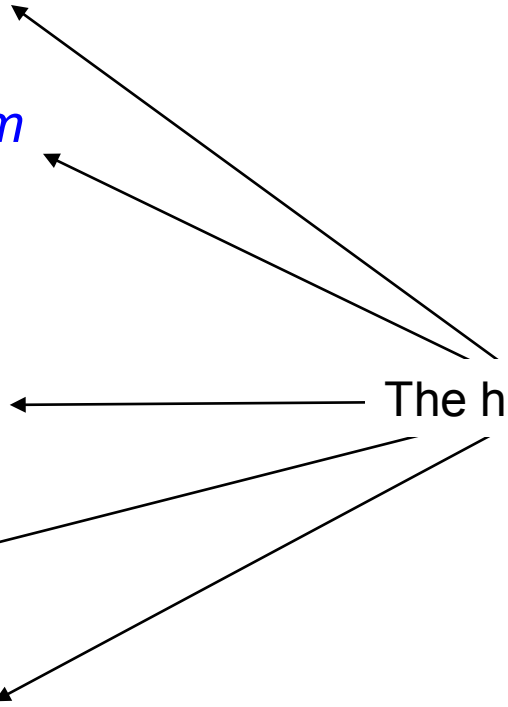
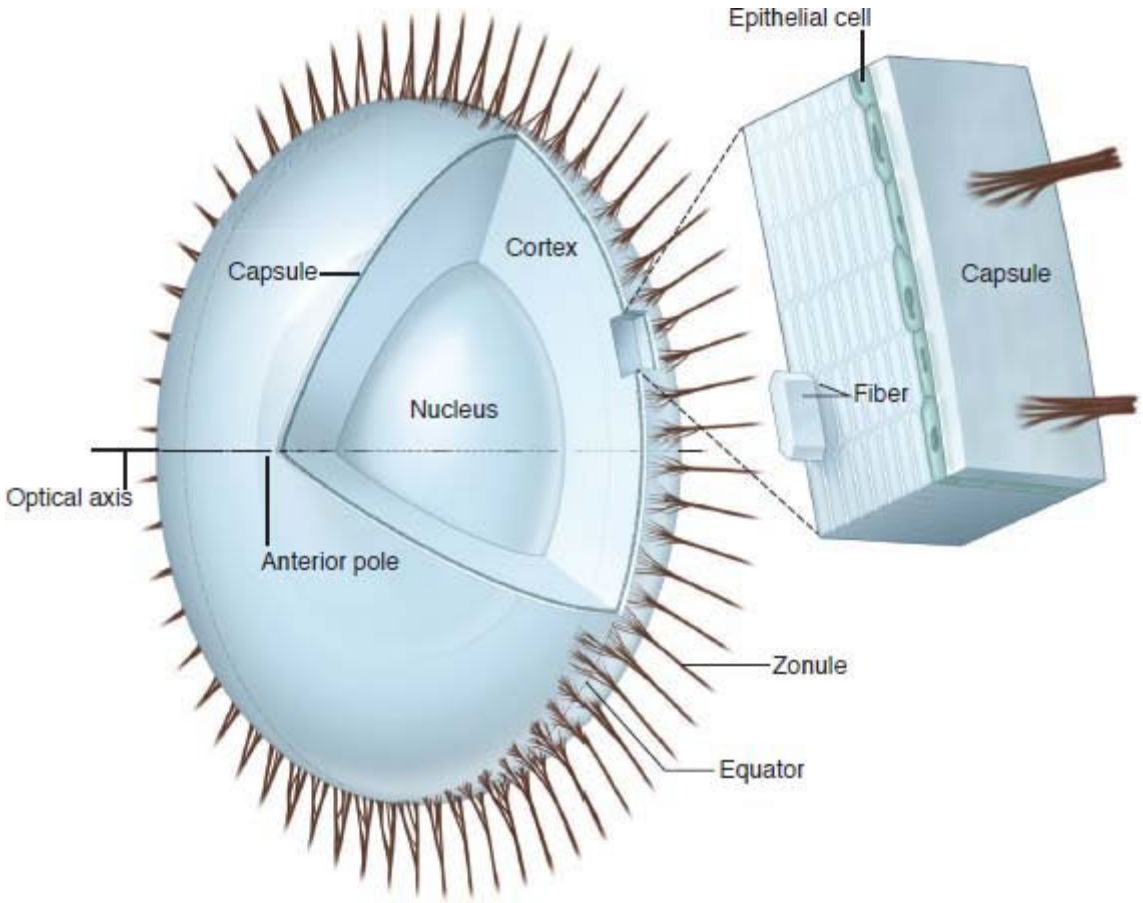
Lens/Cataracts Overview

- Anatomy of the mature* lens
  - *Capsule*
  - *Epithelium*
  - *Nucleus*
  - *Cortex*
  - *Zonules*



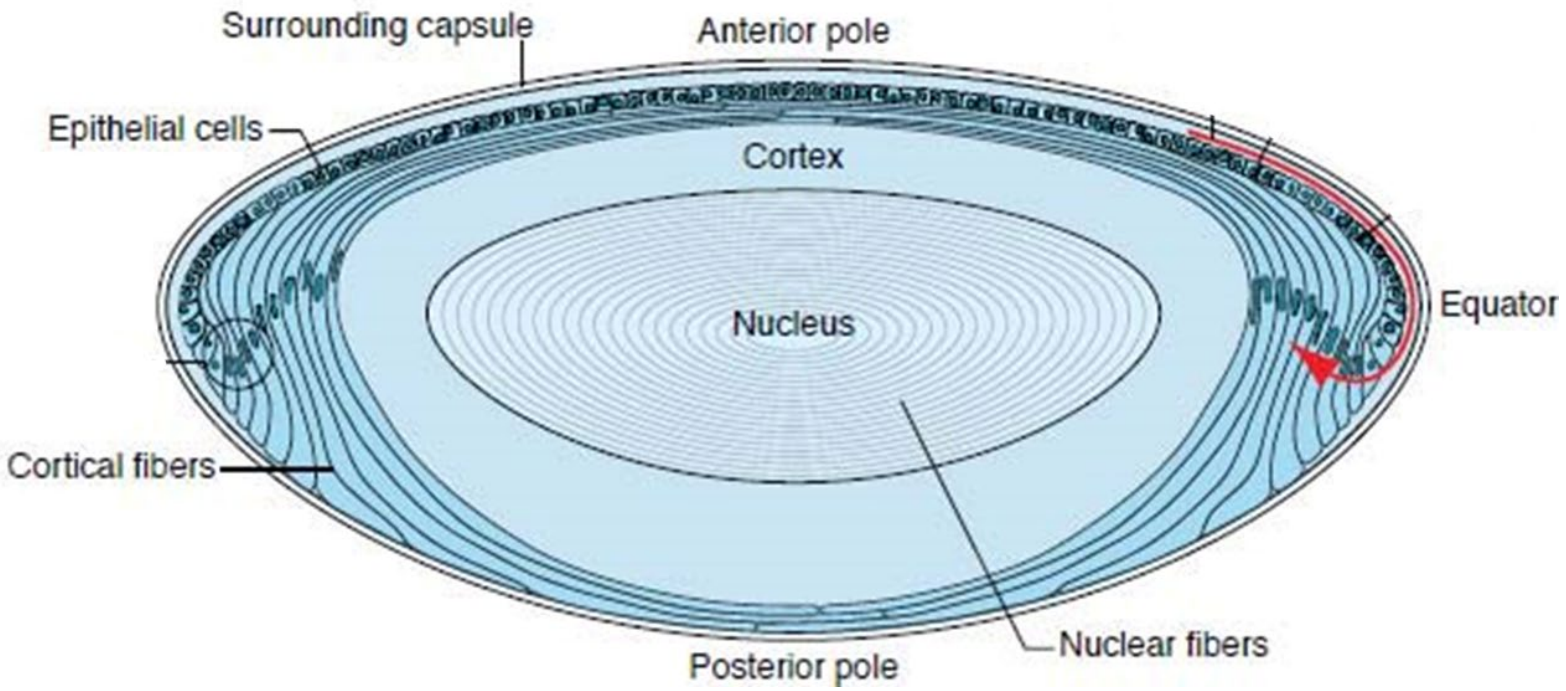
*'Mature' meaning 'postnatal;' **not** referring here to a 'mature' cataract

Lens/Cataracts Overview



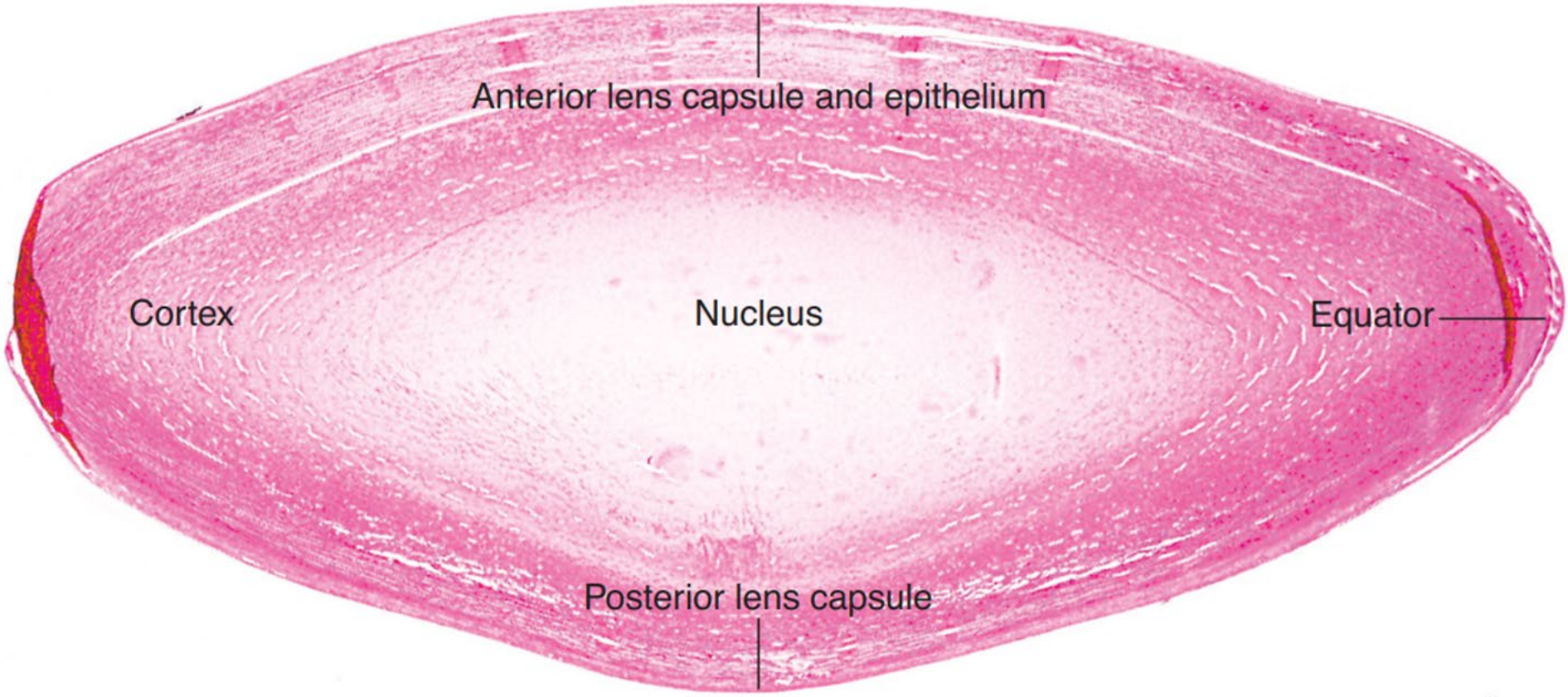
Basic components of the mature lens

Lens/Cataracts Overview



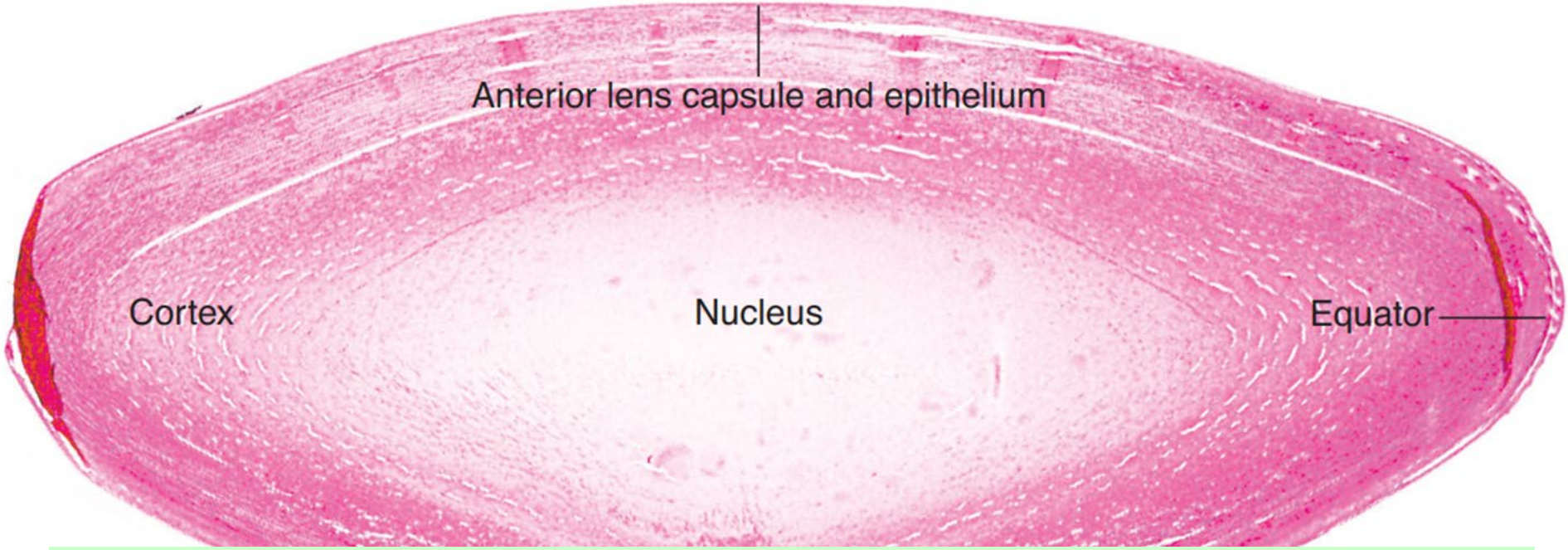
Basic components of the mature lens: Another depiction

Lens/Cataracts Overview



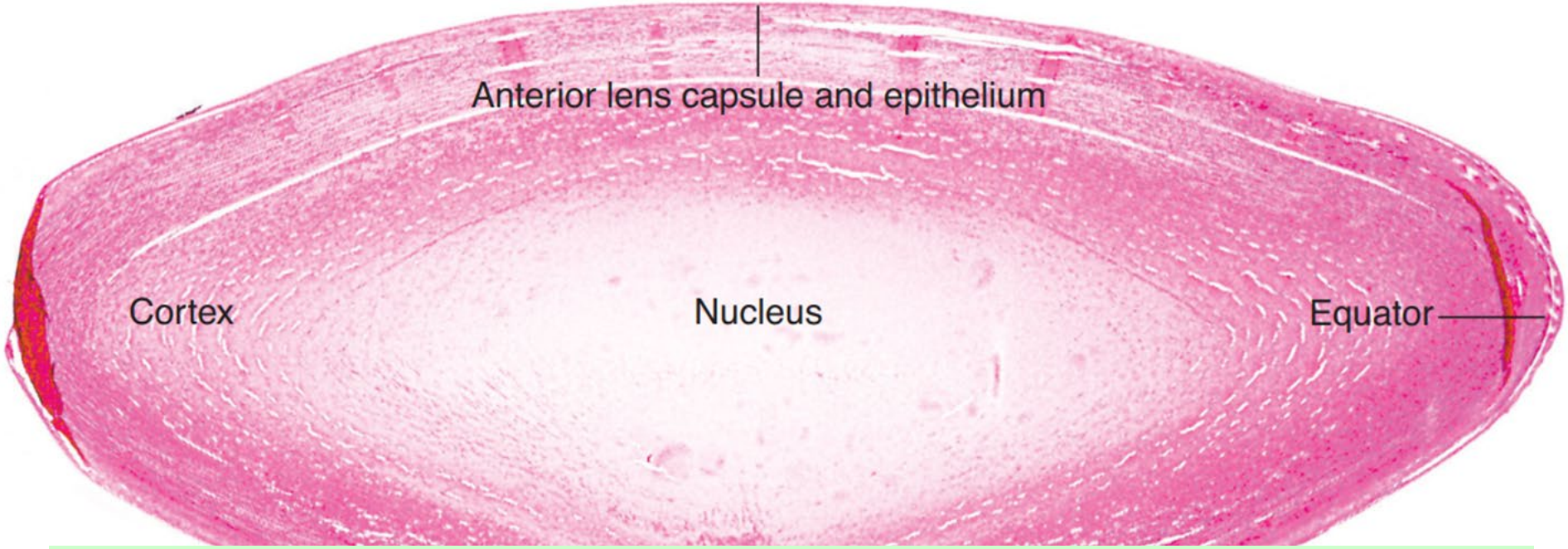
Basic components of the mature lens: Photomicrograph

Lens/Cataracts Overview



Note on a nomenclature-related source of confusion if you've ever sat in on cataract surgery:
--During the case, the surgeon likely made reference at some point to the cataract's *epinucleus*, and you may be wondering why no such layer is depicted above.
--More puzzling, the surgeon may have used the term *cortex* in referring to a very thin, sticky layer adherent to the capsule—a tissue *nothing* like the cortex depicted here.
What's going on?

Lens/Cataracts Overview



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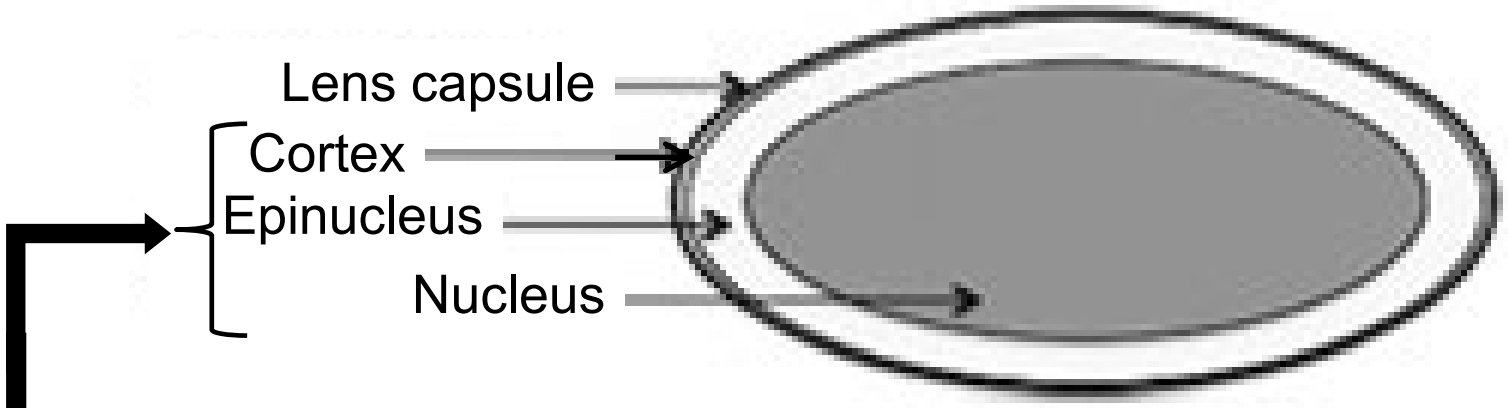
What's going on is that the surgeon was referring to the *surgical* layers of the lens, not its *anatomic* layers. During cataract surgery, portions of the lens 'behave' very differently from one another, and it is with respect to these behaviors that surgeons conceptualize the makeup of the lens. (Cont)

Lens/Cataracts Overview

Surgical

Layers of the lens:



*These are the **surgical layers** of the lens…*

- **Nucleus**
- **Epinucleus**
- **Cortex**

Lens/Cataracts Overview

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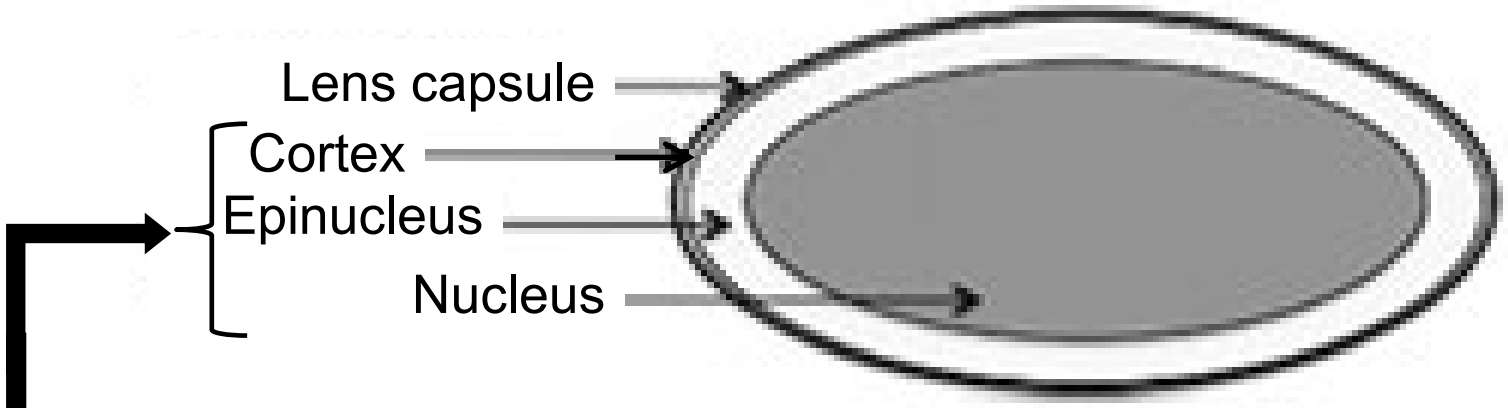

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Epinucleus

Cortex

Lens/Cataracts Overview

Surgical

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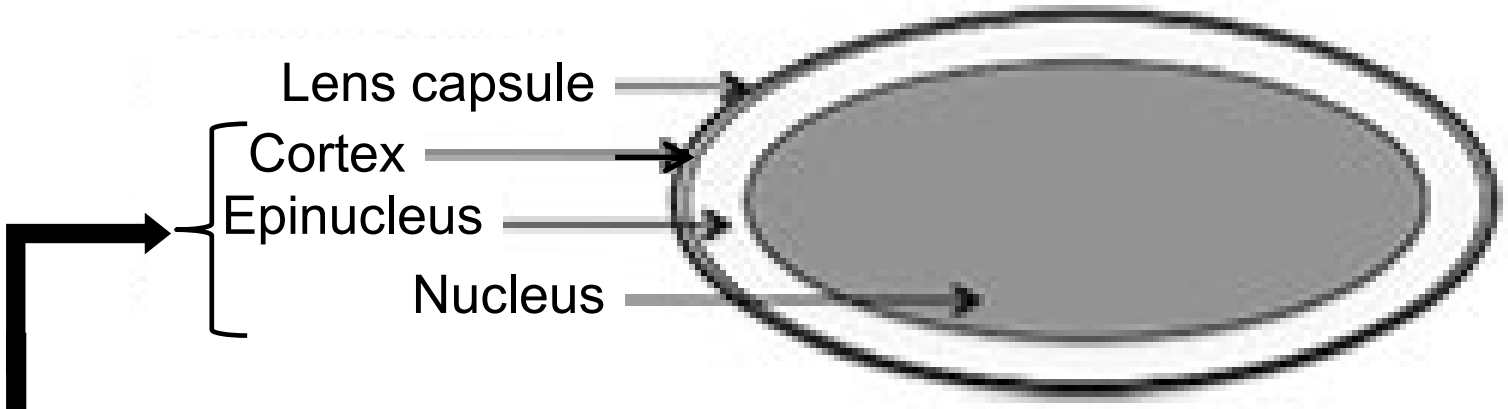

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Nucleus: Opaque, usually with an amber hue. The nucleus is firm, and cannot be aspirated from the eye until/unless it is broken up (ie, *emulsified*, hence the term *phacoemulsification*).

Epinucleus

Cortex

Lens/Cataracts Overview

Surgical

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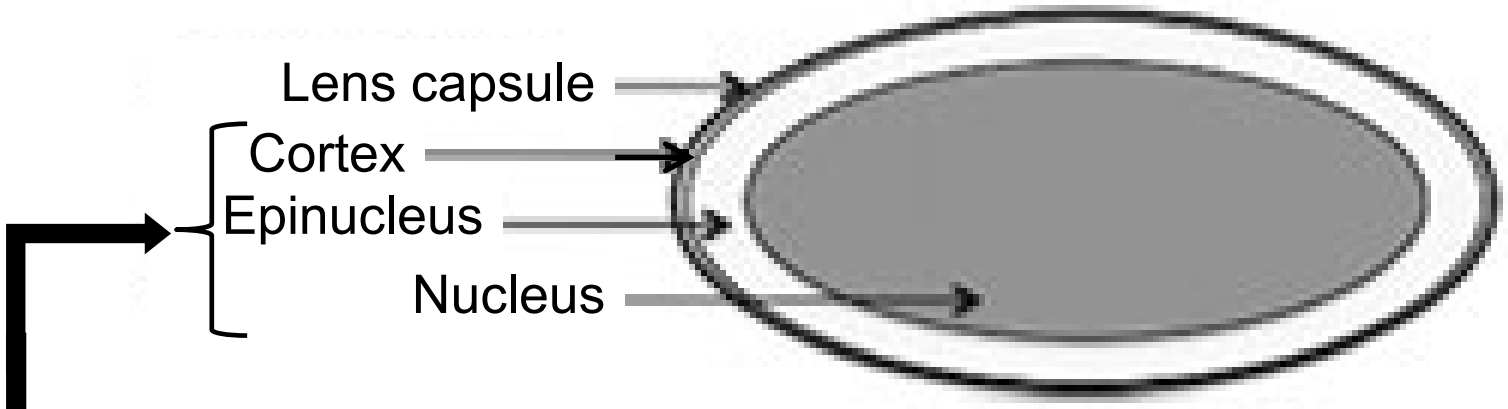

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Cortex

Lens/Cataracts Overview

Surgical

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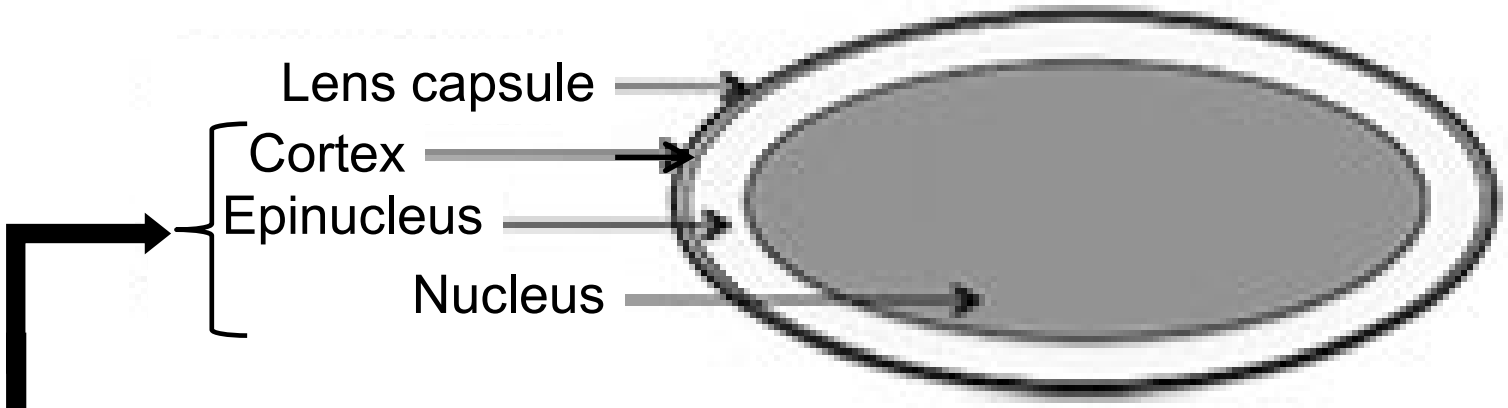

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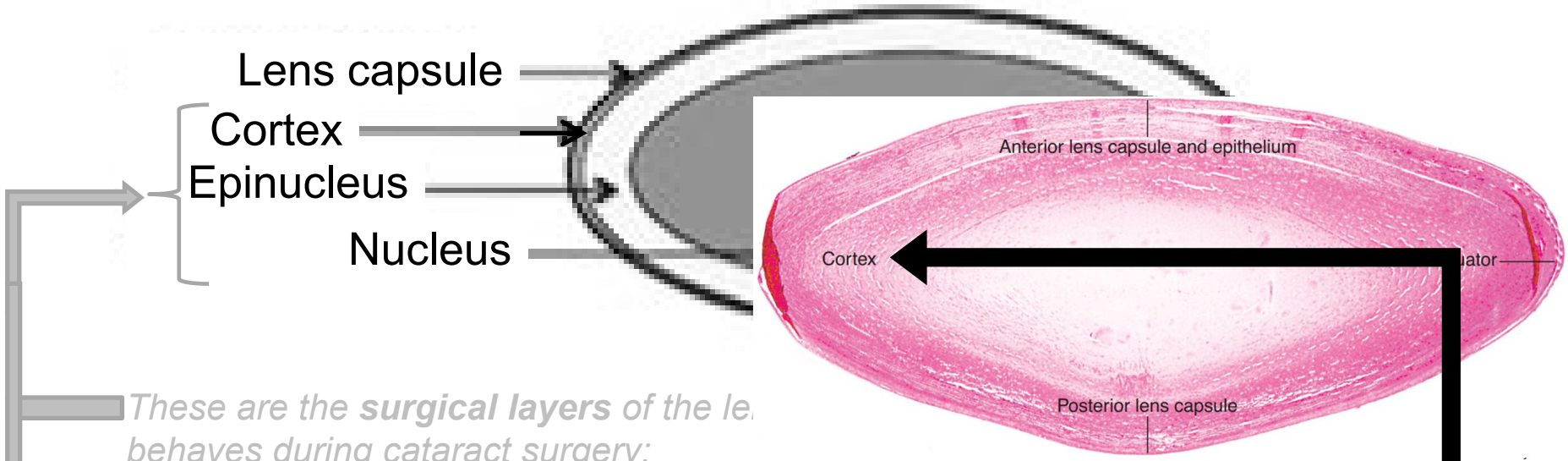
Cortex: Thin and wispy, the cortex is like a layer of tape stuck to the inner aspect of the capsule. Using aspiration and vacuum power, it is peeled off at the end of the case. It requires no emulsification.

Lens/Cataracts Overview

Surgical

Layers of the lens:



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Lens/Cataracts Overview

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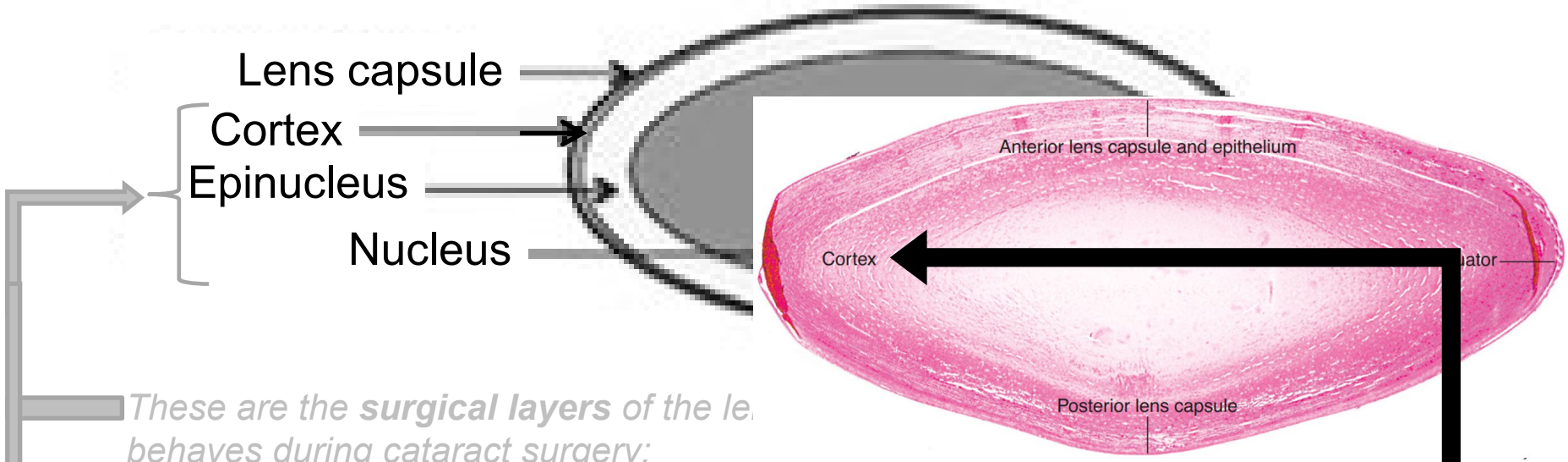

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Lens/Cataracts Overview

- Anatomy of the mature lens
  - ***Capsule***
    - Type IV collagen
  - *Epithelium*
  - *Nucleus*
  - *Cortex*
  - *Zonules*

The capsule is comprised mainly of type IV collagen. (And that's all we'll have to say about that.)

Lens/Cataracts Overview

- Anatomy of the mature lens
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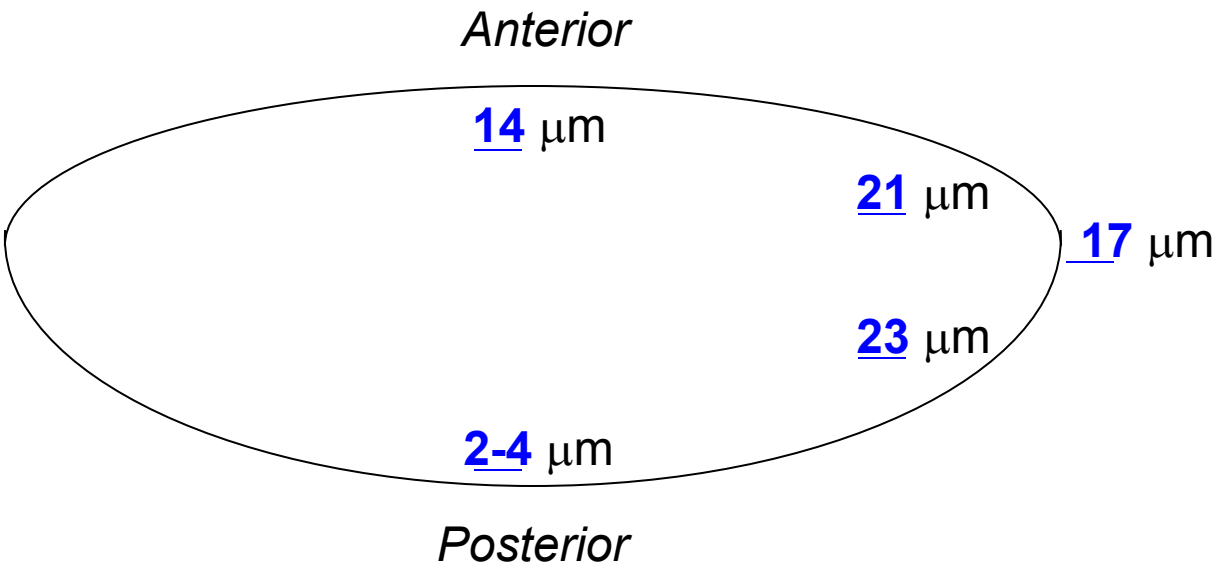
A weird-but-important point about the capsule: Despite the fact that it is on the outside of the lens, *the capsule is the basement membrane of the underlying lens epithelium*. (We will see how this counterintuitive histologic relationship comes to be when we look at lens embryology later.)

Lens/Cataracts Overview

Lens capsule thickness has important clinical and surgical implications.



Lens/Cataracts Overview

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Key takeaway: While the entire capsule is thin…

Lens/Cataracts Overview

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Lens/Cataracts Overview

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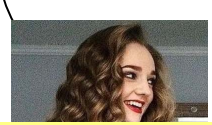


Anterior

14 μm

21 μm

17 μm

23 μm

(By way of comparison, human hair ~70 μm)

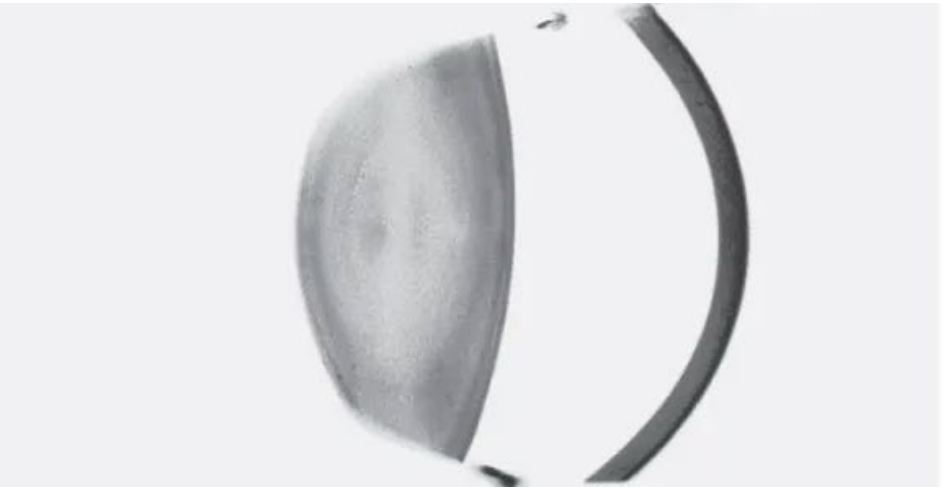
2-4 μm

Posterior

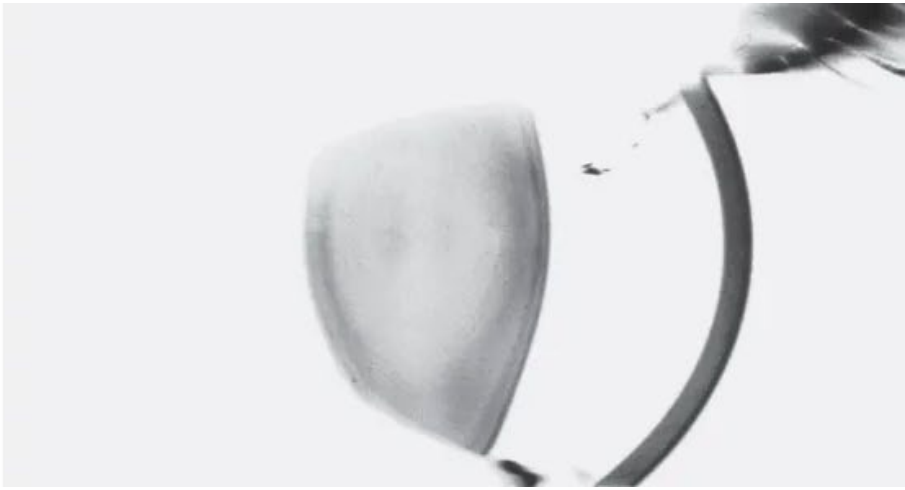
In fact, the posterior capsule is so thin it is **always distended**. Thus, all changes in lens shape during accommodation occur at the ***anterior*** capsule.

Key takeaway: While the entire capsule is thin…Its posterior aspect is **really** thin

Lens/Cataracts Overview



A



B

The lens of a 25-year-old woman demonstrated by Scheimpflug photography. The lens is in the nonaccommodative state in *A*, and accommodating in *B*. Note that the anterior radius of curvature is shortened (ie, the surface is more steeply curved) in *B*.

Lens/Cataracts Overview

- Anatomy of the mature lens
  - *Capsule*
    - Type IV collagen
  - ***Epithelium***
    - Single layer of cuboidal cells beneath anterior and equatorial capsule
  - *Nucleus*
  - *Cortex*
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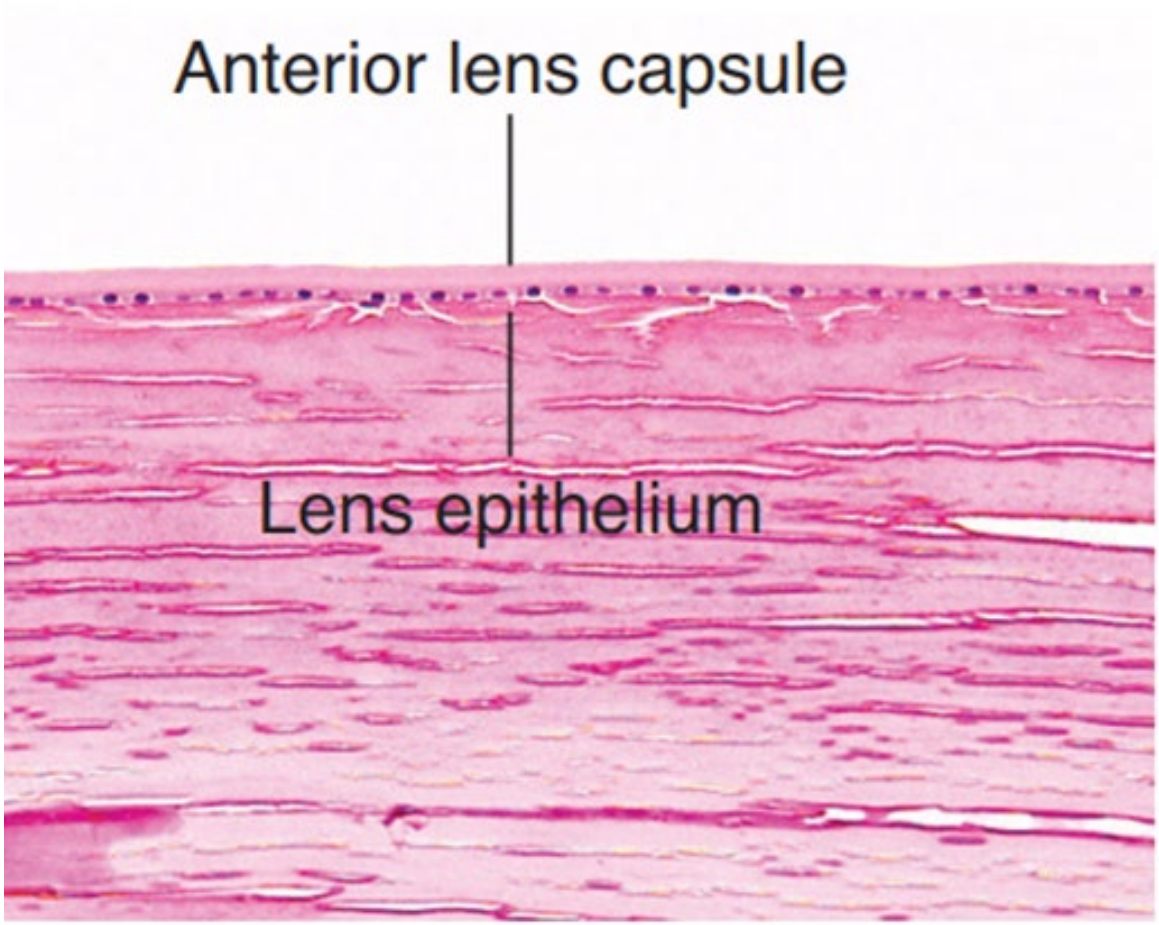
Lens/Cataracts Overview



Lens epithelium

Lens/Cataracts Overview

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  - *Capsule*
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  - ***Epithelium***
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    -
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  - *Zonules*

Lens epithelial cells are cuboidal in shape, and arranged in a single layer. Their presence is limited to the anterior and equatorial portions of the capsule.

Lens/Cataracts Overview

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Let's sidebar to consider several important issues related to lens metabolism

Lens/Cataracts Overview

Re lens metabolism, bear these two facts in mind:

1)

2)

Lens/Cataracts Overview

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1) **Glucose** is the substrate for lens metabolism.

2)

Lens/Cataracts Overview

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2) The vast majority of lens glucose is metabolized anaerobically.

- **Anaerobic Glycolysis** (majority of glucose)
- HMP Shunt (5% of glucose)

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A related metabolic challenge concerns getting the needed glucose (and other metabolic substrates) to its cells. Like every cell in the body, lens fibers must communicate with the 'outside world' to receive metabolic substrates and expurgate metabolic waste. Most (non-lens) cells accomplish this via the circulatory system.

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Now, communicating in this manner is not difficult for the lens epithelium and outermost cortical fibers, as the fluid is just on the other side of the capsule from them. But what of centrally located fibers?

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Now, communicating in this manner is not difficult for the lens epithelium and outermost cortical fibers, as the fluid is just on the other side of the capsule from them. But what of centrally located fibers? To connect *them* to the aqueous and/or vitreous, the lens employs a 'bucket brigade' in which metabolic substrates and waste products are passed cell-to-cell (via gap junctions) to get where they need to go. It should not surprise that *the density of gap junctions in lens-fiber cells is greater than that of any other cells in the body*.

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Lens/Cataracts Overview

The final metabolism-related issue: The maintenance of **lens transparency**. Lens transparency is exquisitely sensitive to the water content of the lens—a touch too much water and the lens scatters light; a touch more and it becomes opaque. Because of this, intralenticular water levels must be scrupulously maintained. And because water follows osmotic gradients, intralenticular ion levels are tightly controlled. In this regard, the most important ions are **sodium** and **potassium**.

K^+

Na^{2+}

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	Aqueous	**Vitreous**
K^+	*Plasma(ish)*	*Plasma(ish)*
Na^{2+}	*Plasma(ish)*	*Plasma(ish)*

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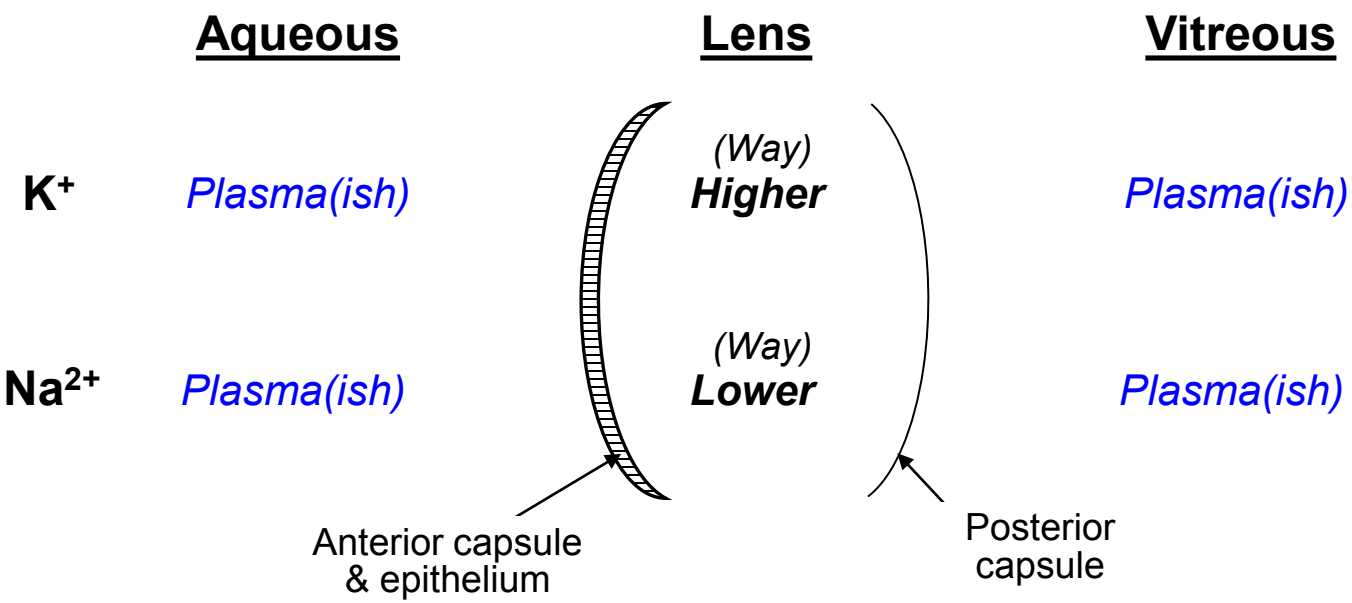

Lens/Cataracts Overview

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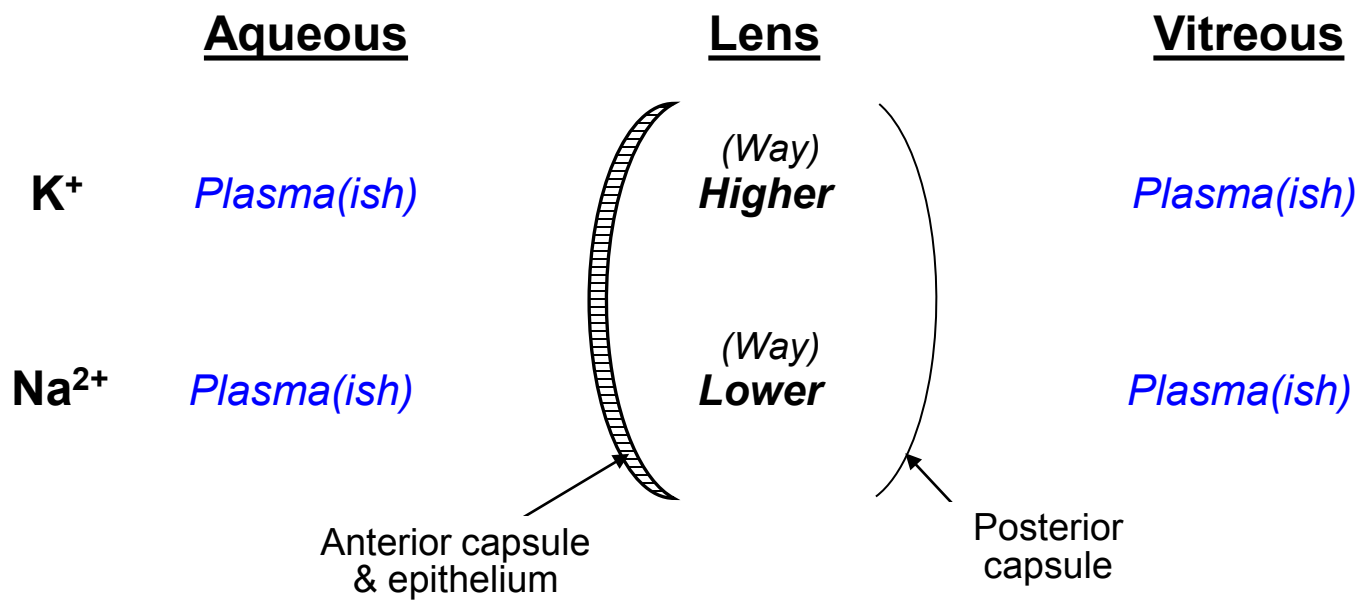

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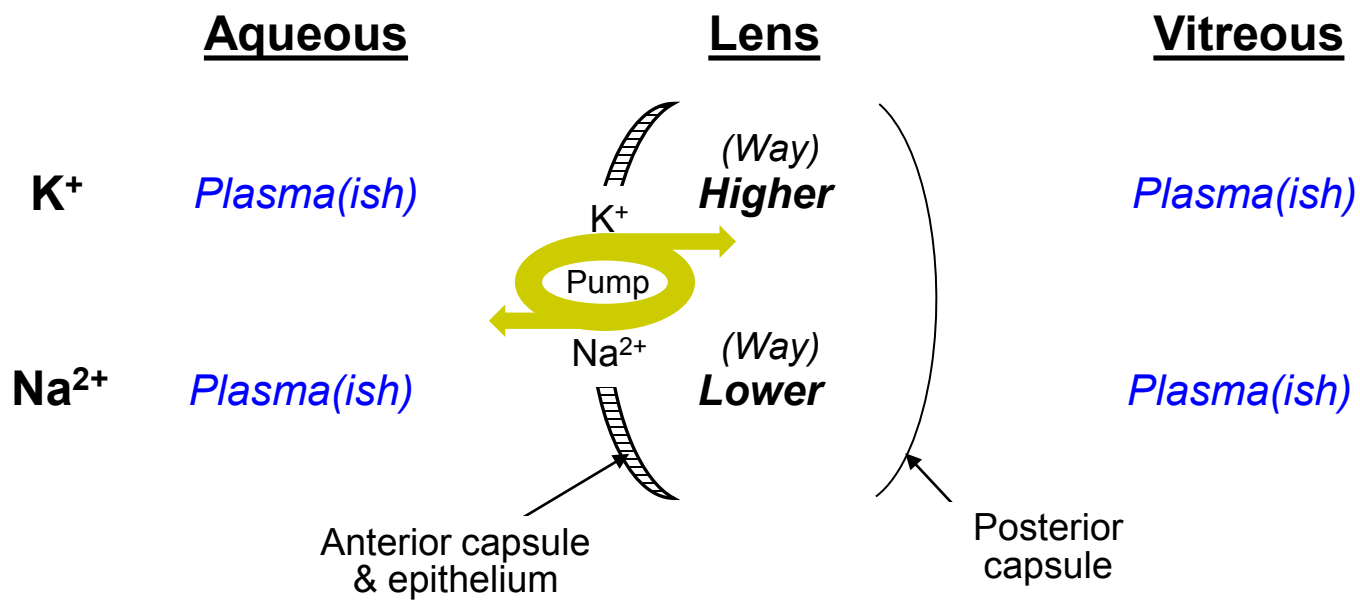
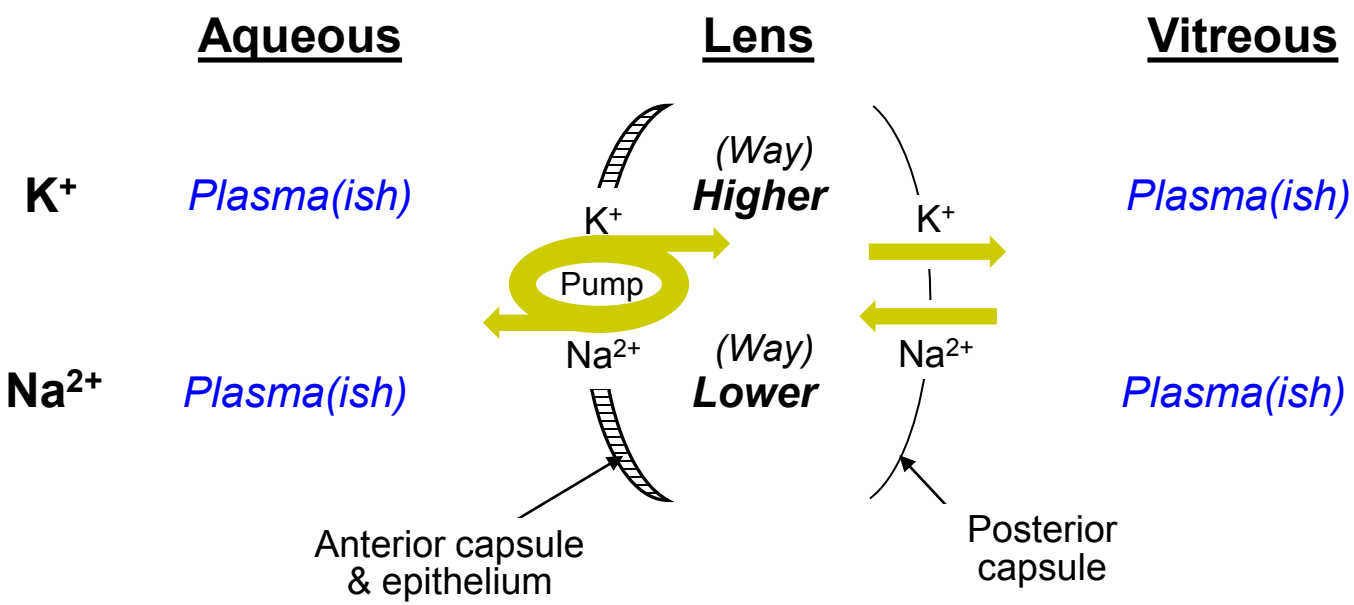


Lens/Cataracts Overview

To achieve **this**, the lens employs the **Pump-Leak System**. Lens epithelial cells contain membrane-bound, ATP–powered, sodium-potassium transporters that drive (ie, they 'pump') Na^{2+} out of the lens and K^{+} into it. In contrast, at the epithelium-less *posterior* capsule, ions move passively down their concentration gradients (ie, they 'leak')—Na^{2+} in, K^{+} out.

, the intralenticular concentration of K^{+} is an order of magnitude higher, and Na^{2+} an order of magnitude lower, than their concentrations in the aqueous and vitreous.



Lens/Cataracts Overview

- Anatomy of the mature lens
  - *Capsule*
    - Type IV collagen
  - ***Epithelium***
    - Single layer of cuboidal cells beneath anterior and equatorial capsule
    - Metabolically active; **mitotically active**
    - **Give rise to all new lens fibers**
  - *Nu*
  - *Co*
  - *Zo*

After their creation, newly-minted epi cells migrate to the lens's equatorial region, where they begin the process of terminal differentiation into lens fibers. This process is characterized by 1) cell elongation, 2) the creation of new intracellular proteins called *crystallins*, and 3) the loss of intracellular organelles.

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Lens/Cataracts Overview

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  - *Capsule*
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    - Metabolically active; mitotically active
    - Give rise to all new lens fibers
  - ***Nucleus***
    - Older fibers densely packed in central lens
  - *Cortex*
    -
  - *Zonules*

The **nucleus** consists of fibers that are either OGs (ie, those created prenatally) or were created prior to age 20 years or so, and thus have been around long enough to get packed down into the dense structure we call the nucleus.

Lens/Cataracts Overview

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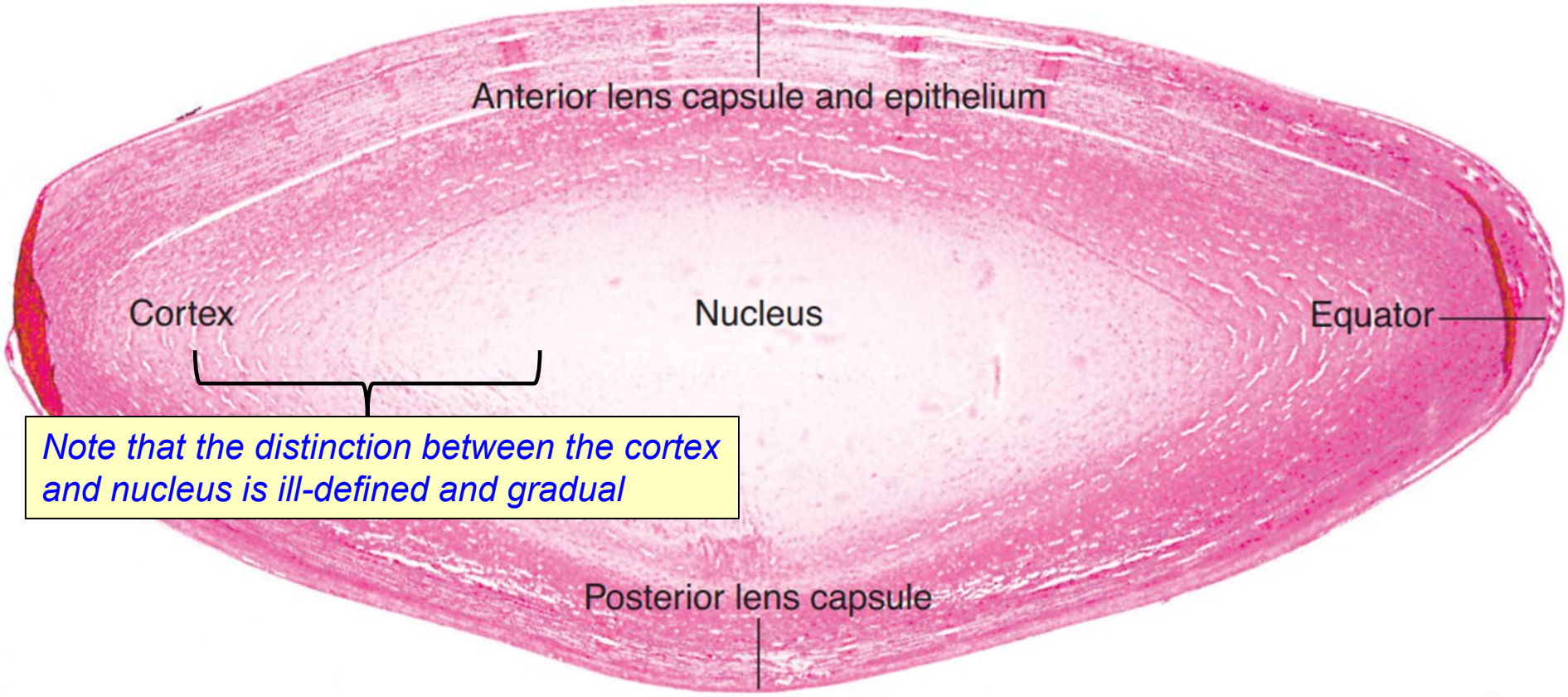
    - Newer fibers between nucleus and capsule/epithelium
  - *Zonules*

Fibers created after age 20 will live out their lives in the **cortex**.

Lens/Cataracts Overview



Note that the distinction between the cortex and nucleus is ill-defined and gradual

Lens/Cataracts Overview

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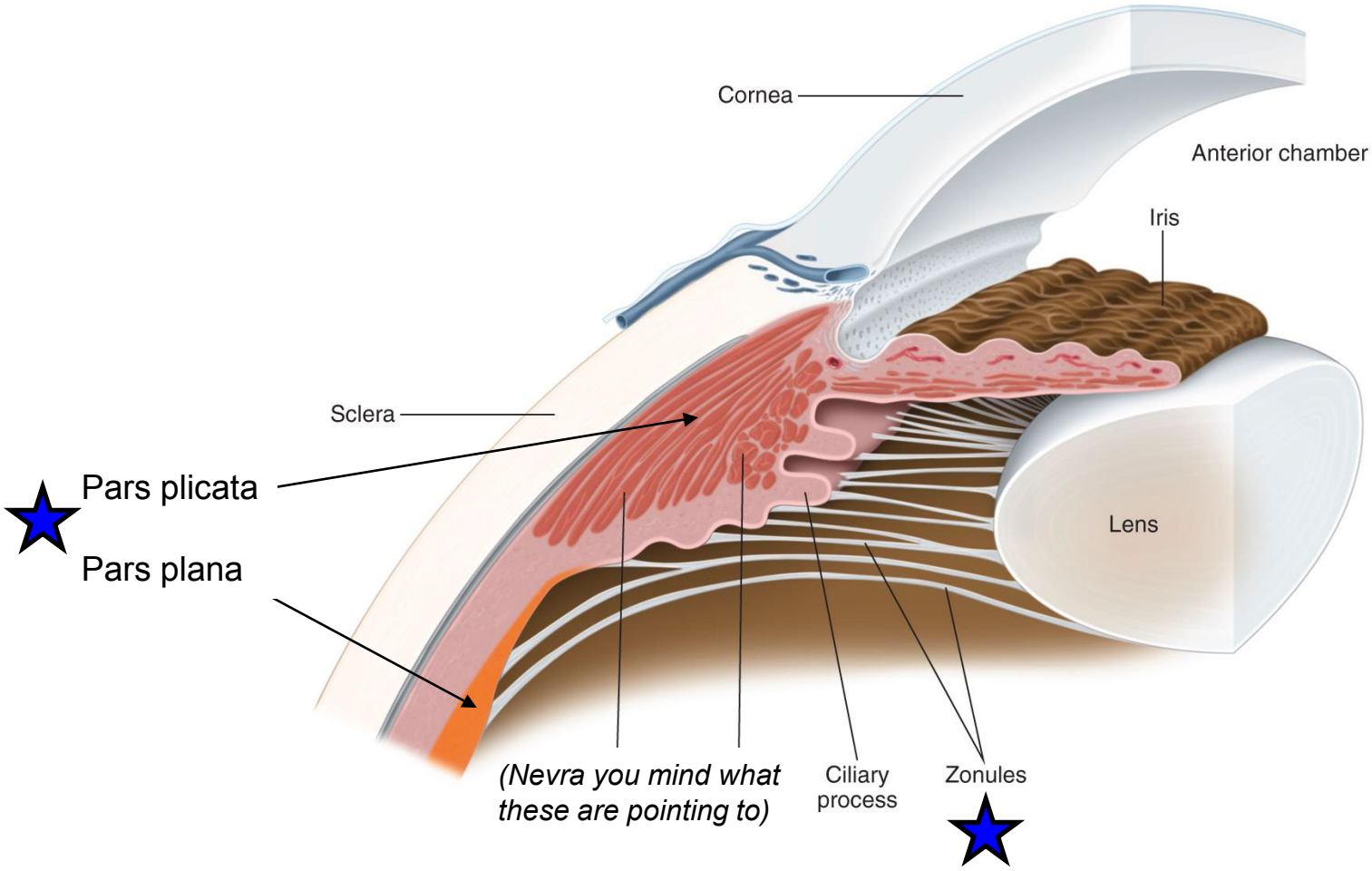
  - *Cortex*
    - Newer fibers between nucleus and capsule/epithelium
  - ***Zonules***
    - Originate from the basal lamina of the nonpigmented epithelium of the pars plana and pars plicata of the ciliary body

The **zonules** support the lens, and transmit to it the forces that produce accommodation. (Their origins are as described above.)

Lens/Cataracts Overview



Zonular origins

Lens/Cataracts Overview

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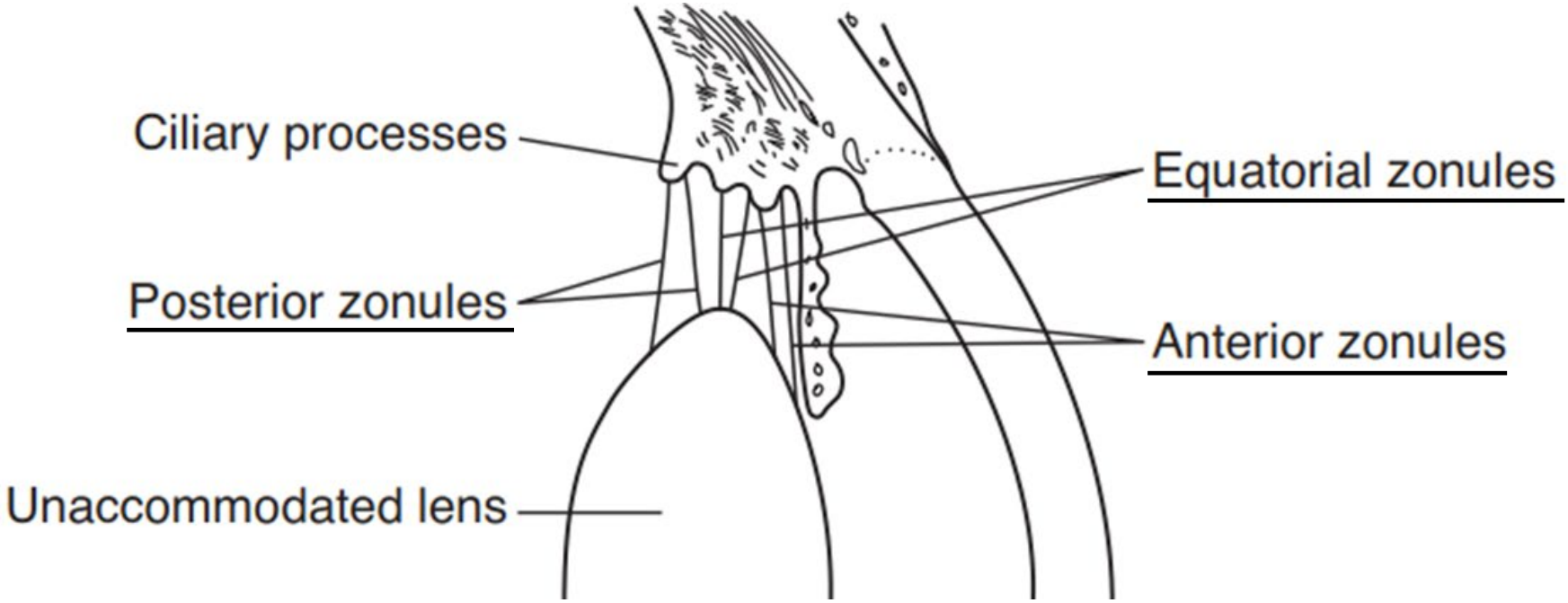
    - Originate from the basal lamina of the nonpigmented epithelium of the pars plana and pars plicata
    - Three sets of fibers:
      - Anterior
      - Equatorial
      - Posterior

Based on their site of insertion, there are three sets of fibers: Anterior, equatorial, and posterior.

Lens/Cataracts Overview



Zonular insertions on the lens

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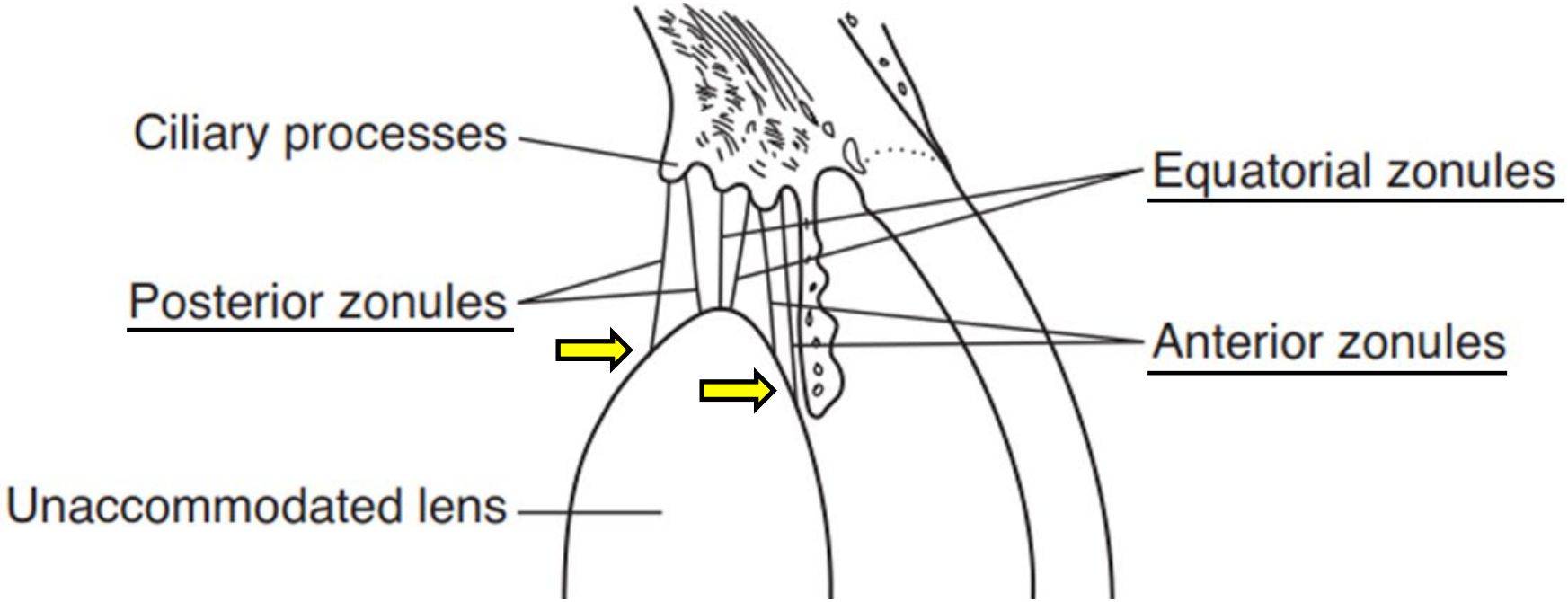
    - Originate from the basal lamina of the nonpigmented epithelium of the pars plana and pars plicata
    - Three sets of fibers:
      - *Anterior:* Insert *more* centrally
      - *Equatorial*
      - *Posterior:* Insert *less* centrally

Based on their site of insertion, there are three sets of fibers: Anterior, equatorial, and posterior. The equatorial fibers regress, leaving only the anterior and posterior sets. The anterior fibers extend farther (ie, insert more centrally) than do the posterior ones.

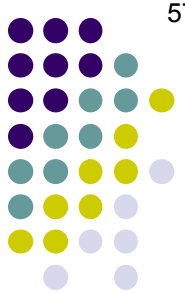
Lens/Cataracts Overview



Zonular insertions on the lens

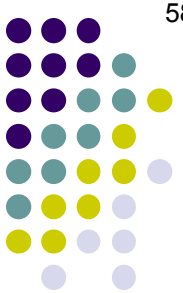
(Note the relative locations of the insertions of the anterior vs posterior zonules—the anterior insert more centrally than do the posterior)

Lens/Cataracts Overview



- Lens measurements
  - Birth: 6.4 mm equatorial, 3.5 mm anteroposterior
  - Adult: 9-10 mm equatorial, 5.0 mm anteroposterior

Lens/Cataracts Overview



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Probably good enough to ballpark the lens as 6x3 mm at birth and 10x5 mm late in life. (Note that the diameter and depth maintain about a 2:1 relationship.) As the lens never stops creating new fibers, it never stops growing.

Lens/Cataracts Overview

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- With age…
  - Lens curvature increases → ↑ refractive power
  - Refractive index decreases → ↓ refractive power

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The *Lens* book is confusing re what happens to the refractive index and refractive status of eyes as we age. The above is straight from Chapter 2. However, in Chapter 5 it states that NSCs "cause an **increase** in the refractive index" (emphasis mine) and a "myopic shift." (It goes on to say hyperopic shifts are "rare.") What makes this confusing is that NSCs are very much age-related. Caveat emptor on this score.

Lens/Cataracts Overview

Let's drill down on the highly OKAPable topic of Lens Proteins

Lens/Cataracts Overview

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Lens Proteins constitute about 1/3 of the lens (by weight).

No other tissue in the body comes close to this—it's *2-3x* the protein content of most of them!

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Water Soluble *aka…* **Crystallins**

Water Insoluble

Lens proteins come in one of two basic types: Water-soluble (aka the *crystallins*), and water-**in**soluble.

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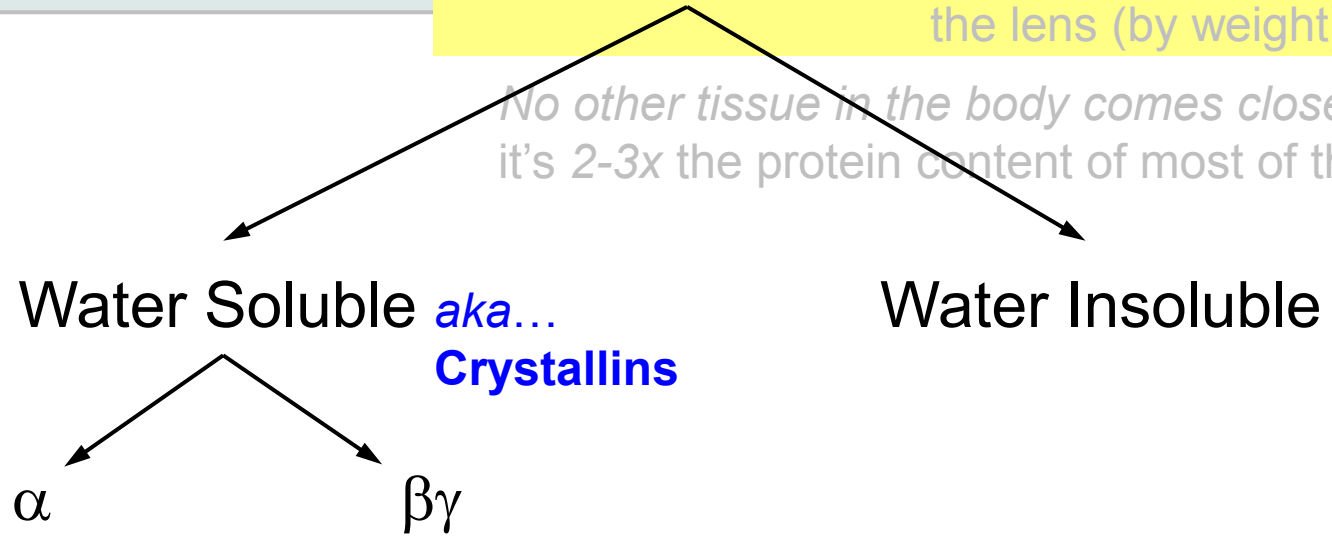

Lens proteins come in one of two basic types: Water-soluble (aka the *crystallins*), and water-**in**soluble. The crystallins come in three types, but two of them (β and γ) are grouped together, and stand apart from the other (α).

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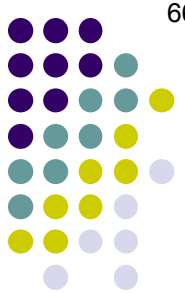
Lens/Cataracts Overview



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No other tissue in the body comes close to this— it's *2-3x* the protein content of most of them!

Next we will look at the development/embryology of the lens

Crystallins

α βγ

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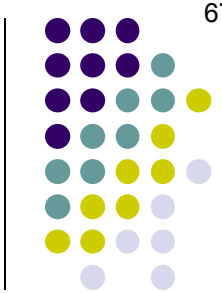
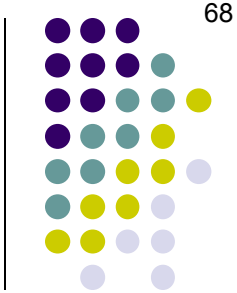


The *lens* originates as a thickening of surface ectoderm overlying the *optic* (not lens!) *vesicle*, an outpouching of the primitive forebrain destined to become the neurosensory retina, RPE, and ciliary body epithelium (among other things).

Lens/Cataracts Overview



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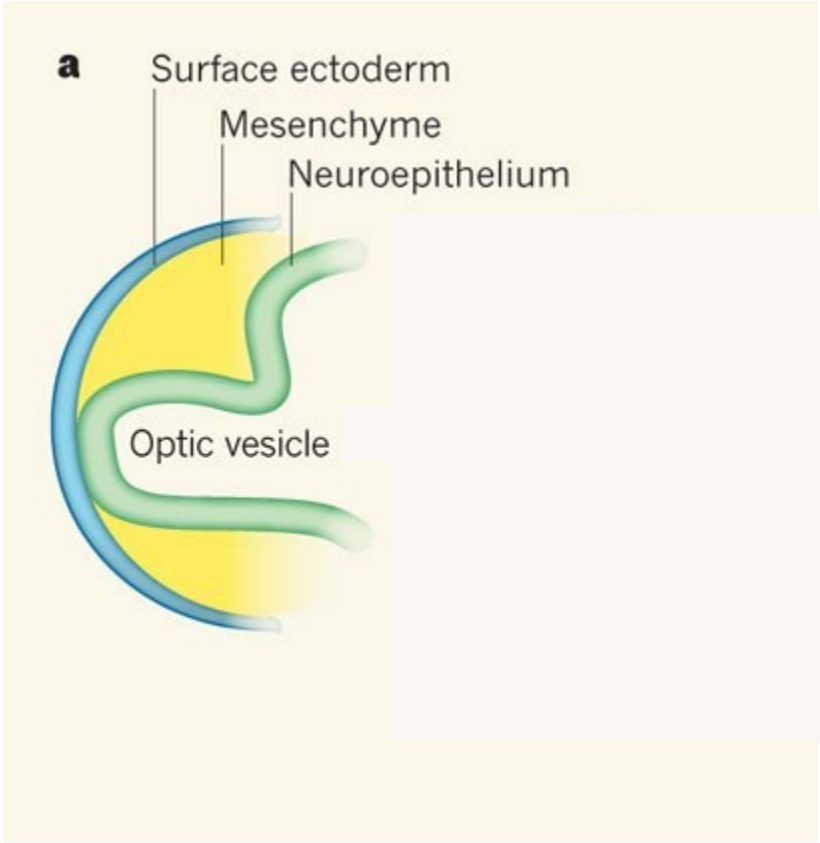
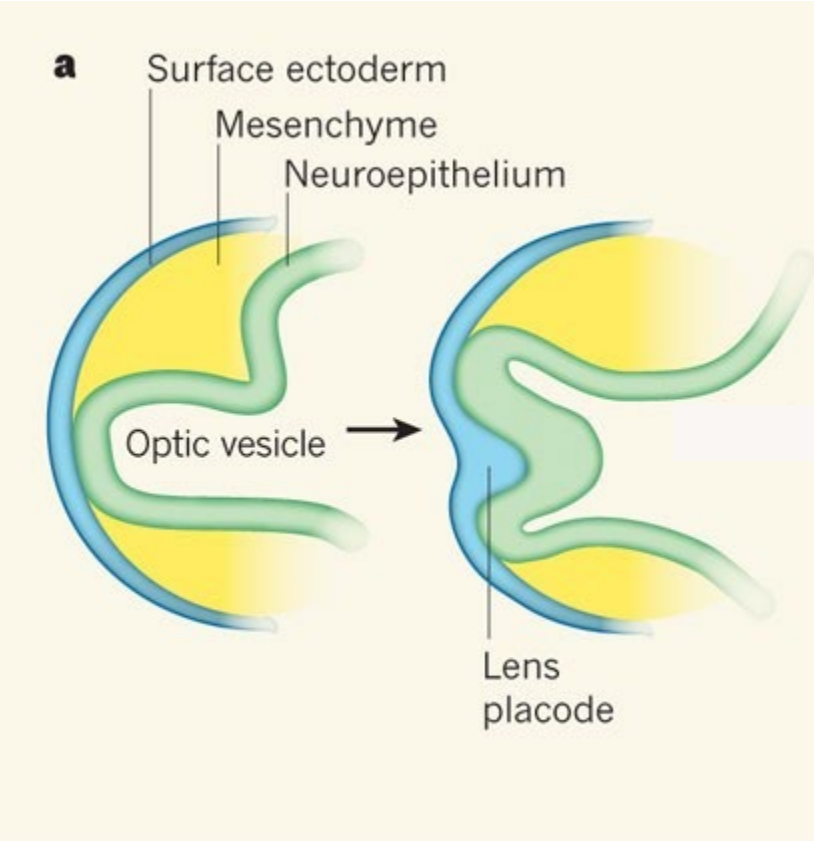
Lens/Cataracts Overview



Re surface ectoderm and lens formation:

(Glance at this, then keep going to see the points being made)

Lens/Cataracts Overview



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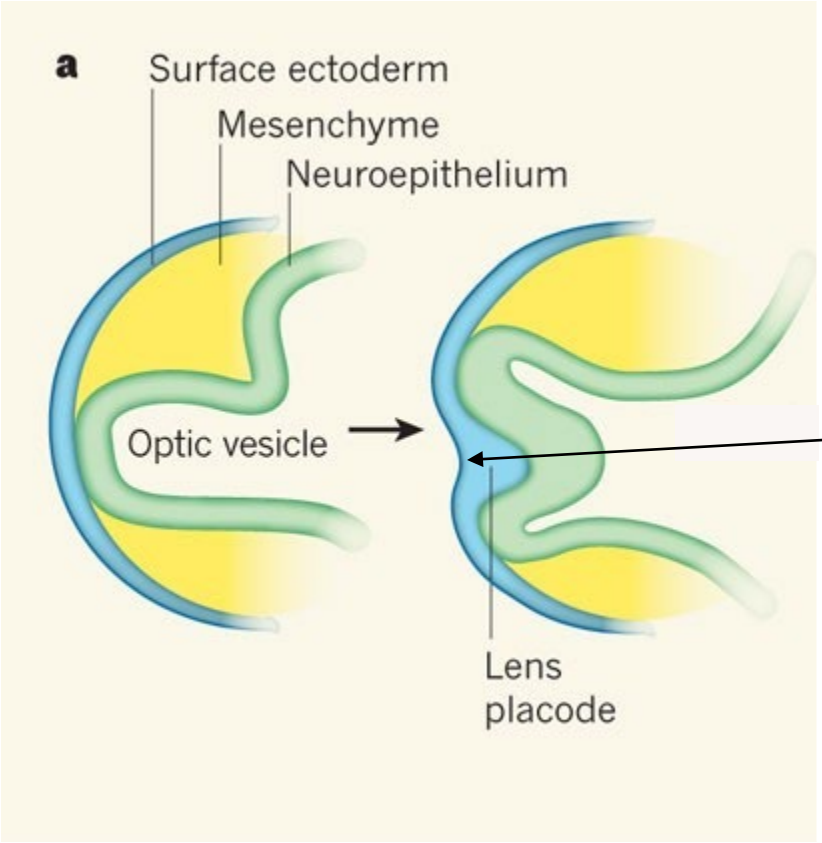
--A portion of surface ectoderm thickens to form the lens placode

Lens/Cataracts Overview



Note the presence of an indentation in the lens placode; this is called the lens **pit**

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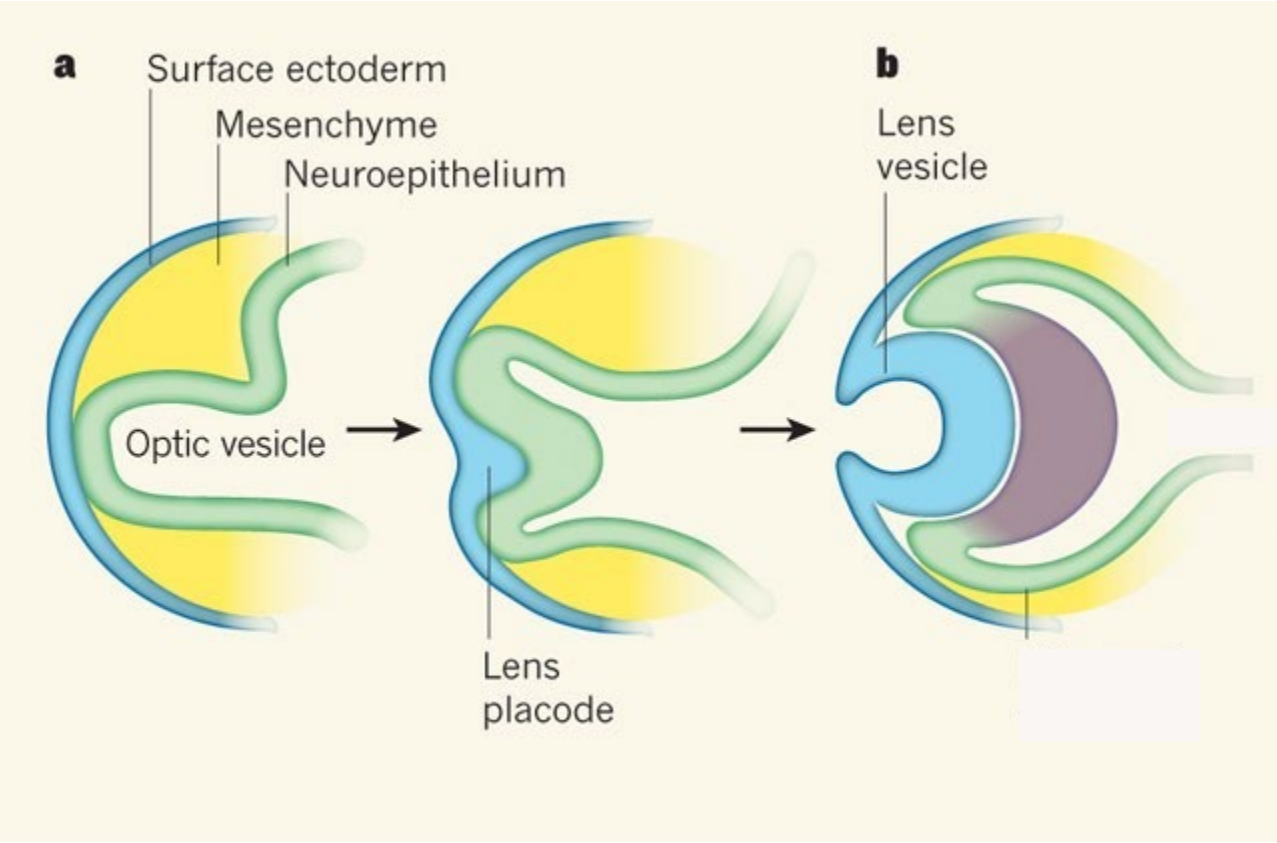
Lens/Cataracts Overview



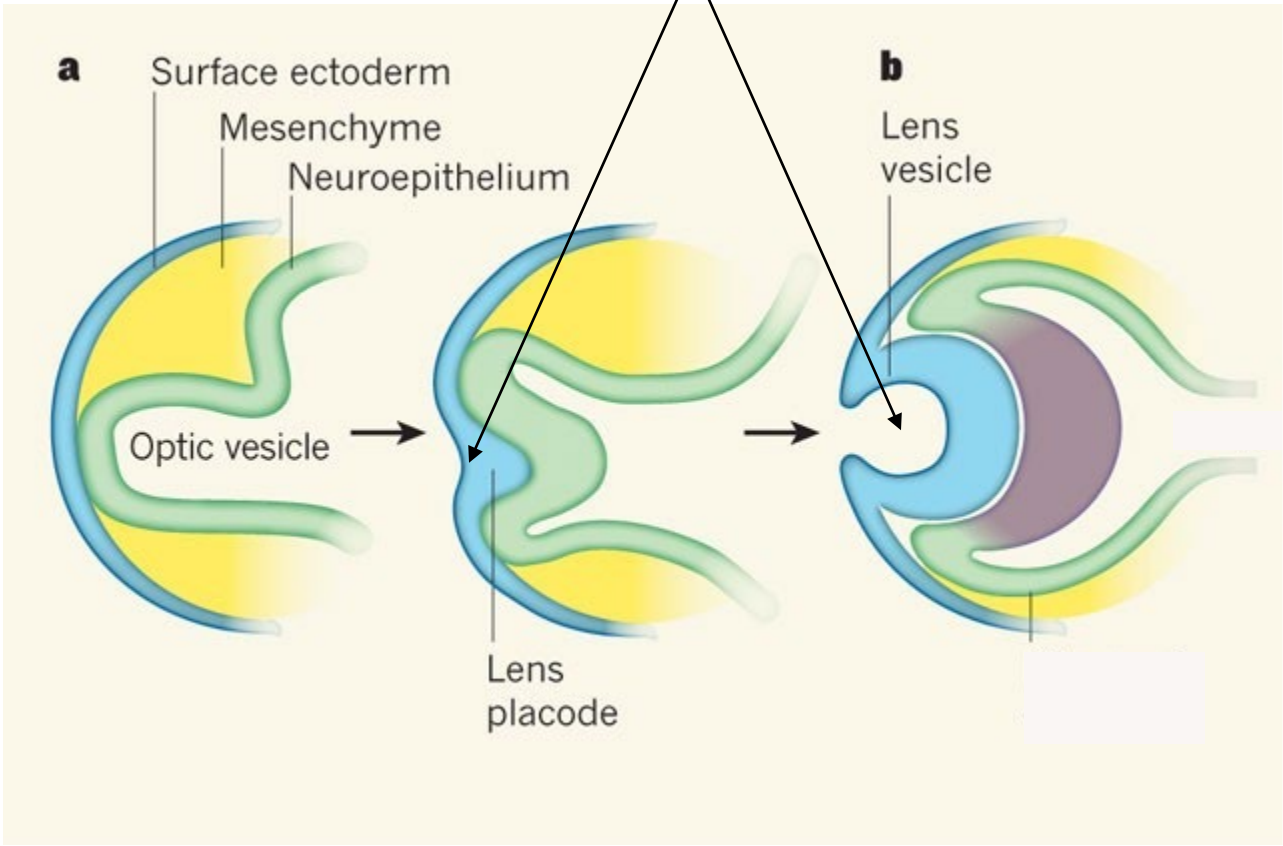
Re surface ectoderm and lens formation:

--A portion of surface ectoderm thickens to form the lens placode

--The placode invaginates to form the lens vesicle

Lens/Cataracts Overview

(Note that the invagination process consists of a progressive deepening of the lens pit)



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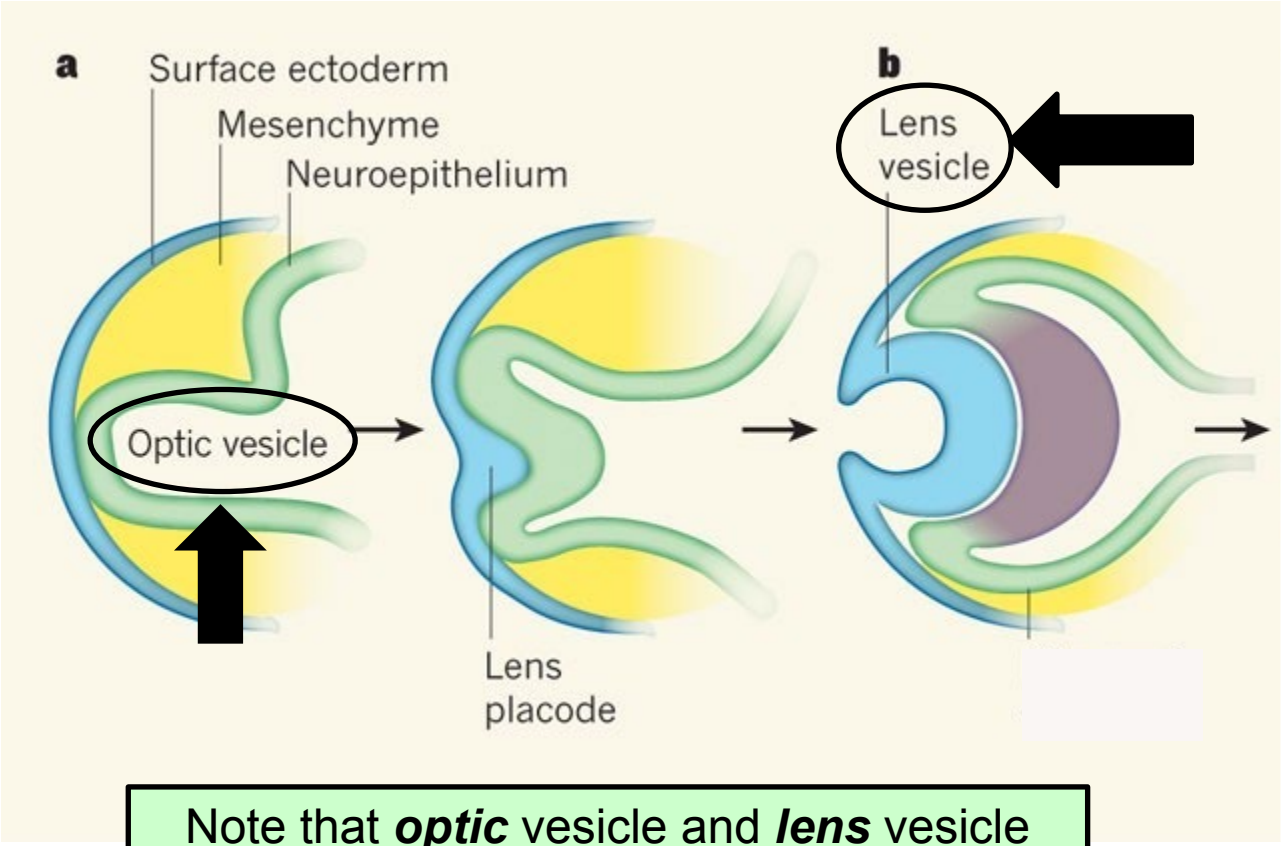

Note that ***optic*** vesicle and ***lens*** vesicle are different structures—don't mix them up!

Re s

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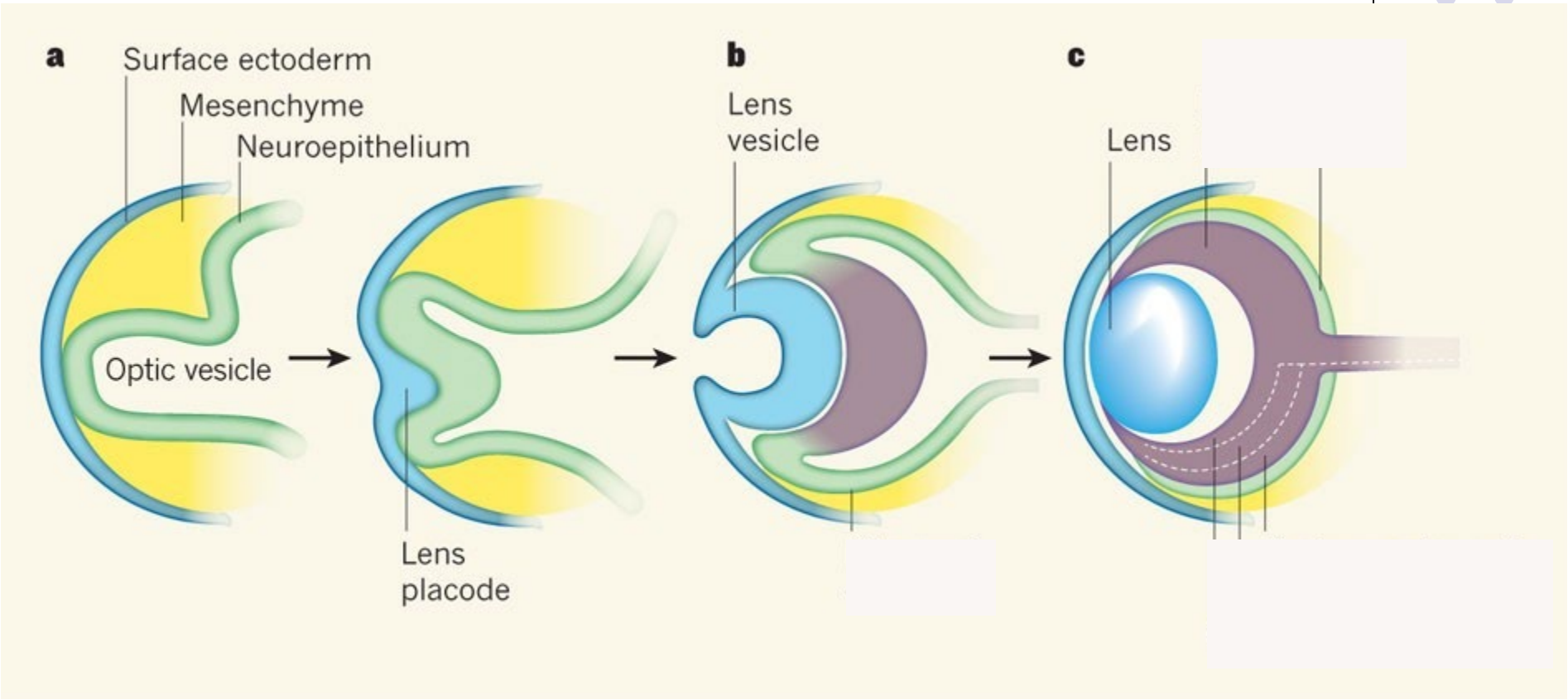
Lens/Cataracts Overview



Re surface ectoderm and lens formation:

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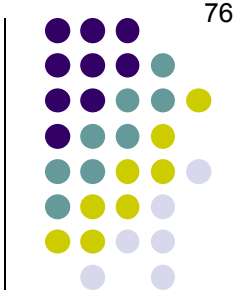
--The placode invaginates to form the lens vesicle

--The lens vesicle goes on to form (eventually; there are intervening steps) the mature lens.

Lens/Cataracts Overview



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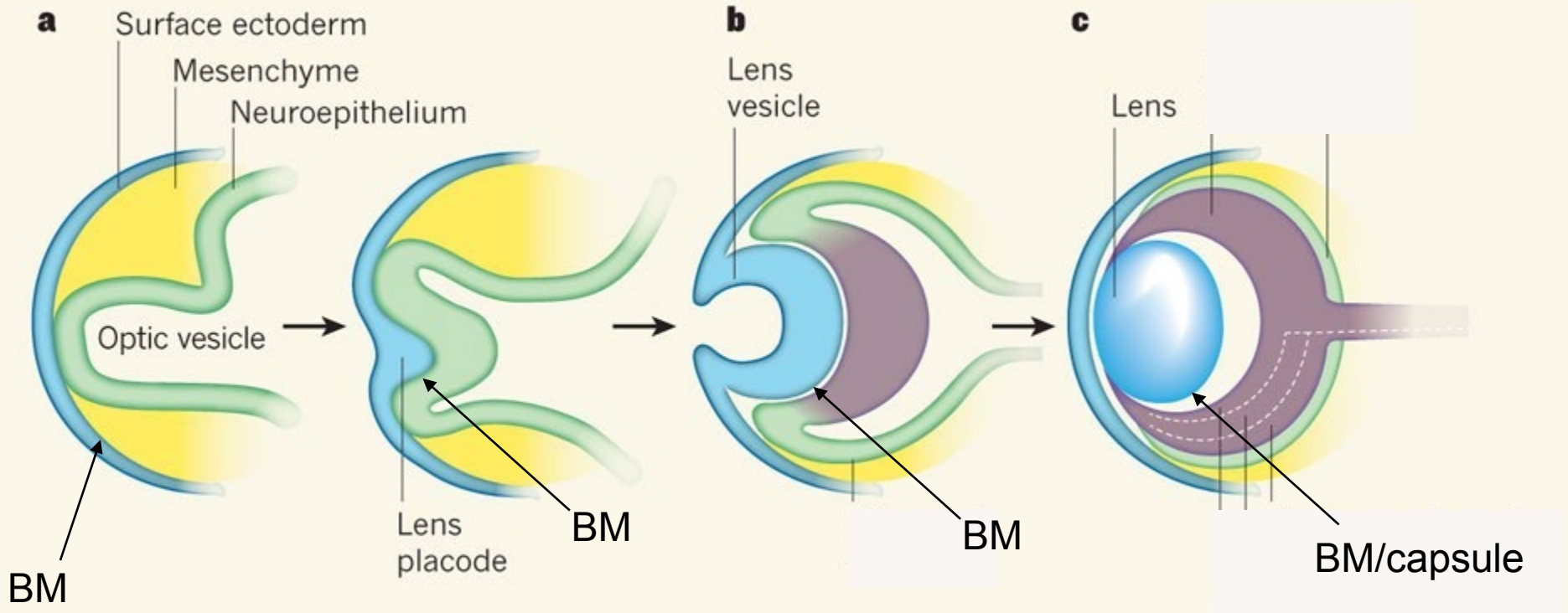
Lens/Cataracts Overview



The invagination process leads to the weird result of a structure (the lens) that has its epithelium on its *inside* and its basement membrane on its *outside*.

Re s

--A p

--The placode invaginates to form the lens vesicle

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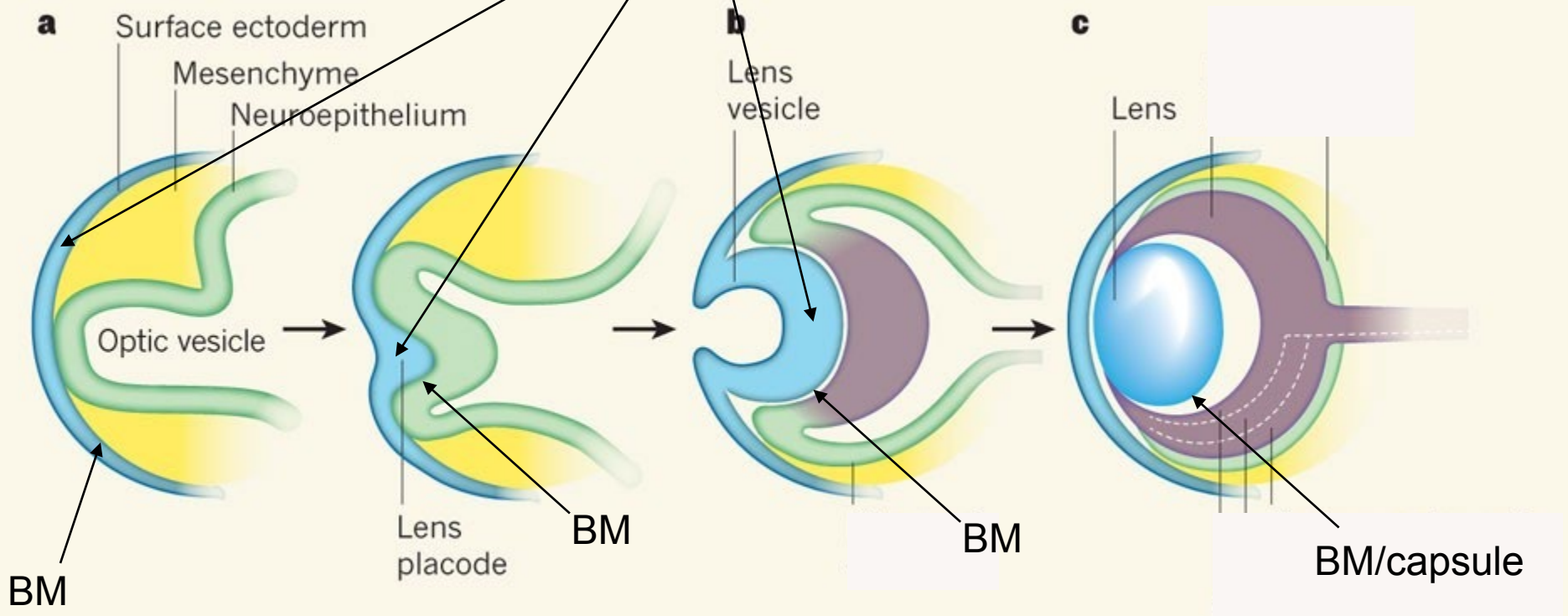
Lens/Cataracts Overview

It also explains how surface ectodermal cells…



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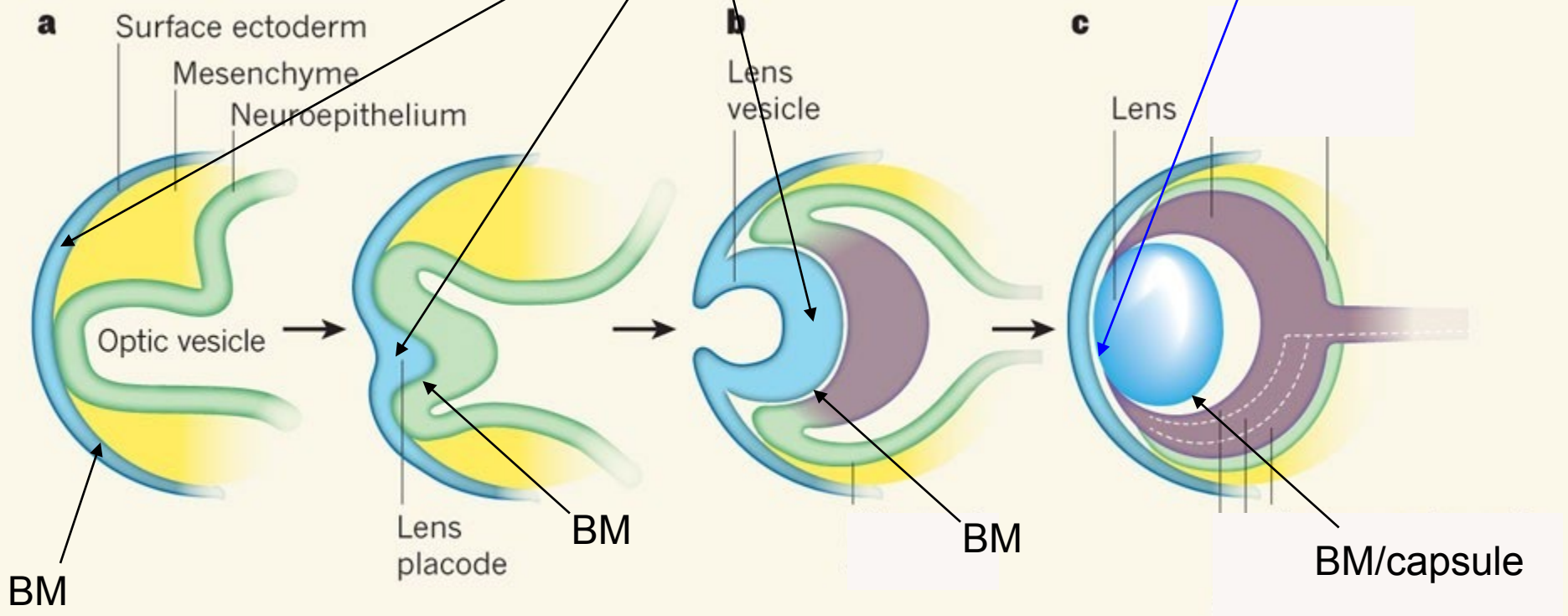
Lens/Cataracts Overview

It also explains how surface ectodermal cells…become lens epithelial cells.



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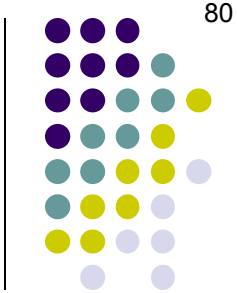
Lens/Cataracts Overview



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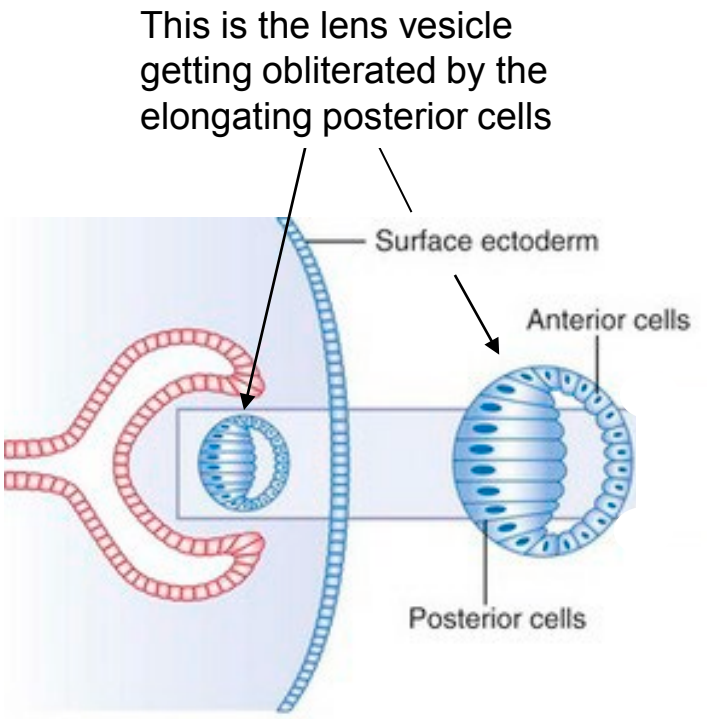
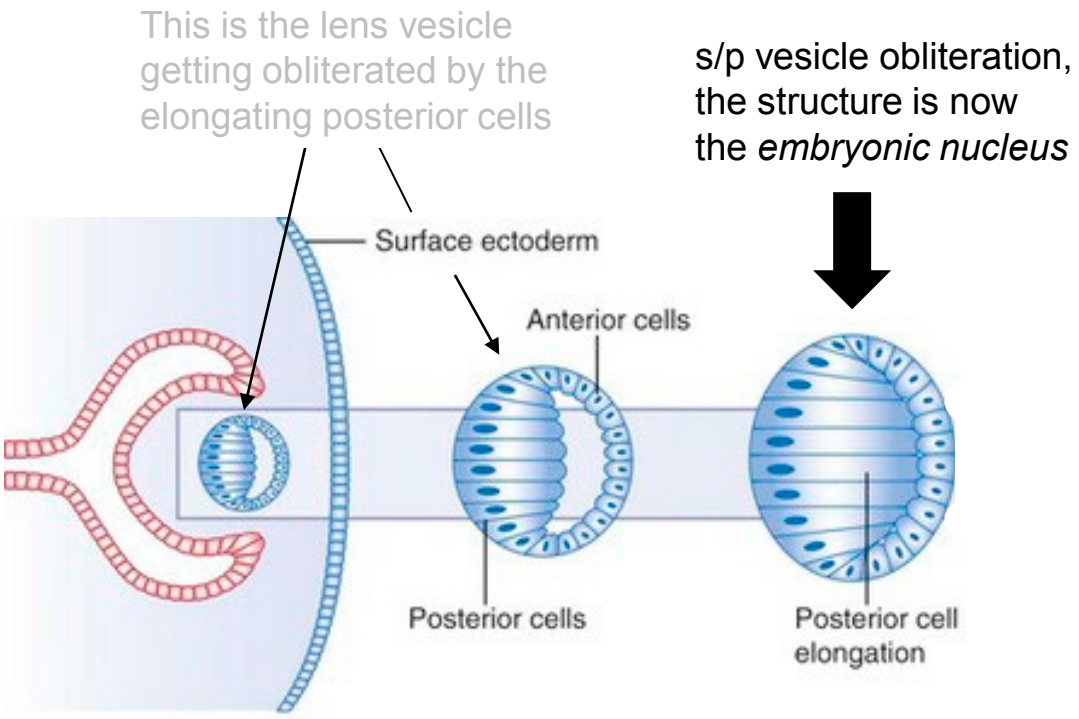
Lens/Cataracts Overview



Posterior cells of the lens vesicle elongate to obliterate the vesicle's lumen, thus creating the embryonic nucleus

Lens/Cataracts Overview

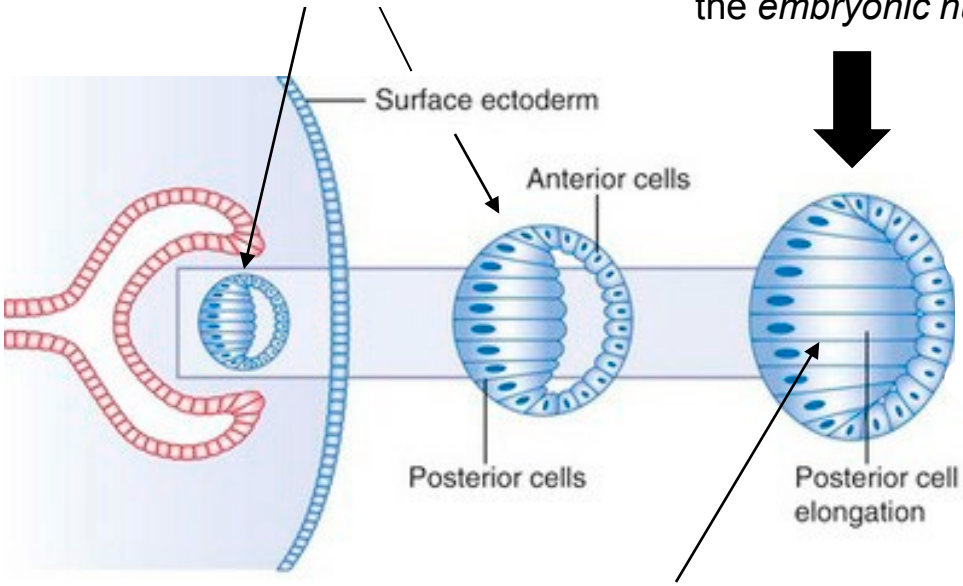


Posterior cells of the lens vesicle elongate to obliterate the vesicle's lumen, thus creating the embryonic nucleus

Lens/Cataracts Overview

This is the lens vesicle getting obliterated by the elongating posterior cells

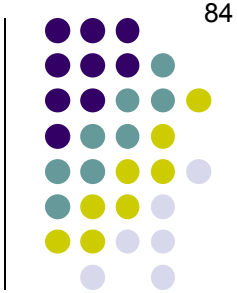
s/p vesicle obliteration, the structure is now the *embryonic nucleus*



As they elongate, these cells lose their organelles and thereby transform into 'fibers.'

Posterior cells of the lens vesicle elongate to obliterate the vesicle's lumen, thus creating the embryonic nucleus

Lens/Cataracts Overview



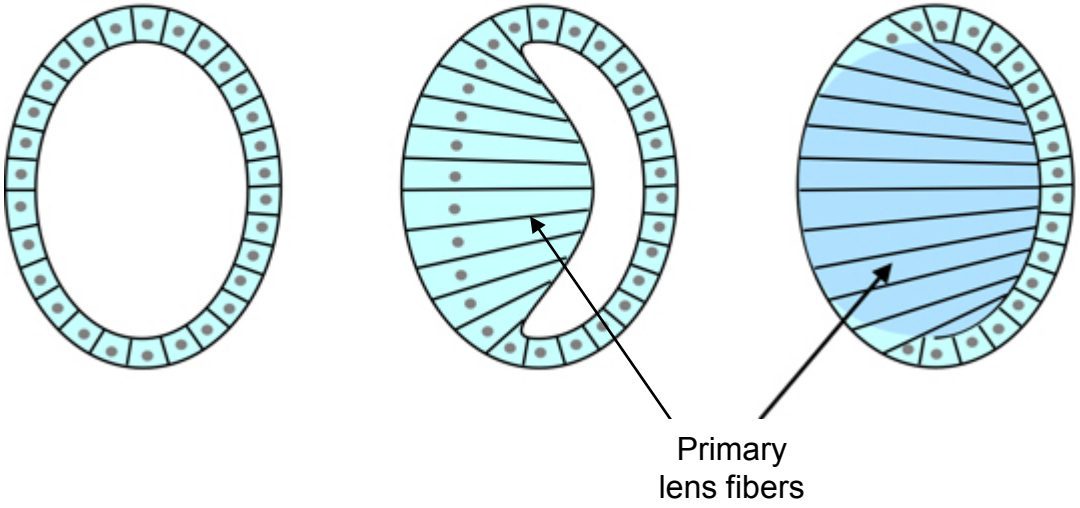
The *lens* originates as a thickening of surface ectoderm overlying the *optic* (not lens!) *vesicle*, an outpouching of the primitive forebrain destined to become the neurosensory retina, RPE, and ciliary body epithelium (among other things). This thickened area of surface ectoderm is called the *lens placode*. The placode subsequently invaginates (at the *lens pit*), eventually forming a fluid-filled sphere containing a single layer of cells; this sphere is the *lens* (not optic!) *vesicle*. The outer wall of the lens vesicle consists of the basement membrane of the surface ectoderm cells that line the *inner* aspect of the vesicle; these cells will become the *lens epithelium*, and their BM will form the *lens capsule*. The cells at the posterior aspect of the vesicle elongate to obliterate the vesicle's lumen and transform into the lens fibers that comprise the *embryonic nucleus*.

Soon thereafter, equatorial epithelial cells elongate both anteriorly and posteriorly; as they encounter one another at the anterior and posterior poles, they interdigitate in a manner that creates the *Y sutures*. The fibers formed by this 'second wave' comprise the *fetal nucleus*.

Lens/Cataracts Overview

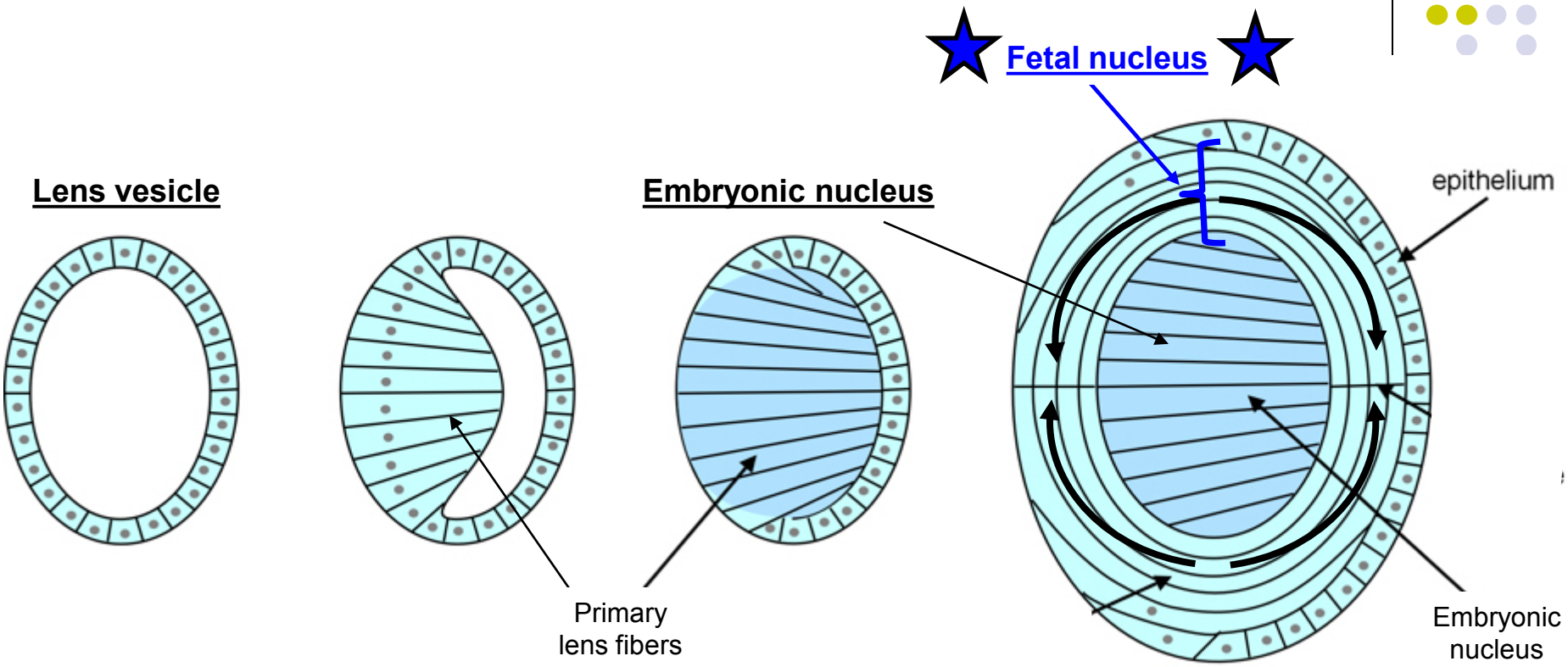
Lens vesicle

Embryonic nucleus



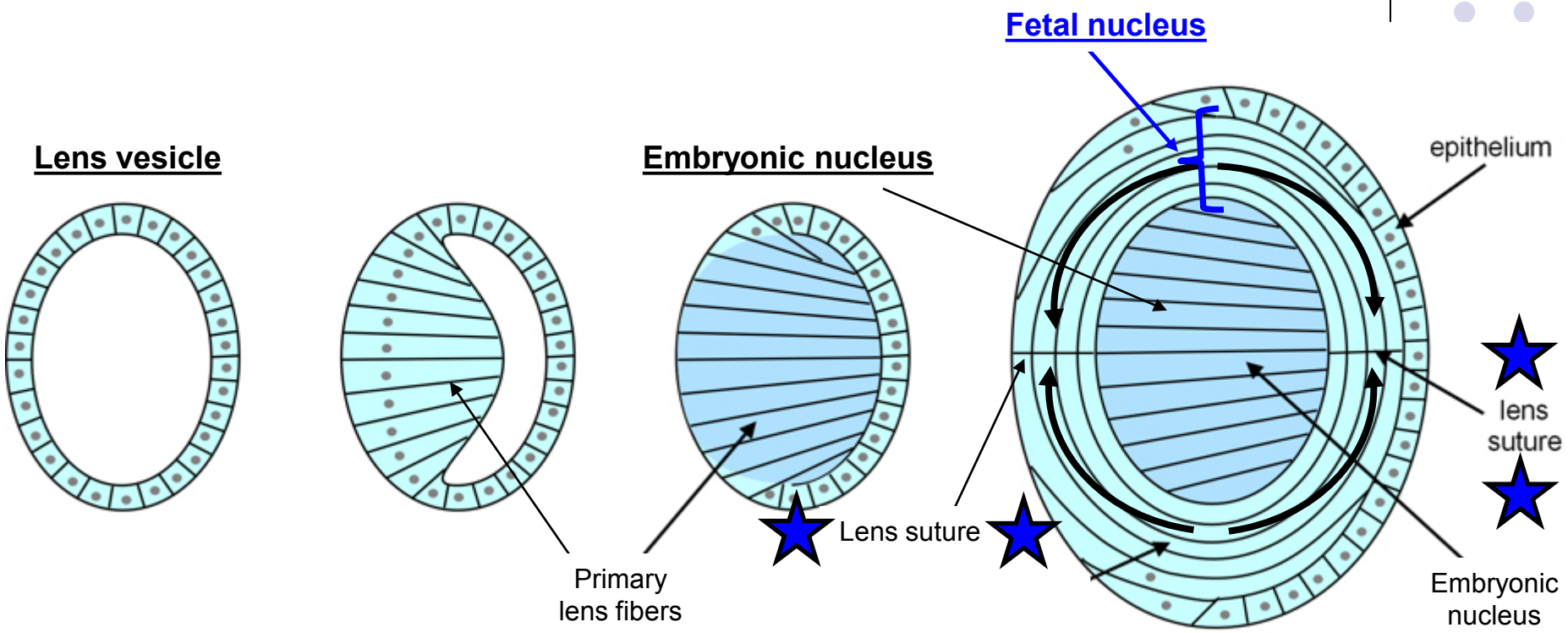
As we've seen, the **embryonic nucleus** is formed when the elongating posterior lens fibers obliterate the vesicle.

Lens/Cataracts Overview



As we've seen, the **embryonic nucleus** is formed when the elongating posterior lens fibers obliterate the vesicle. The **fetal nucleus** is formed by the **equatorial** epithelial cells as they elongate both anteriorly (insinuating themselves between the anterior epithelial cells and the lens fibers of the embryonic nucleus) and posteriorly (insinuating themselves between the originations of the embryonic lens fibers and the underlying capsule).

Lens/Cataracts Overview



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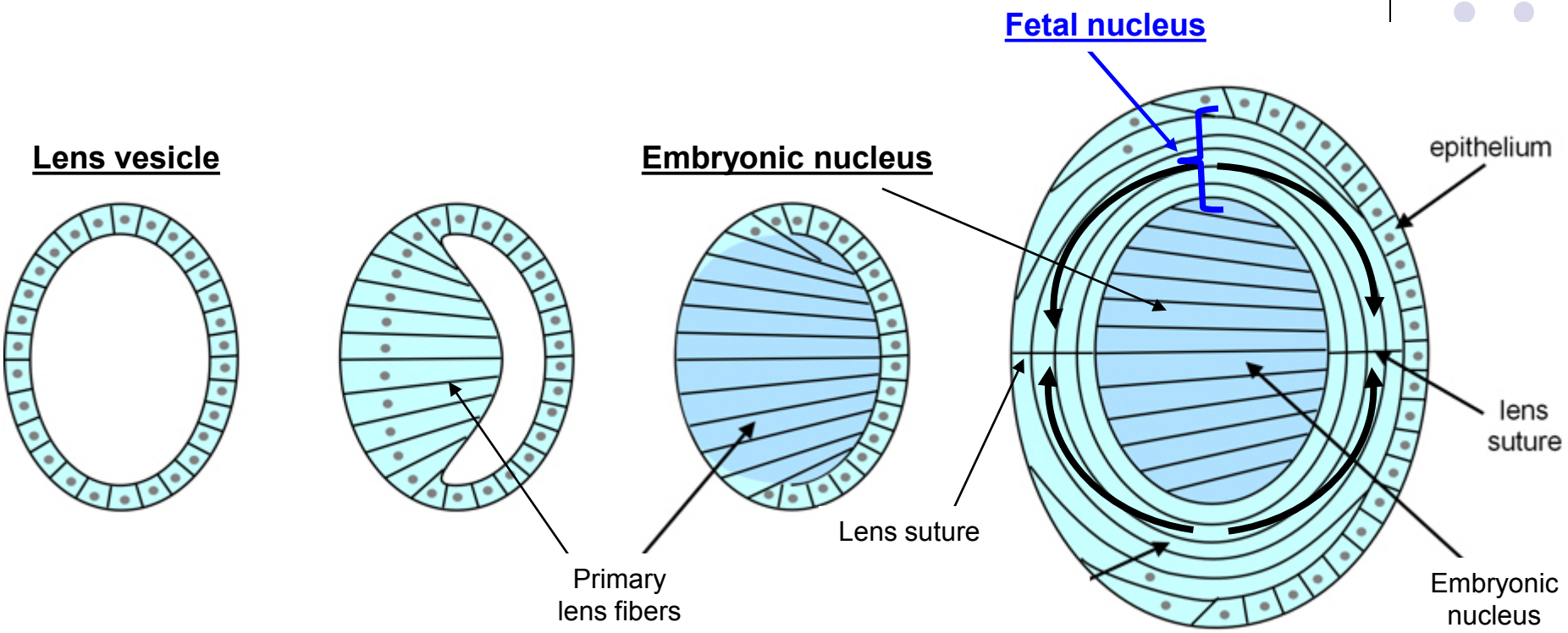
To be clear: The fetal nucleus is **not** this entire structure; rather, it is only the portion formed by the secondary lens fibers, as indicated by the { .



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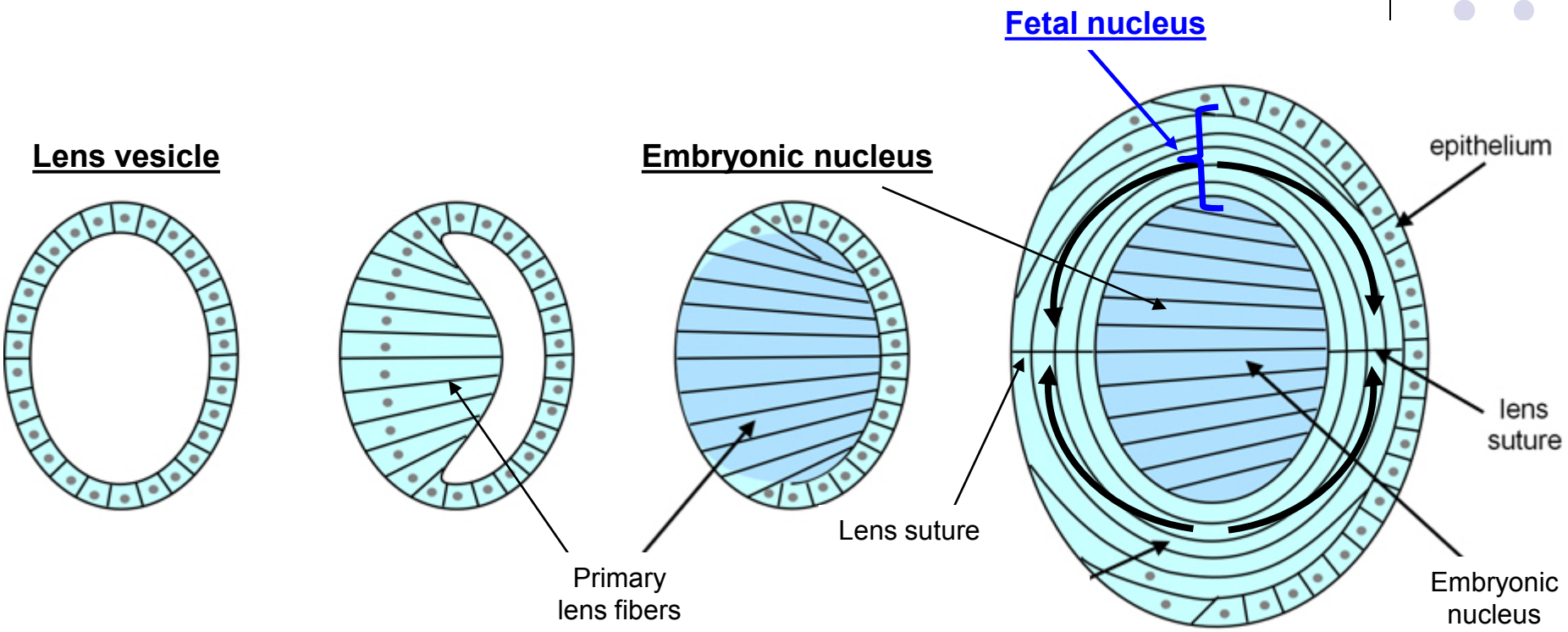
Put another way: The fetal nucleus *surrounds* the embryonic nucleus.



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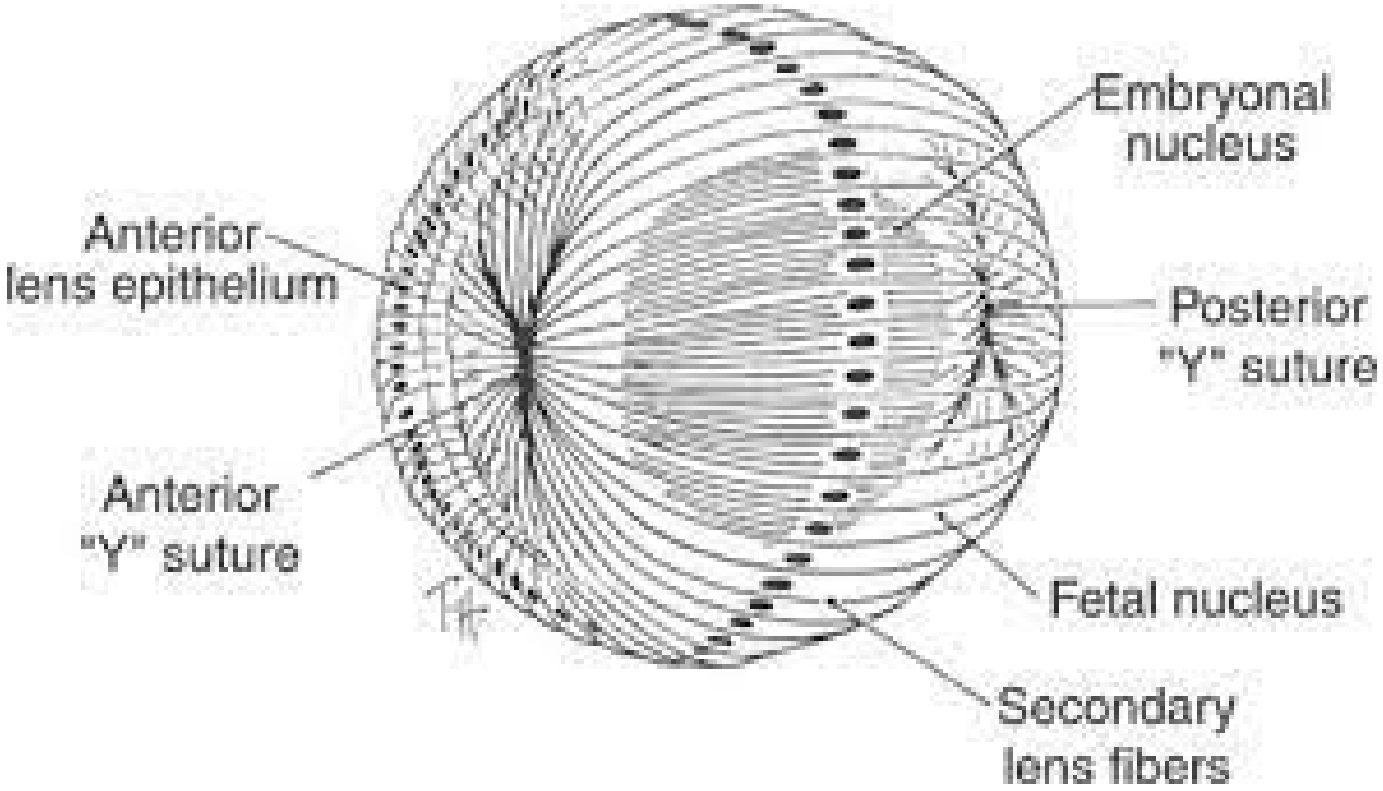
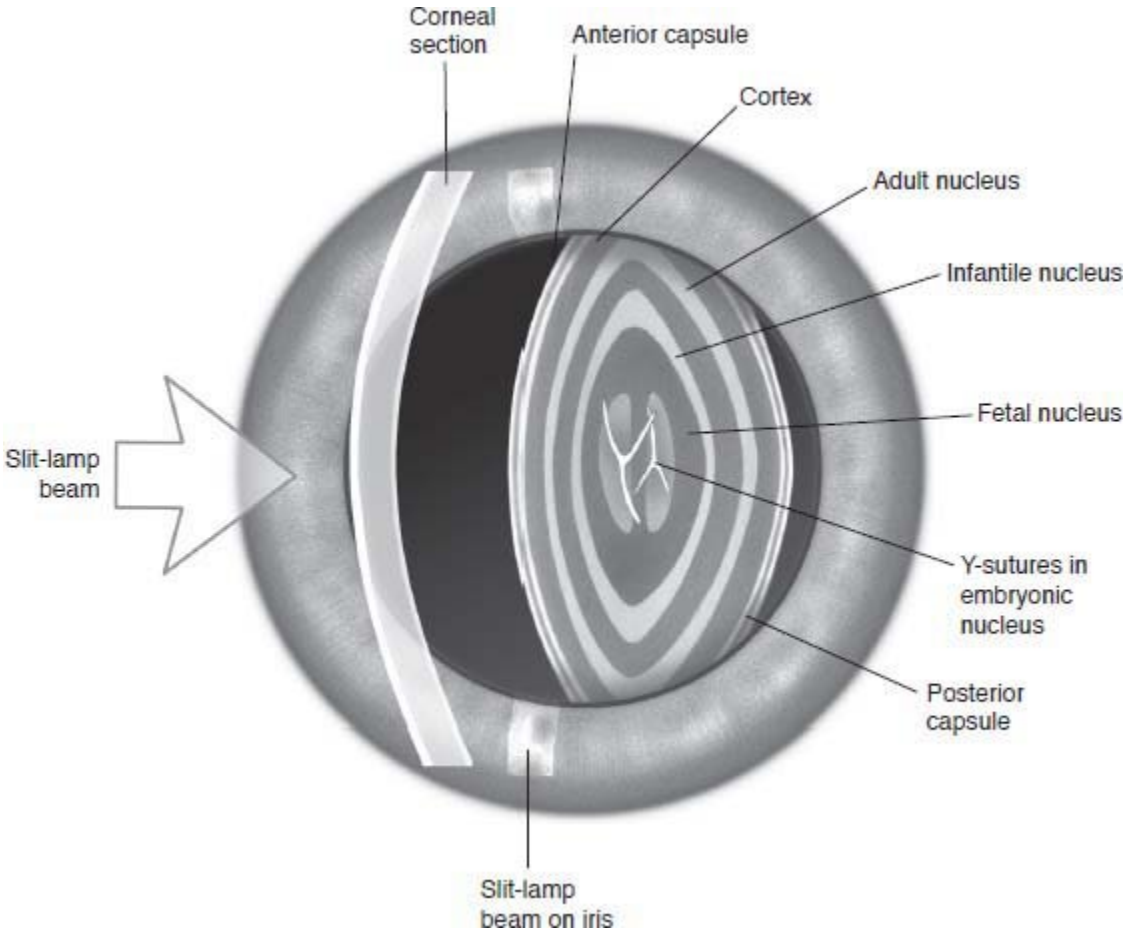
Lens/Cataracts Overview



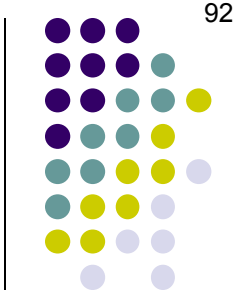
Lens: *Y* suture formation

Lens/Cataracts Overview



Y sutures as they might be seen at the slit lamp

Lens/Cataracts Overview



Now let's look at the **fetal vasculature** *of the lens*

Lens/Cataracts Overview

- The vascular supply encapsulating the developing lens is called the tunica vasculosa lentis.

Lens/Cataracts Overview

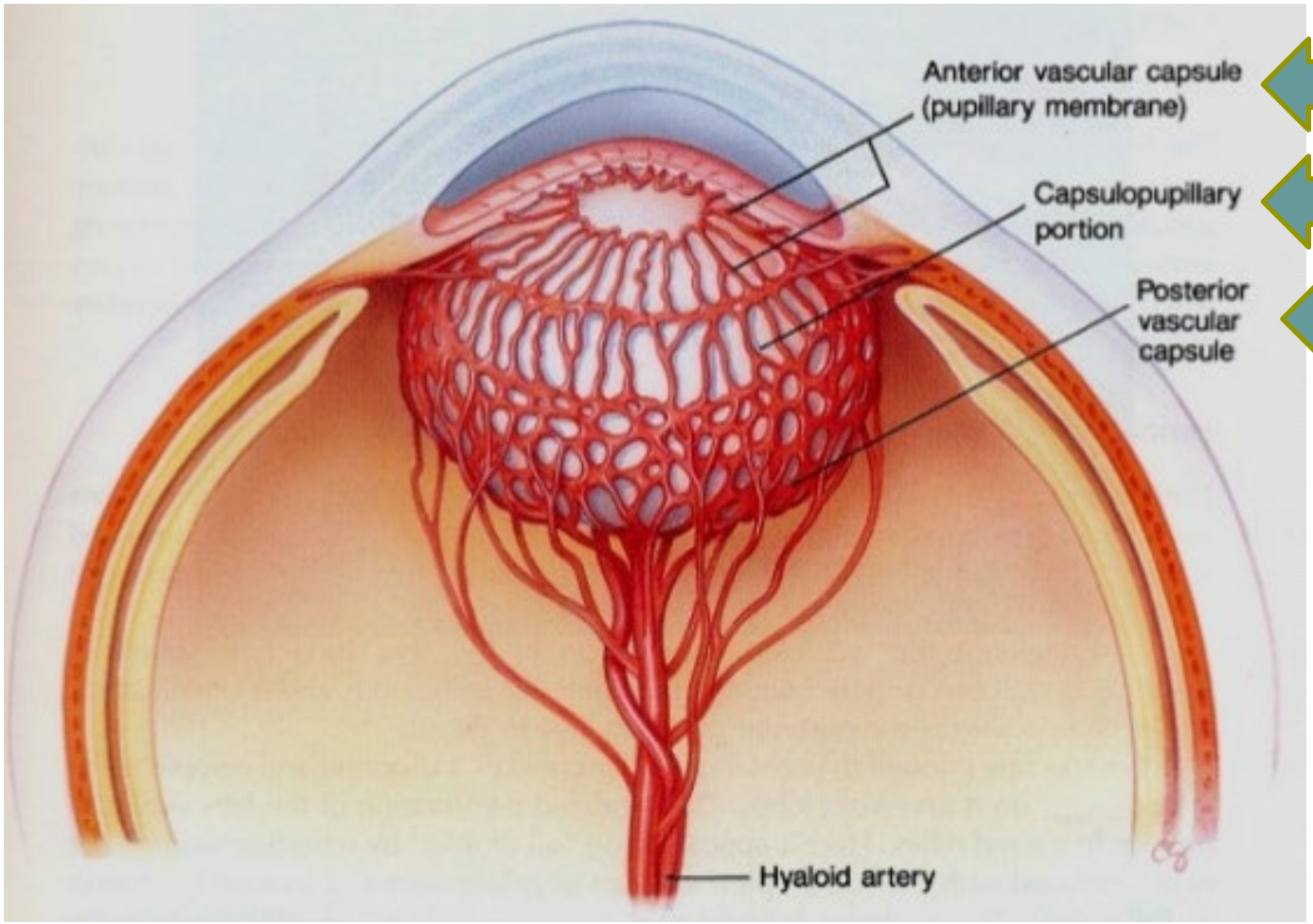
- The vascular supply encapsulating the developing lens is called the tunica vasculosa lentis.
  It has three sections:

  1) The *posterior vascular capsule*

  2) The *anterior vascular capsule*

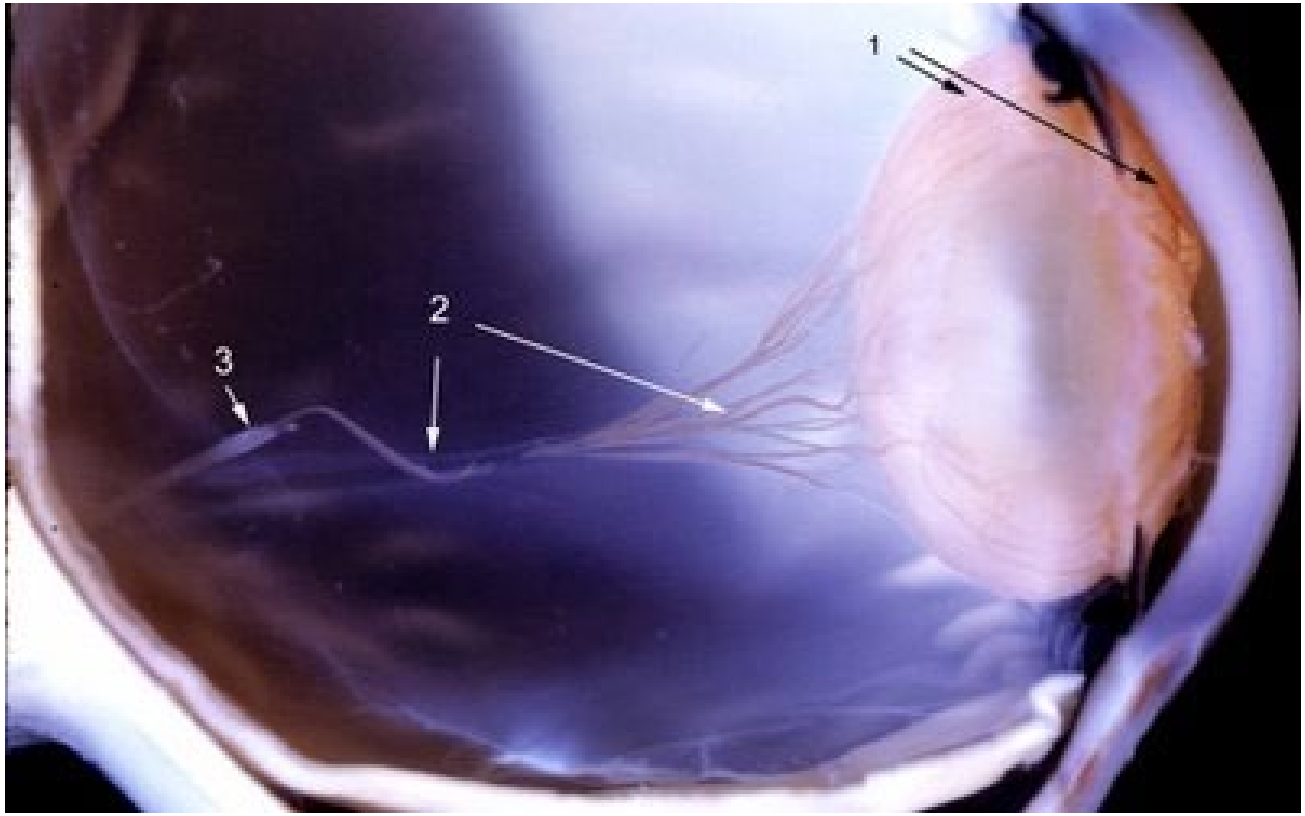
  3) The *capsulopupillary portion*

Lens/Cataracts Overview



Tunica vasculosa lentis

Lens/Cataracts Overview



In the eye of this very premature infant, the **tunica vasculosa lentis** surrounds the lens (arrows 1).

(We'll get to Arrows 2 and 3 shortly)

Lens/Cataracts Overview

- The vascular supply encapsulating the developing lens is called the tunica vasculosa lentis.
  It has three sections:

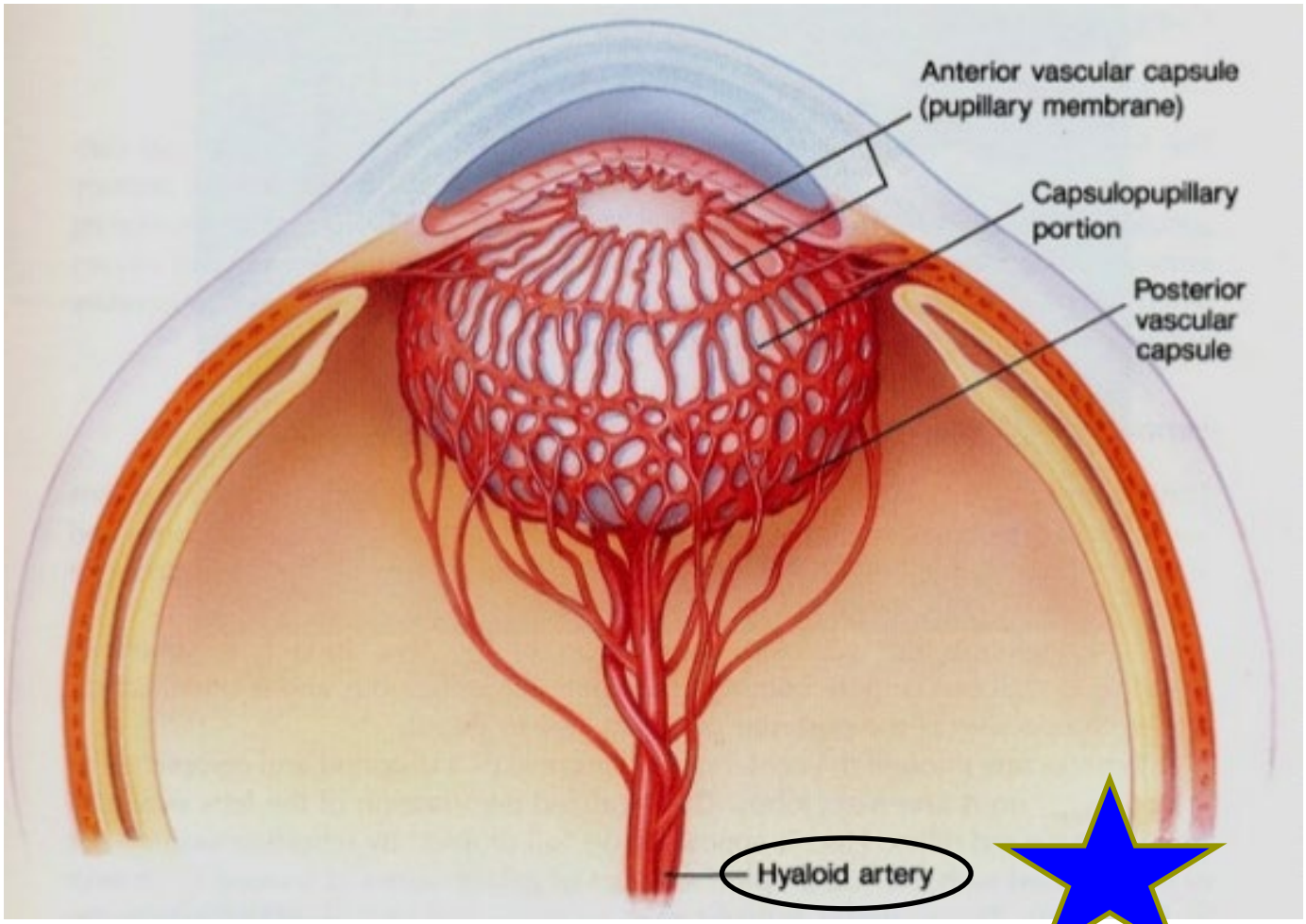
  1) The *posterior vascular capsule* arises from the hyaloid artery

  2) The *anterior vascul*

  3) The *capsulopupillary portion*

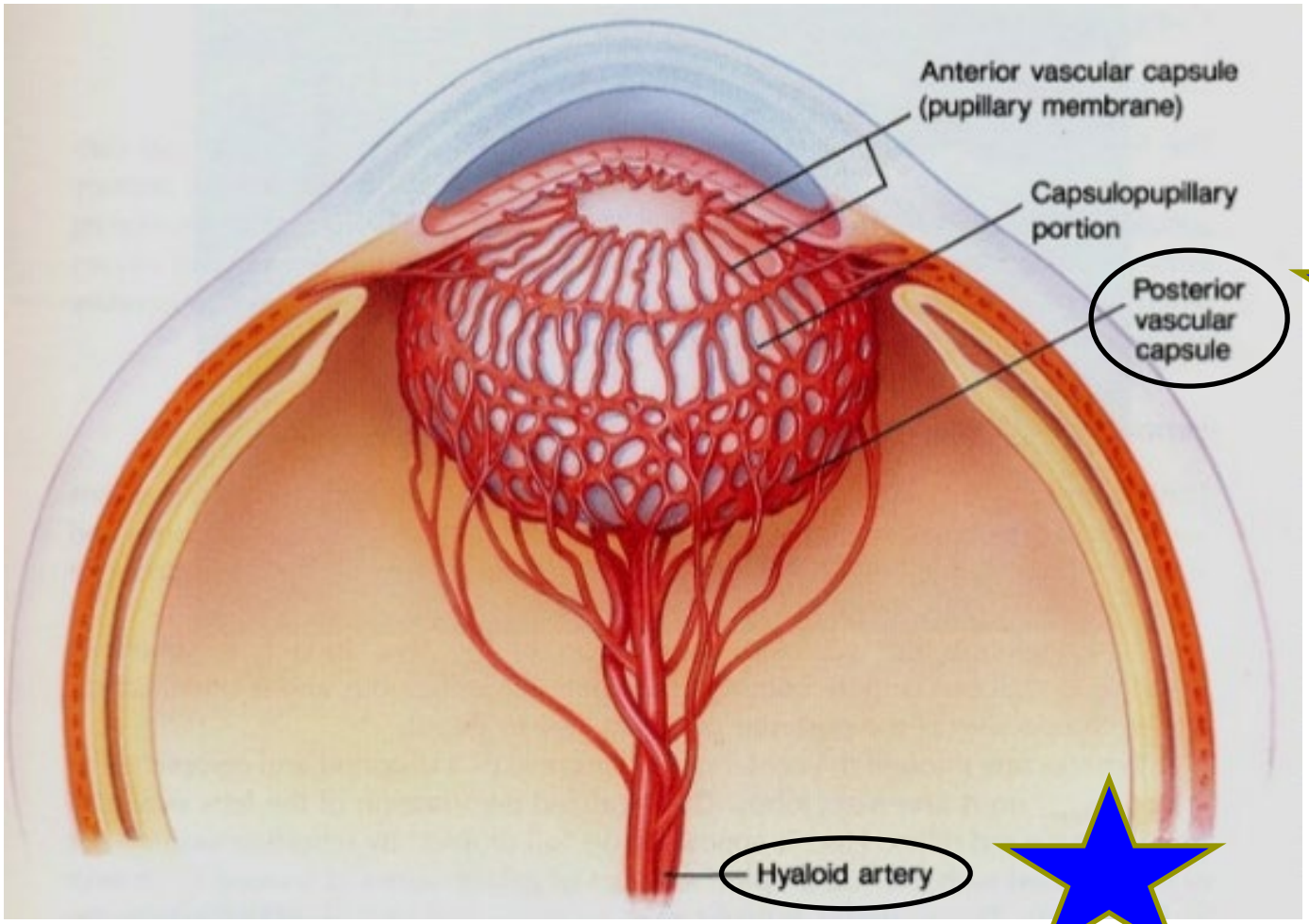
The **hyaloid artery** runs from the optic nerve head to the back of the fetal lens.

Lens/Cataracts Overview



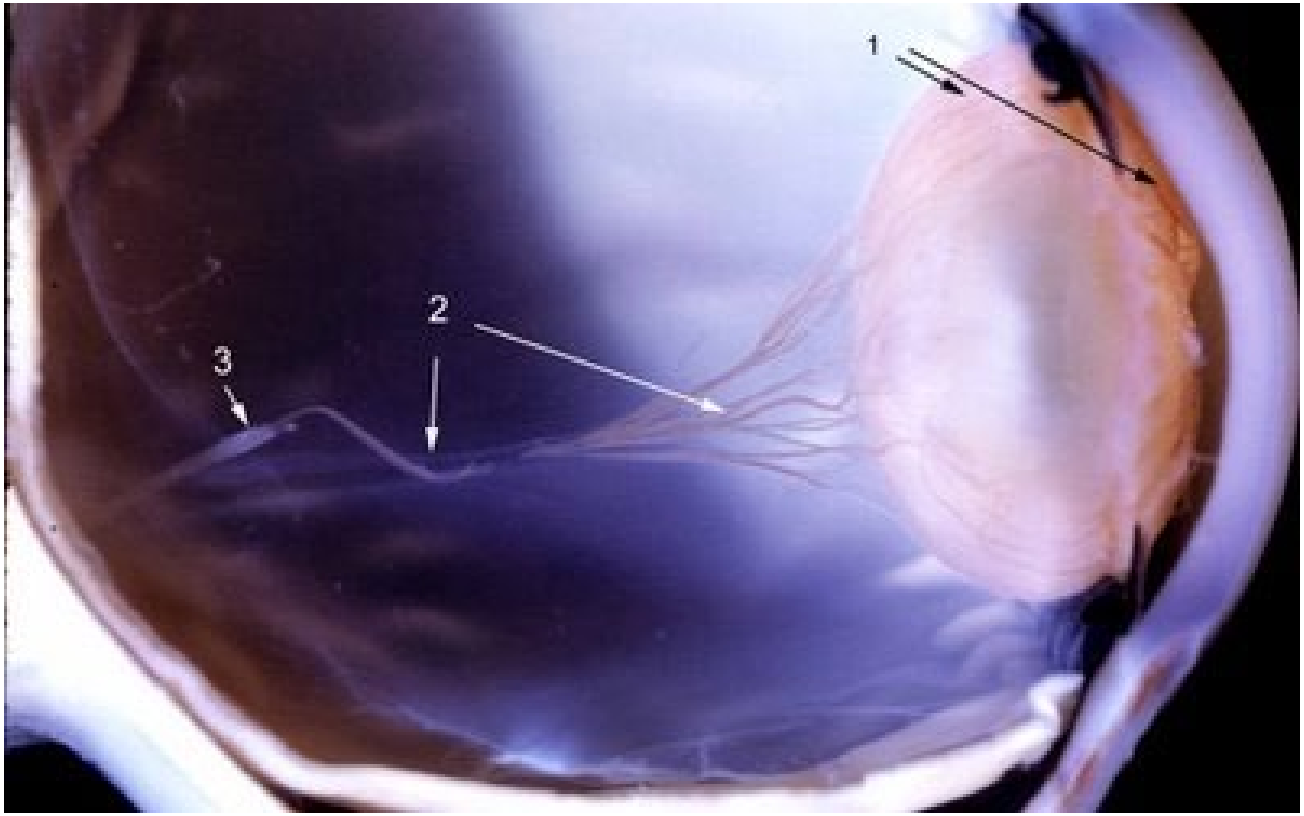
Tunica vasculosa lentis: The hyaloid artery…

Lens/Cataracts Overview



Tunica vasculosa lentis: The hyaloid artery…forming the posterior vascular capsule

Lens/Cataracts Overview



In the eye of this very premature infant, the **tunica vasculosa lentis** surrounds the lens (arrows 1). It is contiguous with the hyaloid artery and its branches (arrow 2).

Lens/Cataracts Overview

- The vascular supply encapsulating the developing lens is called the tunica vasculosa lentis.
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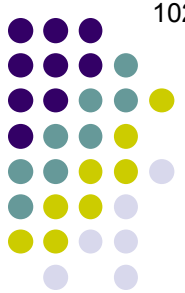
  The hyaloid artery runs from the optic nerve head to the back of the fetal lens. It is supposed to regress prior to birth—but doesn't always, as we are about to see.

  2) The *anterior vascul*

  3) The *capsulopupillary portion*

Lens/Cataracts Overview



- The vascular supply encapsulating the developing lens is called the tunica vasculosa lentis.
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  1) The *posterior vascular capsule* arises from the hyaloid artery
     - A common, clinically insignificant remnant is the Mittendorf dot

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Lens/Cataracts Overview

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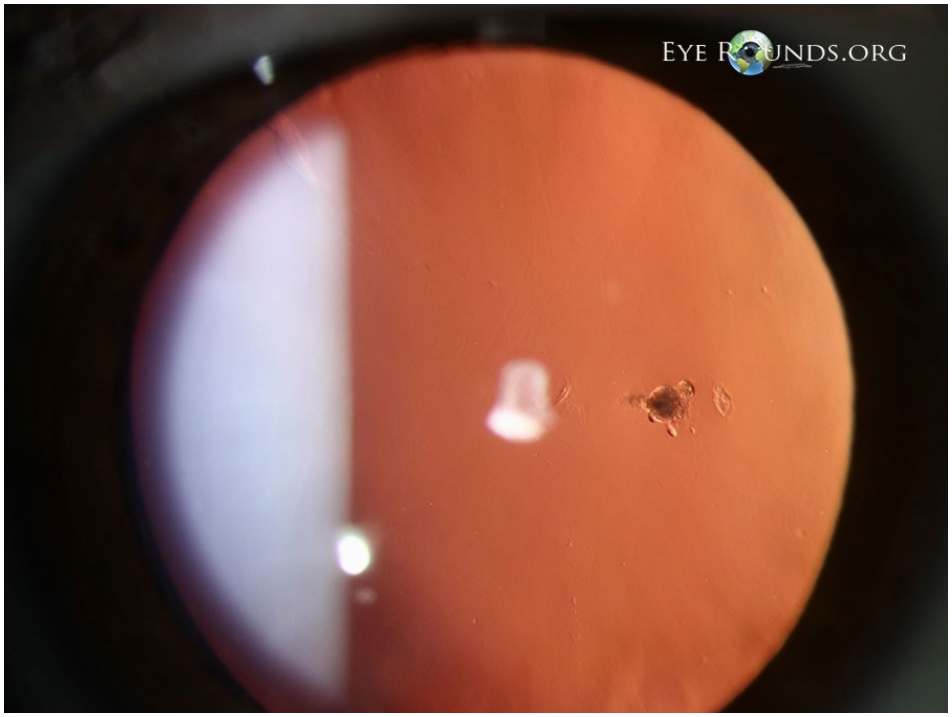
  2) The *anterior va*

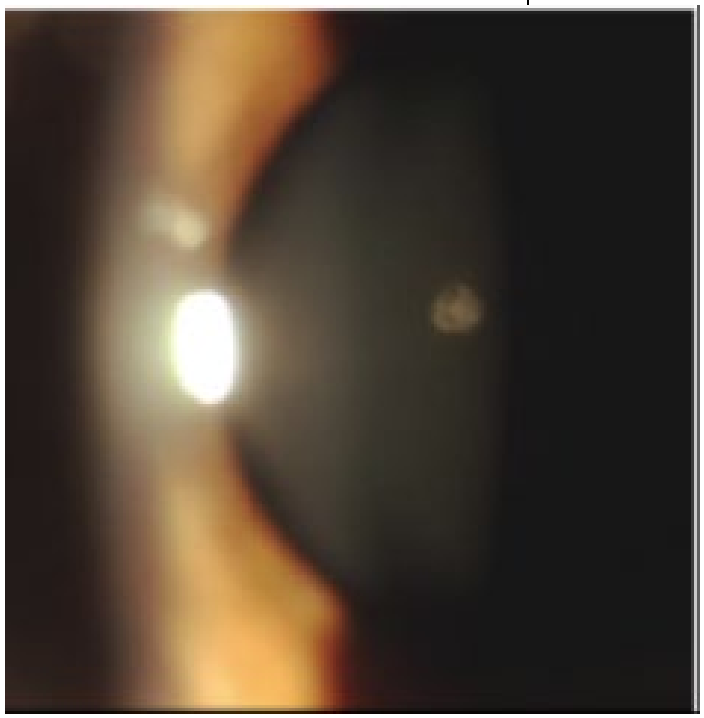
  The Mittendorf dot presents as a small white dot on the posterior capsule of the lens. It is an extremely common finding.

  3) The *capsulopupillary portion*

Lens/Cataracts Overview



Retroillumination



Direct illumination

Mittendorf dot

Lens/Cataracts Overview

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  2) In PFV (*persistent fetal vasculature*; aka *persistent hyperplastic primary vitreous*, PHPV), the remnant posterior vascular capsule forms a retrolental fibrovascular membrane.

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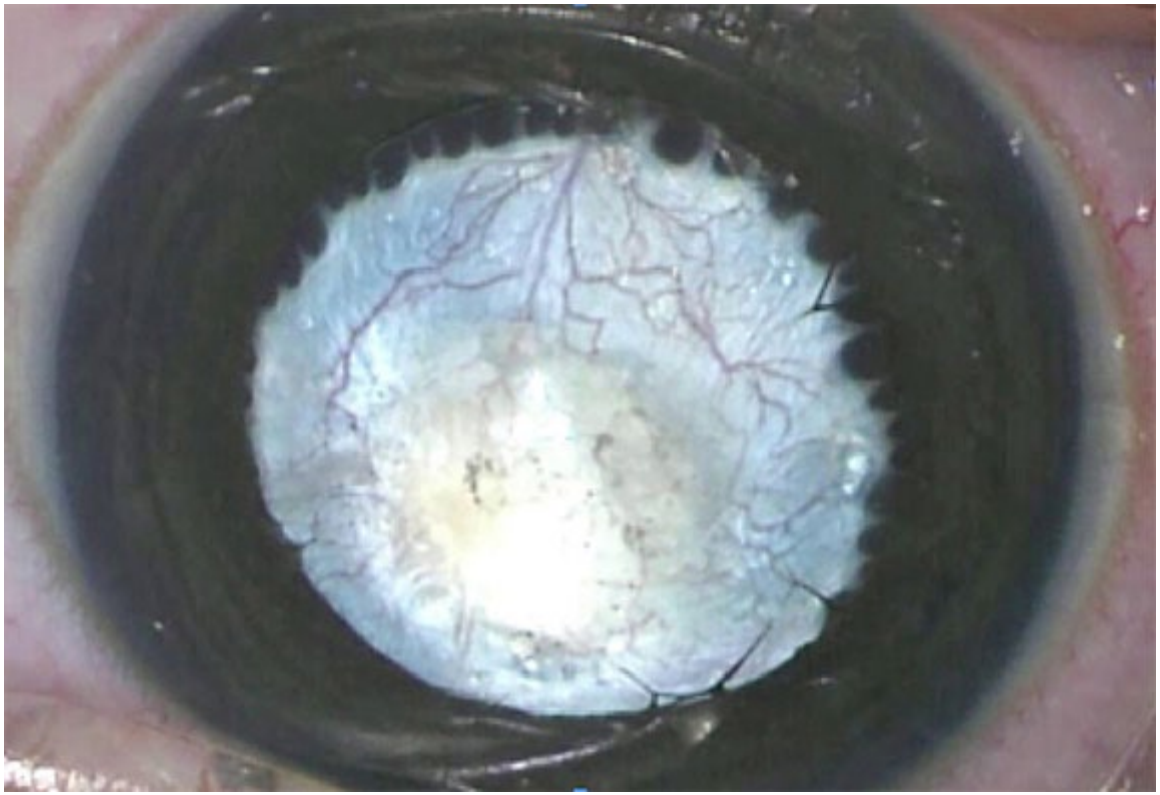
Lens/Cataracts Overview



PFV: Retrolental fibrovascular membrane

Lens/Cataracts Overview

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  2) In PFV (*persistent fetal vasculature*; aka *persistent hyperplastic primary vitreous*, PHPV), the remnant posterior vascular capsule forms a retrolental fibrovascular membrane. This membrane induces a variety of sight-threatening conditions including cataract, progressive AC shallowing with subsequent glaucoma, and retinal detachment.

  3) The *capsulopupillary portion*

Lens/Cataracts Overview

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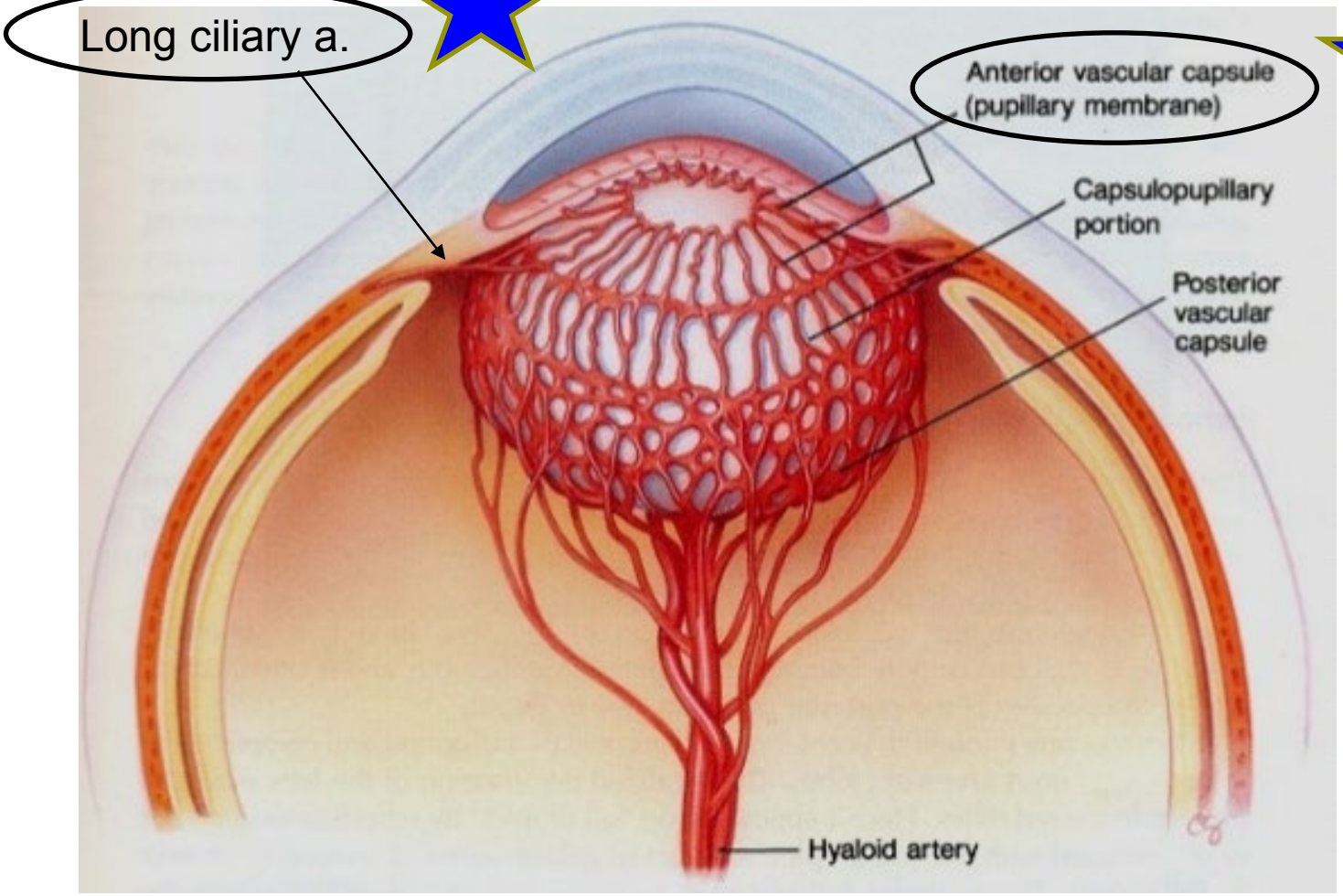
  3) The *capsulopupillary portion*

Lens/Cataracts Overview



Tunica vasculosa lentis: Anterior vascular capsule

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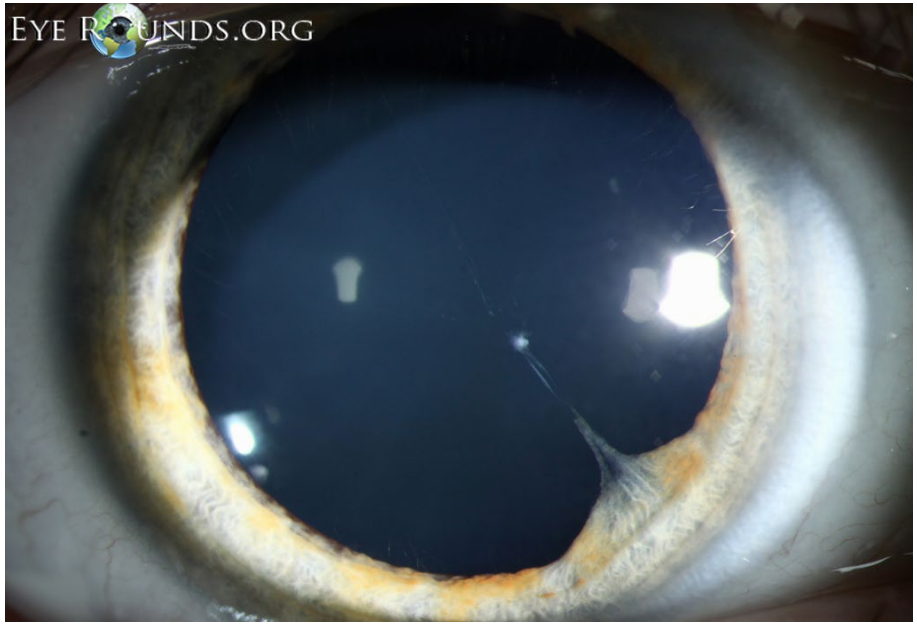
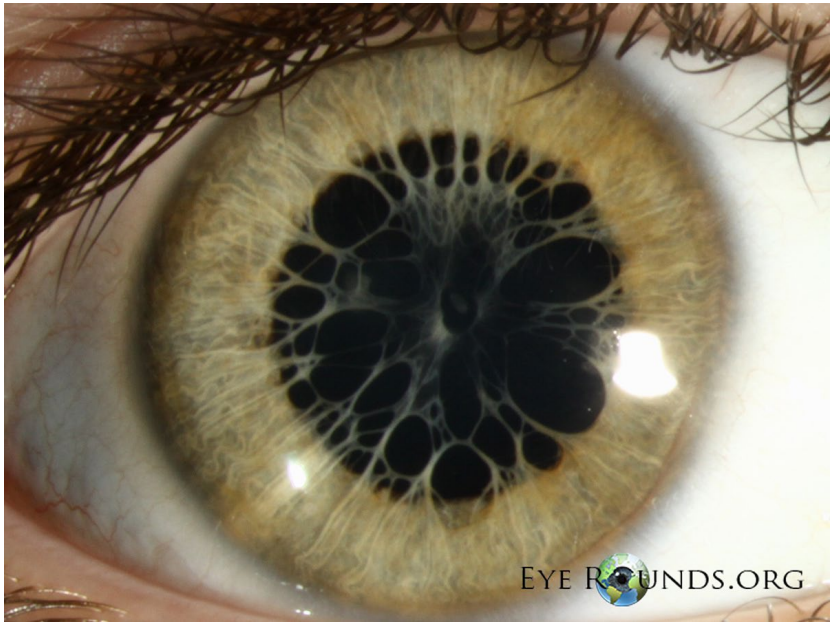
     - A common, clinically insignificant (usually) remnant is a persistent pupillary membrane
  3) The *capsulopupillary portion*

Lens/Cataracts Overview



Trivial case



Hey now

Persistent pupillary membrane

Lens/Cataracts Overview

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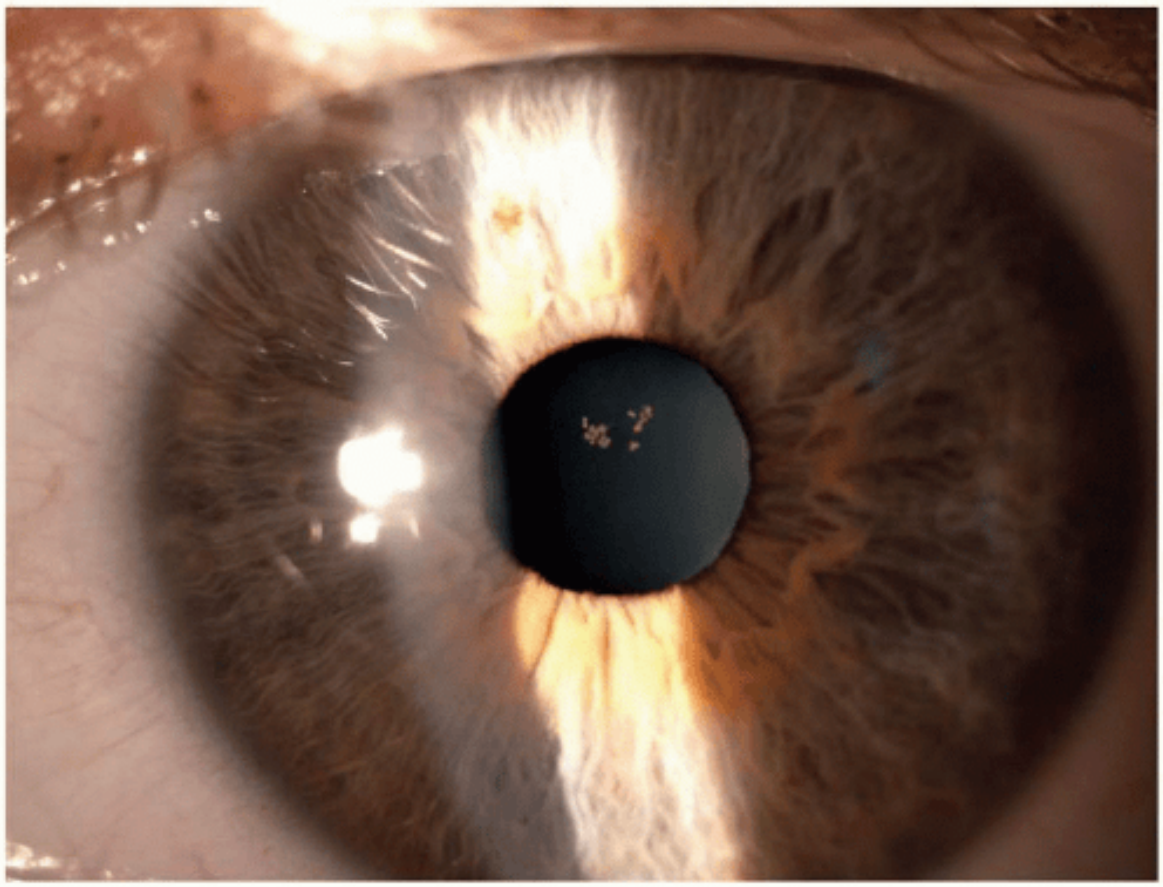
     - Another common remnant is the epicapsular star, colloquially referred to as 'chicken feet' on the anterior capsule
  3) The *capsulopupillary portion*

Lens/Cataracts Overview



Epicapsular star

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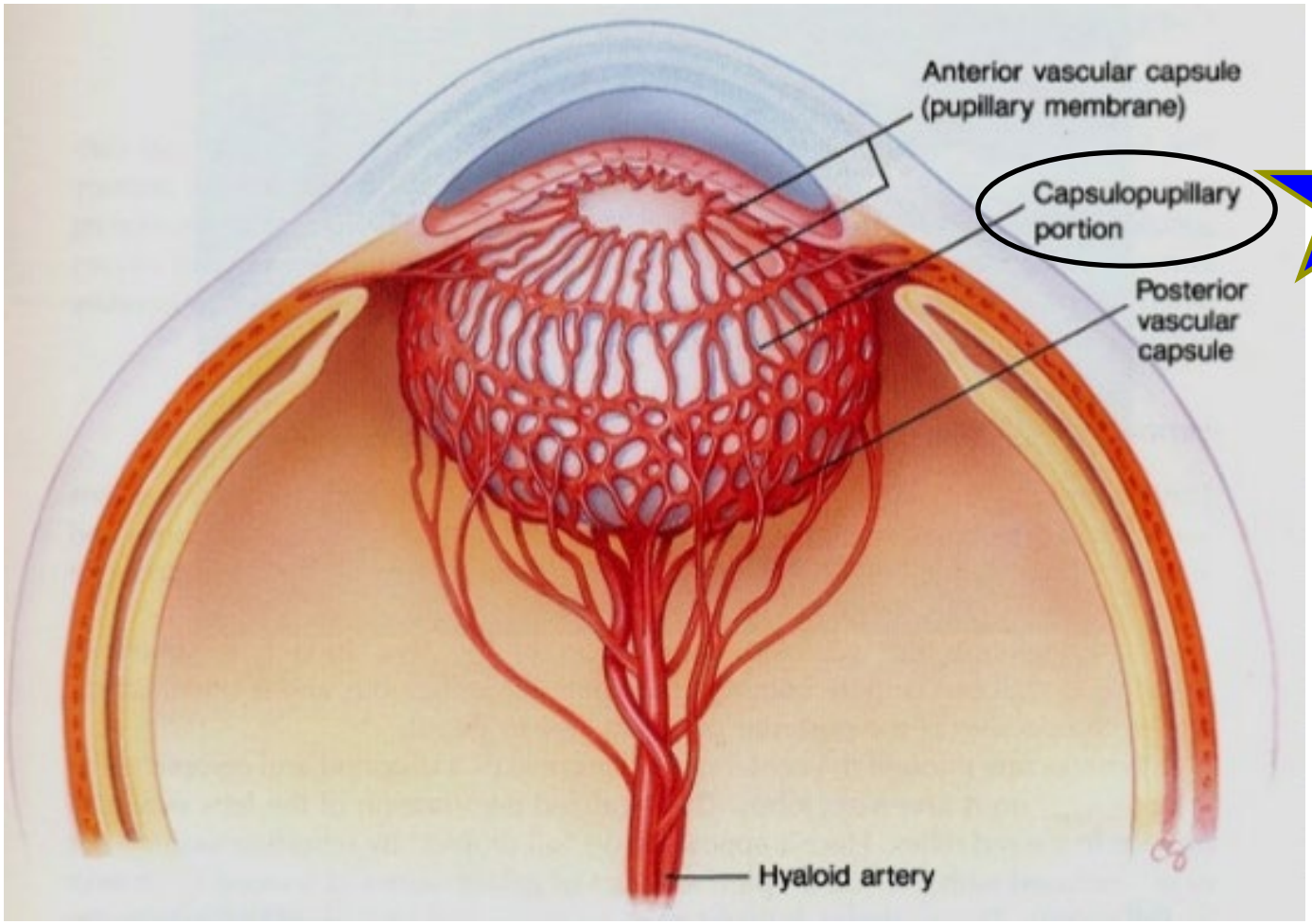
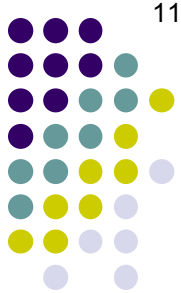
  3) The *capsulopupillary portion* anastomoses the anterior and posterior sections of the tunica

Lens/Cataracts Overview



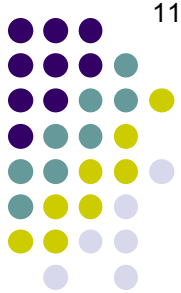
Tunica vasculosa lentis: Capsulopupillary portion

Lens/Cataracts Overview



- **Zonules** are secreted by the ciliary epithelium near the end of the third month of gestation

Lens/Cataracts Overview



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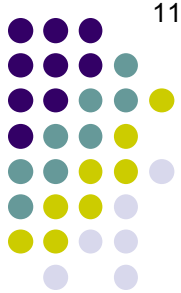
- Zonules comprise the so-called *tertiary vitreous*

Lens/Cataracts Overview



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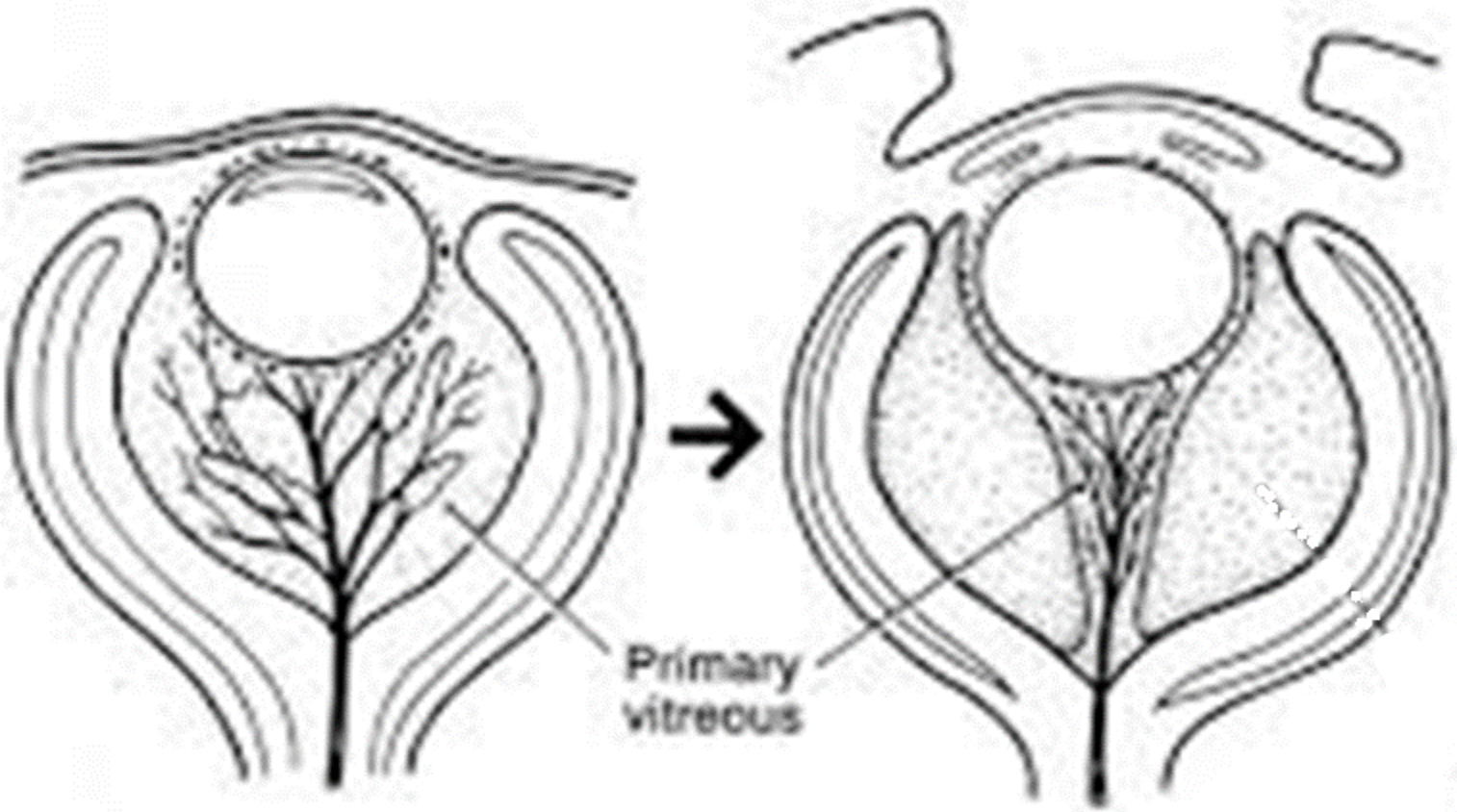
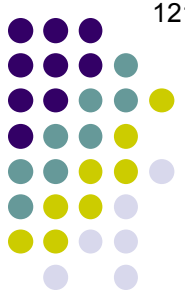
  - As you already know, the hyaloid vasculature comprises the primary vitreous
    - Hence PFV is aka *persistent hyperplastic primary vitreous*

Lens/Cataracts Overview



Primary vitreous

Lens/Cataracts Overview



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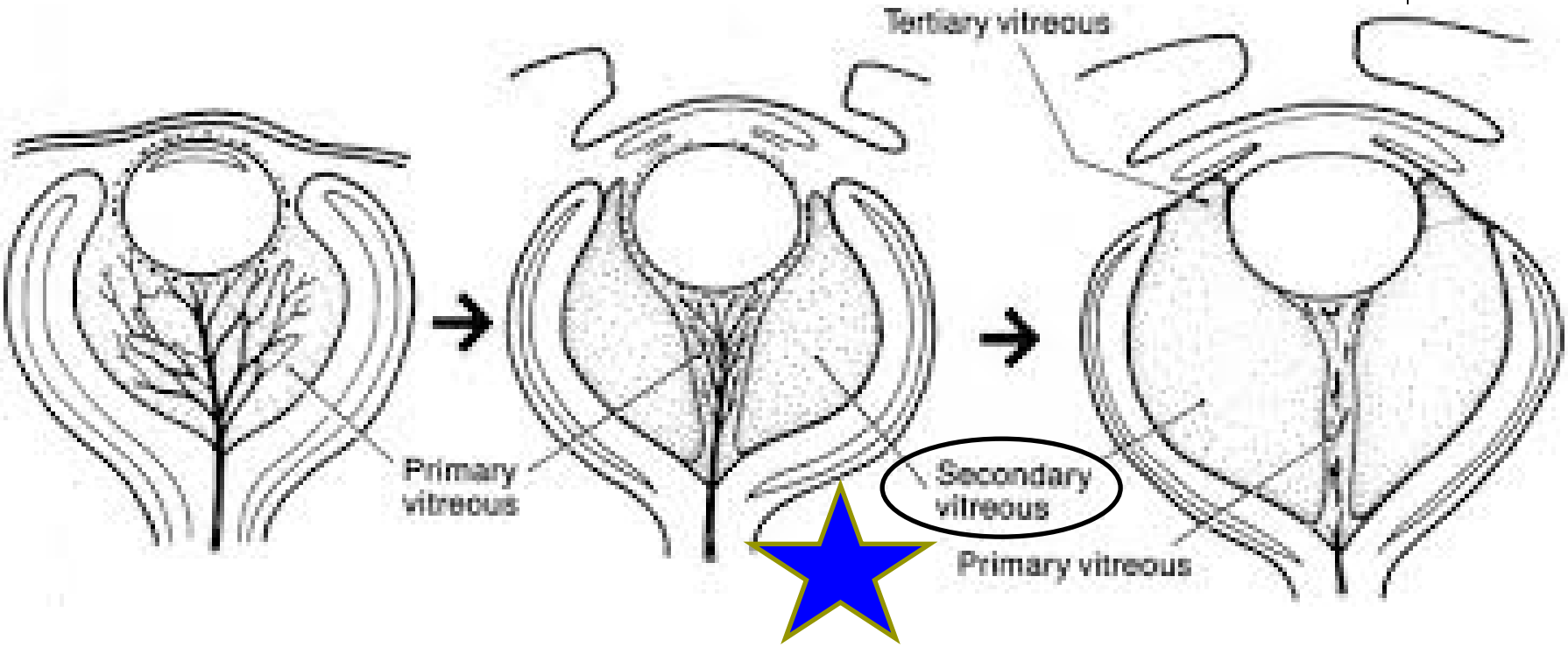
  - *The secondary vitreous* is the main vitreous body

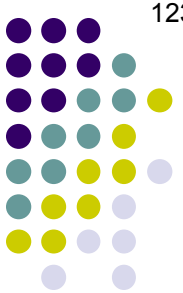
Lens/Cataracts Overview

(Tertiary vitreous will form the zonules)



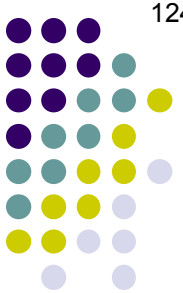
Secondary vitreous

Lens/Cataracts Overview



At long last we're ready to address the cataract portion of the lens/cataract overview. Obviously, cataracts and their extraction are central to the practice of ophthalmology.

Lens/Cataracts Overview



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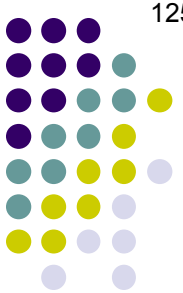
Lens/Cataracts Overview



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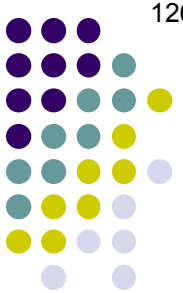
Lens/Cataracts Overview



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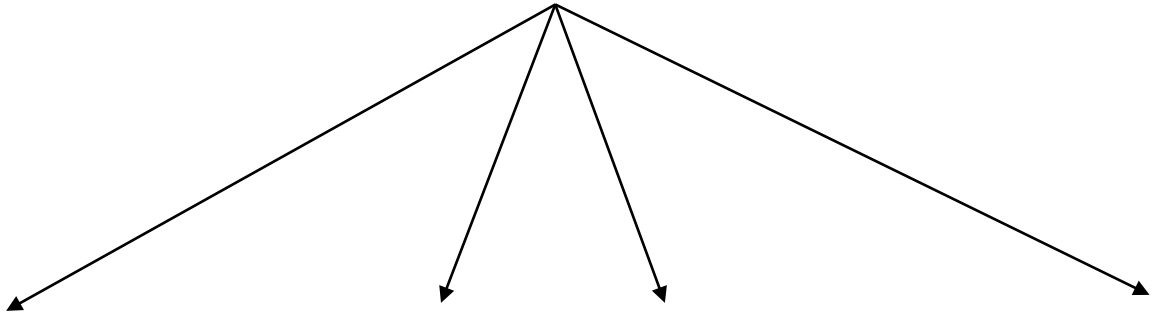
Lens/Cataracts Overview

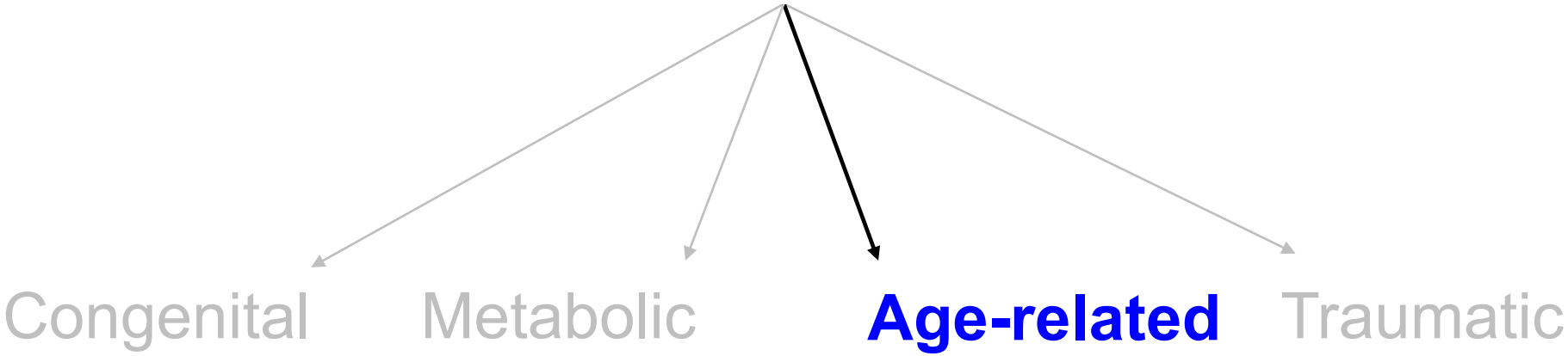
Per the *Lens* book, there are the four categories of cataracts:



Congenital Metabolic Age-related Traumatic

Lens/Cataracts Overview

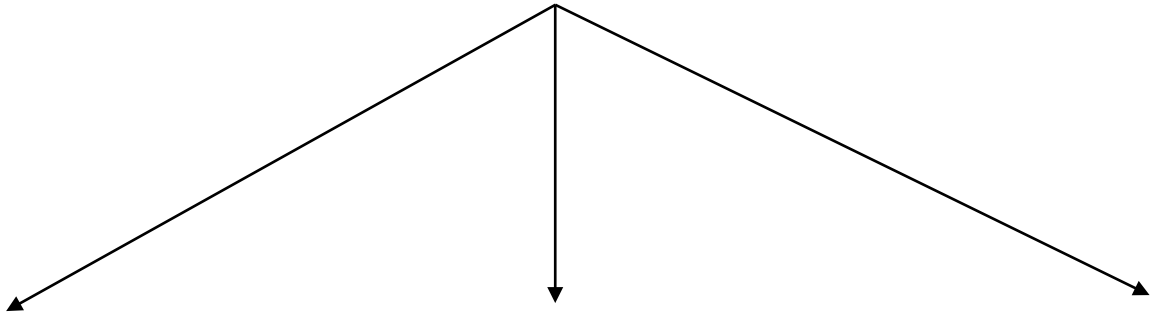
Per the *Lens* book, there are the four categories of cataracts:



The remainder of this slide-set will focus on age-related cataracts

Lens/Cataracts Overview

There are three age-related types of cataracts:

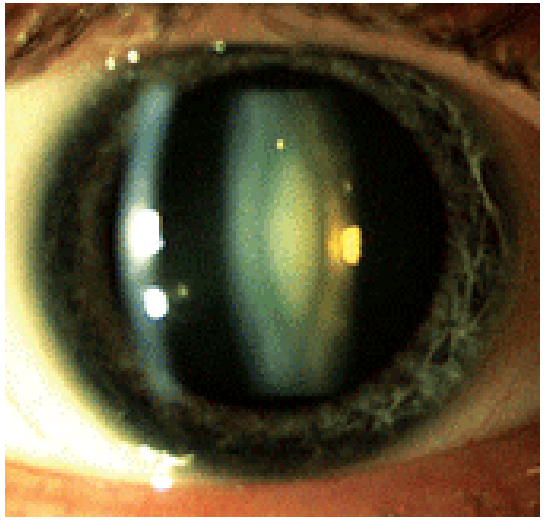


Lens/Cataracts Overview

There are three age-related types of cataracts:

NSC

(Nuclear sclerotic cataract)



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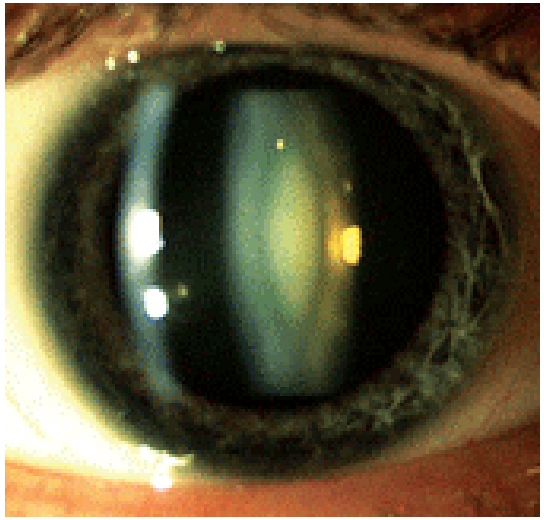
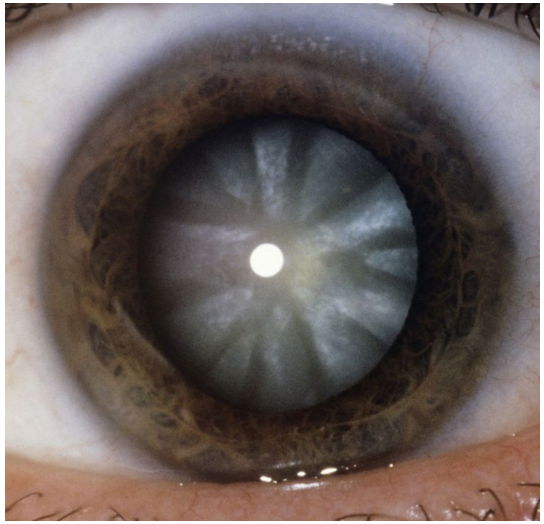


Cortical



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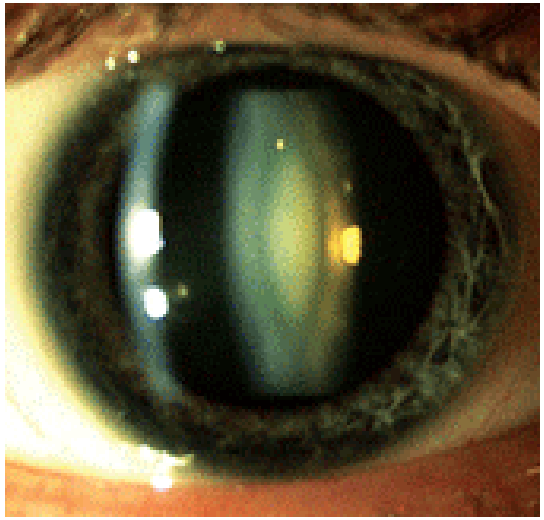

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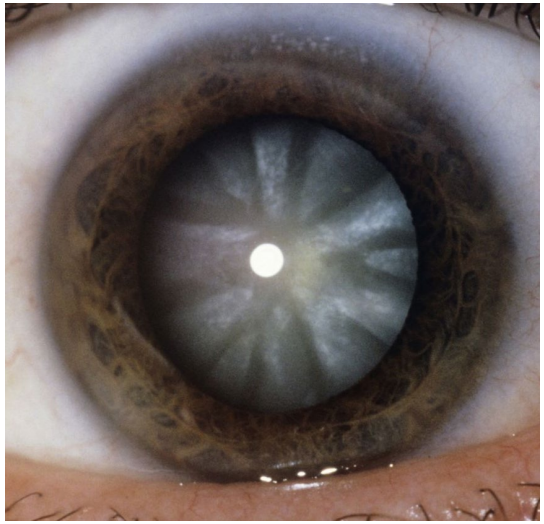
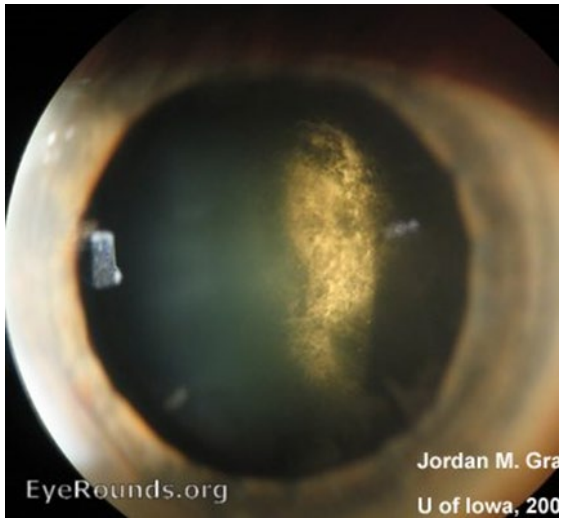


PSC
(Posterior subcapsular cataract)



Lens/Cataracts Overview

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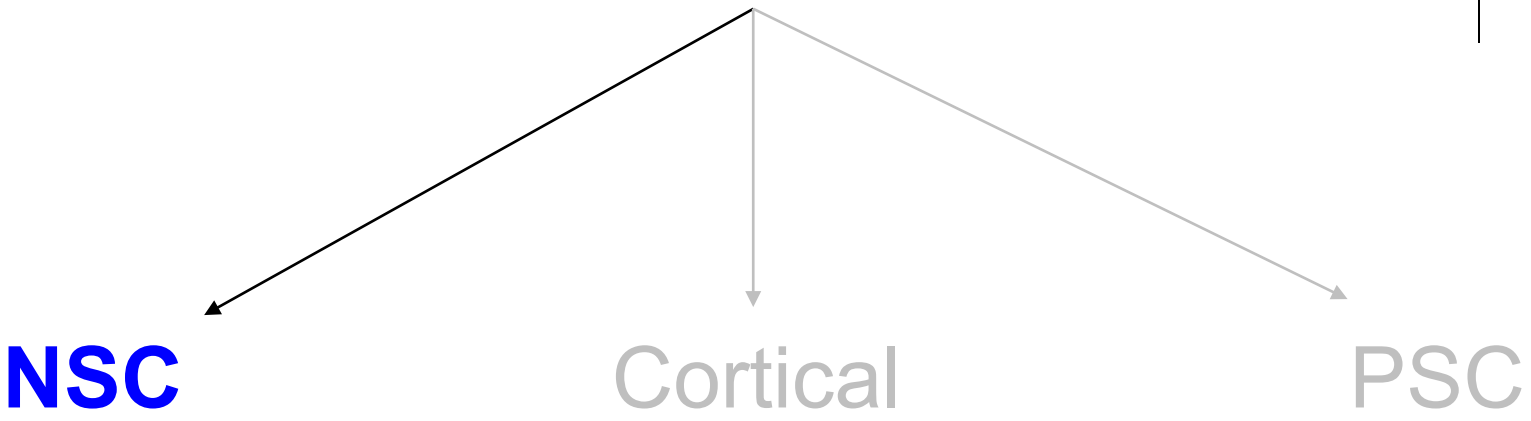
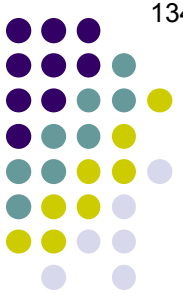


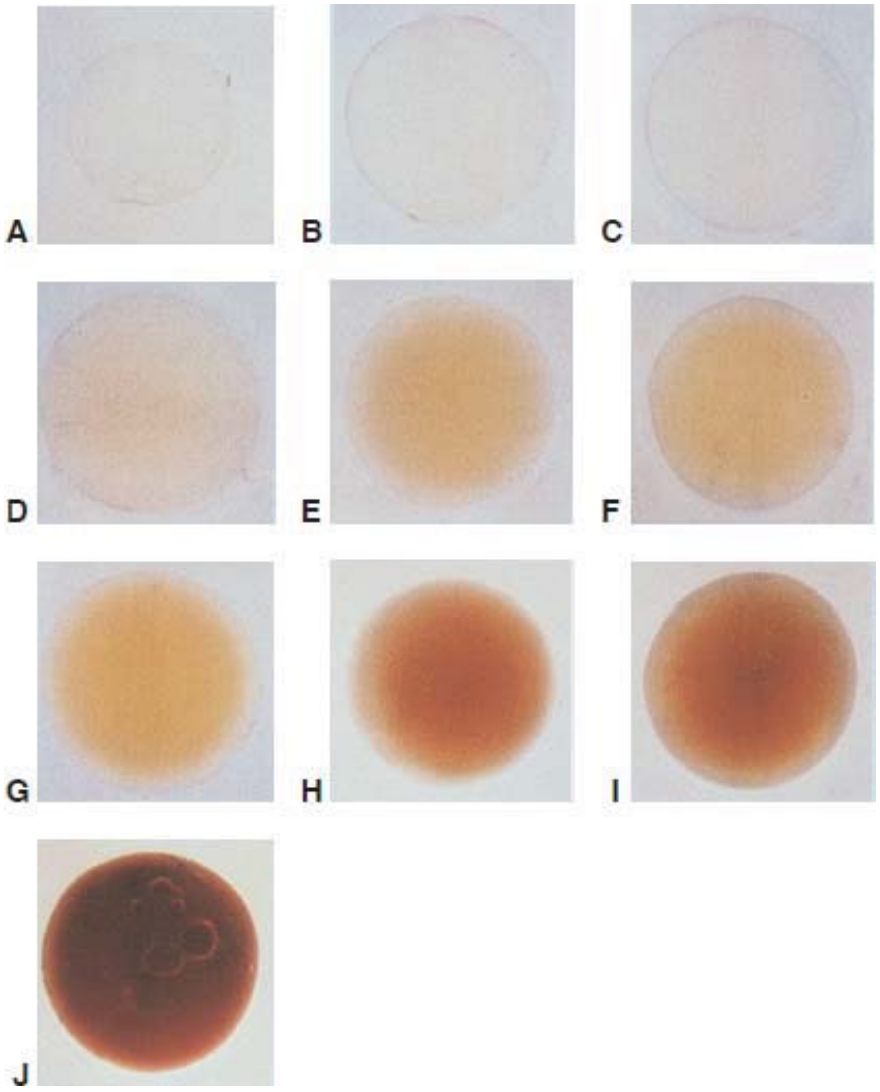
Let's look at NSCs *first*

Lens/Cataracts Overview



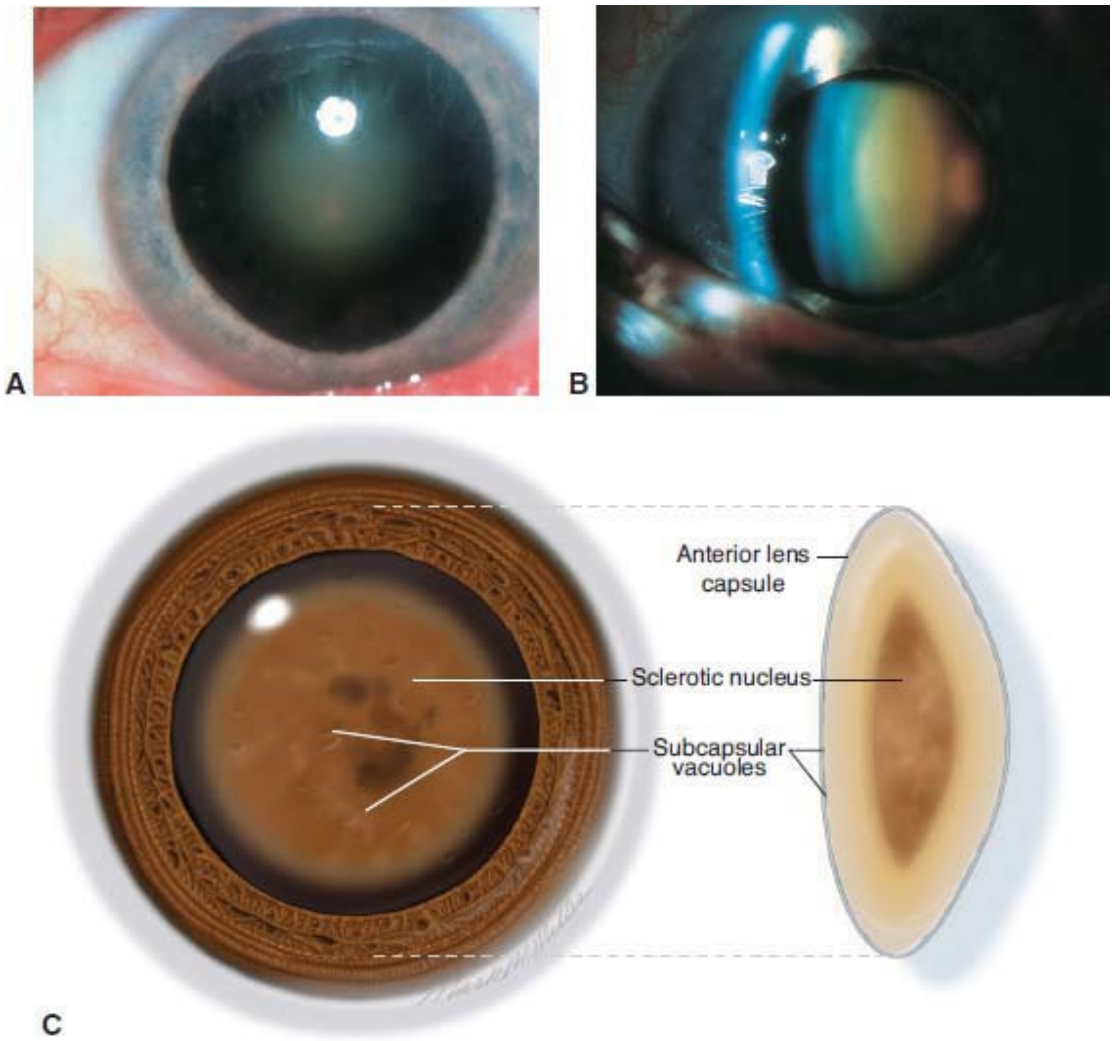
NSCs have two distinctive traits: Their **color** and their **hardness**. Color-wise, NSCs are typically on the amber-to-brown spectrum. Why those colors? No one knows. (Per the *Lens* book, the pathogenesis of NSC discoloration is “poorly understood” at this time.) Yellowing of the lens with aging is normal, and is considered pathologic (ie, an NSC) only when it compromises vision.

Lens/Cataracts Overview



Increasing yellow-to-brown coloration of the human lens from age 6 months (A) to 8 years (B), 12 years (C), 25 years (D), 47 years (E), 60 years (F), 70 years (G), 82 years (H), and 91 years (I). J, Brown nuclear cataract in a 70-year-old patient.

Lens/Cataracts Overview



Nuclear cataract viewed with diffuse illumination (*A*) and with a slit beam (*B*). *C*, Schematic of nuclear cataract

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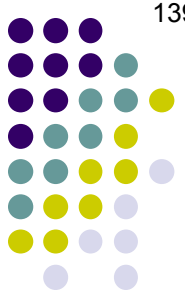
Lens/Cataracts Overview



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With respect to vision, pts with NSCs usually c/o difficulty at distance more than near, and in dim light more than bright. As mentioned previously, NSC development is associated with a refractive shift, usually myopic. In some hyperopes and/or presbyopes the myopic shift will temporarily *improve* vision, a phenomenon called *second sight*.

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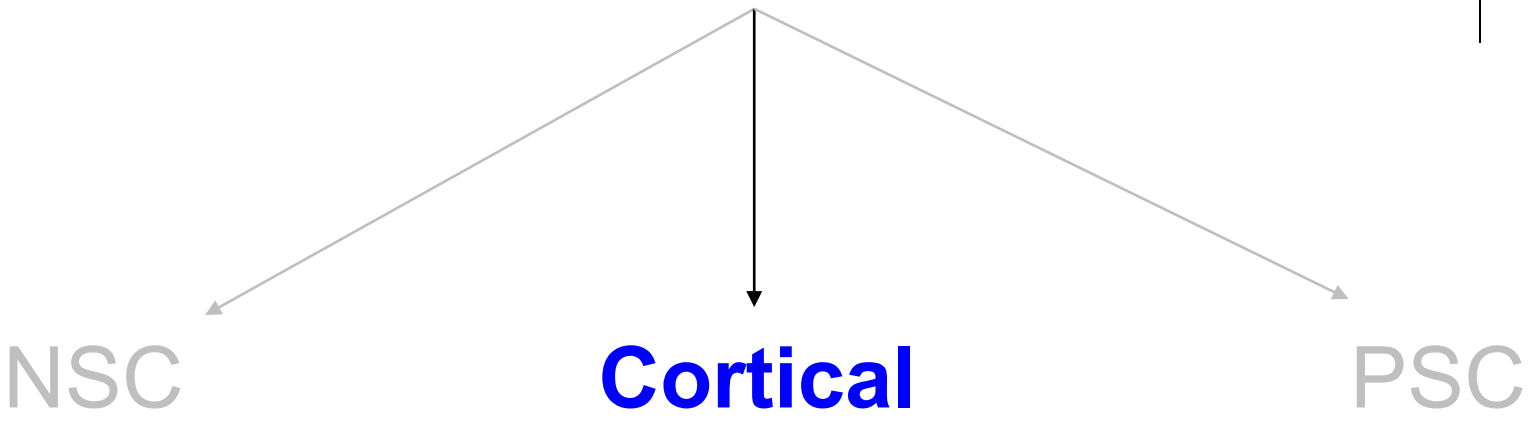
Lens/Cataracts Overview

There are three age-related types of cataracts:



Next let's look at cortical *cataracts*

Lens/Cataracts Overview

Unlike in NSCs, histopathologic changes *can* be identified in cortical cataracts, as they are characterized by lens fiber swelling and disruption. This loss of cell-membrane integrity leads to protein oxidation and precipitation. This in turn disrupts normal intralenticular osmotic gradients, resulting in an increase in intralenticular water content.

Lens/Cataracts Overview

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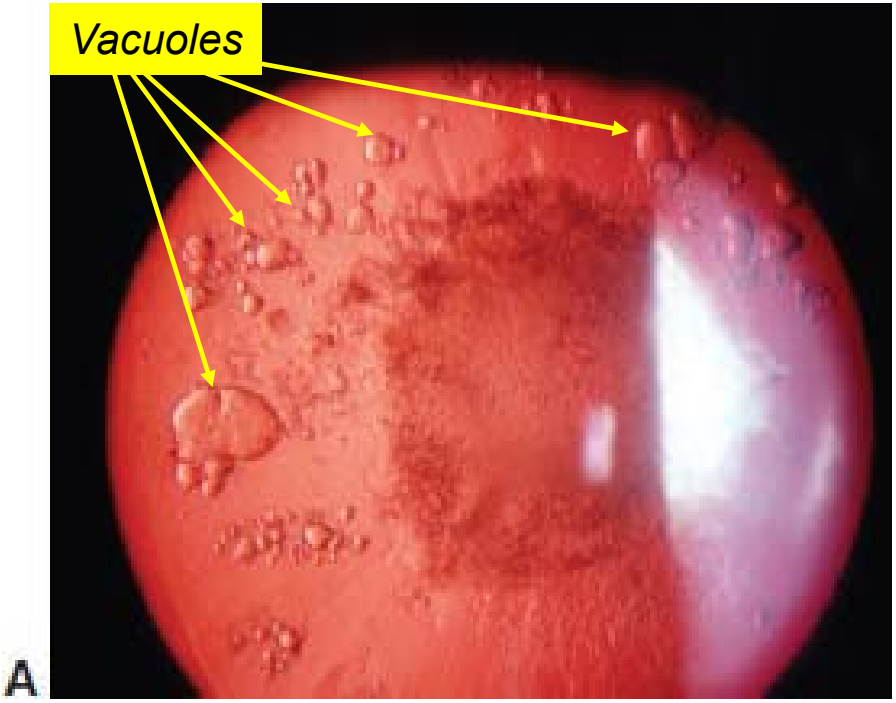
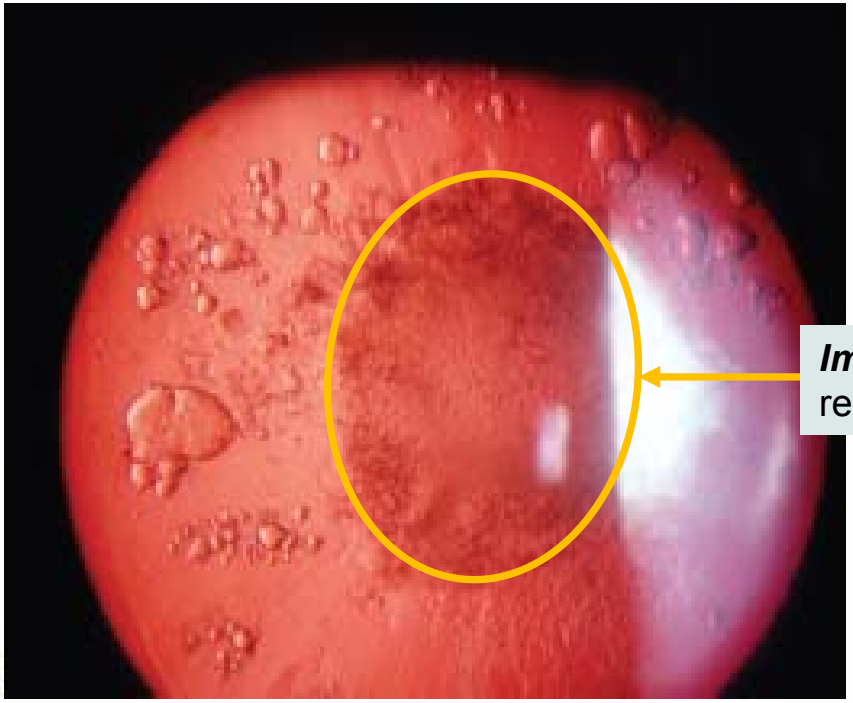
Cortical cataracts pass through a series of defined stages. The first manifestations of an ***immature*** *cortical cataract* are the presence of water clefts and vacuoles.

Lens/Cataracts Overview



Early cortical cataract development as viewed at the slit lamp using retroillumination. *A*, Vacuoles.

Lens/Cataracts Overview



Important: The opacification in this area is **not** representative of cortical changes, but rather is a **PSC**.

Early cortical cataract development as viewed at the slit lamp using retroillumination. *A*, Vacuoles.

Lens/Cataracts Overview

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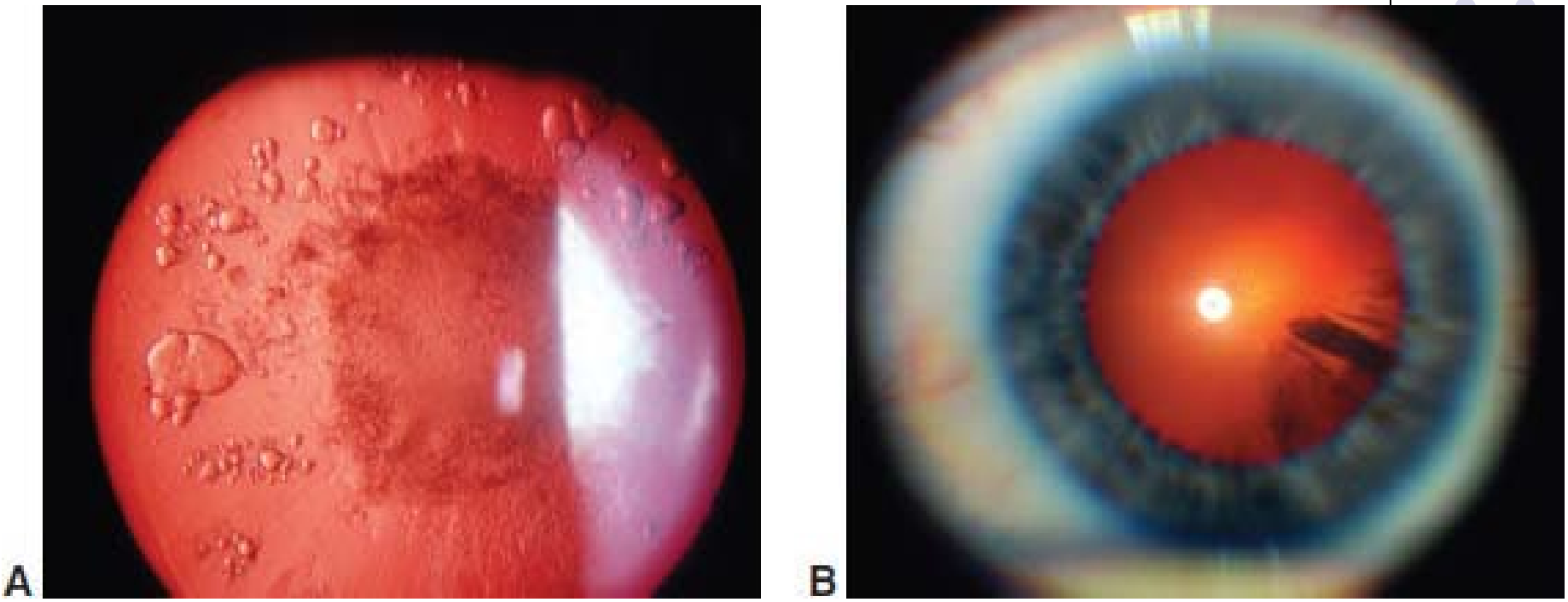
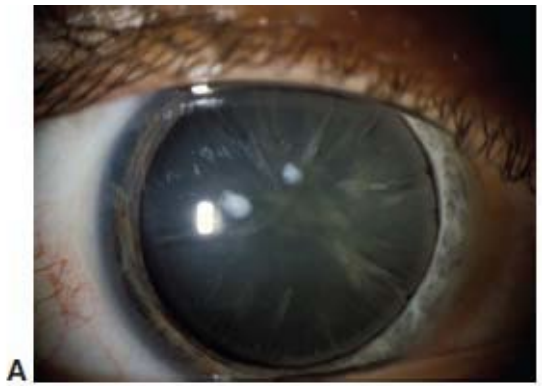
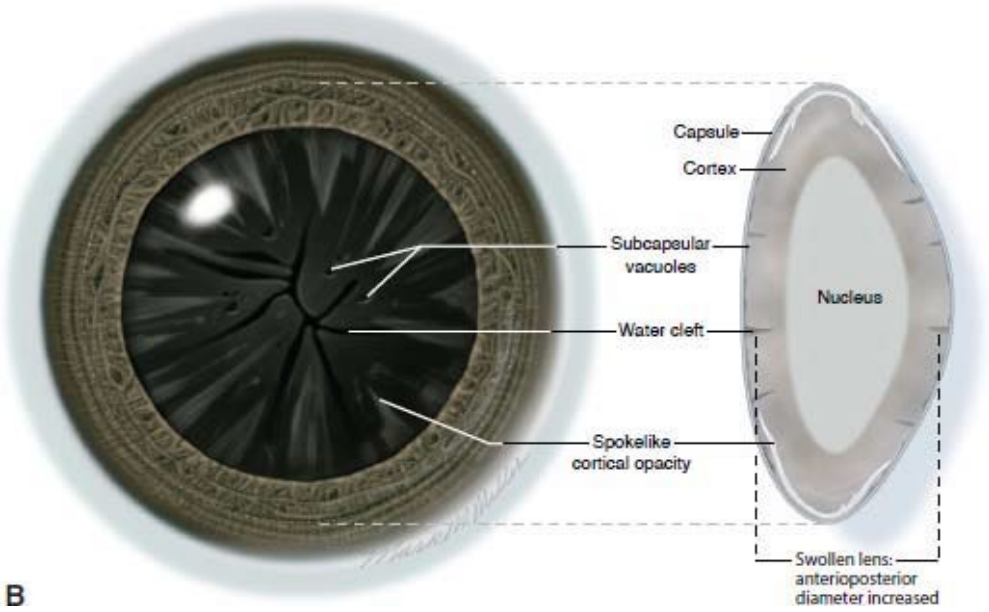
Lens/Cataracts Overview



Early cortical cataract development as viewed at the slit lamp using retroillumination. *A*, Vacuoles. *B*, Typical cortical spokes

Lens/Cataracts Overview

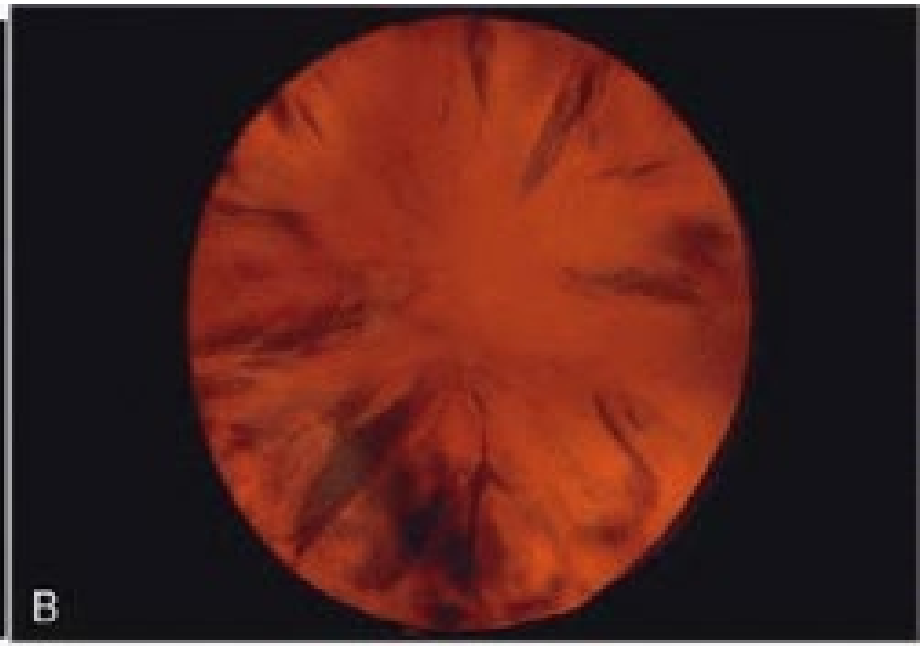




A, Cortical cataract viewed by oblique view at the slit lamp. *B*, Schematic of immature cortical cataract

Lens/Cataracts Overview

Direct illumination



Retroillumination

Cortical cataract: Early spokes

Lens/Cataracts Overview

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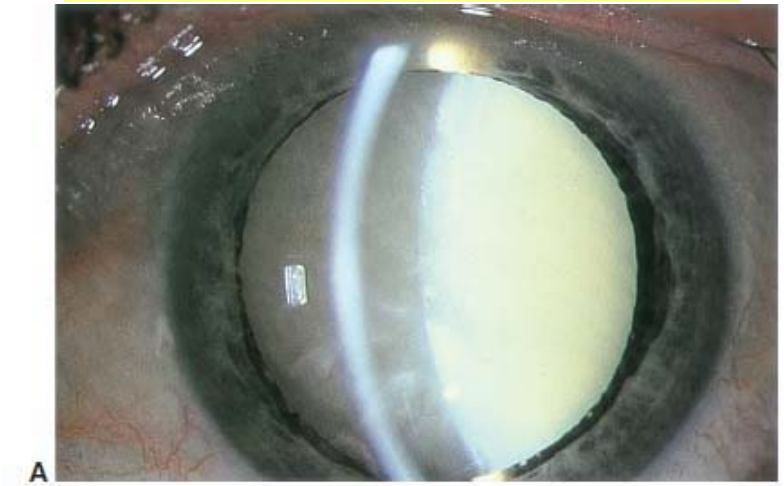
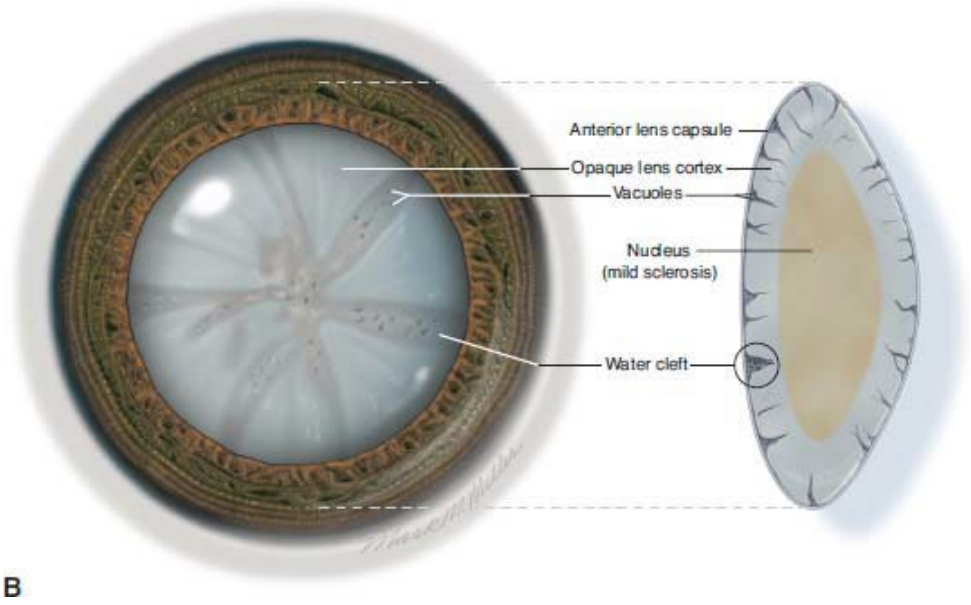
Eventually, the cataract will progress until the entirety of the cortex (ie, from the capsule to the nucleus) is opacified and/or white. At this juncture it has become a ***mature*** *cortical cataract*.

Lens/Cataracts Overview





Mature cortical cataract. *A*, Mature cortical cataract viewed at the slit lamp. *B*, Schematic of mature cortical cataract.

Lens/Cataracts Overview

Cortical cataract: Mature

Lens/Cataracts Overview

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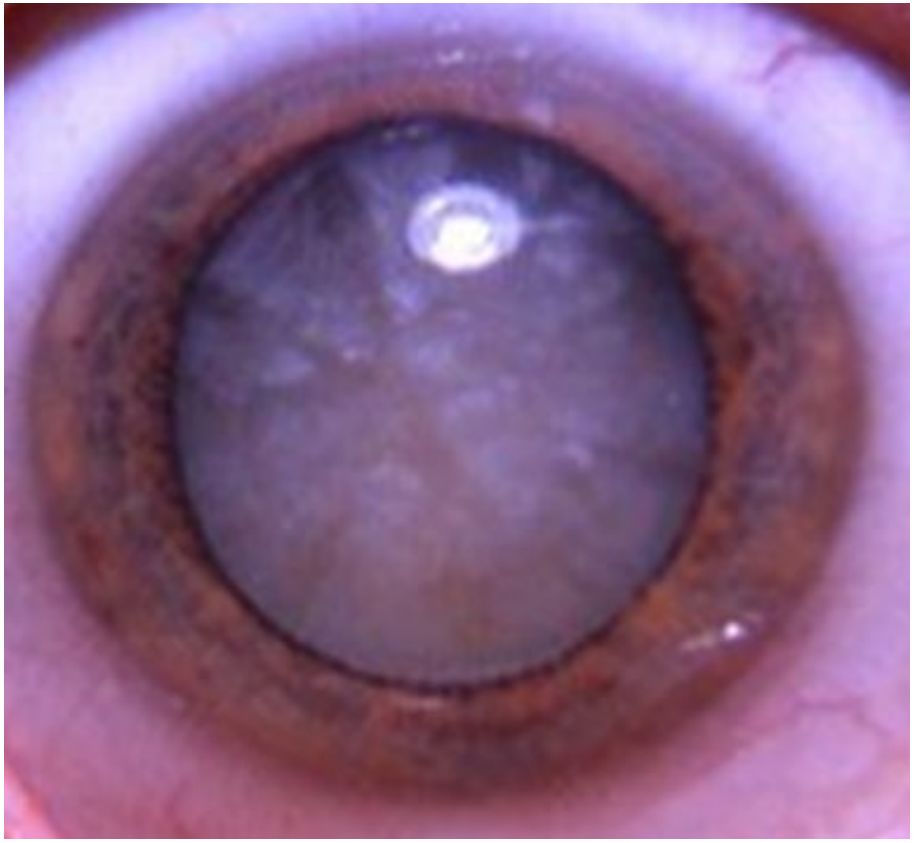
Eventually, the cataract will progress until the entirety of the cortex (ie, from the capsule to the nucleus) is opacified and/or white. At this juncture it has become a ***mature*** *cortical cataract*.

Many mature cortical cataracts absorb a significant further amount of water. The increase in lens volume enlarges it, often narrowing the angle (and increasing the risk of angle-closure glaucoma) in the process. This stage is called an ***intumescent*** *cortical cataract*.

Lens/Cataracts Overview



Intumescent cortical cataract

(Lens intumescence isn't really appreciable in a photo, so don't be concerned if it doesn't look significantly different from a mature cataract)

Lens/Cataracts Overview

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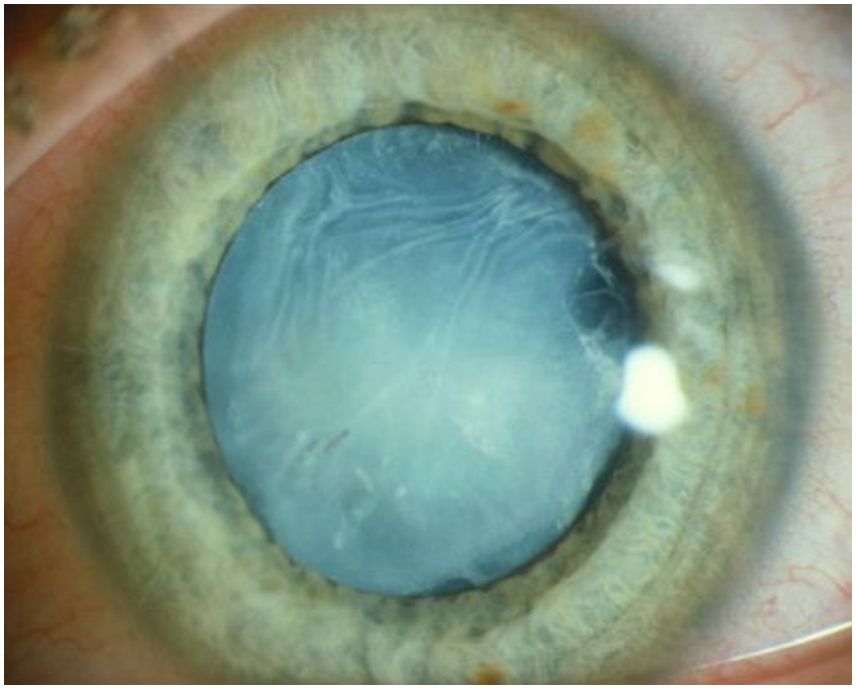
As cortical material continues to degenerate, some will leach through the lens capsule, markedly **decreasing** lens volume. In fact, the volume reduction is significant enough that the previously taut anterior capsule wrinkles in response. This wrinkled capsule is the hallmark of the next stage, the ***hypermature*** *cortical cataract*.

Lens/Cataracts Overview



Hypermature cataract. Note the capsular wrinkling

Lens/Cataracts Overview

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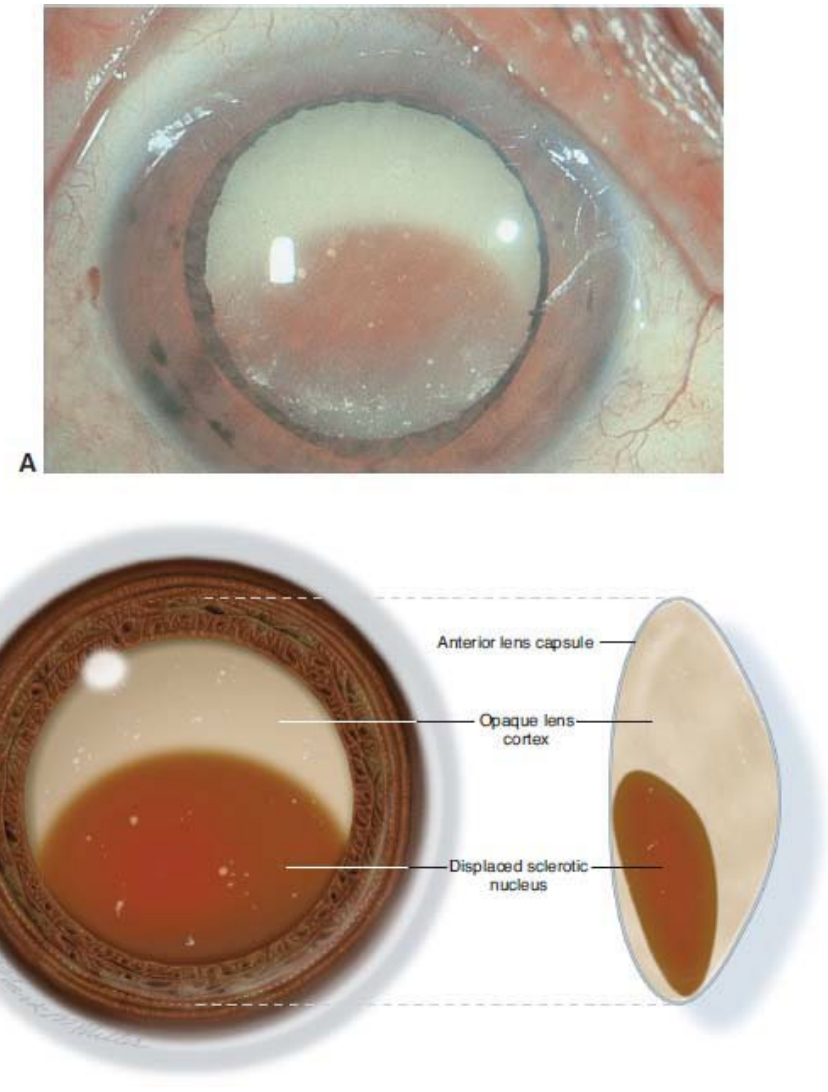
Lens/Cataracts Overview



Morgagnian cataract. A, Clinical photo of morgagnian cataract. B, Schematic of morgagnian cataract.

Lens/Cataracts Overview

Morgagnian cataract

Lens/Cataracts Overview

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Take note of the stages:

Mature cataract → intumescent cataract → hypermature cataract

Cataract ***absorbs*** water ← What happens → Cataract ***leaks*** water

Lens/Cataracts Overview

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Cortica… …defined stages. The first manifestations of an ***immat…*** …e of water clefts and vacuoles. This is followed by the dev… …-shaped opacifications at the lens periphery.

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No red reflex

Many mature cortical cataracts absorb a significant further amount of water. The increase in len… …sure gla…

As …

For all three stages, the red reflex during cataract surgery is completely obscured. As most cataract surgeons rely on the red reflex to visualize the anterior capsule during capsulorrhexis, this step cannot be performed in a conventional manner.

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Cortica… define… of an ***immat…*** …e of wa… …llowed by the dev… …e-shap… …phery.

Eventu… …he enti… …psule to the nuc… …is junc… …tical *cataract*.

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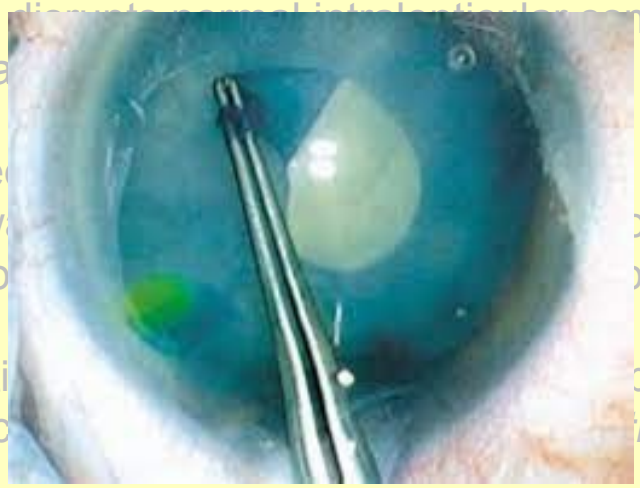
No red reflex



Trypan blue rhexis

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Take note of the stages:

Mature cataract → intumescent cataract → hypermature cataract

Cataract ***absorbs*** water ← What happens → Cataract ***leaks*** water

Lens/Cataracts Overview

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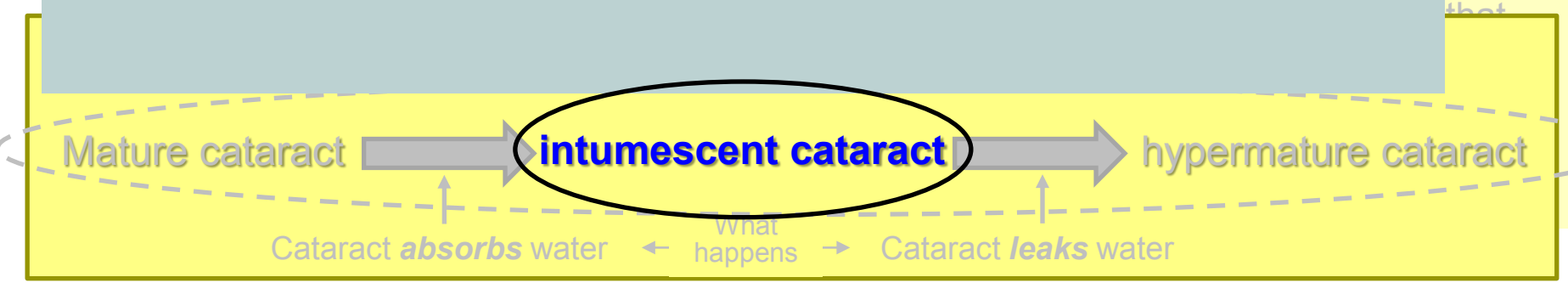
Many mature cortical cataracts absorb a significant further amount of water. The increase in

As if obscuration of the red reflex wasn't enough, the increased intralenticular pressure of an intumescent cataract poses an additional challenge during capsulorrhexis.



Lens/Cataracts Overview

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C… …es of defined stages. The first manifestations of an ***i*** …sence of water clefts and vacuoles. This is followed by t… …vedge-shaped opacifications at the lens periphery.

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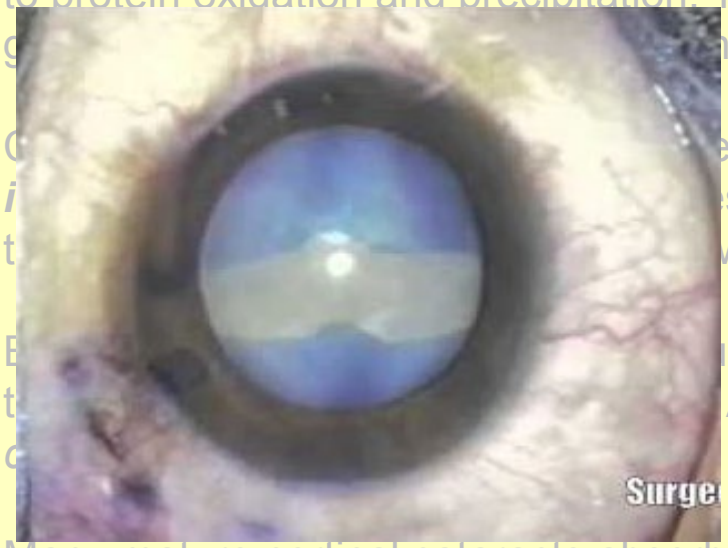

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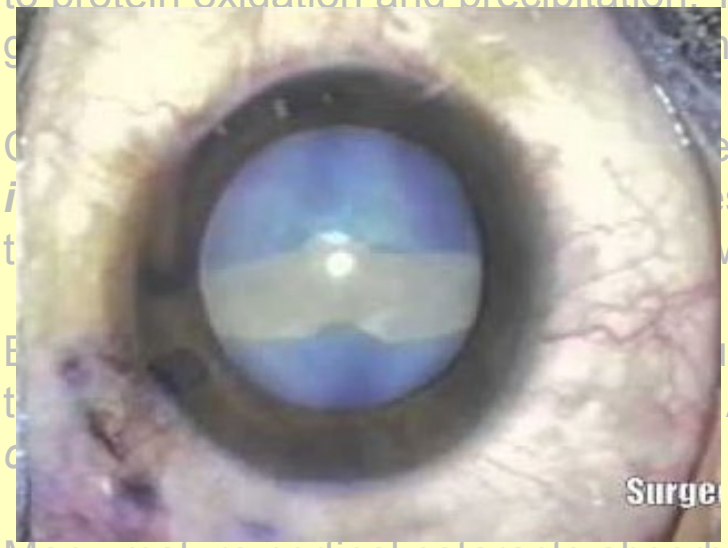
Mature cataract → **intumescent cataract** → hypermature cataract

Cataract ***absorbs*** water ← What happens → Cataract ***leaks*** water

Lens/Cataracts Overview

Unlike in NSCs, histopathologic changes *can* be identified in cortical cataracts, as they are characterized by lens fiber swelling and disruption. This loss of cell-membrane integrity leads to protein oxidation and precipitation. This in turn disrupts normal intralenticular osmotic



Many mature cortical cataracts absorb a significant further amount of water. The increase in

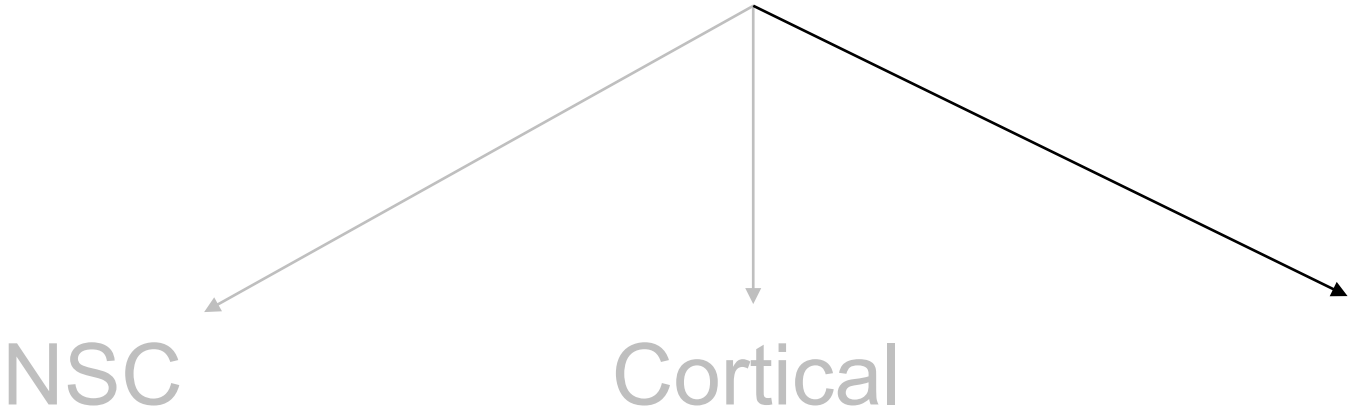
As if obscuration of the red reflex wasn't enough, the increased intralenticular pressure of an intumescent cataract poses an additional challenge during capsulorrhexis. When the surgeon makes the initial rent in the capsule to start the rhexis, the increased pressure within an intumescent cataract may cause the rent to suddenly and uncontrollably extend to the periphery—thereby producing the dreaded **Argentinian flag sign.**

Mature cataract → **intumescent cataract** → hypermature cataract

Cataract ***absorbs*** water ← What happens → Cataract ***leaks*** water

Lens/Cataracts Overview

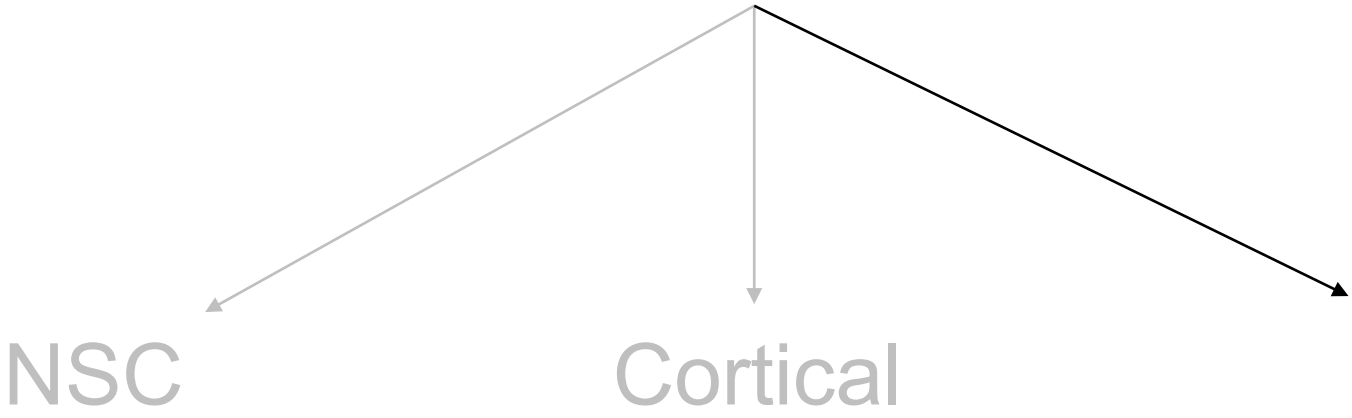
There are three age-related types of cataracts:



And lastly, PSCs

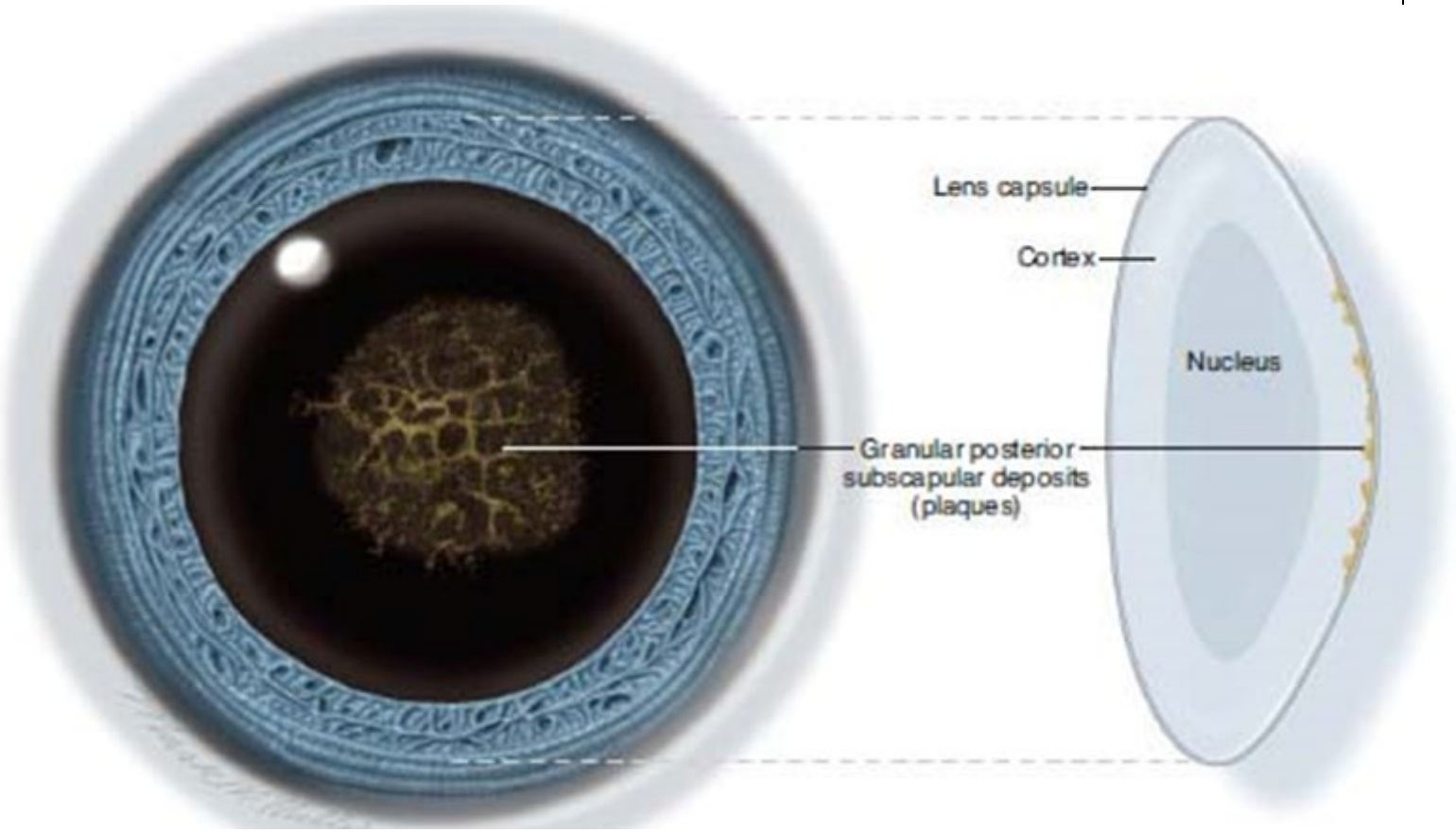
Lens/Cataracts Overview

There are three age-related types of cataracts:



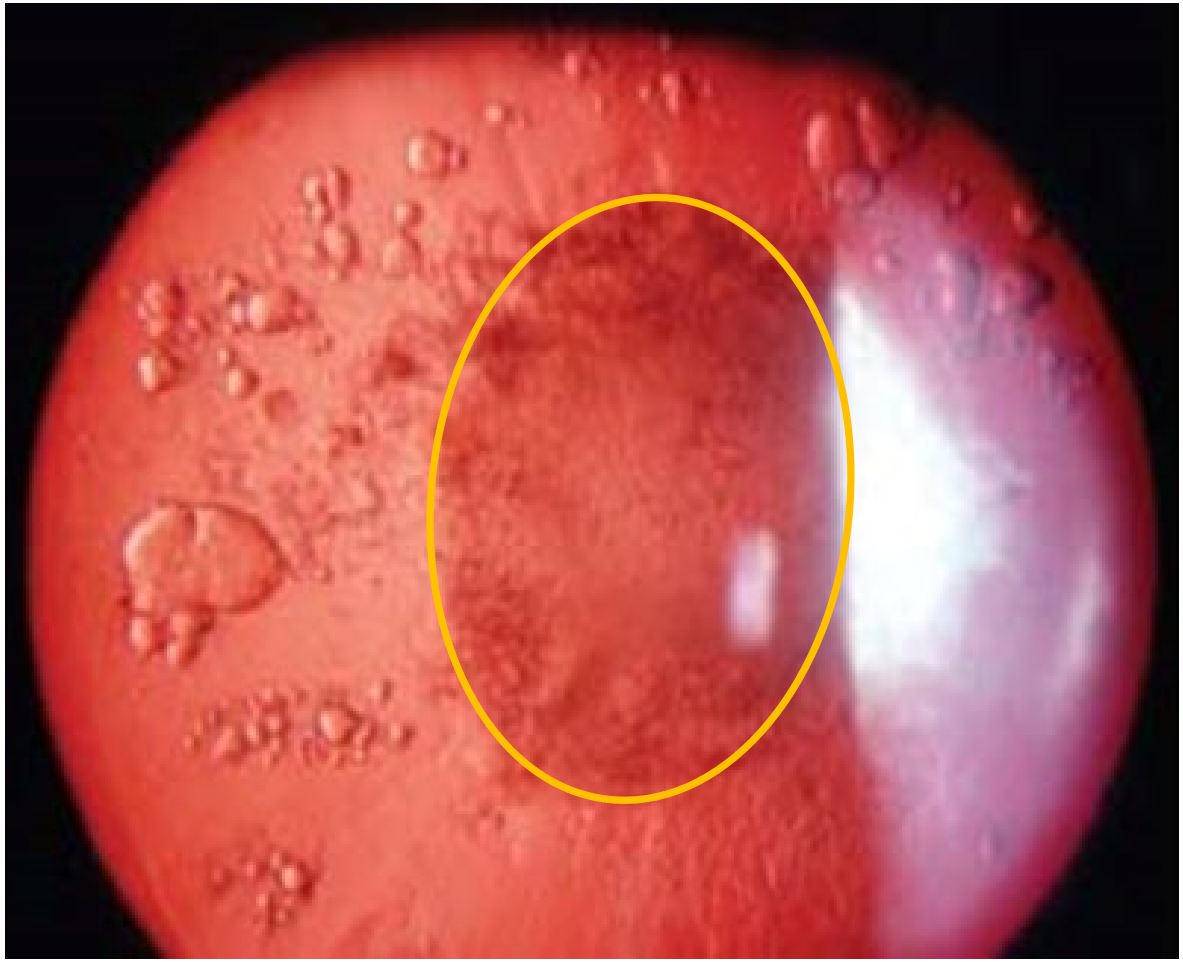
The first and fundamental step in PSC pathophysiology is the migration of equatorial epithelial cells to and across the posterior capsule (PC). As these cells slither across the PC, they swell substantially. These swole cells (called *bladder cells* or *Wedl cells*) cause significant degradation of vision if they're in the visual axis.

Lens/Cataracts Overview



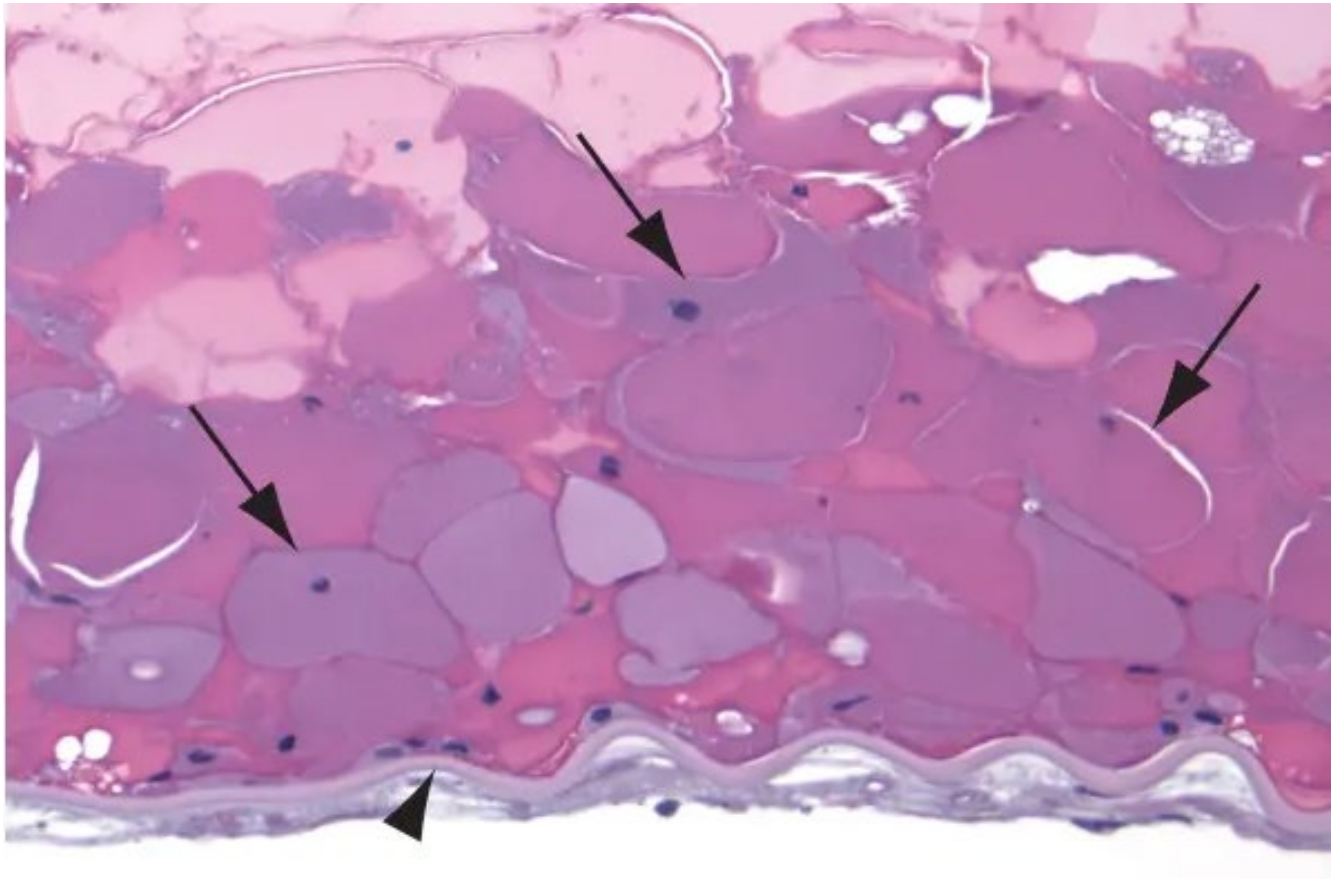
Posterior subcapsular cataract

Lens/Cataracts Overview



The big ol' gnarly PSC encountered in the *cortical cats* section

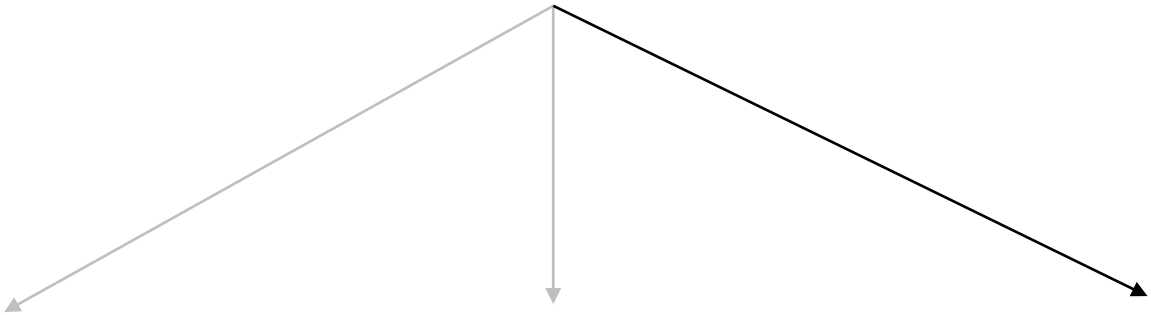
Lens/Cataracts Overview



Posterior subcapsular cataract. Oval to round nucleated Wedl cells *(arrows)* and smaller lens epithelial cells line the posterior lens capsule *(arrowhead).*

Lens/Cataracts Overview

There are three age-related types of cataracts:

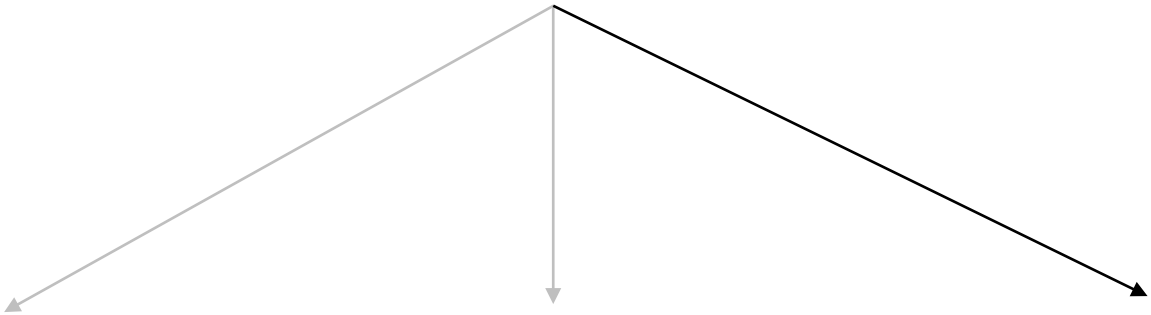


NSC Cortical **PSC**

The first and fundamental step in PSC pathophysiology is the migration of equatorial epithelial cells to and across the posterior capsule (PC). As these cells slither across the PC, they swell substantially. These swole cells (called *bladder cells* or *Wedl cells*) cause significant degradation of vision if they're in the visual axis. If a visual-axis PSC is small, its effect on vision may be lessened in dim light, when pupil dilation allows light to go around it. Similarly, because the near reflex induces miosis, PSC pts often complain that near vision is more degraded than distance vision.

Lens/Cataracts Overview

There are three age-related types of cataracts:



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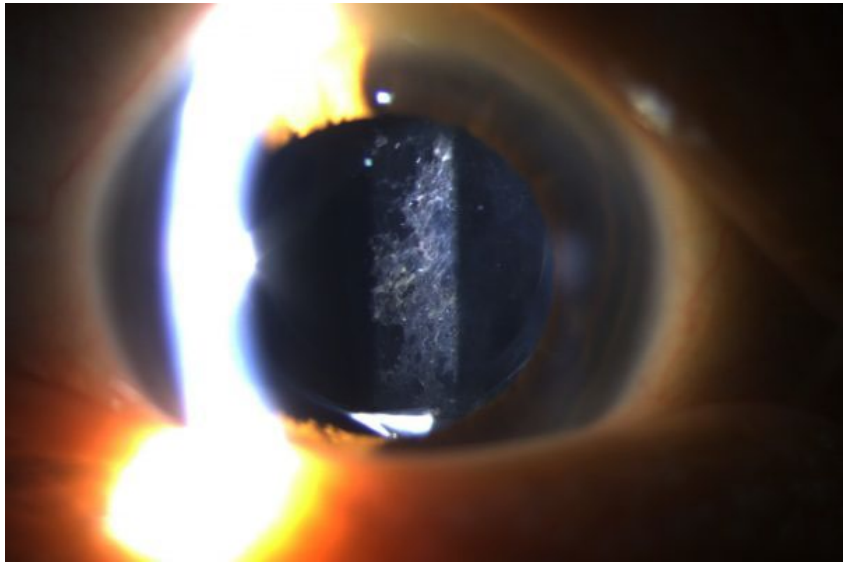
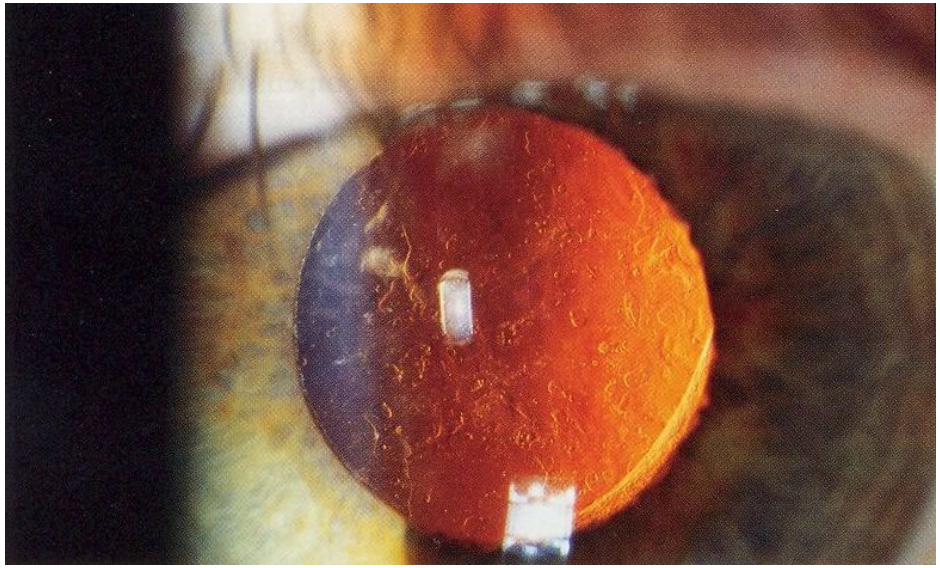
The first and fundamental step in PSC pathophysiology is the migration of equatorial epithelial cells to and across the posterior capsule (PC). As these cells slither across the PC, they swell substantially. These swole cells (called *bladder cells* or *Wedl cells*) cause significant degradation of vision if they're in the visual axis. If a visual-axis PSC is small, its effect on vision may be lessened in dim light, when pupil dilation allows light to go around it. Similarly, because the near reflex induces miosis, PSC pts often complain that near vision is more degraded than distance vision.

Important sidebar: The same pathologic process—migration and swelling of equatorial epithelial cells—is responsible for the most common post-CE complication, that being *posterior capsule opacification*. (Up to half of all adult CE pts will develop a PCO, as will essentially **all** peds cases.)

Lens/Cataracts Overview

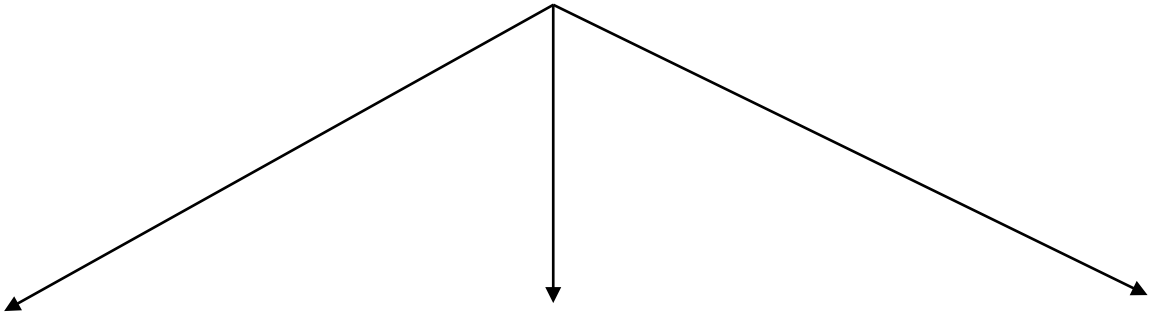




PCO

Lens/Cataracts Overview

There are three age-related types of cataracts:



NSC

Risk factors:

Cortical

Risk factors:

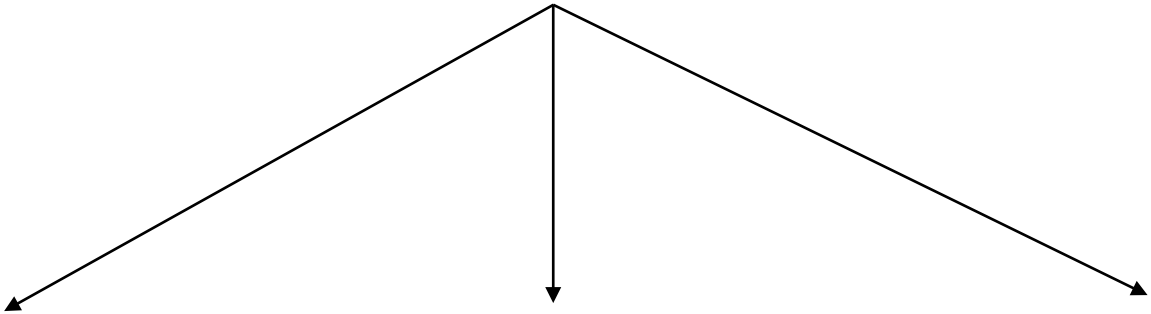
PSC

Risk factors:

Next we will look at risk factors for each of the age-related cataract types

Lens/Cataracts Overview

There are three age-related types of cataracts:



NSC

Risk factors:

Cortical

Risk factors:

PSC

Risk factors:

--**Steroids**

Steroids

Lens/Cataracts Overview

There are three age-related types of cataracts:

Any route of steroid administration you can think of has been associated with PSC formation:
--Topical
--Subconjunctival
--Sub-Tenon's
--Intravitreal
--PO
--IV
--Inhaled
--Intranasal

PSC

Risk factors:
--**Steroids**

Steroids

Lens/Cataracts Overview

There are three age-related types of cataracts:

Any route of steroid administration you can think of has been associated with PSC formation:
--Topical
--Subconjunctival
--Sub-Tenon's
--Intravitreal
--PO
--IV
--Inhaled
--Intranasal
In general, steroid-induced PSCs do not regress with cessation of steroids (with the notable exception of steroid-induced PSCs in *children*).

PSC

Risk factors:
--**Steroids**

Steroids

Lens/Cataracts Overview

There are three age-related types of cataracts:

Any route of steroid administration you can think of has been associated with PSC formation:
--Topical
--Subconjunctival
--Sub-Tenon's
--Intravitreal
--PO
--IV
--Inhaled
--Intranasal
In general, steroid-induced PSCs do not regress with cessation of steroids (with the notable exception of steroid-induced PSCs in *children*).

Interestingly, if a pt has a propensity to develop a steroid-induced PSC, s/he is also at increased risk of steroid-induced ocular hypertension.

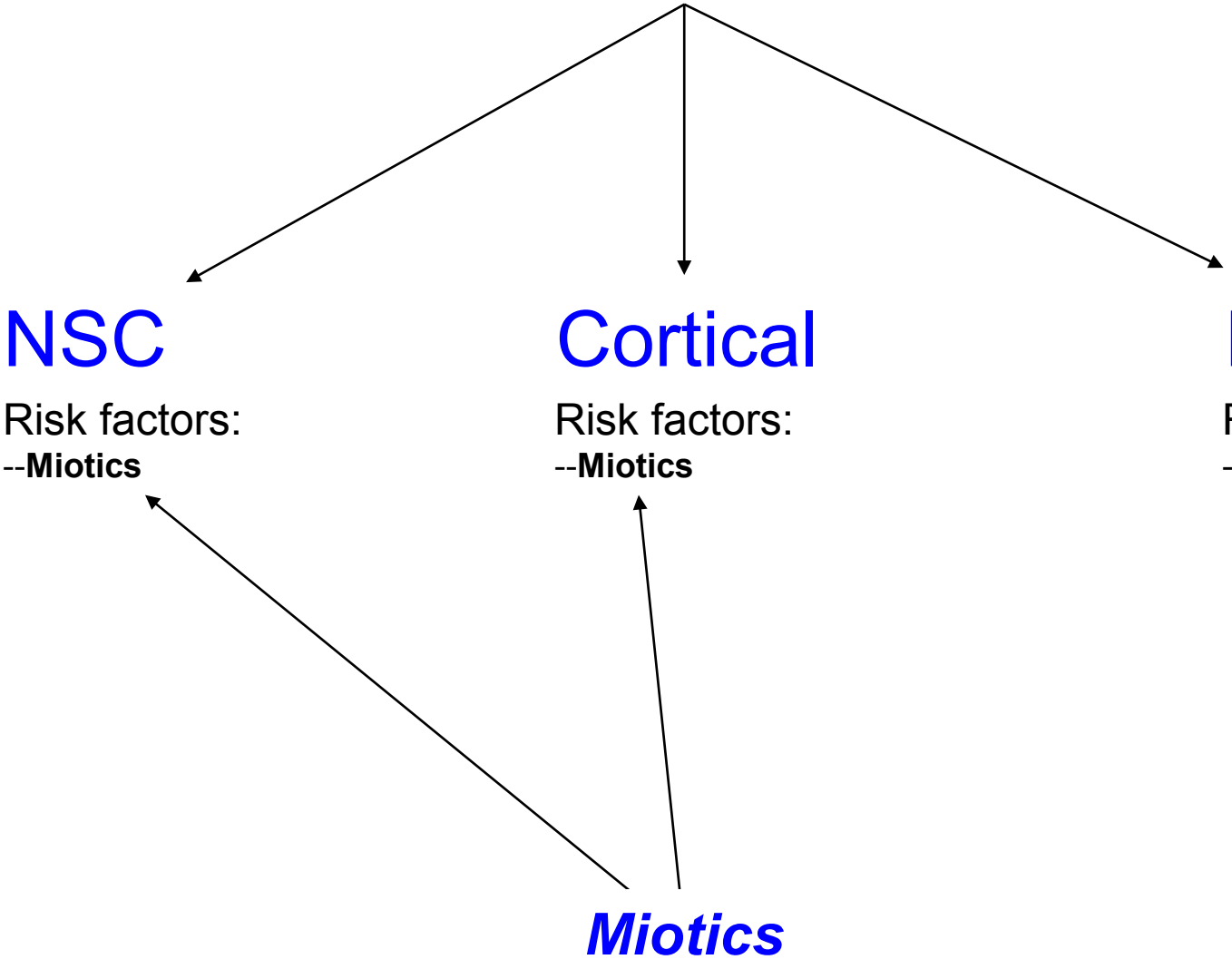
PSC

Risk factors:
--**Steroids**

Steroids

Lens/Cataracts Overview

There are three age-related types of cataracts:



Lens/Cataracts Overview

There are three age-related types of cataracts:

NSC

Risk factors:
--Miotics
--**Statins**

Cortical

Risk factors:
--Miotics

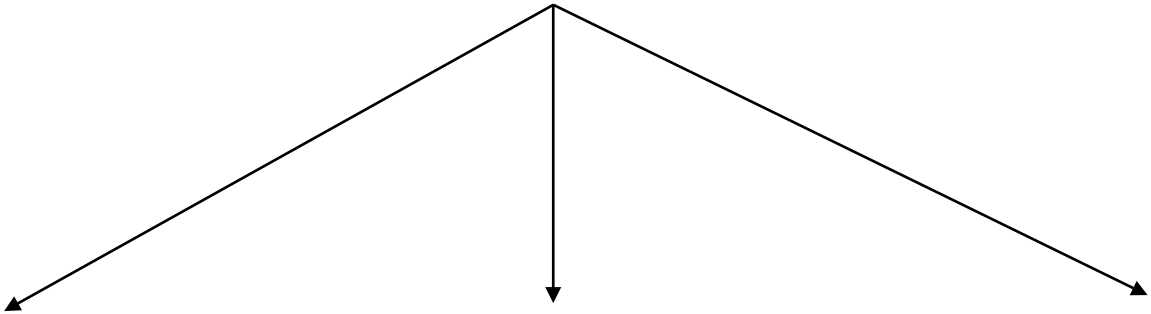
PSC

Risk factors:
--Steroids

Statins

Lens/Cataracts Overview

There are three age-related types of cataracts:



NSC

Risk factors:
--Miotics
--Statins

Cortical

Risk factors:
--Miotics
--**Infrared radiation**
--**UV radiation**

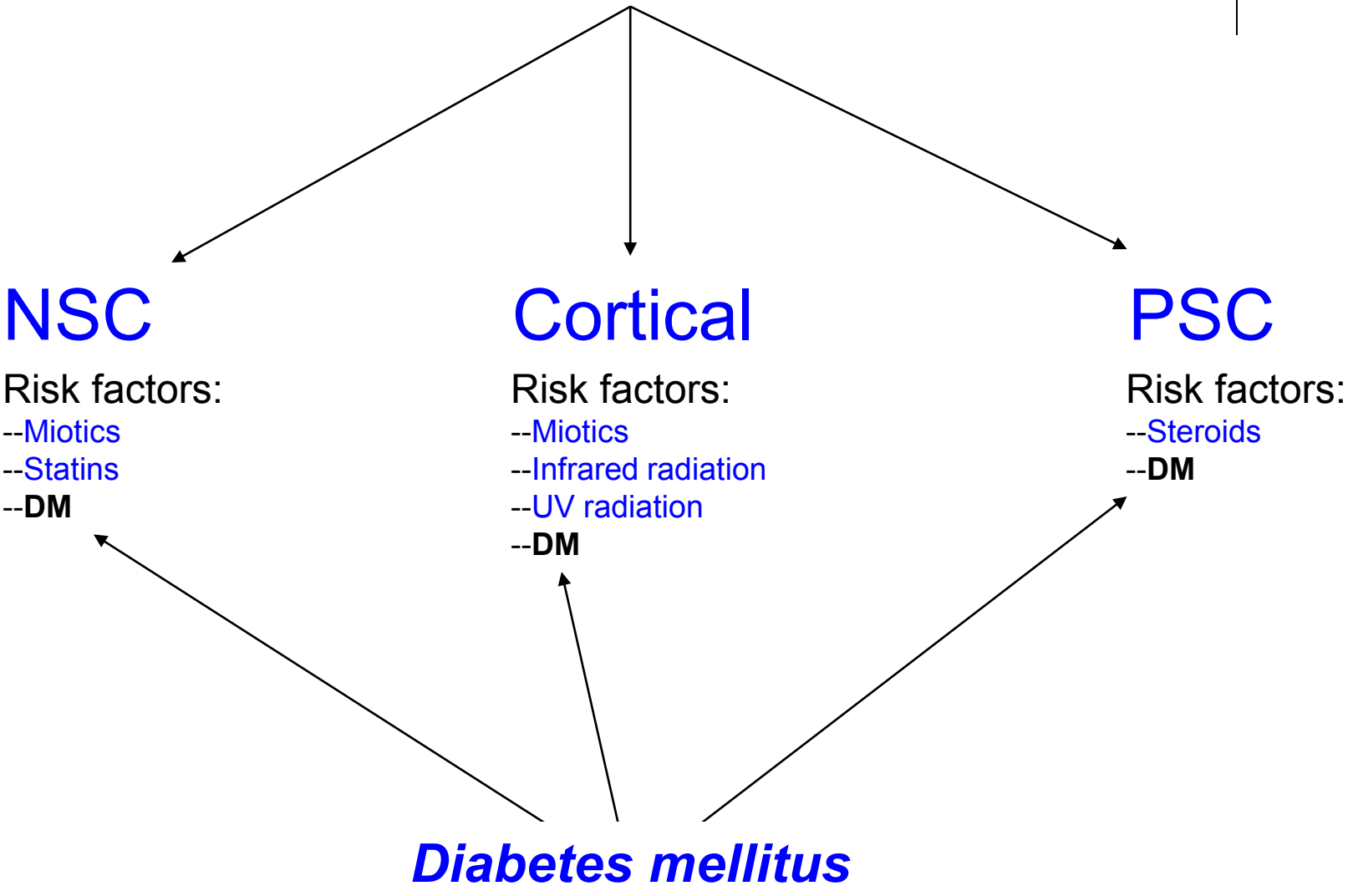
PSC

Risk factors:
--Steroids

Infrared and/or UV radiation

Lens/Cataracts Overview

There are three age-related types of cataracts:



Lens/Cataracts Overview

There are three age-related types of cataracts:

NSC

Risk factors:
--Miotics
--Statins
--**DM**

Cortical

Risk factors:
--Miotics
--Infrared radiation
--UV radiation
--**DM**

PSC

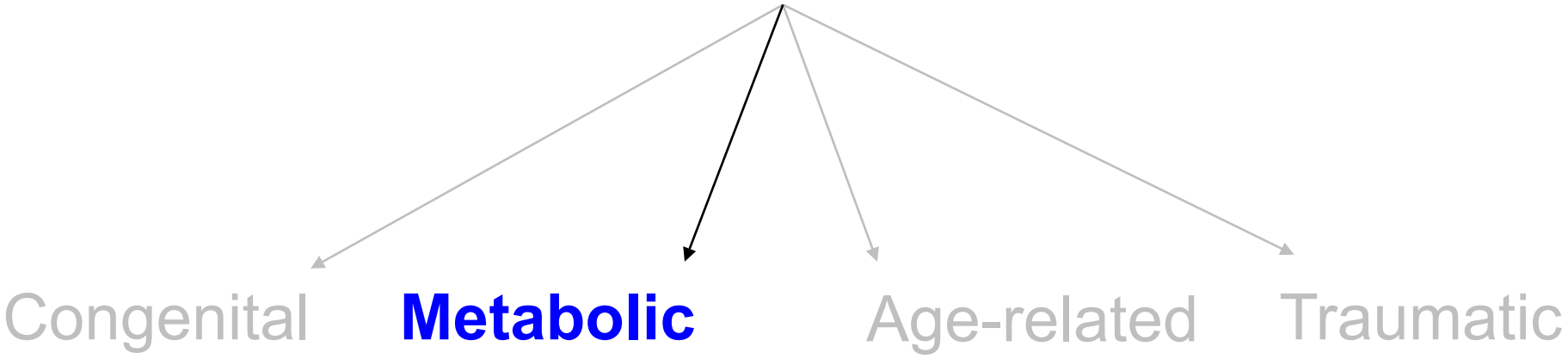
Risk factors:
--Steroids
--**DM**

Two sidebars re DM and cataracts:
1) Diabetes-related NSCs, cortical cataracts, and PSCs don't differ histopathologically from those associated with age; rather, DM seems to cause age-related cataracts to occur at an earlier age

Diabetes mellitus

Lens/Cataracts Overview

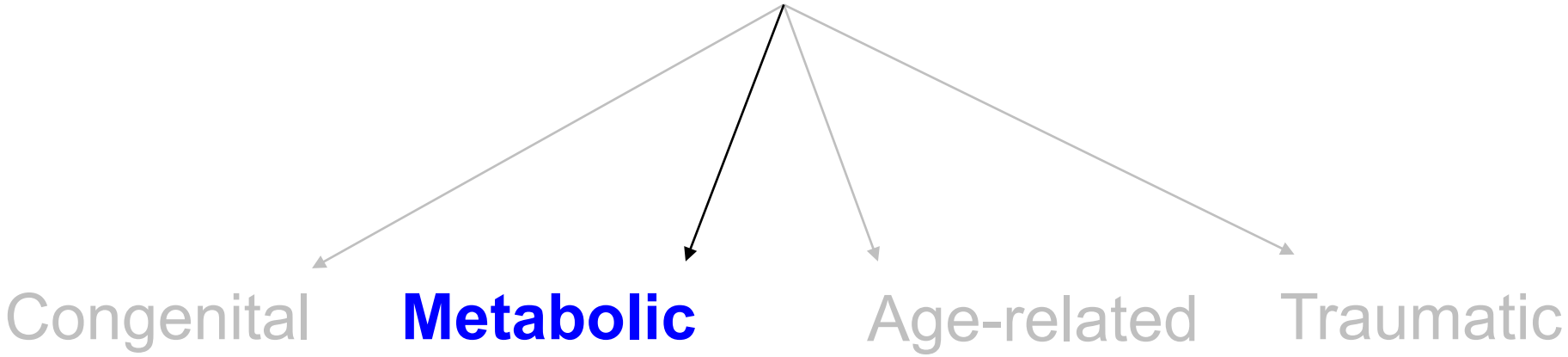
Per the *Lens* book, there are the four categories of cataracts:



Two sidebars re DM and cataracts:
2) Recall that, early in the Cataract section, we noted that cataracts can be **metabolic** in origin. In that regard, diabetes is one of the most common and important causes of metabolic cataract.

Lens/Cataracts Overview

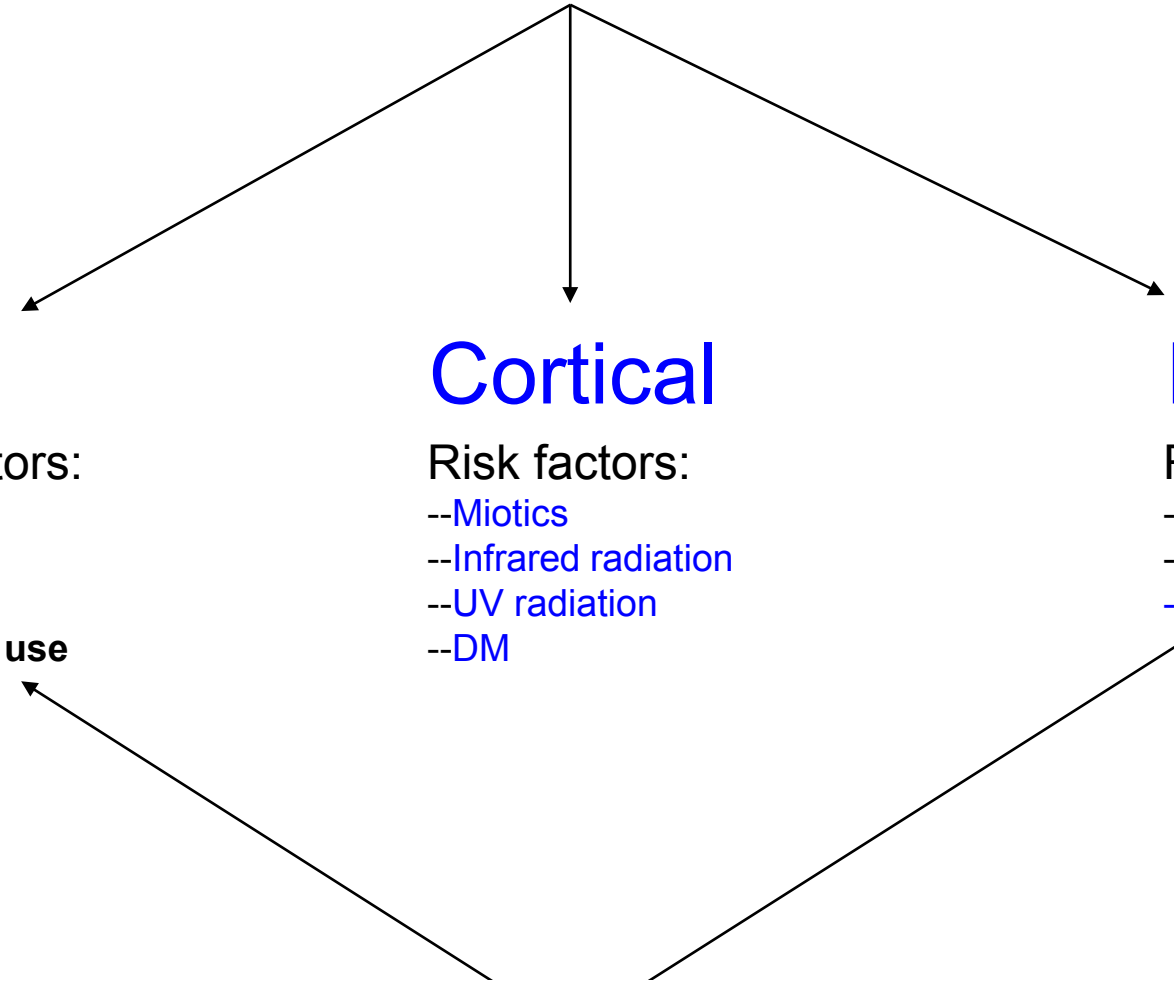
Per the *Lens* book, there are the four categories of cataracts:



Two sidebars re DM and cataracts:
2) Recall that, early in the Cataract section, we noted that cataracts can be **metabolic** in origin. In that regard, diabetes is one of the most common and important causes of metabolic cataract. But note that the pathophysiology underlying a DM-related metabolic cataract (aka a *sugar cataract*) is separate and distinct from DM's role in hastening the development of age-related cataracts.

Lens/Cataracts Overview

There are three age-related types of cataracts:



NSC

Risk factors:
--Miotics
--Statins
--DM
--**Tobacco use**

Cortical

Risk factors:
--Miotics
--Infrared radiation
--UV radiation
--DM

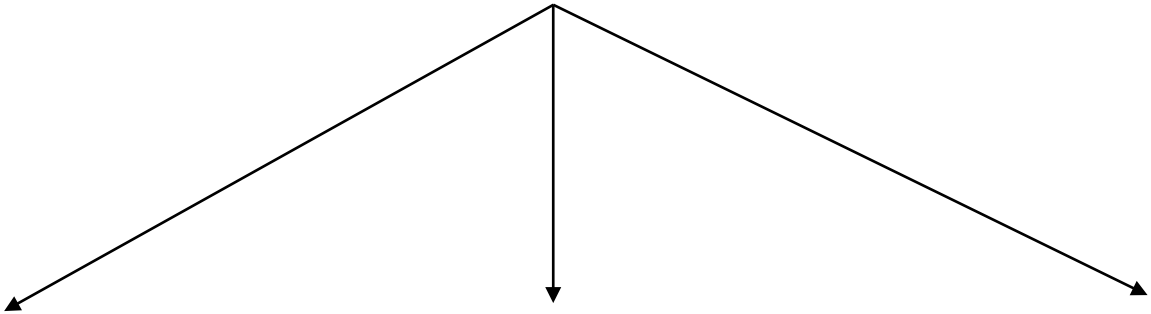
PSC

Risk factors:
--Steroids
--DM
--**Tobacco use**

Tobacco use (Both smoking and smokeless tobacco products)

Lens/Cataracts Overview

There are three age-related types of cataracts:



NSC

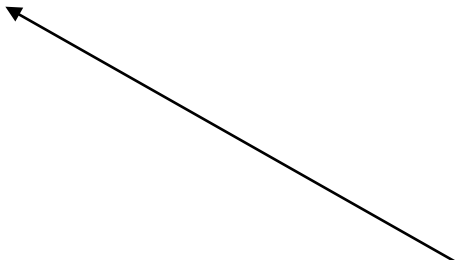
Risk factors:
--Miotics
--Statins
--DM
--Tobacco use
--**High myopia**

Cortical

Risk factors:
--Miotics
--Infrared radiation
--UV radiation
--DM

PSC

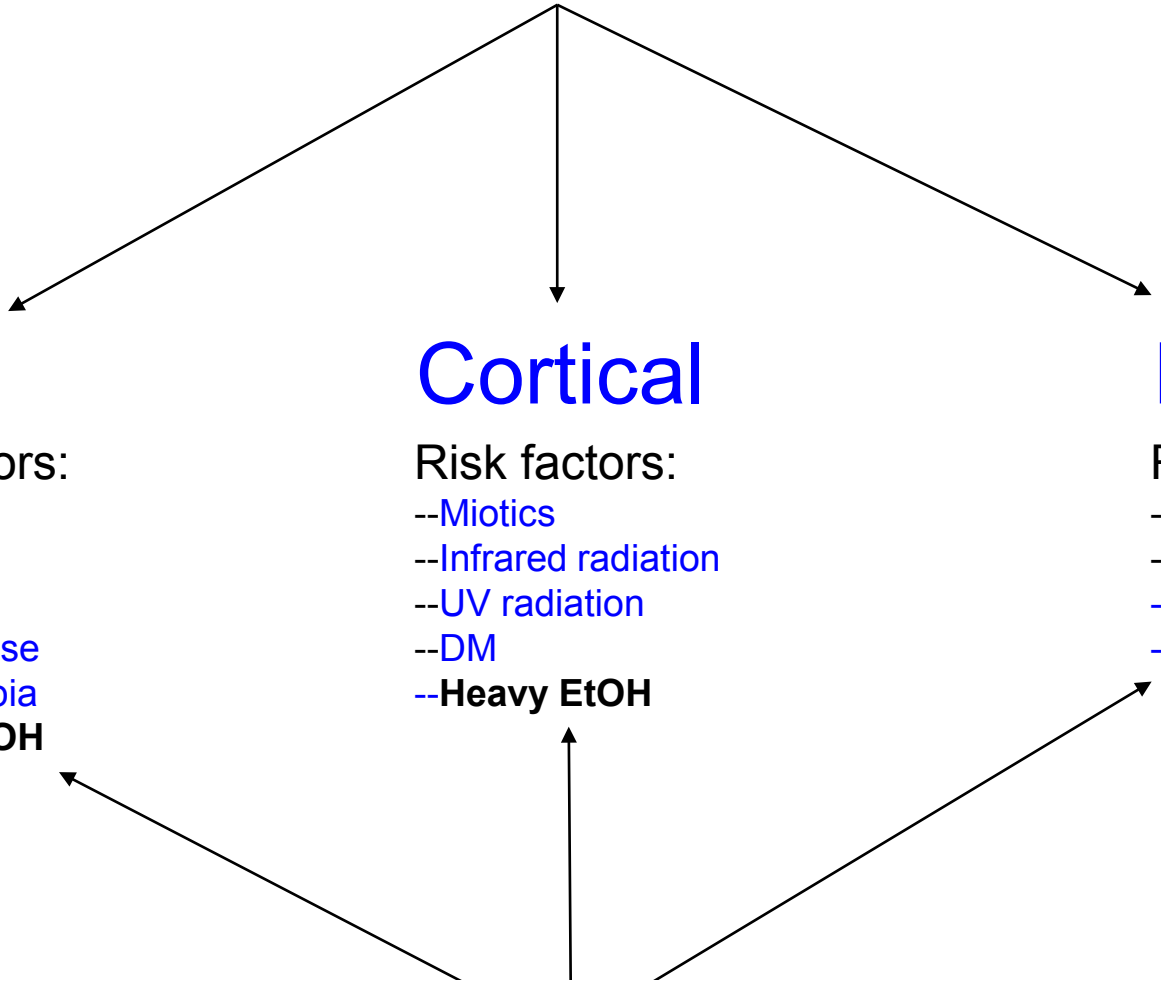
Risk factors:
--Steroids
--DM
--Tobacco use



High myopia

Lens/Cataracts Overview

There are three age-related types of cataracts:



Lens/Cataracts Overview

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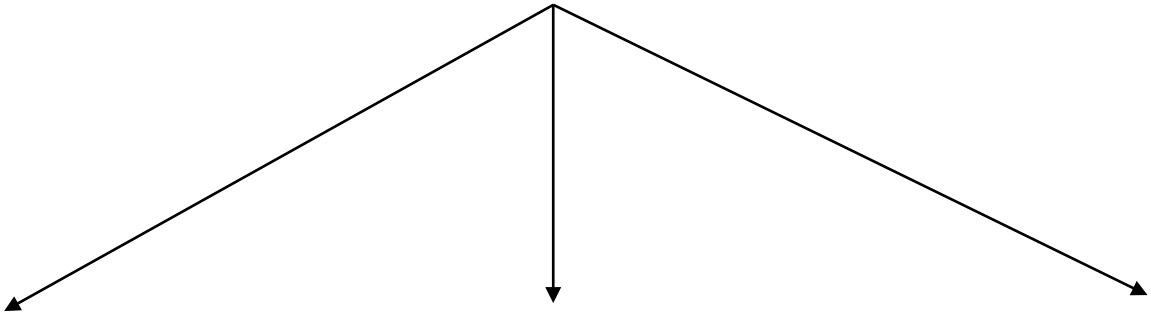


NSC

Risk factors:

--Miotics

--Statins

--**Tobacco use**

--**Heavy EtOH**

Cortical

Risk factors:

--Miotics

--Infrared radiation

--UV radiation

--**Heavy EtOH**

PSC

Risk factors:

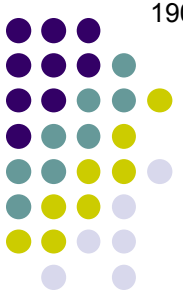
--Steroids

--**Tobacco use**

--**Heavy EtOH**

*Note that smoking, the use of smokeless tobacco products, and heavy alcohol consumption are all **modifiable risk factors** for cataract development*

Lens/Cataracts Overview



That's it! Go through this slide-set a couple of times (at least) until you feel like you have a handle on it. When you're ready, do slide-set *L14*, which covers this material in a Q&A format (and more detail).