An Overview of Anatomy and Physiology of the Eye
Changes in the eyelid fissure

A, Graves disease stare.
B, Myathenia gravis.
C, Congenital ptosis of right eye.
D, Levator disinsertion.
E, Horner syndrome or oculosympathetic denervation of left eye.
F, Left seventh nerve palsy.

(Photographs courtesy of Dr. Jeffery Nerad)
Eye Color
Common myths for vision or eye

A. 20/20 is perfect vision.

B. Reading in the dark will hurt your eyes.

C. Eating carrots will make your vision better.

D. You have to wait for a cataract to be “ripe” before having it removed.

E. It will hurt a child’s eyes to sit too close to the television set.
Fig. 1.1  Diagram illustrating the anatomical planes of reference.
Landmarks of the external eye. The palpebral fissure is approximately 27-30 mm long and 8-11 mm wide in the adult. The caruncle and plica semilunaris and seen near the medial canthus.
A Side View Of The Eye

- Upper lid
- Superior fornix
- Bulbar conjunctiva
- Limbus
- Corneal epithelium is continuous with surface epithelium of conjunctiva
- Limbus
- Bulbar conjunctiva
- Inferior fornix
- Palpebral conjunctiva
Eyelids and the lacrimal secretory and excretory systems

a. The lacrimal gland, the orbital lobe (Lo) and the palpebral lobe (Lp), is separated by the tear ducts (arrow).

b. The accessory lacrimal exocrine glands (blue) contribute to the aqueous layer of the precorneal tear film.

c. The conjunctiva (the Bulbar conjunctiva of the eyeball and the Palpebral conjunctiva of the eyelid) and tarsal mucin-secreting goblet cells (green) produce a musoprotein layer covering the epithelial surface of the cornea and conjunctiva.
The lacrimal drainage system includes canaliculi, the tear sac and the nasolacrimal duct.
Tenon’s capsule is composed entirely of compactly arranged collagen fibers and a few fibroblasts. Anteriorly, it fuses with the conjunctiva slightly posterior to the corneoscleral junction (limbus). Posteriorly, it is perforated by the optic nerve sheath and by the posterior ciliary vessels and nerves and becomes more attenuated. The vortex veins pass through the capsule near the equator of the globe. Tenon’s capsule and the intermuscular fibrous membranes surrounding the 4 rectus muscles fuse to form a type of fibrous sling or support.
The pattern of orientation of the collagen bundles in the scleral stroma in relation to the extraocular muscle tendinous insertions
Eye Movement is Controlled by Six Muscles

Four rectus muscles (superior, inferior, medial and lateral)  
Two oblique muscles (superior and inferior)

The medial rectus tendon is closest to the limbus, and the superior rectus tendon is farthest from it. By connecting the insertions of the tendons beginning with the medial rectus, then the inferior rectus, then the lateral rectus, and finally the superior rectus, a spiral is obtained. This is called the spiral of Tillaux.
The Eye Position and Its Control

Ocular Motility and Strabismus (heterotropia)
Strabismus is due to some type of extraocular muscle imbalance, one eye is not aligned with the other eye, also called “heterotropia” or “tropia.”

The two most common types of strabismus—esotropia and exotropia.

Esotropia is often congenital. Exotropia often develops in infancy or in early childhood.

Treatments — visual therapy or surgery.
The Eye (appearance and outside)

Key Points:

• The eyeball is located in the anterior portion of the orbit and attached by the extraocular muscles and Tenon’s capsule.
• The eyelids protect the eye from trauma, dryness, and too much light.
• The secreteory system (the lacrimal gland and the torsal gland) for the delivery of the tears and the excretory system for disposal of the tears.
Eye Anatomy
OphthoBook.com
Eye glasses?
The main points of the eye

The eye is a highly specialized organ of photoreception for processing light energy from the environment to produce action potentials in specialized nerve cells, which subsequently relayed to the optic nerve and then to the brain where the information is processed and consciously appreciated as vision.

In order to perform this basic physiological process, the other structures (Cornea, Lens, Iris, Ciliary body) in the eye are necessary parts of the system for focusing and transmitting the light onto the retina and for nourishing and supporting the tissues of the eye (the choroid, aqueous outflow system, and lacrimal apparatus).

The eyeball is made up of two spheres joined at the limbus (junction of the cornea and sclera). The cornea is the smaller anterior “sphere” with a radium of 7.8 mm, and the sclera is the larger posterior “sphere” with a radius of 17 mm. The anterior-posterior diameter (visual axis) of the eye ball is about 24 mm.
Eye Size and Growth

The eye is approximately a sphere **24 mm in diameter** with a volume of **6.5 ml**.

The diameter is approximately **16 mm** at birth and reaches about **23 mm** by 3 years of age. The eye reaches maximum size before puberty.
•There is variation in eye size between individuals, but the average axial length of the globe is 24 mm (range 21-26 mm). The horizontal length approximately 23.5 mm.

*Small eyes* (<20 mm) is hyperopic while *large eyes* (26-29 mm) are myopic.
Sagittal section of eye with major structures identified
Dimensions are the average dimension in the normal adult eye

Anterior segment

Posterior segment
The Cornea

The transparency of the cornea is its most important property.

The surface curvature of the cornea is responsible for most of the refraction of the eye.

The refractive index of cornea changes little with age (LASIK)
Cornea video 1 - LASIK in old days
LASIK – in clinic at UCBSO
New development
The cornea is composed of five layers:

- Epithelium
- Bowman’s layer
- Stroma
- Descemet’s membrane
- Endothelium
1. Corneal epithelium is a stratified epithelium (possessing five or six layers) and is 50-60 um in thickness.

The anterior surface of the corneal epithelium is characterized by numerous **microvilli** and **microplicae** (ridges) which interact with the precorneal tear film.

The superficial cells are flattened, nucleated, and nonkeratinized and adjacent cells are held together by numerous **desmosomes**.

The basal epithelial cells rest on a thin basal lamina (Bowman’s layer). Corneal epithelial adhesion is maintained by a basement membrane complex which anchors the epithelium to Bowman’s layer via a complex mesh of anchoring fibrils, **hemidesmosomes**, and anchoring plaques (different types of collagen).
Figure 15 Three dimensional drawing of the corneal epithelium

The five layers of cells forming this epithelium are shown. The drawing brings out the polygonal shape of the basal and surface cells and their relative size. The wing cell processes fill the spaces formed by the dome-shaped apical surface of the basal cells. The turnover time for these cells is seven days, and during this time the columnar basal cell is gradually transformed into a wing cell, then into a thin flat surface cell.
Corneal stroma: collagen fibrils, proteoglycans and keratocytes (2.4 million, which occupy about 5% of the stromal volume)

Figure 17 Corneal Stroma

The ground substance of the cornea consists of proteoglycans that run along between the collagen fibrils. Their glycosaminoglycan components (e.g., keratan sulfate) are highly charged and account for the swelling property of the stroma. The keratocytes lie between the corneal lamellae and synthesize both collagen and proteoglycans.

The cornea has about 2.4 million keratocytes, which occupy about 5% of the stromal volume; the density is higher anteriorly (1058 cells/mm²) than posteriorly (771 cells/mm²).
Posterior Part of The Cornea

Total about 500,000 endothelial cells with the density about 3000 cells/mm²
Specular micrographs of the corneal endothelium

A. Norma person.  B, Patient with Fuchs endothelial dystrophy
Appearance of the eye (color)
Cross-section of iris and cornea
External view of blue and brown irides
Limbus is the transition zone between the cornea and the sclera about 1-1.5 mm, is the area for the surgeon performing cataract extraction or a glaucoma-filtering procedure.

Two zones - an anterior bluish gray zone overlying clear cornea and extending from Bowman’s layer to Schwalbe’s line; A posterior white zone overlying the trabecular meshwork and extending from Schwalbe’s line to the scleral spur or iris root.
Schematic diagram of the human eye in horizontal section revealing the major components and the arrangement of the three layers. The corneoscleral envelope (blue), the uveal tract (orange/red) and the inner neural layer (purple).
The Eye is made up of **Three Basic Layers** (or Coats)

• **The fibrous (corneoscleral) layer**
The cornea and sclera together form a tough protective fibrous envelope that protects the ocular tissues. This layer also provides important structural support for intraocular contents and for attachment of extraocular muscles. The cornea meets the sclera at the limbus (or corneoscleral junction).

• **The uvea or uveal tract** (composed of iris, ciliary body and choroid)
The uvea contains vasculature to support the intraocular contents.

• **The neural layer (retina)**
The retina transforms the light energy into the neural action potentials

The coats surround **the lens and the transparent media** (aqueous humor and vitreous body)
Optic disc

Macula

Fovea

Foveola

Fundus Examination

Macula (macula lutea—"yellow spot" due to the presence of carotenoid pigments)
The **Fovea** is a concave central retinal depression approximately 1.5 mm in diameter, it is comparable in size to the optic nerve head.

Scanning electron micrograph of a retinal vascular cast at the fovea showing the foveal avascular zone and underlying choriocapillaris.
Cones concentrate in the fovea

This diagram shows the distribution of cones along a horizontal strip of retina that includes the fovea and the optic disc. The region around the center of the fovea contains only cones. Toward the center of the fovea, the inner and outer segments of the cones are thinner than elsewhere, and the spatial density of cones rises to a sharp peak. Away from the center of the fovea, the spatial density of cones drops rapidly, and beyond 3 mm, levels off to a value of about 7000 cones/mm²:
Retinal Histology and Cell Types

Choriocapillaris
Bruch’s membrane

Retinal pigment epithelium

Outer segment
Inner segment
• External (outer) limiting membrane

Outer nuclear layer

Outer plexiform (synaptic) layer

Inner nuclear layer

Inner plexiform (synaptic) layer

Ganglion cell layer
Optic fiber layer

• Internal limiting membrane (separates the retina from the vitreous)

Rod photoreceptor cells (R); Cone photoreceptor cells (C); Bipolar cells (DPBC or HPBC); Horizontal cells (HC); Amacrine cells (AC); Müller cells (MC); Ganglion cells (GC)
The posterior side of the eye
Retinal Vasculature (entering with optic nerve)
Choroidal Vasculature (through sclera)

Age-related Macular Degeneration (AMD)
Schematic diagram of the isolated sclera and structures that blend with it (muscle tendons and optic nerve)
Main Points:

• Conjunctiva covers the anterior eyeball (Bulbar) and the inner surface of the eyelids (Palpebral). It plays an immunological defense system of the external eye.

• The episclera is the outermost layer of the sclera and has an extensive blood supply from the anterior ciliary arteries. Inflammation makes these vessels (posterior to the bulbar conjunctiva) much more visible.

• The sclera is the white, firm, protective layer for housing the retina. It is composed of dense collagen fibers with limited fiber cells.
Fundus Photo