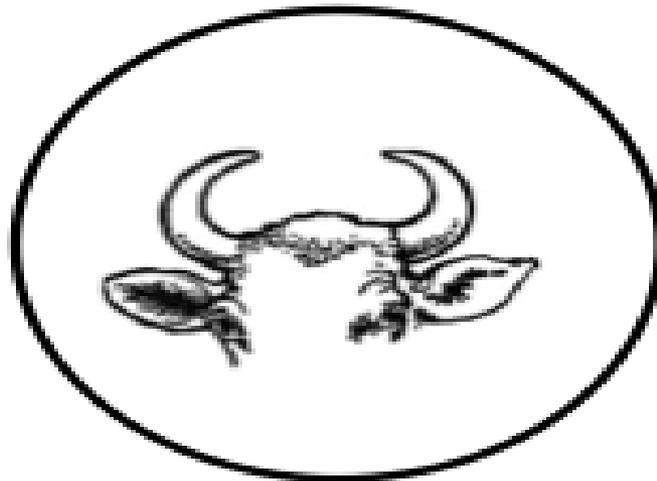


# Anatomy of cornea

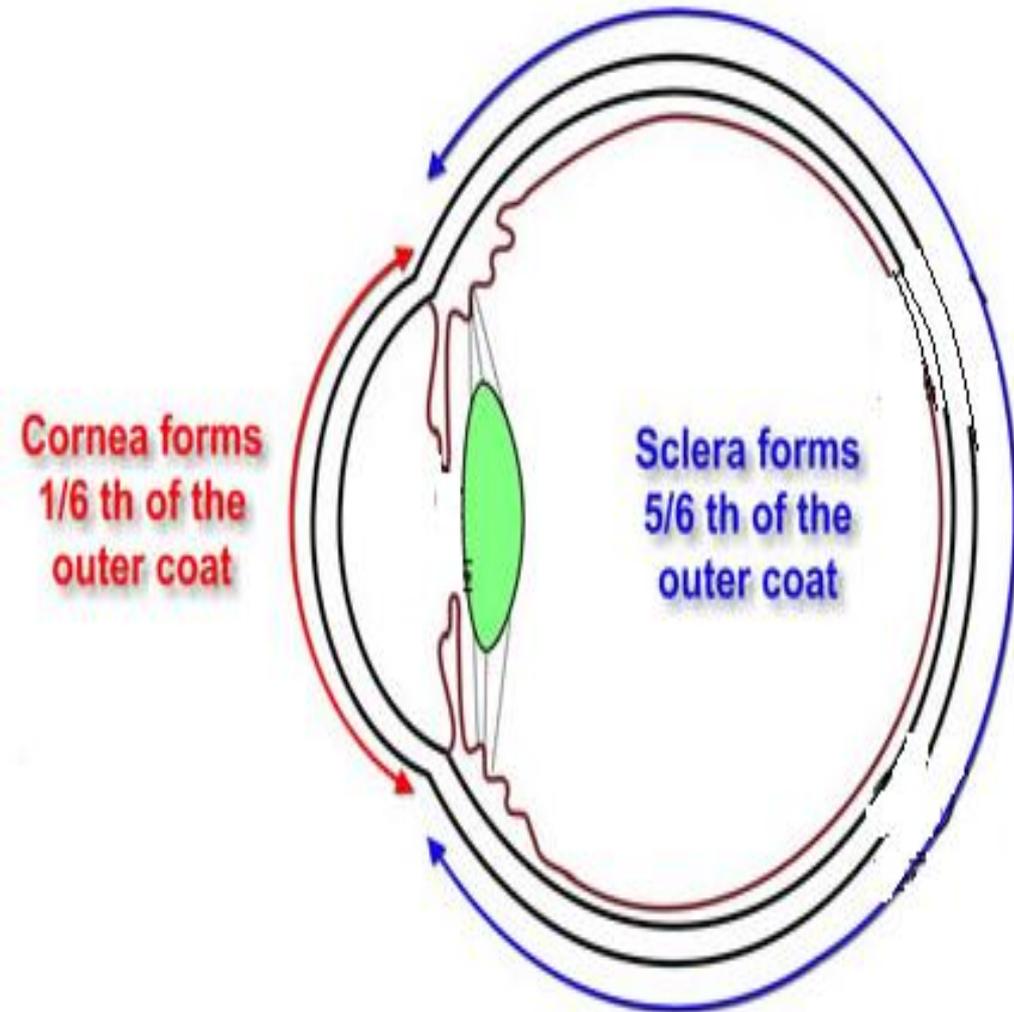
Sourav

# Introduction

- The word cornea has come from “Kerato”. The term “Kerato” in greek means horn or shield like. Ancient Greek used to believe that cornea is derived from same material like that of thinly sliced horn of animal.



# Anatomical consideration



- The cornea is the transparent tissue that covers the front of the eye. It forms anterior 1/6th of the outer fibrous coat of eyeball.

# Embryology

**Structure**

Corneal epithelium

Stroma, Descmet's membrane, endothelium

**Derived from**

Surface ectoderm

Paraxial mesoderm

# Dimensions

- Anterior surface of the cornea is elliptical with an average horizontal diameter is 11.7 mm and vertical diameter is 11mm.
- Posterior surface of cornea is circular with an average diameter is 11.5 mm
- The radius of curvature of cornea is 8 (7.8 mm).It is the result of differences in radius of curvature in the vertical horizontal meridians which causes astigmatism.

- Refractive power of anterior surface of cornea is +48 D posterior surface is -5 D
- Refractive power of cornea is about +43D
- Which is 3-4<sup>th</sup> of the total refractive power of the eye
- Refractive index is 1.37

**Microcornea**

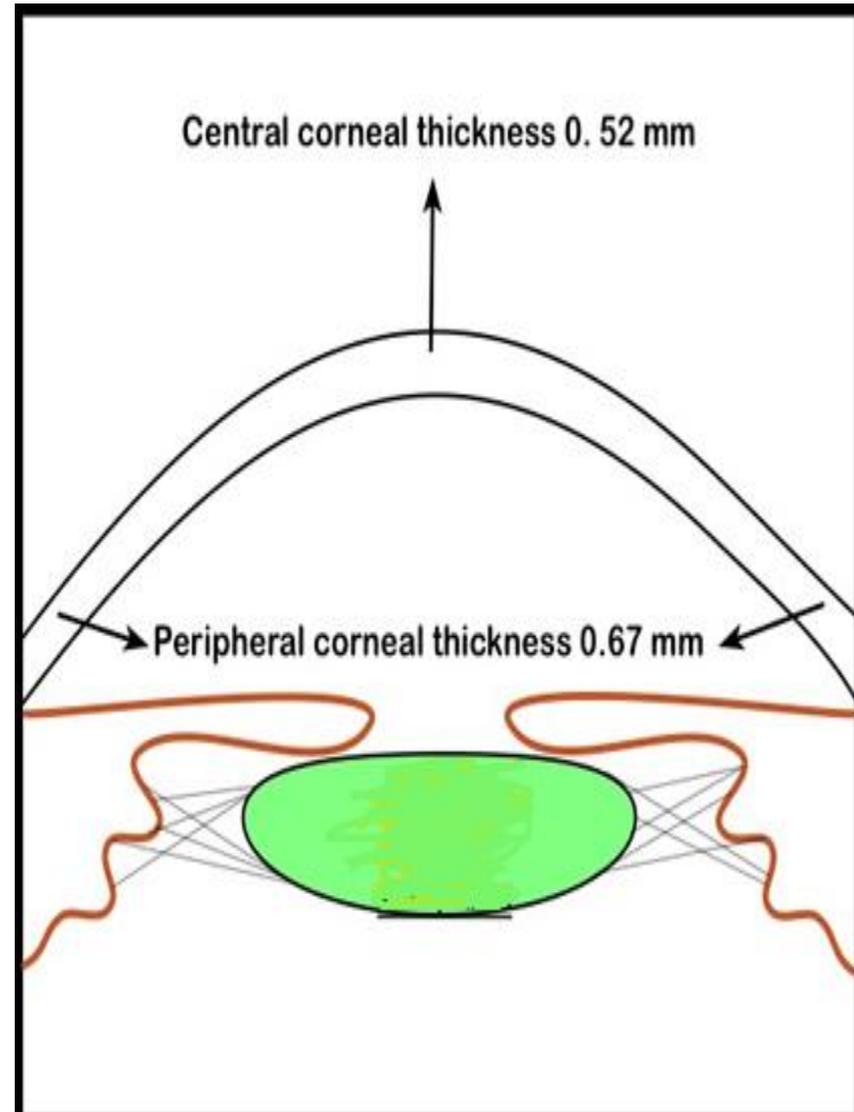
when HCD is less than 10mm

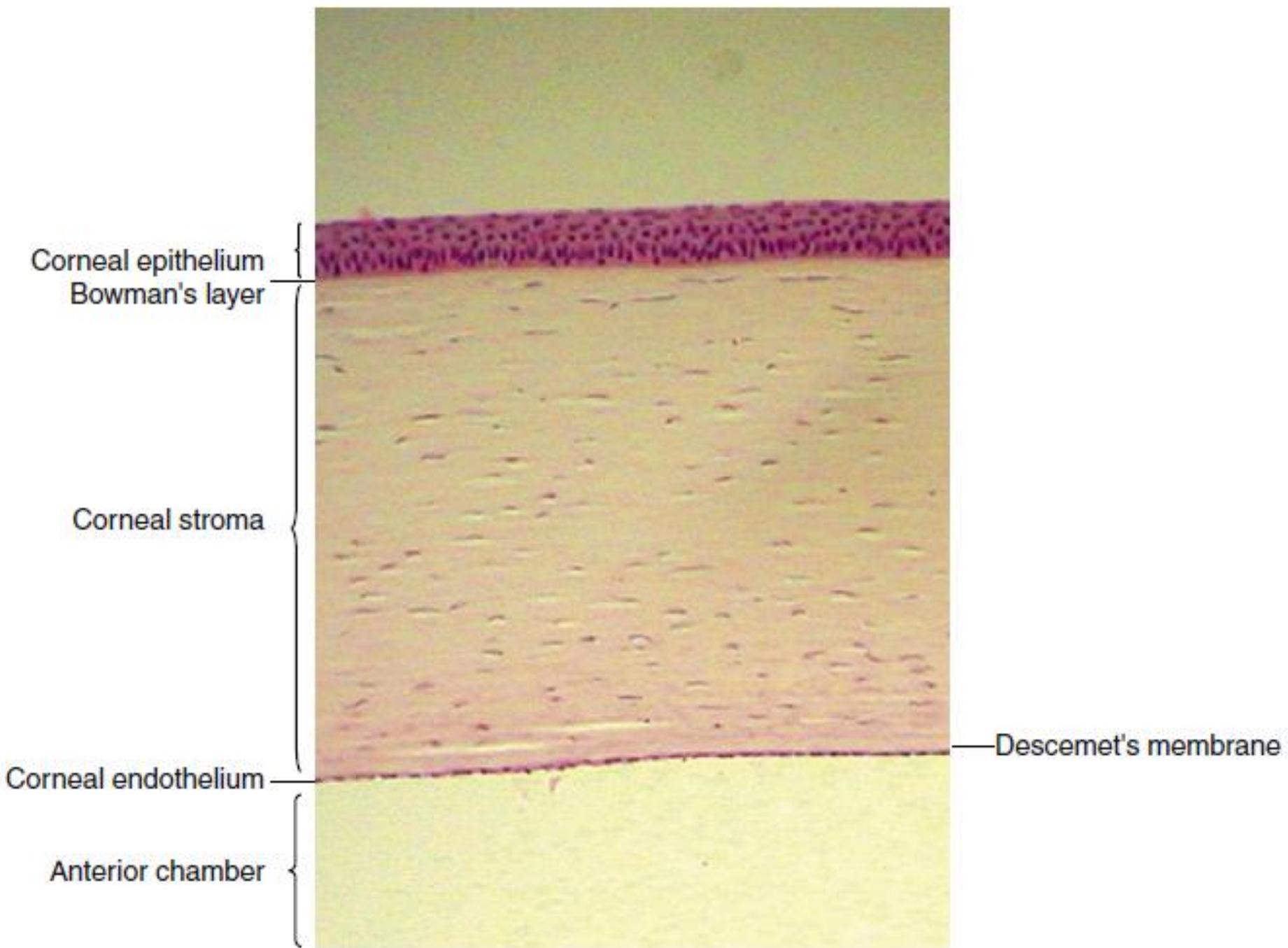
**Macrocornea**

when HCD is more than 13 mm

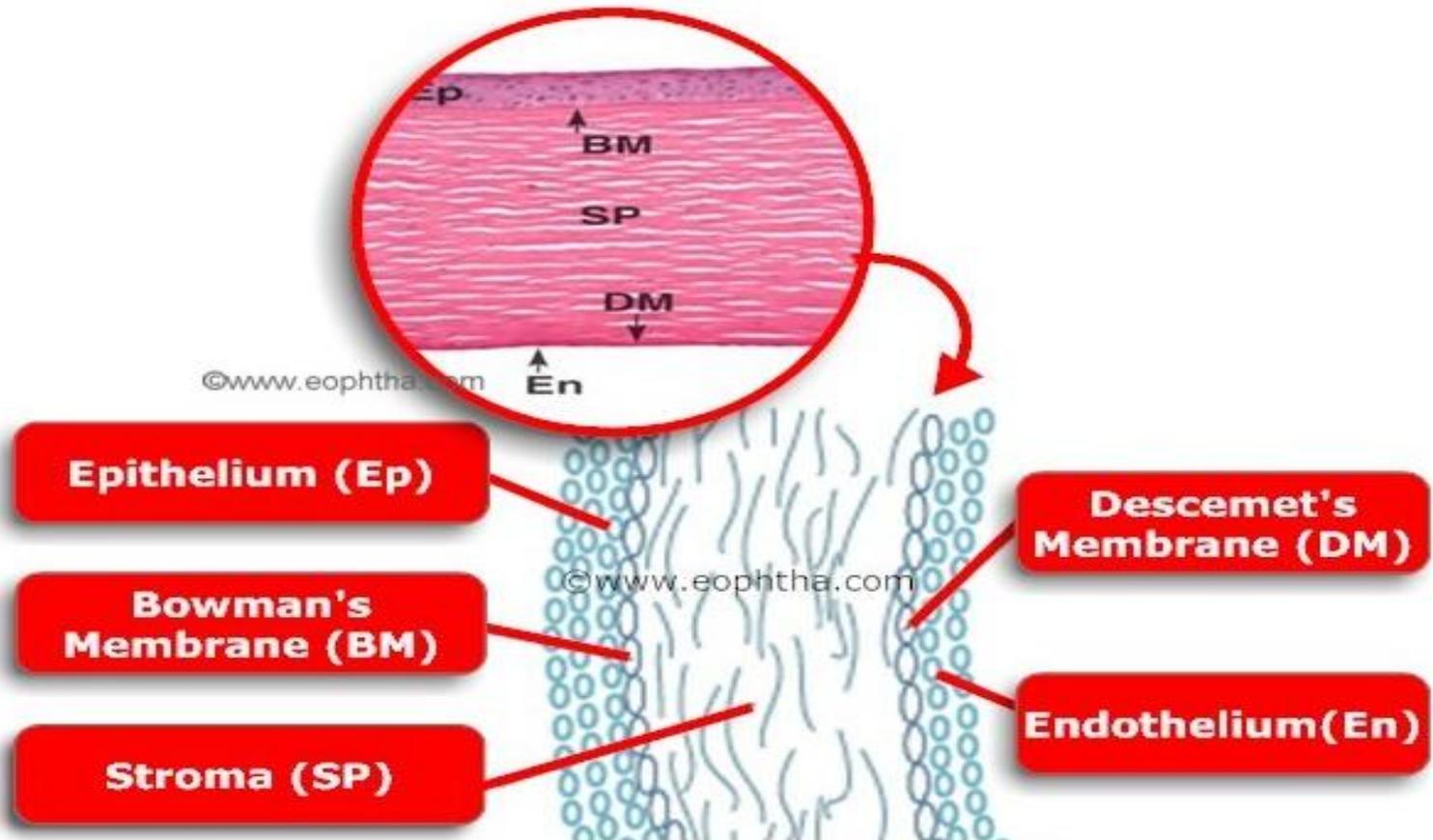
# Continue...

- The central corneal thickness is 0.52 mm, whereas periphery is 0.67 mm thick.
- Central corneal thickness has direct influence in IOP measurement. The central 5 mm of the cornea forms the most powerful refracting surface of the eye.





# Microscopic Anatomy of cornea



**Epithelium (Ep)**

**Bowman's Membrane (BM)**

**Stroma (SP)**

**Descemet's Membrane (DM)**

**Endothelium (En)**

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**REMEMBER**

- A- Anterior Epithelium**
- B- Bowman's Membrane**
- C- Corneal Stroma**
- D- Descemet's Membrane**
- E- Endothelium**

| Layers                   | Thickness (in $\mu\text{m}$ ) | Composition   |
|--------------------------|-------------------------------|---|
| Epithelium (Ep)          | 50                            | Stratified Squamous Epithelium                            |
| Bowman's Membrane (BM)   | 8-14                          | Compact layer of unorganised collagen fibres              |
| Stroma (SP)              | 500                           | Orderly arrangement of collagen lamellae with keratocytes |
| Descemet's Membrane (DM) | 10-12                         | Consists of basement membrane materials                   |
| Endothelium (En)         | 5                             | single layer of simple squamous epithelium                |

# Epithelium

- The outermost layer of **stratified corneal epithelium** is five to seven cells thick and measures approximately 50  $\mu\text{m}$ .
- The epithelium thickens in the periphery and is continuous with the conjunctival epithelium at the limbus

# stratified corneal epithelium

- The surface layer of corneal epithelium is two cells thick and displays a very smooth anterior surface. It consists of *nonkeratinized squamous cells*, each of which contains a flattened nucleus and fewer cellular organelles than deeper cells.
- Cell size varies but a superficial cell can be 50  $\mu\text{m}$  in diameter and 5  $\mu\text{m}$  in height

# Continue...

- The plasma membrane of the surface epithelial cells secretes a glycocalyx component that adjoins the mucin layer of the tear film
- Many projections located on the apical surface of the outermost cells increase the surface area, thus enhancing the stability of the tear film. The fingerlike projections are *microvilli*, and the ridgelike projections are *microplicae*

Fine ridges  
(microplicae)  
and  
processes  
(microvilli)  
of corneal  
surface cell



Scanning electron micrograph of junction of three superficial cells in cornea.

# Continue...

- Tight junctions (zonula occludens) join the surface cells along their lateral walls, near the apical surface. These junctures provide a barrier to intercellular movement of substances from the tear layer and prevent the uptake of excess fluid from the tear film.

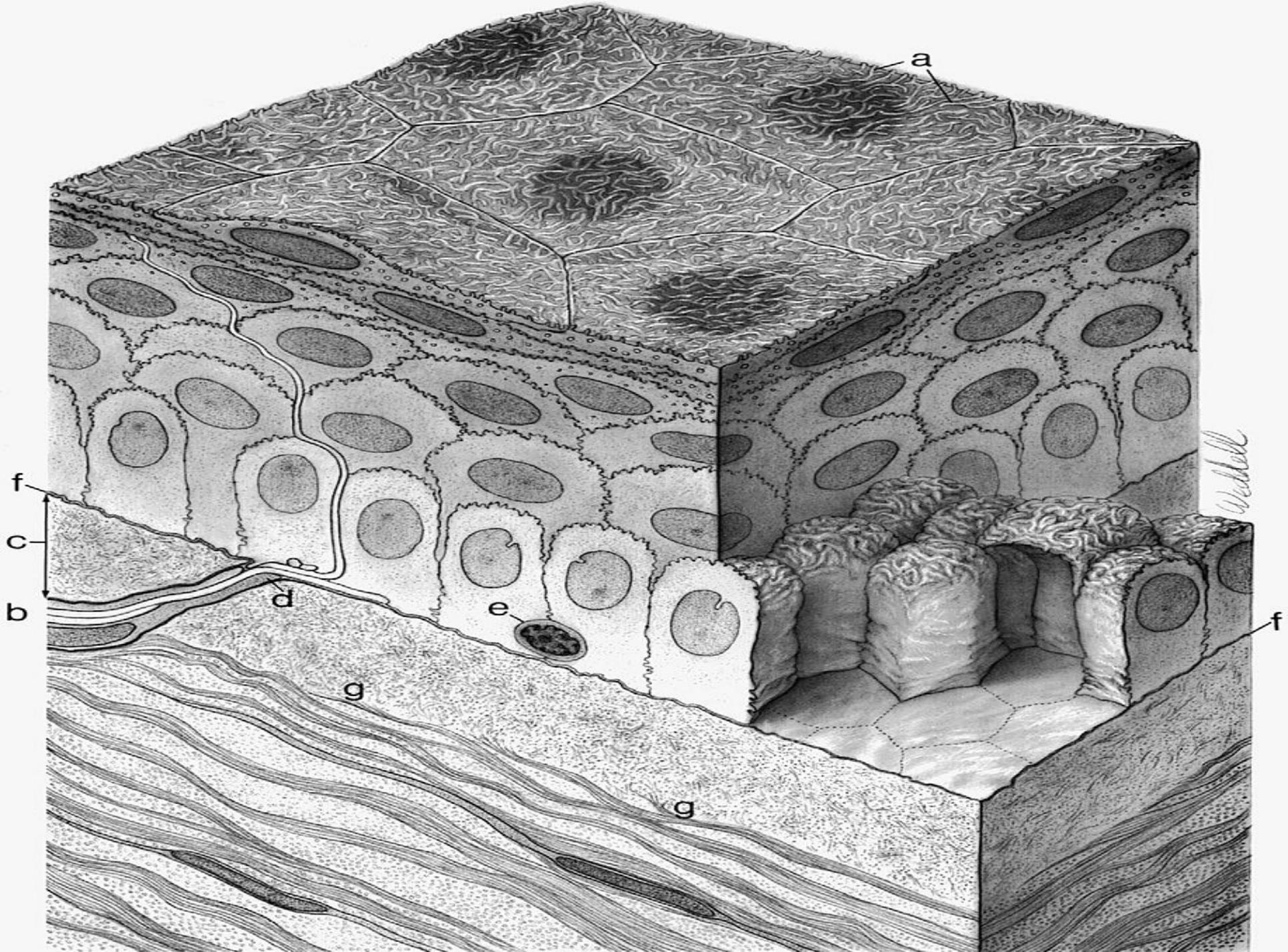
# Continue...

- As the surface cells age, they degenerate. The cytoskeleton disassembles and the cytoplasm condenses. The cells lose their attachments and are sloughed off, being constantly replaced from the layers below.
- The lighter cells are newer replacement cells, whereas the darker cells are those that are degenerating and will soon be sloughed.

| <b>Layers of epithelium</b> | <b>Description</b>  | <b>Mitotic activity</b> |
|-----------------------------|---|-------------------------|
| Basal Cell                  | Single layer of columnar cells found adjacent to basal layer                          | -                       |
| Wing cell                   | 2-3 layers of cells with elongated process  | -                       |
| Surface cells               | 3 layers of flattened epithelial cells with microvilli in contact with the tear film. | +                       |

# wing cells

- The middle layer of the corneal epithelium is made up of two to three layers of wing cells.
- These cells have winglike lateral processes, are polyhedral, and have convex anterior surfaces and concave posterior surfaces that fit over the basal cells.

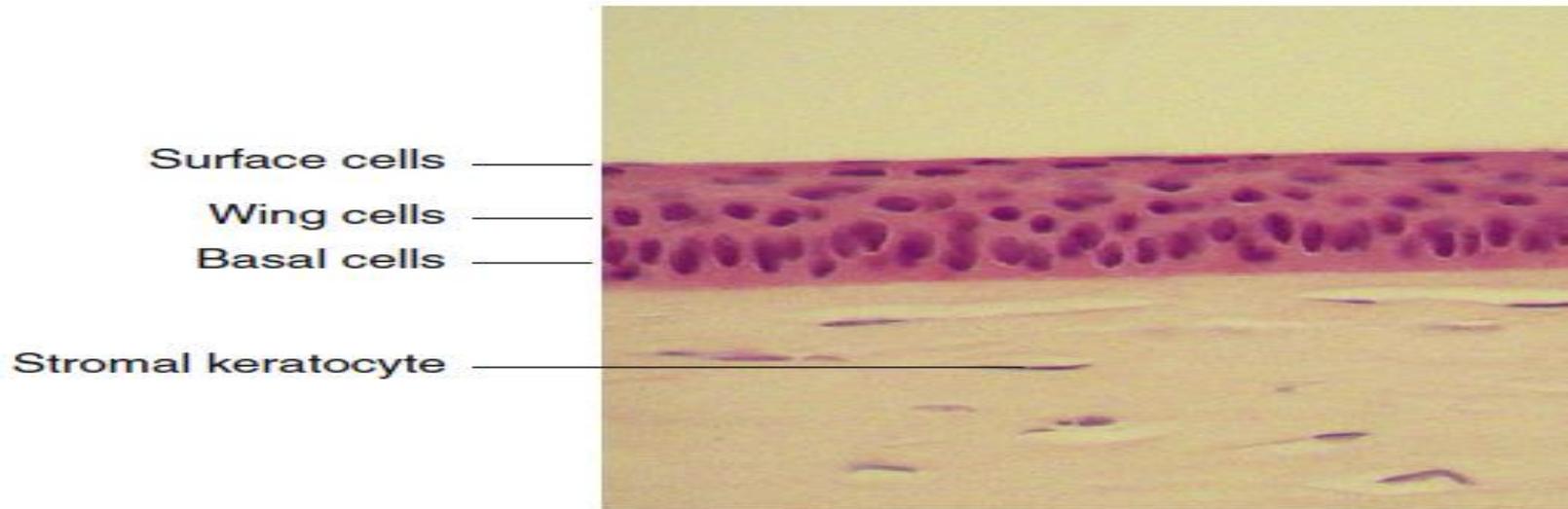


# Continue...

- The diameter of a wing cell is approximately 20  $\mu\text{m}$ . Desmosomes and gap junctions join wing cells to each other, and desmosomes join wing cells to surface and basal cells.

# basal cell layer

- The innermost basal cell layer of the corneal epithelium is a single layer of columnar cells, with diameters ranging from 8 to 10  $\mu\text{m}$ .



Light micrograph of corneal epithelium showing columnar basal cells, wing cells, and squamous surface cells of cornea; Bowman's layer and anterior stroma are also evident.

# Continue...

- These cells contain oval-shaped nuclei displaced toward the apex and oriented at right angles to the surface. The rounded, apical surface of each cell lies adjacent to the wing cells, and the basal surface attaches to the underlying basement membrane

# Continue...

- The basal cells secrete this basement membrane, which attaches the cells to the underlying tissue through hemidesmosomes. Anchoring fibrils pass from these junctions through Bowman's layer into the stroma.
- The basal layer is the germinal layer where mitosis occurs.

- The basal cells are joined to keratin filaments in the basement membrane by hemidesmosomes.

# *Epithelial Replacement*

- Maintenance of the smooth corneal surface depends on replacement of the surface cells that are continually being shed into the tear film. This renewal of the stratified epithelium involves cell division, migration, differentiation.
- Cell proliferation occurs in the basal layer.

# Continue...

- Basal cells move up to become wing cells, and wing cells move up to become surface cells.
- Only the cells in contact with the basement membrane have the ability to divide.
- The cells that are displaced into the wing cell layers lose this ability

# Continue...

- Stem cells located in a 0.5- to 1-mm-wide band around the corneal periphery are the source for renewal of the corneal basal cell layer.
- A slow migration of basal cells occurs from the periphery toward the center of the cornea.

- Turnover time for the entire corneal epithelium is approximately 7 days, which is more rapid than for other epithelial tissues.
- Repair to corneal epithelial tissue proceeds quickly.
- Minor abrasions heal within hours.
- Larger ones often heal overnight. If the basement membrane is damaged,
- Complete healing with replacement basement membrane and hemidesmosomes can take months

# *Bowman's Layer*

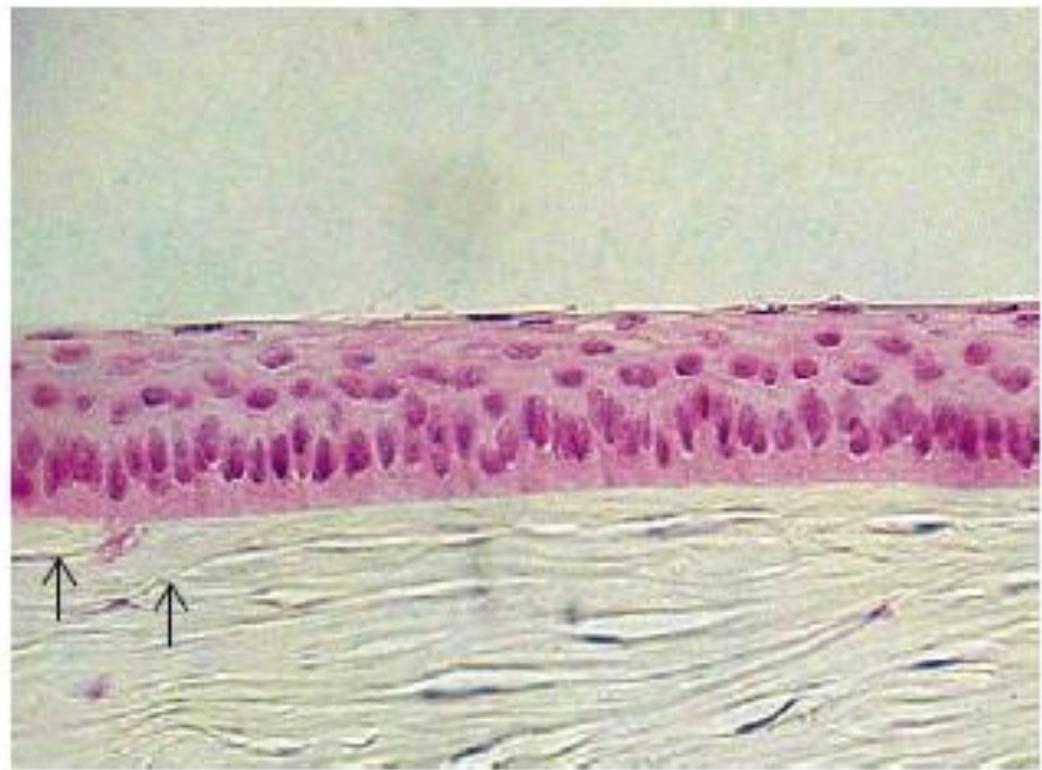
- The second layer of the cornea is approximately 8 to 14  $\mu\text{m}$  thick .
- Bowman's layer is a dense, fibrous sheet of interwoven collagen fibrils randomly arranged in a mucoprotein ground substance.
- The fibrils have a diameter of 20 to 25 nm, run in various directions, and are not ordered into bundles.

# Continue...

- Bowman's layer sometimes is referred to as a "membrane," but it is more correctly a *transition layer to the stroma rather than a true membrane.*
- Bowman's layer might provide biomechanical rigidity and shape to the cornea.
- Bowman's layer is produced prenatally by the epithelium and is not believed to regenerate

Bowman's layer <

Anterior stroma }



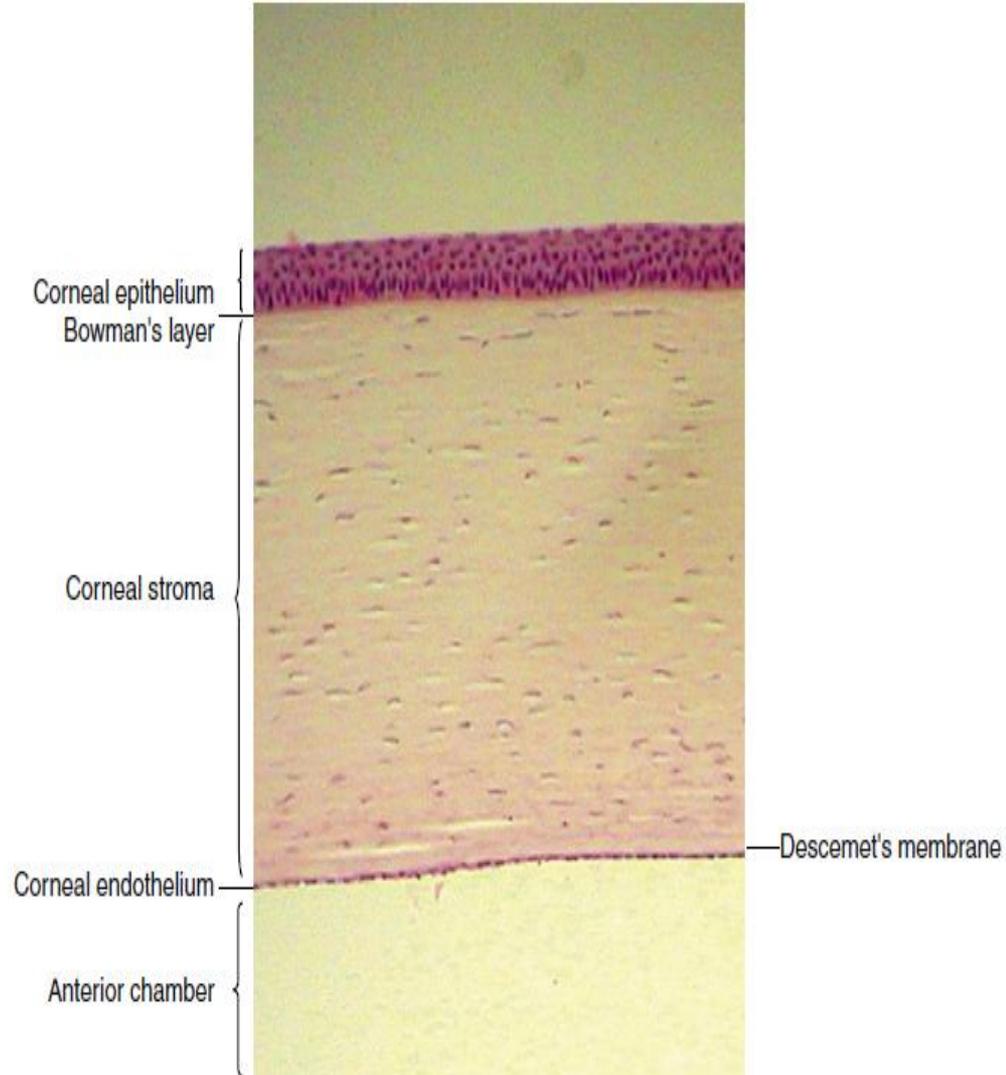
Light micrograph of corneal epithelium, Bowman's layer, and anterior stroma. There is a change in the direction of the superficial lamellae as they curve forward to merge with Bowman's layer (*arrows*).

# Continue...

- If injured, the layer usually is replaced by epithelial cells or stromal scar tissue.
- Bowman's layer is very resistant to damage by shearing, penetration, or infection.
- Corneal nerves passing through Bowman's layer typically lose their Schwann cell covering and pass into the epithelium as naked nerves.

# *Stroma or Substantia Propria*

- The middle layer of the cornea is approximately 500  $\mu\text{m}$  thick, or about 90% of the total corneal thickness.



# Continue...

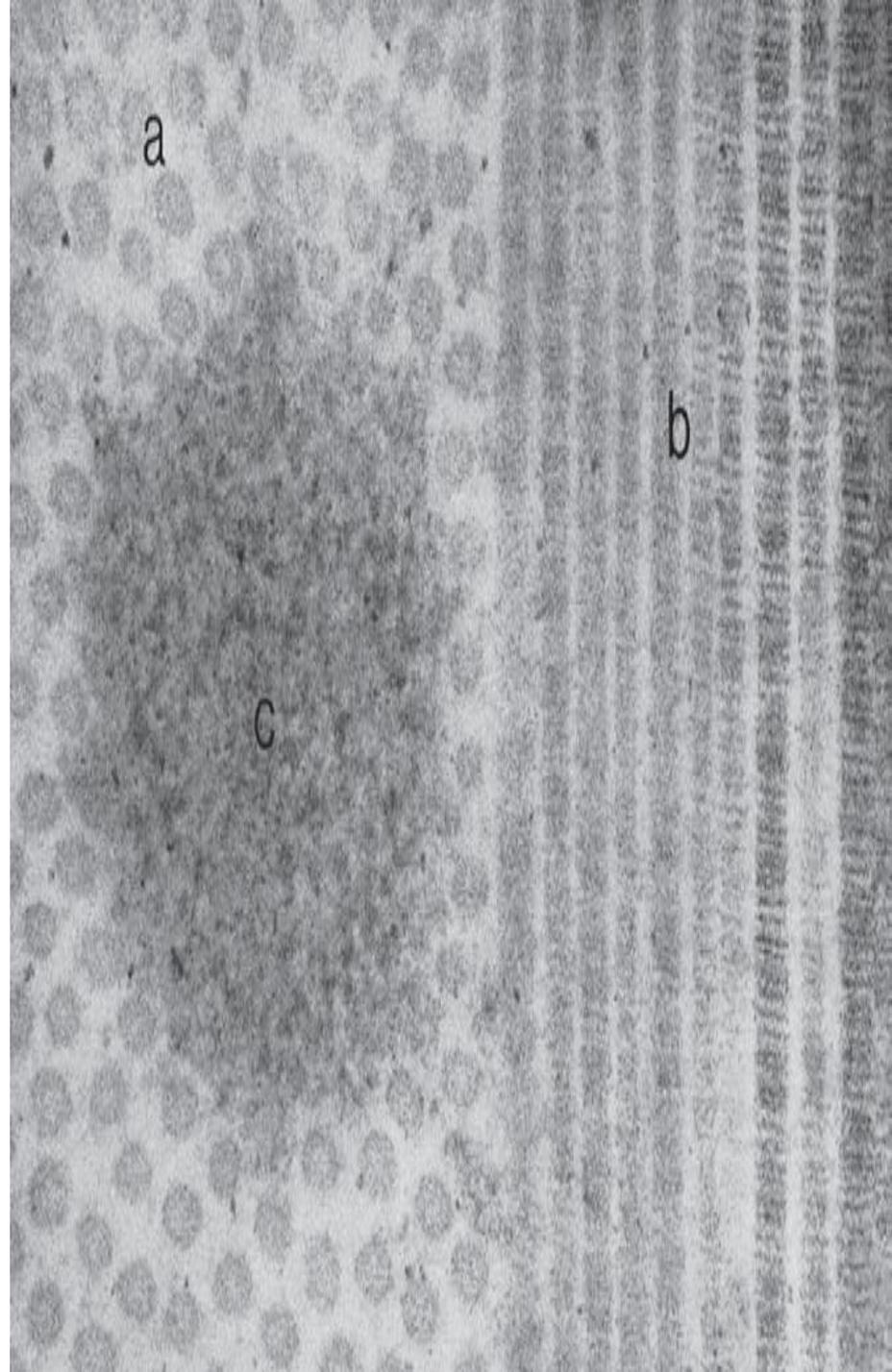
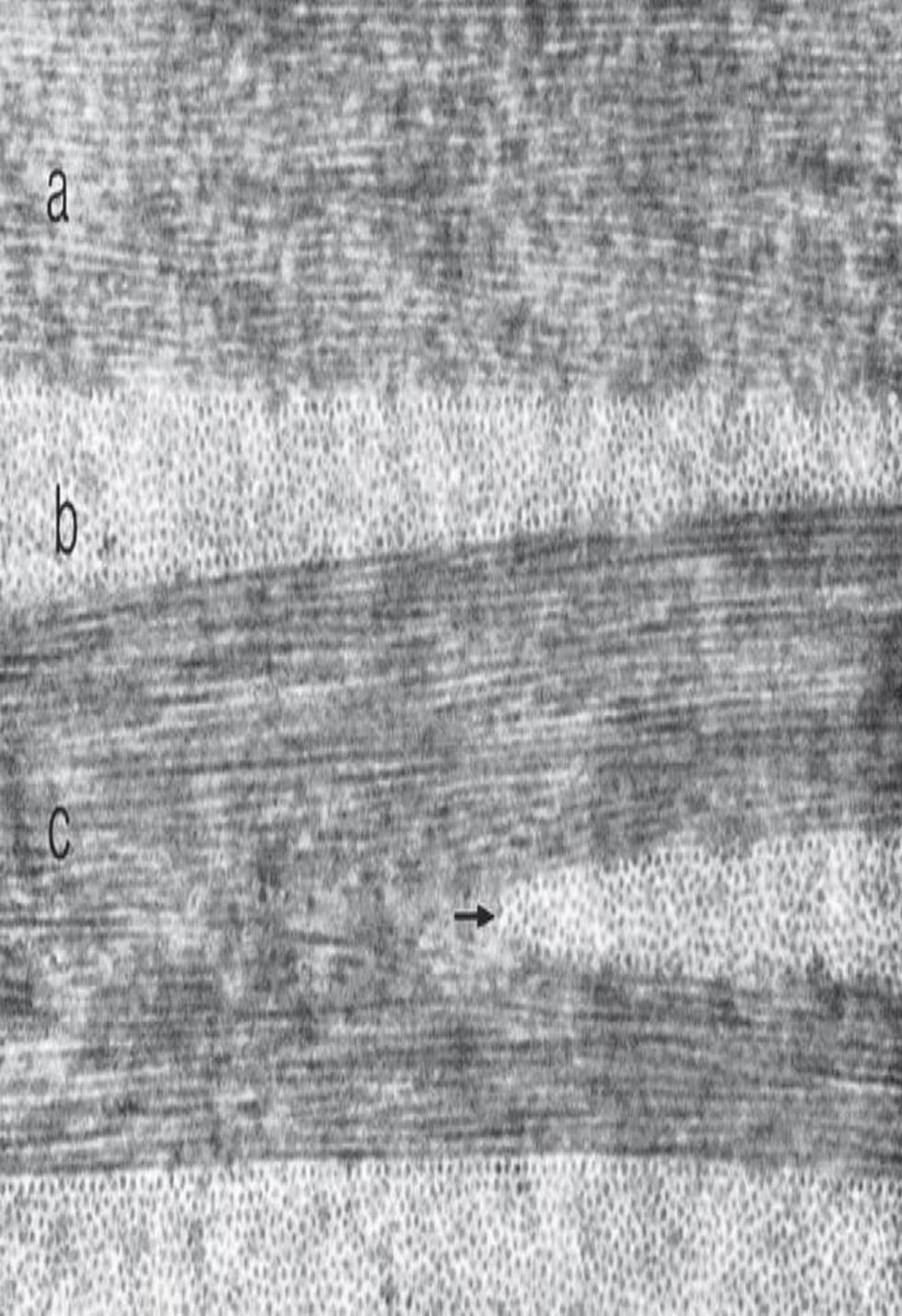
- The stroma (*substantia propria*) is composed of collagen fibrils, keratocytes, and extracellular ground substance.
- The collagen fibrils have a uniform 25- to 35-nm diameter and run parallel to one another.
- forming flat bundles called lamellae.
- The 200 to 300 lamellae are distributed throughout the stroma and lie parallel to the corneal surface.

# Continue...

- Each contains uniformly straight collagen
- fibrils arranged with regular spacing, sometimes described as a “latticework.” The fibrils are also oriented parallel to the corneal surface. Adjacent lamellae lie at angles to one another, but all fibrils within a lamella run in the same direction.

# Continue...

- Each lamella extends across the entire cornea, and each fibril runs from limbus to limbus. Interweaving occurs between the lamellae.



# Continue...

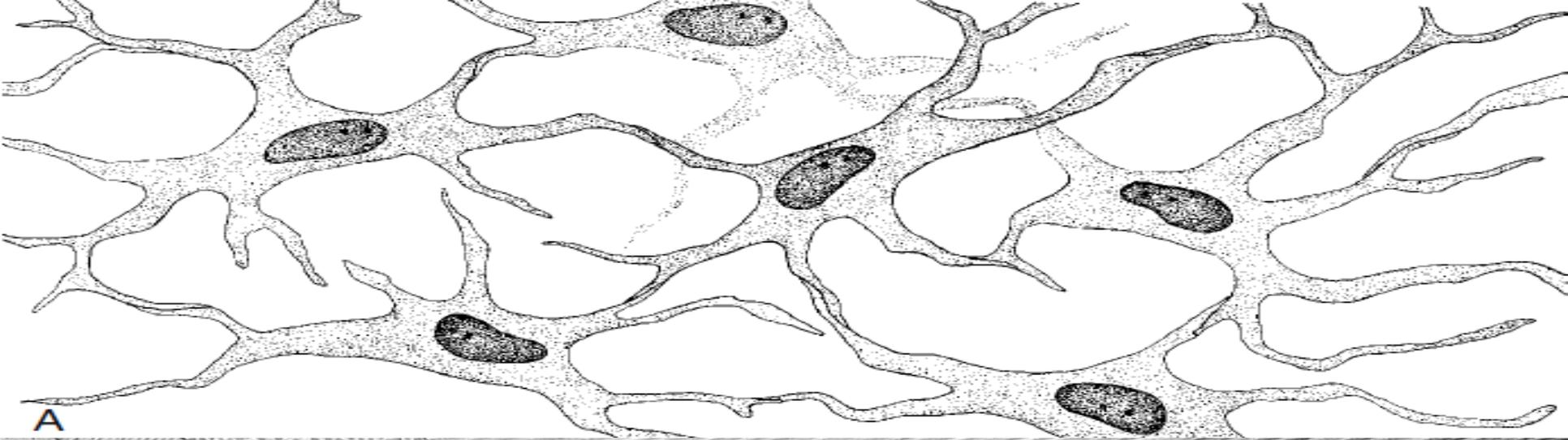
- The arrangement of the lamellae varies slightly within the stroma. In the anterior one third of the stroma, the lamellae are thin (0.5 to 30  $\mu\text{m}$  wide and 0.2 to 1.2  $\mu\text{m}$  thick), and they branch and interweave more than in the deeper layers.

# Continue...

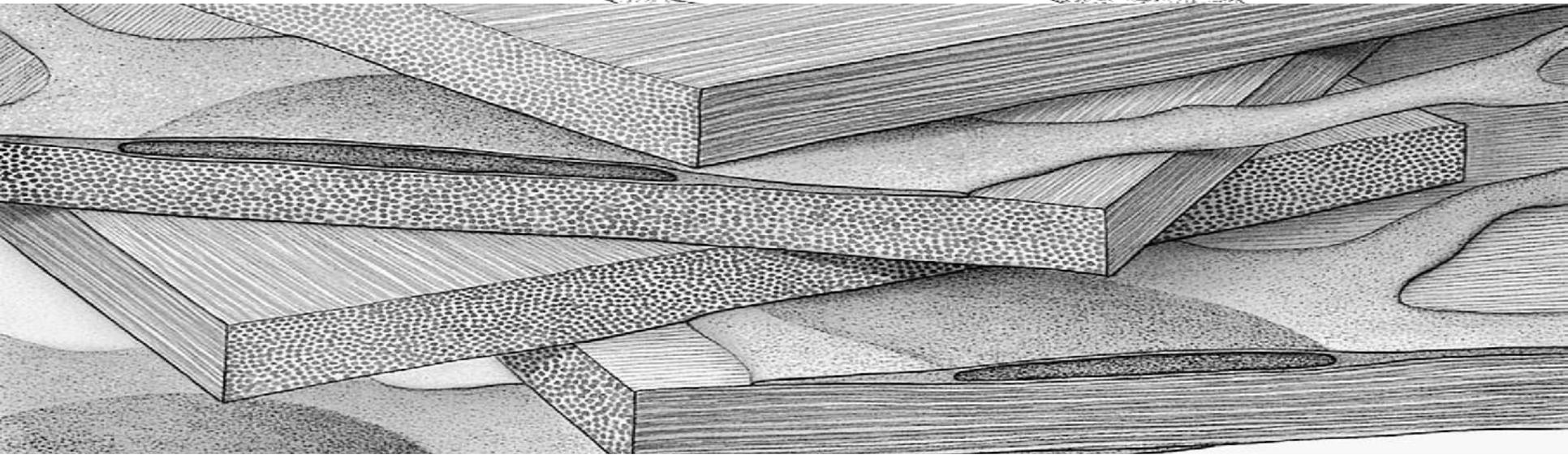
- In the posterior two thirds of the stroma, the arrangement is more regular, and the lamellae become larger (100 to 200  $\mu\text{m}$  wide and 1 to 2.5  $\mu\text{m}$  thick).
- Anterior cornea has a higher incidence of crosslinking and is more rigid, helping to maintain corneal curvature

# Continue...

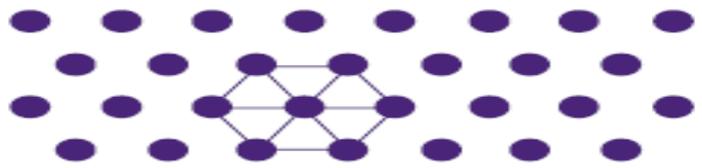
- **Keratocytes (corneal fibroblasts)** are flattened cells that lie between and occasionally within the lamellae.
- The cells are not distributed randomly; a corkscrew pattern is recognizable from anterior to posterior, with the density higher in anterior stroma



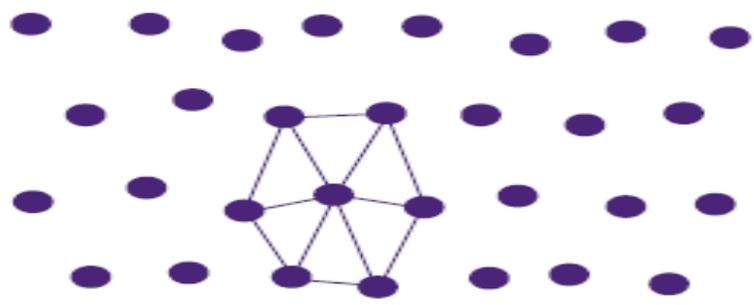
A



C



D



# Continue...

- **Ground substance** fills the areas between fibrils, lamellae, and cells. It contains *proteoglycans (PG)*, *macromolecules* consisting of a core protein with one or more attached glycosaminoglycan.

# Continue...

- **Glycosaminoglycans** are hydrophilic, negatively charged carbohydrate molecules located at specific sites around each collagen fibril.
- They attract and bind with water, maintaining the precise spatial relationship between individual fibrils.

# Continue...

- The very regular arrangement of the stromal components, as well as the small diameter of the fibrils, contributes to stromal transparency.
- The index of refraction of the fibrils is 1.411 and that of the extracellular matrix is 1.365

- If the change in the index of refraction occurs across a distance that is less than one half the wavelength of visible light (400 to 700 nm), *destructive interference occurs, and light scattering is reduced significantly.*
- Although the components of the epithelium, Bowman's layer, and Descemet's membrane are arranged irregularly, the scattering particles are separated by such small distances that light scattering is minimal in these layers.
- The cornea scatters less than 1% of the light that enters it.

# *Descemet's Membrane*

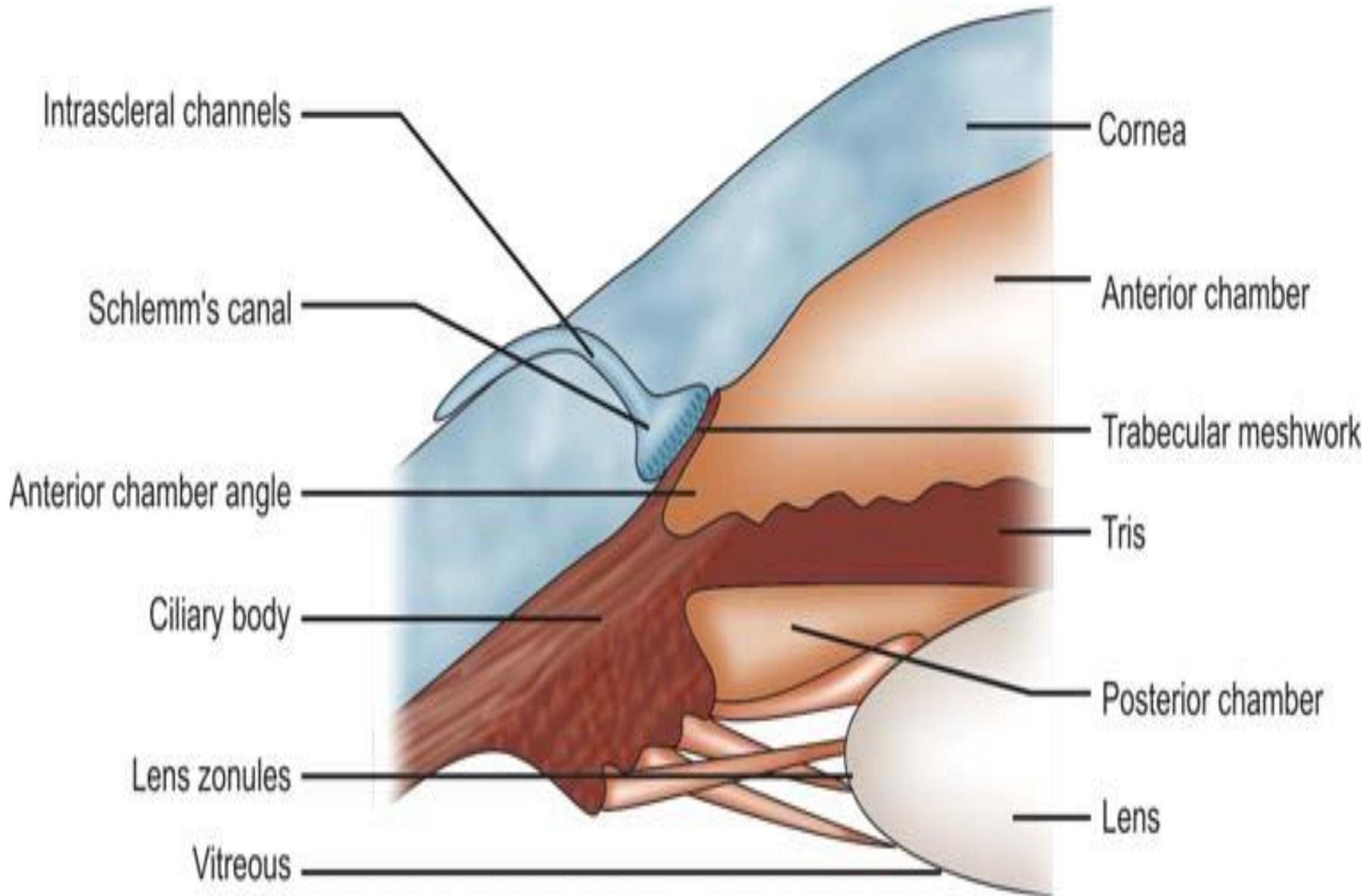
- is considered the basement membrane of the endothelium. It is produced continually and therefore thickens throughout life, such that it has doubled by age 40 years.
- In children it is 5  $\mu\text{m}$  thick and will increase to approximately 15  $\mu\text{m}$  over a lifetime.

# Continue...

- Descemet's membrane consists of two laminae.
  - 1. *anterior lamina.*** approximately 3  $\mu\text{m}$  thick, exhibits a banded appearance and is a latticework of collagen fibrils secreted during embryonic development.
  - 2. *Posterior lamina.*** is nonbanded and homogeneous.

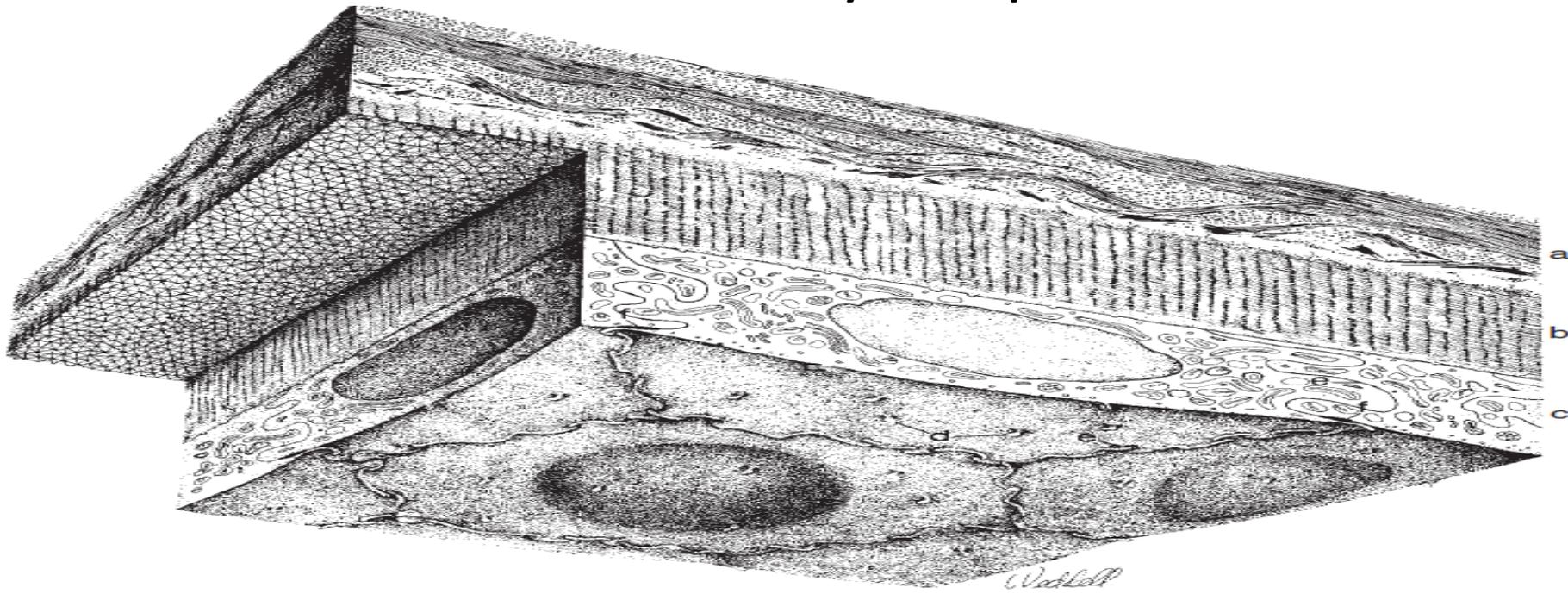
# Continue...

- it is the portion secreted by the endothelium throughout life.
- Descemet's membrane is very resistant to trauma, proteolytic enzymes, and some pathologic conditions but can be regenerated if damaged.
- A thickened area of collagenous connective tissue may be seen at the membrane's termination in the limbus; this circular structure is called Schwalbe's line



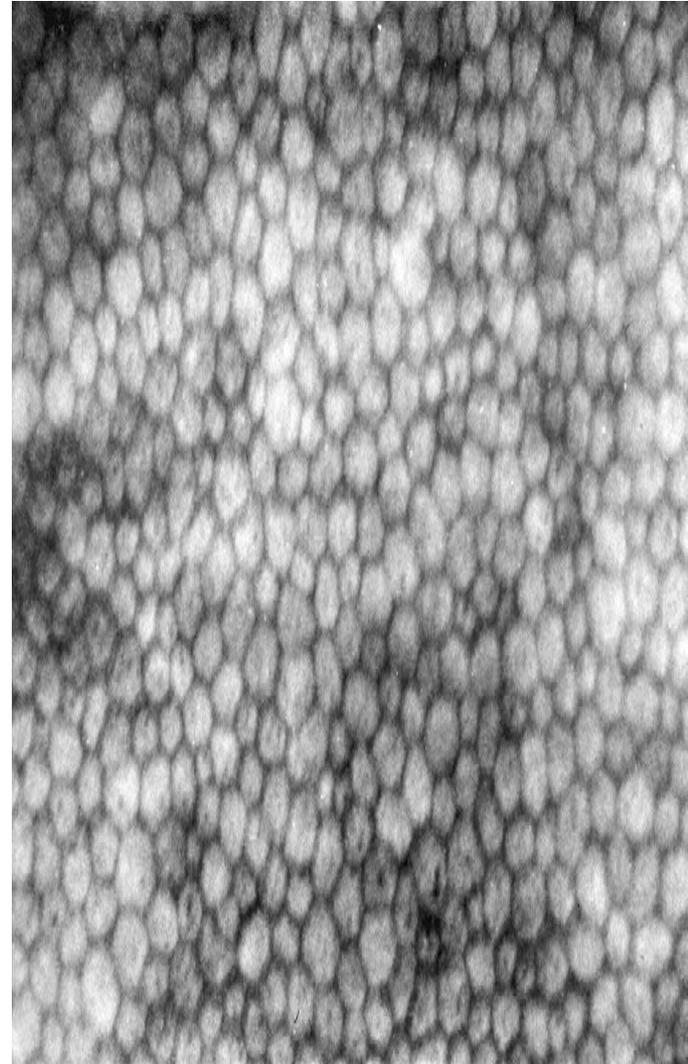
# *Endothelium*

- The innermost layer of the cornea, the endothelium, lies adjacent to the anterior chamber and is composed of a single layer of flattened cells. It normally is 5  $\mu\text{m}$  thick.



# Continue...

- Endothelial cells are polyhedral: five-sided and seven-sided cells can be found in normal cornea, but 70% to 80% are hexagonal.
- The hexagon is considered the most efficacious shape to provide area coverage without gaps.
- The very regular arrangement of these cells is described as the *endothelial mosaic*



# Continue...

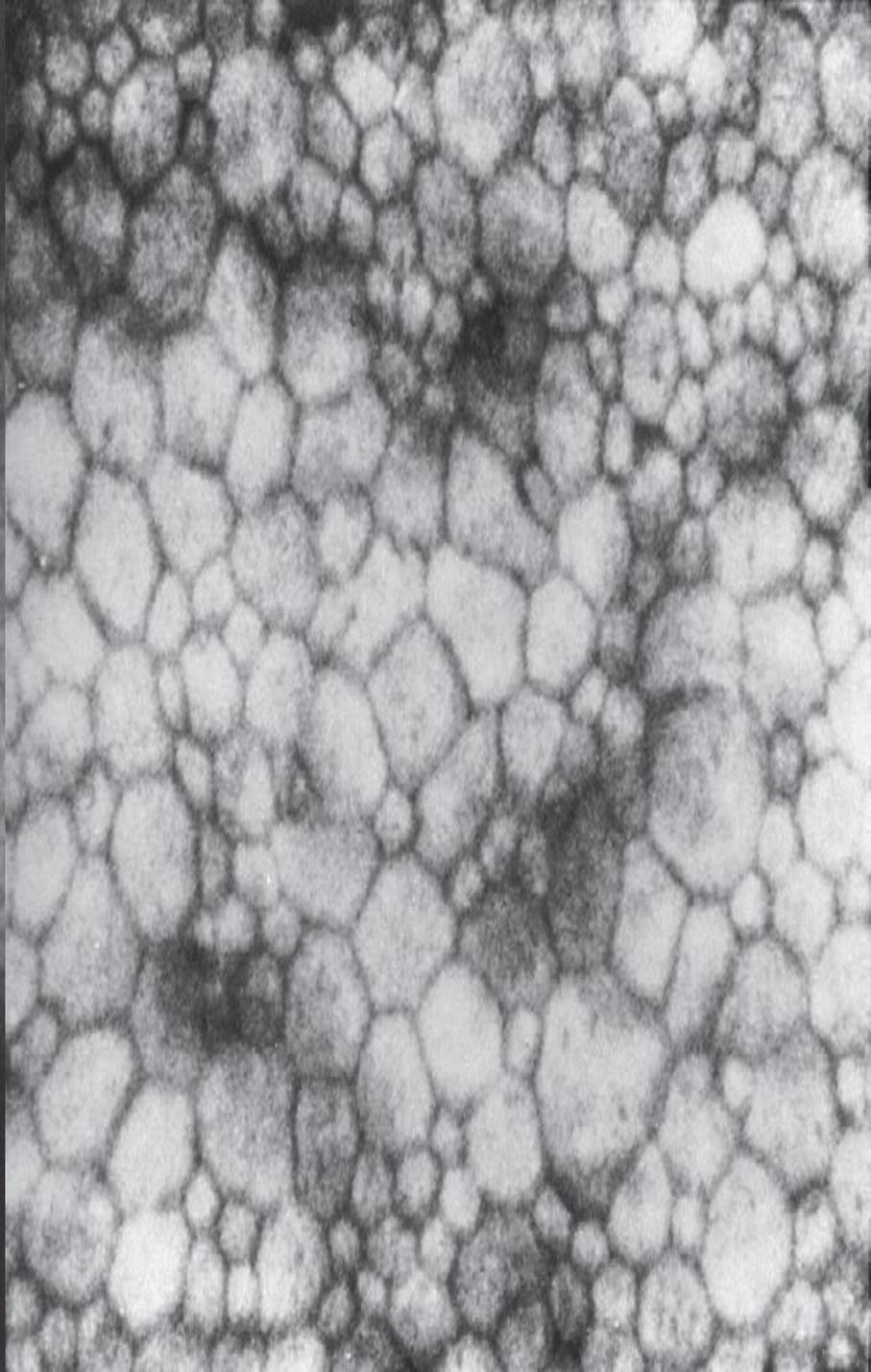
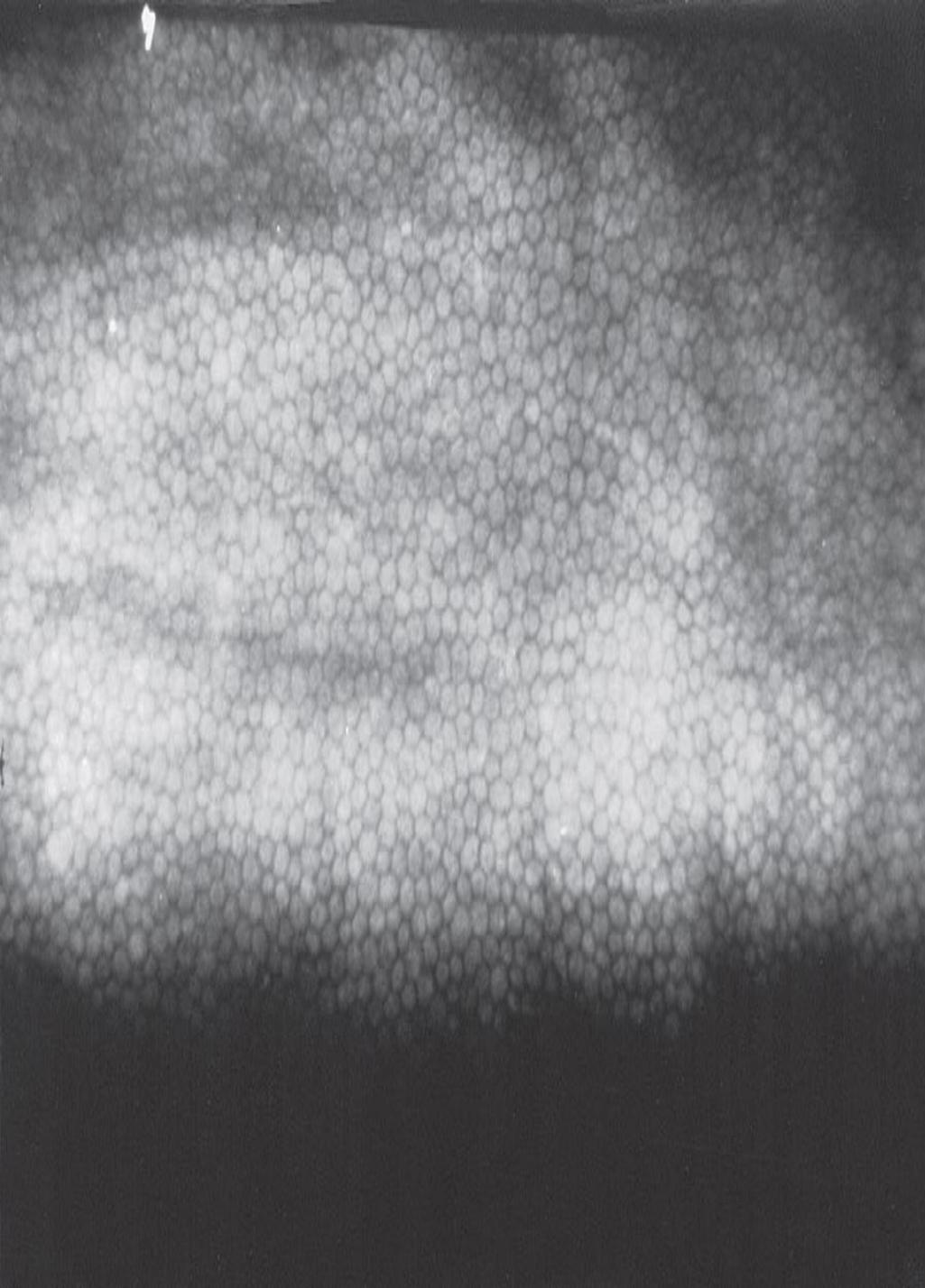
- Tight junctional complexes joining the endothelial cells are located near the cell apex.
- The barrier formed by these adhesions is slightly leaky.
- This incomplete barrier allows the entrance of nutrients, including glucose and amino acids, from the aqueous humor.

# Continue...

- The endothelial cell is rich in cellular organelles; mitochondria reflect high metabolic activity and are more numerous in these cells than in any other cells of the eye, except the retinal photoreceptor cells.
- The cell density (cells per unit area) of the endothelium decreases normally with aging because of cell disintegration

# Continue...

- density ranges from 3000 to 4000 cells/mm<sup>2</sup> in children
- to 1000 to 2000 cells/mm<sup>2</sup> at age 80 years.
- The minimum cell density necessary for adequate function is in the range of 400 to 700 cells/mm<sup>2</sup>
- Disruptions to the endothelial mosaic can include endothelial cell loss or an increase in the variability of cell shape (*pleomorphism*) or size (*polymegathism*)



# Continue...

- The active pump function can be detrimentally affected by polymegathism or morphologic changes.
- An excessive loss of cells can disrupt the intercellular junctions and allow excess aqueous to flow into the stroma, and the endothelial pumps may be unable to compensate for this loss of barrier function.

# CORNEAL FUNCTION

- The cornea has two primary functions: to refract light and to transmit light.
- Factors that affect the amount of corneal refraction include....
  1. the curvature of the anterior corneal surface,
  2. the change in refractive index from air to cornea
  3. Corneal thickness,

# Continue...

4. The curvature of the posterior corneal surface
5. the change in refractive index from cornea to aqueous humor.