Vision Using Lasers to Explore How the Eye Works

PURE OPTICS

Phernell Walker, MBA, ABOM, LDO
Renowned National Speaker
Pure Optics LLC

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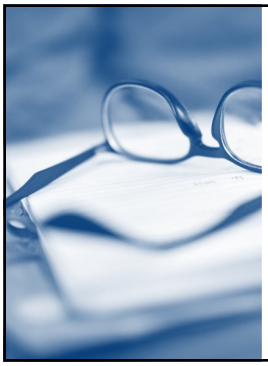

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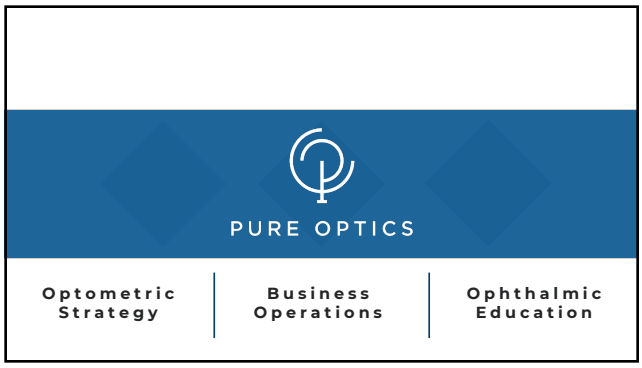
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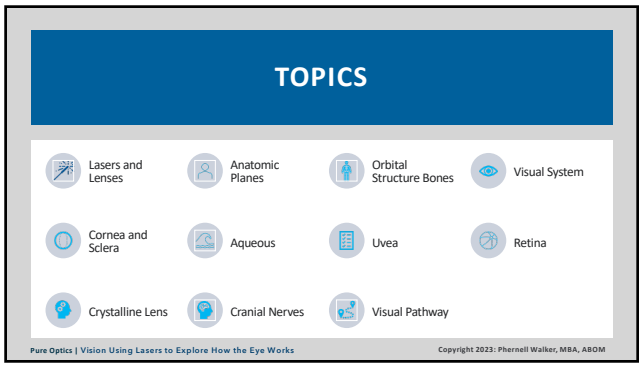
TOPICS
Lasers and Lenses
Anatomic Planes
Orbital Structure Bones
Visual System
Cornea and Sclera
Aqueous
Uvea
Retina
Crystalline Lens
Cranial Nerves
Visual Pathway
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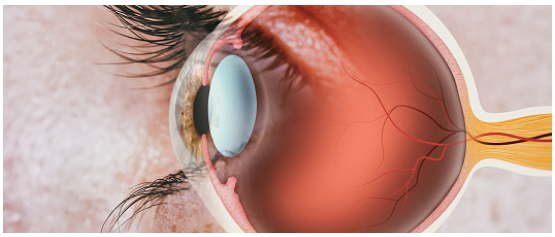
Amazing Optical System



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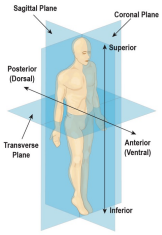
Anatomical Directions & Planes



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Orbital Bones

- **Ethmoid bone** – separates nasal cavity and brain
- **Frontal bone** - two parietal bones, forms superior portion of the socket
- **Lacrimal bone** – provides structure for orbit
- **Maxilla bone** – creates the floor of the orbital over all structure
- **Palatine bone** – forms the orbital floor and lateral walls
- **Sphenoid bone** – forms the orbital floor and lateral walls of the orbit
- **Zygomatic bone** – lateral bone forms the check area

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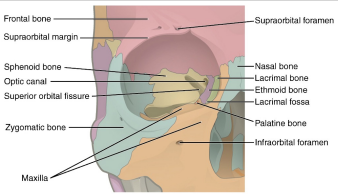
Orbital Structure



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Conjunctiva

- **Palpebral Conjunctiva** is a mucous membrane extending from the lid margins over the sclera to the limbal margins
- **Bulbar Conjunctiva** – mucous membrane that covers the globe

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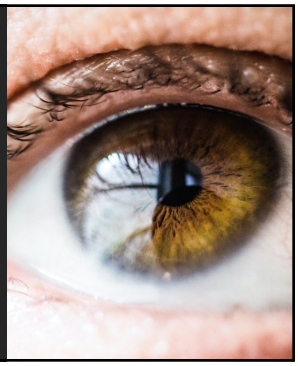
Conjunctiva



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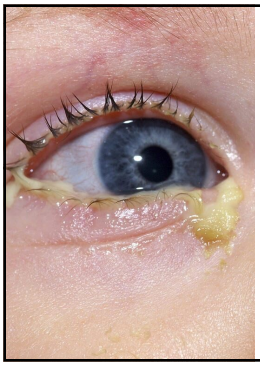

Conjunctiva

Conjunctivitis (pink eye) — red, inflammation of the conjunctiva

Causes:

bacteria or viral infection	allergic reaction from chemical irritants

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Lacrimal Gland

- **Lacrimal Gland** - located above the orbital globe under the eyebrows
- Responsible for producing tears
- Tears moisturize the eyes, distribute oxygen
- Tears contain lysosomes
- **Lysosome** - antibacterial enzyme (germ killer)

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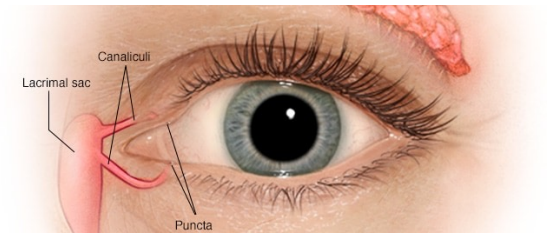
Tear Gland and Ducts



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Palpebrae

- Distribute tears across the cornea and wash away bacteria
- Protects the eye from foreign objects and bright light

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Palpebrae

- Orbicularis oculi muscle is responsible for blinking
- Levator palpebrae superioris muscle keeps the lid open
- Interpalpebral fissure - widest opening (approximately 10mm vertically and 30mm horizontally) between the upper and lower palpebrae

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Meibomian Glands

- **Meibomian glands** (also called tarsal glands) are located along the rims of the eyelid in the tarsal plate (25 upper and 20 on lower lids)
- Produce meibum, an oily substance that prevents evaporation of the tear film
- Meibum prevents tears from spilling onto the cheek, traps them between the oiled edge and the eyeball, and makes the closed lids airtight

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Precorneal Tear Film

Precorneal Tear Film
Lipid – First layer. Oily layer that prevents evaporation of the aqueous layer.
Aqueous – Second layer. Maintains a moist outer eye.
Mucoid – Third layer. Provides a smooth distribution for tears and adherence.

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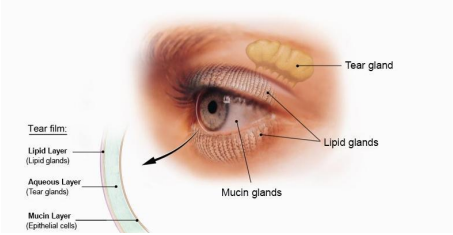
Tear Film



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Lacrimal Lake

- Collection of tears in the medial angle between the eyelids towards the medial canthus
- Blinking causes the tears to be pumped into the punctum

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Ocular Globe

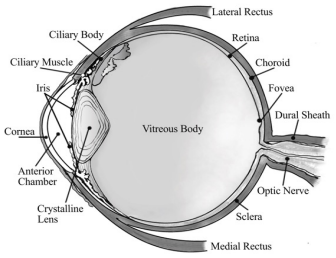

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Image Formation

Physiological

a. Refractive structures of the eye
b. Accommodation by the crystalline lens
c. The depth of field controlled by pupil size
d. Photoreceptors (light receiving)

Rods

a. Scotopic Vision (night)
b. Peripheral retina
c. Light sensitive can detect a single photon

Cones

a. Photopic Vision (daylight)
b. Color vision
c. Cones concentrated in 0.3mm of the fovea centralis.

Both rods and cones

a. Mesopic Vision (twilight)

Optic nerve

Transmits the visual impression to the brain where vision takes place

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Image Formation

System	Anatomical Structure	Provides
Physiological Lens System	Cornea	43 diopters of static power
	Pupil	Depth of field
	Crystalline Lens	19 diopters of variable focus power

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Ocular Refractive Conditions

No Refractive Error

- Emmetropia
- Glasses or Contacts not indicated

Ametropia (Refractive Errors)

- Myopia (nearsighted)
- Hyperopia (farsighted)
- Astigmatism
- Glasses or Contact Lenses indicated

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Emmetrope

Cornea: +43.00 D (t = .5 mm center)

Crystalline Lens = +19.00 D

Index of Refraction:

- Cornea: 1.376n
- Crystalline lens: 1.416n
- Aqueous/ Vitreous: 1.336n
- Abbe Value: 45

Axial length: 24 mm (eye measured from front to back)

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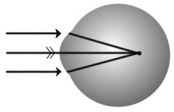
Myopia

Nearsighted

Eyeball is too long

Light's focus is before the retina

Corrected using minus lenses



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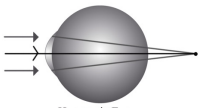
Hyperopia

- Farsighted
- Eyeball is <u>too</u> short
- Light's focus is after the retina
- Corrected using plus lenses



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Astigmatism

- Most common refractive error
- Causes': irregular shaped cornea or lenticular lens

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Laser Ray Tracing

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Cornea

- Thin, transparent membrane that focus' light.
- The corneas attenuates UV radiation between 240 an 310nm.
- Over exposure can result in photokeratitis

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Corneal Layers

- **C**orneal Epithelium
- **B**owman's
- **S**troma (thickest layer 90%)
- **D**ecemets
- **E**ndothelium

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Cornea

- 43.00 D (fixed power)
- 0.5 mm center thickness
- 1.0 mm edge thickness
- Index = 1.376_n
- 5 layers
- Steeper center
- Flatter periphery

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Corneal Epithelium

- **Corneal Epithelium –** outermost layer
- 5 to 7 cells thick
- Microvilli – fingerlike projections increases tear film stability
- Highly sensitive to pain
- Injury causes lacrimation and photophobia

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Bowman's Layer

- **Bowman's** – anterior limiting membrane
- 10 to 12 micrometers
- Collagen fibers
- Non-regenerative
- Barrier from infection

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Storoma

- **Stroma** (thickest layer 90%)
- ~200 sequentially arranged lamellae
- Collagen fibers

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Descemet's Layer

- **Descemet's –** basement membrane
- Acellular – two laminae
- Constantly produced and thickens over time
- Doubles by the age of 40 years

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Endothelium

- Endothelium – innermost layer
- Single layer five and seven sided cells
- Osmatic pump – pumps aqueous from cornea

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Cranial Nerves

- **CN II** - vision
- **CN III** - eye motility
- **CN IV** - superior oblique eye muscle
- **CN VI** - lateral rectus eye muscle
- **CN VII** - facial and lacrimal gland

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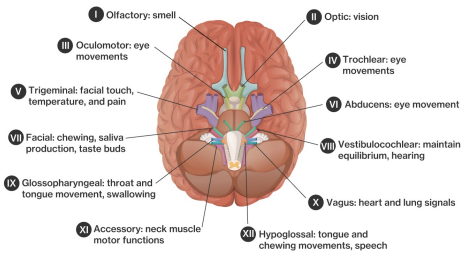
Locations of the Cranial Nerves



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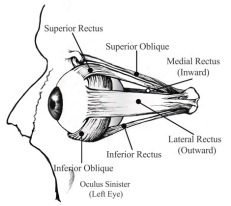
Motility

- Superior
- Inferior
- Medial
- Lateral
- Superior Oblique
- Inferior Oblique



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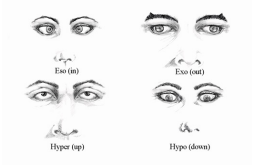
Strabismus

- Esophoria or Esotropia medial
- Exophora or Exotropia lateral
- Hyperphoria or Hypertropia superior
- Hypophoria or Hypotropia inferior



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Tunics

- Outer Fibrous Layer – cornea and sclera
- Middle Vascular Layer (uvea) – iris, ciliary body and choroid
- Inner Neural Layer - retina

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Uveal Tract

- Iris
- Ciliary body
- Choroid

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Ciliary Process

- Aqueous production
- Responsible for providing oxygen, nutrients, and metabolic waste removal to the lens and the cornea, which do not have their own blood supply

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Crystalline Lens

Suspended behind the iris and aqueous fluid (approximately 3.6mm behind the cornea) is the crystalline lens. This bi-convex, transparent lens has approximately 19 diopters of focusing power, an anterior surface curvature of 10 mm, a posterior surface curvature of 5.33mm, a center thickness of 3.5 mm and a refractive index of 1.427n. Its primary function is to focus light on the retina.

The lens also filters harmful ultraviolet radiation. The three parts of the crystalline lens are the Capsule, the Cortex, and the Nucleus.

The Capsule is the outer portion of the lens. The cortex is the core, and the nucleus is the lens' center.

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Crystalline Lens

- **Bi-convex Lens** - attenuates UV radiation
- **Primary Function** - accommodation
- **Dioptric Power** – ~19 D

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Anterior Chamber

- Aqueous Humor - clear fluid behind the cornea in the anterior and posterior chamber
- Refractive index of 1.33n
- Maintains the corneal shape and intraocular pressure
- The Ciliary Body produces the aqueous fluid
- Remains clear due to the filtering through the angle and the "trabecular meshwork"
- Intraocular pressure measured with a tonometer
- Normal pressure is between 15 to 20 Hg (millimeters of mercury)

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Optic Nerve

- **Optic Nerve** - bundle of nerves that carry chemical energy (visual impressions) to the brain
- **Scotoma (blindspot)** – does not contain rods nor cone photoreceptors
- **Occipital Lobe** - area of the brain that interprets images we perceive (vision occurs in the brain not the eye)

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Glaucoma

- **Glaucoma** - ocular disease characterized by optic nerve head damage due to excessive intraocular pressure
- Patients with glaucoma require treatment with prescription medication (example: xalatan, latanoprost and others)

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Optic Disc

- **Optic Disc (optic nerve head) –** site where ganglion cell axons accumulate and exit the eye.
- Horizontal Diameter = ~1.7mm
- Vertical Diameter = ~1.9mm
- Zero photoreceptors = blind spot

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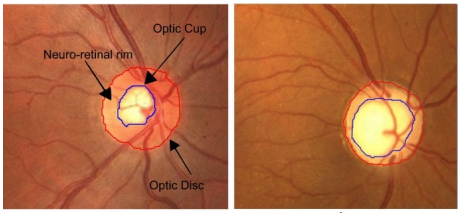
Optic Disc



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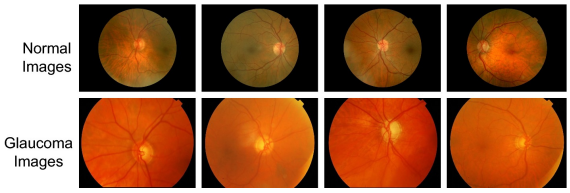
Normal vs. Glaucoma



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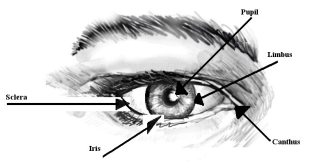
Iris and Pupil



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Iris and Pupil

- **Iris -** circular muscle with an opening in the center
- Regulates the amount of light entering the eye
- Color pigment gives the color
- **Pupil -** the center opening of the iris is the pupil
- Pupil Size – average's 3 to 4 mm diameter
- **Limbus -** outer dark ring around the cornea. Boundary between sclera and cornea

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Limbus

- Limbus - outer dark ring around the cornea
- Boundary between sclera and cornea

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Crystalline Lens

- Crystalline Lens - biconvex, transparent lens
- Approximately 19 D. diopters of focusing power
- Refractive index 1.427n
- Primary function is to focus light on the retina using accommodation
- Accommodation - ability to focus at varying distances
- Attenuates longer Ultraviolet Radiation (UV)

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Cataract

Cataract - opacity of the crystalline lens resulting in reduced vision

- ***Nuclear Sclerosis*** (NS) — lens appears cloudy / hazy. Can be brunescent (brownish color)
- ***Cortical*** - white edges of streaks similar to spokes on a bicycle wheel

Three Categories:

- ***Senile*** - age related or could be environmental (steroid induced or other)
- ***Traumatic*** - injury to the crystalline lens (examples: bb gun, hard blow to the eye, arrow or other bruises the lens)
- ***Congenital*** - occurs at birth

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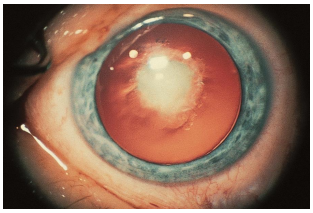
Congenital Cataract



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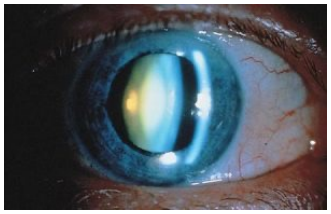
Nuclear Sclerosis



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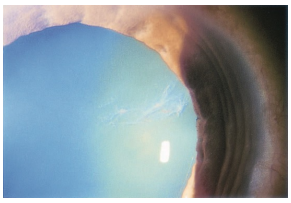
Cortical Cataract



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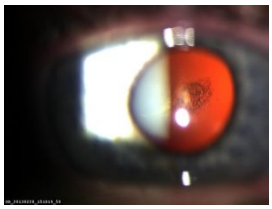
Posterior Subcapsular Cataract (PSC)



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Cataract Surgery

- **Aphakia** (absence of a lens) – crystalline lens, or its nucleus is removed
- **Pseudophakia** (Intraocular Lens or I.O.L.) – cataract surgery is performed. A synthetic lens that is surgically inserted to replace the old lens
- IOL's do not have accommodative power

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Phacoemulsification

- **Phaco and IOL (Intra Ocular Lens) -** Phacoemulsification (phaco) is method of cataract surgery in which the crystalline lens is emulsified using ultrasonic energy and replaced with an intraocular lens implant (IOL).

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Posterior Chamber

- Triangular in shape
- Apex is located where the iris rests on the lens
- Base is the valley between the ciliary processes
- Posterior wall is the lens and zonules
- Anterior wall is the pigment epithelium layer of the iris

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Vitreous

- Vitreous Humor - transparent, gelatinous mass in the posterior chamber
- Floaters - separation of the vitreous particles that appear in the line of sight as moving (floating) dark spots

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Retina

- Retina – light sensitive innermost nerve network of the eye
- 10 layers
- Inner coat posterior ¾ surface
- Contains the macula, rods, cones, and optic disc

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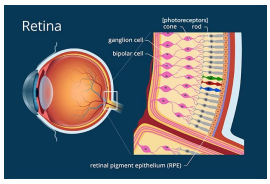
10-Retina Layers

1. RPE - Retinal pigment epithelium
2. Photoreceptor layer
3. External limiting membrane
4. Outer nuclear layer
5. Outer plexiform layer
6. Inner nuclear layer
7. Inner plexiform layer
8. Ganglion cell layer
9. NFL - Nerve fiber layer
10. Internal limiting membrane



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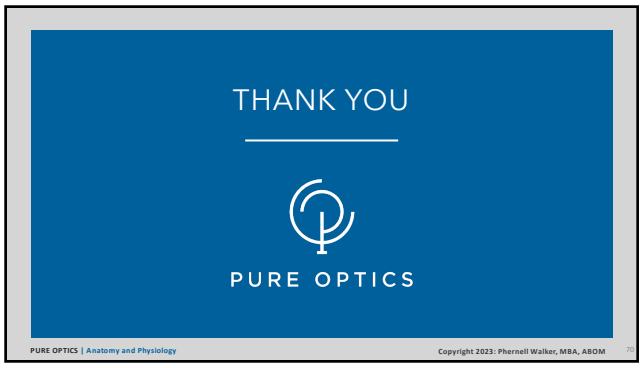
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