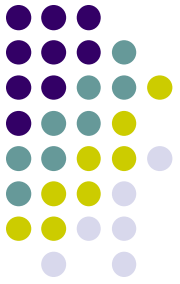


Q

## Glaucoma Overview



*Define glaucoma.*

# A

## Glaucoma Overview

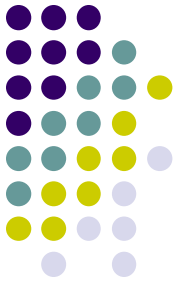


*Define glaucoma.*

A group of optic neuropathies that present with progressive ONH damage and characteristic VF loss

# Q

## Glaucoma Overview



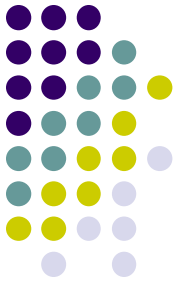
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*Why isn't elevated IOP mentioned above?*

# A

## Glaucoma Overview



*Define glaucoma.*

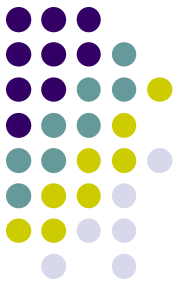
A group of optic neuropathies that present with progressive ONH damage and characteristic VF loss

*Why isn't elevated IOP mentioned above?*

Elevated IOP is a strong risk factor for glaucoma, but it need not be present—IOP can be normal, or even low

# Q

## Glaucoma Overview



*Define glaucoma.*

A group of optic neuropathies that present with progressive ONH damage and characteristic VF loss

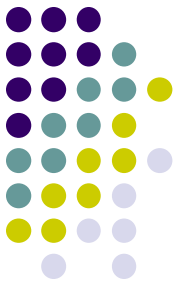
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*In addition to being the strongest risk factor for glaucoma, IOP has another quality that renders it unique—what is it?*

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## Glaucoma Overview



*Define glaucoma.*

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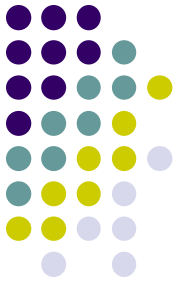
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*In addition to being the strongest risk factor for glaucoma, IOP has another quality that renders it unique—what is it?*

It is the only risk factor that is modifiable in a manner proven to influence the risk of glaucoma progression

# Glaucoma Overview



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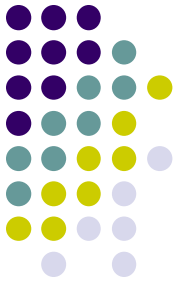
It is the only risk factor that is **modifiable** in a manner proven to influence the risk of glaucoma progression



*That's why glaucoma management concerns nothing but IOP-lowering maneuvers!*

*No question—proceed when ready*

# Glaucoma Overview



*Define glaucoma.*

A group of optic neuropathies that present with progressive ONH damage and characteristic VF loss

*Why isn't elevated IOP mentioned above?*

Elevated IOP is a strong risk factor for glaucoma, but it need not be present—IOP can be normal, or even low

*In addition to being the strongest risk factor for glaucoma, IOP has another quality that renders it unique—what is it?*

It is the only risk factor that is **modifiable** in a manner proven to influence the risk of glaucoma progression

***Speaking of IOP...Let's drill down on the factors that determine it***

*No question—proceed when ready*





## Glaucoma Overview



*Fill in the IOP equation below.*

$$IOP = \frac{\text{[ ]}}{\text{[ ]}} + \text{[ ]}$$

# A

## Glaucoma Overview



*Fill in the IOP equation below.*

$$IOP = \frac{\text{Aqueous Formation Rate } (\mu\text{L/min})}{\text{Outflow Facility } (\mu\text{L/min/mmHg})} + \text{Episcleral Venous Pressure (mmHg)}$$

Q

## Glaucoma Overview



Fill in the IOP equation below. *What is its eponymous name?*

The  equation

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# A

## Glaucoma Overview



*Fill in the IOP equation below. What is its eponymous name?*

**The Goldmann equation**

$$IOP = \frac{\text{Aqueous Formation Rate } (\mu\text{L/min})}{\text{Outflow Facility } (\mu\text{L/min/mmHg})} + \text{Episcleral Venous Pressure (mmHg)}$$

## Glaucoma Overview



Fill in the IOP equation below. *What is its eponymous name?*  
**The Goldmann equation**

$$IOP = \frac{\text{Aqueous Formation Rate } (\cancel{\mu\text{L/min}})}{\text{Outflow Facility } (\cancel{\mu\text{L/min/mmHg}})} + \text{Episcleral Venous Pressure (mmHg)}$$

*Note how the  $\mu\text{L/min}$  cancel, leaving IOP in mmHg*

## Glaucoma Overview



*Fill in the IOP equation below. What is its eponymous name?*

The **Goldmann** equation

$$IOP = \frac{\text{Aqueous Formation Rate } (\mu\text{L}/\text{min})}{\text{Outflow Facility } (\mu\text{L}/\text{min}/\text{mmHg})} + \text{Episcleral Venous Pressure (mmHg)}$$

**Episcleral venous pressure** (EVP) normally measures about # to # mmHg (ie, the same as central venous pressure) in an upright pt.

## Glaucoma Overview

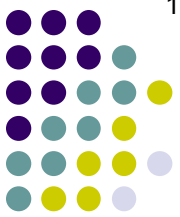


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**Episcleral venous pressure** (EVP) normally measures about 8-12 mmHg (ie, the same as central venous pressure) in an upright pt.



## Glaucoma Overview

*Fill in the IOP equation below. What is its eponymous name?*  
 The **Goldmann equation**

$$IOP = \frac{\text{Aqueous Formation Rate } (\mu\text{L}/\text{min})}{\text{Outflow Facility } (\mu\text{L}/\text{min}/\text{mmHg})} + \text{Episcleral Venous Pressure (mmHg)}$$

**Episcleral venous pressure (EVP)** normally measures about 8-12 mmHg (ie, the same as central venous pressure) in an upright pt. Looking at the Goldmann equation, you can see that, mathematically, it suggests EVP provides a baseline ‘floor’ value for IOP. That is, even if aqueous formation ceased (which would take the first term in the Goldmann equation down to zero), IOP should not fall below EVP; rather, it should be equal to zero plus whatever EVP was at the moment. Further, the Goldmann equation predicts that IOP should vary on a 1-to-1 basis with EVP—that is, each mmHg change in EVP should result in a mmHg change in IOP.



# Glaucoma Overview



*Fill in the IOP equation below. What is its eponymous name?*  
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*No question—proceed when ready*



Fill in the IOP equation below. *What is its eponymous name?*  
**The Goldmann equation**

$$IOP = \frac{\text{Aqueous Formation Rate } (\mu\text{L/min})}{\text{Outflow Facility } (\mu\text{L/min/mmHg})} + \text{Episcleral Venous Pressure (mmHg)}$$

So to lower IOP, one must:

Three maneuvers implied by the Goldmann equation

- the numerator, and/or
- the denominator and/or
- the other thing

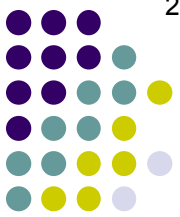


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Three maneuvers implied by the Goldmann equation { So to lower IOP, one must:

- decrease aqueous formation, and/or
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Important maneuver **not** implied by the Goldmann equation → ...and/or three words with a one word agent



Fill in the IOP equation below. *What is its eponymous name?*  
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Fill in the IOP equation below. *What is its eponymous name?*  
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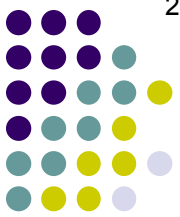
Which classes of meds decrease aqueous formation?

--  
--  
--

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Fill in the IOP equation below. *What is its eponymous name?*  
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Which classes of meds decrease aqueous formation?

- $\beta$  blockers
- CAIs
- $\alpha$  agonists

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What are the two types of outflow?

- 
- 

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- Uveoscleral

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# Glaucoma Overview

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Which class of drugs decrease aqueous formation?

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**Obviously, aqueous-humor dynamics play a central role in glaucoma. Let's delve into its production...**

So to lower IOP, one must:

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Q

## Glaucoma Overview



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*What is the rate of aqueous formation?*

# A

## Glaucoma Overview



Fill in the IOP equation below. *What is its eponymous name?*  
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2-3  $\mu\text{L}/\text{min}$



## Glaucoma Overview



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## Glaucoma Overview



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*What is the rate of aqueous formation?*

2-3  $\mu\text{L}/\text{min}$

*What is the aqueous volume of the anterior chamber?*

200-300  $\mu\text{L}$

# Q

## Glaucoma Overview



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*So then, what percent of AC volume is 'turned over' every minute?*

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## Glaucoma Overview



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About 1%

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Roughly 100 minutes



## Glaucoma Overview



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*Speaking of aqueous formation...What specific tissue makes aqueous?*

What are the two types of outflow?

--**Trabecular meshwork**  
--**Uveoscleral**

--increase outflow facility, *and/or*  
--decrease episcleral venous pressure

...and/or **dehydrate the vitreous** with a  
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# A

## Glaucoma Overview



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The presence of a **pigmented** epithelium

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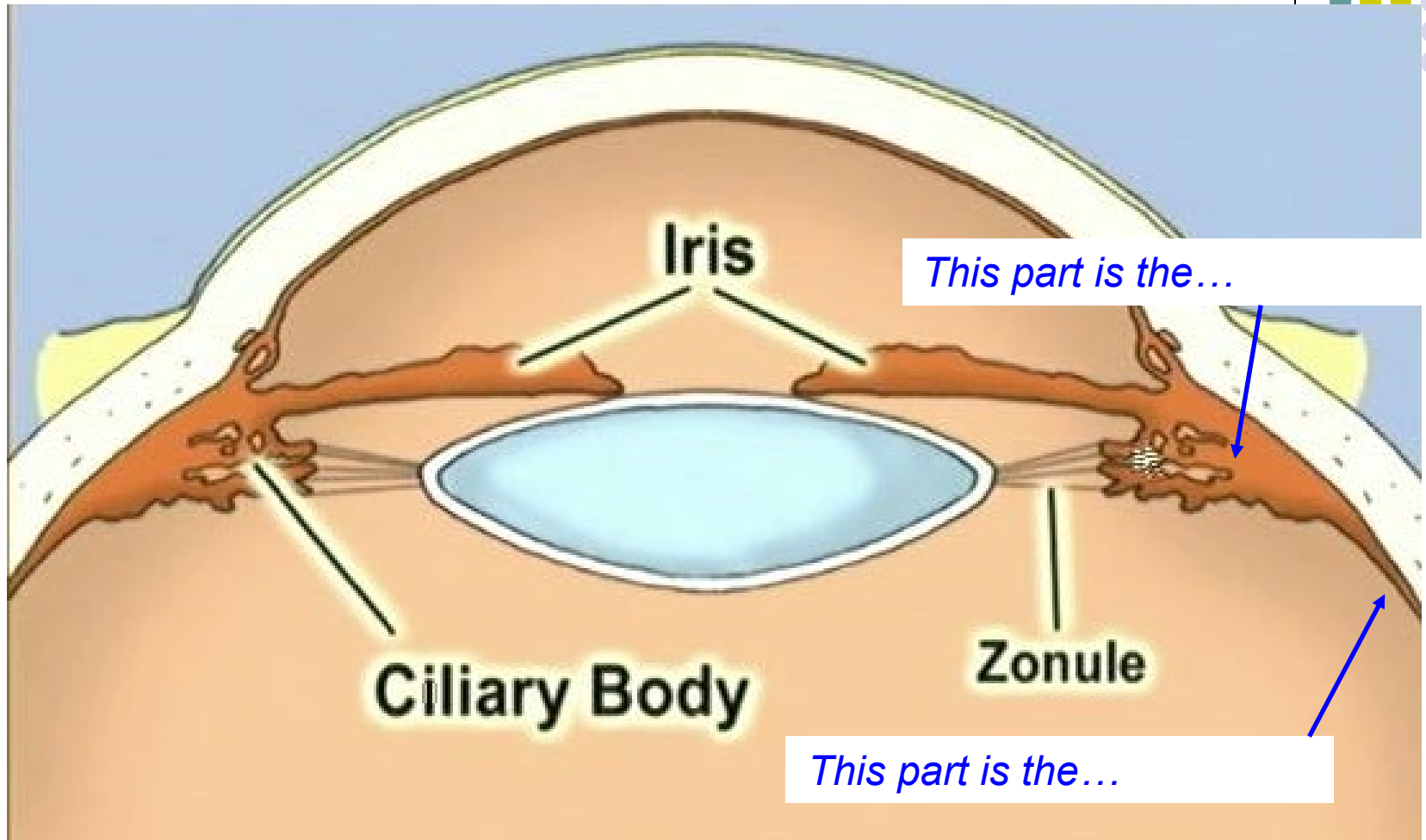
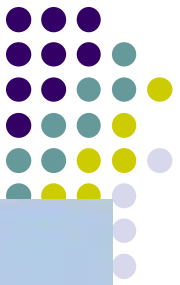
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Q

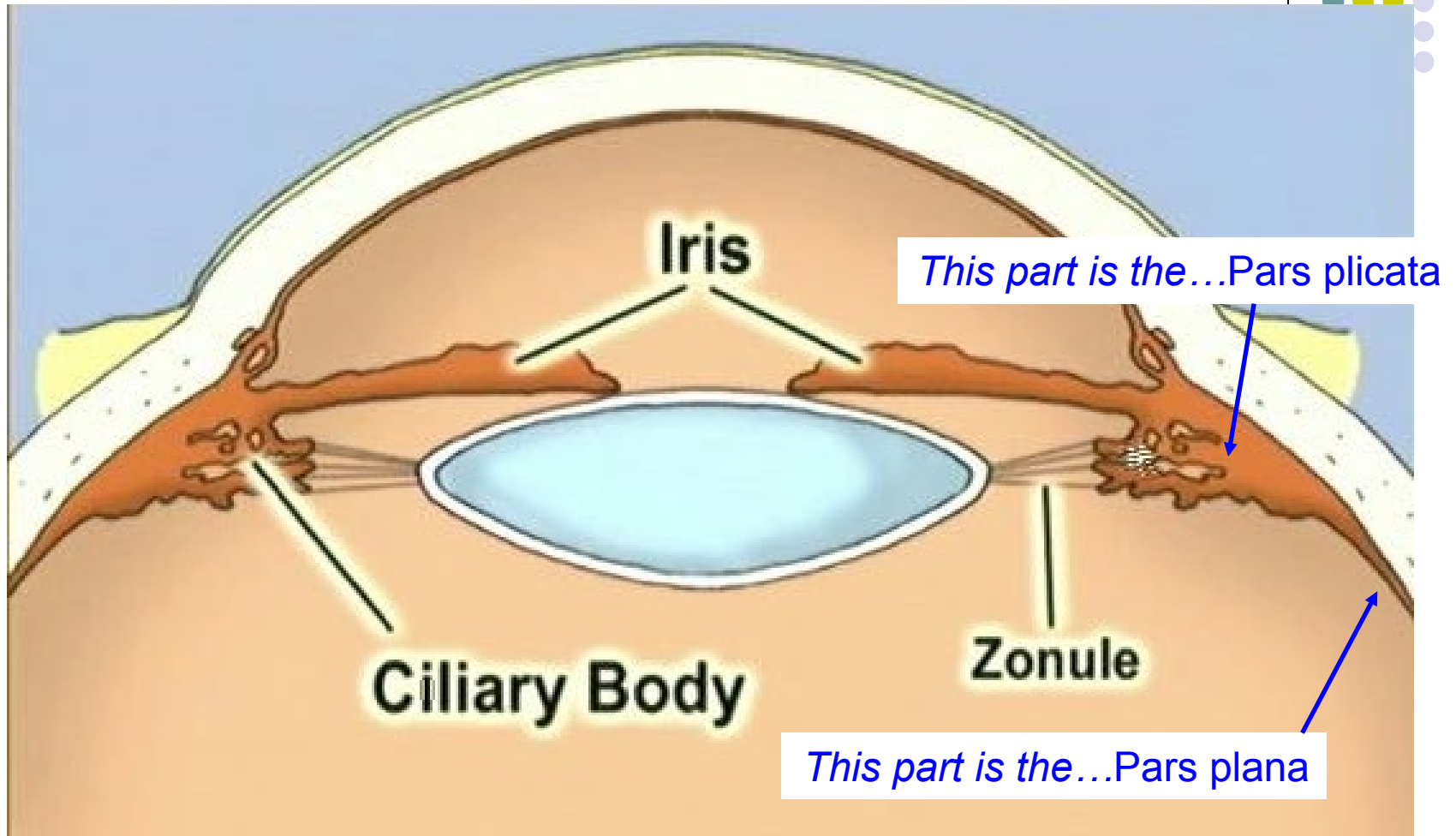
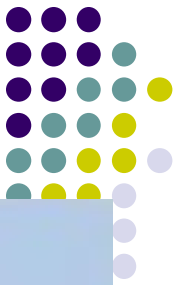
## Glaucoma Overview



Ciliary body: One perspective, two questions

A

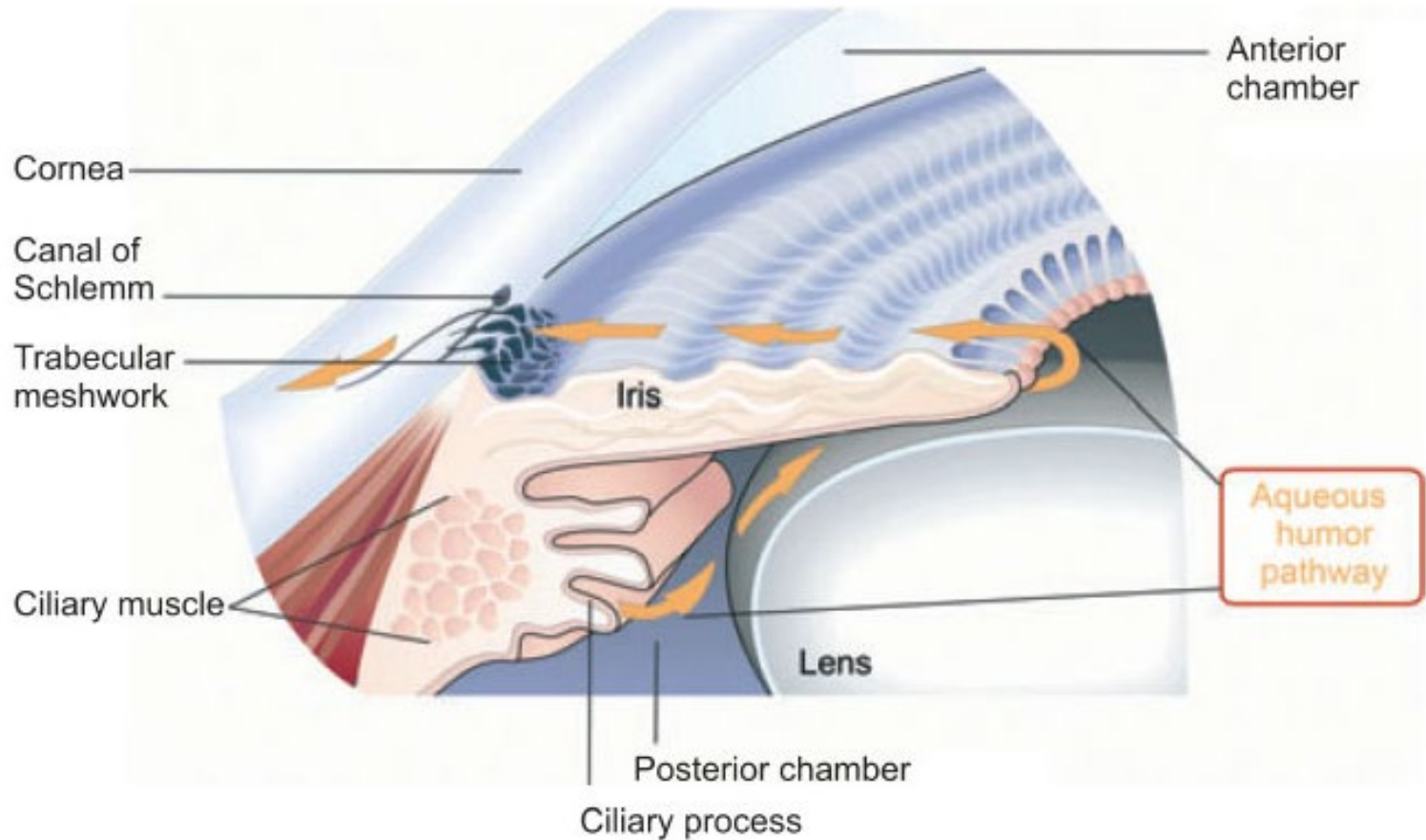
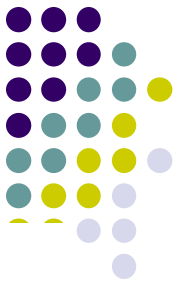
## Glaucoma Overview



Ciliary body: One perspective, two questions

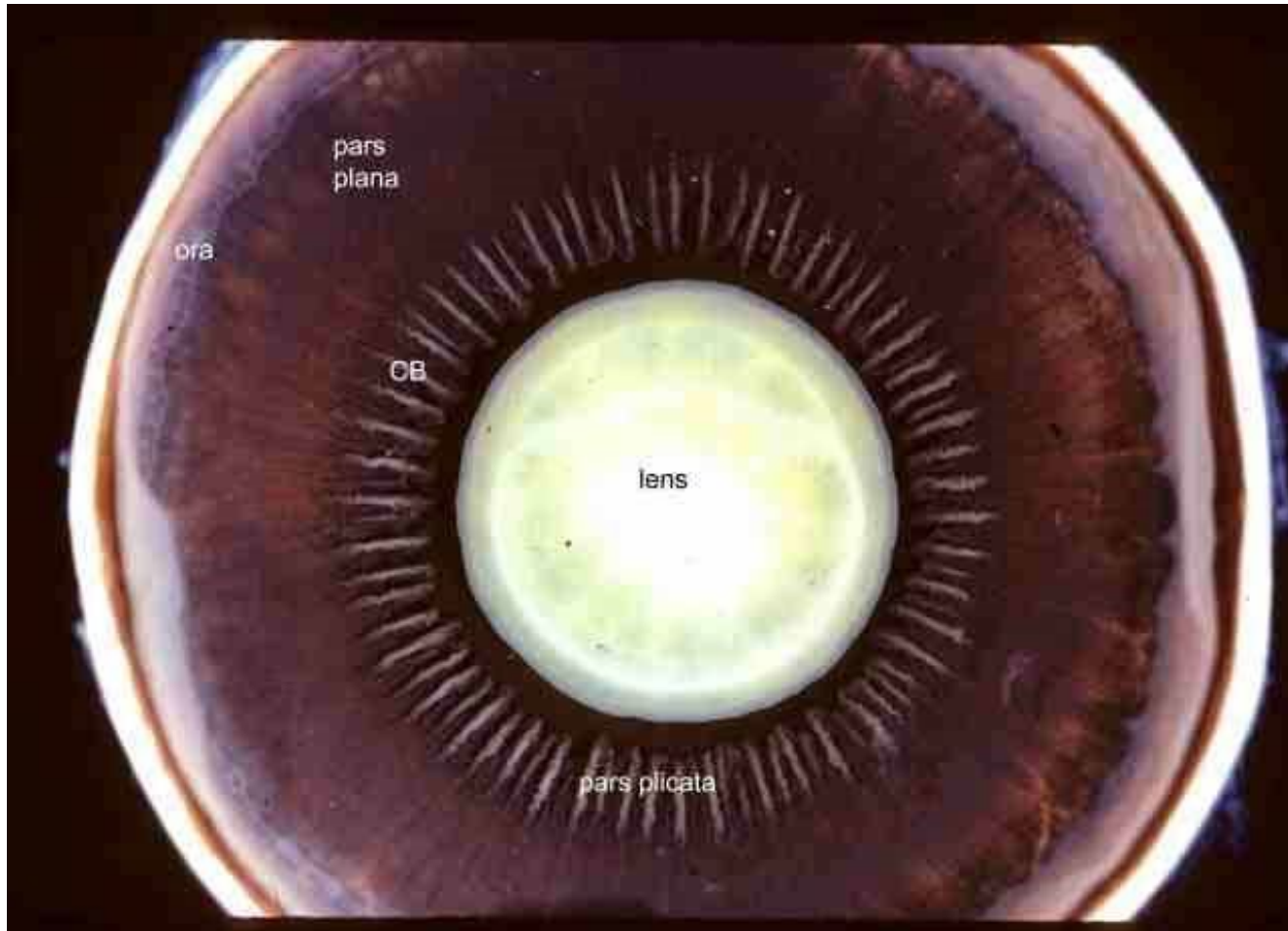
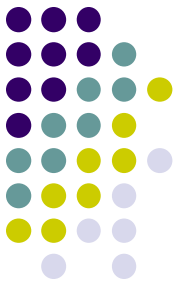


# Glaucoma Overview



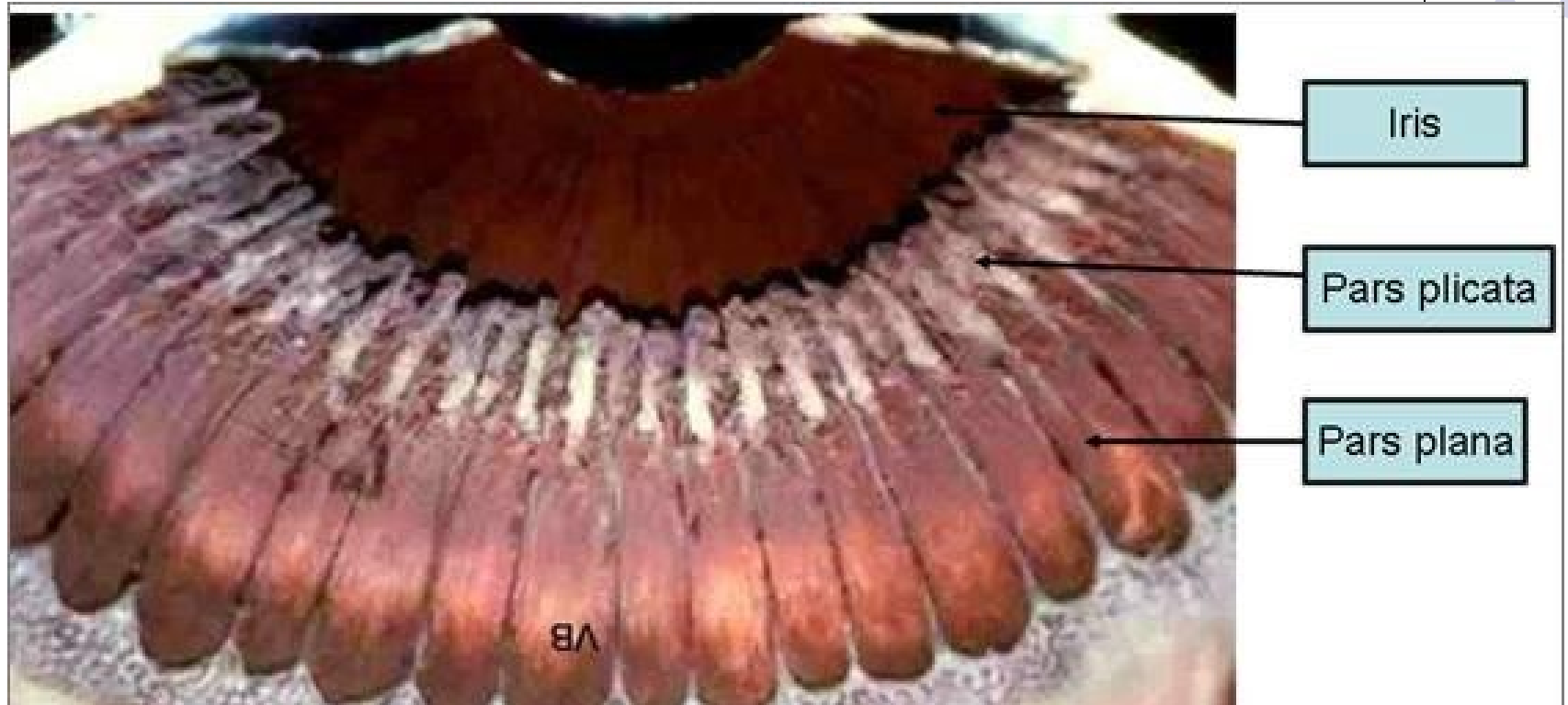
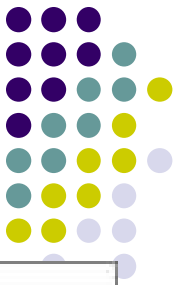
Ciliary body: Another perspective

# Glaucoma Overview



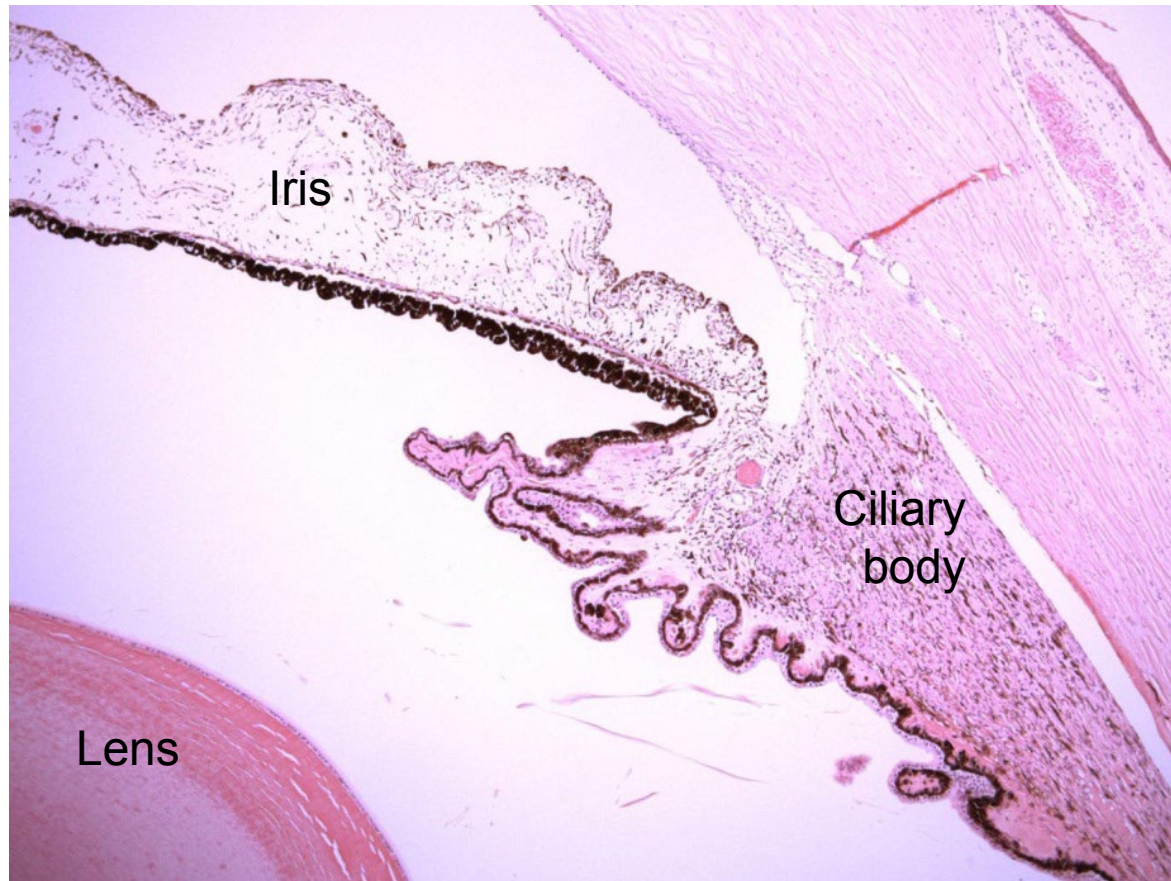
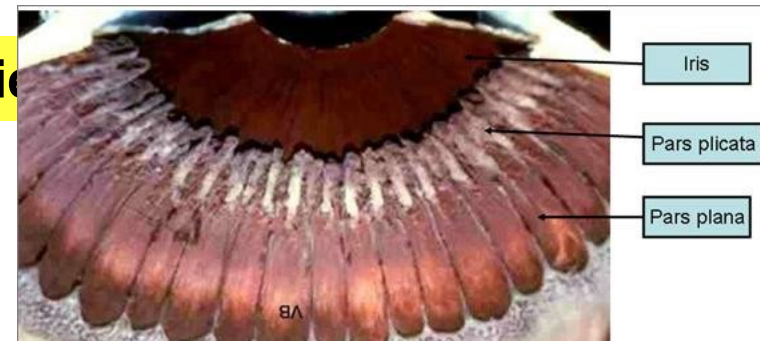
Ciliary body: Another

# Glaucoma Overview



Ciliary body: Another

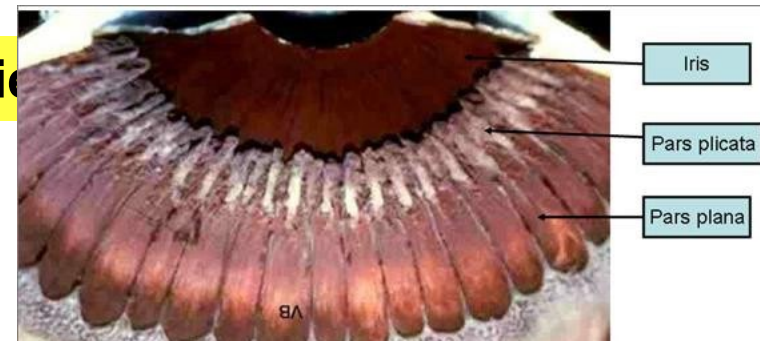
# Glaucoma Overview



Now let's look at the CB epithelium. **Low power** photomicrograph.



# Glaucoma Overview

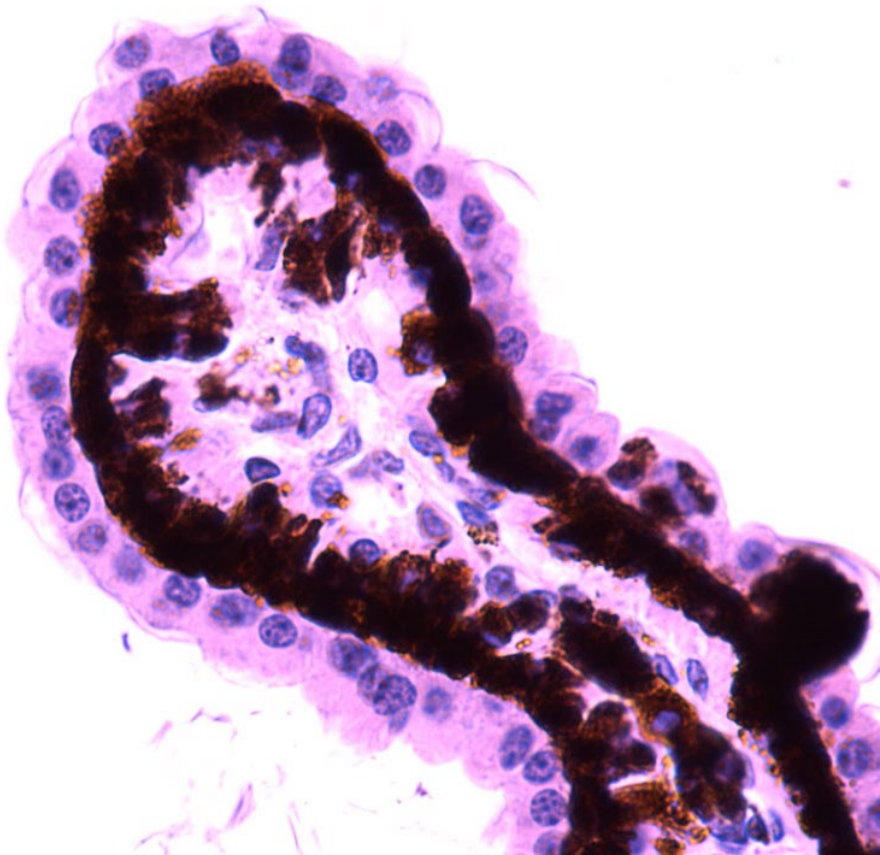
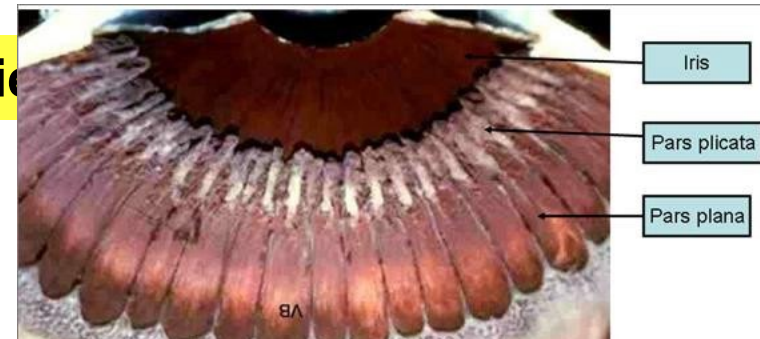


Now let's look at the CB epithelium. **Higher.**

# Glaucoma Overview

*Speaking of aqueous formation...What specific tissue makes aqueous?*  
The nonpigmented epithelium of the pars plicata portion of the ciliary body

*What is implied by the fact that aqueous is made by the 'nonpigmented' epithelium?*  
The presence of a **pigmented** epithelium



Now let's look at the CB epithelium. **High.**

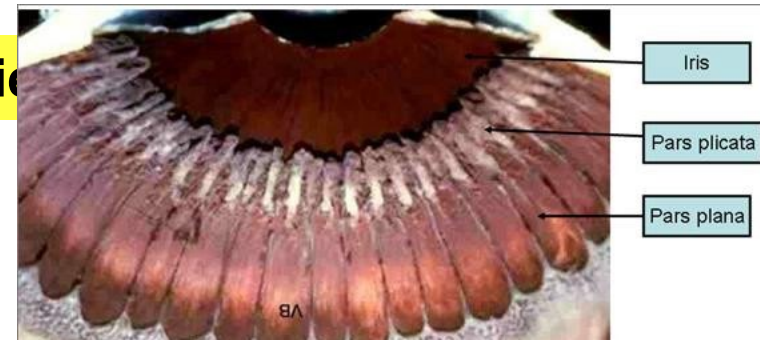
*No question—proceed when ready*

# Q

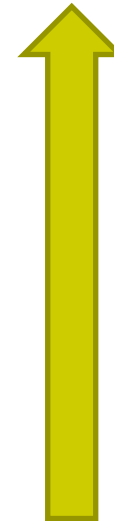
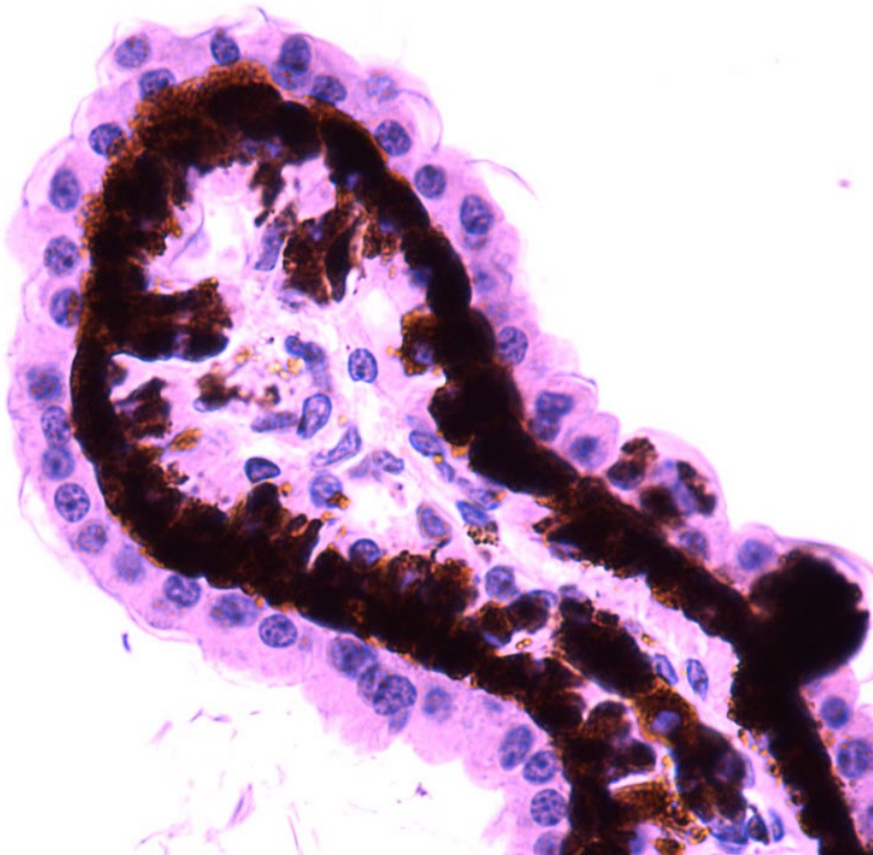
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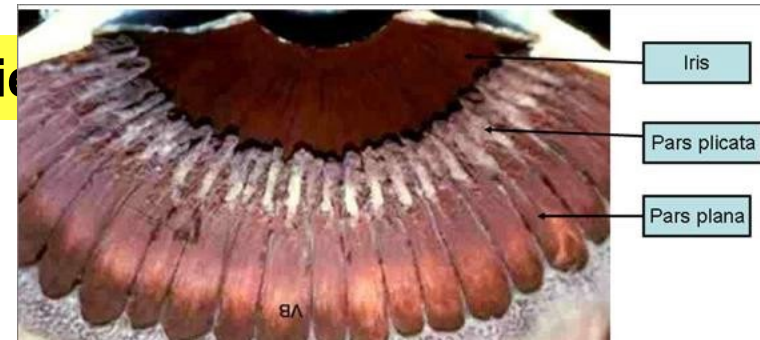


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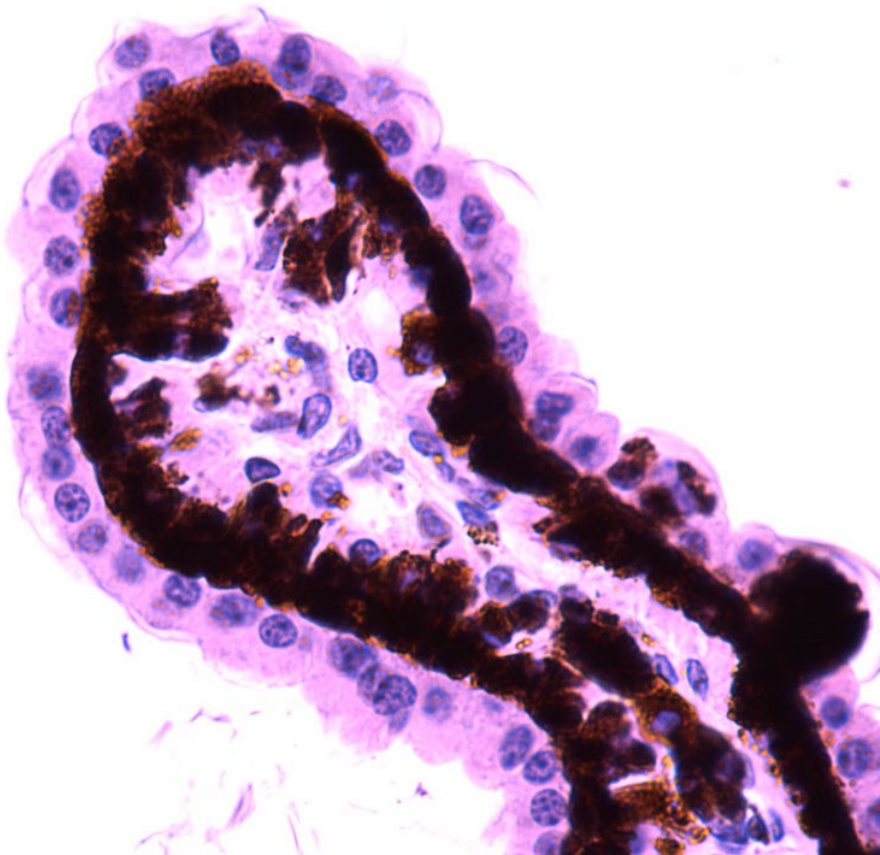
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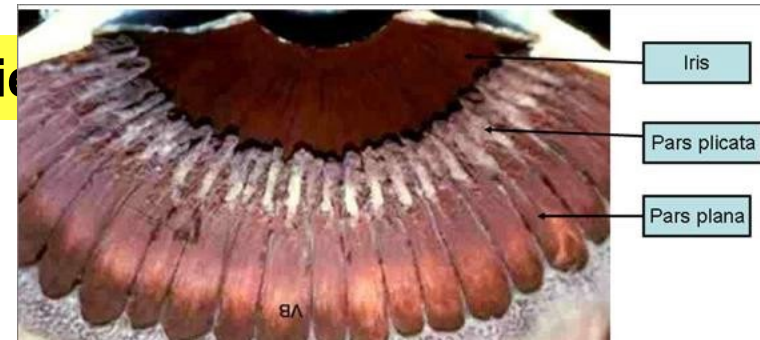


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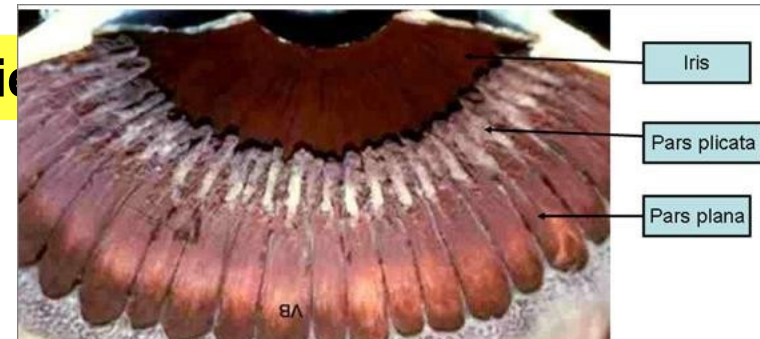


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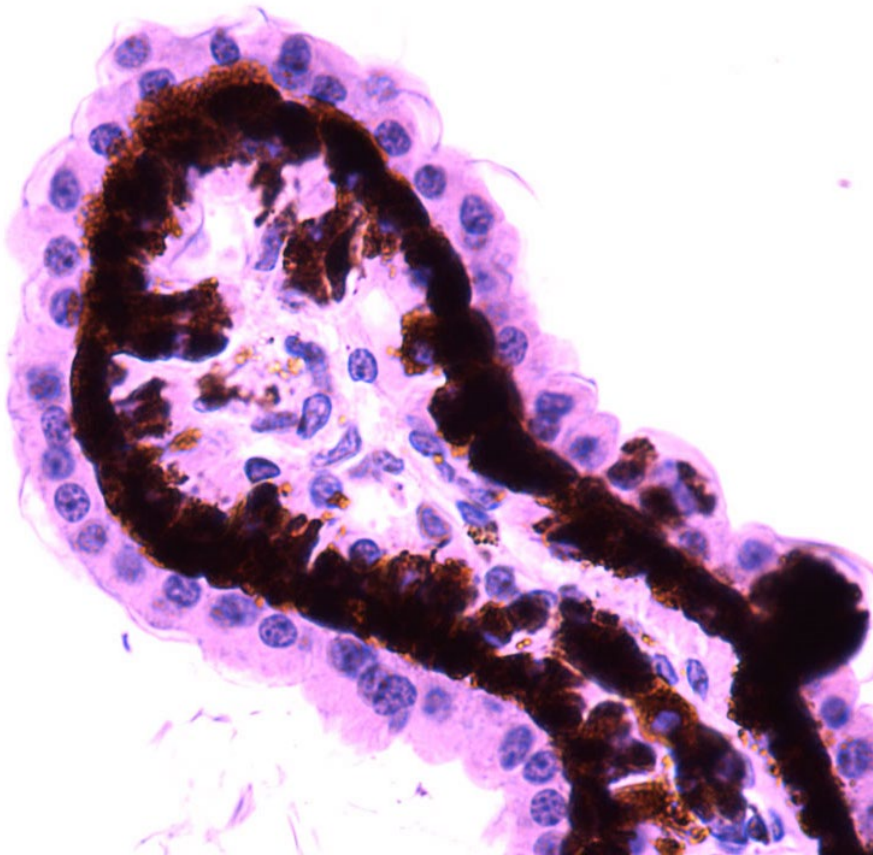


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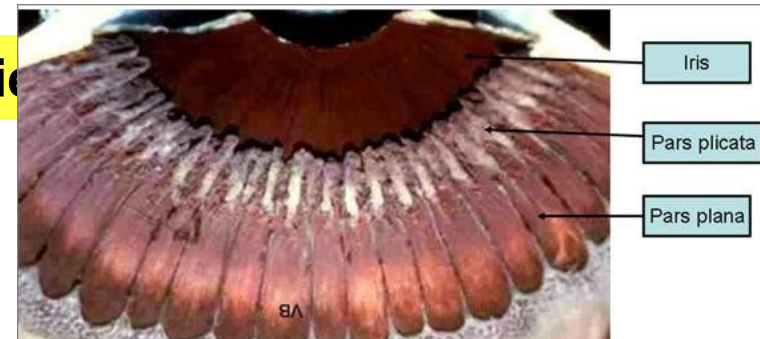


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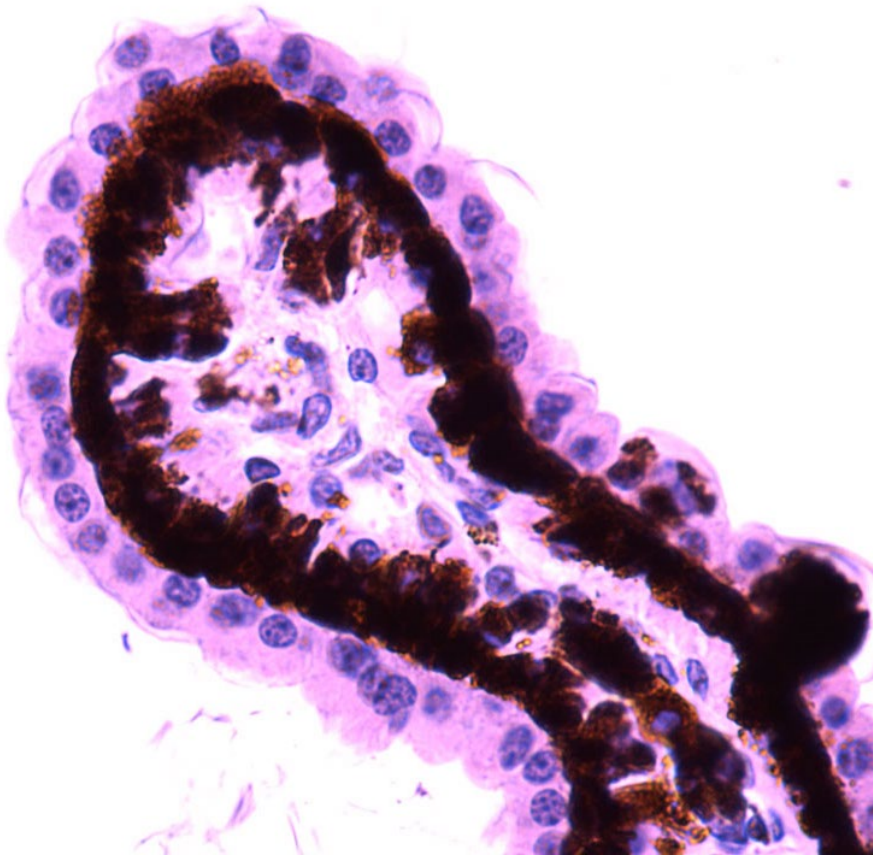
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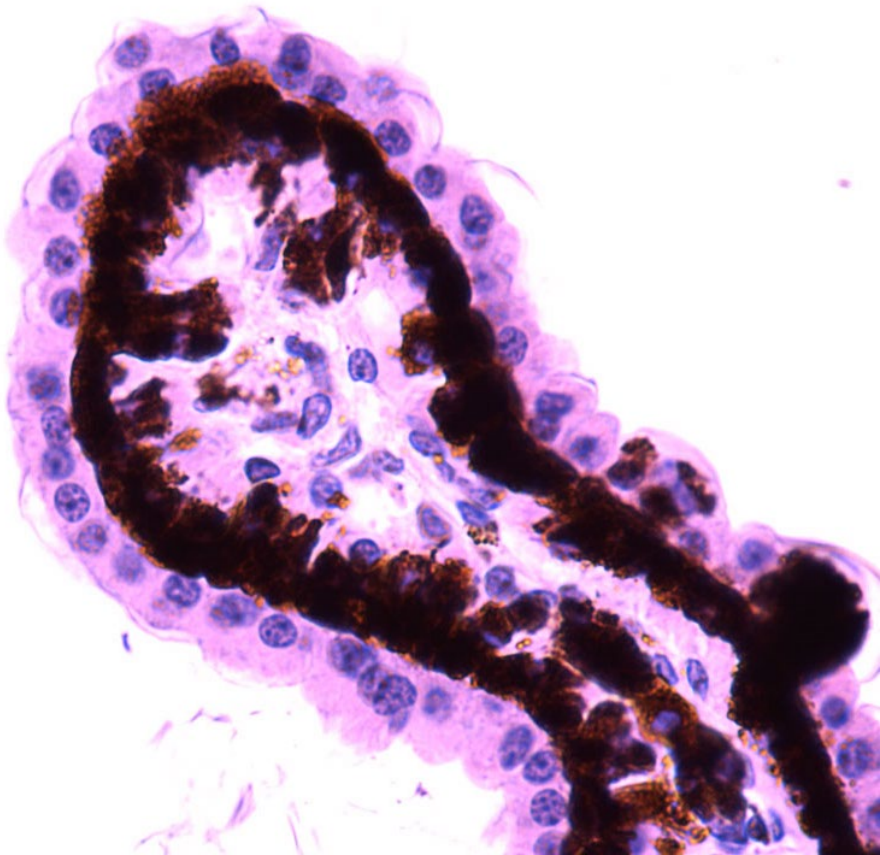
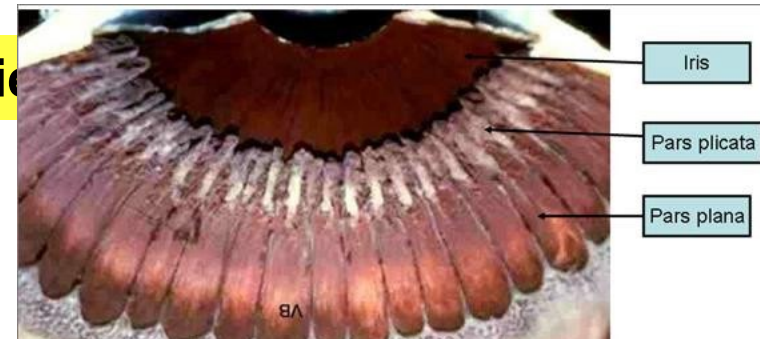


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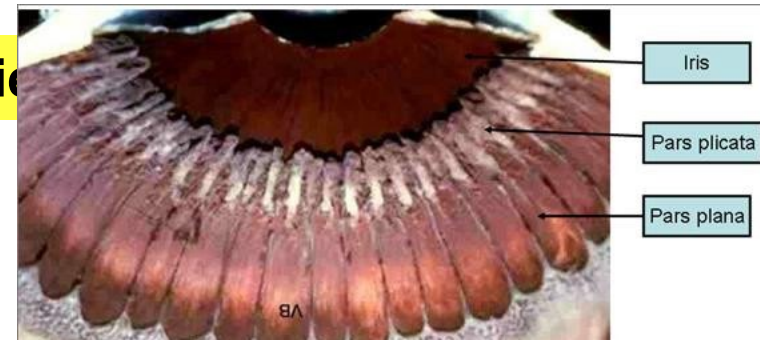
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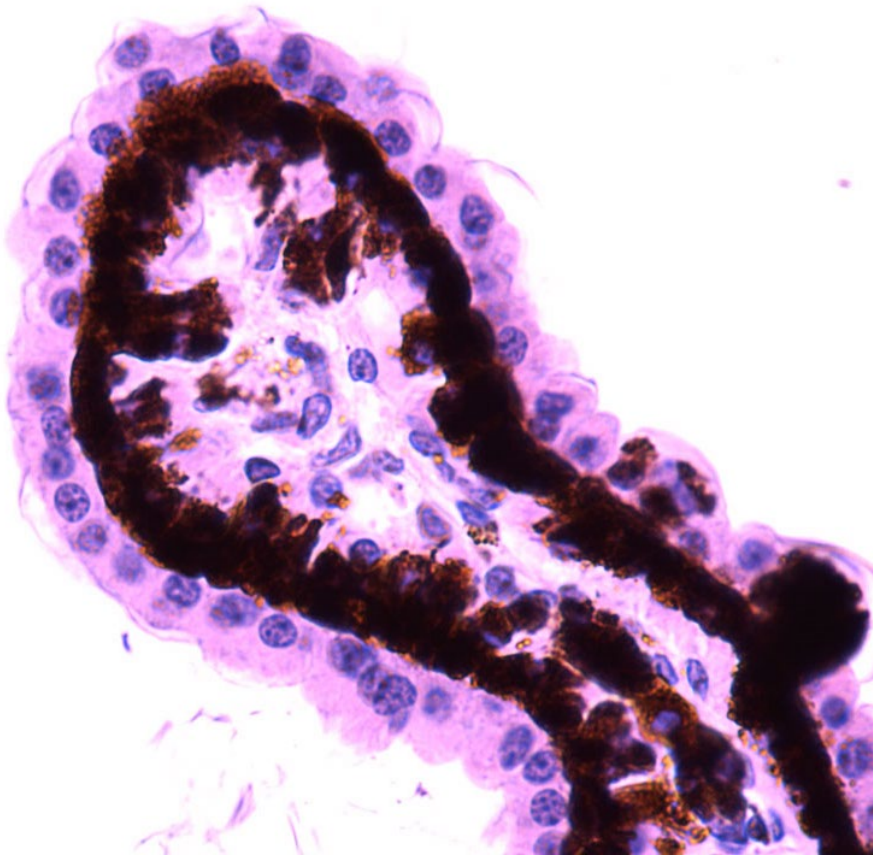
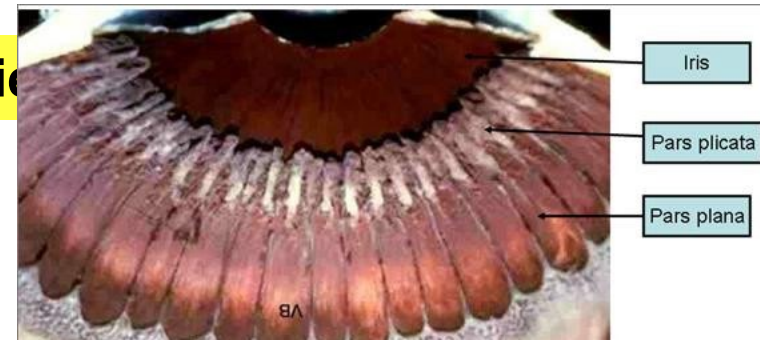


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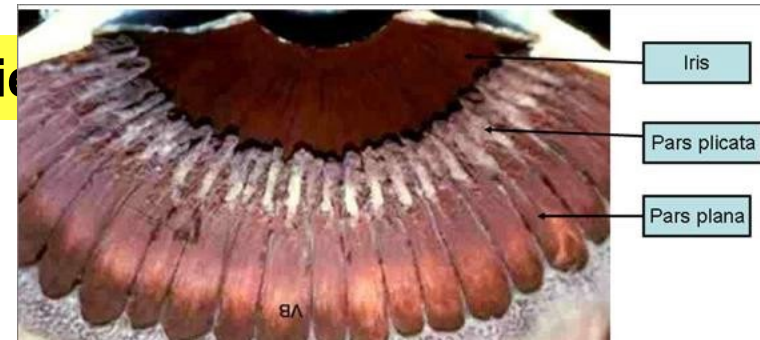


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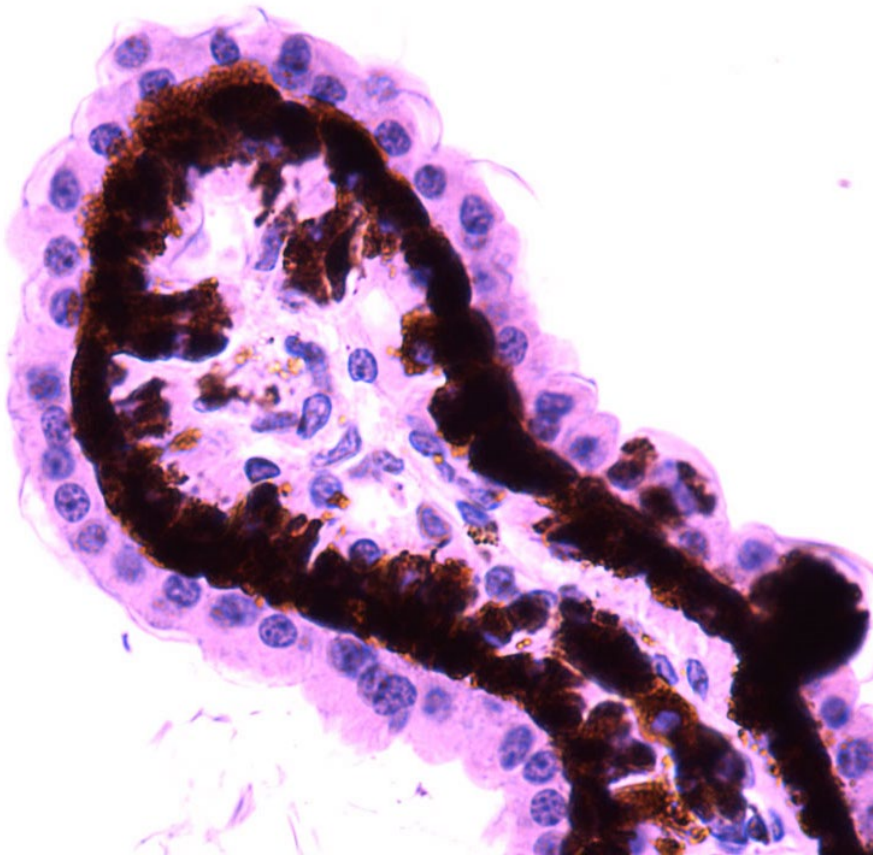
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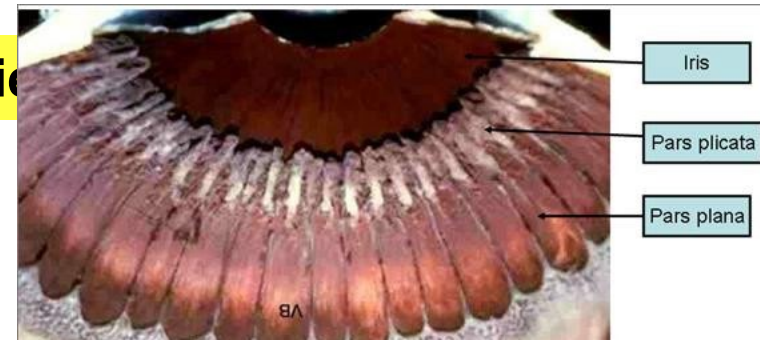


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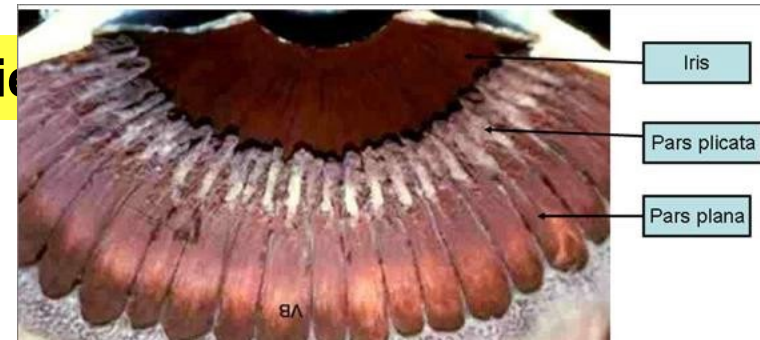


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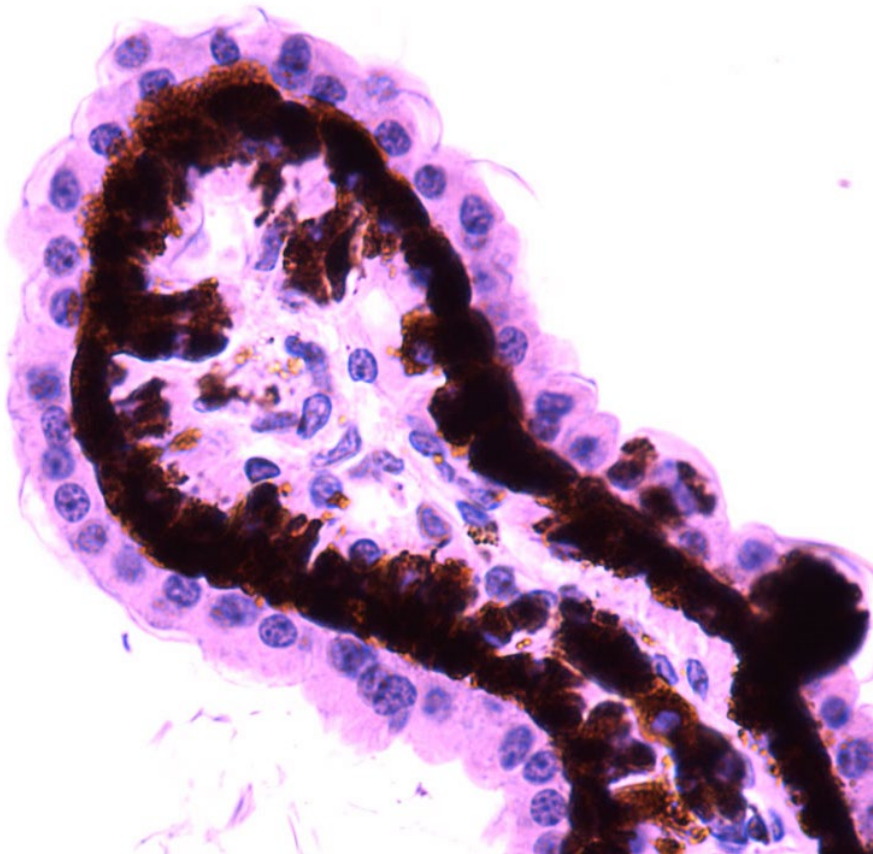
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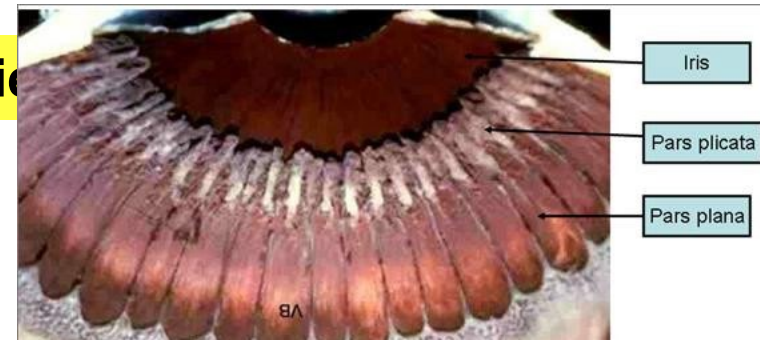


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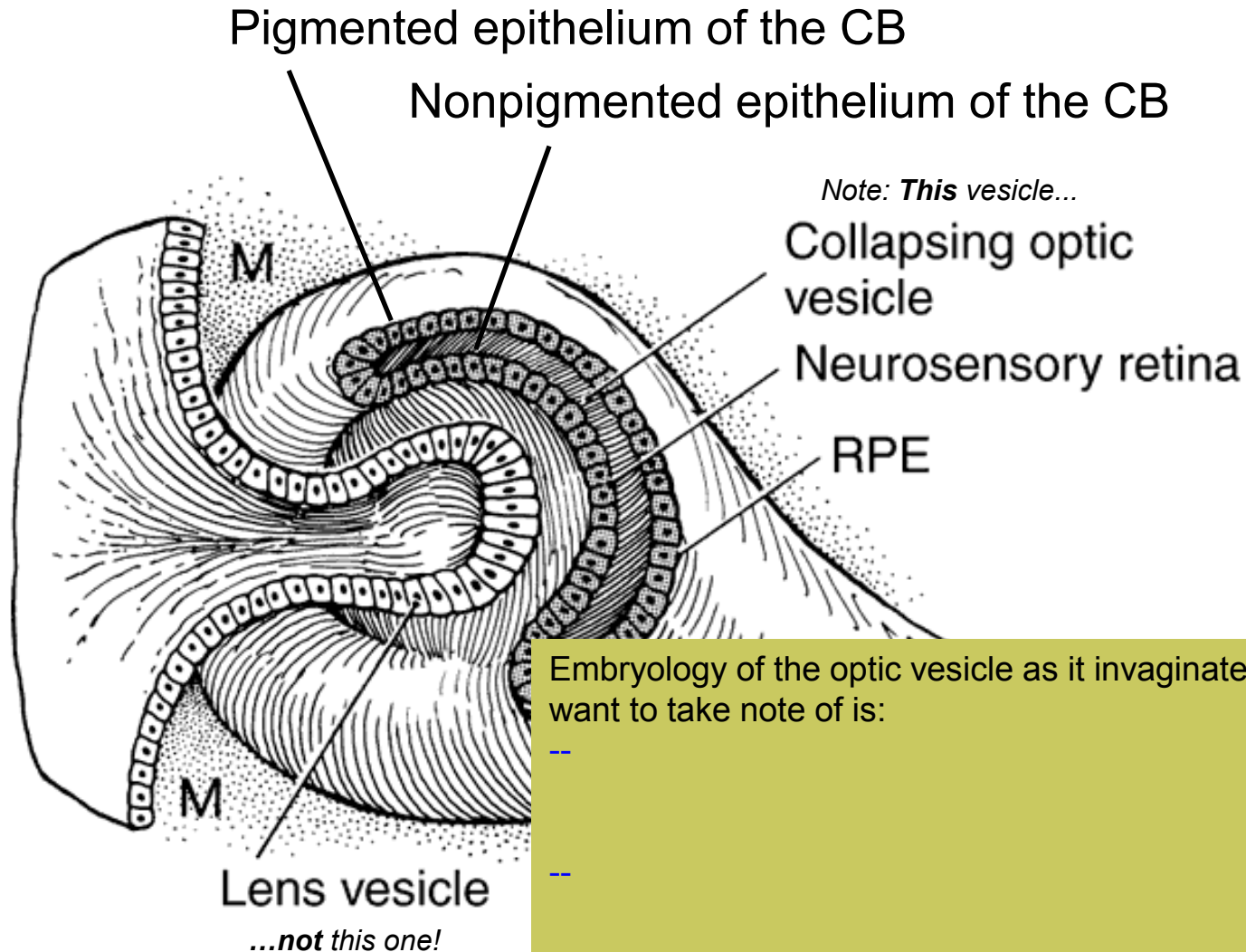
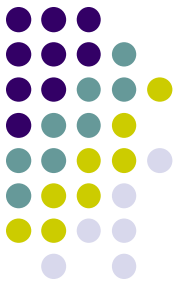
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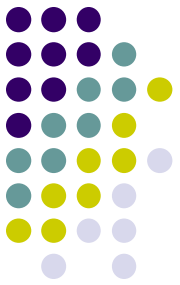
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A

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Pigmented epithelium of the CB★

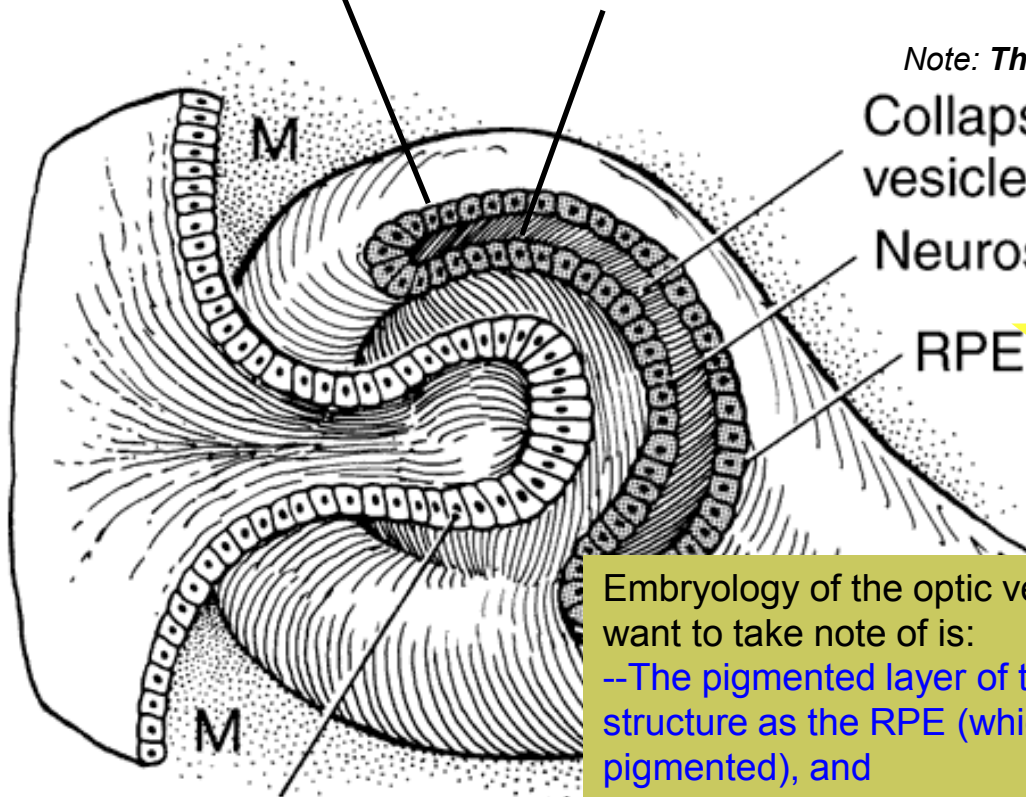
Nonpigmented epithelium of the CB

Note: **This** vesicle...

Collapsing optic  
vesicle

Neurosensory retina

RPE★



B  
Lens vesicle

...*not* this one!

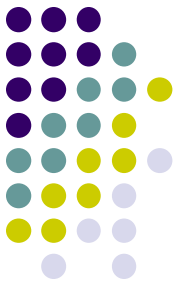
Embryology of the optic vesicle as it invaginates. What you want to take note of is:

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A

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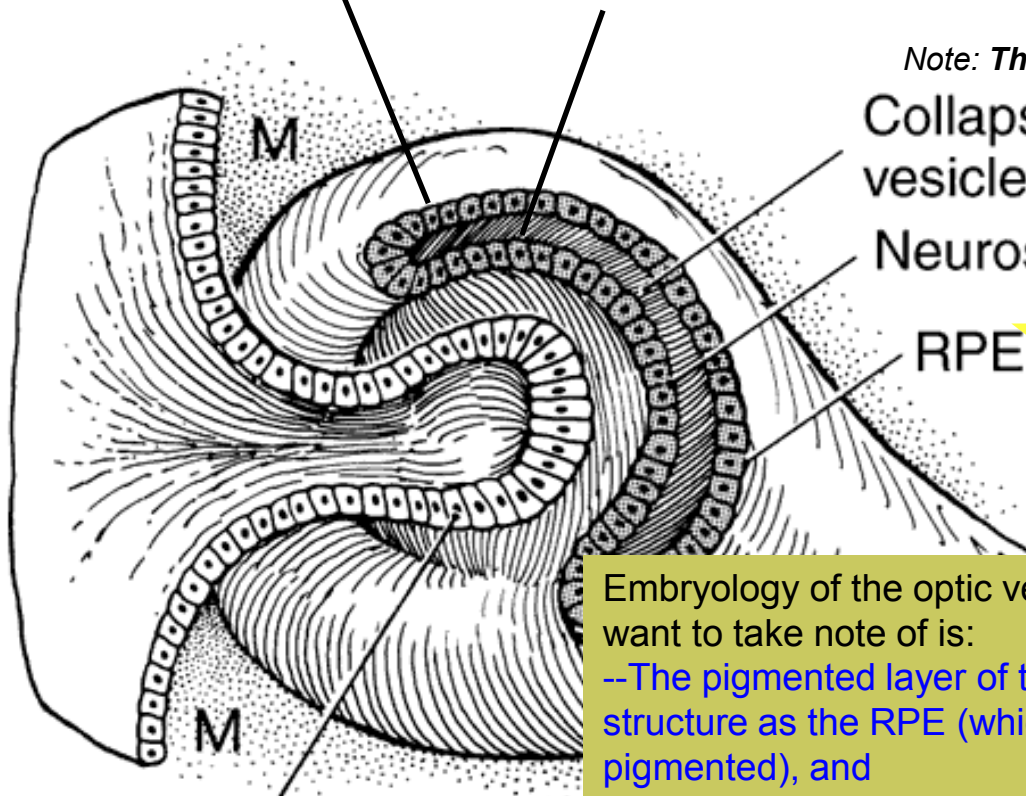
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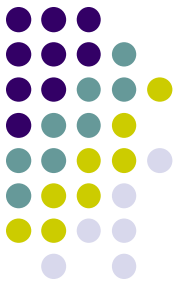
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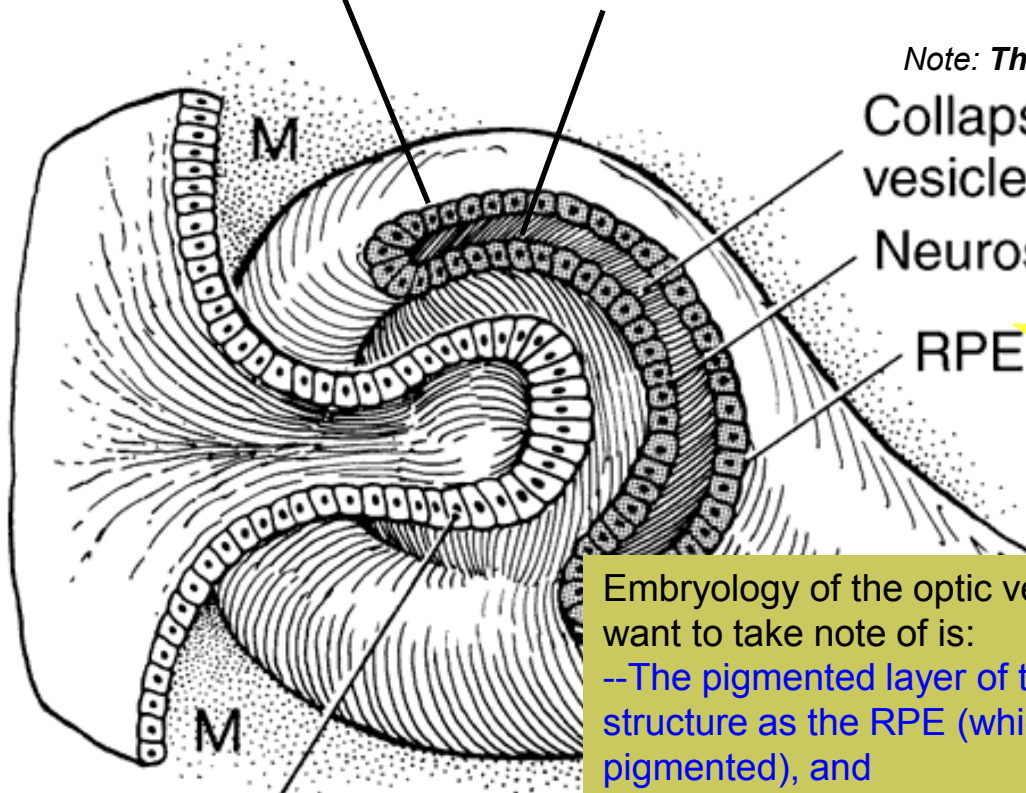
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In other words, what you already know about eye *anatomy* can help you understand and remember eye *embryology*. (For more, see the *Embryology made simply ridiculous* slide-set.)

# B

# Q

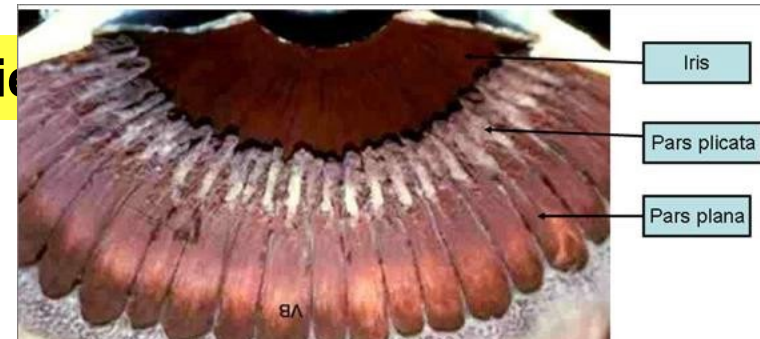
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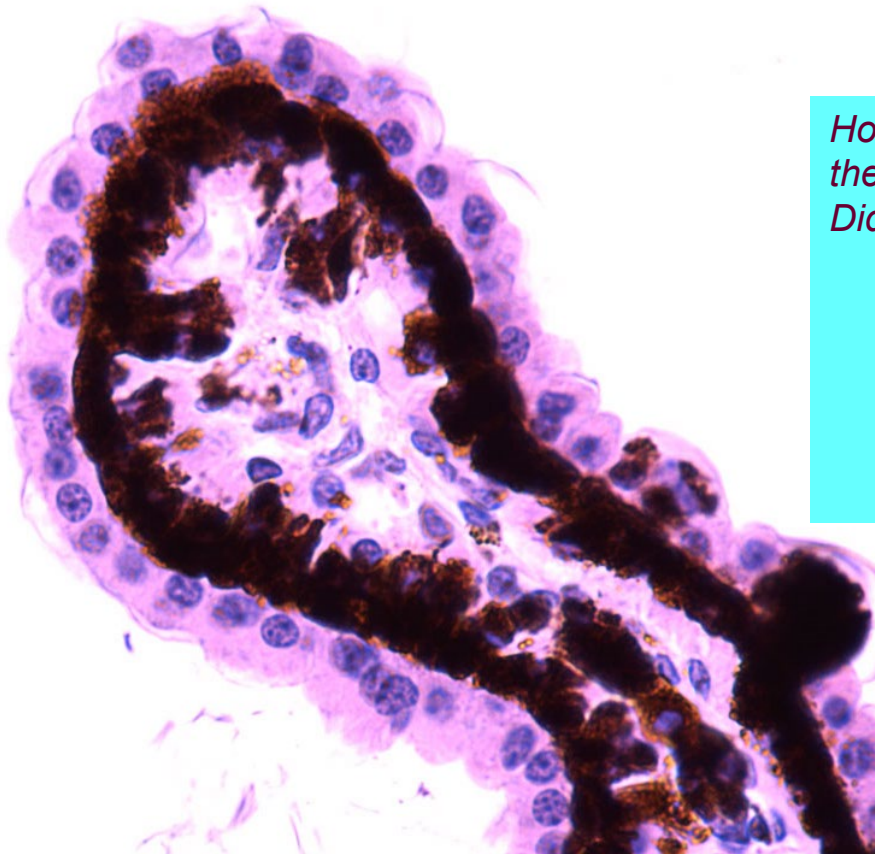
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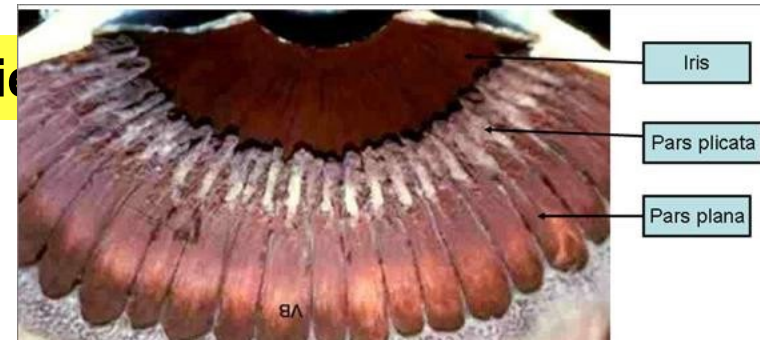
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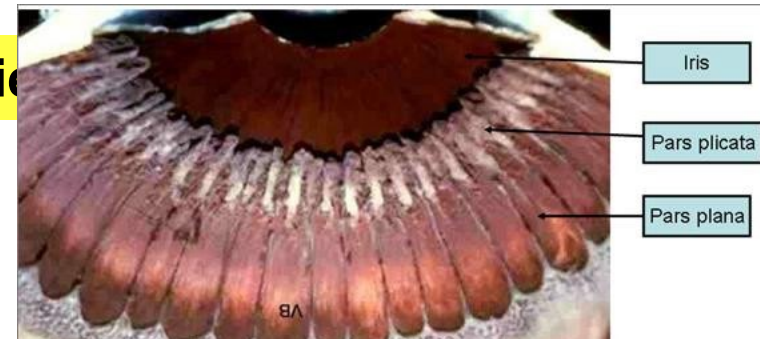
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# Glaucoma Overview

Fill in the IOP equation below. What is its eponymous name?  
The **Goldmann equation**

$$\text{IOP} = \frac{\text{Aqueous Formation Rate } (\mu\text{L/min})}{\text{Outflow Facility } (\mu\text{L/min/mmHg})} + \text{Episcleral Venous Pressure (mmHg)}$$

Which classes of meds decrease aqueous formation?

- $\beta$  blockers
- CAIs
- $\alpha$  agonists

Now let's look at IOP measurement via **Goldmann applanation tonometry**

So to lower IOP, one must:

- decrease aqueous formation, and/or
- increase outflow facility**, and/or
- decrease episcleral venous pressure

What are the two types of outflow?

- Trabecular meshwork**
- Uveoscleral**

...and/or **dehydrate the vitreous** with a hyperosmotic agent



(*P* is for *Pressure*)

- Based on the two-name eponym *principle*:  $\mathbf{P} = \square / \square$



- Based on the *Imbert-Fick* principle:  $P = F / A$



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● Pressure inside a sphere equals what the...  
...*F* stands for divided by the what the *A* stands for

*Principle in words*



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I-F Principle  
in words



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  - Assumes surface is , and  (cornea is neither, obviously)



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increase vs decrease
-------------------------

 IOP reading



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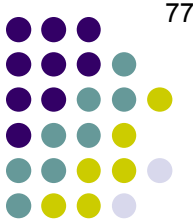
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    - Tear film → capillary attraction → 

increase vs decrease

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*On the other hand:* The first ocular structure encountered by the applanator tip is the tear film. When contact with the tear film is made, a fluid bridge forms between the cornea and the tip. Surface tension of the water in this fluid bridge produces *capillary attraction*, which exerts a slight 'pull' on the applanator tip, drawing it toward the cornea.





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*To be useful, an applanator-type device has to account for these factors. Fortunately, the brilliant Dr. Goldmann was (mostly) up to the challenge...*



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  - Dr Goldmann realized if the diameter of the circle applanated by the device is ### mm, capillary attraction and corneal thickness would cancel each other out (assuming CCT is # μm)

(CCT = Central corneal thickness)



- Based on the *Imbert-Fick* principle:  $P = F / A$ 
  - Pressure inside a sphere equals force needed to flatten its surface divided by the area of flattening
  - Assumes surface is infinitely thin, and dry (cornea is neither, obviously)
    - K thickness → resists appplanation → increases IOP reading
    - Tear film → capillary attraction → decreases IOP reading
  - Dr Goldmann realized if the diameter of the circle applanated by the device is 3.06 mm, capillary attraction and corneal thickness would cancel each other out (assuming CCT is 520  $\mu\text{m}$ )

(CCT = Central corneal thickness)



## Glaucoma Overview

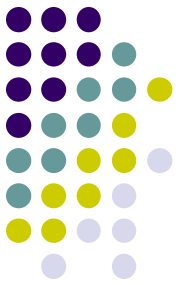
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      - Goldmann believed CCT was ~520, with little variation
- (We now know that CCT averages about 550, with wide variation among individuals)



## Glaucoma Overview

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  - Pressure inside a sphere equals force needed to flatten its surface divided by the area of flattening
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    - Goldmann believed CCT was ~520, with little variation
    - When the mires line up, the diameter of the applanated area is 3.06 mm

# Glaucoma Overview



*Define glaucoma.*

A group of optic neuropathies that present with progressive **ONH** damage and characteristic VF loss



*Why isn't elevated IOP mentioned above?*

Elevated IOP is a strong risk factor for glaucoma, but it need not be present—IOP can be normal, or even low

*In addition to being the strongest risk factor for glaucoma, **IOP** has another quality that renders it unique—what is it?*

It is the only risk factor that is **modifiable** in a manner proven to influence the risk of glaucoma progression

***We mentioned previously that glaucoma presents with “progressive ONH damage.”  
Let’s drill down on the structure of the ONH.***



Q

## Glaucoma Overview

*The optic nerves are composed of what?*

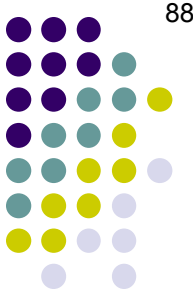


# A

## Glaucoma Overview

*The optic nerves are composed of what?*

The axons of retinal ganglion cells



# Q

## Glaucoma Overview

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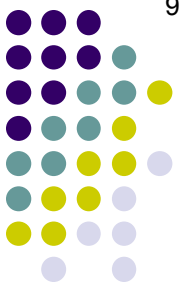
The **axons of retinal ganglion cells**

*How many fibers (axons) comprise an optic nerve?*



# A

## Glaucoma Overview



*The optic nerves are composed of what?*

The **axons of retinal ganglion cells**

*How many fibers (axons) comprise an optic nerve?*

Depends upon which book you ask, but the answer **1.2M** works

Per the...

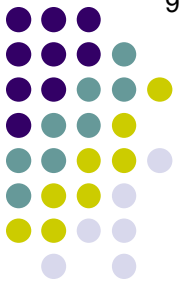
*Glaucoma* book: 1.2-1.5M

*Neuro* book: 1-1.2M

*Fundamentals* book: “more than a million”

# Q

## Glaucoma Overview



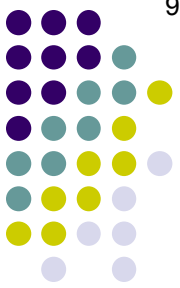
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# A

## Glaucoma Overview



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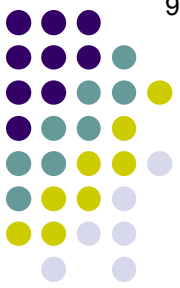
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# Q

## Glaucoma Overview



*The optic nerves are composed of what?*

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No

*Where will they synapse?*



# A

## Glaucoma Overview



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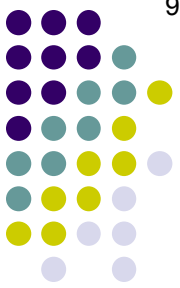
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# Q

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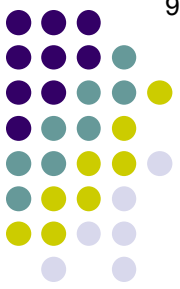
*Where will they synapse?*

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*Most? Where will the others synapse, and what are they responsible for?*

# Q/A

## Glaucoma Overview



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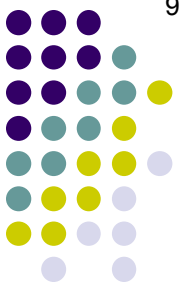
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Most of the others are involved in the **three words**

# A

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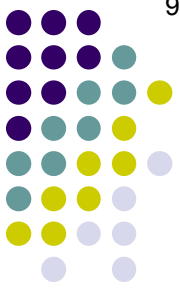
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# Q/A

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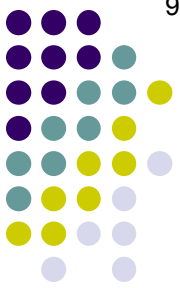
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# A

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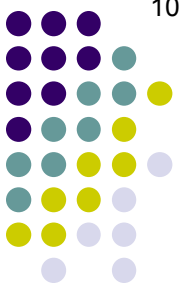
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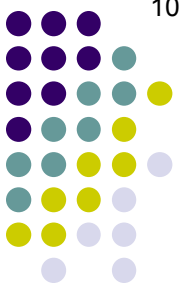
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*There's that word again—'most.' Where will the others synapse, and what are they responsible for?*

The hypothalamus, where they are involved in modulating circadian responses

## Q

## Glaucoma Overview



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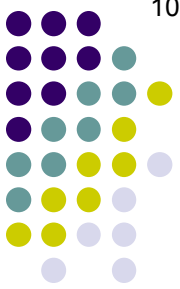
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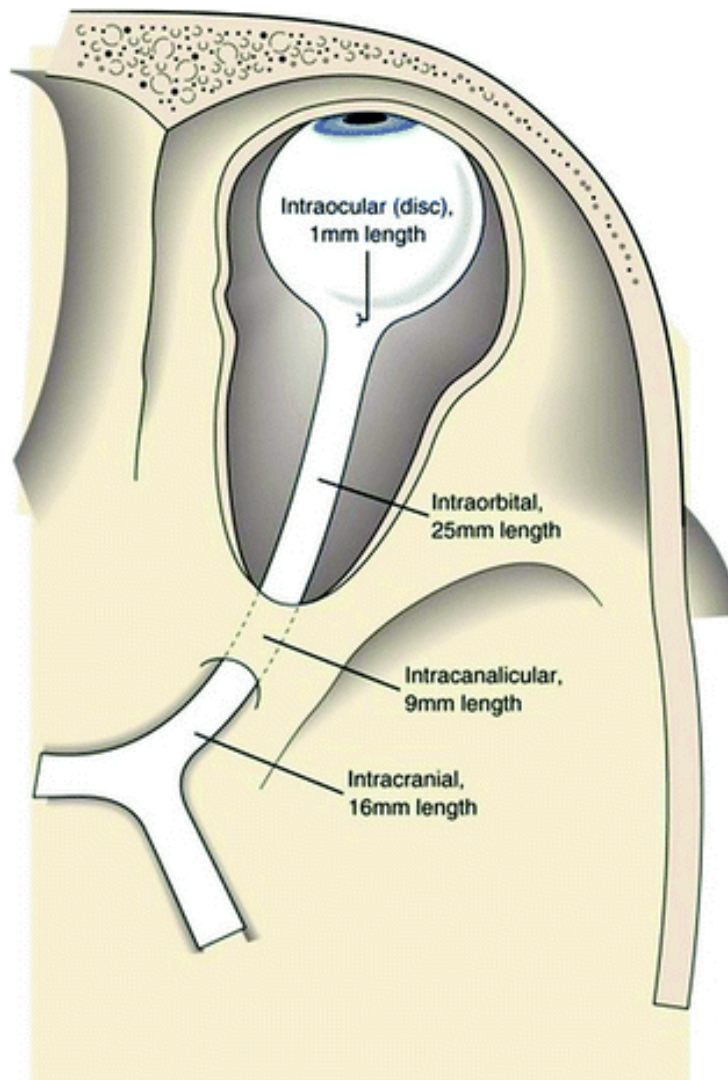
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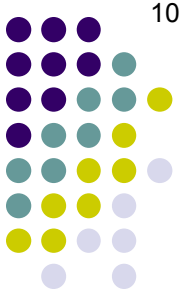
*Anatomically speaking, the optic nerve is considered to have four portions. What are they?*

The **intraocular**, **intraorbital**, **intracanalicular**, and **intracranial**

## Glaucoma Overview



Optic nerve portions (don't memorize the lengths)



# Q

## Glaucoma Overview

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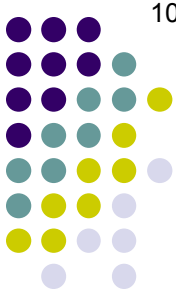
The **intraocular**, intraorbital, intracanalicular, and intracranial

*The intraocular portion is also considered to have four portions. What are they?*

	Portion	
(innermost) →	?	
↑		
↓		
(outermost) →		

# Q/A

## Glaucoma Overview



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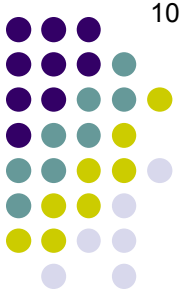
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Portion	
(innermost) →	NFL portion
↑	?
↓	
(outermost) →	

# Q/A

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↑	Pre-laminar
↓	?
(outermost) →	

# Q/A

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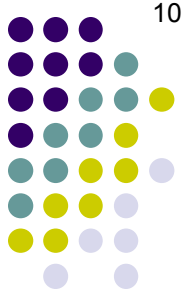
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# A

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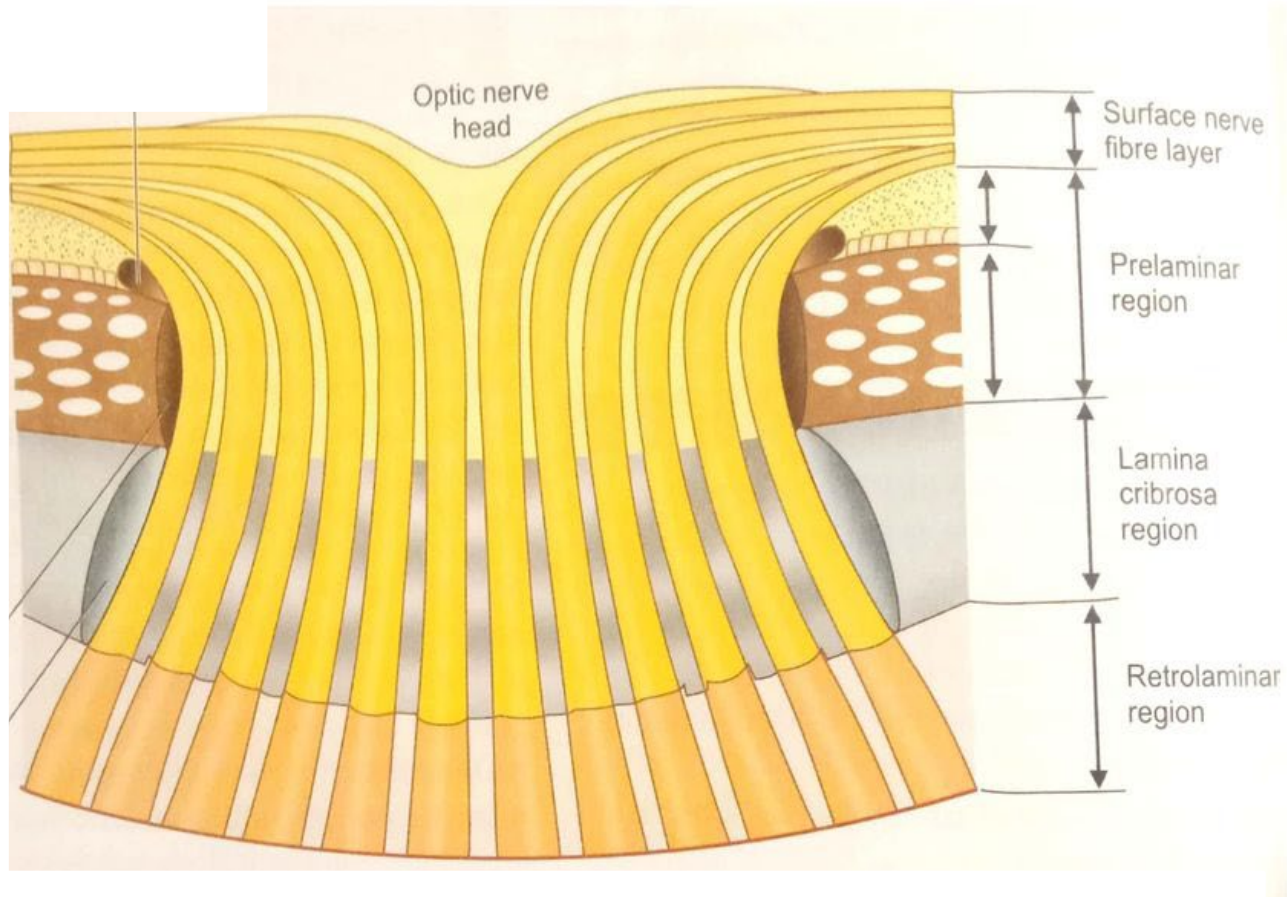
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(innermost) →	NFL portion
↑	Pre-laminar
↓	Laminar
(outermost) →	Retrolaminar

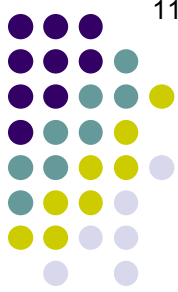
# Glaucoma Overview



Optic nerve head portions

# Q

## Glaucoma Overview



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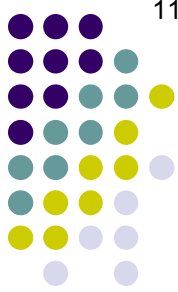
*The intraocular portion is also considered to have four portions. What are they?*

**What is the blood supply for each?**

	Portion	Blood supply
(innermost) →	NFL portion	?
↑	Pre-laminar	
↓	Laminar	
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# Q/A

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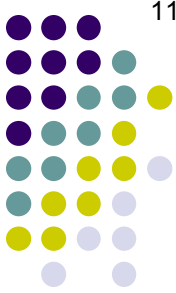
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	<b>Portion</b>	<b>Blood supply</b>
(innermost) →	NFL portion	Central retinal artery (CRA)
↑	Pre-laminar	?
↓	Laminar	
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# Q/A

## Glaucoma Overview



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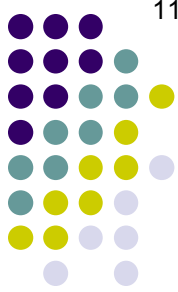
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↓	Laminar	?
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# Q/A

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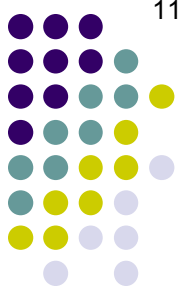
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(outermost) →	Retrolaminar	?

# A

## Glaucoma Overview



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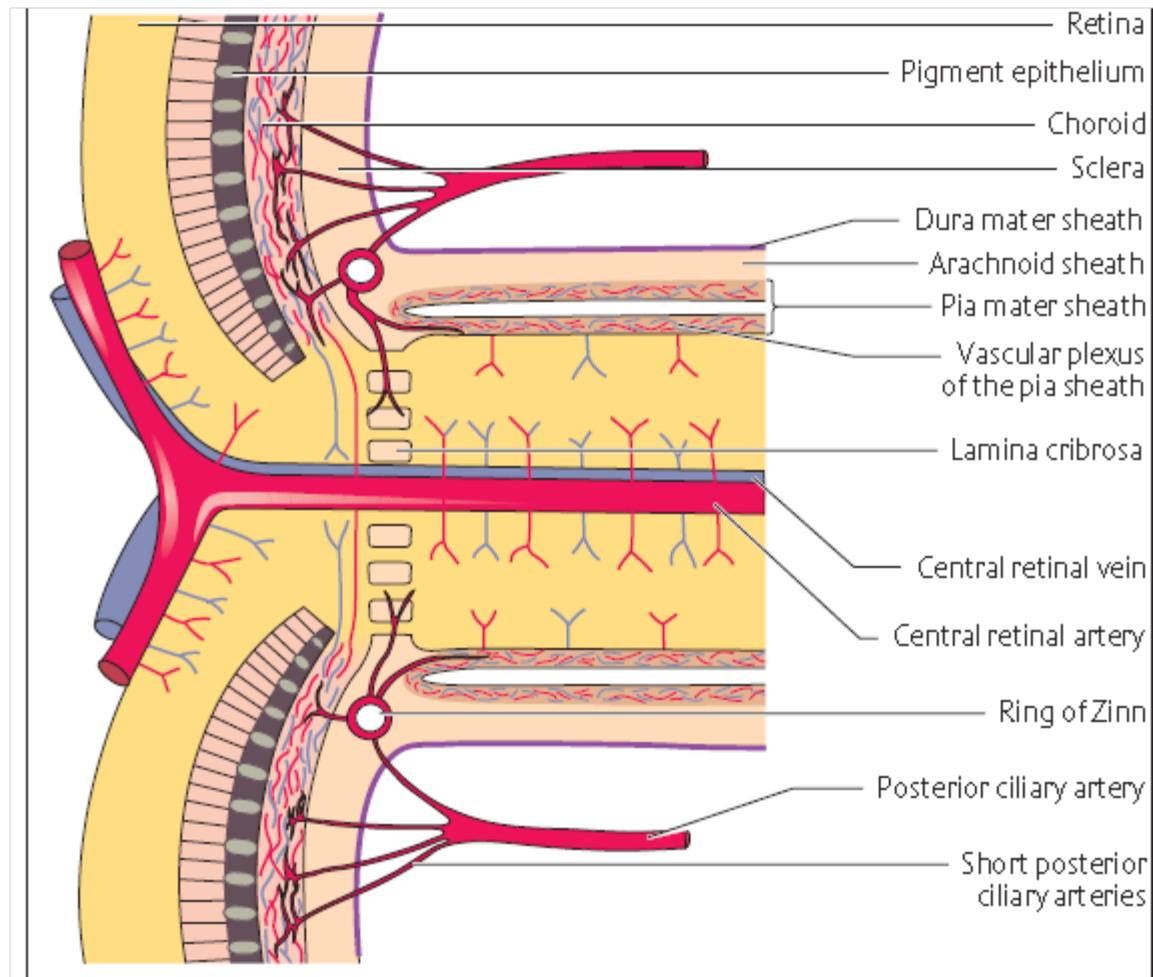
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↑	Pre-laminar	Short posterior ciliary arteries
↓	Laminar	Arterial circle of Zinn & Haller
(outermost) →	Retrolaminar	Centrifugal CRA branches, centripetal pial branches

# Glaucoma Overview



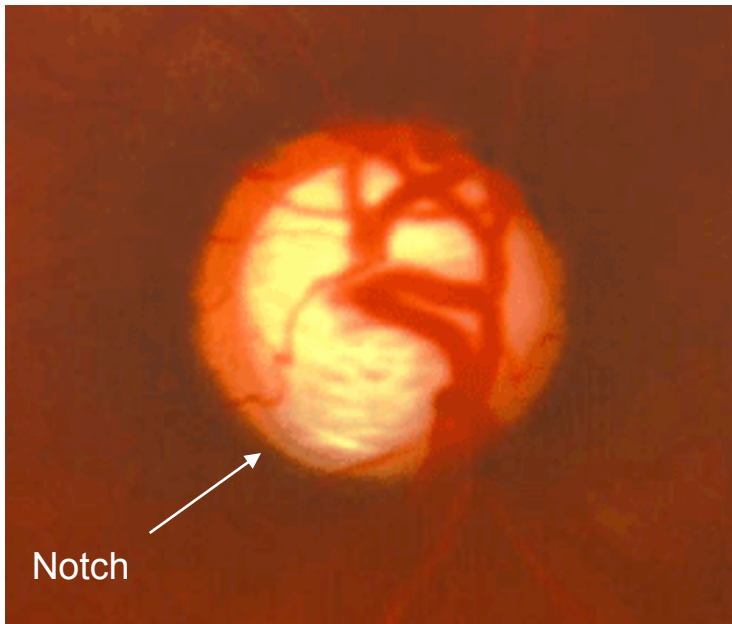
ONH: Blood supply



# Glaucoma Overview



For reasons that have yet to be fully elucidated, glaucomatous optic neuropathy tends to damage the superior and inferior poles of the ONH preferentially and early. This leads to thinning at the poles (focal thinning is often referred to as a 'notch.')



Notch

Glaucomatous ONH



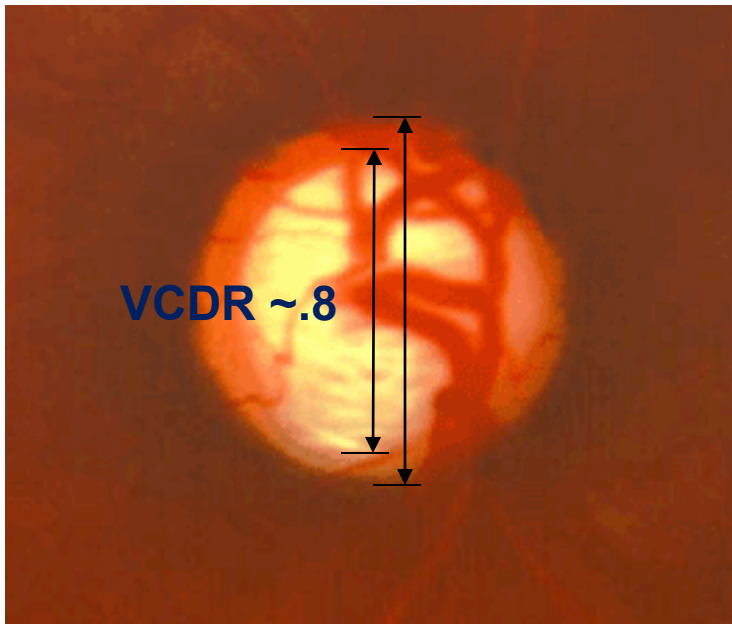
Normal ONH

# Glaucoma Overview

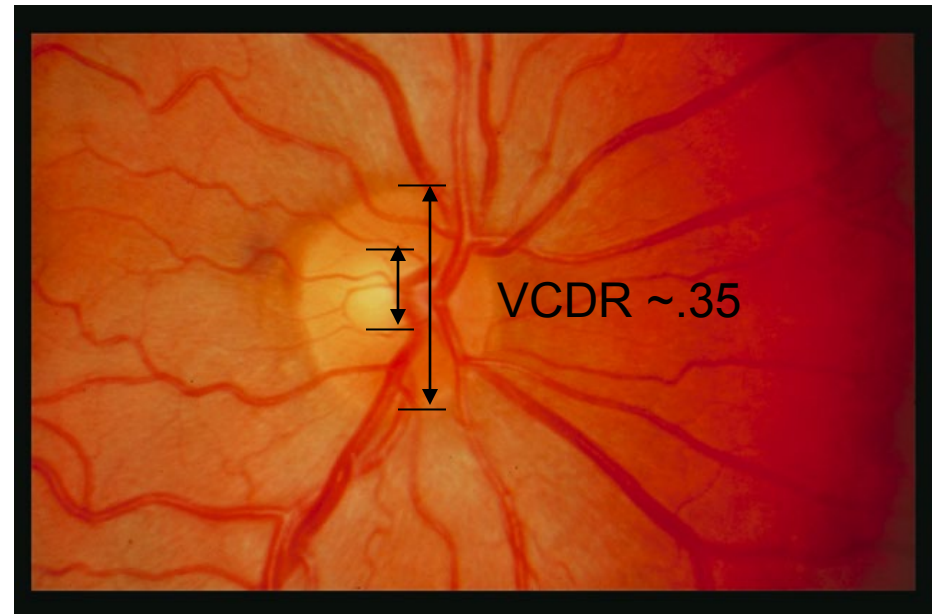


Because of this tendency, ophthalmologists focus on the *vertical cup-disc ratio* (VCDR) when assessing a pt's glaucoma status.

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Glaucomatous ONH

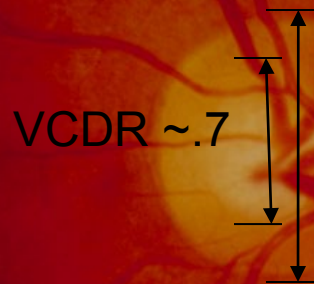


Normal ONH

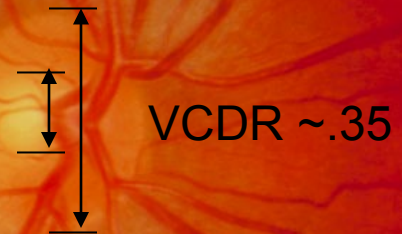
# Glaucoma Overview



Note that the VCDR can be misleading in this regard, as it can be quite pronounced in some normal eyes (especially those with a large disc).



Normal ONH



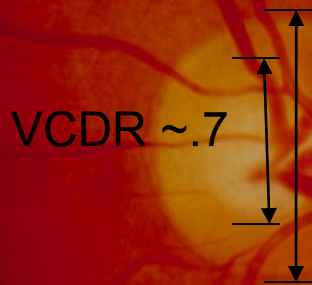
Normal ONH

# Glaucoma Overview

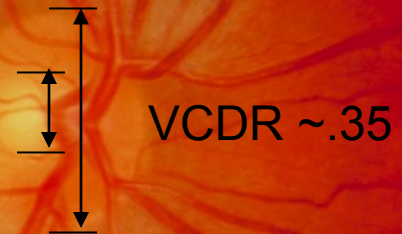


Note that the VCDR can be misleading in this regard, as it can be quite pronounced in some normal eyes (especially those with a large disc).

Thus, in determining the glaucomatous-ness of an ONH, don't just rely on the VCDR--make sure you also *inspect and critically evaluate the status of the neuroretinal rim*.



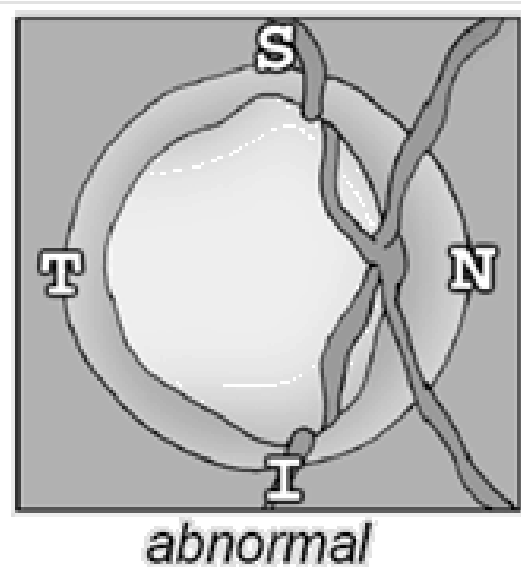
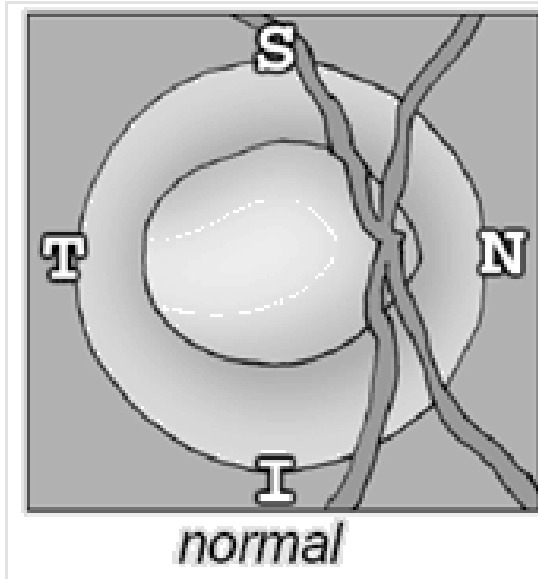
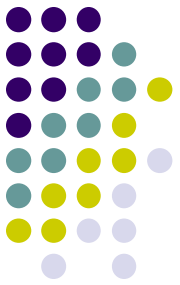
Normal ONH



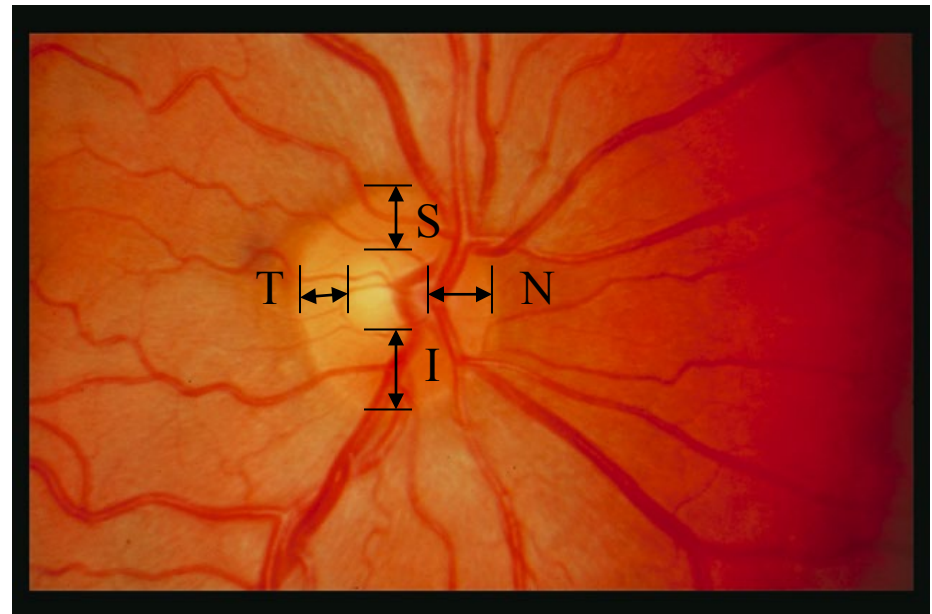
Normal ONH



## Glaucoma Overview

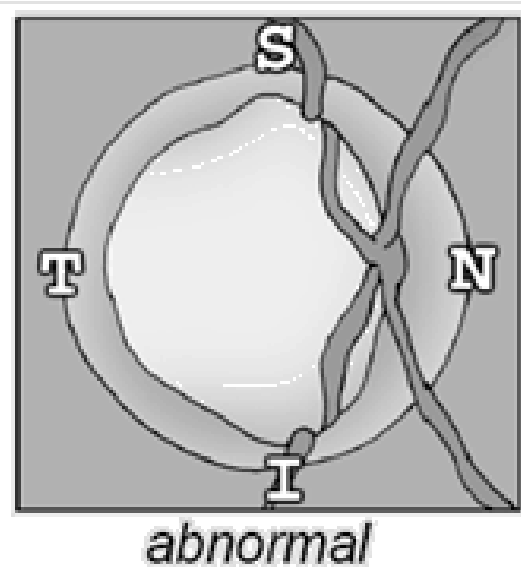
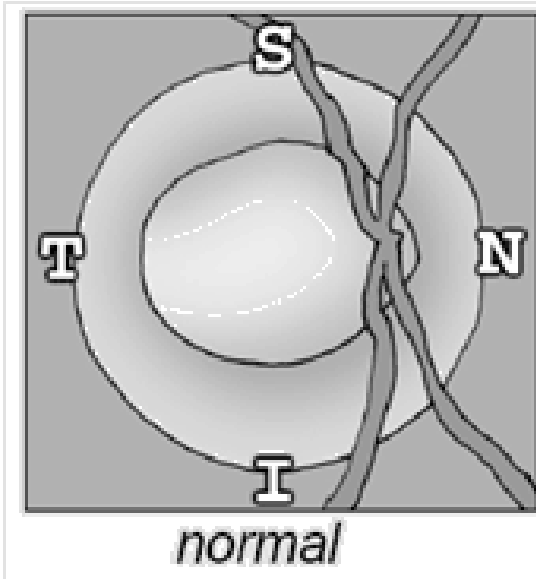
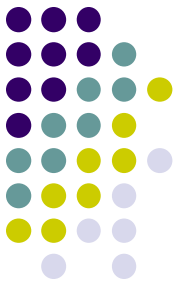


The nonglaucomatous neuroretinal rim tends to follow what's known as the **ISNT rule**: In decreasing order, the rim is thickest at its **Inferior**, **Superior**, **Nasal**, and **Temporal** portions. If an ONH's rim adheres to this rule, it **ISNT** glaucomatous.



Normal ONH

## Glaucoma Overview

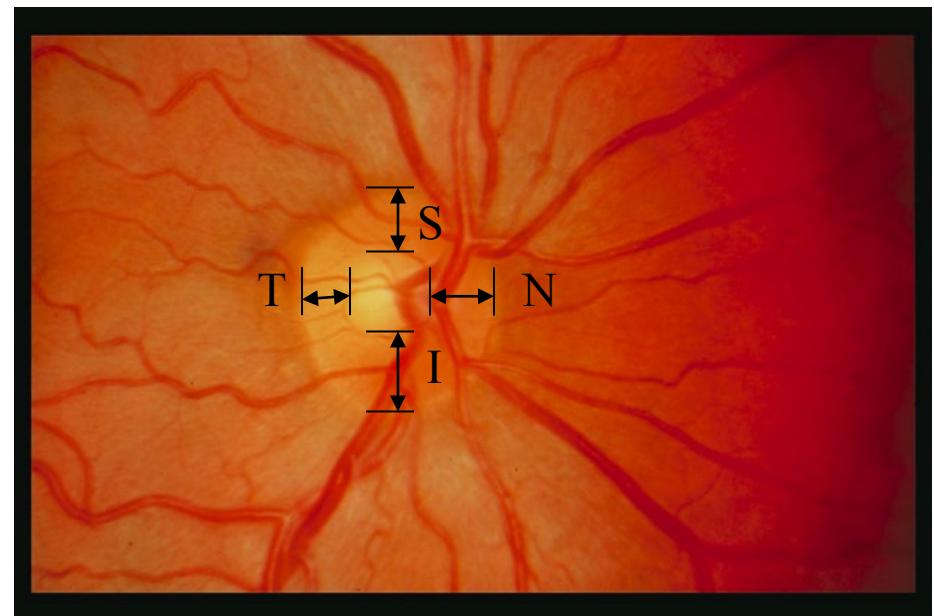


The nonglaucomatous neuroretinal rim tends to follow what's known as the **ISNT rule**: In decreasing order, the rim is thickest at its

**I**nferior,  
**S**uperior,  
**N**asal, and  
**T**emporal

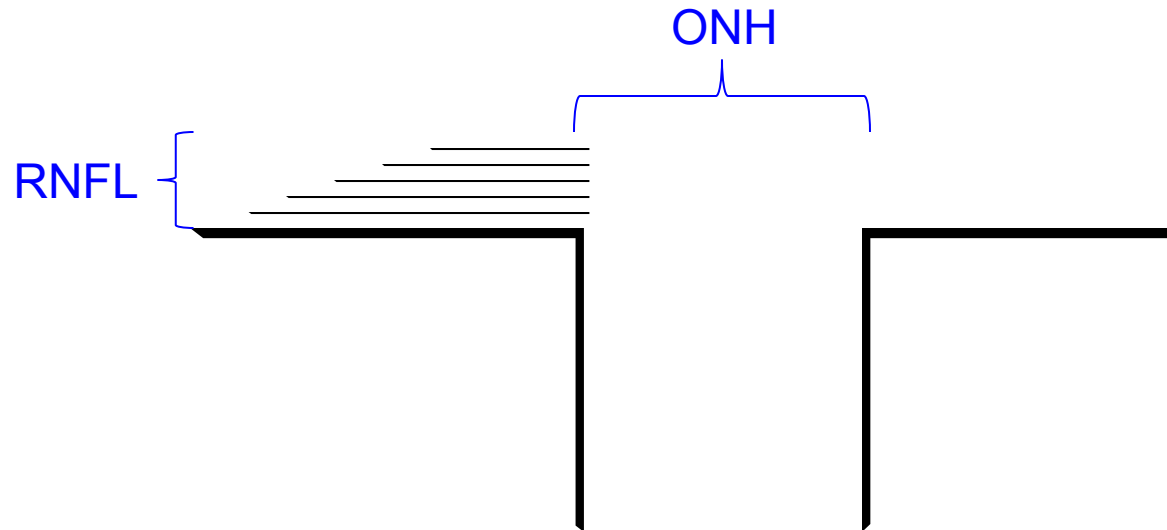
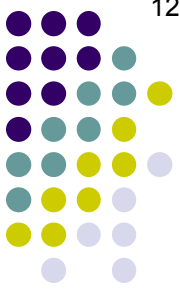
portions. If an ONH's rim adheres to this rule, it **ISNT** glaucomatous.

*Note: Not all glaucoma docs find the ISNT rule to be helpful—YMMV. Ask!*



Normal ONH

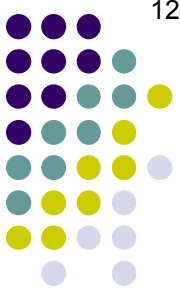
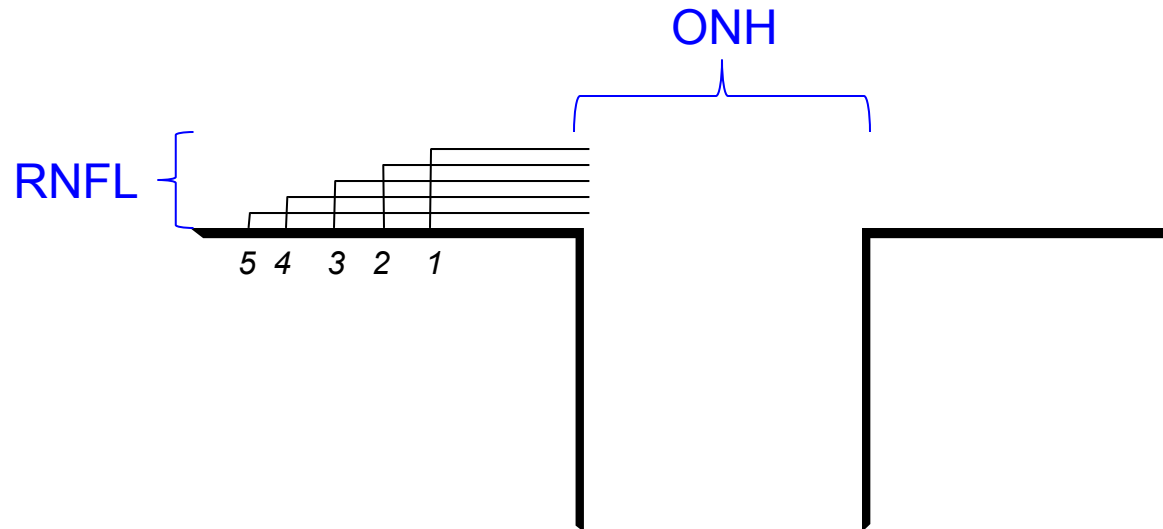
# Glaucoma Overview



Now consider the ONH and retina in cross section. Note that the RNFL and ONH are both organized in a specific fashion:

*No question—proceed when ready*

# Glaucoma Overview



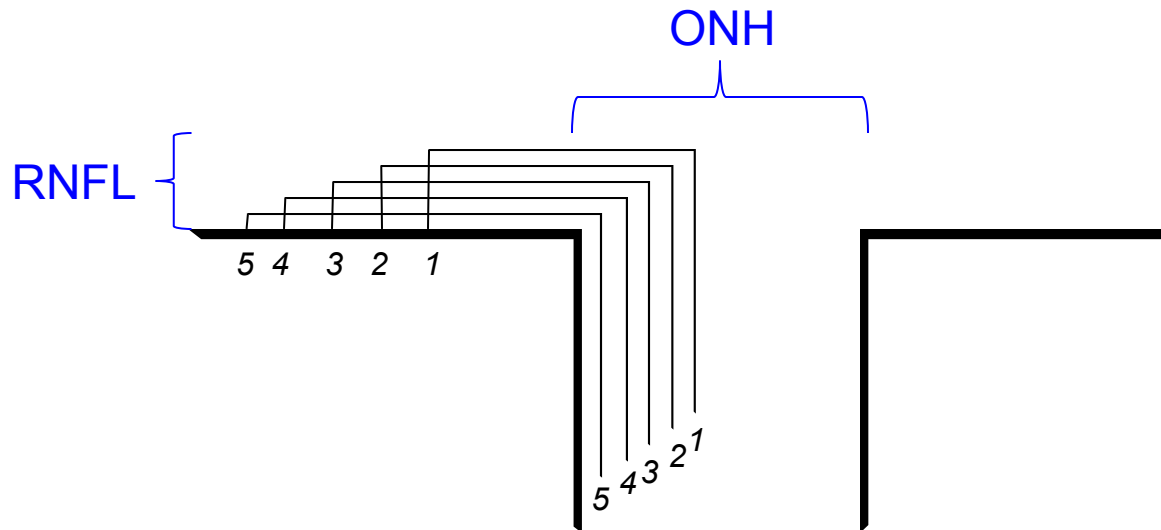
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--The RNFL is stacked *vertically*, with fibers that originate at points distant from the ONH running at the bottom (ie, closer to the RPE); and

*No question—proceed when ready*



# Glaucoma Overview

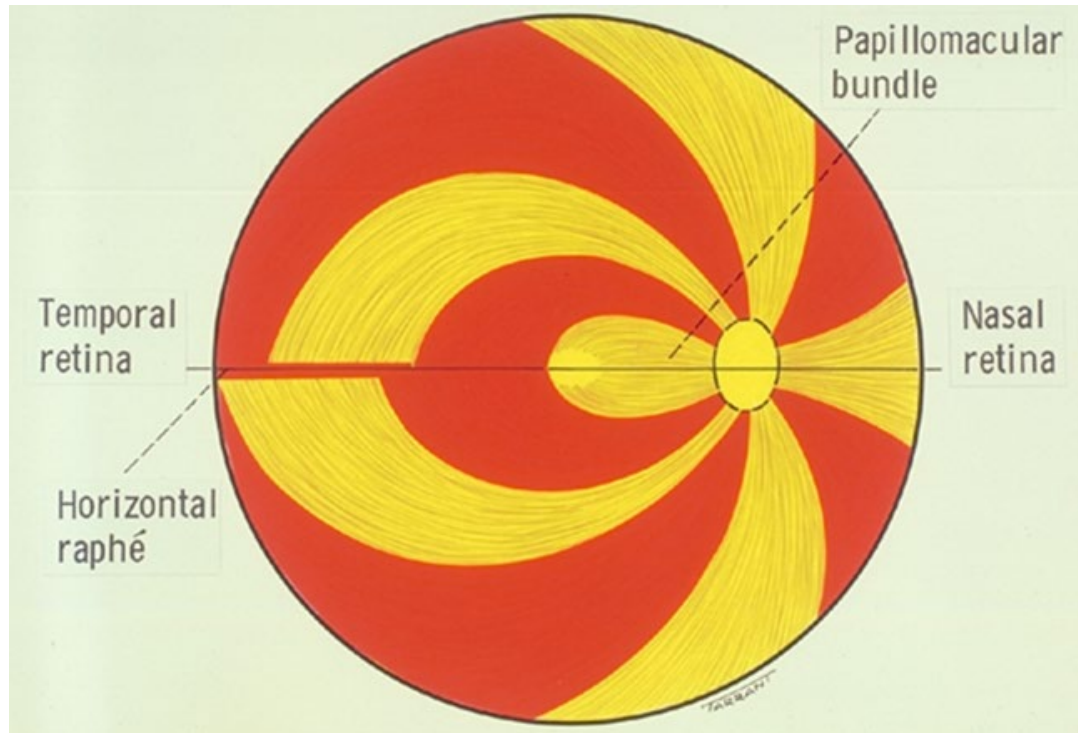
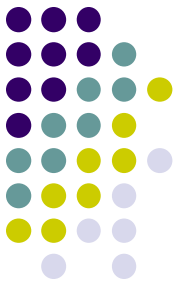


Now consider the ONH and retina in cross section. Note that the RNFL and ONH are both organized in a specific fashion:

- The RNFL is stacked *vertically*, with fibers that originate at points distant from the ONH running at the bottom (ie, closer to the RPE); and
- The ONH is stacked *horizontally*, with its peripheral-most fibers being those originating in the far retina, and its innermost fibers originating in the peripapillary region.

*No question—proceed when ready*

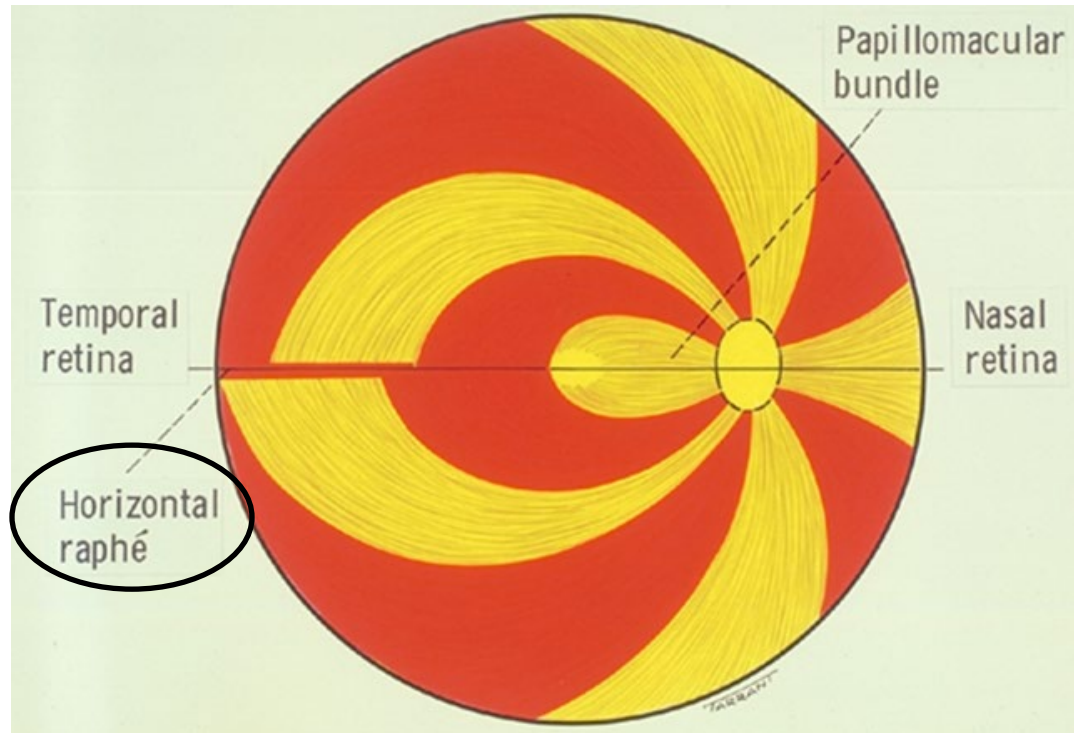
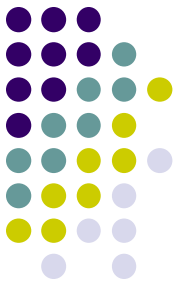
# Glaucoma Overview



Now let's look at the *topography of the retinal nerve fiber layer*, and how that topography relates to the structure of the ONH.

*No question—proceed when ready*

# Glaucoma Overview

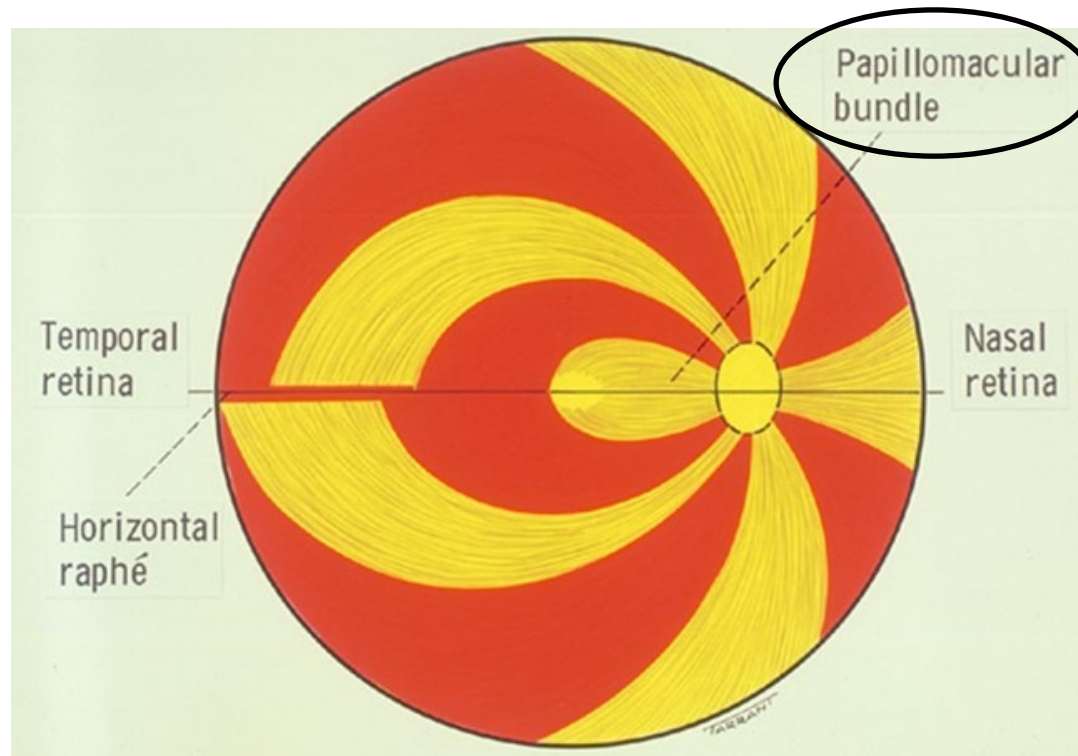
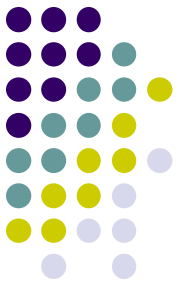


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First, take note of the *horizontal raphé*. Fibers do not cross this anatomic boundary—those superior to it join the superior ONH, and those inferior to it, the inferior ONH.

*No question—proceed when ready*

# Glaucoma Overview



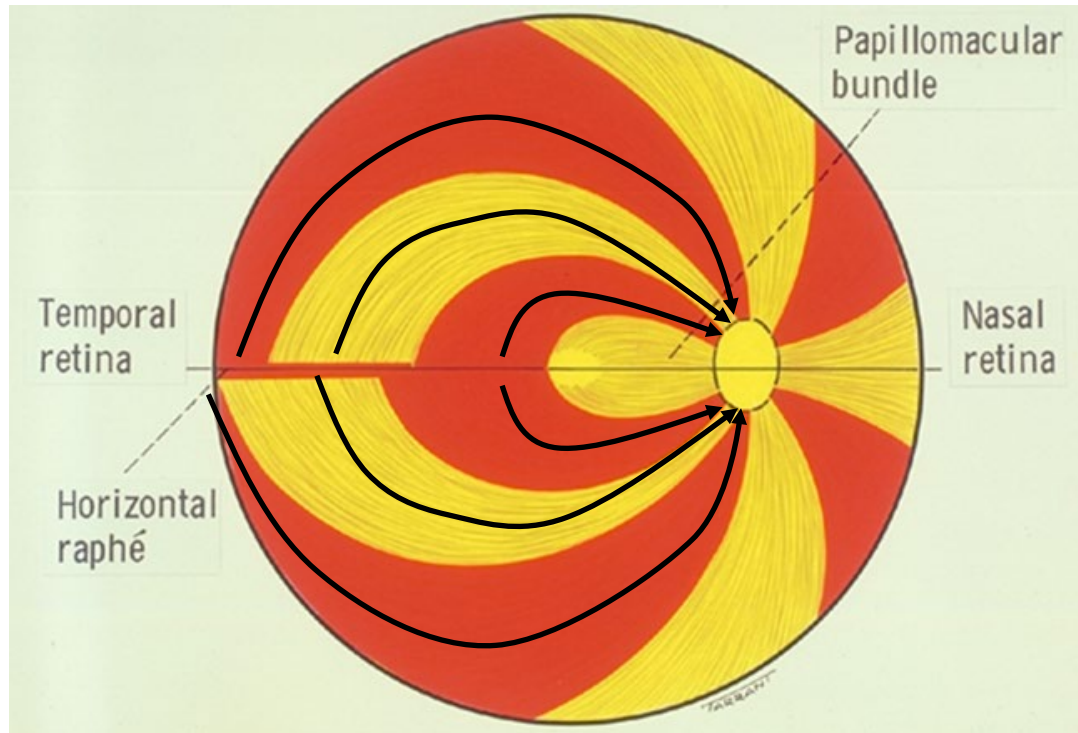
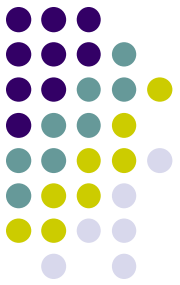
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Next, the *papillomacular (PM) bundle*—the swath of nerve fibers originating in the foveal region. Note how this bundle takes up the lion's share of the temporal ONH.

*No question—proceed when ready*

# Glaucoma Overview



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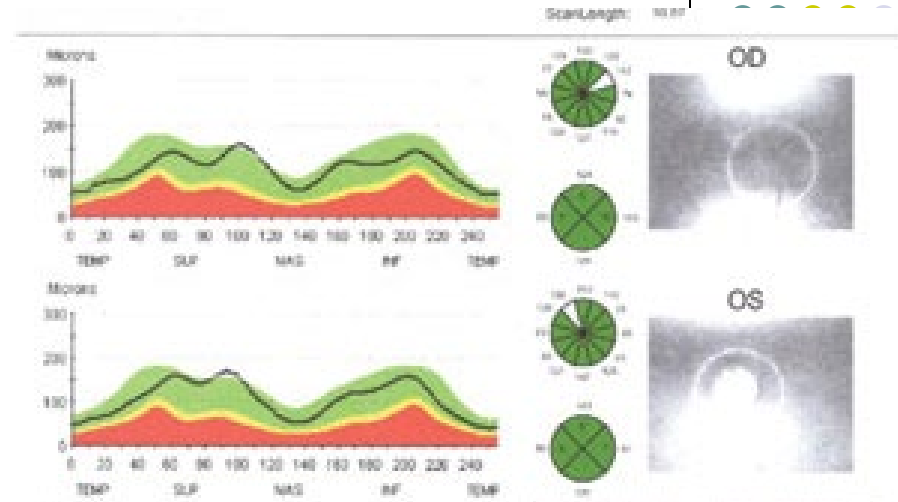
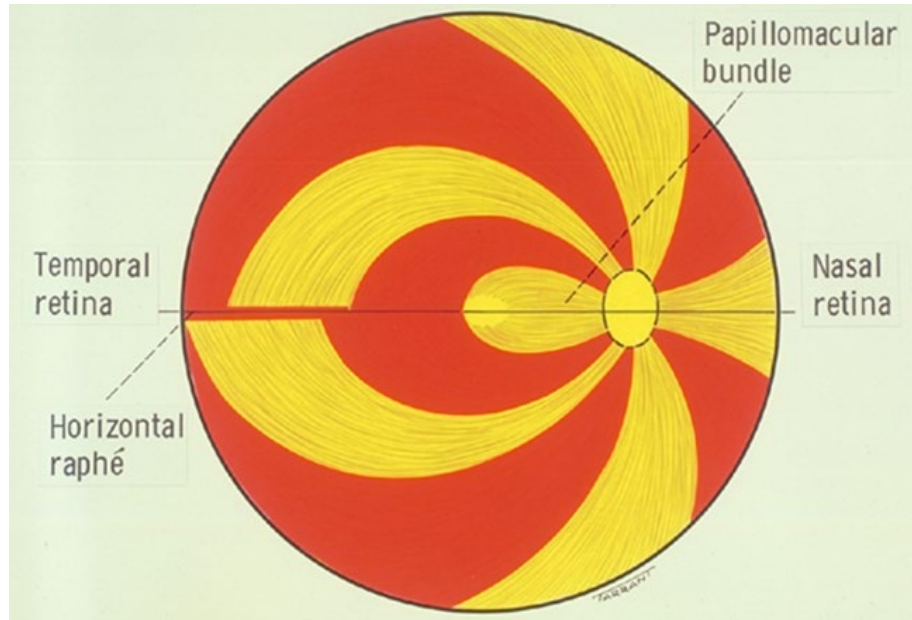
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Next, the *papillomacular (PM) bundle*—the swath of nerve fibers originating in the foveal region. Note how this bundle takes up the lion's share of the temporal ONH.

Finally, note how the PM bundle impacts the structure of the ONH. Because the bundle takes up the temporal ONH, fibers from the temporal perifoveal region and beyond are forced to 'loop around' it, and end up joining the ONH near its superior and inferior poles.

*No question—proceed when ready*

# Glaucoma Overview



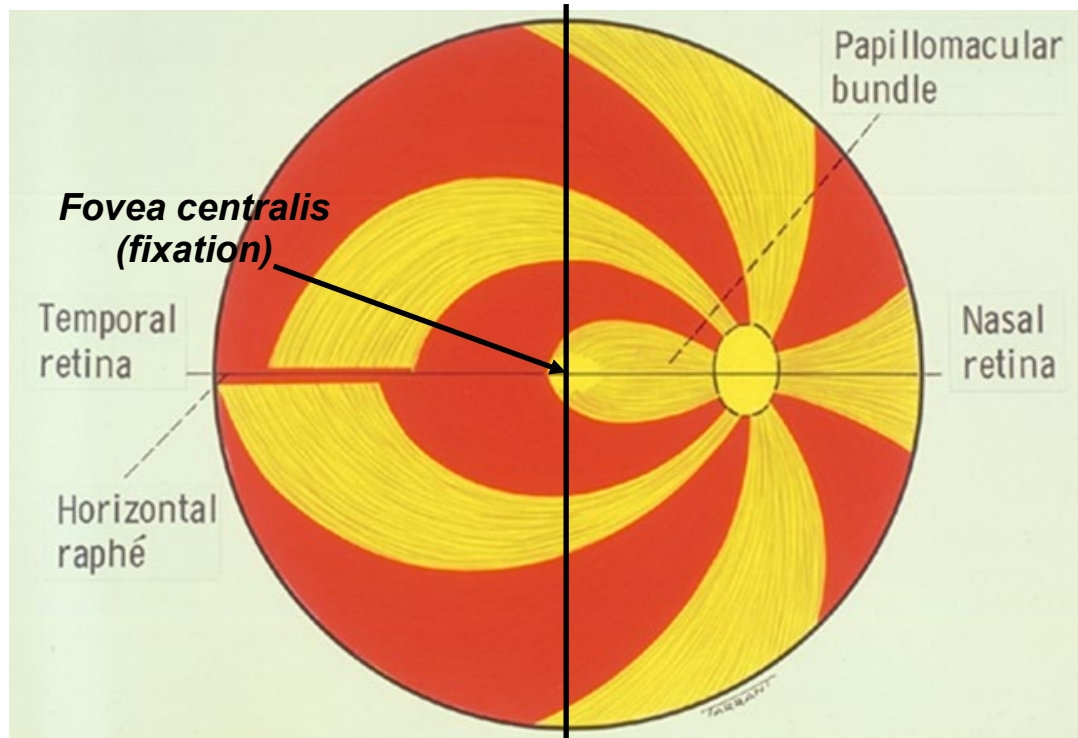
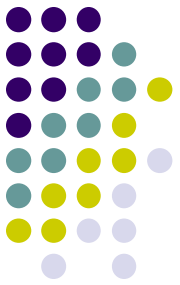
Because there are so many fibers at the superior and inferior poles, the normal ONH rim tends to be thicker at these sites. (This accounts for the relative proportions of the rim segments as captured by the *ISNT rule* described previously.)



Normal ONH



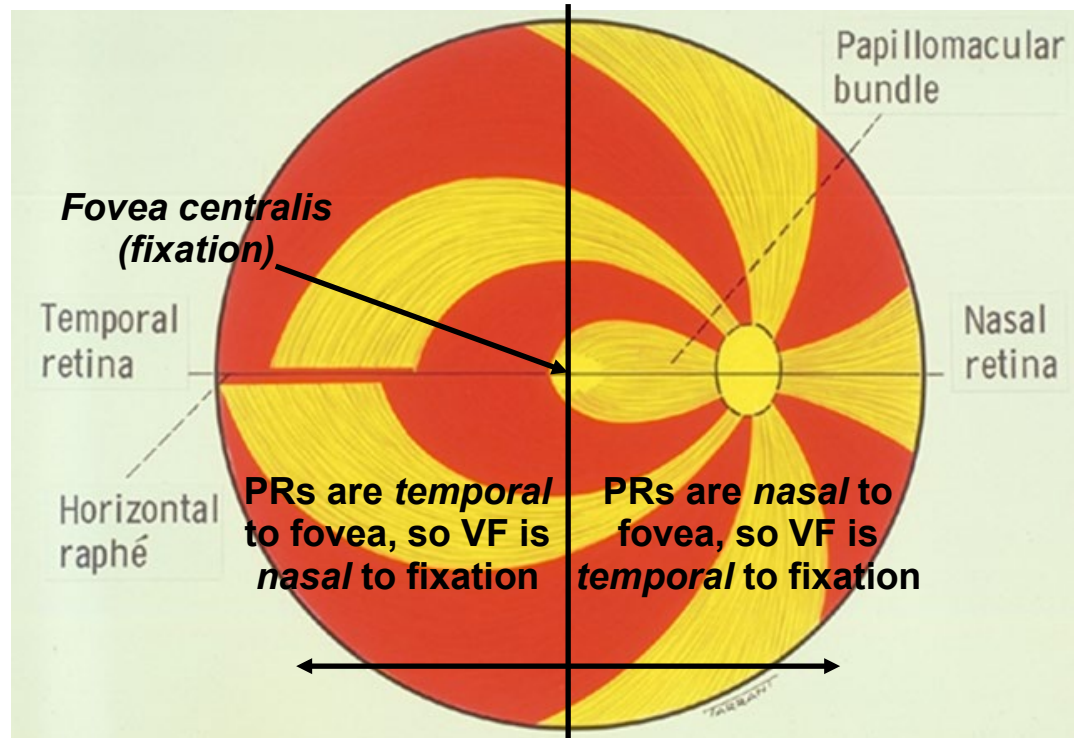
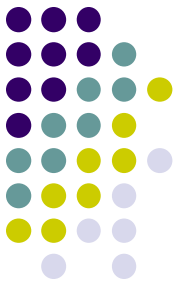
# Glaucoma Overview



Note also that a *vertical meridian* can be described in the retina as well. Unlike the horizontal raphé (which is physically instantiated in the anatomy of the retina), this vertical meridian is purely functional—it cannot be identified via histological examination of the retina.

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# Glaucoma Overview



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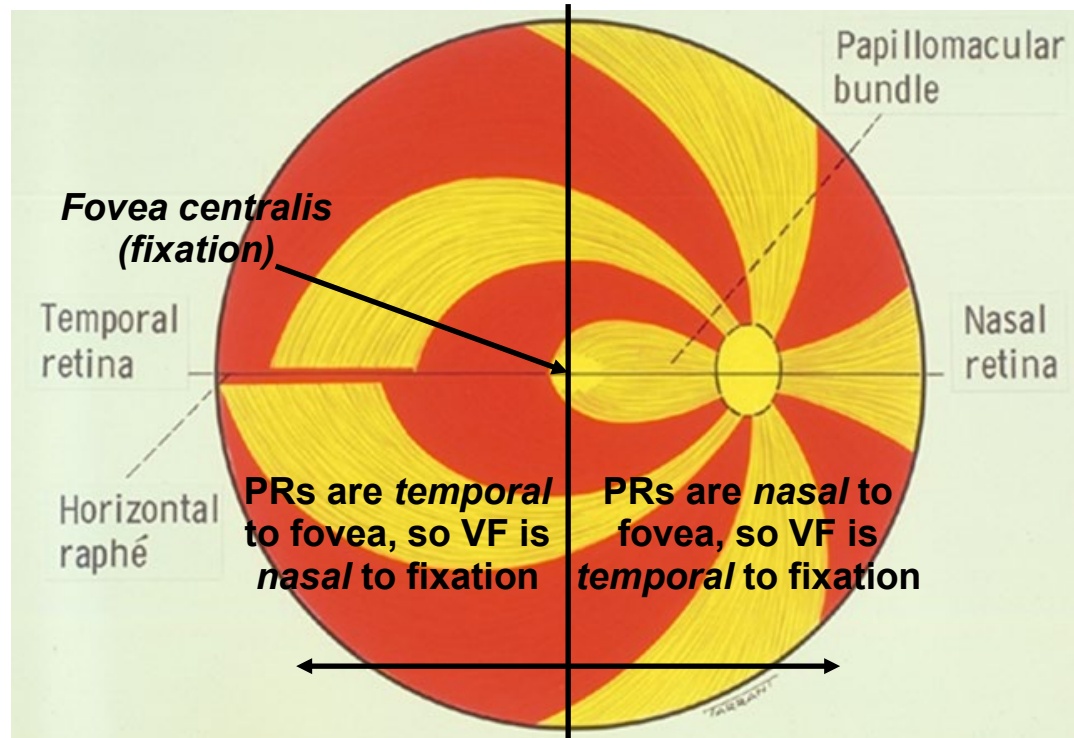
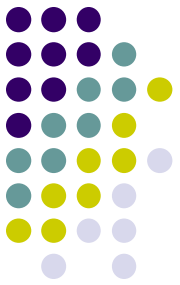
Instead, it is identified via *visual field testing*. Fixation divides the VF into nasal and temporal fields, with the photoreceptors (PRs) responsible for the temporal VF being nasal to the vertical meridian, and those responsible for the nasal VF located temporal to it.

*No question—proceed when ready*



# Q

## Glaucoma Overview



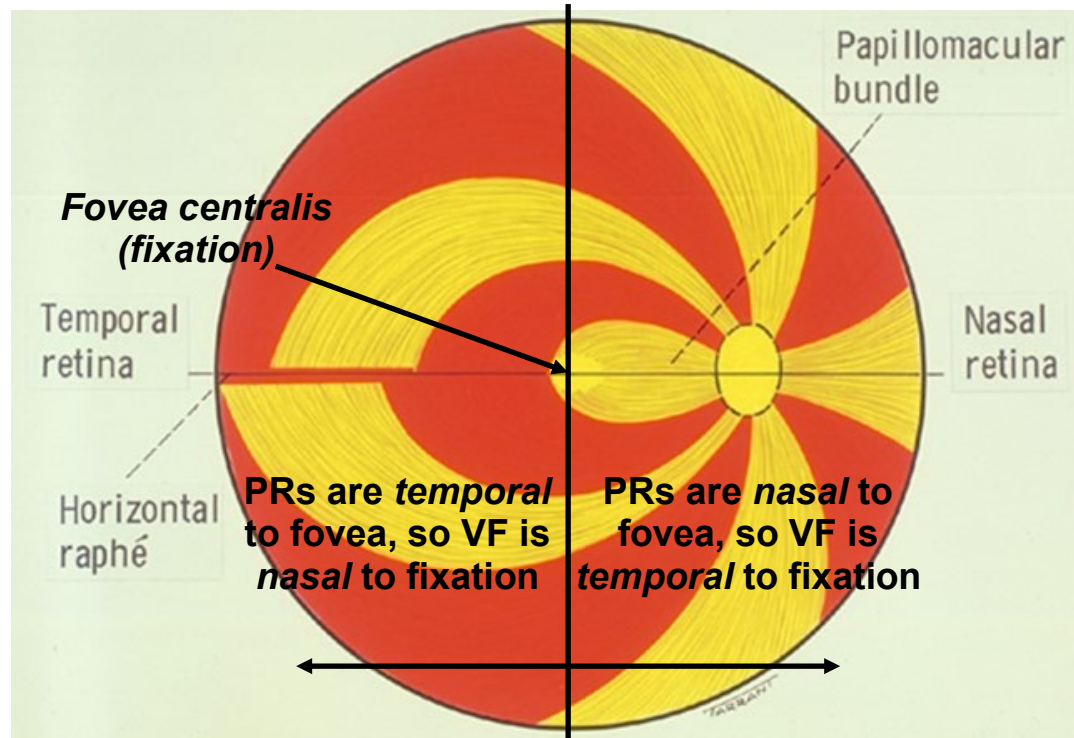
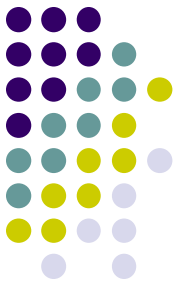
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*If not within the retina, where is the anatomic location for the vertical meridian found in the visual fields?*

# A

## Glaucoma Overview



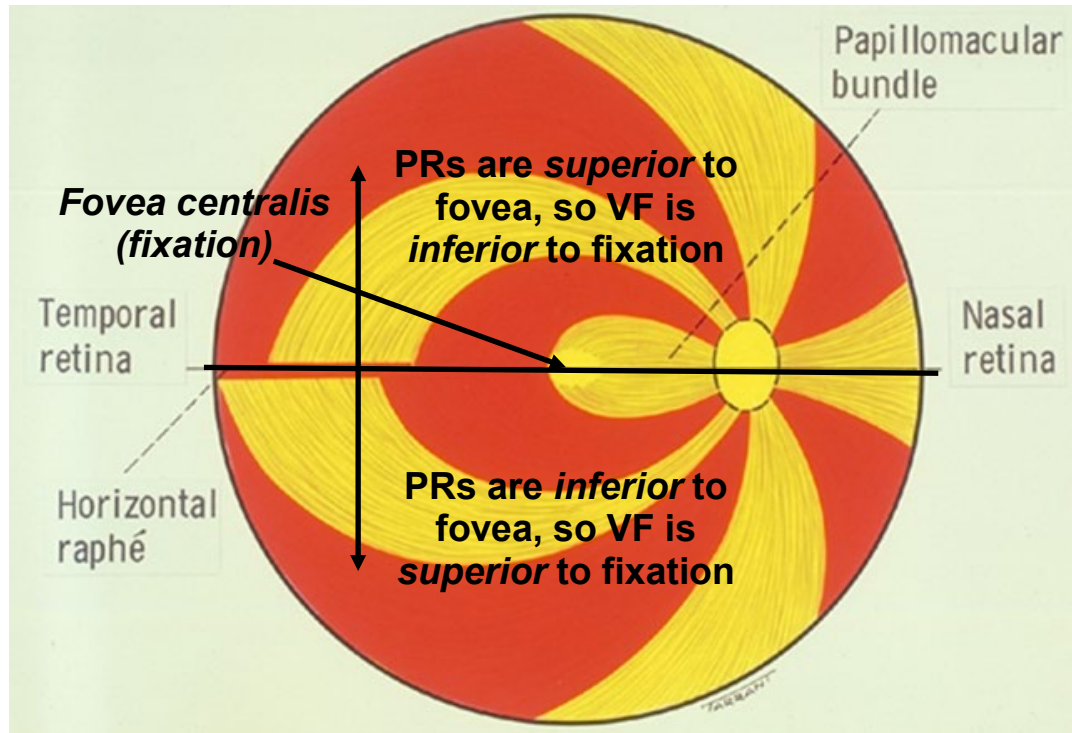
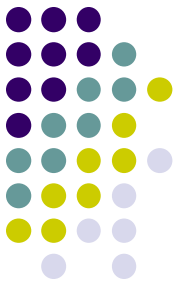
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*If not within the retina, where is the anatomic location for the vertical meridian found in the visual fields?*

The optic chiasm. Recall that it is there that the visual field is divided vertically.

# Glaucoma Overview



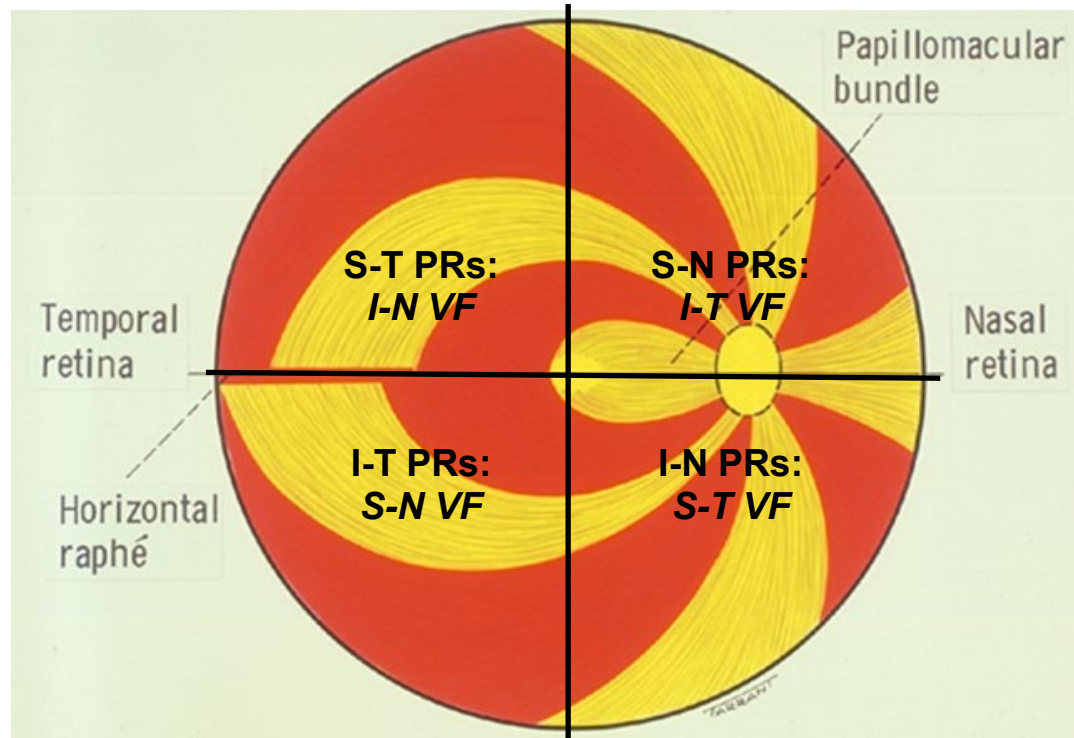
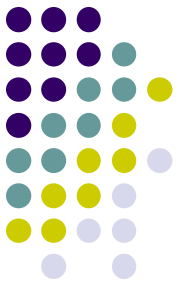
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Finally, note that fixation also divides the VF into superior and inferior VFs. The corresponding portions of the retina related topographically to the horizontal raphé.

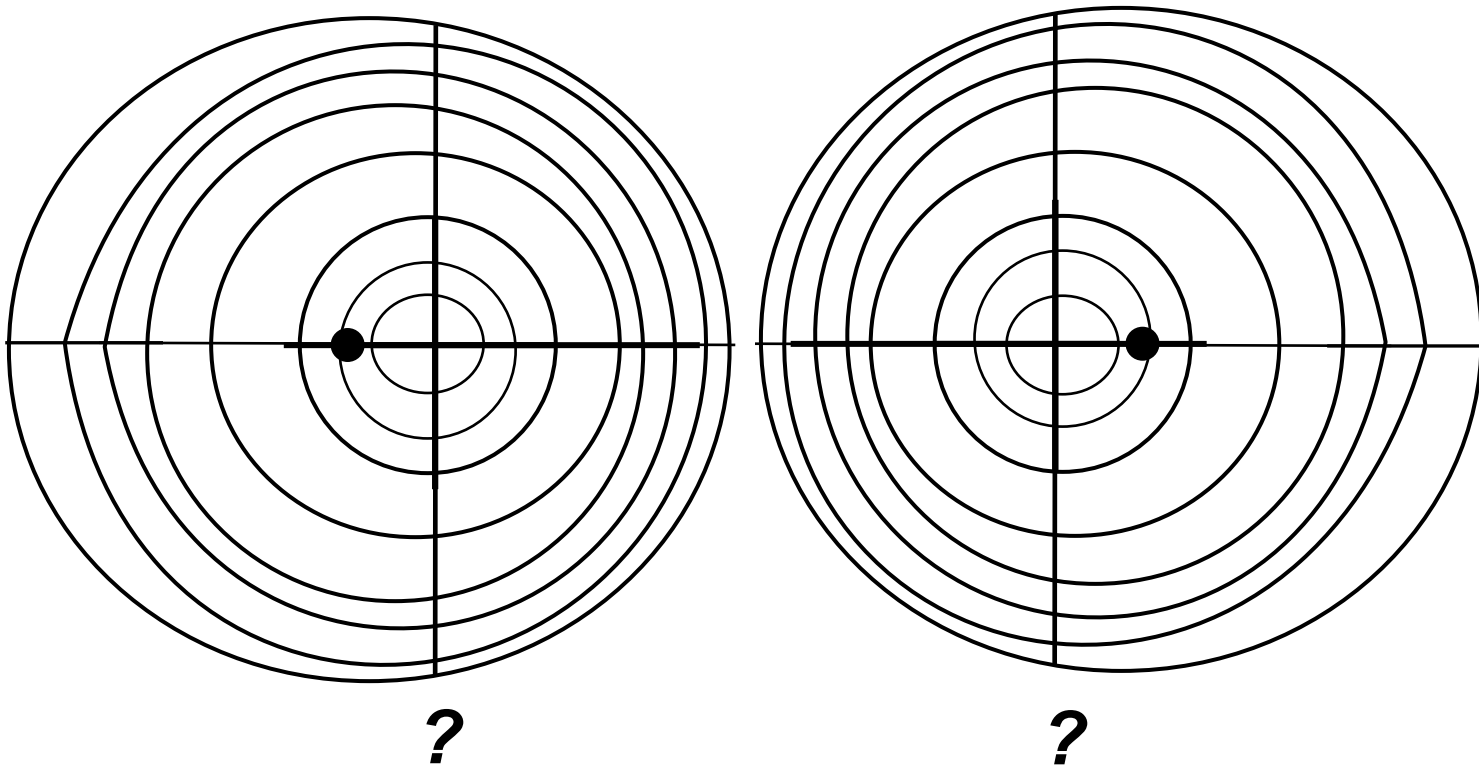
*No question—proceed when ready*

# Glaucoma Overview



**Putting it all together:** The VF can be divided into four quadrants. Together, retinal topography and ONH structure dictate that each quadrant corresponds with a particular anatomic location on the ONH. This relationship is important to understand as it allows the clinician to determine whether VF changes correlate with structural changes in the ONH as detected via DFE and/or imaging technology.

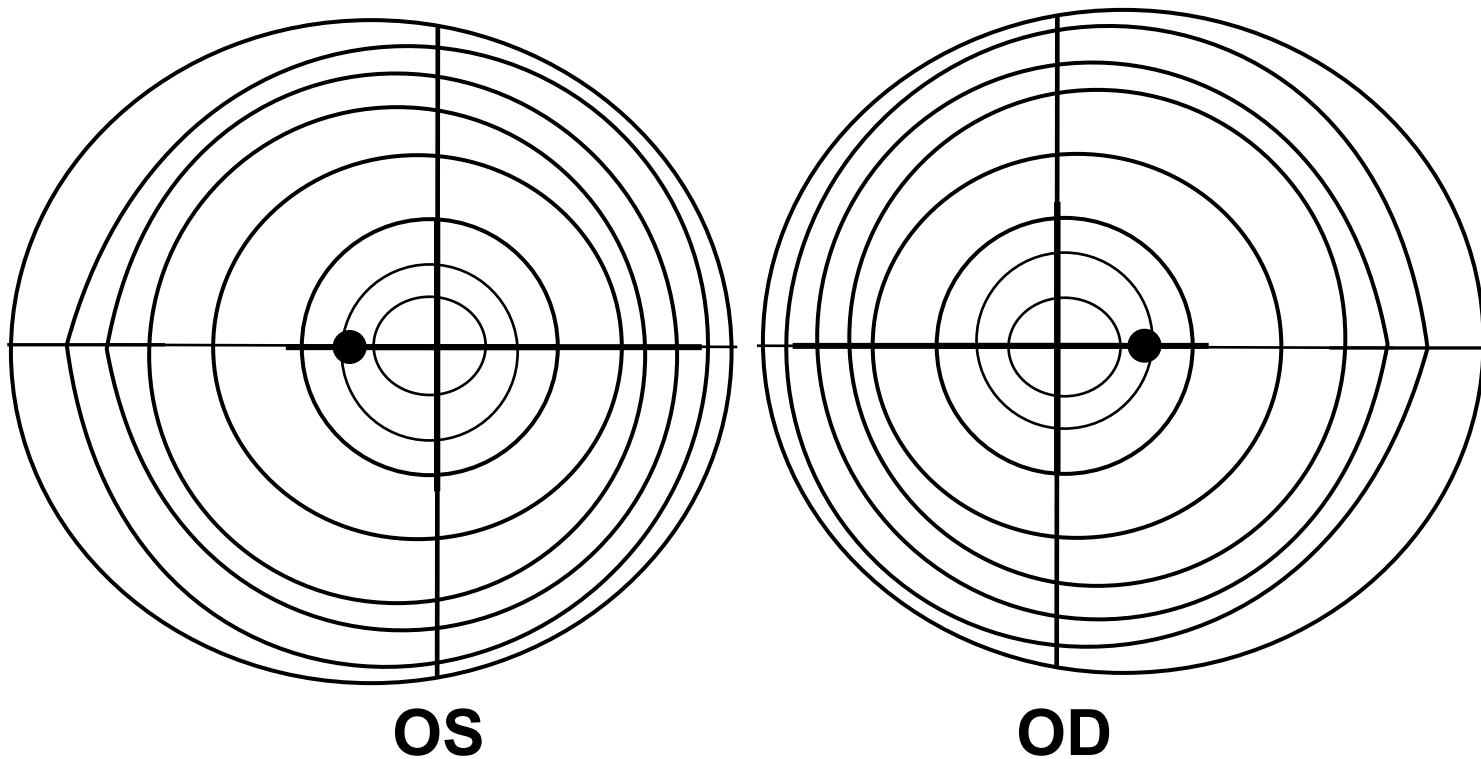
*No question—proceed when ready*



*Here is a representation of the VF for each eye. Which is OD, and which OS?*

## A

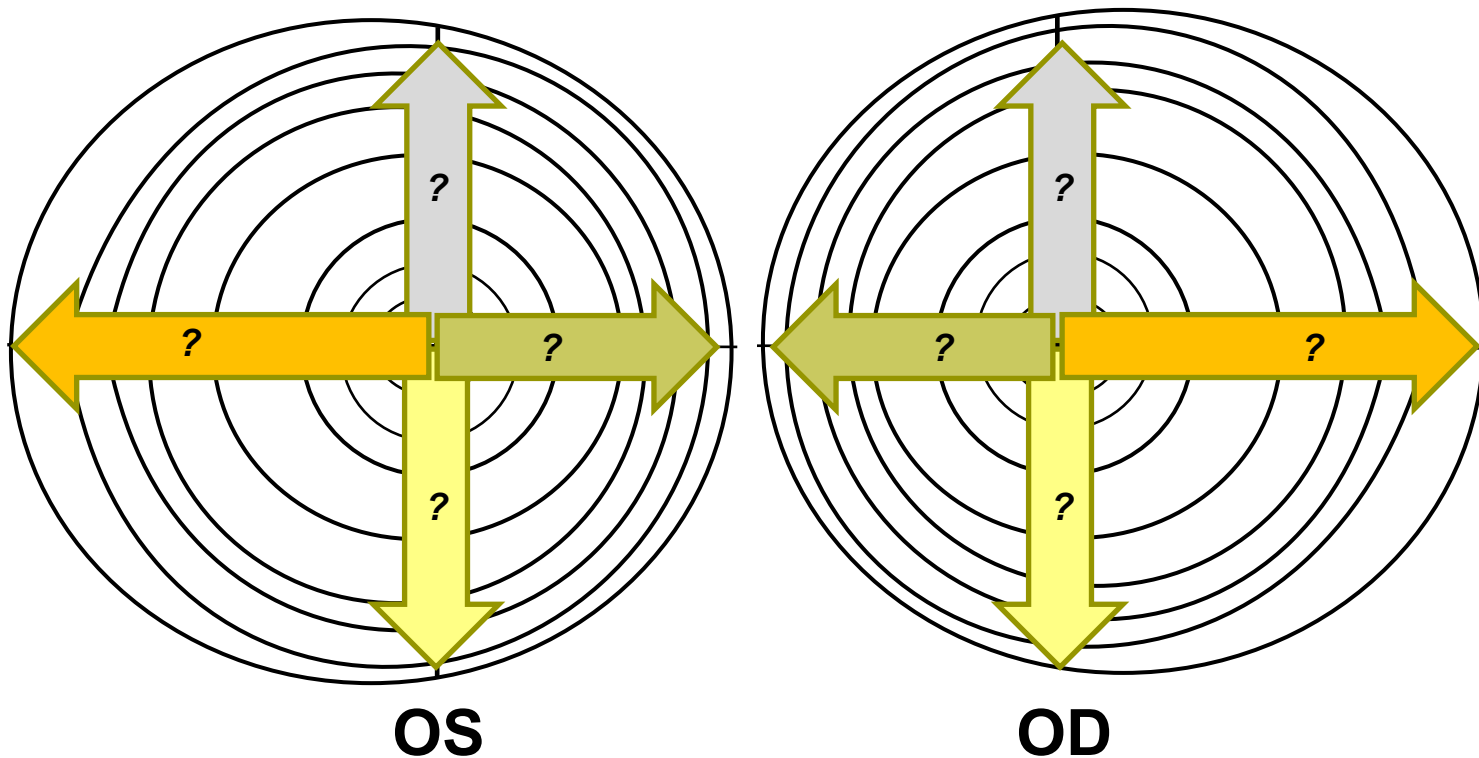
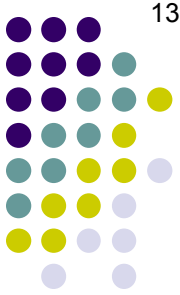
## Glaucoma Overview



*Here is a representation of the VF for each eye. Which is OD, and which OS? Remember, VFs are **not** drawn as if the pt is looking at you; they're drawn as if **you** are the pt!*

## Q

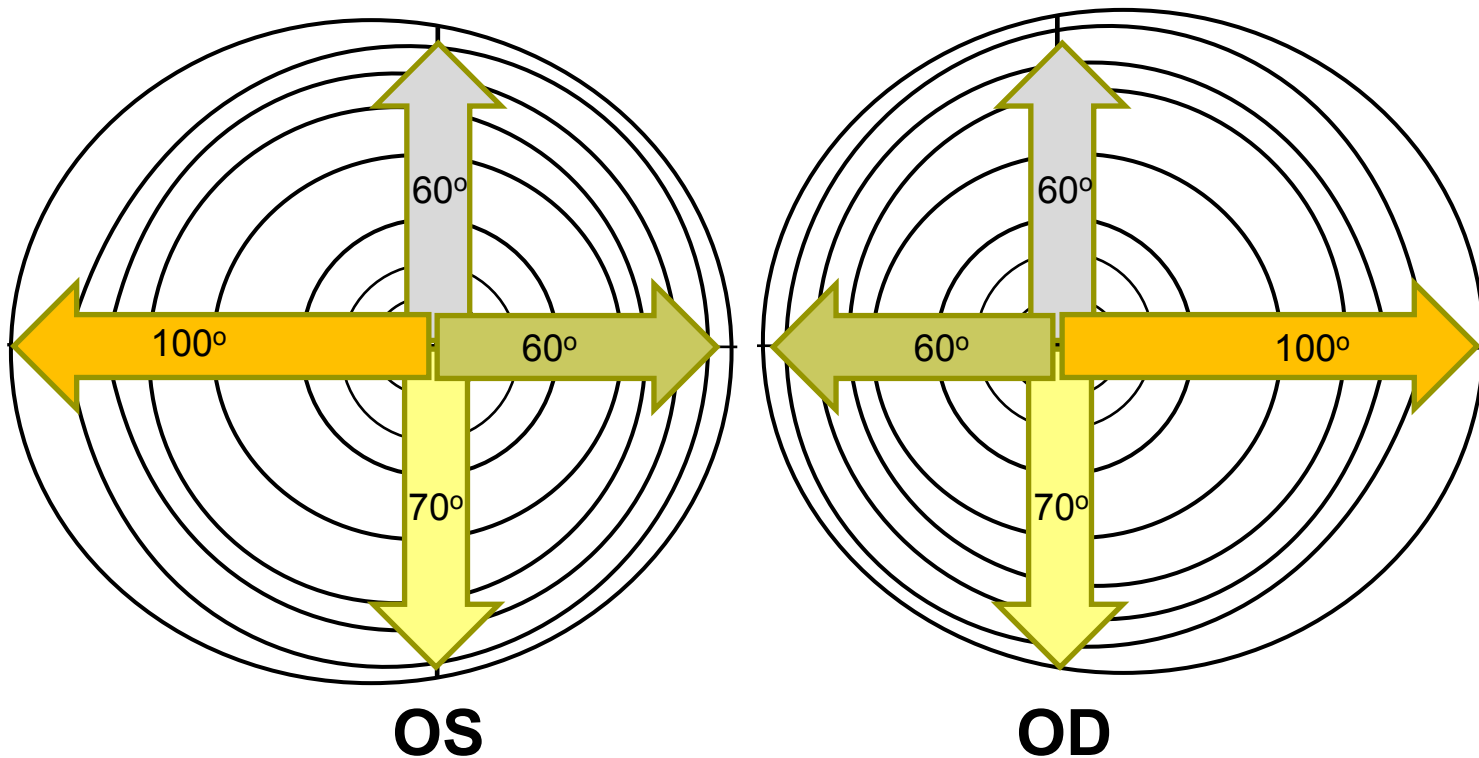
# Glaucoma Overview



*Measured in degrees from fixation, how far does the normal VF extend superiorly, inferiorly, nasally and temporally?*

(Don't get too fixated on these specific numbers--different sources will give slightly different values.)

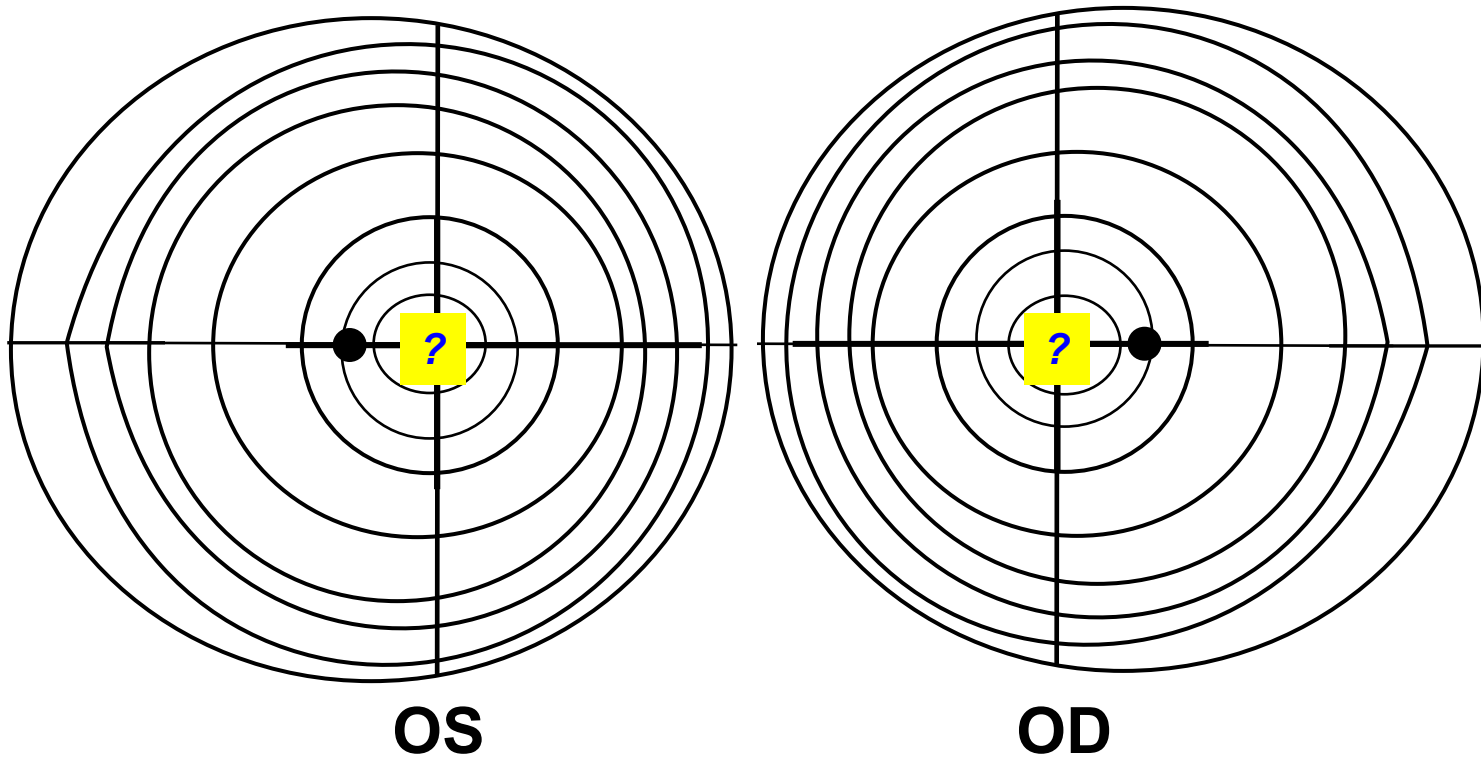
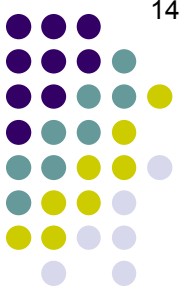




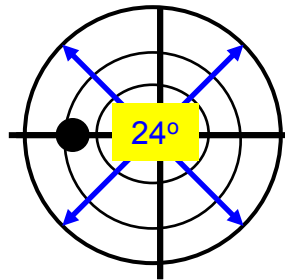
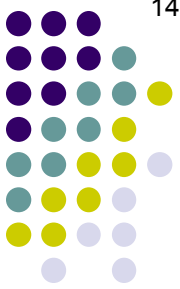
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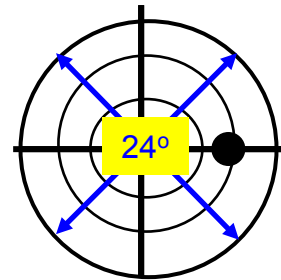




*Measured in degrees from fixation, how much of the VF is assessed via the automated perimetry machines found in most ophthalmology practices?*



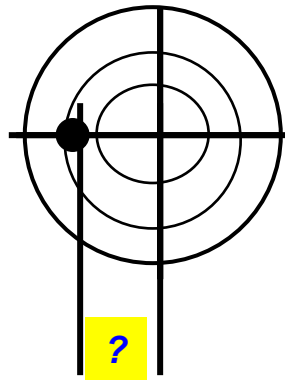
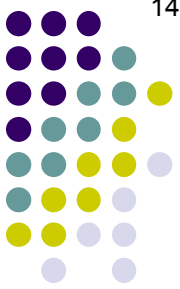
OS



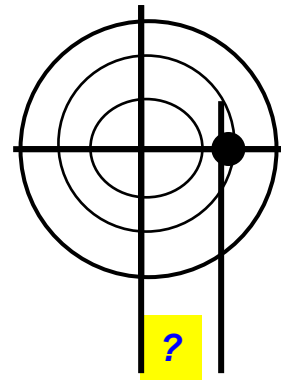
OD

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The central 24 degrees

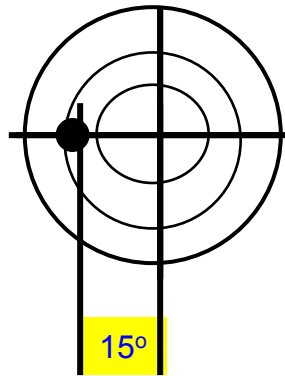
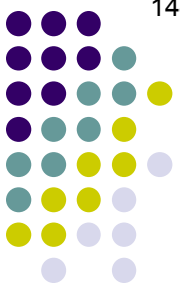


OS

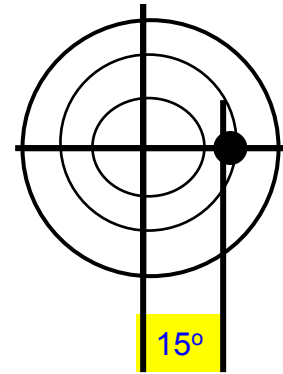


OD

*How far in degrees from fixation is the blind spot?*



OS

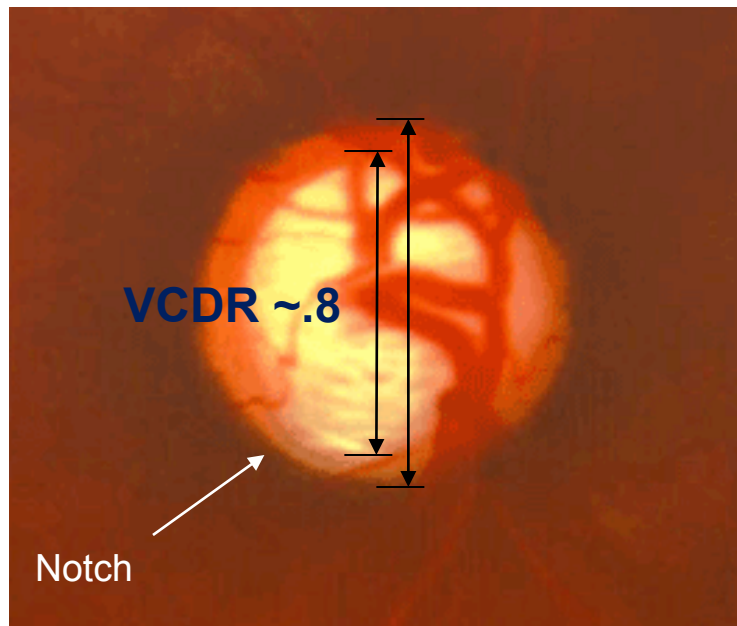


OD

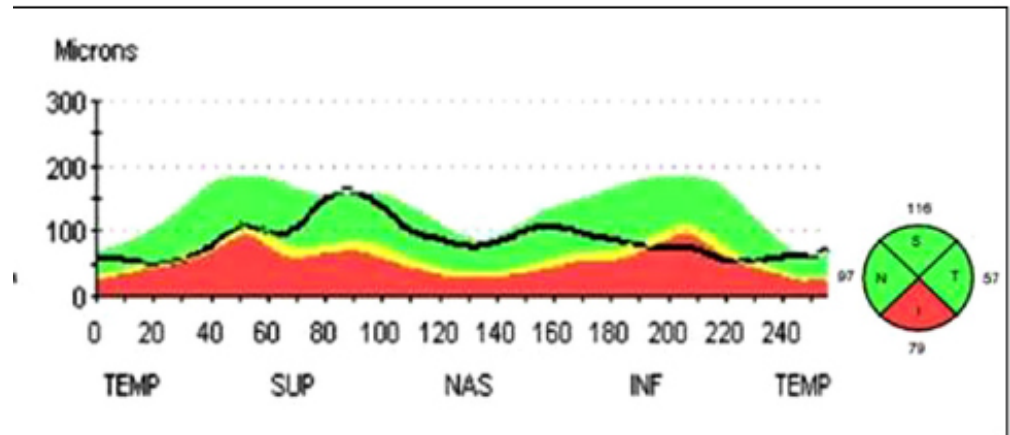
*How far in degrees from fixation is the blind spot?*  
About 15 (again, don't get too hung up on that specific number.)

# Glaucoma Overview

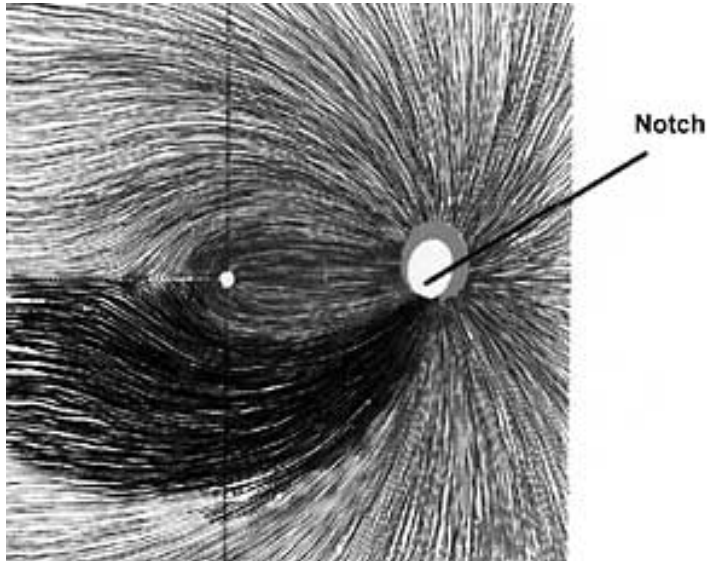
For reasons that have yet to be fully elucidated, glaucoma initially 'prefers' to damage the superior and inferior poles of the ONH. This leads to thinning at the poles (focal thinning is referred to as a 'notch.')



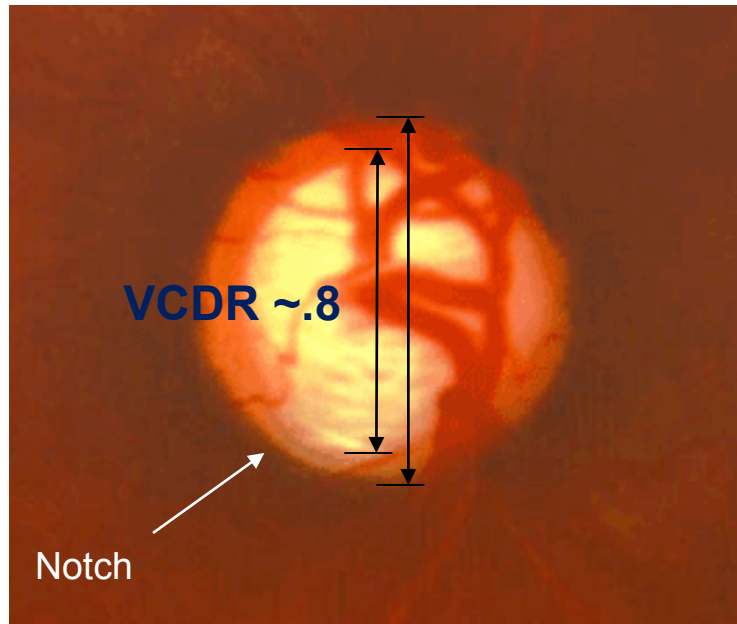
Glaucomatous ONH



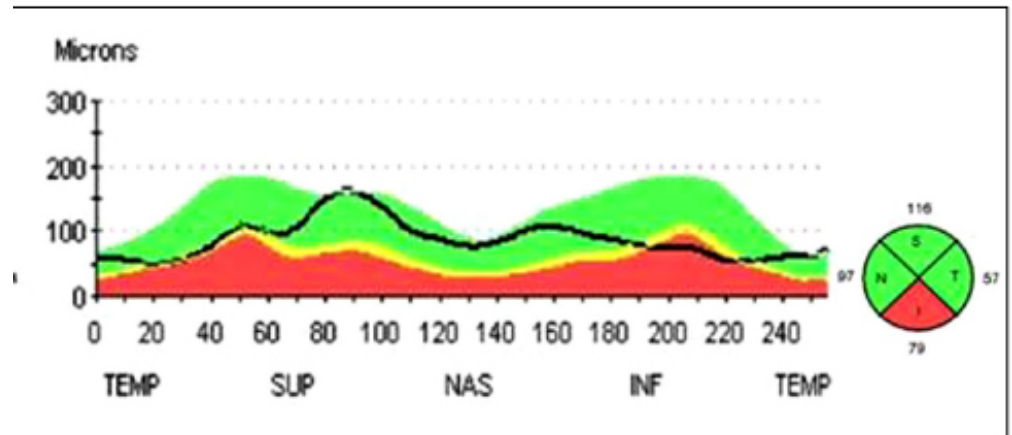
# Glaucoma Overview



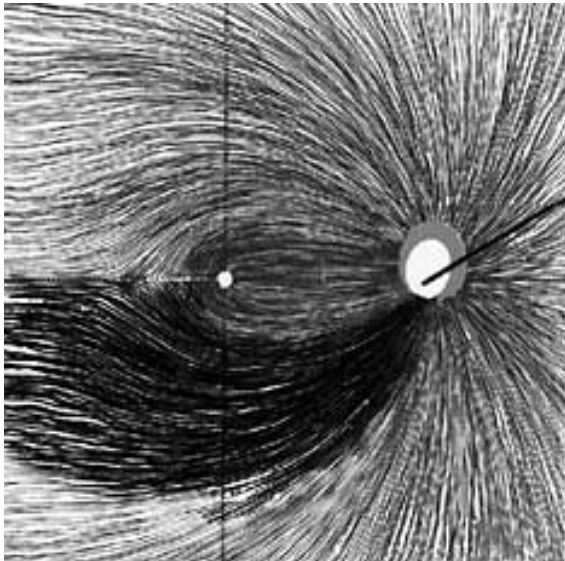
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Glaucomatous ONH



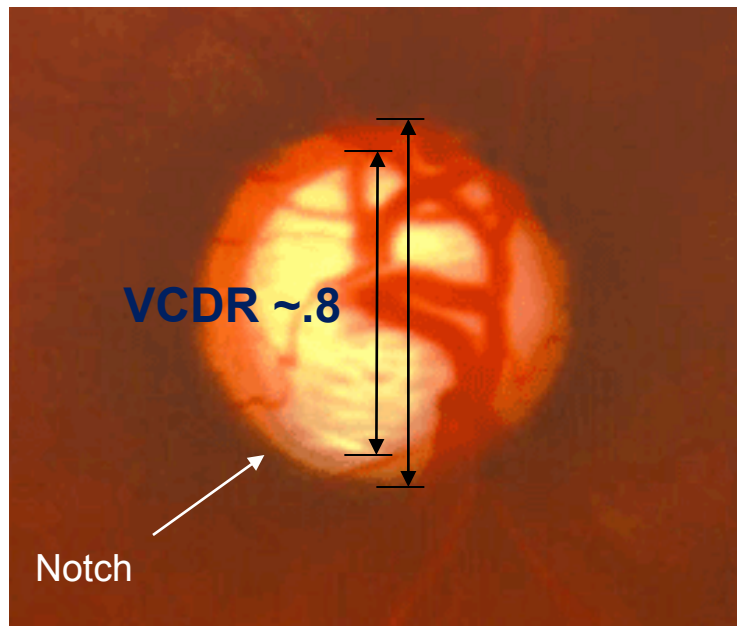
# Glaucoma Overview



Notch

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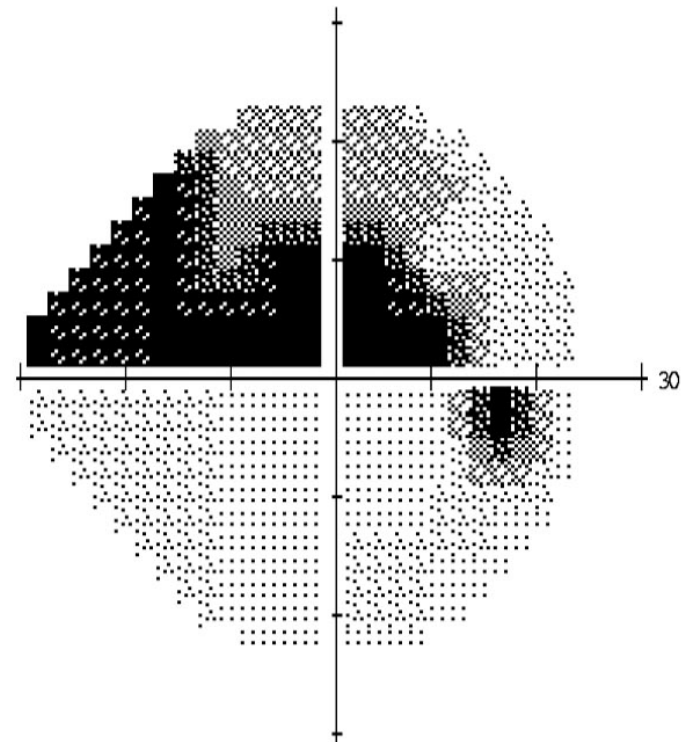
The result of this is that glaucomatous VF defects appear in and extend from the *nasal* visual field.



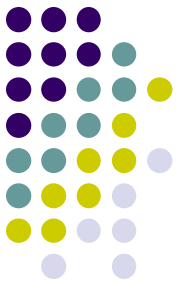
VCDR ~.8

Notch

Glaucomatous ONH



# Glaucoma Overview



★ Define glaucoma.

★ A group of optic neuropathies that present with progressive ONH damage and

**characteristic VF loss**

*Why isn't elevated IOP mentioned above?*

Elevated IOP is a strong risk factor for glaucoma, but it need not be present—IOP can be normal, or even low

*In addition to being the strongest risk factor for glaucoma, **IOP** has another quality that renders it unique—what is it?*

It is the only risk factor that is **modifiable** in a manner proven to influence the risk of glaucoma progression

*It was noted initially that glaucoma presents with “characteristic VF loss.” That’s what we’re getting at here. Let’s take a detailed look at the way glaucomatous VF defects appear and progress.*



# Glaucoma Overview



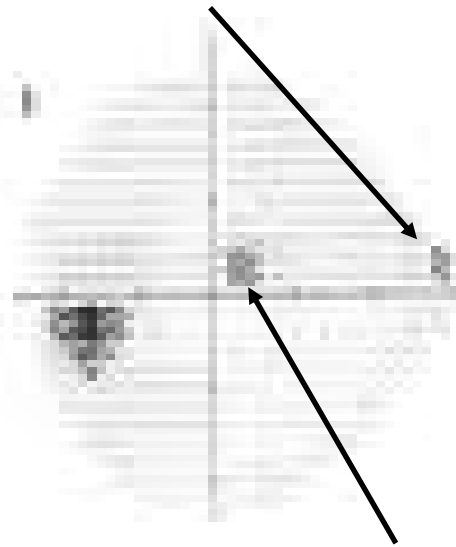
Note: The following set of VFs are from a pt who suffered severe, progressive VF loss in a manner classic for glaucomatous optic neuropathy. I am not personally familiar with this case, and thus cannot provide context regarding the clinical circumstances that resulted in such profound, unchecked VF loss.

*No question—proceed when ready*

# Glaucoma Overview



'Early superior nasal step'



*(not real VF loss—going to go away)*

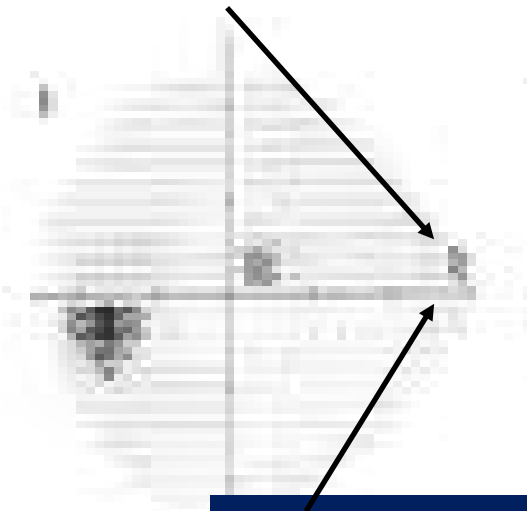
The first location at which glaucomatous VF manifests is near the nasal limit of a 24-2 field, sitting on (or 'hanging' just below) the horizontal midline. This pattern of loss is called a *nasal step*.

*No question—proceed when ready*

# Glaucoma Overview



'Early superior nasal step'



**This** location in the VF...

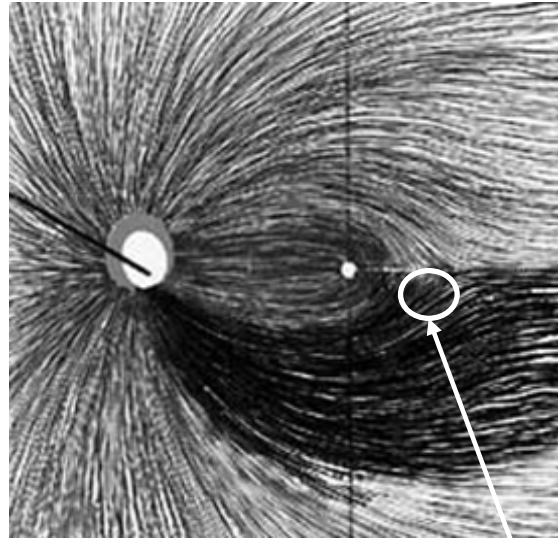
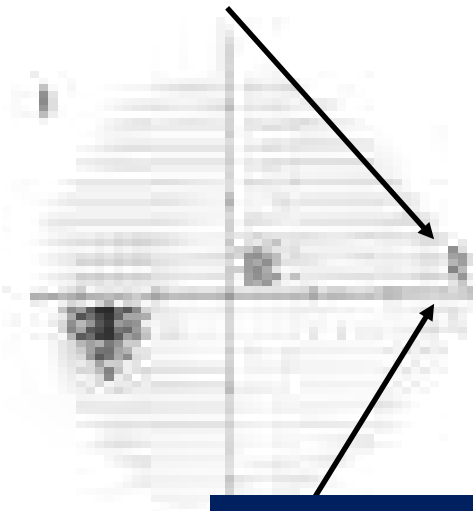
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# Glaucoma Overview



'Early superior nasal step'



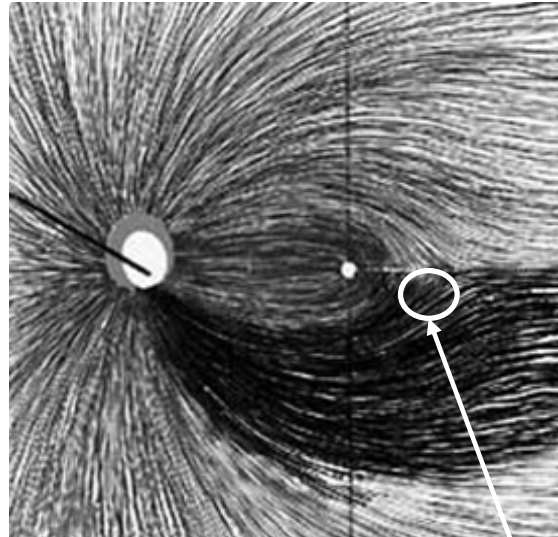
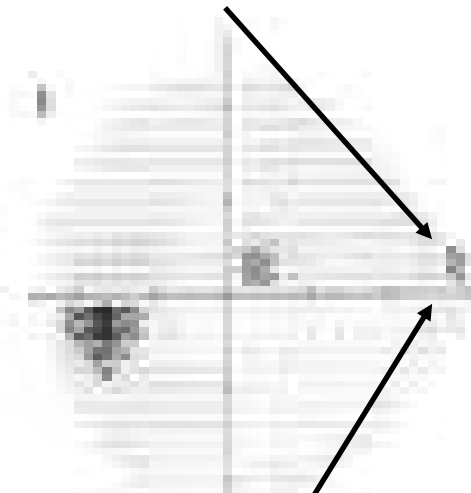
**This** location in the VF...is associated with **this** location on the retina, meaning that the affected nerve fibers originated there...

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# Glaucoma Overview

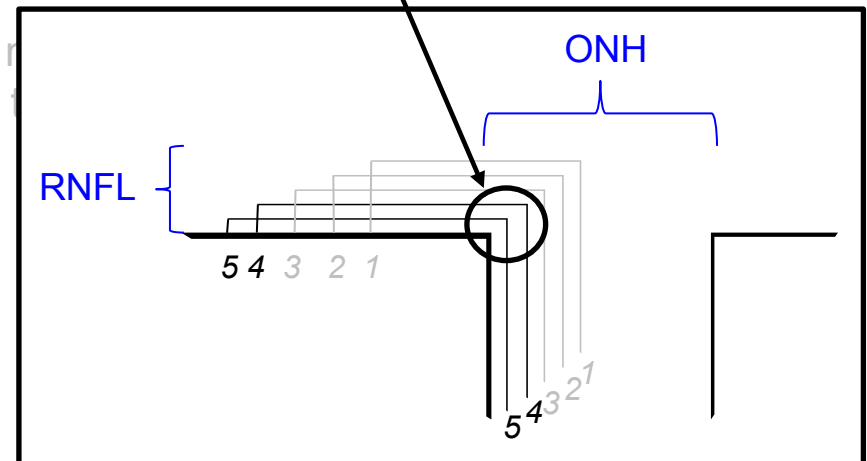


'Early superior nasal step'



**This** location in the VF...is associated with **this** location on the retina, meaning that the affected nerve fibers originated there...and entered the ONH peripherally

The first location at which glaucomatous VF loss is called a *nasal step*.

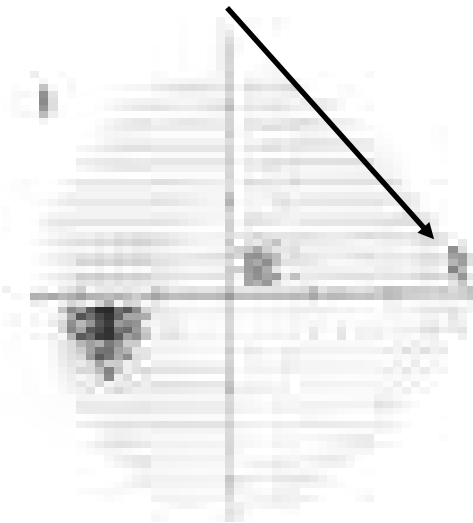


No question—proceed when ready

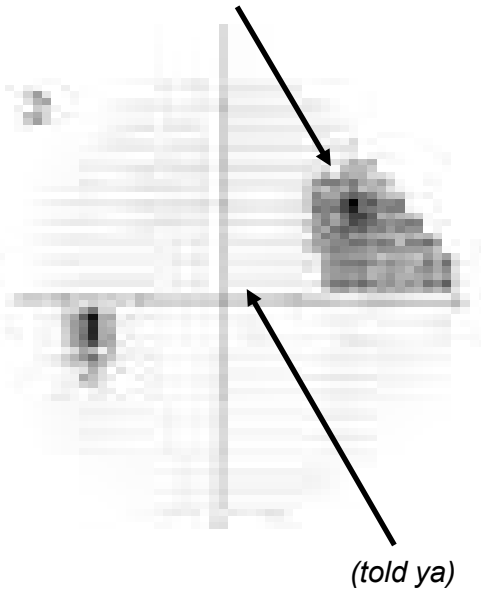
# Glaucoma Overview



'Early superior nasal step'



'Superior nasal step'



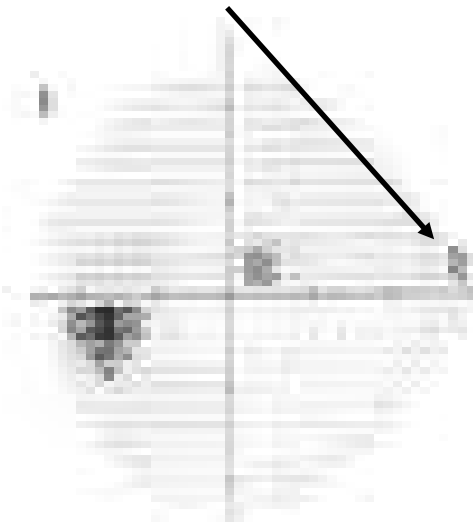
If left untreated, the nasal step will gradually enlarge.

*No question—proceed when ready*

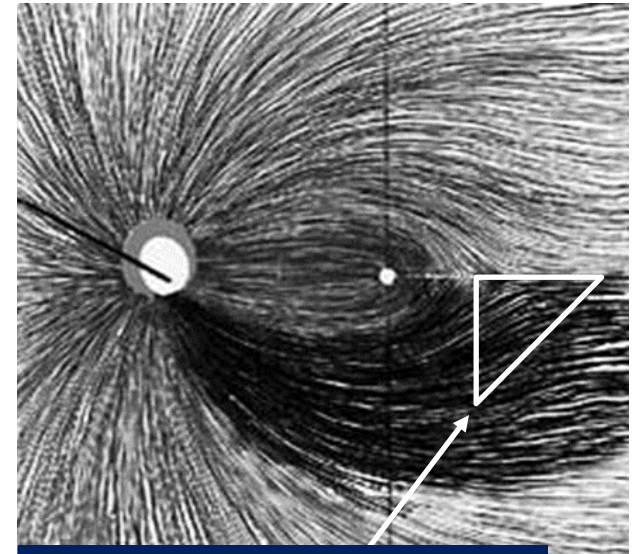
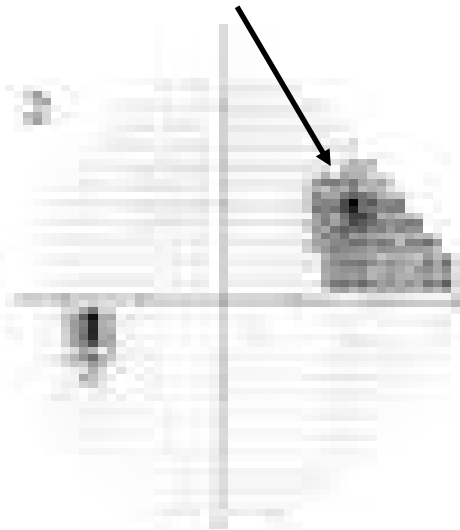
# Glaucoma Overview



'Early superior nasal step'



'Superior nasal step'



*Note the area of origin for affected fibers has grown*

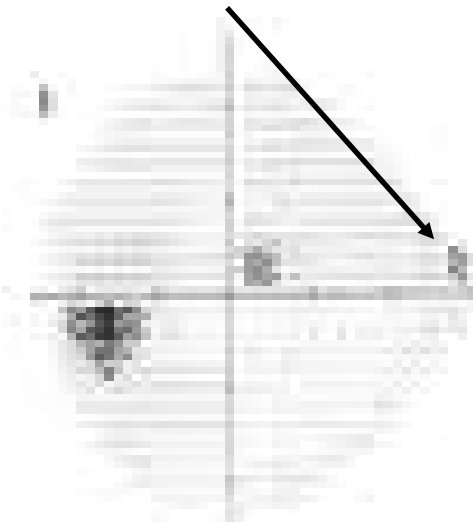
If left untreated, the nasal step will gradually enlarge.

*No question—proceed when ready*

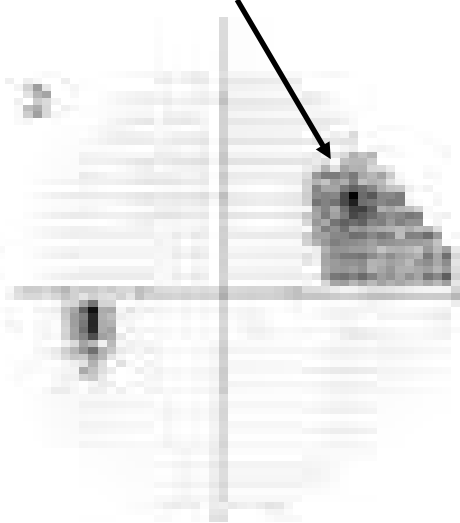
Q

## Glaucoma Overview

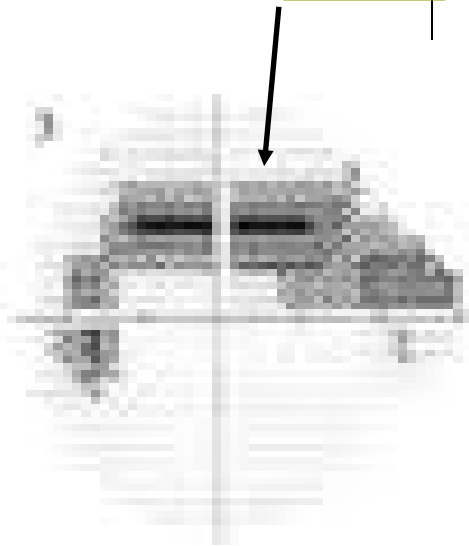
'Early superior nasal step'



'Superior nasal step'



'Superior [redacted]'



As glaucoma damage progresses, further loss of nerve fibers joining at that portion of the ONH will cause the VF defect to arc toward the blind spot. Once the VF loss has connected to the blind spot, the resulting defect is termed an [redacted]

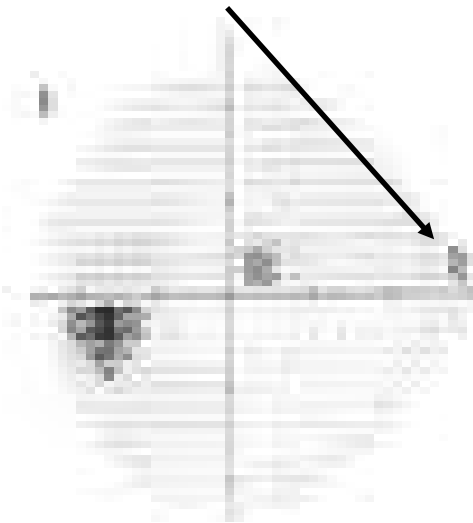


# A

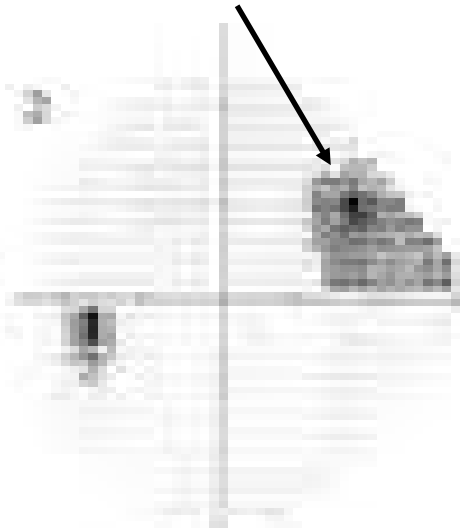
## Glaucoma Overview



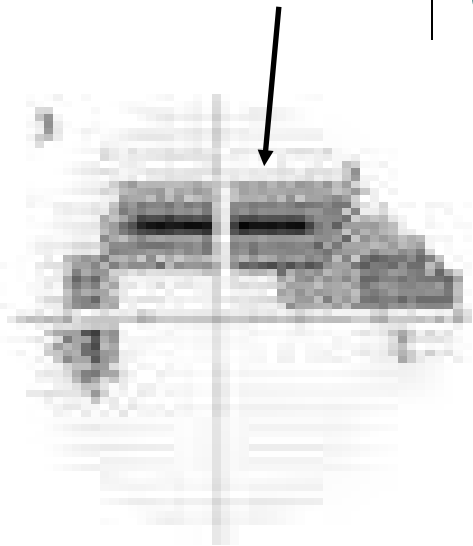
'Early superior nasal step'



'Superior nasal step'



'Superior arcuate'

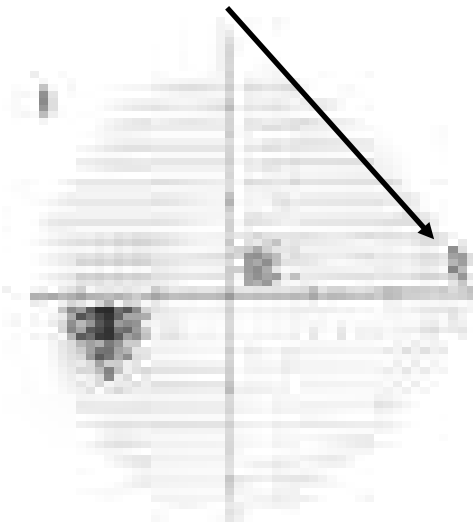


As glaucoma damage progresses, further loss of nerve fibers joining at that portion of the ONH will cause the VF defect to arc toward the blind spot. Once the VF loss has connected to the blind spot, the resulting defect is termed an *arcuate*.

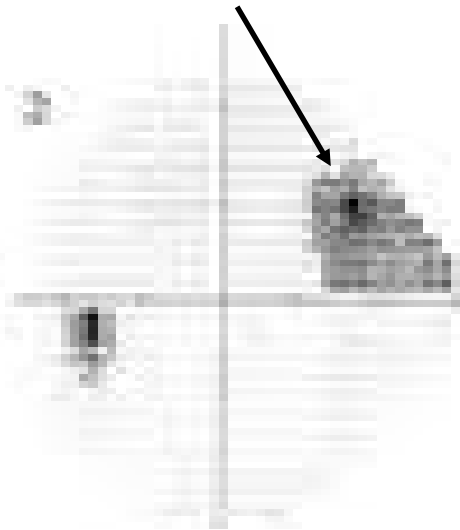
# Glaucoma Overview



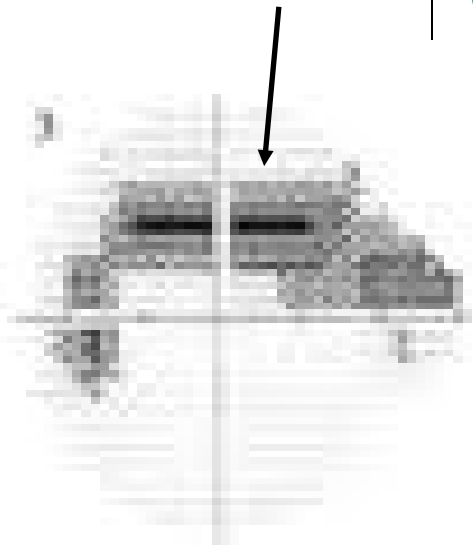
'Early superior nasal step'



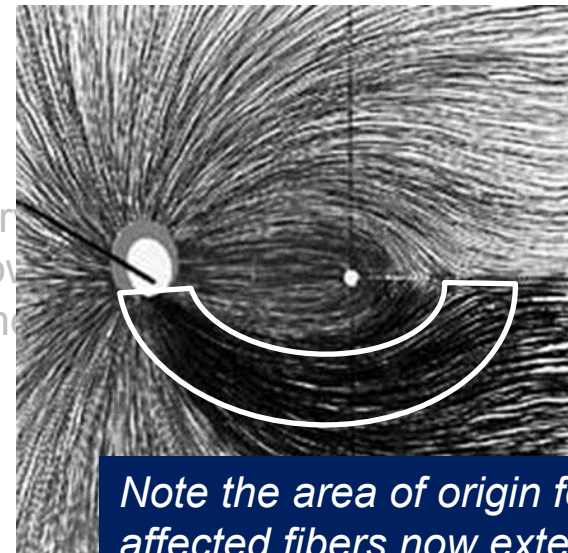
'Superior nasal step'



'Superior arcuate'



As glaucoma damage progresses, further loss of nerve fibers from a portion of the ONH will cause the VF defect to arc toward the blind spot. Once the VF loss has connected to the blind spot, the defect is termed an *arcuate*.



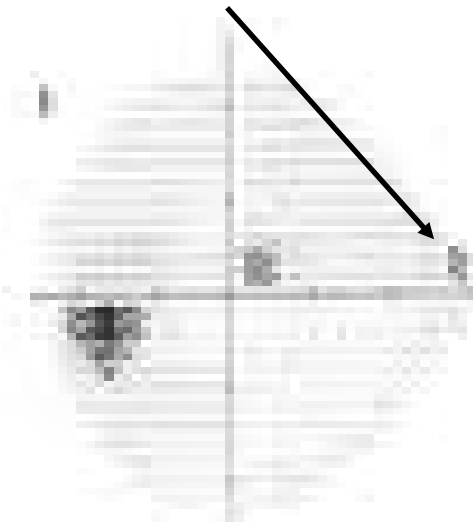
*Note the area of origin for affected fibers now extends all the way to the ONH itself*

*No question—proceed when ready*

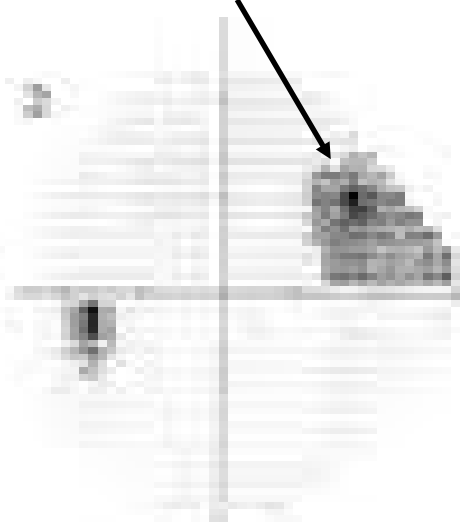
# Glaucoma Overview



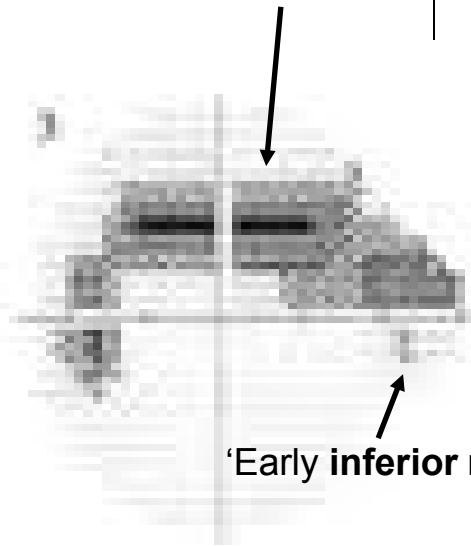
'Early superior nasal step'



'Superior nasal step'



'Superior arcuate'



'Early **inferior** nasal step'

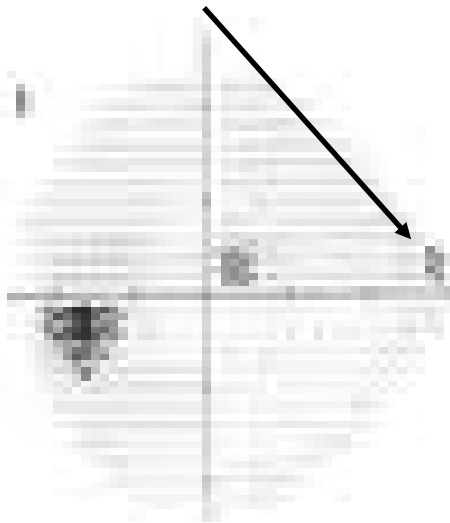
As glaucoma damage progresses, further loss of nerve fibers joining at that portion of the ONH will cause the VF defect to arc toward the blind spot. Once the VF loss has connected to the blind spot, the resulting defect is termed an *arcuate*.

Note also that an early *inferior* nasal step is now present.

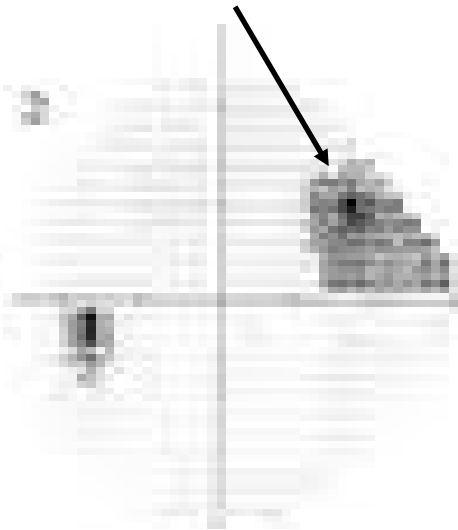
# Glaucoma Overview



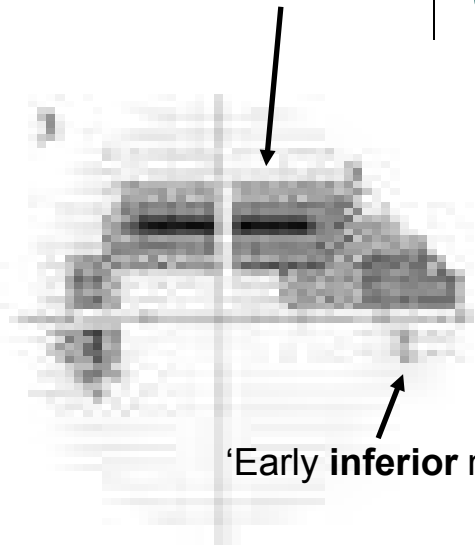
'Early superior nasal step'



'Superior nasal step'

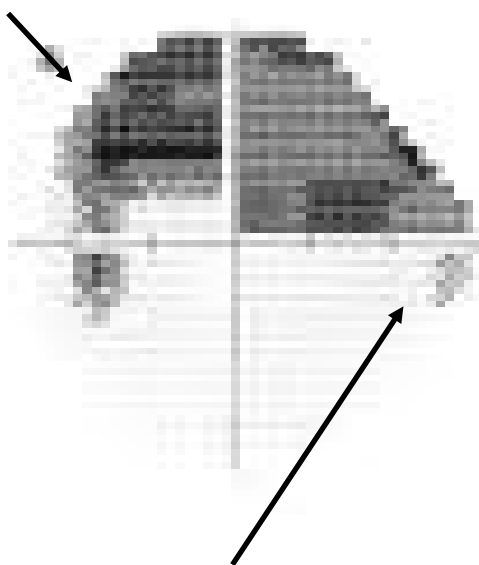


'Superior arcuate'



'Early inferior nasal step'

'Advanced arcuate'



'Early inferior nasal step'

If left unchecked, an arcuate will expand into the surrounding portion of the VF.

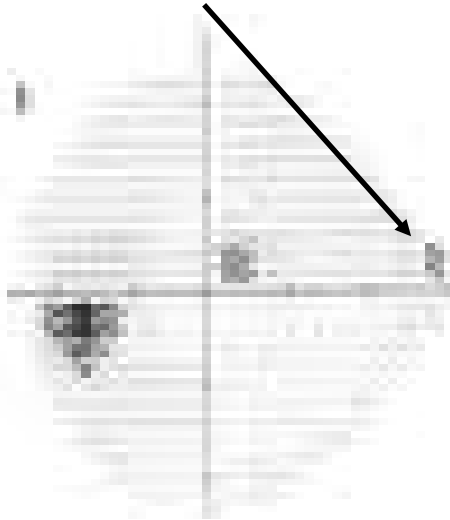
*No question—proceed when ready*

Q

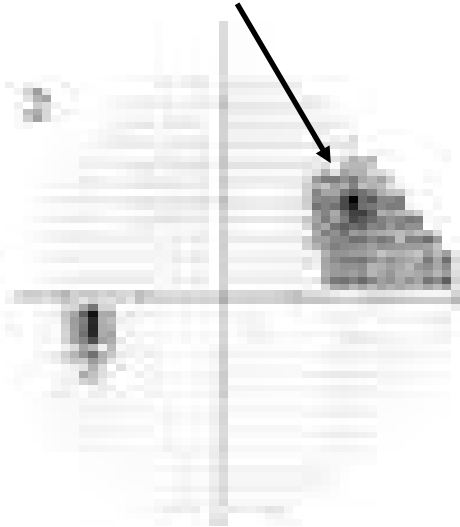
## Glaucoma Overview



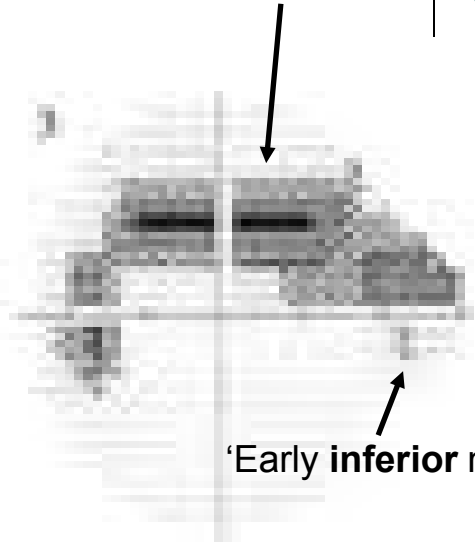
'Early superior nasal step'



'Superior nasal step'

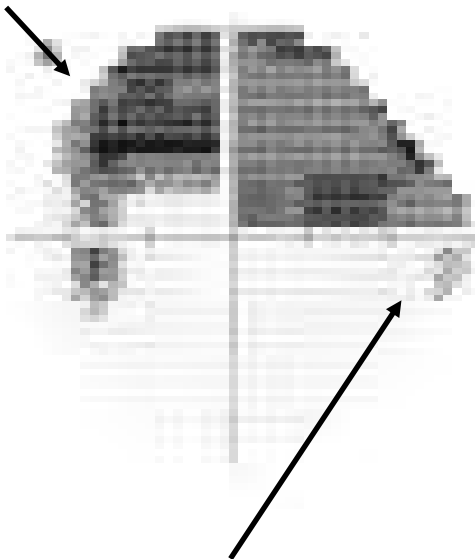


'Superior arcuate'



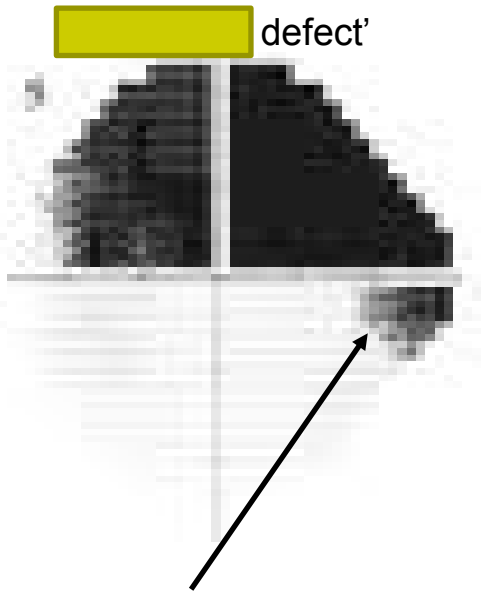
'Early inferior nasal step'

'Advanced arcuate'



'Early inferior nasal step'

defect'



'Inferior nasal step'

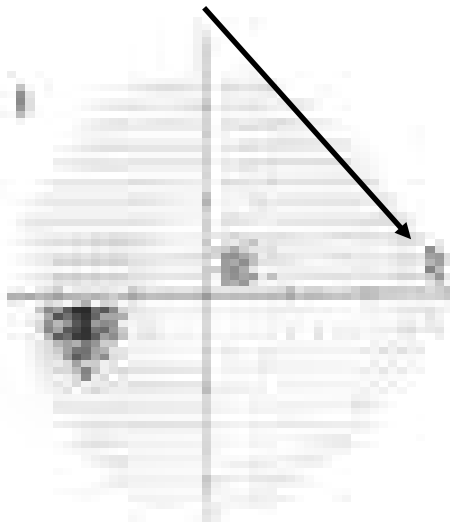
Once an arcuate has expanded sufficiently, it becomes an **defect**. The superior visual field is now all but gone.

# A

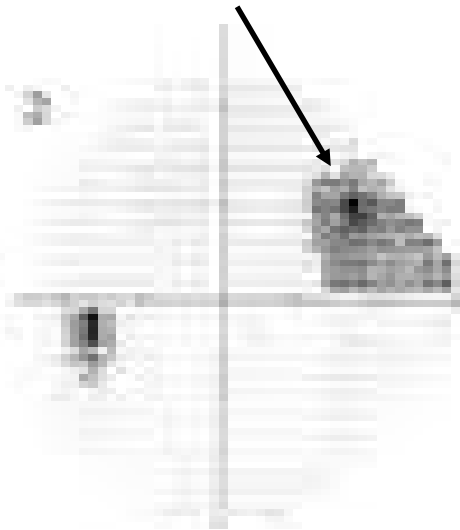
## Glaucoma Overview



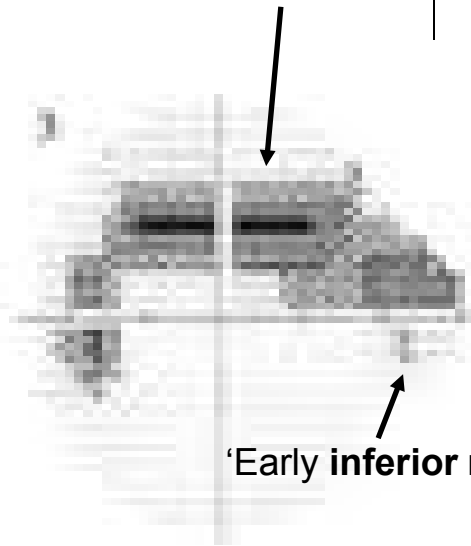
'Early superior nasal step'



'Superior nasal step'

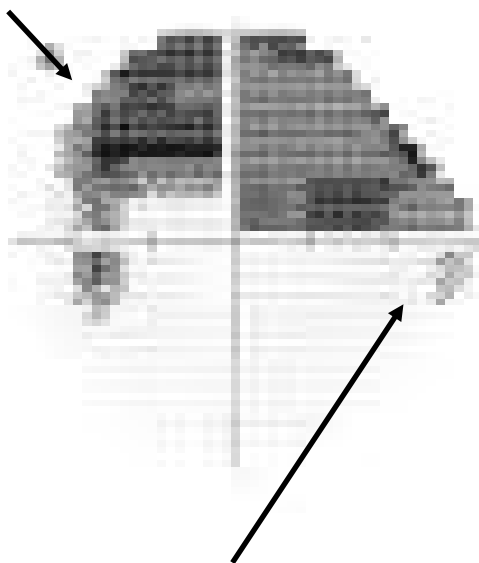


'Superior arcuate'

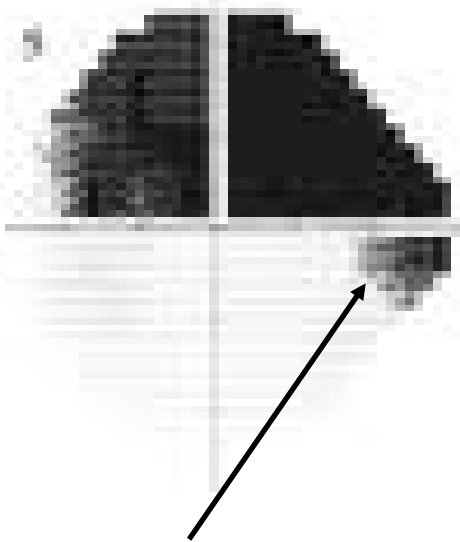


'Early inferior nasal step'

'Advanced arcuate'



'Altitudinal defect'



'Early inferior nasal step'

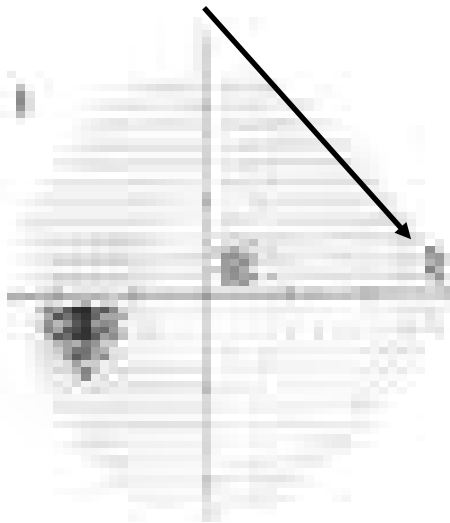
'Inferior nasal step'

Once an arcuate has expanded sufficiently, it becomes an *altitudinal defect*. The superior visual field is now all but gone.

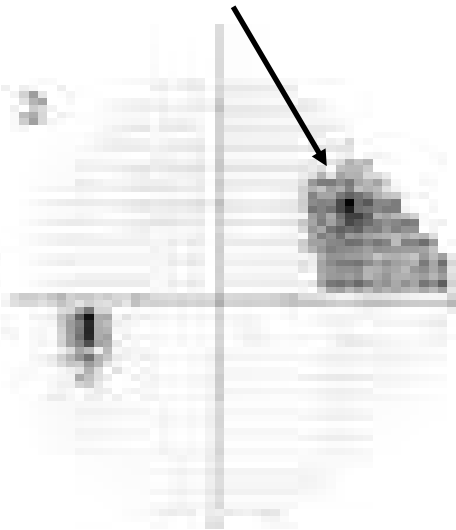
# Glaucoma Overview



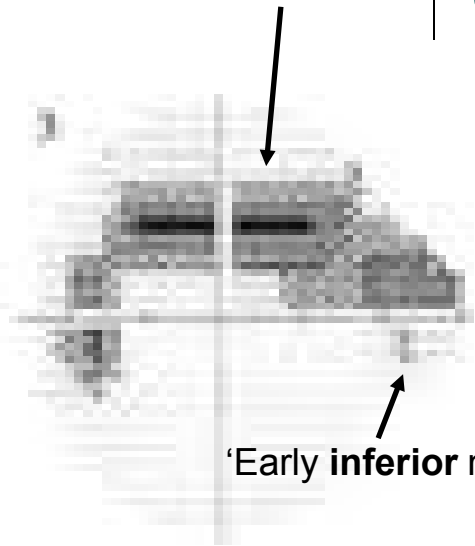
'Early superior nasal step'



'Superior nasal step'

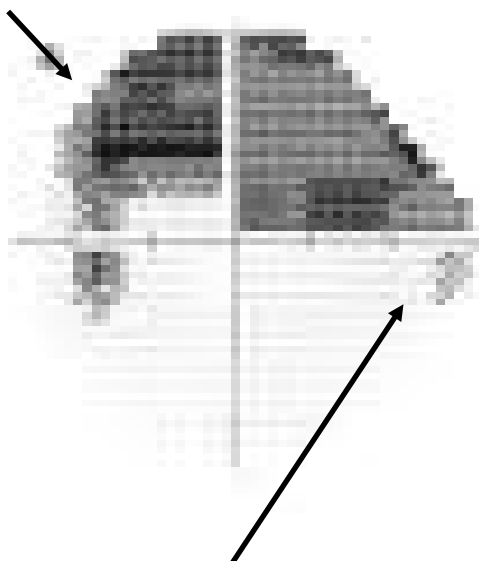


'Superior arcuate'

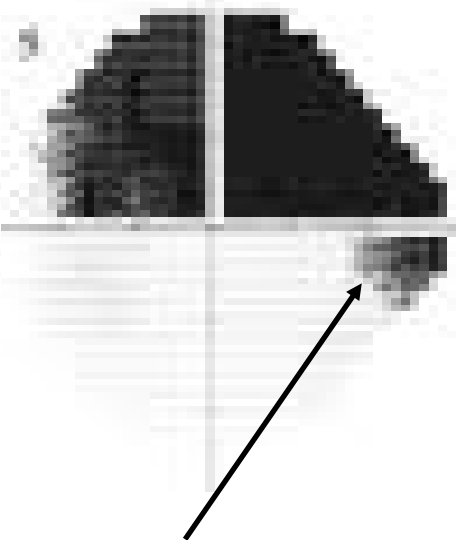


'Early inferior nasal step'

'Advanced arcuate'



'Altitudinal defect'



'Early inferior nasal step'

'Inferior nasal step'

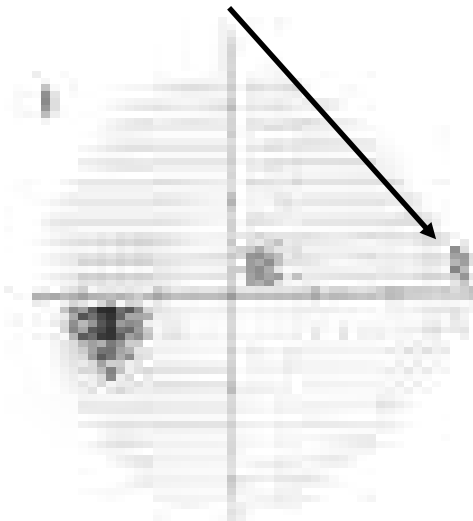
Once an arcuate has expanded sufficiently, it becomes an *altitudinal defect*. The superior visual field is now all but gone. Note the inferior nasal step continues to enlarge.

*No question—proceed when ready*

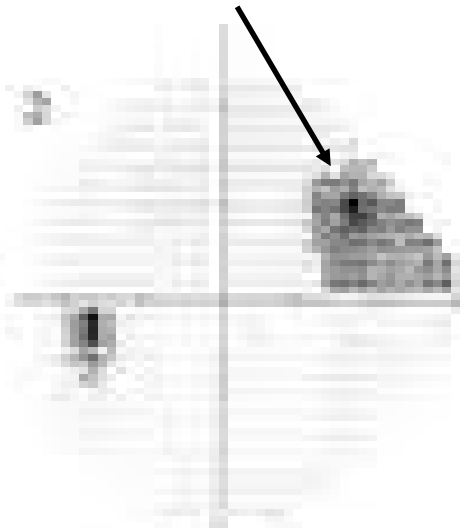
# Glaucoma Overview



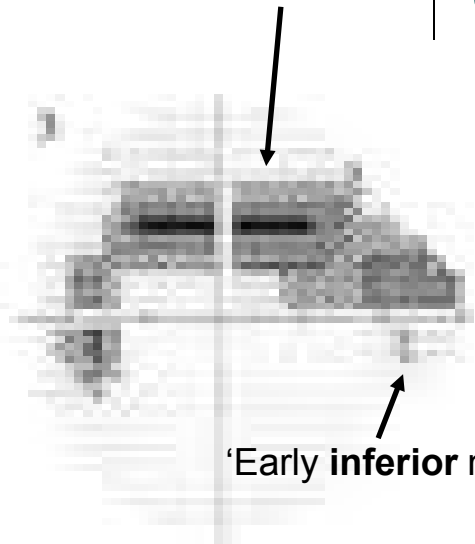
'Early superior nasal step'



'Superior nasal step'

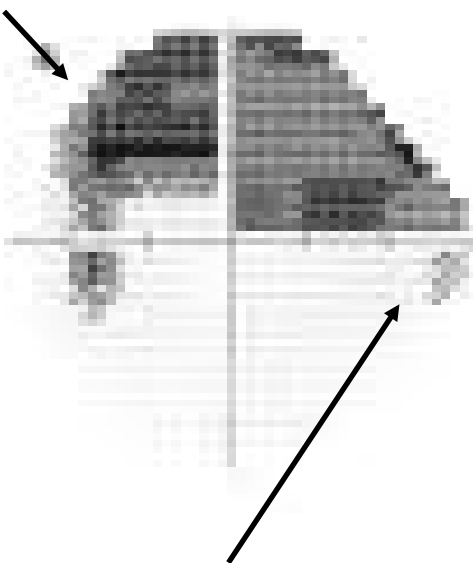


'Superior arcuate'



'Early inferior nasal step'

'Advanced arcuate'



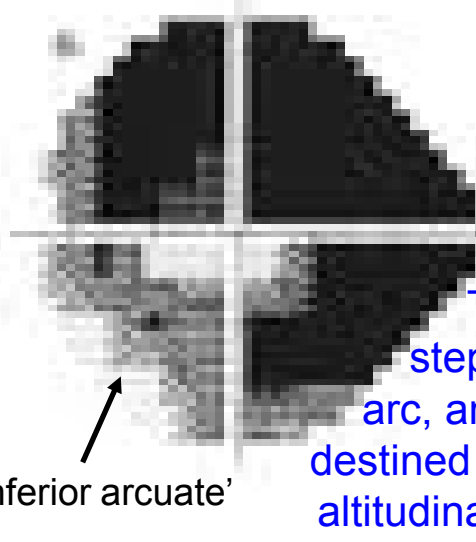
'Early inferior nasal step'

'Altitudinal defect'



'Inferior nasal step'

'Altitudinal defect'

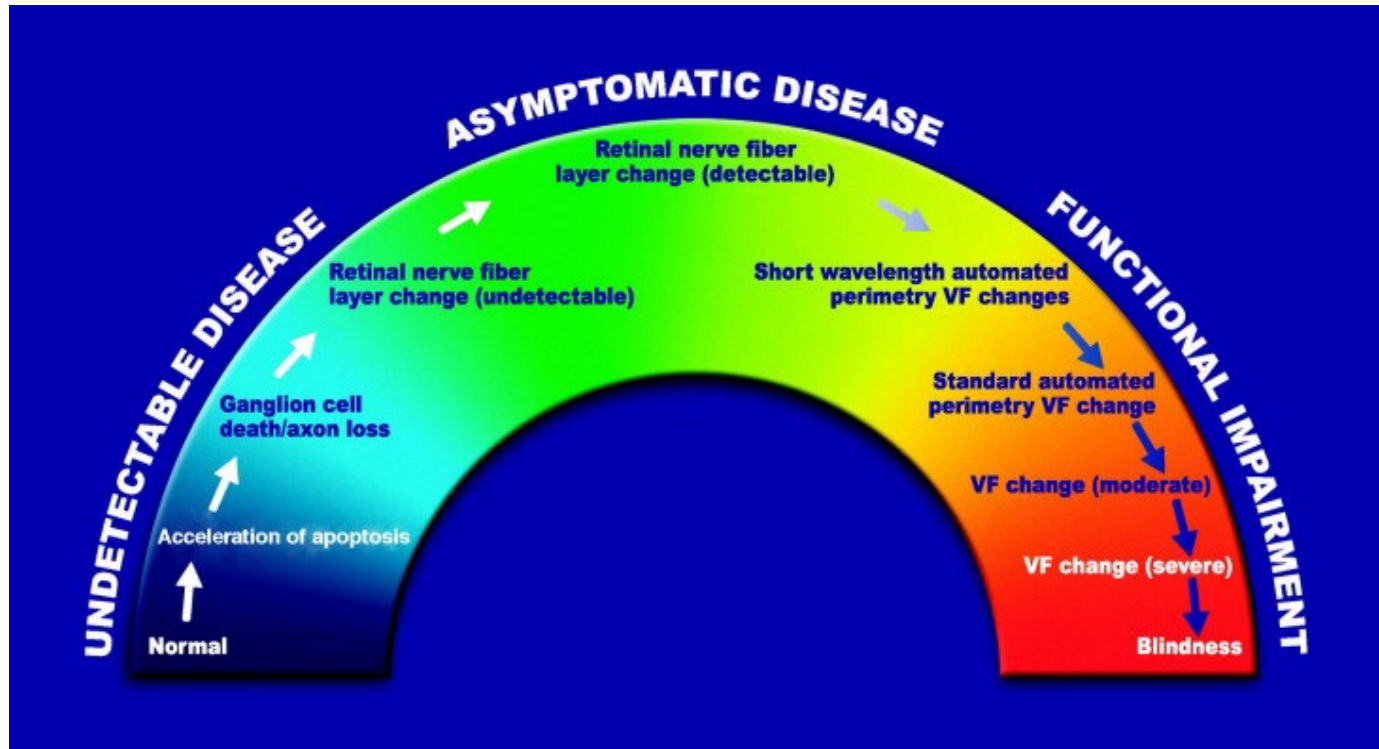
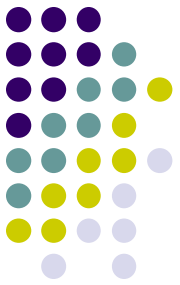


'Inferior arcuate'

The inferior step is now an arc, and appears destined to become altitudinal, resulting in blindness.



# Glaucoma Overview

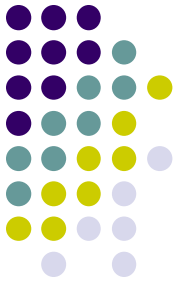


## A note on the 'Glaucoma Continuum'

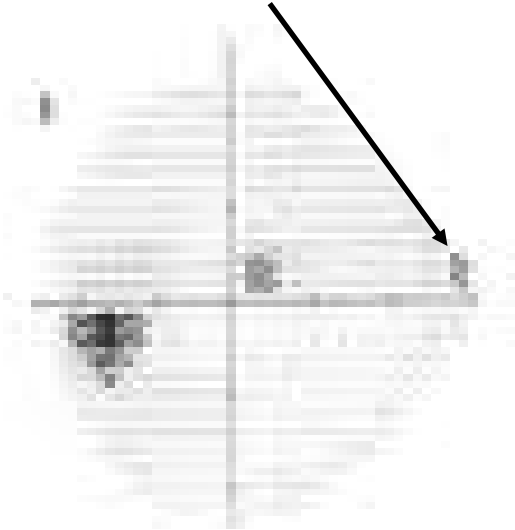
Glaucoma is a progressive condition, passing from undetectable early disease to asymptomatic-but-detectable (via RNFL imaging) disease to functional (ie, marked by VF loss) disease, the last stage of which is severe vision loss and blindness.

*No question—proceed when ready*

# Glaucoma Overview



‘Early nasal step’



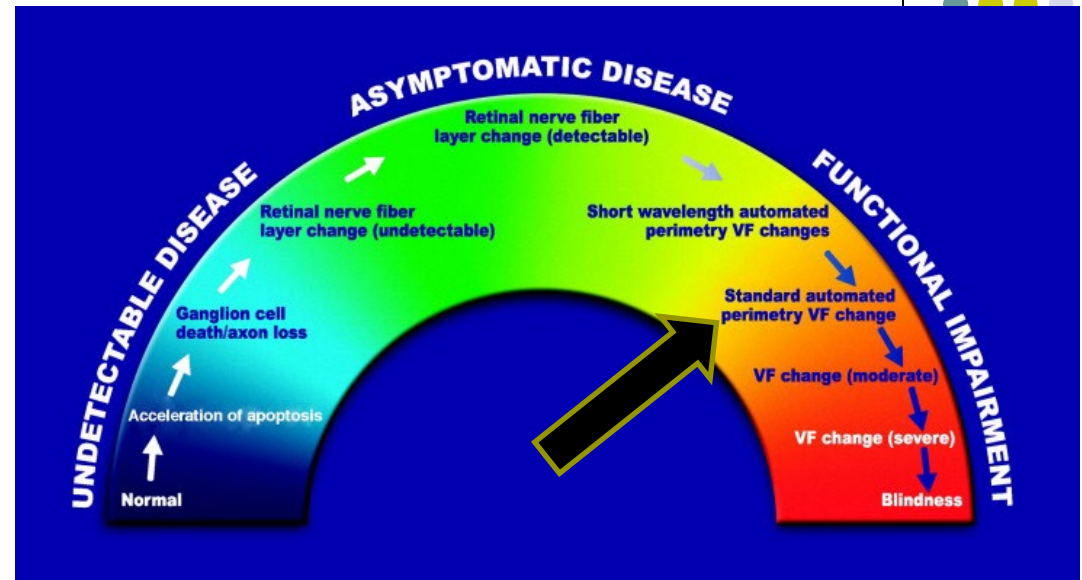
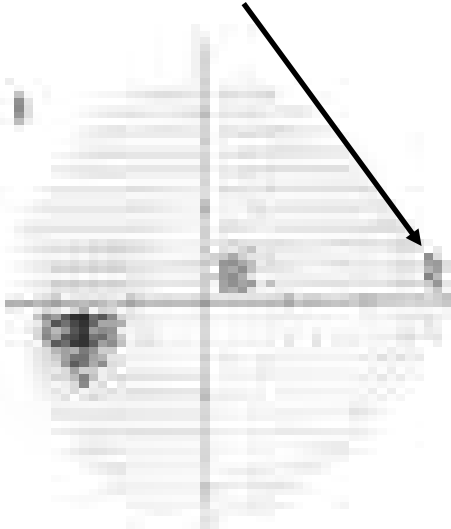
*In this regard, a word on the notion of ‘early’ glaucoma.* We previously described the above VF defect as an ‘early’ nasal step.

*No question—proceed when ready*

# Glaucoma Overview



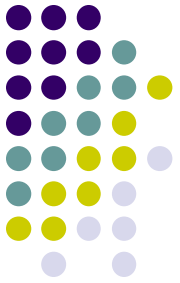
‘Early nasal step’



In this regard, a word on the notion of ‘early’ glaucoma. We previously described the above VF defect as an ‘early’ nasal step. But take note of the point along the glaucoma continuum at which such a VF defect occurs—clearly, it doesn’t qualify as ‘early’ disease with respect to the continuum. *Don’t mistake early VF changes for early disease!*

*No question—proceed when ready*

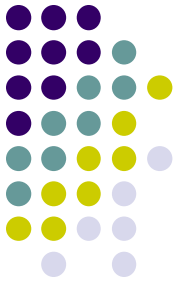
## Glaucoma Overview



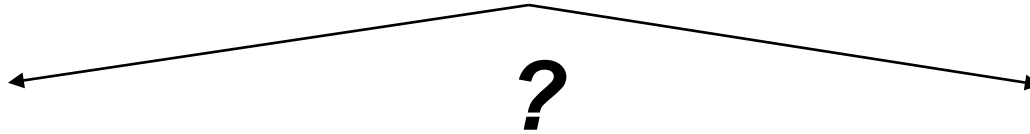
*Finally, let's look briefly at how one should think through the new glaucoma case sitting in your exam chair*

Q

## Glaucoma Overview



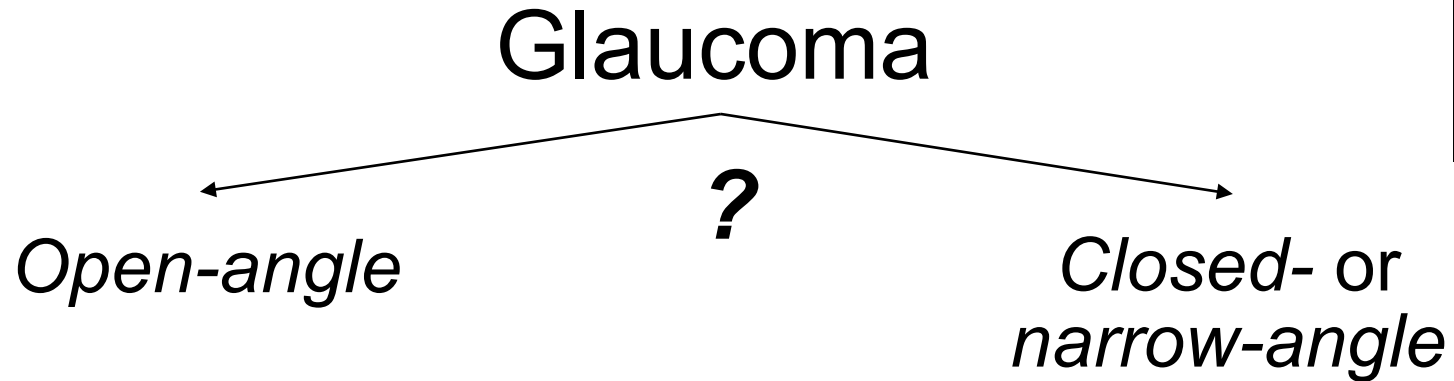
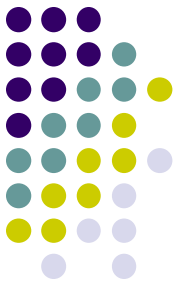
# Glaucoma



The first thought you should have when encountering a pt you suspect has glaucoma is...

A

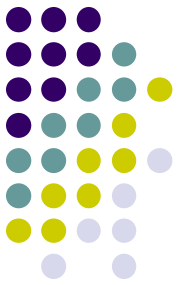
## Glaucoma Overview



The first thought you should have when  
encountering a pt you suspect has glaucoma is...  
***What is the status of the angle?***

Q

## Glaucoma Overview



# Glaucoma

*Open-angle*

*Closed- or  
narrow-angle*

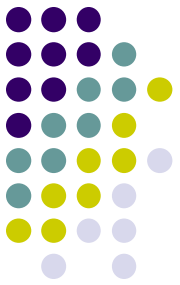
The first thought you should have when  
encountering a pt you suspect has glaucoma is...

***What is the status of the angle?***

*How does one determine the status of the angle?*

A

## Glaucoma Overview



# Glaucoma

*Open-angle*

*Closed- or  
narrow-angle*

The first thought you should have when  
encountering a pt you suspect has glaucoma is...

***What is the status of the angle?***

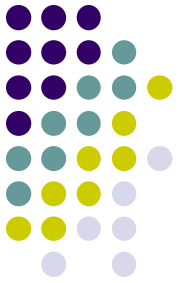
*How does one determine the status of the angle?*

**Gonioscopy.** Don't assume your glaucoma pt has open angles—**prove** it by gonioing them!

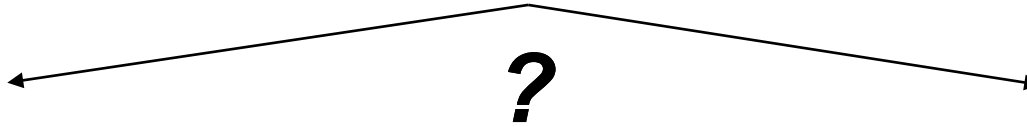


Q

## Glaucoma Overview



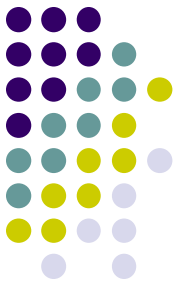
OAG



Once you have determined a pt has open-angle glaucoma,  
the next 'first thought' is to ask...

A

## Glaucoma Overview



OAG

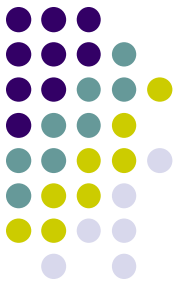
↑ IOP

*Normal-tension  
glaucoma (NTG)*

Once you have determined a pt has open-angle glaucoma,  
the next 'first thought' is to ask...  
***Is it high-pressure OAG, or low (aka normal) tension OAG?***

Q

## Glaucoma Overview



OAG

↑ IOP

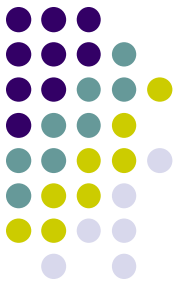
Untreated IOP consistently  
above # mmHg

*Normal-tension  
glaucoma (NTG)*

Untreated IOP consistently  
below # mmHg

A

## Glaucoma Overview



OAG

↑ IOP



Untreated IOP consistently  
above 22 mmHg

*Normal-tension  
glaucoma (NTG)*

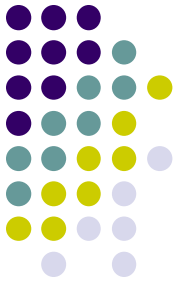


Untreated IOP consistently  
below 22 mmHg

*(Note that this distinction is somewhat controversial, as some glaucomatologists contend NTG is **not** a separate condition.)*

Q

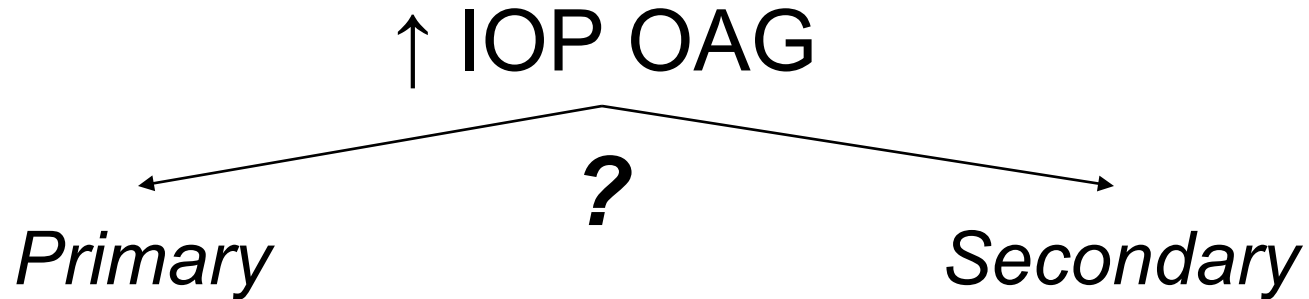
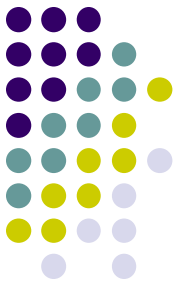
## Glaucoma Overview



Once you have determined a pt has high-pressure open-angle glaucoma,  
the next 'first thought' is to ask...

A

## Glaucoma Overview

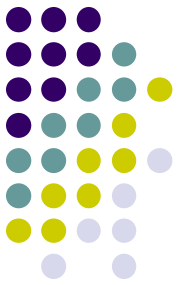


Once you have determined a pt has high-pressure open-angle glaucoma,  
the next 'first thought' is to ask...

***Is it primary open-angle glaucoma (POAG), or secondary OAG?***

Q

## Glaucoma Overview



↑ IOP OAG

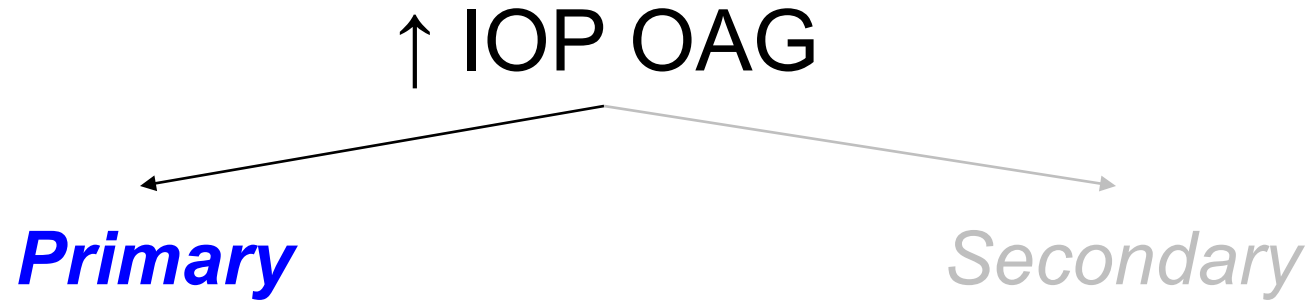
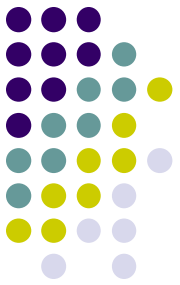
***Primary***

*Secondary*

*How prevalent is POAG in the US?*

Q/A

## Glaucoma Overview



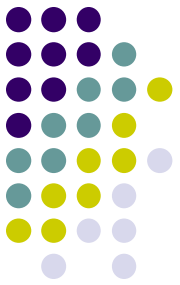
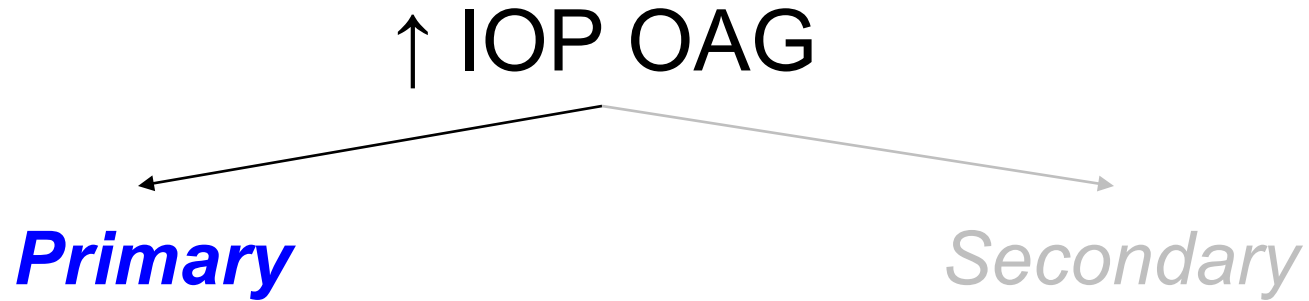
*How prevalent is POAG in the US?*

Very. It affects about % of the over-40 population.



A

## Glaucoma Overview

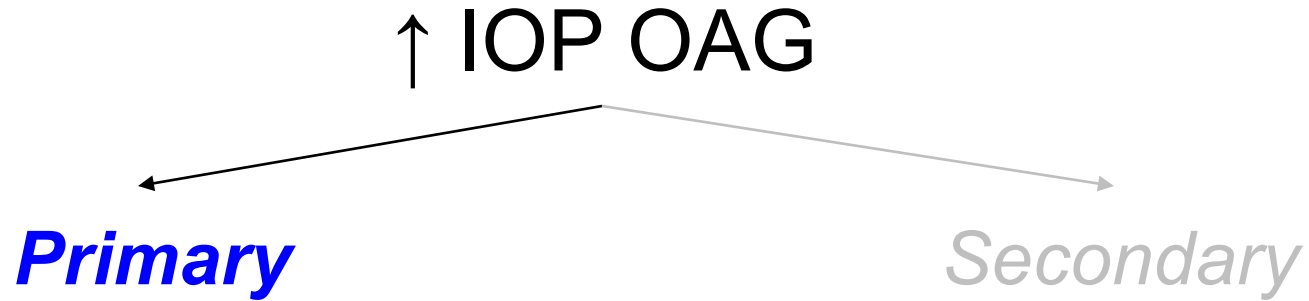
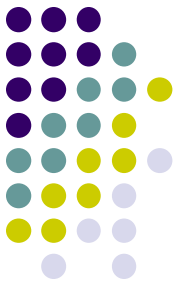


*How prevalent is POAG in the US?*

Very. It affects about 2% of the over-40 population.

Q

## Glaucoma Overview



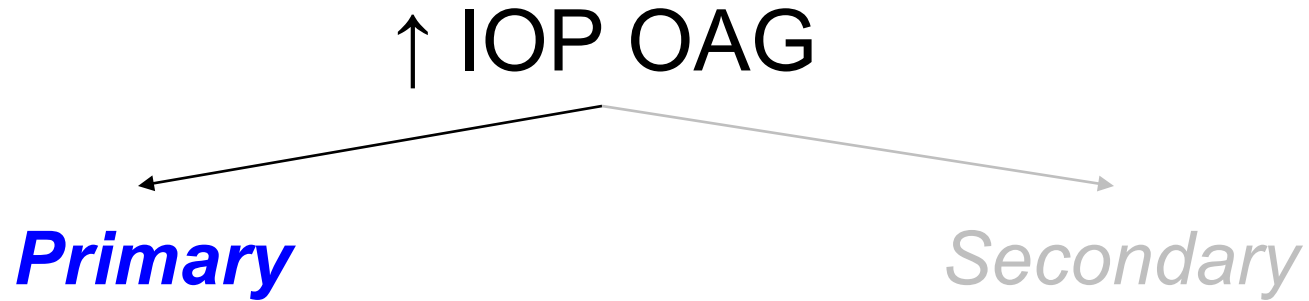
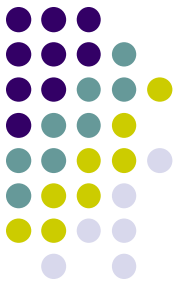
*How prevalent is POAG in the US?*

Very. It affects about **2%** of the over-40 population.

*Where does POAG rank worldwide as a cause of blindness?*

Q/A

## Glaucoma Overview



*How prevalent is POAG in the US?*

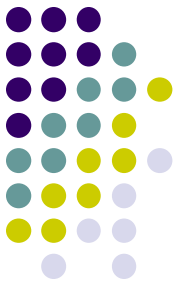
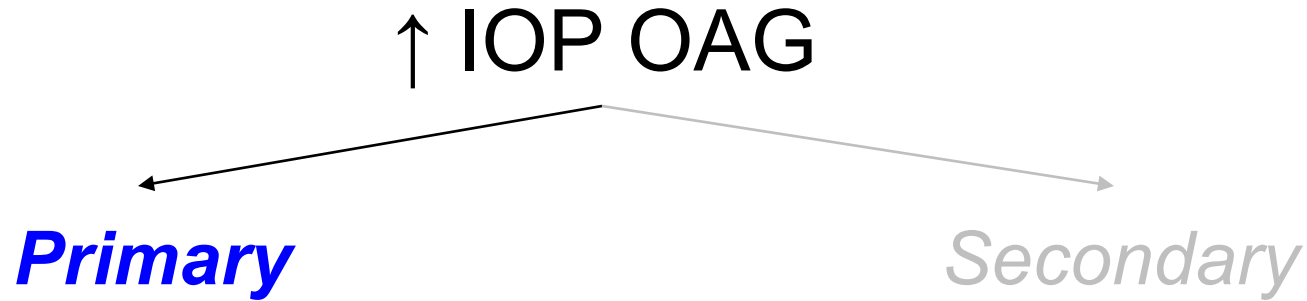
Very. It affects about 2% of the over-40 population.

*Where does POAG rank worldwide as a cause of blindness?*

It is second only to

A

## Glaucoma Overview



*How prevalent is POAG in the US?*

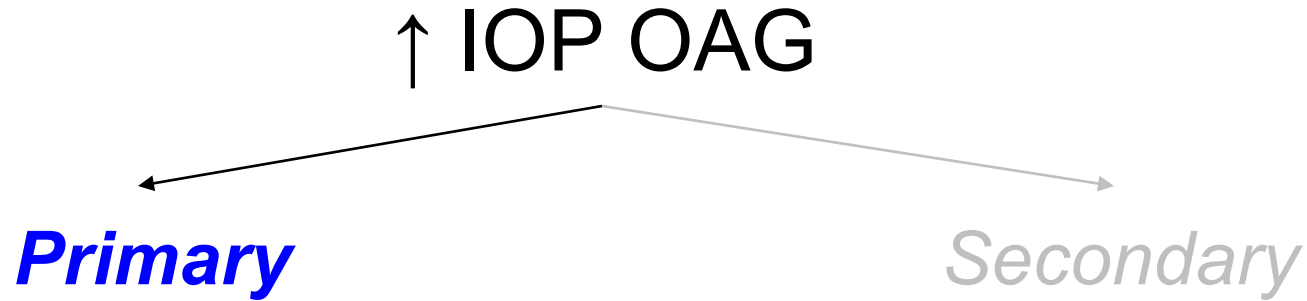
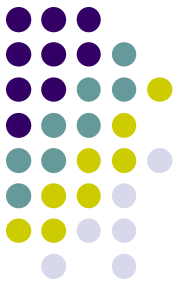
Very. It affects about **2%** of the over-40 population.

*Where does POAG rank worldwide as a cause of blindness?*

It is second only to **cataract**

Q

## Glaucoma Overview



*How prevalent is POAG in the US?*

Very. It affects about 2% of the over-40 population.

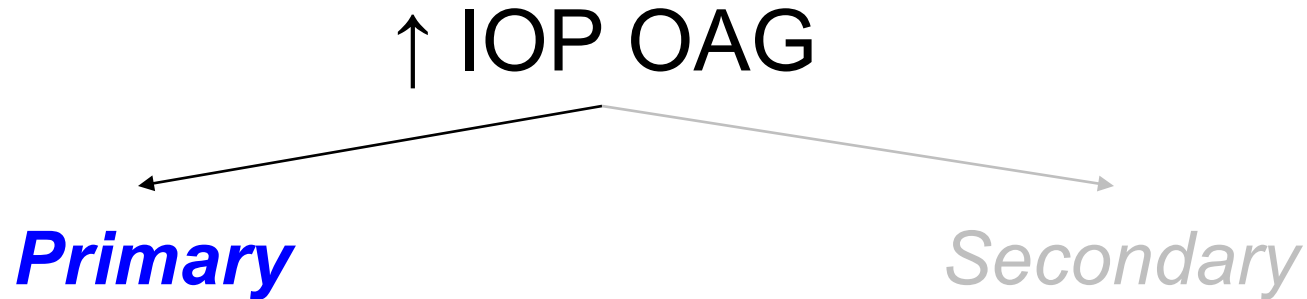
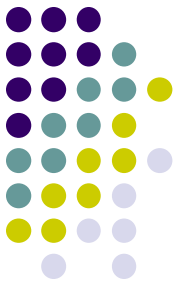
*Where does POAG rank worldwide as a cause of blindness?*

It is second only to cataract

*Is there a racial predilection?*

Q/A

## Glaucoma Overview



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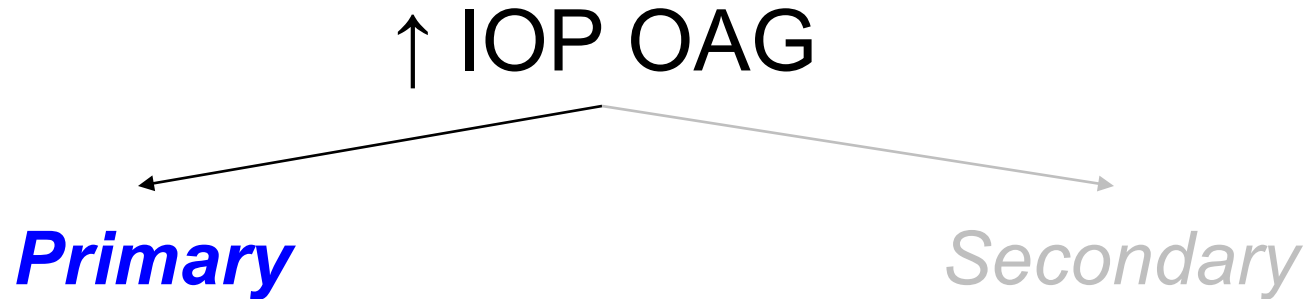
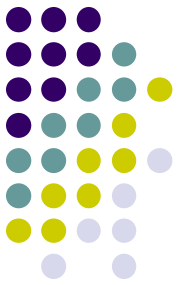
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Yes, individuals of [ ] and [ ] heritage are at a 4x greater risk than are [ ] (and their relative risk of going blind is even higher than that)

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## Glaucoma Overview



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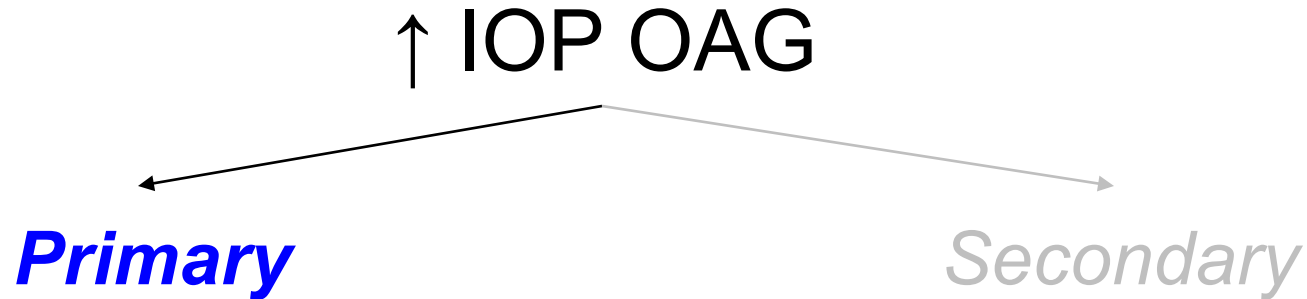
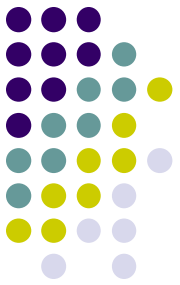
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Yes, individuals of black and Hispanic heritage are at a 4x greater risk than are whites (and their relative risk of going blind is even higher than that)

Q

## Glaucoma Overview



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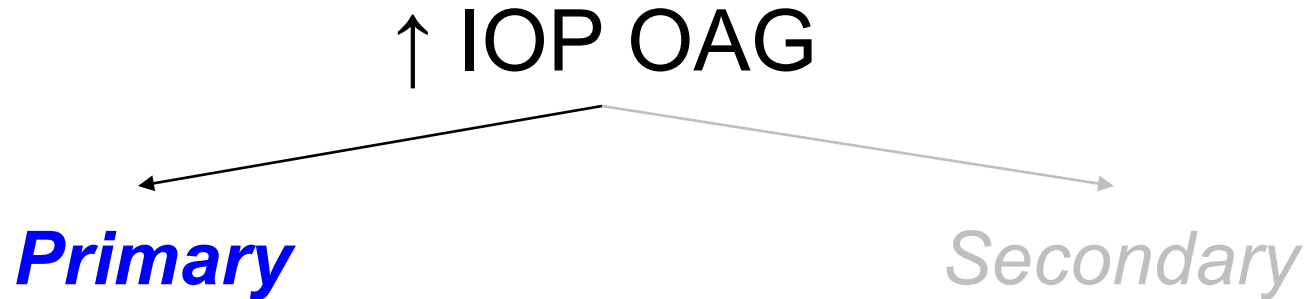
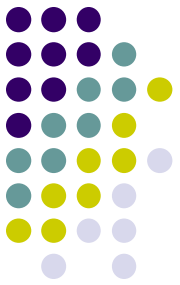
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# A

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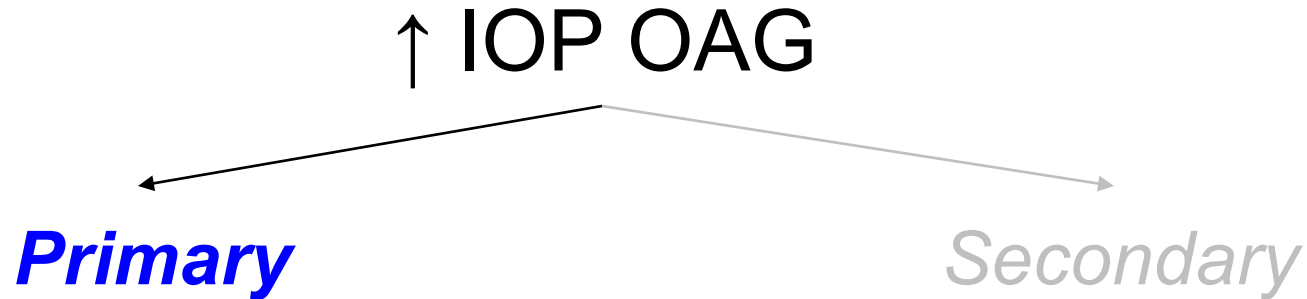
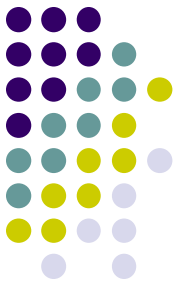
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Yes, POAG rates increase dramatically with age

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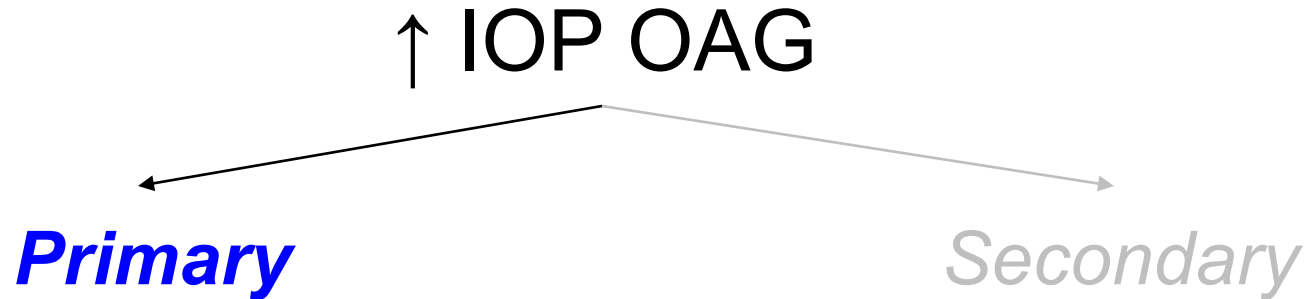
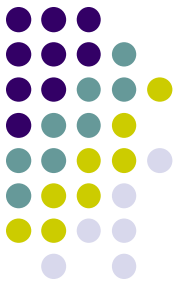
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Elevated IOP

Q

## Glaucoma Overview

↑ IOP OAG



*The BCSC Glaucoma book lists three risk factors for POAG (not including IOP). Two are age and race. What is the third?*

It is second only to cataract

*Is there a **racial predilection**?*

Yes, individuals of **black** and **Hispanic** heritage are at a 4x greater risk than are **whites** (and their relative risk of going blind is even higher than that)

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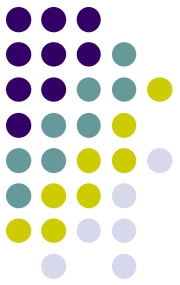
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# A

## Glaucoma Overview

↑ IOP OAG



The BCSC Glaucoma book lists three risk factors for POAG (not including IOP).  
Two are age and race. What is the third?  
Family history

It is second only to cataract

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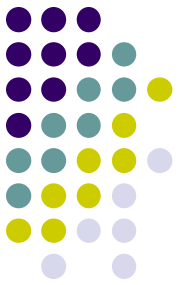
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*While not listed in the section on risk factors, the Glaucoma book alludes to two other variables as being well-established as significant risk factors for POAG. What are they?*  
--?  
--?

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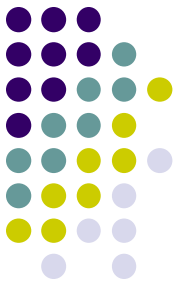
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## Glaucoma Overview

↑ IOP OAG



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Family history

*While not listed in the section on risk factors, the Glaucoma book alludes to two other variables as being well-established as significant risk factors for POAG. What are they?*  
--Central corneal thickness (CCT)  
--Ocular perfusion pressure (OPP)

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Yes, individuals of **black** and **Hispanic** heritage are at a 4x greater risk than are **whites** (and their relative risk of going blind is even higher than that)

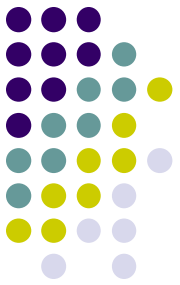
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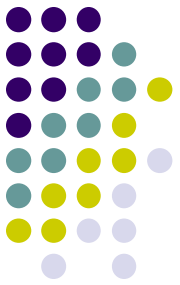
## Glaucoma Overview



*It's critical to note that POAG is a diagnosis of exclusion—*



# Glaucoma Overview



↑ IOP OAG

*Primary*

*Secondary*

PXS

Pigmentary

Tumor-Induced

Lens-Induced

Inflammation-Induced

Drug-Induced

Trauma-Related

↑ EVS

Schwartz syndrome

- Phacolytic
- Phacoantigenic
- Lens particle

- Posner-Schlossman
- Fuchs heterochromic iridocyclitis

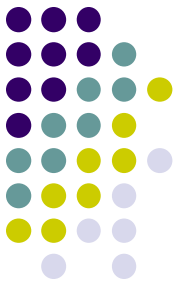
- Steroids
- Mydriatics

- Angle recession
- Cyclodialysis cleft
- Hyphema
- Hemolytic
- Ghost cell

- AVM
- Venous obstruction
- SVC syndrome
- C-C fistula

*It's critical to note that POAG is a diagnosis of exclusion—it can only be made once secondary causes of OAG have been ruled out!*

# Glaucoma Overview



↑ IOP OAG

*Primary*

*Secondary*

PXS

Pigmentary

**Tumor-Induced**

**Lens-Induced**

**Inflammation-Induced**

**Drug-Induced**

**Trauma-Related**

↑ **EVS**

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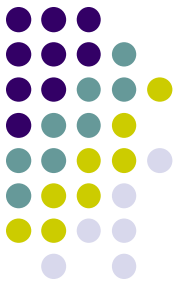
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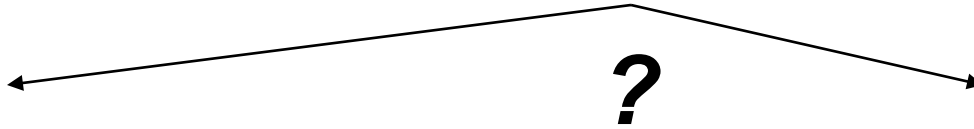
*(Most of these conditions are addressed in detail in other slide-sets—see the Table of Contents)*

Q

## Glaucoma Overview



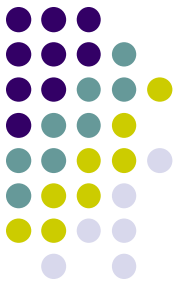
# Angle-Closure Glaucoma



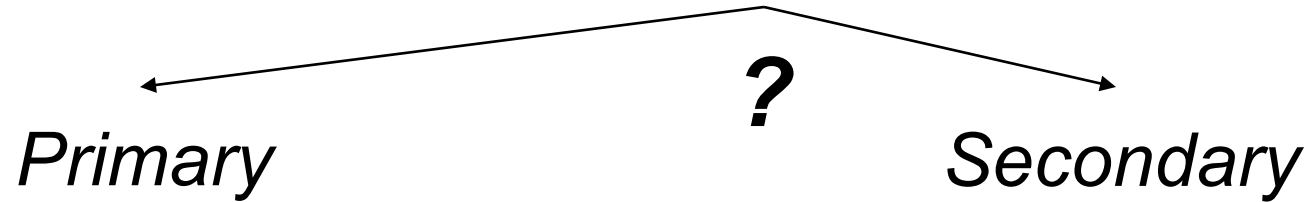
Once you have determined a pt has angle-closure glaucoma,  
the next 'first thought' is to ask...

# A

## Glaucoma Overview



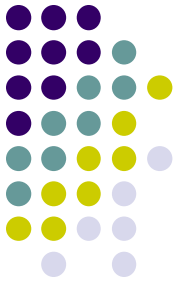
### Angle-Closure Glaucoma



Once you have determined a pt has angle-closure glaucoma,  
the next 'first thought' is to ask...  
***is it primary or secondary?***

Q

## Glaucoma Overview



# Angle-Closure Glaucoma

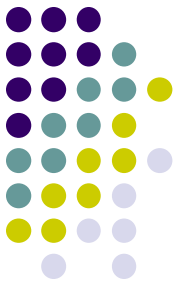
***Primary***

*Secondary*

*Is there a racial predilection regarding the risk of PACG?*

Q/A

## Glaucoma Overview



# Angle-Closure Glaucoma

***Primary***

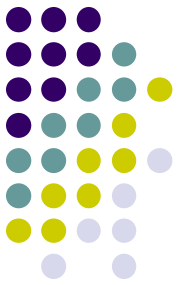
*Secondary*

*Is there a racial predilection regarding the risk of PACG?*

Yes, individuals of   heritage have the highest known risk of PACG

A

## Glaucoma Overview



# Angle-Closure Glaucoma

***Primary***

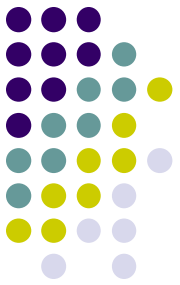
*Secondary*

*Is there a racial predilection regarding the risk of PACG?*

Yes, individuals of **Inuit** heritage have the highest known risk of PACG

Q

## Glaucoma Overview



# Angle-Closure Glaucoma

***Primary***

*Secondary*

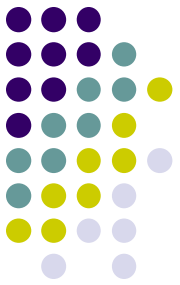
*Is there a racial predilection regarding the risk of PACG?*

Yes, individuals of Inuit heritage have the highest known risk of PACG--their relative risk has been estimated to be as high as #x that of whites.



A

## Glaucoma Overview



# Angle-Closure Glaucoma

***Primary***

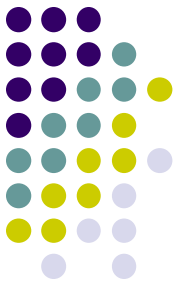
*Secondary*

*Is there a racial predilection regarding the risk of PACG?*

Yes, individuals of Inuit heritage have the highest known risk of PACG--their relative risk has been estimated to be as high as 40x that of whites.

Q

## Glaucoma Overview



# Angle-Closure Glaucoma

**Primary**

*Secondary*

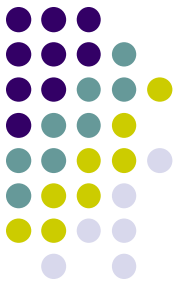
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*What about people of Asian descent?*

A

## Glaucoma Overview



# Angle-Closure Glaucoma

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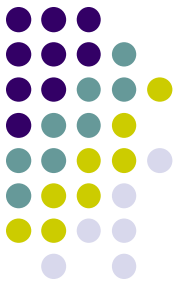
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Q

## Glaucoma Overview



# Angle-Closure Glaucoma

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*Secondary*

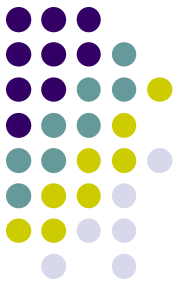
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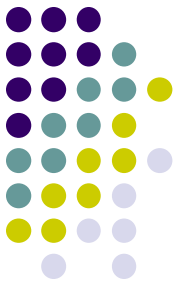
Their relative risk is somewhere between that of the Inuit and whites

*Is age a risk factor?*

Yes, the incidence **increases vs decreases** with age

# A

## Glaucoma Overview



# Angle-Closure Glaucoma

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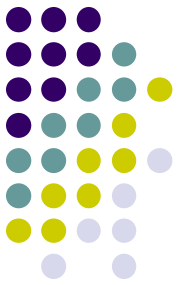
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## Glaucoma Overview



# Angle-Closure Glaucoma

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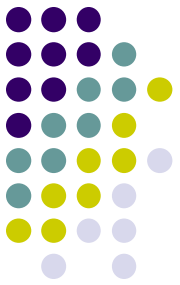
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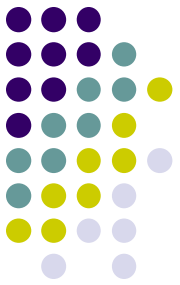
*Is gender a risk factor?*

Yes, **males** are at higher risk



# A

## Glaucoma Overview



# Angle-Closure Glaucoma

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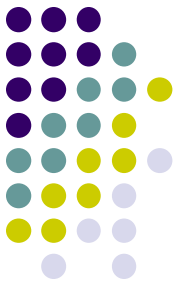
Yes, the incidence increases with age

*Is gender a risk factor?*

Yes, **women** are at higher risk

# Q

## Glaucoma Overview



# Angle-Closure Glaucoma

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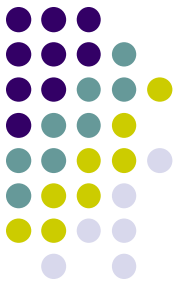
*Is age a risk factor?*

Yes, the incidence increases with age

*Is gender a risk factor?*

Yes, **women** are at higher risk

*Is refraction a risk factor?*



# Angle-Closure Glaucoma

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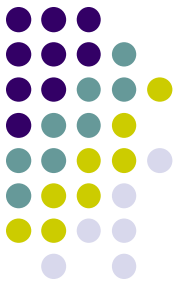
Yes, **women** are at higher risk

*Is refraction a risk factor?*

Yes; PACG is more likely to occur in **[ ]**

# A

## Glaucoma Overview



# Angle-Closure Glaucoma

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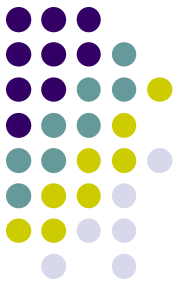
Yes, **women** are at higher risk

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Yes; PACG is more likely to occur in **hyperopes**

Q

## Glaucoma Overview



# Angle-Closure Glaucoma

*Primary*

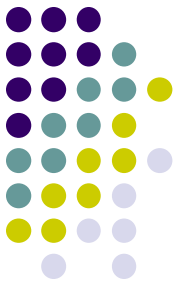
*Secondary*

— ?  
— ?  
— ?  
— ?

*What are the four subtypes of PACG?*

A

## Glaucoma Overview



# Angle-Closure Glaucoma

*Primary*

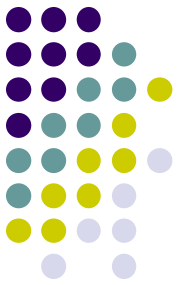
*Secondary*

- Acute
- Subacute
- Chronic
- Plateau Iris

*What are the four subtypes of PACG?*

Q

## Glaucoma Overview



# Angle-Closure Glaucoma

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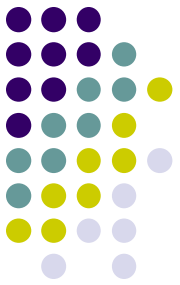
*Secondary*

?

The first thought you should have when encountering a pt you suspect has secondary angle-closure glaucoma is...

A

## Glaucoma Overview



# Angle-Closure Glaucoma

*Primary*

- Acute
- Subacute
- Chronic
- Plateau Iris

*Secondary*

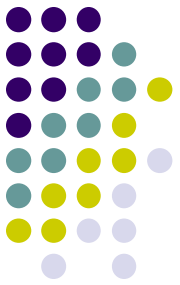
?

*w/ Pupillary Block*

*w/o Pupillary Block*

The first thought you should have when encountering a pt you suspect has secondary angle-closure glaucoma is...  
***is it with or without pupillary block***





# Angle-Closure Glaucoma

## Primary

- Acute
- Subacute
- Chronic
- Plateau Iris

## Secondary

?

*w/ Pupillary Block*

*w/o Pupillary Block*

The first thought you should have when encountering a pt you suspect has secondary angle-closure glaucoma is...  
***is it with or without pupillary block***

*More information is available regarding the various forms of angle-closure glaucoma, check the Table of Contents to find it*