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# Glaucoma Study Guide

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High Yield Review For Ophthalmology Exams



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Ophthalmology Review

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First Edition

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# Introduction

## How To Read This Book

Hello! This is the stand-alone version of the glaucoma section to my upcoming review book, Last Minute Ophthalmology. As I write each chapter, I plan to release them as individual review books, and compile every topic into one complete book (with a few minor differences between them, such as section introductions and descriptions). I have designed the entire book to be a last-minute reference in the preparation for taking ophthalmology examinations. As such, this not meant to be a comprehensive text on the entirety of ophthalmology.

There are various methods I envision this book will be read - as a pure reference by using the table of contents and index to find specific topics, perhaps as a part of a study plan to help review the salient points after finishing a deeper review, or as a last minute read-through right before a test. Or, perhaps there is some other application that would be more useful for your study plan. In any case, I hope that the information that is presented will be useful and not anything too similar to other review texts already available on the market.

## Disclaimers and Acknowledgements

Obviously, there are far more topics beyond the scope of this book. Additionally, the information I've culled for this book is not guaranteed to show up on any test, so if you find that there is a lot of extraneous information, please let me know! Additionally, I am not reproducing test questions from any of the exams I've previously taken; it's been far too long since I've taken the OKAP, Written Qualifying Exam, and Oral Board Exam anyways that I wouldn't be able to accurately recall any of that information.

I had to make the difficult choice of leaving out direct citations within the text as well; as a review book, this just did not seem to flow very well, but while I do claim this work as entirely original (from the standpoint of how I'm writing it and presenting it), obviously the content itself is not original to me and is the organized collection of my notes from studying the many tomes of ophthalmology that we've all used to learn the subject matter. The references I list at the end of this introduction comprise the majority of the sources I used to create this outlined resource.

I ended up creating many mnemonics to help me remember differentials and other pertinent information; however, there were many mnemonics I learned from my peers, review courses, and books. Out of respect to these other individuals since I was unable to get permission to publish their mnemonics, I did not include any unoriginal mnemonics in this guide. As such, you may see specific topics that I've highlighted as sets of lists to memorize. Just because I did not include a mnemonic does not diminish the importance of the subject in any way, and perhaps it will encourage you to find your own ways to help remember the information.

## How This Section Is Organized

Glaucoma is traditionally organized into open-angle, angle-closure glaucoma, and pediatric glaucoma. This book follows that organization, with specific chapters dedicated to different categorizations of each type of glaucoma.

The book itself is formatted as an outline, with the goal of highlighting the essential details about each topic. The assumption is that this information is a review, rather than a detailed explanation of the minutiae. If you are looking for a detailed, nuanced discussion of the topics, I am always working on articles on [Ophthalmology Review](#), or you can check out the references I've listed.

This book is one of the many resources I plan to provide through [Ophthalmology Review](#). As such, you'll probably find that the formatting and organization of information in this book is similar to what you'll find on the website.

Happy studies!

Kevin E. Lai, M.D.  
Founder, Ophthalmology Review

## Sourced References and Suggested Reading

1. *Basic and Clinical Science Course, Section 10: Glaucoma*. 2021-2022 ed. San Francisco: American Academy of Ophthalmology; 2021.
2. Salmon JF. *Kanski's Clinical Ophthalmology: A Systematic Approach*. 9th Ed. Elsevier, 2020.
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# Angle Anatomy and Aqueous Dynamics

## Angle Anatomy

### Limbus (Corneoscleral Junction)

	Anterior Limit	Posterior Limit
Pathology Definition	End of Bowman layer to Schwalbe line	Plane perpendicular to surface passing through scleral spur
Anatomy/Surgical Definition	Blue-gray zone of cornea from Bowman layer to Schwalbe line	White zone of trabecular meshwork from Schwalbe line to scleral spur/iris root

### Anterior Chamber

#### Scleral Spur

- **Point of attachment for the longitudinal ciliary muscle**

#### Trabecular Meshwork

- **Uveal meshwork:** cordlike trabeculae containing pigment
- **Corneoscleral meshwork:** contains thin trabecular cells with multiple pinocytotic vesicles
- **Juxtacanalicular (endothelial) meshwork: greatest contribution to outflow resistance**

#### Schlemm Canal

- **Embryology:** originates from **mesoderm**
- **Histology:** circular monolayer tube of nonfenestrated epithelium; vacuoles in wall help in **pressure-dependent outflow**
- **Collector channels:** drains from Schlemm canal to venous plexuses
- **Blood in Schlemm canal:** occurs when episcleral venous pressure > IOP
  - **Causes: compression of episcleral veins by gonioles (most common), hypotony, carotid-cavernous fistula, Sturge-Weber**

**Angle Structures**  
**"I Can See The Line"**

- Iris
- Ciliary body
- Scleral spur
- Trabecular meshwork
- Schwalbe Line

#### Gonioscopy

- **Critical angle for tear-air interface (causing total internal reflection): 46°**

#### Shaffer Grading System

Grade	Angle Between Iris and Trabecular Meshwork	Comments
Grade 4	45°	
Grade 3	Between 20° and 45°	
Grade 2	20°	Angle closure is possible
Grade 1	10°	Angle closure is probable over time
Slit	< 10°	Angle closure is very likely
Grade 0	Iris is against the trabecular meshwork	Angle closure is present

## Spaeth Grading System

Iris Insertion	Angle of Iris Insertion	Iris Configuration
A: Anterior to TM	10°	b (bowing anteriorly)
B: Behind Schwalbe line	20°	f (flat)
C: Posterior to scleral spur	30°	c (concave bowing posteriorly)
D: Deep into ciliary body face (iris root attaches to anterior ciliary body)	40°	p (plateau iris)
E: Extremely deep ciliary body (> 1 mm of ciliary body visible)		

## Ciliary Apparatus Anatomy

### Ciliary Body

- **Orientation:** apex directed posteriorly toward ora serrata; iris rises from base, base attaches at scleral spur (longitudinal fibers)
- **Pars plicata:** consists of ciliary processes; **zonules attach in valleys and pars plana**
- **Pars plana:** spans from ora serrata to ciliary processes, located **3-4 mm posterior to limbus** (injections, pars plana vitrectomy)

### Ciliary Epithelium and Stroma

#### Nonpigmented (Inner) Ciliary Epithelium

- Continuous with posterior pigmented iris epithelium anteriorly and neurosensory retina posteriorly
- **Embryology:** **neuroectoderm** (inner layer of optic cup)
- **Zonulae occludentes:** found at apex; **tight junctions that form blood-aqueous barrier**
- **Histology:** **cuboidal** (pars plana), **columnar** (pars plicata); "apex-to-apex" configuration between epithelial layers
- **Secretes aqueous humor**

#### Pigmented (Outer) Ciliary Epithelium

- Continuous with anterior pigmented iris epithelium anteriorly and retinal pigment epithelium posteriorly
- **Embryology:** **neuroectoderm** (outer layer of optic cup)
- **Histology:** epithelial cells with many **melanosomes**

### Ciliary Muscles

- **Histology:** smooth, nonstriated muscle, rich in type VI collagen
- **Muscle fibers**
  - **Longitudinal fibers:** outermost layer, inserts at scleral spur
  - **Radial fibers:** middle layer, arises in midportion of ciliary body
  - **Circular fibers:** innermost layer, runs perpendicular to longitudinal fibers
  - **Angle recession:** **split between circular and longitudinal fibers**
- **Innervation:** **parasympathetics (CN III via short ciliary nerves)**

## Aqueous Production

- Aqueous is produced by the **nonpigmented (inner) ciliary body epithelium** in the **ciliary processes**
- **Mechanisms for aqueous production:** **active secretion (majority of production, pressure independent)**, ultrafiltration (pressure dependent), simple diffusion

## Aqueous Outflow

### *Trabecular Meshwork Outflow*

- **Pressure-dependent outflow**
- **Juxtacanalicular (endothelial) meshwork:** inner wall of Schlemm canal, greatest contribution to outflow resistance
- **Changes with increased age:** ↑ pigment, ↑ basement membranes, ↓ trabeculocytes (**ALT/SLT induces trabeculocyte division**)

### *Uveoscleral Outflow*

- **Pressure-independent outflow**
- **Things that increase uveoscleral outflow:** cycloplegia, adrenergic agents, prostaglandin analogs, cycloidalysis
- **Things that decrease uveoscleral outflow:** miotics, increased age (stiff sclera)

### *Episcleral Venous Pressure*

- **Normal episcleral venous pressure:** 8-10 mmHg
- **Gonioscopy: blood in Schlemm canal**
- **Conditions associated with increased episcleral venous pressure:** facial hemangiomas (Sturge-Weber), Klippel-Trenaunay-Weber, distensible venous malformation (orbital varix), superior vena cava disease, thyroid eye disease, carotid-cavernous fistula

# Perimetry

## Basic Principles of Perimetry

### Terminology

- **Threshold:** light sensitivity seen 50% of the time (suprathreshold: brighter than threshold)
- **Isopter:** line of spatial points of the same threshold
- **Decibel (dB):** 0.1 log unit; attenuation of the maximum light intensity available in perimeter
- **Intensity:** major step (1-4:  $\Delta 5$  dB), minor step (a-e:  $\Delta 1$  dB)
- **Stimulus size:** **Size III is most commonly used size for Humphrey Field Analyzer;** Size V used for poor vision

0	I	II	III	IV	V
1/16 mm <sup>2</sup>	1/4 mm <sup>2</sup>	1 mm <sup>2</sup>	4 mm <sup>2</sup>	16 mm <sup>2</sup>	64 mm <sup>2</sup>

- **Examples:** I1e = small stimulus, dim intensity; V4e = largest stimulus, brightest intensity

## Perimetry Techniques

### Manual Perimetry

#### Goldmann Kinetic Perimetry

- **Armaly-Drance screening technique:** most common technique used for manual perimetry
  - I-2e stimulus with special attention to 15° straddling horizontal/vertical meridians
  - I-2e stimulus to measure blind spot in 8 directions
  - I-4e stimulus for peripheral isopter
- Helpful for defects outside of central 30° (e.g., monocular temporal crescent), end-stage visual loss, functional visual loss

### Automated Perimetry

#### Standard Automated Perimetry (SAP)

- **"White-on-white" is gold standard for functional evaluation in glaucoma**
- Typically tests central 24° (Octopus 32, Humphrey 24-2) to 30° (Octopus G1, Humphrey 30-2) of visual field
- **Full-threshold (staircase) algorithm:** conventional method of testing each spot using a bracketed approach increasing and decreasing intensity of light at each location to determine the threshold
- **Swedish Interactive Thresholding Algorithm (SITA):** forecasting/logical best guess; Bayesian test strategy used in Humphrey VF
  - Uses database of age-adjusted healthy and diseased individuals to generate threshold probability distribution function for each test spot, adjusted in real-time as the individual provides responses
  - **SITA-Standard:** 50% less time compared to full-threshold testing
  - **SITA-Fast:** 30% less time compared to SITA-Standard
  - **SITA-Faster:** 30% less time compared to SITA-Fast (50% less time than SITA-Standard)
- **Tendency-oriented perimetry (TOP):** estimation of threshold sensitivity by testing single location and combine info with surrounding locations; used in Octopus VF

#### Frequency-Doubling Technology (FDT)

- Flickering motion instead of lights; sensitive at detecting early glaucoma; designed to evaluate magnocellular (M) pathway

## Short-Wavelength Automated Perimetry (SWAP)

- Blue-violet (440 nm wavelength) on yellow background; stimulates small bistratified ganglion cells (koniocellular (K) pathway)

## Visual Field Patterns

### Artifacts

Artifact	Description	Mechanism of Artifact
Lens rim	Peripheral loss	Machine's corrective lens is decentered or too far from the eye
Lens-associated generalized depression	Generalized depression	Inappropriate corrective lens selection
Eyelid artifact	Superior defect	Partial ptosis
Cloverleaf	Constriction/tunnel	Patient stops paying attention partway through test
High false-positive rate	High threshold, loss of blind spot	Patient responds when no test stimulus is presented

### Glaucomatous Visual Field Defects

- Arcuate or Bjerrum scotoma
- Nasal step
- Paracentral scotoma
- Altitudinal defect
- Generalized depression (rare in glaucoma)
- Temporal wedge (rare)