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         i. Iris
         ii. Ciliary body
         iii. Choroid
      c. Neural tunic (Retina)
   4. Optic Nerve

B. Eyelid

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      a. External ear
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Fig 23-1, Junqueira, 13th ed.
Keywords

Anterior chamber  Nucleated fibers
Bowman's membrane  Optic disc
Canal of Schlemm  Optic nerve
Choroid  Outer plexiform layer
Ciliary body  Pigmented epithelium
Ciliary processes  Posterior chamber
Cochlea  Retina
Cochlear duct  Rods
Cones  Scala media
Conjunctiva  Scala tympani
Cornea  Scala vestibuli
Descemnet's membrane  Scleral venous sinus
Dilator pupillae m.  Sphincter pupillae m.
Fovea  Spiral ganglion
Hair cells  Spiral organ of Corti
Inner limiting membrane  Stria vascularis
Inner plexiform layer  Substantia propria
Iris  Suspensory ligament
Lens  Tarsal plate
Limbus  Tectorial membrane
Meibomian glands  Vestibular membrane

Lab 20 – Special Senses
IUSM – 2016

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the eye is divided into two cavities based upon the lens: posterior to the lens is the posterior cavity containing the vitreous body (humor) which is a large gelatinous mass of transparent connective tissue composed mainly of water; anterior to the lens is the anterior cavity which is subdivided into the anterior and posterior chambers based upon the iris; the anterior cavity is filled with aqueous humor which is produced by the ciliary processes in the posterior chamber and flows through the pupil into the anterior chamber.
the **lens** is an avascular, biconvex, transparent disc derived from epithelium and attached to the ciliary body by the suspensory ligament; the flexibility of the lens allows it to change shape to affect light refraction upon the retina; its transparency is principally due to the loss of light-scattering organelles (such as the nucleus), the presence of crystallin proteins, and the precise shape and organized packing of its non-nucleated fibers.
the **fibrous tunic** is the outermost layer of the eye; it consists of two major regions:

1. **sclera** - posterior 5/6th; the “white” of the eye; consists of dense CT that protects the eye and serves as site for extraocular muscle attachment
2. **cornea** - anterior 1/6th; transparent and avascular; serves as primary site of light refraction; density of pain receptors is >100x greater than in skin and >10x than in dental pulp

the sclera and cornea are joined at the **limbus** (Lt. “edge”) which encircles the cornea and serves as its source of stem cells; it becomes more stratified at the **conjunctiva** which is the stratified columnar mucous membrane with numerous goblet cells that covers the exposed portion of the sclera (not the cornea) and the inside of the eyelid
Slide 78: Eye, H&E

- Corneal epithelium: stratified squamous
- Substantia propria (stroma): lamellae of collagen bundles with interspersed keratocytes
- Bowman's membrane: (anterior limiting membrane)
- Descemet's membrane: (des-suh-mays) (posterior limiting membrane)
the corneal epithelium is nonkeratinized stratified squamous epithelium generally with 5-7 cell layers; cell turnover is about 7 days from stem cells located in the limbus; unlike the overlying epithelium, Bowman's membrane is relatively static and does not regenerate after injury; the uniform orientation of the CT fibers within the substantia propria contributes to corneal transparency
the cornea is avascular, so most metabolic exchange occurs across the corneal endothelium with the aqueous humor in the anterior chamber; additionally the endothelium keeps the cornea dehydrated by actively pumping Na+ into the chamber (water follows); Descemet’s membrane separates the endothelium from the substantia propria, but unlike Bowman’s membrane it is readily regenerated after injury if the endothelium is intact; unlike the corneal epithelium, the endothelium has limited regenerative potential
the **sclera** (Gr. “hard”) is the opaque layer of dense CT constituting the posterior 5/6th of the fibrous tunic; it serves to maintain the rigidity of the eye and as the site of attachment for the tendons of the extraocular muscles.
the vascular tunic (uvea) is the middle layer of the eye; it consists of three parts:

1. **iris**: most anterior portion of vascular tunic; contains many melanocytes that provide the color of the eye and prevent the passage of light, leaving only the central **pupil** (opening) for light to pass through; contains:
   a. dilator pupillae m.
   b. sphincter pupillae m.

2. **ciliary body**: expansion of the vascular tunic, encircling the lens; consists of:
   a. ciliary muscle
   b. ciliary processes

3. **choroid**: located in posterior 2/3rd of eye; contains:
   a. loose CT
   b. lots of vasculature
   c. melanocytes
the iris consists of a CT stroma with an uncovered anterior surface, not lined by an epithelium bordering the anterior chamber; the posterior pigmented epithelium blocks light entering the eye except through the pupil and separates the stroma from the posterior chamber, however the basal lamina faces the chamber side, not the stroma; the sphincter pupillae m. has parasympathetic innervation and constricts the pupil; the dilator pupillae m. is a thin layer of myoepithelial cells with sympathetic innervation that dilate the pupil.
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the ciliary body controls the shape of the lens and produces aqueous humor; it is composed of the ciliary muscle and the ciliary processes; the ciliary muscle is attached to the lens via zonular fibers from between the ciliary processes to form the suspensory ligament; during accommodation, contraction of the ciliary muscle releases tension on the ligament causing the lens to thicken permitting focus on near objects; the ciliary processes are covered by a double layer of columnar epithelium which secretes aqueous humor into the posterior chamber; the aqueous humor then passes through the pupil to enter the anterior chamber where it drains into the trabecular meshwork and the scleral venous sinus to return to the systemic circulation.
the choroid contains loose CT, vasculature, and melanocytes
the vasculature provides oxygen and nutrients to the adjacent tissues
the melanocytes provide the dark coloration of the choroid and serve to absorb scattered light and reduce reflection
1. **inner limiting layer**: basal lamina of Müller cells (glial cells) which support the cells and processes of retina; they extend to the outer limiting layer, where they form tight/adherens junctions with rods and cones.

2. **nerve fiber layer**: axons from ganglionic layer below; axons converge at the optic disc and collectively leave the eye as the optic nerve.

3. **ganglionic layer**: cell bodies of multipolar ganglion cells; axons will collectively form the optic nerve.

4. **inner plexiform layer**: axodendritic connections between bipolar neurons and ganglion cells.

5. **inner nuclear layer**: cells bodies of bipolar cells and other neurons; bipolar cells (interneurons) connect photoreceptors to ganglion cells.

6. **outer plexiform layer**: axodendritic connections between photoreceptors and neurons from the inner nuclear layer.

7. **outer nuclear layer**: cell bodies of rods and cones (photoreceptors).

8. **outer limiting layer**: junctions between rods/cones and Müller cells.

9. **photoreceptors**: photosensitive processes of rods (light) and cones (color).

10. **pigmented epithelium**: melanin-containing cuboidal epithelium; absorbs light, forms part of blood-retina barrier, and aids chromophore recycling.

**choroid of vascular tunic**
pathway of light:

1. through cornea where it is refracted (air-corneal surface), accounting for 2/3 of eye’s total optical power

2. through anterior cavity, where additional refraction occurs; muscles of the iris regulate amount of light passing through pupil and "entering the eye"

3. through the lens it again is refracted; the lens accounts for 1/3 of the eye’s total optical power; ciliary mm. can affect shape of lens (contract to loosen tension on suspensory ligaments to accommodate near vision) affecting refraction

4. through vitreous body, transmitting light to retina

5. through retinal layers to “deepest” level for photoreceptors

pathway of “information”:

1. inhibition of photoreceptors (inhibitory): photons hit chromophore molecules (e.g., retinal in rods) on “stacked” membranes of photoreceptors (rods or cones); the energized chromophore leads to a confirmation change in its associated opsin protein (rhodopsin in rods, or one of 3 iodopsins for cones); the opsin activates transducin, leading to decreased cGMP and closure of Na+ channels; cell becomes hyperpolarized and stops releasing neurotransmitter (glutamate) to bipolar cells

2. bipolar cells are no longer inhibited by photoreceptors; they depolarize and send action potentials (APs) to ganglion cells

3. ganglion cells conduct APs through axons into optic nerve

4. optic nerve → optic chiasm → LGN (thalamus) → primary visual cortex in occipital lobe of brain → “vision”
nerve fibers from the retina (cell bodies in the ganglionic layer) converge at the optic disc to form the optic nerve (CN II), which carries the sensory information into the brain; because the optic disc consists of bundles of nerve fibers and lacks photoreceptors, it is a “blind spot” in the visual field.
the eyelids provide a protective covering of the anterior surface of the eye; they consist of skin lining the outer surface and an inner core of fibroelastic CT known as the tarsus (Gr. “flat surface”); lining the innermost surface of the tarsus is the conjunctiva (mucous membrane) continuous onto the anterior sclera of the eye.
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**tarsus (tarsal plate)**
dense fibroelastic CT that contributes form and support to the eyelid

**tarsal (Meibomian) glands**
sebaceous glands which produce oils that form a surface layer on tear film, reducing evaporation, and lubricating ocular surface

**conjunctiva**
mucous membrane with a stratified columnar epithelium w/ goblet cells, providing lubrication of surfaces; covers internal eyelid and anterior (exposed) portion of the sclera
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The external **auditory meatus** (acoustic canal) is the air-filled canal that transmits sounds collected by the auricle of the ear to the tympanic membrane (eardrum); the canal is lined with skin and contains large **ceruminous glands**; the outer (lateral) portion of the canal is supported by **elastic cartilage**, continuous with the cartilage of the auricle.
the bony **cochlea** (Lt. “snail shell”) of the **inner ear** arises from the vestibule and makes 2 ¾ turns (more are visible on slide above since guinea pig, not human); the cochlear canal is divided into three compartments: the **scala vestibuli** and **scala tympani** which connect at the apex of the cochlea and are filled with perilymph, and the central **scala media** (**cochlear duct**) which contains the sensory **organ of Corti** and is filled with endolymph
the spiral **organ of Corti** is responsible for the sensation of sounds; it rests on the **basilar membrane** within the **scala media**; its **hair cells** (outer and inner) have stereocilia attached to the connective tissue **tectorial membrane**; sound energy creates a shearing effect between the basilar and tectorial membranes, causing the **hair cells** (surrounded by endolymph with high K+) to release neurotransmitters to cells in the **spiral ganglion**.
1. pressure waves from the oval window travel through the scala vestibuli, causing the vestibular membrane to move, and generating pressure waves in the scala media; the scala vestibuli connects to the scala tympani through the helicotrema at the apex of the cochlea, permitting pressure waves to displace the round window into middle ear

2. pressure waves pass in the scala media displace the basilar membrane; composition of the basilar membrane differs according to its location and affects its displacement: high-frequency sounds displace it near the oval window while low-frequency sounds travel farthest and cause displacement at the most distal portion, near the helicotrema

3. outer hair cells (3–5 rows), with stereocilia (no kinocilium) in tectorial membrane, depolarize when stereocilia are deformed by movement of basilar membrane; depolarization causes cells to rapidly shorten, pulling down on tectorial membrane which pulls and deforms the stereocilia of the inner hair cells

4. inner hair cells depolarize if pulled toward longest stereocilium, releasing neurotransmitters that synapse with bipolar neurons in spiral ganglion; these neurons fire APs down their axons which form the cochlear branch of CN VIII (vestibulocochlear)

5. CN VIII → cochlear nuclei → sup. olivary nuclei → inf. colliculus → MGN (thalamus) → primary aud. cortex in temporal lobe → “hearing”
Common Confusion:
Lip vs. Eyelid

**Lip:** movable fold of soft tissue surrounding the mouth

Look for: (1) internal surface is lined by oral mucosa with non-keratinized stratified squamous epithelium; (2) transition zone between skin and mucosa is more external than in eyelid so skin does not cover anterior surface; (3) mucous labial salivary glands deep to skeletal muscle.

**Eyelid:** protective covering for the anterior surface of the eye

Look for: (1) internal surface is lined by conjunctiva with stratified columnar epithelium and many goblet cells; (2) skin extends over anterior surface; (3) sebaceous tarsal glands deep to skeletal muscle; (4) dense fibroelastic CT tarsal plate.