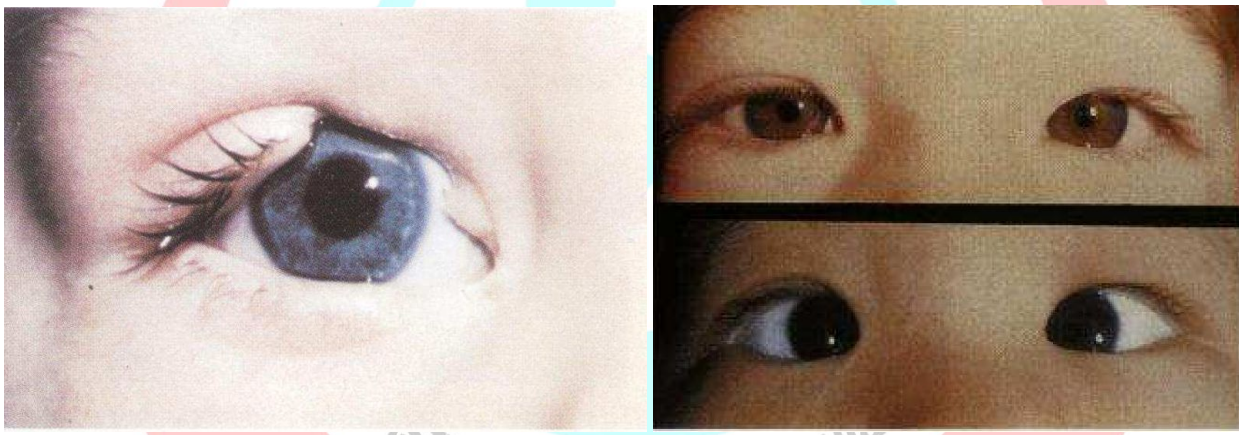


Figure 23 : coloboma

Figure 21: Epicanthus

REFERENCES AND RECOMMENDED READINGS:

16. **Gray' s anatomy for students,2nd edition,2011, Darke R . et al.**
17. **ATLAS OF HUMAN anatomy (Netter)**

Recomended books: Clinical Anatomy by Regions, 9th edition, 2011, Snell RS

18. Last's Anatomy: Regional and Applied, 12th edition, 2011. Sinnatamby CS.
19. Langman's Medical Embryology, 12th edition.

PART II
Physiology

Physiology Course Description

This course will introduce the basic structure and function of the visual system. This involves acquiring detailed knowledge, and understanding of the human eye in health and disease. Students will learn about basic concepts of neural processing of information as well as the skills to examine the eye.

Core Knowledge

By the end of this course, students should be able to:

- Describe the general and basic structure of the orbit of the human body .
- Describe the sequence of events taking place during early prenatal development of the human embryo or common causes of congenital malformations
- Discuss the anatomical features of any structure (fascia, regions, muscles, vessels, nerves) of the orbit.
- Describe the developmental process and/or congenital anomalies of the eye.
- Explain the physiological basis of how the components of the visual system operate to set up conscious visual images.
- Identify the various parts of the eye and outline the functions of each.
- Describe the pathophysiology of glaucoma, cataract, and errors of refraction.
- Recognize how to assess the visual acuity, determine and correct errors of refraction. Evaluate the field of vision, eye movement, color vision, and fundus of the eye.

Core Skills

By the end of this course, students should be able to:

- Use reasoning in solving clinical problems related to the eye based on anatomical knowledge.
- Enumerate the protective mechanisms of the eye.
- Summarize how light rays are brought to a focus on the retina.
- Give a brief idea about corneal function, nutrition, hydration, transparency, and list causes of corneal transparency.

- Demonstrate aqueous humor formation and drainage, and explain its role in maintaining intraocular pressure as well as in glaucoma.
- Recognize the function of iris, and list causes of miosis and mydriasis.

- Describe lens function and outline the causes of cataract.
- Understand the role of accommodation in light refraction.
- Differentiate hyperopia, myopia, astigmatism, and presbyopia.
- Identify Retinal layers and write a brief idea about photoreceptors.
- Explain dark and light adaptation.
- Describe the visual pathways that convey visual signals from the retina to the visual cortex.
- Identify the physiological and neurological basis of color vision. List causes and types of color blindness.
- Demonstrate the field of vision, binocular vision.
- Identify marked bony features or attachments on real bones or projected pictures of bones of the skull.
- Identify marked structures (e.g., muscles, vessels, nerves, ligaments, viscera … etc.) in the orbit in dissected cadavers, plastic models or projected pictures.
- Assess the visual acuity.
- Perform fundus examination and determine myopia and hypermetropia.
- Examine the field of vision and determine field defects.
- Assess the integrity of accommodation and light neural pathways.
- Evaluate color vision.

Chapter 5

A) Functional eye structure

B) Corneal physiology

Objectives

- Describe the functional structure of the eye.
- Recognize the protective mechanisms of the eye.
- Understand principles of light refraction and image formation on retina
- Give a brief idea about corneal function, nutrition, hydration, transparency, and list causes of corneal opacity.

Overview

- The eyes are complex sense organs.
- The visual system performs 2 major steps:
  - focus the light rays (light refraction) on the retina
  - Then the retina converts electromagnetic light waves reflected from the objects to nerve impulses that reach our brain.
- Brain can describe the size, shape and site of the object.
- Brain can detect the speed and the direction of moving objects
- Brain uses this information to learn and to keep body balance.

A) Functional structure of the eye

I-Eye has 3layers:

Outer fibrous protective, middle vascular, inner neural layer

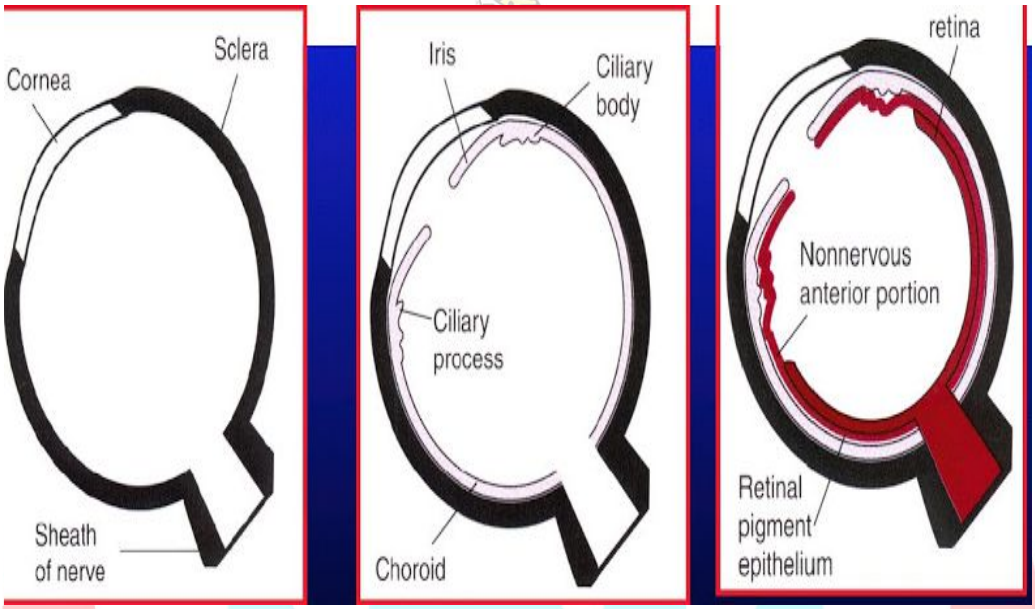


Figure (8.1): **The 3 layers of the eye**

1- ***The outer fibrous protective layer:***

- The posterior part is called **Sclera**: **hard** to protect the eye
- The anterior part is called **cornea**: **transparent** to allow light rays entry

2- ***The middle vascular layer*****:**

a) The *posterior part: is called the* ***choroid****:*

- has many blood vessels to provide **nutrition** to the retina
- **Pigmented** to **absorb excess light** and **prevent blurring of vision.**

b) The *anterior part:* is formed of the

- **The ciliary body** that **suspend the lens**
- **Iris:** formed of **muscles** that surround a **hole** called **pupil. Iris control amount of light** entering eye ball.

3- ***The inner neural layer***:

The retina that contain the **receptors;** which are certain cells that have the ability to **convert light energy to nerve impulses** to be carried to the brain **through the optic nerve.**

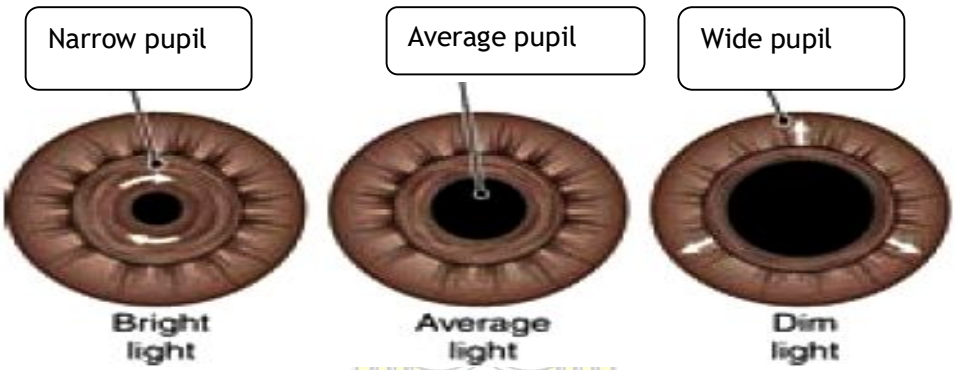


Figure (8.2): **Iris muscles controlling pupil size**

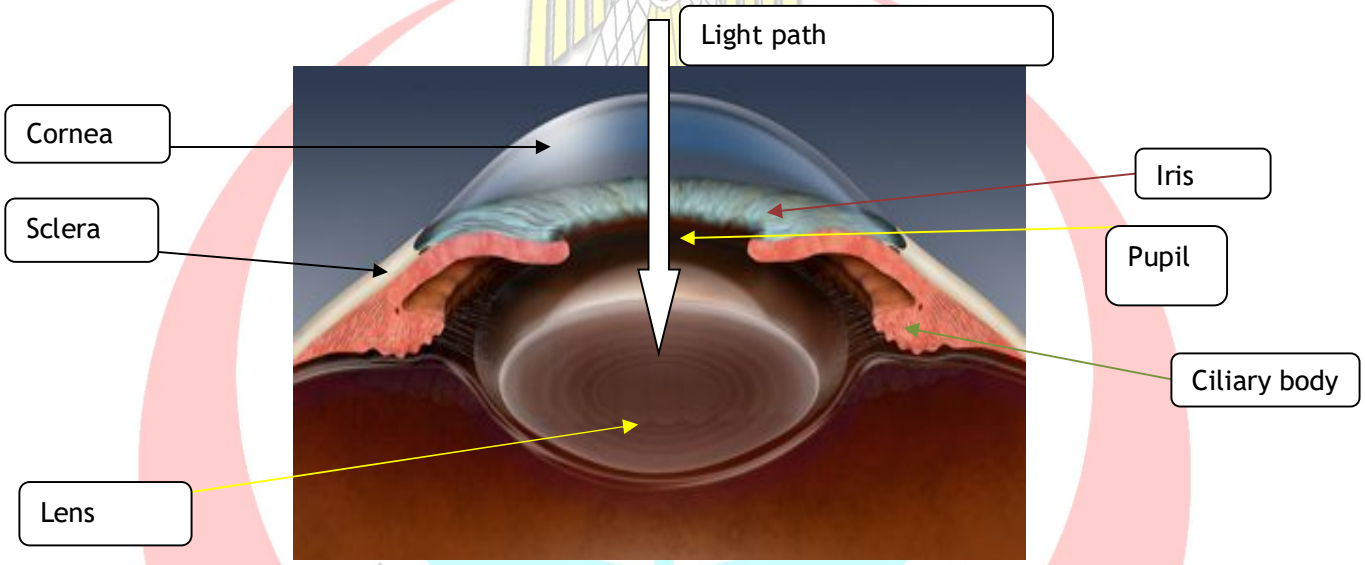


Figure (8.3): **Anterior eye segment, ciliary body holding the lens**

- Both cornea and lens **refract light** rays and **focus** the light on the retina.
- The space between lens and cornea is filled with a transparent, watery fluid called the **Aqueous humor**
- The space between the lens and the retina is filled with **vitreous body** which is a jelly-like substance that keeps the **spherical shape of the eye**.

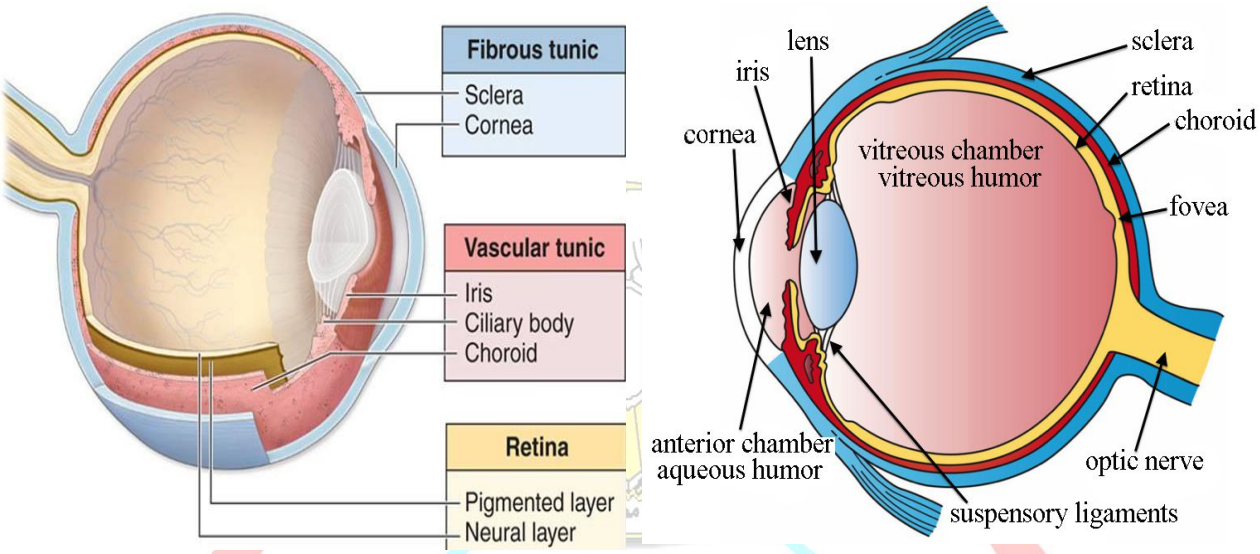


Figure (8.4): **The eye structure**

II- The eyes are protected by several mechanisms:

1- Anatomical position:

-Anterior 1/6 is protected by the eye lids that can cover the eye.

- Posterior 5/6 is protected by the strong bony orbit

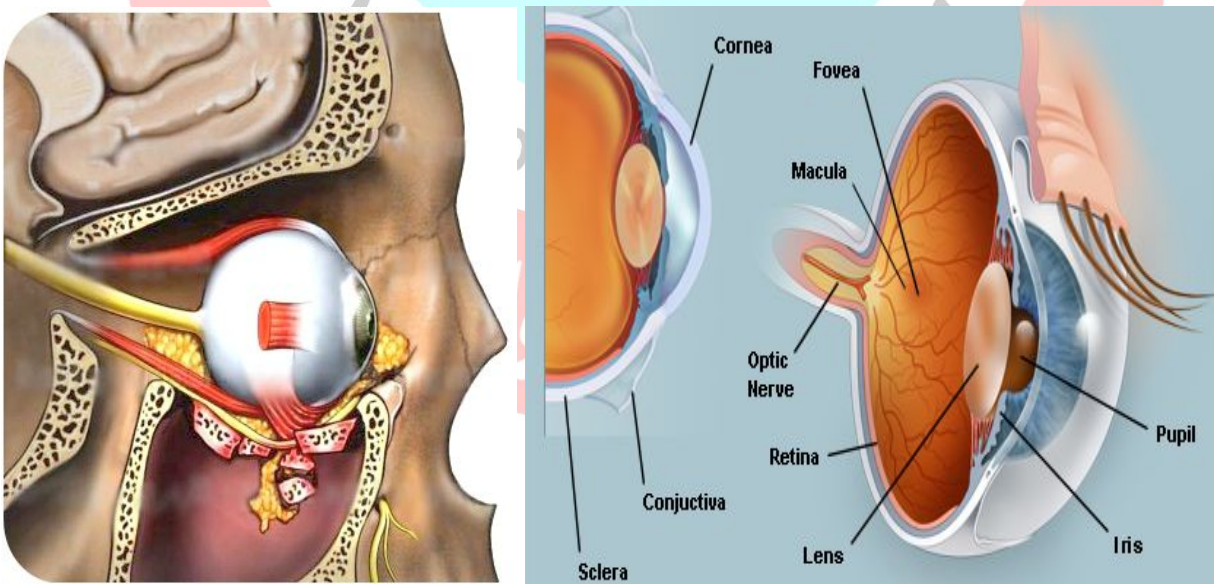


Figure (8.5): **The eye ball inside the skull, covered by the eyelids**

2-Protective corneal reflex:

Bilateral blinking (Rapid reflex closure of eye) on touching cornea.

- Reflex means: a response to a stimulus
- Reflex depends on: Nerves *carrying the stimulus* to brain
- then brain *send response orders* to the eye through other nerves

	Corneal reflex:
Stimuli	**Touching cornea**
Response	Eye closure 

Figure (8.6): **corneal reflex**

3-Tear film

- Secreted from lacrimal gland
- Moistens and protects the cornea and gives the eye luster.

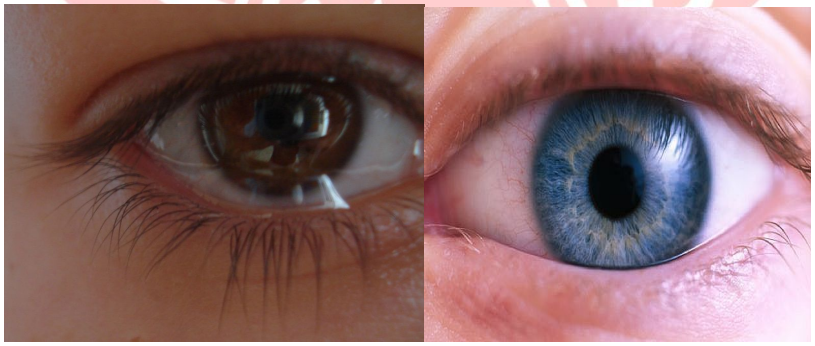


Figure (8.7): **a-tear film, b- Dry eye with no luster, dehydrated cornea**

The visual system performs 2 major steps:

- Focus the light rays (light refraction) on the retina
- Then the retina converts electromagnetic light waves reflected from the objects to nerve impulses that reach our brain.

B) Refraction in the eye

- **The wave length of visible light ranges from 400 -700 nanometer**

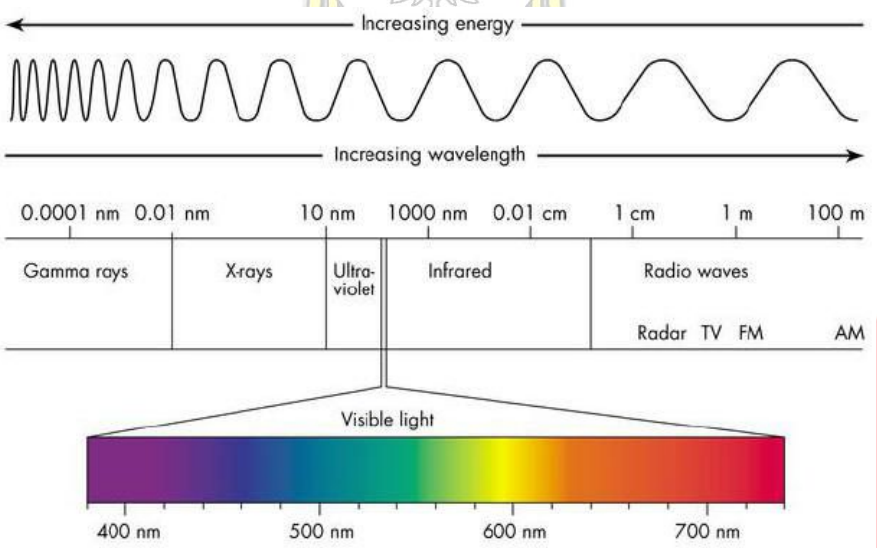


Figure (8.8): **visible spectrum**

1. Light waves normally travel in a straight line.
2. If light passes from air (velocity=300,000 Km /sec) to a denser medium(glass), it is refracted towards the perpendicular line

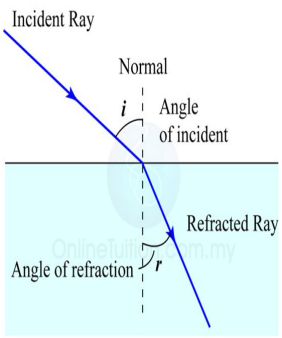


Figure (8.9): **refracted light ray**

3. The degree of refraction depends on:

A- <u>The Refractive index:</u>

➢ The difference between the densities of the two media as indicated by their refractive index.

Refractive index= Light velocity in air/ Light velocity in medium

➢ Light rays pass from the **cornea** to **aqueous humor** then through the **pupil** to the **lens** to **vitreous humor.**

Refractive indicies	
Cornea	1.38
Aqueous humor	1.33
Crystalline lens	1.4 Its center has greater refractive index than peripheral parts
Vitreous humor	1.34

- **Since the greatest difference in refractive index occurs at the air-cornea interface, so the light is refracted mostly at the cornea**

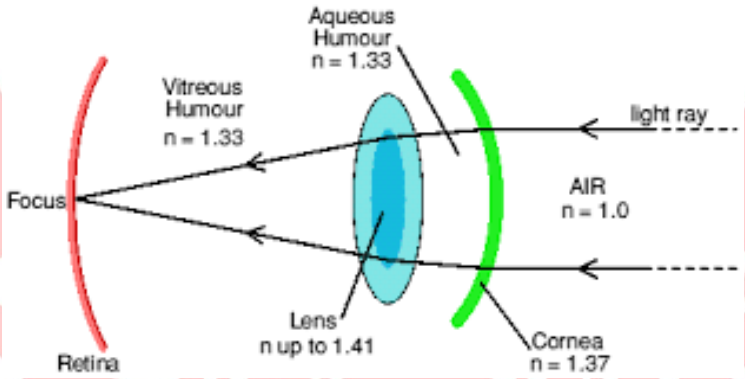


Figure (8.10): **Light refraction in different eye parts**

B- <u>The interface curvature:</u>

➢ The curvature of the cornea is constant, but the curvature of the lens can be varied because its capsule is attached to the ciliary body (ciliary muscles). So refractive properties of the **lens can thus provide fine control for focusing light on the retina.**

- The Refractive power (measured in diopters) is greatest when the curvature of a lens is greatest.

4- **What is the Diopter?**

It is the unit of power of lenses= 1/focal length in **meter**

Focal length: distance between center of the lens (nodal point) and the focal point.

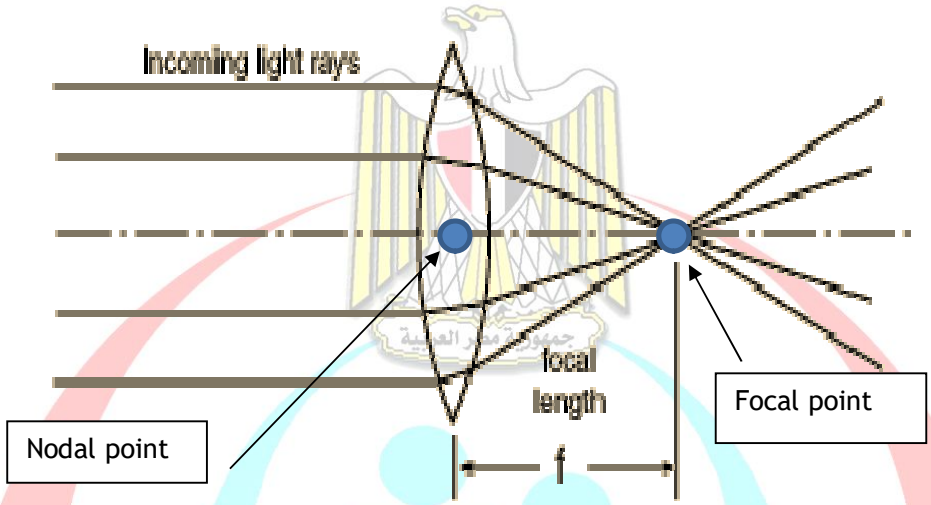


Figure (8.11): **eye focal length**

- Focal length is the distance between the retina and the lens=17 mm
- Total refractive power of the eye=60D
- The power of the cornea = +42 D.
- The power of the lens = +18 D.

5- **Eye axis:**

Optic axis: Line from the center of cornea to posterior pole of the eye

Visual axis: Line from the nodal point of the eye to the fovea (focus on the retina)

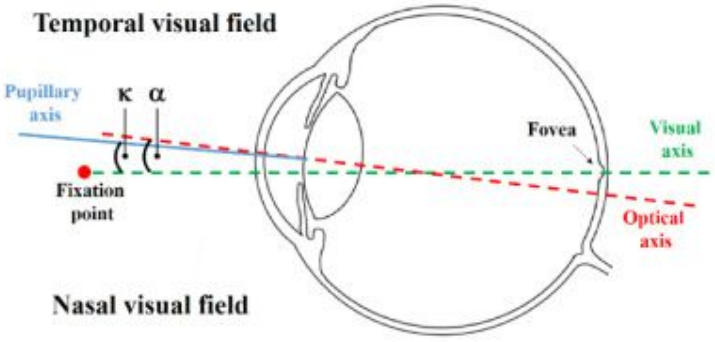


Figure (8.12): **eye axis**

6- The image is formed on the retina inverted

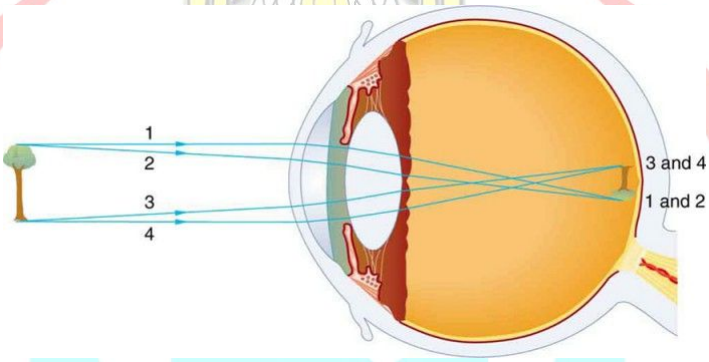


Figure (8.13): **Inverted image on the retina**

c) Outer eye coat physiology

- Outer eye coat is formed of the Cornea, sclera

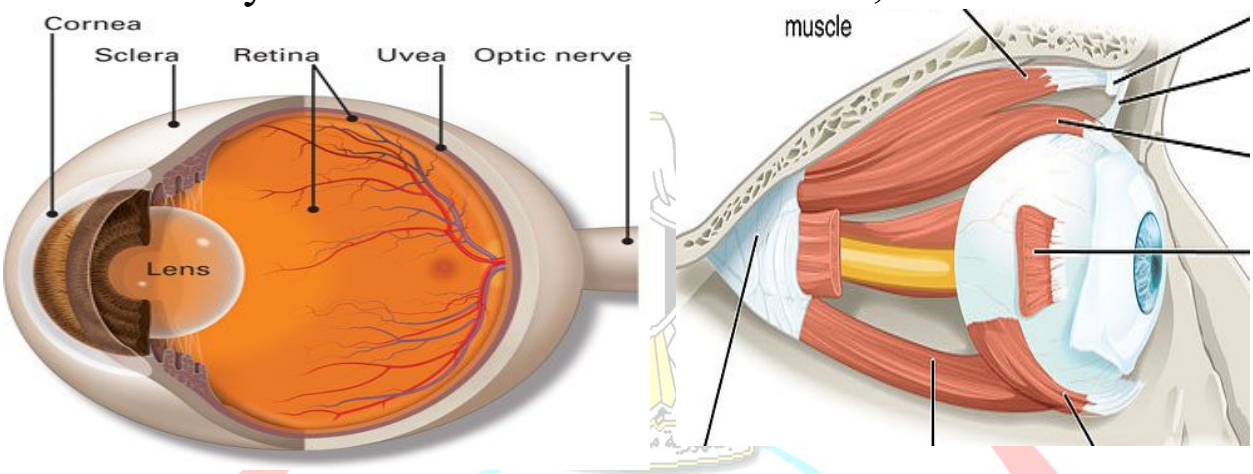


Figure (8.8): **the outer eye coat**

I-Sclera:

Hard fibrous layer, protects the eye and gives origin to the eye muscles

II- Cornea:

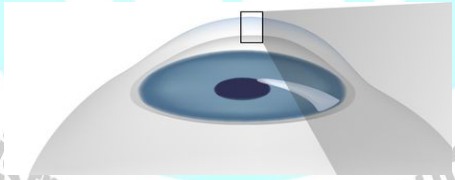


Figure (8.9): **the transparent cornea**

A-Corneal properties:

1- Transparent: allow light entry

2-Regular curvature:

It has 2/3 Refractive eye power (42 D) and form sharp retinal images.

3-Protective function: by absorbing ultraviolet rays and by corneal reflex.

Why most of the eye diopteric power is caused by the cornea?

- **Most light refraction occurs at air-cornea interface, but the lens is surrounded by aqueous humor and vitreous humor with nearly equal refractive index**

B-Causes of corneal transparency:

1- Tissues are arranged regularly

2- No vessels

3- Thin nerves

4- Corneal dehydration due to the presence of a pump that transport the water out of the cornea

- **Corneal nutrition comes from aqueous humor and tear film**.
- Corneal injury can lead to **corneal opacity**

Figure (8.10): **corneal opacity**

Chapter 6

Middle eye layer A) Aqueous humor physiology B) Iris physiology and light reflex

Objectives

- Identify functions of ciliary body
- Identify the physiological and clinical importance of aqueous humor
- Recognize functions of iris
- Interpret the light reflex components and importance

Middle eye layer

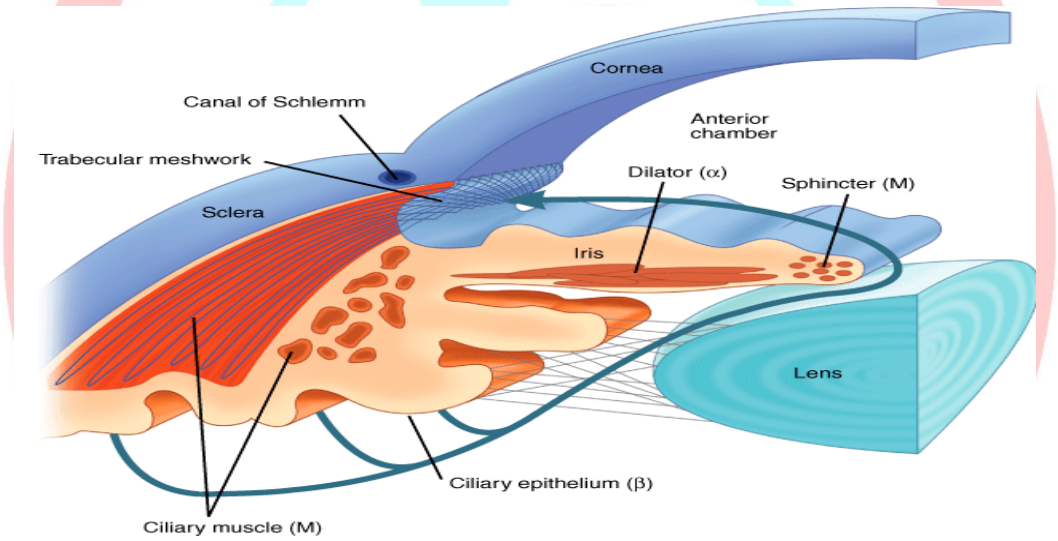


Figure (9.1): **The anterior part of the middle eye layer**

➢ The middle eye layer is formed of 3 parts: choroid, ciliary body and the iris

Functions of ciliary body:

1- Ciliary processes that secrete aqueous humor
2- Suspend the lens
3- Ciliary muscles: change the lens convexity because they are connected to the lens capsule by ligaments.

A) Aqueous humor

What is aqueous humor ?

It is the clear watery transparent fluid that fills the space between the cornea and the lens.

- It is secreted by the ciliary process and is drained through an angle between the cornea and the iris.

Aqueous humor importance

1-It maintains the normal pressure inside the eye (10 - 24 mmHg).

2-It supplies nutrition and drainage of waste products to avascular structures of the eye (cornea & lens).

3-It acts as a refractive medium

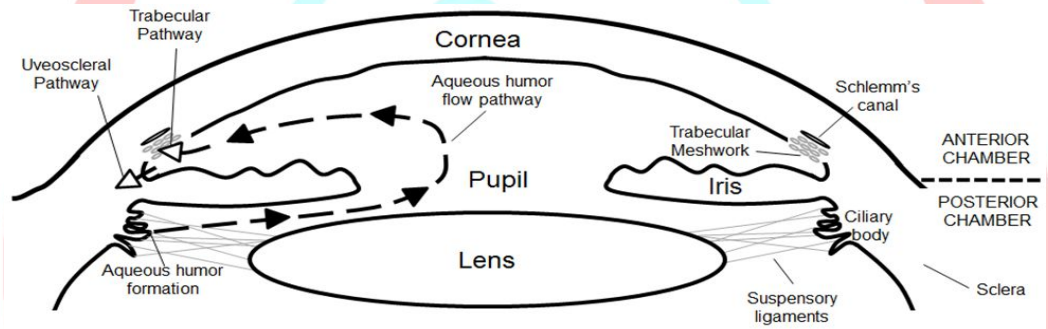


Figure (9.2): **Aqueous humor circulation**

Clinical point:

-Glaucoma: This is increased eye pressure that will destroy eye neural layer and cause pain and blindness.

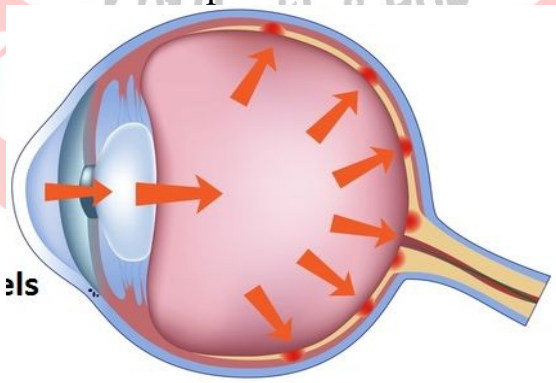


Figure (9.3): **Increased eye pressure**

B) Iris physiology

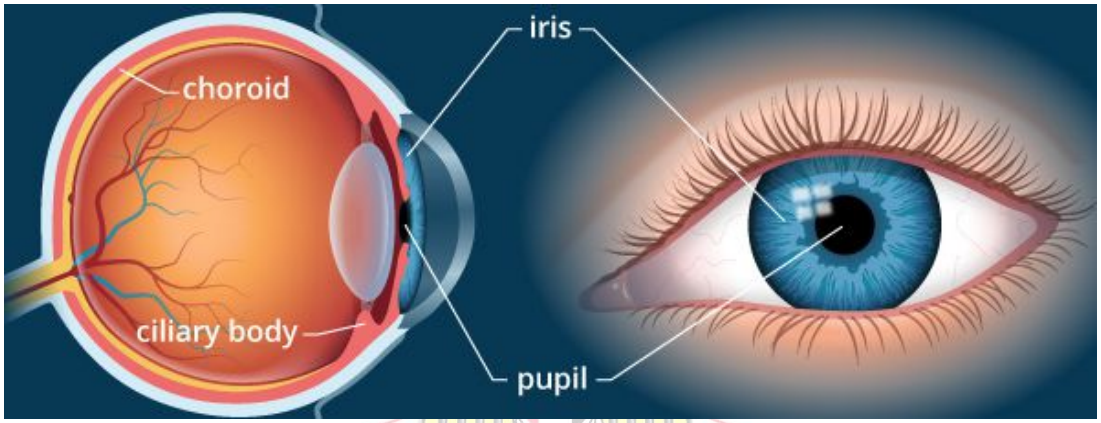


Figure (9.4): **The iris surrounding the pupil**

- Circular **muscular pigmented** disc with a **hole** in its center called the Pupil

Functions of the iris:

1 - Gives the eye its **color** according to the amount of **melanin pigments** in them. Blue eyes have the least pigment and black eyes have the greatest pigments

Albinism: Congenital absence of melanin pigment in all parts of the body

- **Complain:** weak vision as a result of reflection of light in all directions.

Figure (9.5): **blue iris, brown iris and iris of albino patient**

2-Control pupil size:

- Iris is formed of 2 muscles. Muscles are supplied by certain nerves.
- In bright light : the circular muscles contract to narrow pupil (miosis)to limit the amount of light entering the eye (protection)
- In dim light: The radial muscle contract (mydriasis) to dilate pupil to allow as much as possible light to enter.

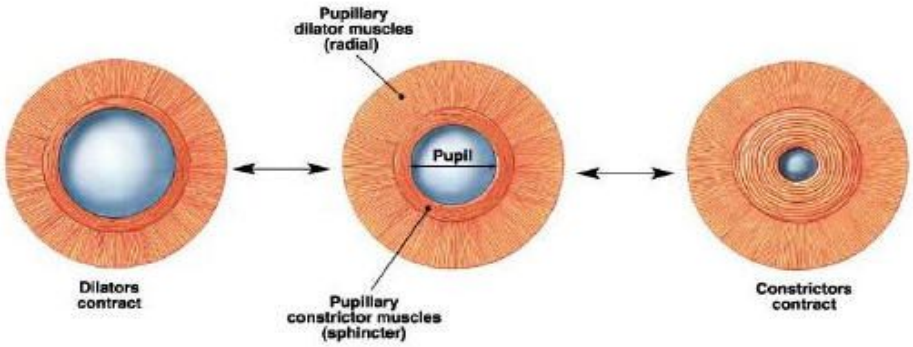


Figure (9.6): **Iris controlling pupil size**

What is the importance of controlling pupil size?

1- It regulates the amount of light entering to the retina

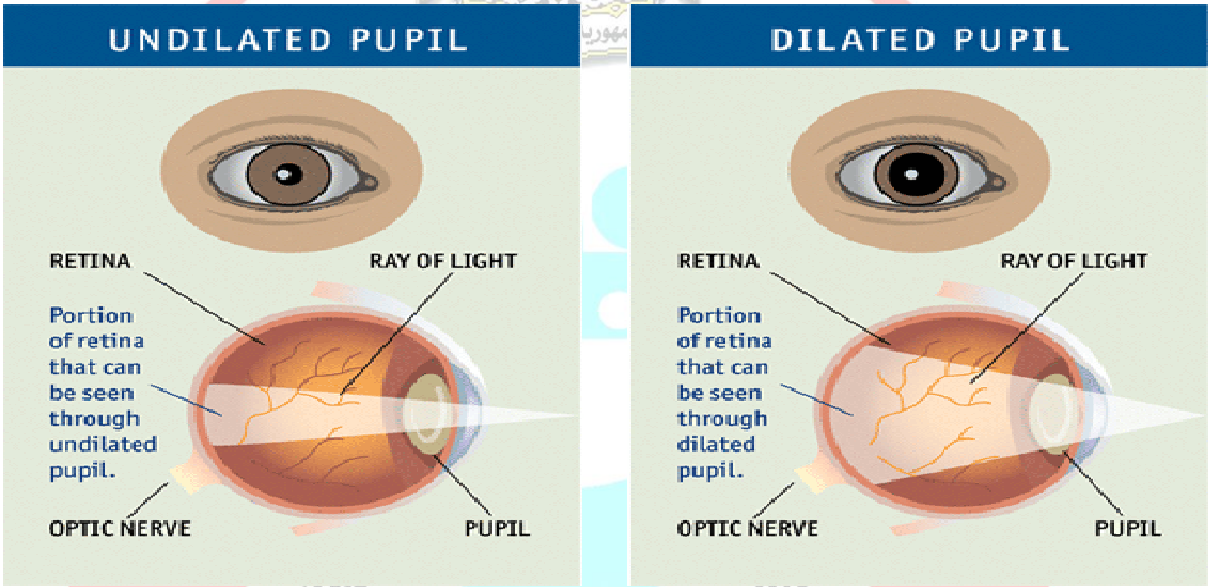


Figure (9.7): **pupil size control amount of light entering the eye**

2-It prevents light passage through the peripheral parts of the lens, thus prevents spherical and chromatic aberrations.

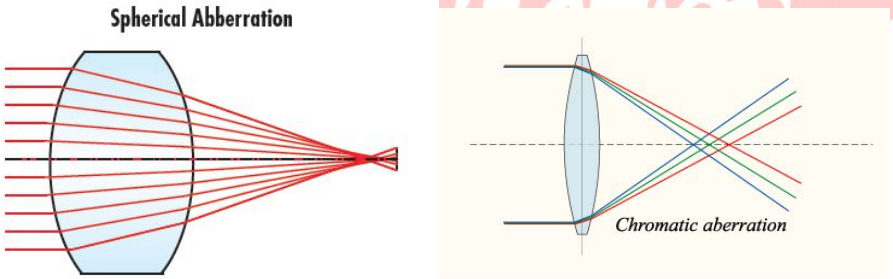


Figure (9.8): **spherical and chromatic aberration**

3- **The pupillary light reflex:**

Figure (9.9): **Light reflex**

Stimulus	Light
Receptors	Photoreceptors in retina send afferent to brain
Response	Efferent nerve from brain stimulate circular muscles contraction to narrow pupil (miosis) (pupillary constriction) **Both eyes**
Importance	protection

causes of miosis and mydriasis:

Pupilloconstriction (Miosis)	**Pupillodilatation (Mydriasis)**
Light exposure{ pupillary light reflex}	Light withdrawal {Dark adaptation}
Near vision (Accommodation reflex)	Far vision
At rest , sleep	At stress, awaking, fear, pain:

Iris is innervated by 2 nerves

At rest	At stress
Parasympathetic nerves	Sympathetic nerves
Secrete chemical substance called acetyl choline	Secrete chemical substance called nor epinephrine

Chapter 7

A) Functions of lens

B) Accommodation reflex

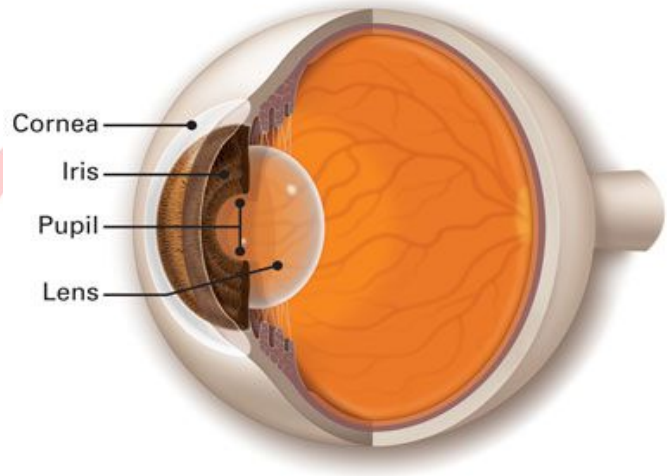


Figure (10.1): **crystalline lens**

Objectives

- Identify main lens properties
- Recognize cataract
- Identify components of accommodation reflex

Main lens properties:

1-Biconvex lens

2- High refractive index (1.40): due to high protein concentration

- Anterior surface is less curved, but with a higher RI.

3-Capsulated

-Lens capsule is: elastic membrane and attached to the ciliary body {accommodation}

4-The diopteric power of the lens:

-During rest i.e with no accommodation 20 D.

-During full accommodation = 34 D.

5- Transparent: not vascular and have regular fibers

Cataract

- If the Lens becomes cloudy and opaque as if seeing through frosted glass
- Cause: old age, excessive exposure to ultraviolet rays or X-ray radiation
- Treatment: Surgical removal of the lens, then either to put new lens or to wear glasses with thick lens that functions similar to the normal lens.

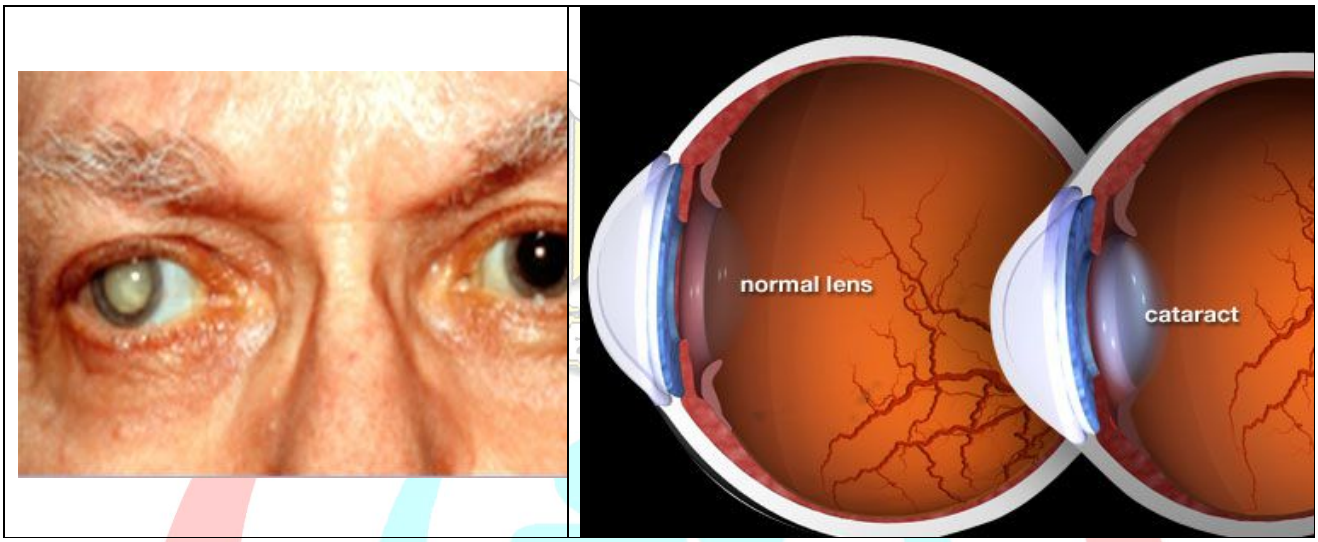


Figure (10.2): **opaque lens in cataract**

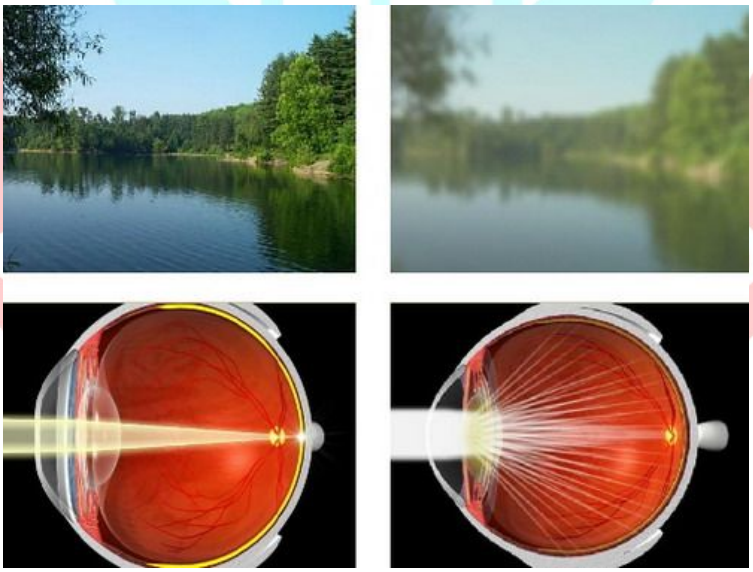


Figure (10.3): **vision with cataract**

Lens functions:

- Important refractive medium with 1/3 diopteric power of the eye
- Change its power to see near objects clearly{Accommodation process}
- Near response {Accommodation reflex}

B) Near response {Accommodation reflex}

Definition: Near response is the process by which the optical system of the eye is adjusted to see near object (less than 6 meters) clearly.

3 changes that occur in eye during accommodation:

A- Medial convergence:

Both eyes look to the inside

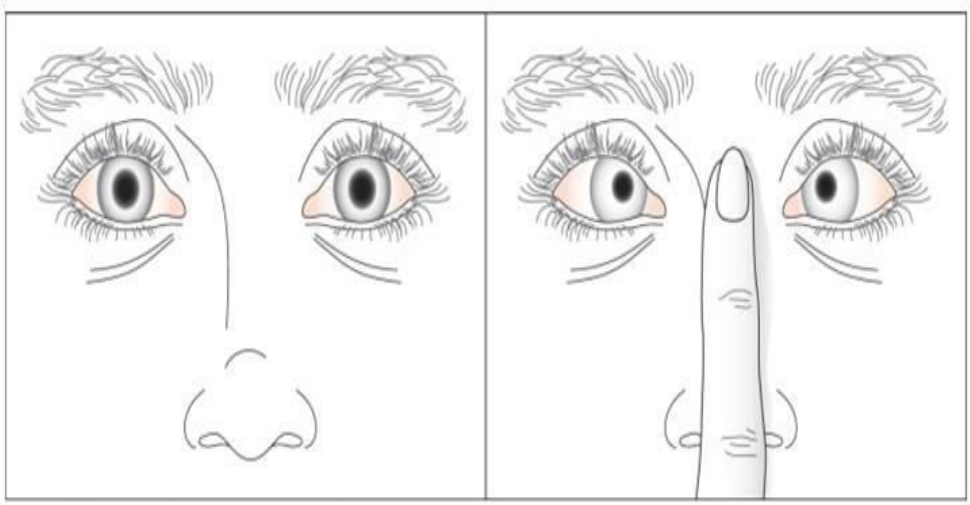


Figure (10.4): **two eyes looks to inside in near vision**

Aim: To allow the images of the near object of **both eyes** to fall on central part of both retinae and this will prevent double vision.

Mechanism: contraction of the eye muscles

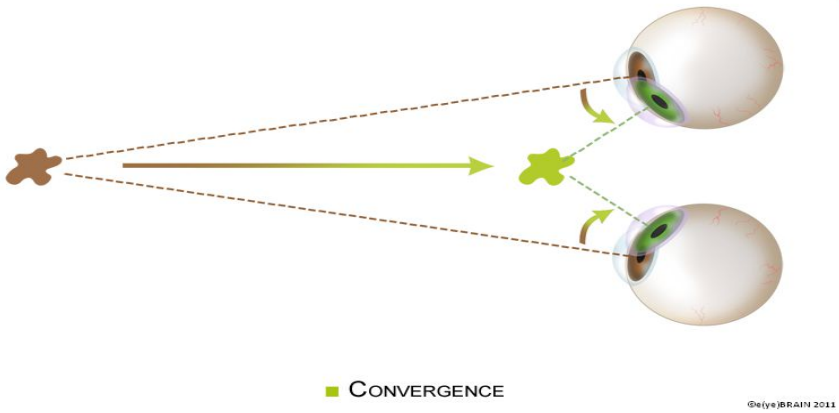


Figure (10.5): **Medial convergence**

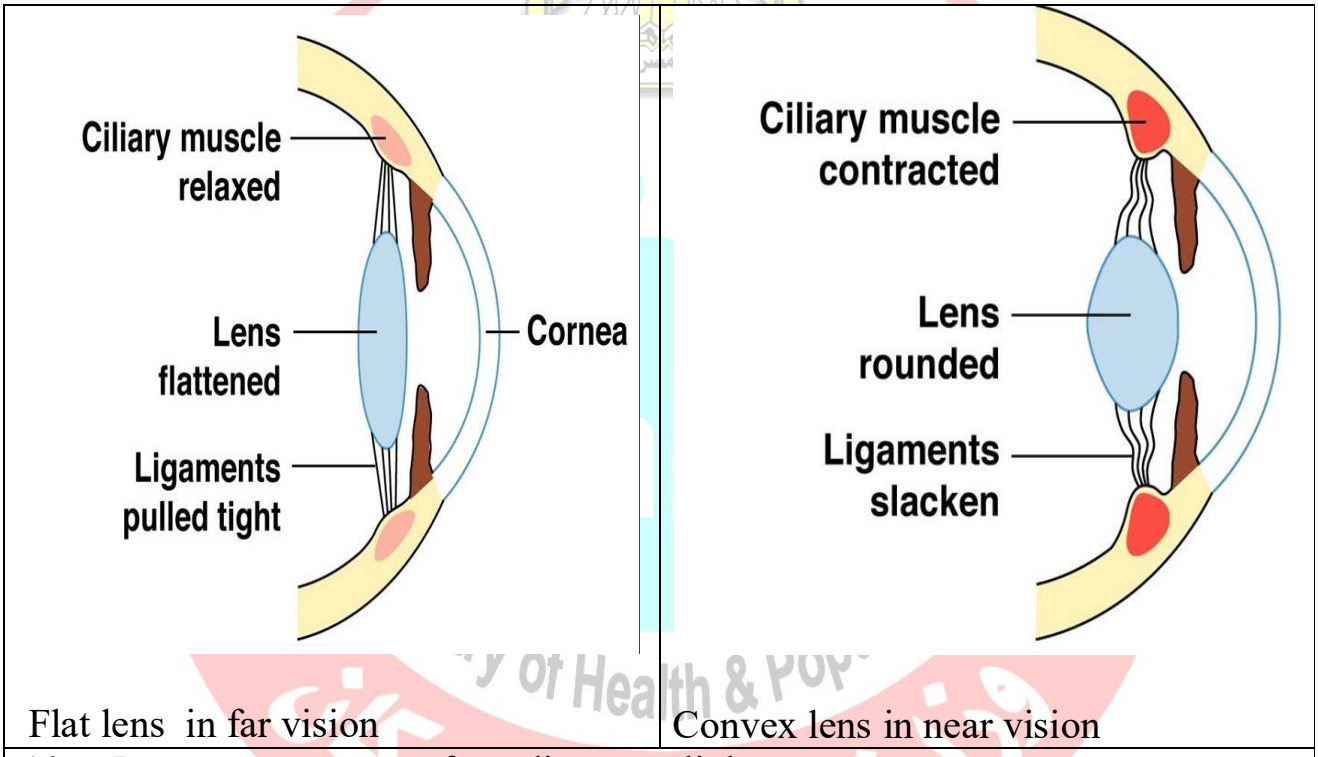
B- Bilateral miosis

Aim: Decrease the amount of light entering the eye to prevent both spherical and chromatic aberrations.
Mechanism: circular muscles contraction to narrow pupil (miosis) (pupillary constriction).
-Spherical aberration: multiple foci, blurred image as the peripheral parts of the lens have different refractive index (RI)
-Chromatic aberrations: The peripheral parts of the lens act as a prism which analyses the white light into its spectral components.

C-Bilateral accommodation

Definition:

Increase dioptric power of the lens by **increasing the curvature** of the anterior surface of the lens.



Flat lens in far vision | Convex lens in near vision

Aim: Increase power to refract divergent light rays

Mechanism: Ciliary muscle contraction, decreasing the tension of the suspensory ligaments, decrease pull on lens capsule

Define near point:

It is the nearest point at which objects can be clearly seen with maximum

Define Presbyopia:
-Gradual loss of accommodation due loss of lens elasticity with aging

Effect
-Near point far away
-Accommodation power decreases.

Correction: By convex lens for near vision only

Chapter 8

Errors of refraction

Objectives

- **Differentiate between the different errors of refraction**
- **Identify types of lenses used in correcting each error**

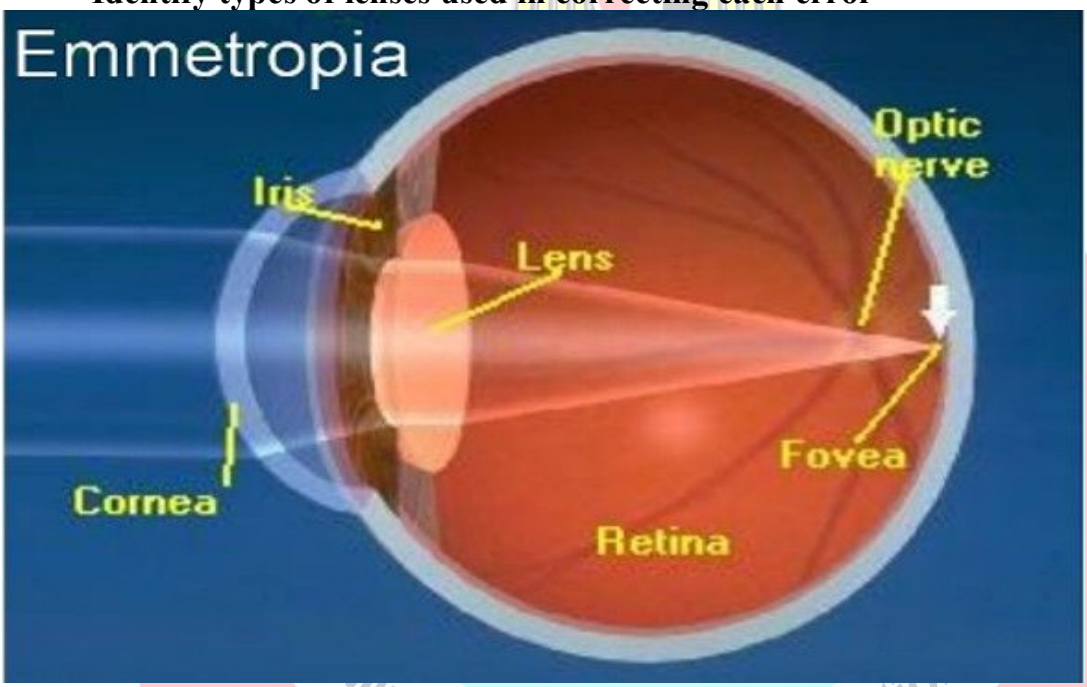


Figure (11.1): **Emmetropic eye**

- Normally the <u>emmetropic</u> eye: Focus **parallel light rays** on the retina

<u>What are the errors of refraction:</u>

<u>1- Myopia</u>
<u>2- Hypermetropia</u>
<u>3- Astigmatism</u>
<u>4- presbyopia</u>

1-Myopia:

Myopic eye: Focus parallel light rays infront of retina, while accommodation is relaxed

Cause:

Axial myopia: The myopic eye is longer than the normal eye, each 1 mm difference cause -3D myopia (Long eyeball)

Refracrive myopia:

Increase in the refraction power of the lens or the cornea due to the increase in their convexity.

Effect:

- ***Far vision:*** light rays are focused infront of the retina
- ***Near vision:*** not affected, accommodation is at rest

Treatment:

Wearing glasses with concave lens –ve (divergent lens)

Figure (11.2): **Myopic eye focusing light rays infront of retina**

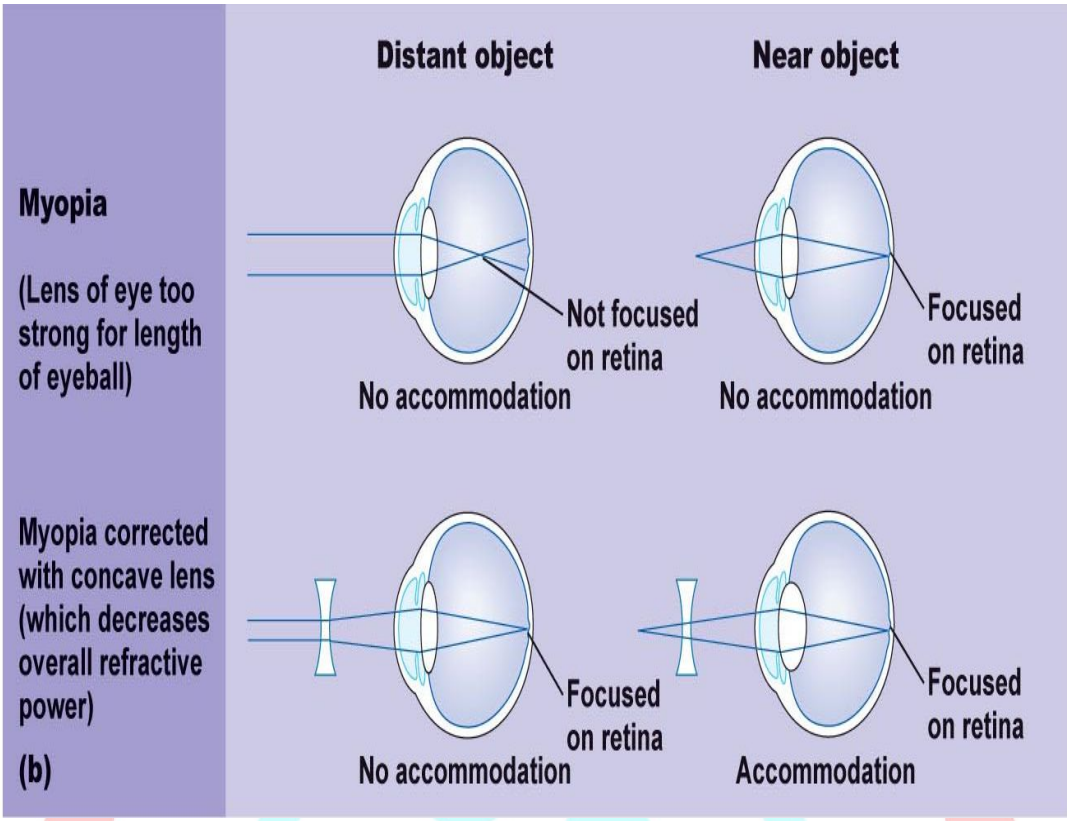


Figure (11.3): **Myopic eye error and correction**

2- Hypermetropic eye: Focus parallel light rays behind the retina, while accommodation is relaxed

Cause:

Axial hyermetropia: The eye is shorter than the normal eye, each 1 mm difference cause +3D myopia (short eyeball)

Refracrive myopia:

Decrease in the refraction power of the lens or the cornea due to the decrease in their convexity.

Effect:

- ***Far vision:*** not affected
- ***Near vision:*** focus behind retina

Treatment:

Wearing glasses with convex lens +ve (convergent lens)

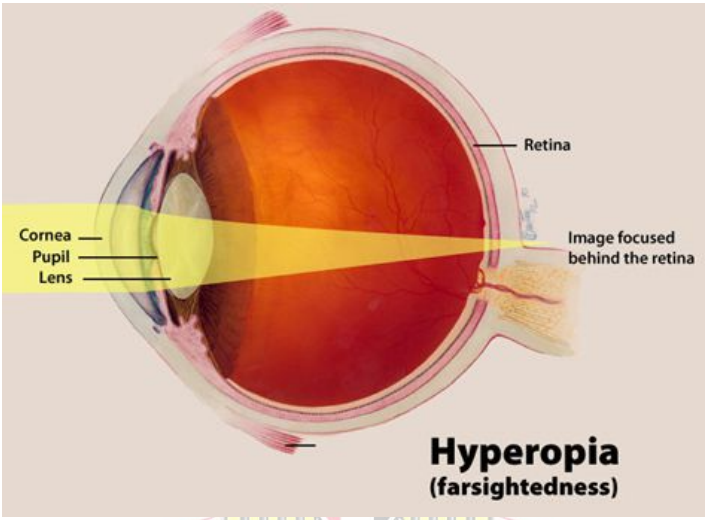


Figure (11.4): **hypermetropic eye**

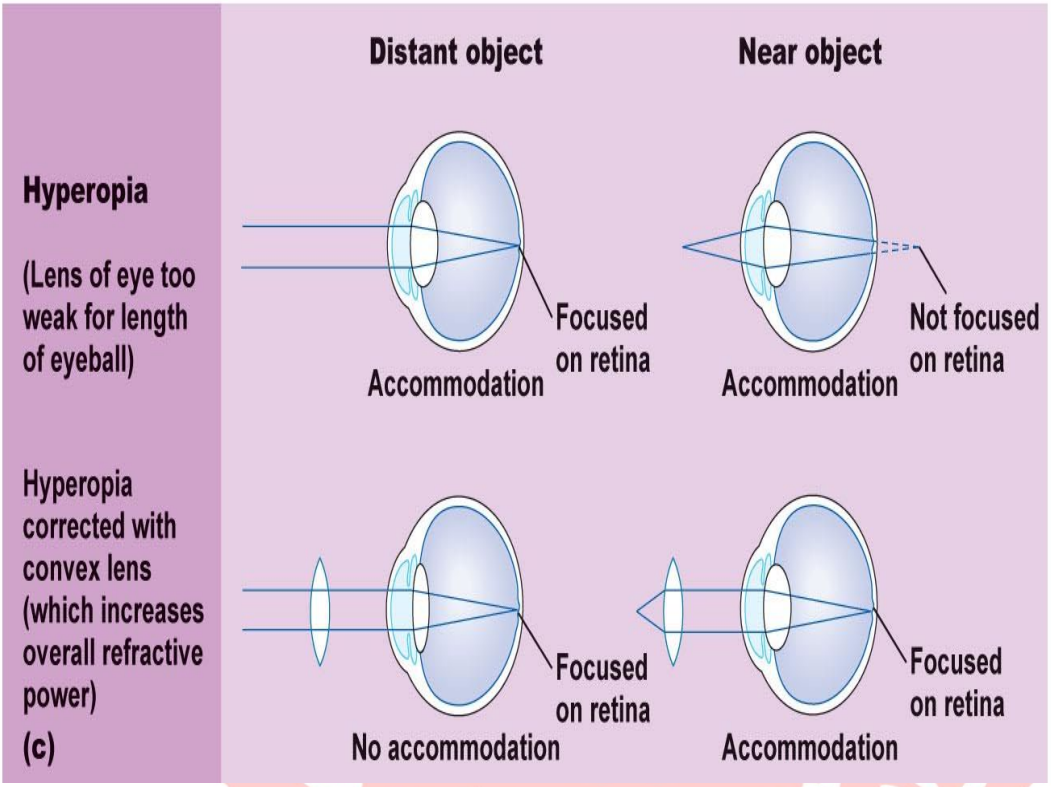


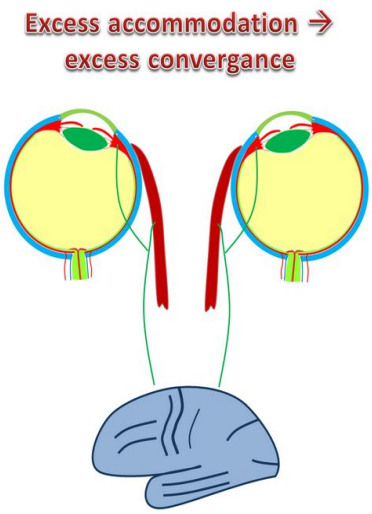
Figure (11.5): **hypermetropic eye error and correction**

In hypermetropia:

- The patient continuously uses accommodation to bring the focus on retina and so medial eye muscles are continuously contracting.
- ***Effect***

➢ *Headache and eye fatigue.*

➢ Convergent squint (in children).



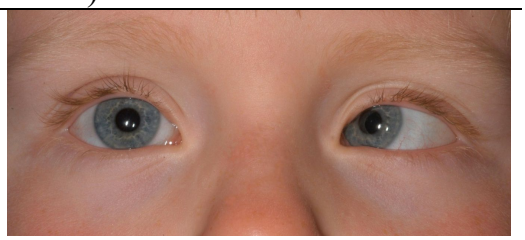


Figure (11.6): **Squint in child with neglected hypermetropia**

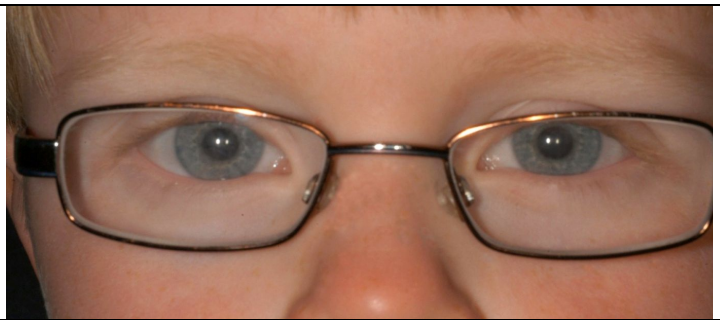


Figure (11.7): **corrected hypermetropia with eye glasses**

3- Astigmatism:

-Parallel rays come into **different foci, blurred image**

Cause:

-The refractive power of the eye **is not the same** in **different meridia**

- Curvature of cornea and lens is not equal or uniform

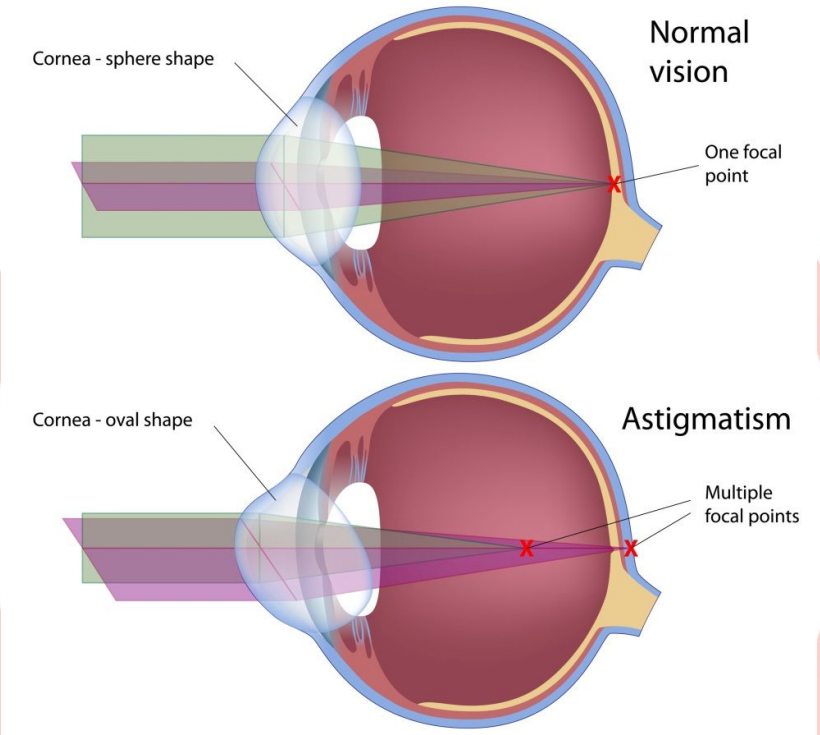


Figure (11.8): **Astigmatism**

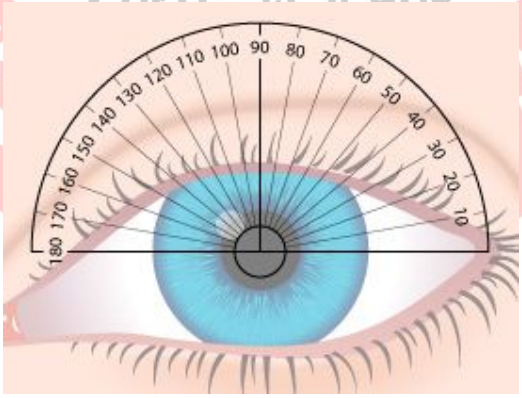


Figure (11.9): **eye has different meridians**

Types of astigmatism

Regular astigmatism			Irregular Astigmatism
Simple regular	**Compound regular**	**Mixed regular**	
-One meridian is **emmetropic** (focused onto the retina) - The other meridian is **ametropic** { myopic or hypermetropic}	**Both** meridians are **ametropic** but of the **same type** Meridian is Myopic , other is more mypoic Meridian is hypermetropic, other is more hypermetropic	One meridian is **hypermetopic** & the other is **myopic**	All the meridians are **irregular**
Treated by cylindrical lens Its axis is placed at right angle to the meridian to be corrected	Treated by combination of spherical & cylindrical lenses	Treated by combination of spherical & cylindrical lenses	Treated by: 1-Hard contact lens to replace the irregular surface of the anterior surface of the cornea by the regular surface of the contact lens 2-Keratoplasty

Types of lenses:

Spherical lenses:	**Cylindrical lens**	**Spherocylindrical lenses**	**Contact lenses**
They are parts of spheres . Same power in all meridian Focus the parallel rays into point	-They are parts of cylinders. -They have different powers in different meridian	They are combined spherical + cylindrical lenses. They are used to correct compound regular astigmatism and mixed astigmatism.	Thin, plastic lenses applied directly on cornea
Concave (-): myopia Convex(+): hypermetropia, presbyopia	The meridian of axis = zero The meridian perpendicular on the axis has maximal power . (+), (-) correct regular astigmatism	Both lenses may be (+) or (-) , or one is (+) and the other is (-). Correct simple regular astigmatism	canceling the anterior corneal surface and replace it by the surface of the contact lens

Contact lenses Indications:

1-High spherical errors (cosmetics).

2-Irregular astigmatism .

Types : Soft or hard contact lenses

Hard contact lenses are used to correct irregular corneal astigmatism.

Disadvantages:

1-Needs special care & cleaning &easy loss or damage.

2-Corneal oedema & ulcers

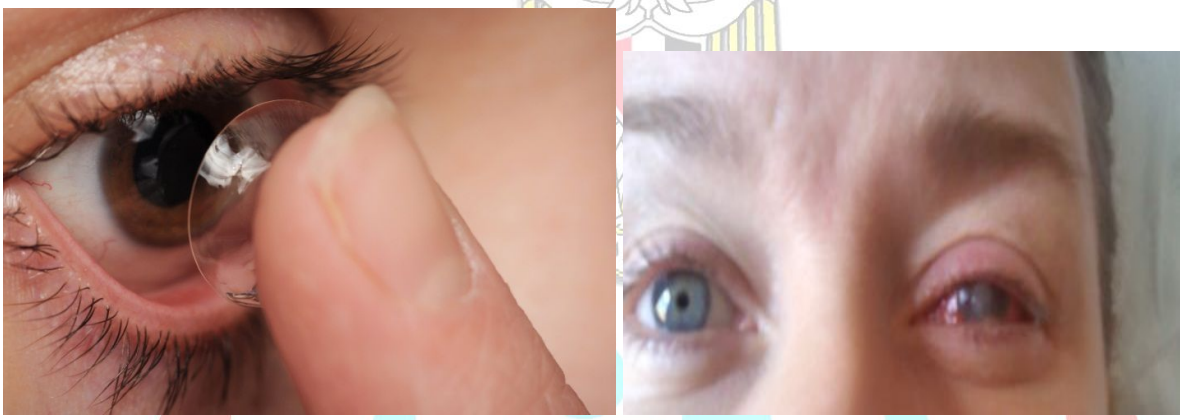


Figure (11.10): **eye contact lens**

Chapter 9

A) Retinal physiology
B) Visual field
C) Visual pathway

Objectives

- **Identify Retinal layers and its photoreceptors.**
- **Explain dark and light adaptation.**
- **Identify the concept of visual field**
- **Describe the visual pathways that convey visual signals from the retina to the visual cortex**

-The retina is the most inner sensitive layer of the eye.
-It is a thin transparent membrane between the vitreous body internally and choroid externally.

- It is formed of many layers

A- Main retinal layers

The pigmented epithelial:	-Absorbs light and prevents its reflection - Stores large quantities of **vitamin A** which is the main component of the photo receptors - Albino patients have weak vision
photoreceptors	Visual photoreceptors {rods and cones}
Other layer cells:	- Increase visual contrast and help in color vision

B-Regions of the Retina:

1-Optic disc

Site: 3mm medial to posterior pole
Size: 1.5 mm in diameter.
Properties:
-It is the site of:
Optic nerve exist

Retinal blood vessels entry

-No visual receptors insensitive to light {**Blind spot**}

-Sharp edges

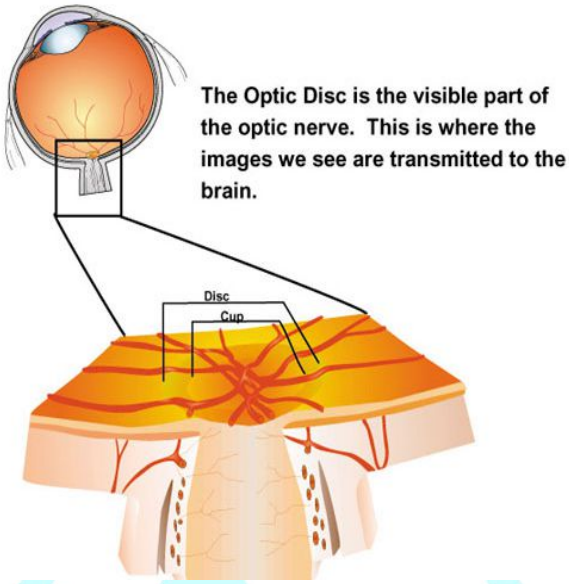


Figure (12.1): **Optic disc**

2- Maculae lutae

Site: located at the center of the retina.

Size: yellowish spot (less than 1 mm^2) yellow color is due to special type of melanin pigments

Properties:

Highest visual acuity

Why does the maculae has the highest visual acuity?

1-It contains mainly cones that are responsible for the detection of the details and colors of the objects.

2- It doesn't contain blood vessels

C- Photoreceptors {Rods and cones}

1- They convert light energy to electric activity transmitted through retinal layers to optic nerve to brain

2- They contain specific photosensitive pigments that are degraded or chemically changed on exposure to light a process called (Bleaching), but reformed on the dark

3- They contain large amounts of vitamin A

4- They are 2 types:

- Rods
- Cones

D- Compare between rods and cones

	Rods	**cones**
1-number	120 million/retina	6 million/retina
2-distribution	periphery	Central mainly in fovea
3-Photosensitive pigment	Rhodopsin	Iodopsin
7-Visual acuity	Low	High, sharp detect details and colors
4-Light sensitivity	Highly sensitive can be stimulated by low intensity light	Low sensitivity must be stimulated by high intensity light
8-function	Scotopic dark vision	Photopic day light vision

E-scotopic and photopic vision

Scotopic vision {Dim light vision}	**Photopic vision {Day light vision}**
➢ Rods function	➢ Cones function
➢ Details, boundaries are not seen	➢ Details, boundaries are seen with high visual acuity
➢ No color vision	➢ Colors are seen
➢ Wide pupil	➢ Narrow pupil

F- How retina adapt to varying light intensities

Shifting from dark place to bright light leads to:
1- Narrowing of pupil
2- Bleaching or breakdown of photosensitive pigments in photoreceptors

Shifting from bright light to dark place leads to:
1- Widening of pupil
2- Reformation of photopigments in photoreceptors

- **Cones adapt to dark faster than rods**

G-Role of vitamin A:

Vitamin A is present in rod and form rhodopsin

Night blindness:

- Vitamin A deficiency leads to decrease amount of photo pigments.
- The patient is unable to see perfectly by night.

B) Visual field

-The Normal visual field is called "Island of vision surrounded by a sea of blindness"

Visual field definition:

- It is the maximal area of space that can be seen by single fixed eye.

Visual field

- Normal visual field is not circular because it is limited at most points by anatomical factors e.g:

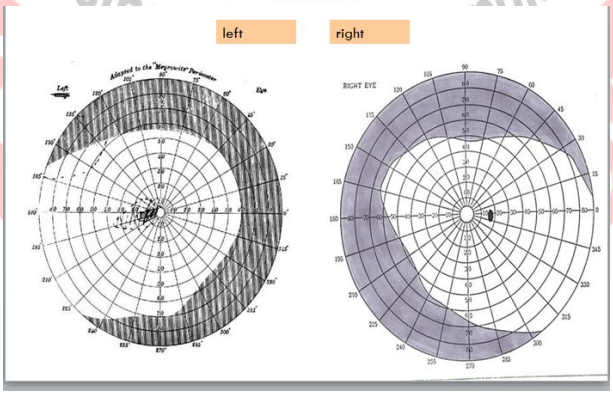


Figure (12.2): **visual field**

Up 60^0 (limited by the eye brow).	**Nasally** 60^0 (limited by the nose).
Down 70^0 (limited by the checks).	**Temporally** 90°- 100° (not limited).

1-Nasal field of vision:

- Area seen to the nasal (medial) side.
- divided into upper quadrant & lower quadrant
- perceived by the temporal half of the retina

2-Temporal field of vision:

- Area seen to the temporal (lateral) side.
- Divided into Upper and lower quadrants
- Perceived by the nasal half of the retina

C)Visual pathway

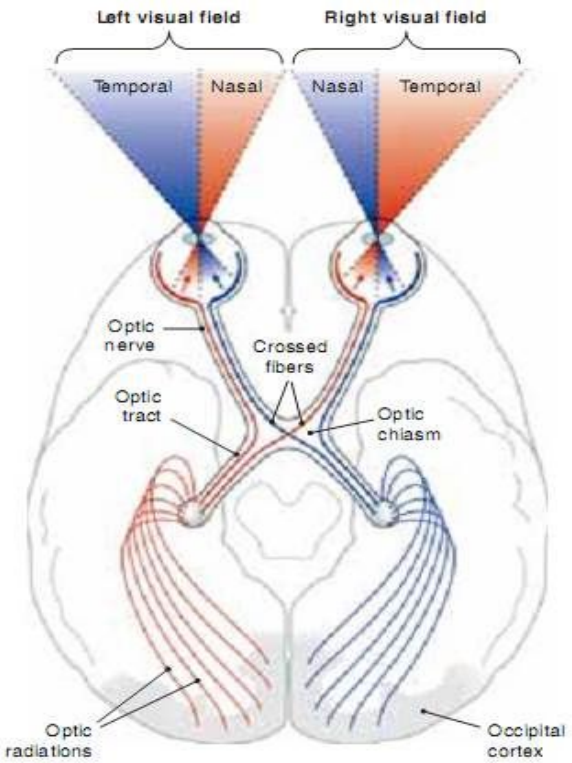


Figure (12.3): **visual pathway**

- Each side of the retina receives light rays from the opposite part of the visual field

- An object placed in the **temporal** part of the visual **field** projects its rays to the **nasal** side of the **retina.**

- **<u>In the retina</u>**:

Visual impulses from photoreceptors rods and cones pass through retinal layers to the optic nerve

- Fibers coming from the **nasal** part of the retina cross to reach the optic tract of the **opposite** side while the **temporal** fibers go to the optic tract of the **same** side.

- **<u>Optic tract :</u>**

It contains **temporal** fibers of **same** side and the **nasal** fibers of the **opposite** side

- Fibers reach brain at the **<u>visual cortex</u>**:

A) Receives visual information, fuse images of both eyes
B) Understand the meaning of the images

Chapter 10

A) Binocular vision

B) Color vision

Objectives

- **Identify concept of binocular vision and its importance.**
- **Identify the mechanism of seeing colors and types of color blindness**

Binocular vision

It is the ability to use both eyes without diplopia (double vision).

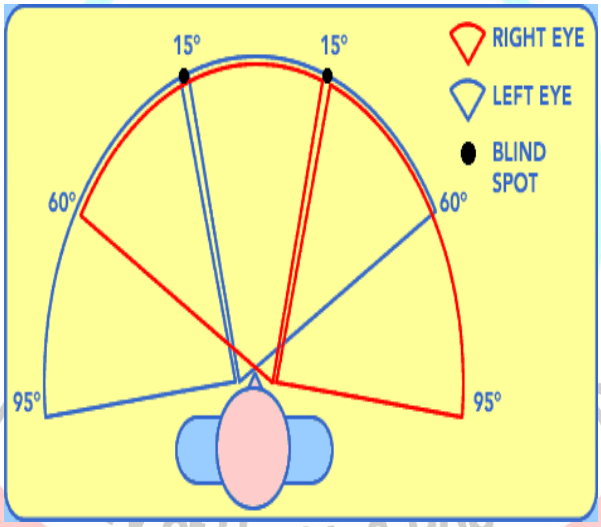


Figure (13.1): **Binocular visual field**

Advantages of binocular vision

1- Larger visual field: visual field of both eyes together is greater than each eye separately.

2- Optical defect on one eye are masked by normal eye.

3- Gives better stereoscopic vision to see the 3 dimensions of the objects as width, length and depth.

Binocular vision mechanism

-The central part of the visual fields of both eyes overlap so objects placed in the overlapping area form images on the retinae, of both eye.

Requirements for fusion of retinal images by brain

A-***Sensory requirement:***

Both retinal images should be **equal** in **shape, clarity, size** and **colours**

- Depend on:

a) Equal refraction.

b) Normal lens.

c) Functions retina.

d) Intact visual path way.

B- Motor requirements:

Both images must fall on corresponding sites on retina and this requires normal extra-ocular muscles with normal nerves.

C-Cortical requirements:

Normal visual cortex is essential for fusion of the 2 retinal images

Figure (13.2): **Double vision**

B) Colour vision

It is the ability of the retina to discriminate different colors.

- It is the cones function, present in photopic vision

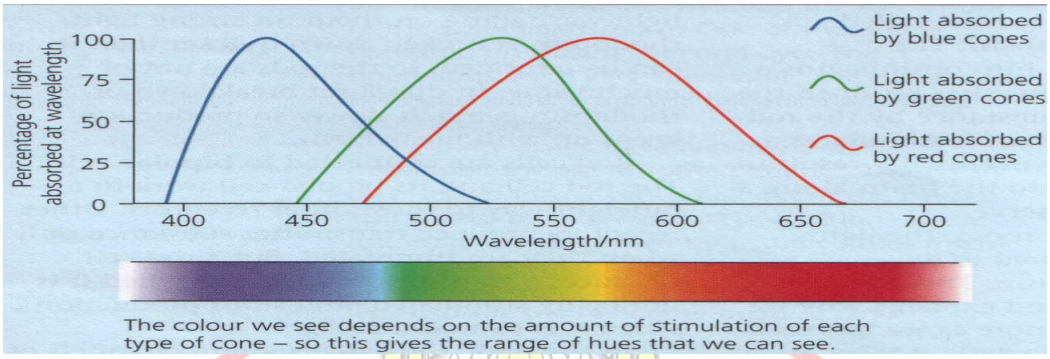


Figure (13.2): **different colors wavelengths can stimulate 3 cones**

- Eye has 3 types of cones:

Red cone	Green cone	Blue cone
have a maximal absorption at 565 nm	have a maximal absorption at 535 nm	have a maximal absorption at 445 nm

- Any spectrum color can be formed by mixing various proportions of the 3 primary colors: red –green- blue

Color vision mechanism: Tri-chromatic theory

- Colour sensation perceived by the visual cortex depends upon the **relative frequency of impulses in each 3cones**.
- Equal stimulation of the 3 cones=white colour.
- Unequal stimulation of the 3cones----- different colour sensation
- yellow results from stimulation of both red and green cones
- if the red cones are stimulated more strongly than the green cones , we will see orange instead of yellow

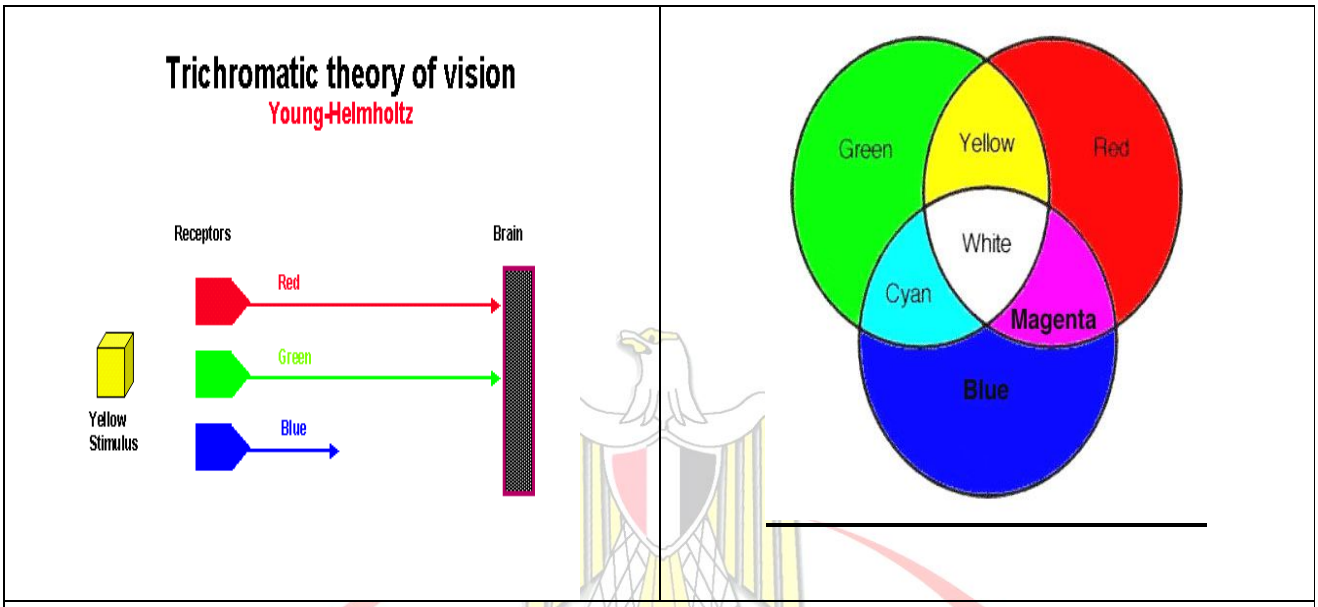


Figure (13.3): **Color vision theory**

Color blindness definition:

Inability to discriminate light of different-colours

Causes:

X-linked recessive

Types:

Trichromats: *3 cones working, with one weak*

a-Protanomely = red colour weakness.

b-Deutranomely = green colour weakness.

c-Tritanomely blue colour weakness.

Dichromatos:

2 cones only, one missing protanopia, deuteranopia, tritanopia

Monochromatos: only one cone

REFERENCES AND RECOMMENDED READINGS:

-Review Of Medical Physiology: William F. Ganong.

- Human physiology: Stuart Ira Fox.

- Textbook Of Medical Physiology: Guyton & Hall.