Before you begin: This is a big topic, and big topics beget big slide-sets. There’s are a couple of natural breaks in the material (around slide 251, and again around 372); I placed *break time!* slides at those locations.
Anatomy of the mature* lens

- Type IV collagen
- Single layer of cuboidal cells
- Metabolically active; mitotically active
- Give rise to all new lens fibers
- Older, more densely packed fibers in central lens
- Newer fibers between nucleus and capsule/epithelium
- Originate from the basal lamina of the nonpigmented epithelium of the pars plana and pars plicata of the ciliary body

**The human lens has five basic components**—what are they?

*‘Mature’ meaning ‘postnatal;’ not referring here to a ‘mature’ cataract*
Anatomy of the mature* lens

- **Capsule**
- **Epithelium**
  - Single layer of cuboidal cells
  - Metabolically active; mitotically active
  - Give rise to all new lens fibers
- **Nucleus**
  - Older, more densely packed fibers in central lens
- **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
  - Three sets of fibers:
    - Anterior
    - Equatorial
    - Posterior

*‘Mature’ meaning ‘postnatal;’ not referring here to a ‘mature’ cataract*
Basic components of the mature lens
Lens/Cataracts Overview

Basic components of the mature lens: Another depiction
Basic components of the mature lens: Photomicrograph
Bruh, I’ve watched a lot of cataract surgery, and the labeling here is not right.

Basic components of the mature lens: Photomicrograph

No question yet—proceed when ready
Bruh, I’ve watched a lot of cataract surgery, and the labeling here is not right. For example, the ‘cortex’ is mos def **not** thick as suggested by this image; rather, it is a very thin layer adherent to the capsule that gets peeled off at the end of a case. What’s up?
Bruh, I’ve watched a lot of cataract surgery, and the labeling here is not right. For example, the ‘cortex’ is mos def not thick as suggested by this image; rather, it is a very thin layer adherent to the capsule that gets peeled off at the end of a case. What’s up?

What’s up is, you are confusing the anatomic cortex with the surgical cortex—they are not the same. (We will address this head-on later in the slide-set.)
Anatomy of the mature lens

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

- **Capsule**
  - Type IV collagen

- **Epithelium**

- **Nucleus**

- **Cortex**

- **Zonules**
Anatomy of the mature lens

- **Capsule**
  - Type IV collagen
- **Epithelium**
- **Nucleus**
- **Cortex**
- **Zonules**

Speaking histologically, what fundamental tissue structure does the capsule comprise?
Anatomy of the mature lens

- **Capsule**
  - Type IV collagen

- **Epithelium**
  - Single layer of cuboidal cells
  - Metabolically active; mitotically active
  - Give rise to all new lens fibers

- **Nucleus**
  - Older, more densely packed fibers in central lens

- **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
  - Three sets of fibers:
    - Anterior
    - Equatorial
    - Posterior

Q/A

- **Speaking histologically, what fundamental tissue structure does the capsule comprise?**
  - It is the **two words** of the lens epithelium.
Anatomy of the mature lens

- **Capsule**
  - Type IV collagen

- **Epithelium**
  - Single layer of cuboidal cells
  - Metabolically active; mitotically active
  - Give rise to all new lens fibers

- **Nucleus**
  - Older, more densely packed fibers in central lens

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  - Newer fibers between nucleus and capsule/epithelium

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    - Three sets of fibers:
      - Anterior
      - Equatorial
      - Posterior

Speaking histologically, what fundamental tissue structure does the capsule comprise?

It is the basement membrane of the lens epithelium.
Anatomy of the mature lens

- **Capsule**
  - Type IV collagen

- **Epithelium**
  - Single layer of cuboidal cells
  - Metabolically active; mitotically active
  - Give rise to all new lens fibers

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

---

**Q:**

Speaking histologically, what fundamental tissue structure does the capsule comprise?

It is the basement membrane of the lens epithelium

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**Q:**

But but but…The capsule is on the outside of the lens, and its epithelium is on the inside. Given this, how can the capsule possibly be the epithelium’s BM?
Anatomy of the mature lens

- **Capsule**
  - Type IV collagen
  - Speaking histologically, what fundamental tissue structure does the capsule comprise? It is the basement membrane of the lens epithelium.

- **Epithelium**
  - Single layer of cuboidal cells
  - Metabolically active; mitotically active
  - Give rise to all new lens fibers

- **Nucleus**
  - Older, more densely packed fibers in central lens

- **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
  - Three sets of fibers:
    - Anterior
    - Equatorial
    - Posterior

**Lens/Cataracts Overview**

But but but…The capsule is on the outside of the lens, and its epithelium is on the inside. Given this, how can the capsule possibly be the epithelium’s BM? It’s possible because *embryology*. We will have a great deal to say about lens embryology later in the slide-set, at which time the ‘How’ of the epi-capsule arrangement will be made clear.
Lens capsule thickness has important clinical and surgical implications. Let’s review it.

Anterior

Posterior

No question yet—proceed when ready
Lens/Cataracts Overview

Lens capsule thickness: Fill in the blanks

Anterior

? µm

? µm

Posterior

? µm

? µm

? µm

? µm
Q/A

Lens/Cataracts Overview

*Lens capsule thickness: Fill in the blanks*

Anterior

14 µm

? µm

? µm

Posterior

? µm

? µm

? µm
Lens/Cataracts Overview

Lens capsule thickness: Fill in the blanks

Anterior

14 µm

21 µm

Posterior

? µm

Q/A

2-4 µm
Q/A

Lens/Cataracts Overview

Lens capsule thickness: Fill in the blanks

Anterior

14 µm

21 µm

Posterior

17 µm

? µm

? µm

? µm
**Lens/Cataracts Overview**

**Lens capsule thickness: Fill in the blanks**

**Anterior**
- 14 µm
- 21 µm
- 23 µm

**Posterior**
- 17 µm
- ? µm

**Q/A**
Lens/Cataracts Overview

Lens capsule thickness: Fill in the blanks

Anterior

14 μm
21 μm
23 μm
2-4 μm

Posterior

17 μm
At 2-4 µm, the posterior capsule is so thin it is *always distended*. Thus, all changes in lens shape during accommodation occur at the *anterior* capsule.

Lens capsule thickness: Fill in the blanks

No question—proceed when ready
At 2-4 µm, the posterior capsule is so thin it is always distended. Thus, all changes in lens shape during accommodation occur at the anterior capsule.
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.
Anatomy of the mature lens

- **Capsule**
  - Type IV collagen

- **Epithelium**
  - Single layer of cuboidal cells
  - Metabolically and mitotically active
  - Give rise to all new lens fibers

- **Nucleus**
  - Older, more densely packed fibers in central lens

- **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
  - Three sets of fibers:
    - Anterior
    - Equatorial
    - Posterior
Anatomy of the mature lens

- **Capsule**
  - Type IV collagen

- **Epithelium**
  - Single layer of cuboidal cells

- **Nucleus**

- **Cortex**

- **Zonules**
Anatomy of the mature lens

- **Capsule**
  - Type IV collagen

- **Epithelium**
  - Single layer of cuboidal cells beneath capsule

- **Nucleus**
- **Cortex**
- **Zonules**

Zonules:
- Originate from the basal lamina of the nonpigmented epithelium of the pars plana and pars plicata of the ciliary body.
- Three sets of fibers:
  - Anterior
  - Equatorial
  - Posterior
Anatomy of the mature lens

- **Capsule**
  - Type IV collagen

- **Epithelium**
  - Single layer of cuboidal cells beneath anterior and equatorial capsule

- **Nucleus**

- **Cortex**

- **Zonules**

Lens/Cataracts Overview
Anterior lens capsule

Lens epithelium
Anatomy of the mature lens

- **Capsule**
  - Type IV collagen

- **Epithelium**
  - Single layer of cuboidal cells beneath anterior and equatorial capsule
  - Metabolically active vs inactive

- **Nucleus**

- **Cortex**

- **Zonules**
  - Originate from the basal lamina of the nonpigmented epithelium of the pars plana and pars plicata of the ciliary body
    - Three sets of fibers:
      - Anterior
      - Equatorial
      - Posterior
Anatomy of the mature lens

- **Capsule**
  - Type IV collagen

- **Epithelium**
  - Single layer of cuboidal cells beneath anterior and equatorial capsule
  - Metabolically active

- **Nucleus**

- **Cortex**

- **Zonules**
Anatomy of the mature lens

- **Capsule**
  - Type IV collagen

- **Epithelium**
  - Single layer of cuboidal cells beneath anterior and equatorial capsule
  - Metabolically active; mitotically inactive

- **Nucleus**

- **Cortex**

- **Zonules**

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

- **Nucleus**

- **Cortex**

- **Zonules**
Anatomy of the mature lens

- **Capsule**
  - Type IV collagen

- **Epithelium**
  - Single layer of cuboidal cells beneath anterior and equatorial capsule
  - Metabolically active; mitotically active

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**Let’s sidebar on a couple of important topics related to lens metabolism**

- **Cortex**

- **Zonules**
What is the primary substrate in lens metabolism?
What is the primary substrate in lens metabolism?

Glucose
What is the primary process by which glucose is used to generate energy?

(majority of glucose)
What is the primary process by which glucose is used to generate energy?

**Anaerobic Glycolysis**
(majority of glucose)
Glucose $\xrightarrow{\text{Hexokinase}}$ G6P

(The majority of glucose) accounts for most of the rest

Anaerobic Glycolysis (majority of glucose) (5% of glucose)
The top-line point: **Lens metabolism is dependent upon the presence of glucose, not oxygen.**
The top-line point: **Lens metabolism is dependent upon the presence of glucose, not oxygen.** Even in a zero-oxygen environment (such as can be created in a lab setting), a lens will remain transparent and viable so long as it has an adequate glucose supply.
The top-line point: **Lens metabolism is dependent upon the presence of glucose, not oxygen.** Even in a zero-oxygen environment (such as can be created in a lab setting), a lens will remain transparent and viable so long as it has an adequate glucose supply. However, in the reverse environmental situation—that is, one in which oxygen is abundant but glucose is absent—the lens will become cloudy and nonviable in a matter of hours.
Anatomy of the mature lens

- **Capsule**
  - Type IV collagen

- **Epithelium**
  - Single layer of cuboidal cells beneath anterior and equatorial capsule
  - Metabolically active; mitotically active

- **Nucleus**
  - Older, more densely packed fibers in central lens

- **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
    - Three sets of fibers:
      - Anterior
      - Equatorial
      - Posterior

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Lens/Cataracts Overview

The cells in one section of the epithelium are especially mitotically active—which section?
Q/A

Anatomy of the mature lens

- **Capsule**
  - Type IV collagen

- **Epithelium**
  - Single layer of cuboidal cells beneath anterior and equatorial capsule
  - Metabolically active; mitotically active

- **Nucleus**
  - Older, more densely packed fibers in central lens

- **Cortex**

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

**Lens/Cataracts Overview**

The cells in one section of the epithelium are especially mitotically active—which section? Those located in the \textit{germinative zone} (GZ)
Anatomy of the mature lens

- Capsule
  - Type IV collagen
- Epithelium
  - Single layer of cuboidal cells beneath anterior and equatorial capsule
  - Metabolically active; mitotically active
- Nucleus
- Cortex
- Zonules

Lens/Cataracts Overview

The cells in one section of the epithelium are especially mitotically active—which section? Those located in the germinative zone (GZ)
Anatomy of the mature lens

- **Capsule**
  - Type IV collagen

- **Epithelium**
  - Single layer of cuboidal cells beneath anterior and equatorial capsule
  - Metabolically active; mitotically active

- **Nucleus**
  - Older, more densely packed fibers in central lens

- **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
  - Three sets of fibers:
    - Anterior
    - Equatorial
    - Posterior

---

The cells in one section of the epithelium are especially mitotically active—which section?

Those located in the **germinative zone** (GZ). The \( \text{peripheral v central} \) -shaped GZ is located in the aspect of the anterior capsule.
Anatomy of the mature lens

- **Capsule**
  - Type IV collagen

- **Epithelium**
  - Single layer of cuboidal cells beneath anterior and equatorial capsule
  - Metabolically active; mitotically active

- **Nucleus**
  - Older, more densely packed fibers in central lens

- **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
  - Three sets of fibers:
    - Anterior
    - Equatorial
    - Posterior

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**Lens/Cataracts Overview**

The cells in one section of the epithelium are especially mitotically active—which section? Those located in the *germinative zone* (GZ). The ring-shaped GZ is located in the peripheral aspect of the anterior capsule.
Lens epi cells and their relation to the capsule and GZ
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

- **Nucleus**

- **Cortex**

- **Zonules**
  - Originate from the basal lamina of the nonpigmented epithelium of the pars plana and pars plicata of the ciliary body
  - Three sets of fibers:
    - Anterior
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Anatomy of the mature lens

- **Capsule**
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  - Metabolically active; mitotically active
  - Give rise to all new lens fibers

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- **Cortex**

- **Zonules**
Anatomy of the mature lens

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

- **Nucleus**
  - *How does the epi give rise to lens fibers?*
  - After their creation in the GZ, newly-minted epi cells migrate to the so-called **region** of the equatorial lens

- **Cortex**

- **Zonules**
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**

- **Nucleus**
  - *How does the epi give rise to lens fibers?*
  - After their creation in the GZ, newly-minted epi cells migrate to the so-called *bow region* of the equatorial lens

- **Cortex**

- **Zonules**
Lens epi cells and their relation to the capsule, GZ, and bow region
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**

- **Nucleus**
  - How does the epi give rise to lens fibers?
  - After their creation in the GZ, newly-minted epi cells migrate to the so-called bow region of the equatorial lens. **It is in the bow region that these cells begin the process of terminal differentiation into lens fibers**, a process characterized by 1) elongation of the cell, and 2) the loss of its organelles.

- **Cortex**

- **Zonules**
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

- **Nucleus**
  - Older, more densely packed fibers in central lens

- **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

  - Three sets of fibers:
    - Anterior
    - Equatorial
    - Posterior

---

**Lens/Cataracts Overview**

Q

- **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
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    - Older, more densely packed fibers in central lens
  - **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
    - Three sets of fibers:
      - Anterior
      - Equatorial
      - Posterior

---

**How does the epi give rise to lens fibers?**

After their creation in the GZ, newly-minted epi cells migrate to the so-called **bow region** of the equatorial lens. It is in the bow region that these cells undergo terminal differentiation into lens fibers, characterized by 1) elongation of the cell and 2) the loss of organelles.

**Is it pronounced ‘bow’ as in ‘bow tie,’ or bow as in ‘take a bow’?**
Anatomy of the mature lens

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  - Type IV collagen

- **Epithelium**
  - Single layer of cuboidal cells beneath anterior and equatorial capsule
  - Metabolically active; mitotically active
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    - Anterior
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---

**Lens/Cataracts Overview**

How does the epi give rise to lens fibers?

After their creation in the GZ, newly-minted epi cells migrate to the so-called *bow region* of the equatorial lens. It is in the bow region that these cells begin the process of terminal differentiation into lens fibers, characterized by 1) elongation of the cell, and 2) the loss of its organelles.

Is it pronounced ‘bow’ as in ‘bow tie,’ or bow as in ‘take a bow’?

It’s pronounced ‘bow’ as in ‘the bow of a ship,’ which is what it looks like in cross-section; check it on the Figure again (re-presented on the next slide).
Lens epi cells and their relation to the capsule, GZ, and bow region
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**

- **Nucleus**
  - How does the epi give rise to lens fibers?
  - After their creation in the GZ, newly-minted epi cells migrate to the so-called bow region of the equatorial lens. It is in the bow region that these cells begin the process of terminal differentiation into lens fibers, a process characterized by 1) elongation of the cell, and 2) the loss of its organelles.

- **Cortex**

- **Zonules**
  - **Elongation**

How much elongation are we talking about here?
Anatomy of the mature lens

- **Capsule**
  - Type IV collagen

- **Epithelium**
  - Single layer of cuboidal cells beneath anterior and equatorial capsule
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- **Nucleus**
  - Older, more densely packed fibers in central lens

- **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
  - Three sets of fibers:
    - Anterior
    - Equatorial
    - Posterior

Q/A

**How does the epi give rise to lens fibers?**
After their creation in the GZ, newly-minted epi cells migrate to the so-called bow region of the equatorial lens. It is in the bow region that these cells begin the process of terminal differentiation into lens fibers, a process characterized by 1) elongation of the cell, and 2) the loss of its organelles.

**How much elongation are we talking about here?**
Lots. As in, fibers elongate both anteriorly and posteriorly until they run into an elongating fiber from the other side (occurs near the lens’s poles).
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**

- **Nucleus**
  - How does the epi give rise to lens fibers?
  - After their creation in the GZ, newly-minted epi cells migrate to the so-called *bow region* of the equatorial lens. It is in the bow region that these cells begin the process of terminal differentiation into lens fibers, a process characterized by 1) elongation of the cell, and 2) the loss of its organelles.

- **Cortex**

- **Zonules**
  - **elongation**

How much elongation are we talking about here?
Lots. As in, fibers elongate both anteriorly and posteriorly until they run into an elongating fiber from the *other* side (occurs near the lens’s poles).
Anatomy of the mature lens

- **Capsule**
  - Type IV collagen

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

---

How does the epi give rise to lens fibers?
After their creation in the GZ, newly-minted epi cells migrate to the so-called bow region of the equatorial lens. It is in the bow region that these cells begin the process of terminal differentiation into lens fibers, a process characterized by 1) elongation of the cell, and 2) the loss of its organelles.

How much elongation are we talking about here?
Lots. As in, fibers elongate both anteriorly and posteriorly until they run into an elongating fiber from the other side (occurs near the lens’s poles). Thus, the typical fiber will run roughly halfway around the extent of the lens.
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

- **Nucleus**
  - Older, more densely packed fibers in central lens

- **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
  - Three sets of fibers:
    - Anterior
    - Equatorial
    - Posterior

---

**Lens/Cataracts Overview**

**Q** How does the epi give rise to lens fibers?

After their creation in the GZ, newly-minted epi cells migrate to the so-called **bow region** of the equatorial lens. It is in the bow region that these cells begin the process of terminal differentiation into lens fibers, a process characterized by 1) elongation of the cell, and 2) the loss of its organelles.

**How much elongation are we talking about here?**

Lots. As in, fibers elongate both anteriorly and posteriorly until they run into an elongating fiber from the other side (occurs near the lens’s poles). Thus, the typical fiber will run roughly halfway around the extent of the lens.

**What do fibers do when they encounter a fellow-traveler elongating from the opposite side of the lens?**
Anatomy of the mature lens

- **Capsule**
  - Type IV collagen

- **Epithelium**
  - Single layer of cuboidal cells beneath anterior and equatorial capsule
  - Metabolically active; mitotically active
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- **Nucleus**
  - Older, more densely packed fibers in central lens

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  - 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
  - Three sets of fibers:
    - Anterior
    - Equatorial
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---

**Q/A**

**How does the epi give rise to lens fibers?**

After their creation in the GZ, newly-minted epi cells migrate to the so-called bow region of the equatorial lens. It is in the bow region that these cells begin the process of terminal differentiation into lens fibers, a process characterized by 1) elongation of the cell, and 2) the loss of its organelles.

**How much elongation are we talking about here?**

Lots. As in, fibers elongate both anteriorly and posteriorly until they run into an elongating fiber from the other side (occurs near the lens’s poles). Thus, the typical fiber will run roughly halfway around the extent of the lens.

**What do fibers do when they encounter a fellow-traveler elongating from the opposite side of the lens?**

The two fibers interdigitate with one another.
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**

- **Nucleus**
  - How does the epi give rise to lens fibers?
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- **Cortex**

- **Zonules**
  - **Elongation**

How much elongation are we talking about here?
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What do fibers do when they encounter a fellow-traveler elongating from the opposite side of the lens?
The two fibers interdigitate with one another
Photomicrograph demonstrating ‘packing’ of lens fibers (just because it’s cool)

Photomicrograph demonstrating fibers interdigitating* (the hard-to-see arrows)

*I know, the depicted interdigitations are side-by-side, whereas the discussion has been of interdigitations that are head-on. Couldn’t find a pic of that, sorry.
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- **Nucleus**
  - Older, more densely packed fibers in central lens

- **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
  - Three sets of fibers:
    - Anterior
    - Equatorial
    - Posterior

**Lens/Cataracts Overview**

> How does the epi give rise to lens fibers?

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> Which organelles go bye-bye?
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- **Cortex**

- **Zonules**
  - Which organelles go bye-bye?
  - Pretty much all of them, including the nucleus and mitochondria
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So is it safe to assume lens fibers are nonliving structures, like (say) hair and nails?
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So is it safe to assume lens fibers are nonliving structures, like (say) hair and nails? Far from it. Not only are they living cells, they must be so for the lens to remain optically clear—fiber cells turn opaque within hours if their metabolic needs are unmet.
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---

**Q**

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- **Why is organelle disintegration critical to lens function?**
  - **Loss of its organelles**

  Because most organelles are large enough to where they would scatter incoming light, and thus their presence would compromise vision.
Anatomy of the mature lens

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**Q/A**

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Pretty much all of them, including the nucleus and mitochondria.

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**Loss of its organelles**
A

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Which organelles go bye-bye?
Pretty much all of them, including the nucleus and mitochondria of the epi cells.

Why is organelle disintegration critical to lens function?
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*If you answered “absorb,” that’s OK too*
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**At what point during this transformation does organelle disintegration occur?**

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At what point during this transformation does organelle disintegration occur?
Not until the very end, ie, upon meeting and interdigitating with another fiber

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**Is there a reason the organelles have to stick around until the end?**

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Very much so. Consider: When a cuboidal epi cell (scale: microns) transforms into a fiber (scale: millimeters, or even centimeters), its intracellular volume increases enormously—by multiple orders of magnitude. This space has to contain something, and in the case of lens fibers it is filled with lens proteins.

Thus, while the fiber is elongating, its intracellular machinery is cranking out lens proteins to fill the space, a process that can't end until the fiber has fully elongated. (BTW, we will have much more to say about lens proteins later in the slide-set.)

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**Lens/Cataracts Overview**

How does the epi give rise to lens fibers?

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1. **Elongation of the cell**
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**At what point during this transformation does organelle disintegration occur?**

Not until the very end, ie, upon meeting and interdigitating with another fiber.

**Is there a reason the organelles have to stick around until the end?**

Very much so. Consider: When a cuboidal epi cell (scale: microns) transforms into a fiber (scale: millimeters, or even centimeters), its intracellular volume increases enormously—by multiple orders of magnitude. This space has to contain something, and in the case of lens fibers it is filled with lens proteins.

Thus, while the fiber is elongating, its intracellular machinery is cranking out lens proteins to fill the space, a process that can’t end until the fiber has fully elongated. (BTW, we will have much more to say about lens proteins later in the slide-set.)

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Which organelles go bye-bye?

Pretty much all of them, including the nucleus and mitochondria. So is it safe to assume lens fibers are nonliving structures, like (say) hair and nails?

Far from it. Not only are they living cells, they must be so for the lens to remain optically clear—fiber cells turn opaque within hours if their metabolic needs are unmet. (And to anticipate a reasonable inference—no, fiber-cell death is not implicated in cataract formation.)

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Does it though? That is, why does the intracellular space of lens fibers have to contain something besides a fluid that is roughly isotonic to that of the extracellular space?

The reason lens fibers must be filled with something other than isotonic fluid can be summed up in two words: Snell's law. Allow me to explain.

Rhetorical question—keep going
Anatomy of the mature lens

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**Lens/Cataracts Overview**

**At what point during this transformation does organelle disintegration occur?** Not until the very end, ie, upon meeting and interdigitating with another fiber.

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**Does it though? That is, why does the intracellular space of lens fibers have to contain something besides a fluid that is roughly isotonic to that of the extracellular space?** The reason lens fibers must be filled with something other than isotonic fluid can be summed up in two words: **Snell’s law.** Allow me to explain.

No question yet—keep going
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Lens/Cataracts Overview

But first, consider the primary purpose of the lens: Focusing incoming light on the fovea.

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Which organelles go bye-bye?
Pretty much all of them, including the nucleus and mitochondria.

So is it safe to assume lens fibers are nonliving structures, like (say) hair and nails?
Far from it. Not only are they living cells, they must be so for the lens to remain optically clear—fiber cells turn opaque within hours if their metabolic needs are unmet. (And to anticipate a reasonable inference—no, fiber-cell death is not implicated in cataract formation.)

What about the intracellular organelles? Did they all just up and leave?
Yes and no. As a general rule, lens fibers are optically clear, but they are filled with specialized proteins that are synthesized by the lens epidermis.

Does it though? That is, why does the intracellular space of lens fibers have to contain something besides a fluid that is roughly isotonic to that of the extracellular space?
The reason lens fibers must be filled with something other than isotonic fluid can be summed up in two words: Snell’s law. Allow me to explain.

Snell’s law tells us that the dioptric power at a refracting surface is:

\[ n' \frac{r}{n} \]

where
- \( n' \) is the refractive index of the substance the light is heading into (the lens in this case),
- \( n \) is the refractive index of the substance the light is coming from (the aqueous), and
- \( r \) is the radius of curvature of the refracting surface (the anterior lens capsule).

This space has to contain something. It’s not all just empty, as might be the case with (say) hair and nails.

Far from it. Not only are they living cells, they must be so for the lens to remain optically clear—fiber cells turn opaque within hours if their metabolic needs are unmet. (And to anticipate a reasonable inference—no, fiber-cell death is not implicated in cataract formation.)
But first, consider the primary purpose of the lens: Focusing incoming light on the fovea. To do this, the lens must supply \textbf{[ ]} (aka \textbf{[ ]}) power.

\textbf{Does it though?} That is, why does the intracellular space of lens fibers have to contain something besides a fluid that is roughly isotonic to that of the extracellular space? The reason lens fibers must be filled with something other than isotonic fluid can be summed up in two words: \textbf{Snell's law}. Allow me to explain.

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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

Nucleus

Older, more densely packed fibers in central lens

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

Three sets of fibers:

- Anterior
- Equatorial
- Posterior

Lens/Cataracts Overview

But first, consider the primary purpose of the lens: Focusing incoming light on the fovea. To do this, the lens must supply \textit{plus} \textit{(aka converging)} power.

\textbf{This space has to contain something}

\textit{Does it though? That is, why does the intracellular space of lens fibers have to contain something besides a fluid that is roughly isotonic to that of the extracellular space? The reason lens fibers must be filled with something other than isotonic fluid can be summed up in two words: Snell's law. Allow me to explain.}

Far from it. Not only are they living cells, they \textbf{must} be so for the lens to remain optically clear—fiber cells turn opaque within hours if their metabolic needs are unmet. \textbf{(And to anticipate a reasonable inference—no, fiber-cell death is not implicated in cataract formation.)}
**Anatomy of the mature lens**

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**Lens/Cataracts Overview**

But first, consider the primary purpose of the lens: Focusing incoming light on the fovea. To do this, the lens must supply **plus** (aka converging) power. Of the roughly # of converging power possessed by the typical eye, # are supplied by the lens (the other # being supplied by the **capsule**). How does the epi give rise to lens fibers?

After their creation in the GZ, newly-minted epi cells migrate to the so-called **bow** region of the equatorial lens. It is in the bow region that these cells begin the process of terminal differentiation into lens fibers, a process characterized by 1) elongation of the cell, and 2) the loss of its organelles.

Which organelles go bye-bye? Pretty much all of them, including the nucleus and mitochondria. So is it safe to assume lens fibers are nonliving structures, like (say) hair and nails? Far from it. Not only are they living cells, they must be so for the lens to remain optically clear—fiber cells turn opaque within hours if their metabolic needs are unmet. (And to anticipate a reasonable inference—no, fiber-cell death is **not** implicated in cataract formation.)

At what point during this transformation does organelle disintegration occur? Not until the very end, ie, upon meeting and interdigitating with another fiber. Is there a reason the organelles have to stick around until the end? Very much so. Consider: When a cuboidal epi cell (scale: microns) transforms into a fiber (scale: millimeters, or even centimeters), its intracellular volume increases enormously—by multiple orders of magnitude. This space has to contain something, and in the case of lens fibers it is filled with lens proteins. Thus, while the fiber is elongating, its intracellular machinery is cranking out lens proteins to fill the space, a process that can't end until the fiber has fully elongated. (BTW, we will have much more to say about lens proteins later in the slide-set.)

Does it though? That is, why does the intracellular space of lens fibers have to contain something besides a fluid that is roughly isotonic to that of the extracellular space? The reason lens fibers must be filled with something other than isotonic fluid can be summed up in two words: **Snell's law**. Allow me to explain.

Snell's law tells us that the dioptric power at a refracting surface is:

\[
D = \frac{n'}{n}r
\]

where
- $n'$ is the refractive index of the substance the light is heading into (the lens in this case),
- $n$ is the refractive index of the substance the light is coming from (the aqueous), and
- $r$ is the radius of curvature of the refracting surface (the anterior lens capsule).

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A

**Lens/Cataracts Overview**

But first, consider the primary purpose of the lens: Focusing incoming light on the fovea. **To do this, the lens must supply plus (aka converging) power.** Of the roughly 60D of converging power possessed by the typical eye, 20D are supplied by the lens (the other 40D being supplied by the cornea.)

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### Anatomy of the mature lens

- **Capsule**
  - Type IV collagen
  - Single layer of cuboidal cells beneath anterior and equatorial capsule
  - Metabolically active; mitotically active
  - Give rise to all new lens fibers

- **Nucleus**
  - Older, more densely packed fibers in central lens

- **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
  - Three sets of fibers:
    - Anterior
    - Equatorial
    - Posterior

---

**Does it though?** That is, why does the intracellular space of lens fibers have to contain something besides a fluid that is roughly isotonic to that of the extracellular space? The reason lens fibers must be filled with something other than isotonic fluid can be summed up in two words: **Snell’s law.** Allow me to explain.

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Lens/Cataracts Overview

But first, consider the primary purpose of the lens: Focusing incoming light on the fovea. To do this, the lens must supply **plus** (aka converging) power. Of the roughly 60D of converging power possessed by the typical eye, 20D are supplied by the lens (the other 40D being supplied by the cornea.)

Here's where Snell's law comes into play. Snell's law tells us that the dioptric power produced at a refracting surface is

\[ D = \frac{n' - n}{r} \]

where \( n' \) is the refractive index of the substance the light is heading into (the lens in this case), \( n \) is the refractive index of the substance the light is coming from (the aqueous), and \( r \) is the radius of curvature of the refracting surface (the anterior lens capsule).

This space has to contain something

Does it though? That is, why does the intracellular space of lens fibers have to contain something besides a fluid that is roughly isotonic to that of the extracellular space? The reason lens fibers must be filled with something other than isotonic fluid can be summed up in two words: **Snell's law**. Allow me to explain.

Far from it. Not only are they living cells, they must be so for the lens to remain optically clear—fiber cells turn opaque within hours if their metabolic needs are unmet. (And to anticipate a reasonable inference—no, fiber-cell death is not implicated in cataract formation.)

No question—advance when ready
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
- **Nucleus**: Older, more densely packed fibers in central lens
- **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
  - Three sets of fibers:
    - Anterior
    - Equatorial
    - Posterior

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**Lens/Cataracts Overview**

OK, but what does all this have to do with the intracellular composition of lens fibers? The issue is one of refractive index. Look at Snell’s law again, and note that the magnitude of the numerator is determined not by the values of the two refractive indices, but rather by the *difference* between the values.

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D = \frac{n' - n}{r}
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where \( n' \) is the refractive index of the substance the light is heading into (the lens in this case), \( n \) is the refractive index of the substance the light is coming from (the aqueous), and \( r \) is the radius of curvature of the refracting surface (the anterior lens capsule).

By very much so. Consider: When a cuboidal epi cell (scale: microns) transforms into a fiber (scale: millimeters, or even centimeters), its intracellular volume increases enormously—by multiple orders of magnitude. This space has to contain something, and in the case of lens fibers it is filled with lens proteins.

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Anatomy of the mature lens

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**Lens/Cataracts Overview**

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D = \frac{n' - n}{r}
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Far from it. Not only are they living cells, they must be so for the lens to remain optically clear—fiber cells turn opaque within hours if their metabolic needs are unmet. (And to anticipate a reasonable inference, no, fiber cell death is not implicated in cataract formation.)

No question—advance when ready
Anatomy of the mature lens

- Capsule
  - Type IV collagen
  - Epithelium
    - Single layer of cuboidal cells beneath anterior and equatorial capsule
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    - Give rise to all new lens fibers

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  - Older, more densely packed fibers in central lens

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**Lens/Cataracts Overview**

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By way of an example, consider: Why is underwater vision so blurry?

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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
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**Lens/Cataracts Overview**

**How does the epi give rise to lens fibers?**

After their creation in the GZ, newly-minted epi cells migrate to the so-called **bow region** of the equatorial lens. It is in the bow region that these cells begin the process of terminal differentiation into lens fibers, a process characterized by 1) elongation of the cell, and 2) the loss of its organelles.

**Which organelles go bye-bye?**

Pretty much all of them, including the nucleus and mitochondria.

**Is it safe to assume lens fibers are nonliving structures, like (say) hair and nails?**

Far from it. Not only are they living cells, they **must** be so for the lens to remain optically clear—fiber cells turn opaque within hours if their metabolic needs are unmet. (And to anticipate a reasonable inference—no, fiber-cell death is **not** implicated in cataract formation.)

**At what point during this transformation does organelle disintegration occur?**

Not until the very end, ie, upon meeting and interdigitating with another fiber.

**Is there a reason the organelles have to stick around until the end?**

Very much so. Consider: When a cuboidal epi cell (scale: microns) transforms into a fiber (scale: millimeters, or even centimeters), its intracellular volume increases enormously—by multiple orders of magnitude. This space has to contain something, and in the case of lens fibers it is filled with lens proteins.

Thus, while the fiber is elongating, its intracellular machinery is cranking out lens proteins to fill the space, a process that can't end until the fiber has fully elongated. (BTW, we will have **much** more to say about lens proteins later in the slide-set.)

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**OK, but what does all this have to do with the intracellular composition of lens fibers?**

The issue is one of refractive index. Look at Snell’s law again, and note that the magnitude of the numerator is determined not by the values of the two refractive indices, but rather by the **difference** between the values. **Thus, if there is little to no difference between the ns at an interface, there will be little to no refraction at it.**

**By way of an example, consider: Why is underwater vision so blurry?**

The $n$ of the cornea is about $\#$, and the $n$ of air is $\#$, so the difference between them (ie, the numerator of Snell’s law as it pertains to the air-cornea interface) is $\#$.

**The reason lens fibers must be filled with something other than isotonic fluid can be summed up in two words: Snell’s law. Allow me to explain.**

**Q**

**D = \frac{n' - n}{r}**

OK, but what does all this have to do with the intracellular composition of lens fibers? The issue is one of refractive index. Look at Snell’s law again, and note that the magnitude of the numerator is determined not by the values of the two refractive indices, but rather by the difference between the values. Thus, if there is little to no difference between the $n$s at an interface, there will be little to no refraction at it.

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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

- **Nucleus**
  - Older, more densely packed fibers in central lens

- **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
  - Three sets of fibers:
    - **Anterior**
    - **Equatorial**
    - **Posterior**

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**Lens/Cataracts Overview**

**How does the epi give rise to lens fibers?**

After their creation in the GZ, newly-minted epi cells migrate to the so-called bow region of the equatorial lens. It is in the bow region that these cells begin the process of terminal differentiation into lens fibers, a process characterized by 1) elongation of the cell, and 2) the loss of its organelles.

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Thus, while the fiber is elongating, its intracellular machinery is cranking out lens proteins to fill the space, a process that can't end until the fiber has fully elongated. (BTW, we will have much more to say about lens proteins later in the slide-set.)

**By way of an example, consider:** Why is underwater vision so blurry? The *n* of the cornea is about 1.34, and the *n* of air is 1.0, so the difference between them (ie, the numerator of Snell’s law as it pertains to the air-cornea interface) is 0.34.

**Snell’s law**

\[ D = \frac{n' - n}{r} \]

where *n'* is the refractive index of the substance the light is heading into (the lens in this case), *n* is the refractive index of the substance the light is coming from (the aqueous), and *r* is the radius of curvature of the refracting surface (the anterior lens capsule).

**OK, but what does all this have to do with the intracellular composition of lens fibers?**

The issue is one of refractive index. Look at Snell’s law again, and note that the magnitude of the numerator is determined not by the values of the two refractive indices, but rather by the difference between the values. **Thus, if there is little to no difference between the *ns* at an interface, there will be little to no refraction at it.**

Here’s where Snell’s law comes into play. Snell’s law tells us that the diopteric power produced at a refracting surface is

Something besides a fluid that is roughly isotonic to that of the extracellular space? The reason lens fibers must be filled with something other than isotonic fluid can be summed up in two words: **Snell’s law.** Allow me to explain.

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Anatomy of the mature lens

- **Capsule**
  - Type IV collagen
  - Single layer of cuboidal cells beneath anterior and equatorial capsule
  - Metabolically active; mitotically active
  - Give rise to all new lens fibers

- **Nucleus**
  - Older, more densely packed fibers in central lens

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

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

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**Lenses/Cataracts Overview**

OK, but what does all this have to do with the intracellular composition of lens fibers? The issue is one of refractive index. Look at Snell’s law again, and note that the magnitude of the numerator is determined not by the values of the two refractive indices, but rather by the difference between the values. **Thus, if there is little to no difference between the ns at an interface, there will be little to no refraction at it.**

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Something besides a fluid that is roughly isotonic to that of the extracellular space? The reason lens fibers must be filled with something other than isotonic fluid can be summed up in two words: **Snell’s law.** Allow me to explain.

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Lens/Cataracts Overview

How does the epithelial cell give rise to lens fibers?

After their creation in the GZ, newly-minted epithelial cells migrate to the so-called bow region of the equatorial lens. It is in the bow region that these cells begin the process of terminal differentiation into lens fibers, a process characterized by 1) elongation of the cell, and 2) the loss of its organelles.

Which organelles go bye-bye?

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At what point during this transformation does organelle disintegration occur?

Not until the very end, i.e., upon meeting and interdigitating with another fiber.

Is there a reason the organelles have to stick around until the end?

Very much so. Consider: When a cuboidal epithelial cell transforms into a fiber (scale: millimeters, or even centimeters), its intracellular volume increases enormously—by multiple orders of magnitude. This space has to contain something, and in the case of lens fibers it is filled with lens proteins.

Thus, while the fiber is elongating, its intracellular machinery is cranking out lens proteins to fill the space, a process that can’t end until the fiber has fully elongated. (BTW, we will have much more to say about lens proteins later in the slide set.)

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By way of an example, consider: Why is underwater vision so blurry? The n of the cornea is about 1.34, and the n of air is 1.0, so the difference between them (i.e., the numerator of Snell’s law as it pertains to the air-cornea interface) is 0.34. In contrast, the n of water is 1.33. Thus, when you open your eyes underwater, the Snell’s law numerator at the water-cornea interface is only 0.01, which renders the value of the overall fraction almost zero.

But first, consider the primary purpose of the lens: Focusing incoming light on the fovea. To do this, the lens must supply 20D of converging power. Of the roughly 60D of converging power possessed by the typical eye, 20D are supplied by the lens (the other 40D being supplied by the cornea.) Here’s where Snell’s law comes into play: Snell’s law tells us that the dioptric power produced at a refracting surface is

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By way of an example, consider: Why is underwater vision so blurry? The n of the cornea is about 1.34, and the n of air is 1.0, so the difference between them (i.e., the numerator of Snell’s law as it pertains to the air-cornea interface) is 0.34. In contrast, the n of water is 1.33. Thus, when you open your eyes underwater, the Snell’s law numerator at the water-cornea interface is only 0.01, which renders the value of the overall fraction almost zero.
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

- Nucleus
  - Older, more densely packed fibers in central lens

- 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
    - Three sets of fibers:
      - Anterior
      - Equatorial
      - Posterior

Lens/Cataracts Overview

How does the epi give rise to lens fibers?

After their creation in the GZ, newly-minted epi cells migrate to the so-called bow region of the equatorial lens. It is in the bow region that these cells begin the process of terminal differentiation into lens fibers, a process characterized by 1) elongation of the cell, and 2) the loss of its organelles.

Which organelles go bye-bye?

Pretty much all of them, including the nucleus and mitochondria.

So is it safe to assume lens fibers are nonliving structures, like (say) hair and nails?

Far from it. Not only are they living cells, they must be so for the lens to remain optically clear—fiber cells turn opaque within hours if their metabolic needs are unmet. (And to anticipate a reasonable inference—no, fiber-cell death is not implicated in cataract formation.)

At what point during this transformation does organelle disintegration occur?

Not until the very end, i.e., upon meeting and interdigitating with another fiber.

Is there a reason the organelles have to stick around until the end?

Very much so. Consider: When a cuboidal epi cell (scale: microns) transforms into a fiber (scale: millimeters, or even centimeters), its intracellular volume increases enormously—by multiple orders of magnitude. This space has to contain something, and in the case of lens fibers it is filled with lens proteins.

Thus, while the fiber is elongating, its intracellular machinery is cranking out lens proteins to fill the space, a process that can't end until the fiber has fully elongated. (BTW, we will have much more to say about lens proteins later in the slide-set.)

Does it though? That is, why does the intracellular space of lens fibers have to contain something besides a fluid that is roughly isotonic to that of the extracellular space?

The reason lens fibers must be filled with something other than isotonic fluid can be summed up in two words: Snell’s law. Allow me to explain.

Snell’s law tells us that the dioptric power produced at a refracting surface is

\[ D = \frac{n' - n}{r} \]

where \( n' \) is the refractive index of the substance the light is heading into (the lens in this case), \( n \) is the refractive index of the substance the light is coming from (the aqueous), and \( r \) is the radius of curvature of the refracting surface (the anterior lens capsule).

OK, but what does all this have to do with the intracellular composition of lens fibers?

The issue is one of refractive index. Look at Snell’s law again, and note that the magnitude of the numerator is determined not by the values of the two refractive indices, but rather by the difference between the values. Thus, if there is little to no difference between the \( n \)s at an interface, there will be little to no refraction at it.

By way of an example, consider: Why is underwater vision so blurry? The \( n \) of the cornea is about 1.34, and the \( n \) of air is 1.0, so the difference between them (ie, the numerator of Snell’s law as it pertains to the air-cornea interface) is 0.34. In contrast, the \( n \) of water is 1.33. Thus, when you open your eyes underwater, the Snell’s law numerator at the water-cornea interface is only 0.01, which renders the value of the overall fraction almost zero. This means that essentially no refraction takes place at the cornea underwater, effectively eliminating 40 of the 60D of convergence needed for clear vision.

Something besides a fluid that is roughly isotonic to that of the extracellular space?
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
- Nucleus
  - Older, more densely packed fibers in central lens
- 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
  - Three sets of fibers:
    - Anterior
    - Equatorial
    - Posterior

Lens/Cataracts Overview

- How does the epi give rise to lens fibers?
  - After their creation in the GZ, newly-minted epi cells migrate to the so-called bow region of the equatorial lens.
  - It is in the bow region that these cells begin the process of terminal differentiation into lens fibers, a process characterized by 1) elongation of the cell, and 2) the loss of its organelles.

- Which organelles go bye-bye?
  - Pretty much all of them, including the nucleus and mitochondria.

- Is it safe to assume lens fibers are nonliving structures, like (say) hair and nails?
  - Far from it. Not only are they living cells, they must be so for the lens to remain optically clear—fiber cells turn opaque within hours if their metabolic needs are unmet. (And to anticipate a reasonable inference—no, fiber-cell death is not implicated in cataract formation.)

- At what point during this transformation does organelle disintegration occur?
  - Not until the very end, ie, upon meeting and interdigitating with another fiber.

- Is there a reason the organelles have to stick around until the end?
  - Very much so. Consider: When a cuboidal epi cell transforms into a fiber (scale: millimeters, or even centimeters), its intracellular volume increases enormously—by multiple orders of magnitude. This space has to contain something, and in the case of lens fibers it is filled with lens proteins.
  - Thus, while the fiber is elongating, its intracellular machinery is cranking out lens proteins to fill the space, a process that can't end until the fiber has fully elongated. (BTW, we will have much more to say about lens proteins later in the slide-set.)

- Does it though? That is, why does the intracellular space of lens fibers have to contain something besides a fluid that is roughly isotonic to that of the extracellular space?
  - The reason lens fibers must be filled with something other than isotonic fluid can be summed up in two words: Snell’s law. Allow me to explain.

  - By way of an example, consider: Why is underwater vision so blurry? The n of the cornea is about 1.34, and the n of air is 1.0, so the difference between them (ie, the numerator of Snell’s law as it pertains to the air-cornea interface) is 0.34. In contrast, the n of water is 1.33. Thus, when you open your eyes underwater, the Snell’s law numerator at the water-cornea interface is only 0.01, which renders the value of the overall fraction almost zero. This means that essentially no refraction takes place at the cornea underwater, effectively eliminating 40 of the 60D of convergence needed for clear vision. This is how the numerator in Snell’s law transforms an on-land emmetrope into an underwater hyperope (and a very high one at that).

  - Something besides a fluid that is roughly isotonic to that of the extracellular space?
    - Snell’s law tells us that the dioptric power produced at a refracting surface is
      \[ D = \frac{n' - n}{r} \]
      where n’ is the refractive index of the substance the light is heading into (the lens in this case), n is the refractive index of the substance the light is coming from (the aqueous), and r is the radius of curvature of the refracting surface (the anterior lens capsule).

  - OK, but what does all this have to do with the intracellular composition of lens fibers?
    - The issue is one of refractive index. Look at Snell’s law again, and note that the magnitude of the numerator is determined not by the values of the two refractive indices, but rather by the difference between the values. Thus, if there is little to no difference between the ns at an interface, there will be little to no refraction at it.

  - Snell’s law comes into play. Snell’s law tells us that the dioptric power produced at a refracting surface is
OK, but what does all this have to do with the intracellular composition of lens fibers? The issue is one of refractive index. Look at Snell’s law again, and note that the magnitude of the numerator is determined not by the values of the two refractive indices, but rather by the *difference* between the values. Thus, if there is little to no difference between the refractive indices, there will be little to no refraction at it. This is how the numerator in Snell’s law transforms an on-land emmetrope into an underwater hyperope (and a very high one at that).

The refractive index of air is 1.0, so the difference between them (ie, the numerator of Snell’s law as it pertains to the air-cornea interface) is 0.34. In contrast, the N of water is 1.33. Thus, when you open your eyes underwater, the Snell’s law numerator at the water-cornea interface is only 0.01, which renders the value of the overall fraction almost zero. This means that essentially no refraction takes place at the cornea underwater, effectively eliminating 40 of the 60D of convergence needed for clear vision. This is how the numerator in Snell’s law transforms an on-land emmetrope into an underwater hyperope (and a very high one at that).

You have probably anticipated the implications of all this for the composition of the intracellular space in lens fibers. Something besides a fluid that is roughly isotonic to that of the extracellular space? The reason lens fibers must be filled with something other than isotonic fluid can be summed up in two words: **Snell’s law**. Allow me to explain.

By way of an example, consider: Why underwater vision is so blurry? The aqueous (1.34) has a *higher* refractive index than the air (1.0). Thus, if there is a 0.34 difference between the values of the two refractive indices, there will be little to no refraction at the interface (the air aqueous interface) is 0.34. In contrast, the N of water is 1.33. Thus, when you open your eyes underwater, the Snell’s law numerator at the water-cornea interface is only 0.01, which renders the value of the overall fraction almost zero. This means that essentially no refraction takes place at the cornea underwater, effectively eliminating 40 of the 60D of convergence needed for clear vision. This is how the numerator in Snell’s law transforms an on-land emmetrope into an underwater hyperope (and a very high one at that).

To do this, the lens must supply *plus* (aka converging) power. Of the roughly 60D of converging power possessed by the typical eye, 20D are supplied by the lens (the other 40D being supplied by the cornea.)

But first, consider the primary purpose of the lens: Focusing incoming light on the fovea. How does the epi give rise to lens fibers? To answer this question, it helps to keep in mind the anatomy of the mature lens:

- **Epithelium**: Originates from the basal lamina of the nonpigmented epithelium of the pars plana and pars plicata of the ciliary body. Metabolically active; mitotically active.
- **Cortex**: Older, more densely packed fibers in central lens. Give rise to all new lens fibers.
- **Nucleus**: Metabolically active; mitotically active.
- **Zonules**: Support and connect the lens to the ciliary body.
- **Capsule**: Allows lens to shrink and expand by regulating water intake.
- **Trabeculae**: Support and connect the lens to the ciliary body.

OK, but what does all this have to do with the intracellular composition of lens fibers? The reason lens fibers must be filled with something other than isotonic fluid can be summed up in two words: **Snell’s law**. Allow me to explain.

You have probably anticipated the implications of all this for the composition of the intracellular space in lens fibers.
OK, but what does all this have to do with the intracellular composition of lens fibers? The issue is one of refractive index. Look at Snell’s law again, and note that the magnitude of the numerator is determined not by the values of the two refractive indices, but rather by the difference between the values. Thus, if there is little to no difference between the refractive indices at an interface, there will be little to no refraction at it. It is in this spirit that we can begin to understand how Snell’s law promotes a cell’s (fiber’s) transformation into an underwater hyperope.

You have probably anticipated the implications of all this for the composition of the intracellular space in lens fibers. If that space was filled with a liquid isotonic to aqueous, the refractive index of the lens would not differ appreciably from that of the aqueous itself. This would render the Snell’s law numerator of the aqueous-lens interface essentially zero, meaning no refraction could occur there.

You have probably anticipated the implications of all this for the composition of the intracellular space in lens fibers. If that space was filled with a liquid isotonic to aqueous, the refractive index of the lens would not differ appreciably from that of the aqueous itself. This would render the Snell’s law numerator of the aqueous-lens interface essentially zero, meaning no refraction could occur there.

Something besides a fluid that is roughly isotonic to that of the extracellular space? The reason lens fibers must be filled with something other than isotonic fluid can be summed up in two words: Snell’s law. Allow me to explain.

Far from it. Not only are they living cells, they must be so for the lens to remain optically clear—fiber cells turn opaque within hours if their metabolic needs are unmet. (And to anticipate a reasonable inference—no, fiber cell death is not implicated in cataract formation.)

No question—advance when ready
value of the overall fraction almost zero. This means that essentially underwater, the Snell’s law numerator at the water-cornea interface is only 0.01, which renders the very high one at that.

By way of an example, consider: Why underwater vision is so blurry? The proteins give the lens a refractive index of about 1.39, which differs enough from that of the aqueous (1.34) that meaningful refraction occurs. But the dense concentration of intracellular proteins gives the lens a refractive index of about \( n \), which differs enough from that of the aqueous \( n' \) that meaningful refraction occurs.

You have probably anticipated the implications of all this for the composition of the intracellular space in lens fibers. If that space was filled with a liquid isotonic to aqueous, the refractive index of the lens would not differ appreciably from that of the aqueous itself. This would render the Snell’s law numerator of the aqueous-lens interface essentially zero, meaning no refraction could occur there. Thus, if there is little to no difference between the at an interface, there will be little to no refraction at it.

Something besides a fluid that is roughly isotonic to that of the extracellular space? The reason lens fibers must be filled with something other than isotonic fluid can be summed up in two words: Snell’s law. Allow me to explain.

OK, but what does all this have to do with the intracellular composition of lens fibers? The issue is one of refractive index. Look at Snell’s law again, and note that the magnitude of the numerator is determined not by the values of the two refractive indices, but rather by the difference between the values. Thus, if there is little to no difference between the two refractive indices, there will be little to no refraction at it.

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OK, but what does all this have to do with the intracellular composition of lens fibers? The issue is one of refractive index. Look at Snell’s law again, and note that the magnitude of the numerator is determined not by the values of the two refractive indices, but rather by the difference between the values. Thus, if there is little to no difference between the refracting surfaces, there will be little to no refraction at it.

But the dense concentration of intracellular proteins gives the lens a refractive index of about 1.39, which differs enough from that of the aqueous (1.34) that meaningful refraction occurs.

You have probably anticipated the implications of all this for the composition of the intracellular space in lens fibers. If that space was filled with a liquid isotonic to aqueous, the refractive index of the lens would not differ appreciably from that of the aqueous itself. This would render the Snell’s law numerator of the aqueous-lens interface essentially zero, meaning no refraction could occur there. But first, consider the primary purpose of the lens: Focusing incoming light on the fovea. To do this, the lens must supply plus (aka converging) power. Of the roughly 60D of total power, 20D are supplied by the cornea (the other 40D being supplied by the cornea). But this would be so for the lens to remain optically clear—fiber cells turn opaque within hours if their metabolic needs are unmet. (And to anticipate a reasonable inference—no, fiber-cell death is not implicated in cataract formation.)
Anatomy of the mature lens

- **Capsule**
  - Type IV collagen
  - Single layer of cuboidal cells beneath anterior and equatorial capsule
  - Metabolically active; mitotically active
  - Give rise to all new lens fibers

- **Nucleus**
  - Older, more densely packed fibers in central lens

- **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
  - Three sets of fibers:
    - Anterior
    - Equatorial
    - Posterior

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**Lens/Cataracts Overview**

**What does the epi give rise to lens fibers?**

After their creation in the GZ, newly-minted epi cells migrate to the so-called bow region of the equatorial lens. It is in the bow region that these cells begin the process of terminal differentiation into lens fibers, a process characterized by 1) elongation of the cell, and 2) the loss of its organelles.

**Which organelles go bye-bye?**

Pretty much all of them, including the nucleus and mitochondria. So is it safe to assume lens fibers are nonliving structures, like (say) hair and nails? Far from it. Not only are they living cells, they must be so for the lens to remain optically clear—fiber cells turn opaque within hours if their metabolic needs are unmet. (And to anticipate a reasonable inference—no, fiber-cell death is not implicated in cataract formation.)

**At what point during this transformation does organelle disintegration occur?**

Not until the very end, i.e., upon meeting and interdigitating with another fiber.

**Is there a reason the organelles have to stick around until the end?**

Very much so. Consider: When a cuboidal epi cell (scale: microns) transforms into a fiber (scale: millimeters, or even centimeters), its intracellular volume increases enormously—by multiple orders of magnitude. This space has to contain something, and in the case of lens fibers it is filled with lens proteins.

Thus, while the fiber is elongating, its intracellular machinery is cranking out lens proteins to fill the space, a process that can't end until the fiber has fully elongated. (BTW, we will have much more to say about lens proteins later in the slide-set.)

**Does it though? That is, why does the intracellular space of lens fibers have to contain something besides a fluid that is roughly isotonic to that of the extracellular space?**

The reason lens fibers must be filled with something other than isotonic fluid can be summed up in two words: Snell's law. Allow me to explain.

**Closing the loop: All of this is why 1) the lens fibers must be filled with something other than isotonic fluid, and**

This space has to contain something.

**OK, but what does all this have to do with the intracellular composition of lens fibers?**

The issue is one of refractive index. Look at Snell's law again, and note that the magnitude of the numerator is determined not by the values of the two refractive indices, but rather by the difference between the values. Thus, if there is little to no difference between the refractive indices at an interface, there will be little to no refraction at it.

You have probably anticipated the implications of all this for the composition of the intracellular space in lens fibers. If that space was filled with a liquid isotonic to aqueous, the refractive index of the lens would not differ appreciably from that of the aqueous itself. This would render the Snell's law numerator of the aqueous-lens interface essentially zero, meaning no refraction could occur there. But the dense concentration of intracellular organelles (i.e., fibers) gives the lens a refractive index of about 1.4, which differs enough from that of the aqueous (1.34) that meaningful refraction occurs.

**Closing the loop:** All of this is why 1) the lens fibers must be filled with something other than isotonic fluid, and 2) why that something is proteins.
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

- Nucleus
  - Older, more densely packed fibers in central lens

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  - Originate from the basal lamina of the nonpigmented epithelium of the pars plana and pars plicata of the ciliary body
  - Three sets of fibers:
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Very much so. Consider: When a cuboidal epi cell (scale: microns) transforms into a fiber (scale: millimeters, or even centimeters), its intracellular volume increases enormously—by multiple orders of magnitude. This space has to contain something, and in the case of lens fibers it is filled with lens proteins.

Does it though? That is, why does the intracellular space of lens fibers have to contain something besides a fluid that is roughly isotonic to that of the extracellular space?

The reason lens fibers must be filled with something other than isotonic fluid can be summed up in two words: Snell’s law. Allow me to explain.

But first, consider the primary purpose of the lens: Focusing incoming light on the fovea.

To do this, the lens must supply  plus \( \text{converging} \) power. Of the roughly 60D of converging power possessed by the typical eye, 20D are supplied by the lens (the other 40D being supplied by the cornea.)

Here’s where Snell’s law comes into play. Snell’s law tells us that the dioptric power produced at a refracting surface is:

\[
D = \frac{n' - n}{r}
\]

where \( n' \) is the refractive index of the substance the light is heading into (the lens in this case), \( n \) is the refractive index of the substance the light is coming from (the aqueous), and \( r \) is the radius of curvature of the refracting surface (the anterior lens capsule).

OK, but what does all this have to do with the intracellular composition of lens fibers?

The issue is one of refractive index. Look at Snell’s law again, and note that the magnitude of the numerator is determined not by the values of the two refractive indices, but rather by the difference between the values. Thus, if there is little to no difference between the \( n \)s at an interface, there will be little to no refraction at it.

You have probably anticipated the implications of all this for the composition of the intracellular space in lens fibers. If that space was filled with a liquid isotonic to aqueous, the refractive index of the lens would not differ appreciably from that of the aqueous itself. This would render the Snell’s law numerator of the aqueous-lens interface essentially zero, meaning no refraction could occur there. But the dense concentration of intracellular proteins (protein fibers) gives the lens a refractive index of about 1.4, which differs enough from that of the aqueous (1.34) that meaningful refraction occurs.

Closing the loop: All of this is why 1) the lens fibers must be filled with something other than isotonic fluid, and 2) why that ‘something’ is proteins.

This space has to contain something, and in the case of lens fibers it is filled with lens proteins.
OK, but what does all this have to do with the intracellular composition of lens fibers? The issue is one of refractive index. Look at Snell’s law again, and note that the magnitude of the numerator is determined not by the values of the two refractive indices, but rather by the difference between the values. Thus, if there is little to no difference between the re n ula tions on the ref ractive index of the substance the light is coming from (the aqueous), and the refractive index of the substance the light is heading into (the lens in this case), there will be little to no refraction at it. This would render the Snell’s law numerator of the aqueous-lens interface essentially zero, and the refractive index of the lens would not differ appreciably from that of the aqueous itself.

To do this, the lens must supply plus (aka converging) power. Of the roughly 60D of converging power possessed by the typical eye, 20D are supplied by the cornea. (But first, consider the primary purpose of the lens: Focusing incoming light on the fovea.)

Before we move on:

--If you’re not grocking this whole Snell’s law thing, review slide-set BO17 (or better still, do the whole Basic Optics tutorial)

--So as not to get bogged down, I simplified the corneal optics involved. See set RS3 for a deep dive on this super-important subject.
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**

- **Nucleus**

- **Cortex**

- **Zonules**

**Q**

- How does the epi give rise to lens fibers?
  - After their creation in the GZ, newly-minted epi cells migrate to the so-called bow region of the equatorial lens. It is in the bow region that these cells begin the process of terminal differentiation into lens fibers, a process characterized by 1) elongation of the cell, and 2) the loss of its organelles.

**Next Q**

- When (ie, at what point in life) does fiber creation cease?
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- **Cortex**
  - Where does lens fiber creation cease?
  - Not until one has shuffled off this mortal coil, as the Bard put it. That is, lens fiber formation never ceases.
Anatomy of the mature lens

- **Capsule**
  - Type IV collagen

- **Epithelium**
  - Single layer of cuboidal cells beneath anterior and equatorial capsule
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- **Cortex**

- **Zonules**
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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

- **Nucleus**
  - Older, more densely packed fibers in central lens

- **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
  - Three sets of fibers:
    - Anterior
    - Equatorial
    - Posterior

---

**Lens/Cataracts Overview**

And this poses a significant metabolic challenge for the lens. Let’s get into it.

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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Lens/Cataracts Overview

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*Rhetorical question—proceed when ready*

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**Lens/Cataracts Overview**

How does the epi give rise to lens fibers?

After their creation in the GZ, newly-minted epi cells migrate to the so-called bow region of the equatorial lens. It is in the bow region that these cells begin the process of terminal differentiation into lens fibers, a process characterized by 1) elongation of the cell, and 2) the loss of its organelles.

When (ie, at what point in life) does fiber creation cease?

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So you still have every lens fiber you’ve ever created, all packed inside the lens capsule.

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**What is the chief metabolic waste product of the lens?**
(You know the answer to this.)

**Lactate (lactic acid if you prefer)**

Why would you assume I know that?

Because you know 1) that the chief source of energy in the lens is anaerobic glycolysis (from this slide-set), and 2) that lactate is the chief byproduct of anaerobic glycolysis (from med school, if not earlier).
Anatomy of the mature lens

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Lenses/Cataracts Overview

How does the epithelium give rise to lens fibers?

After their creation in the GZ, newly-minted epithelial cells migrate to the so-called bow region of the equatorial lens. It is in the bow region that these cells begin the process of terminal differentiation into lens fibers, a process characterized by 1) elongation of the cell, and 2) the loss of its organelles.

When (ie, at what point in life) does fiber creation cease?

Not until one has shuffled off this mortal coil, as the Bard put it. That is, lens fiber formation never ceases. Further, lens fibers are never lost or discarded (like, say, the sloughing of skin cells). So you still have every lens fiber you’ve ever created, all packed inside the lens capsule.

And this poses a significant metabolic challenge for the lens. Let’s get into it.

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. But the adult lens is avascular, so this method is not available to its cells. Instead, they communicate with the environment via the fluids that surround the lens—the aqueous anteriorly and vitreous posteriorly.

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What is the chief metabolic waste product of the lens?

(You know the answer to this.)

Lactate (lactic acid if you prefer)

**metabolic waste**
Anatomy of the mature lens

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Epithelium

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**Lens/Cataracts Overview**

**Q/A**

**Anatomy of the mature lens**

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

  And this poses a significant metabolic challenge for the lens. Let’s get into it.

  **What is the chief metabolic waste product of the lens?**
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  **Why would you assume I know that?**
  Because you know (from this slide-set) that the chief source of energy in the lens is **two words**, and you know (from med school, if not earlier) that lactate is the main byproduct of that process

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What is the chief metabolic waste product of the lens?

(You know the answer to this.)

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Just as the structure and histology of the lens poses a challenge to meeting its metabolic needs, so too does it challenge the maintenance of lens transparency. Lens transparency is exquisitely sensitive to the water content of the lens’s intracellular and extracellular compartments.
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*The cortical cataract is a function of lens water content. (We will have much to say about this later on.)
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*If you said *electrolytes, that’s OK too
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Before we get into intralenticular ion levels, let’s talk about the closely-related (and highly testable in its own right) topic of aqueous ion levels.
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Inorganic and organic
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The BCSC fixates on four inorganic ions— which ones?

Inorganic and organic
Lens/Cataracts Overview

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- Na\(^+\)
- K\(^2+\)
- Mg\(^2+\)
- Ca\(^2+\)

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*Likewise, it fixates on one organic ion— which one?

What are the two general classes of ions in aqueous? (Note: Not ‘anions and cations.’)  

\[
\begin{align*}
\text{Na}^+ & \quad \text{Inorganic} & \quad \text{organic} & \quad \text{?} \\
K^{2+} & \quad \text{?} \\
Mg^{2+} & \\
Ca^{2+} & 
\end{align*}
\]
Lens/Cataracts Overview

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**What are the two general classes of ions in aqueous? (Note: Not ‘anions and cations.’)**

Inorganic and organic

\[ \text{Na}^+ \quad \text{Inorganic and} \quad \text{organic} \quad \text{Lactate} \]

Likewise, it fixates on one organic ion—**which one?**
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- \( \text{Na}^+ \)
- \( \text{K}^{2+} \)
- \( \text{Mg}^{2+} \)
- \( \text{Ca}^{2+} \)

Inorganic and organic Lactate

The concentration of the inorganic ions are all “similar” to that of plasma, with one exception—which is it?
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What are the two general classes of ions in aqueous? (Note: Not ‘anions and cations.’)

Na\(^+\) \hspace{1cm} \text{Inorganic} \hspace{1cm} \text{and organic} \hspace{1cm} \text{Lactate}

K\(^+\)

Mg\(^{2+}\)

Ca\(^{2+}\) \hspace{1cm} \text{The concentration of the inorganic ions are all “similar” to that of plasma, with one exception—which is it? Ca}^{2+}

Ca\(^{2+}\)
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*Intralenticular water levels must be maintained to prevent lens scattering light and becoming opaque.

What are the two general classes of ions in aqueous? (Note: Not ‘anions and cations.’)

- Inorganic
- Organic

\[
\begin{align*}
\text{Na}^+ & \quad \text{Lactate} \\
K^{2+} & \\
Mg^{2+} & \\
\text{Ca}^{2+} & \quad \text{The concentration of the inorganic ions are all “similar” to that of plasma, with one exception—which is it?} \\
\text{Ca}^{2+} & \\
\end{align*}
\]

Is [aqueous Ca\(^{2+}\)] significantly greater than, or less than, [plasma Ca\(^{2+}\)]?
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What are the two general classes of ions in aqueous? (Note: Not ‘anions and cations.’)

- **Na⁺** and **K⁺**
- **Mg²⁺** and **Ca²⁺**

The concentration of the inorganic ions are all “similar” to that of plasma, with one exception—which is it?

- **Ca²⁺**

Is [aqueous Ca²⁺] significantly greater than, or less than, [plasma Ca²⁺]?

Less than—it is about 50% that of [plasma Ca²⁺]
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**intralenticular ion levels**

*What are the two general classes of ions in aqueous? (Note: Not ‘anions and cations.’)*

\[
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\text{K}^{2+} & \quad & \\
\text{Mg}^{2+} & \quad & \\
\text{Ca}^{2+} & \quad & \\
\end{align*}
\]

*The concentration of the inorganic ions are all “similar” to that of plasma, with one exception—which is it?*  

\text{Ca}^{2+}

Is [aqueous Ca\text{\textsuperscript{2+}}] **significantly greater than**, or **less than**, [plasma Ca\text{\textsuperscript{2+}}]?  

Less than—it is about half that of [plasma Ca\text{\textsuperscript{2+}}]
Just as the structure and histology of the lens poses a challenge to meeting its metabolic needs, so too does it challenge the maintenance of lens transparency. Lens transparency is exquisitely sensitive to the water content of the lens’s intracellular and extracellular compartments—a touch too much water and the lens scatters light; a touch more and the lens becomes opaque.* Because of this, intralenticular water levels must be scrupulously maintained. And because water follows osmotic gradients, intralenticular ion levels must also be closely held.

**Intralenticular ion levels**

*Important: The vitreous concentrations of these ions is much higher than their aqueous values.*

**What are the two general classes of ions in vitreous?** (Note: Not ‘anions and cations.’)

- Na$^+$ ↔ Inorganic
- K$^{2+}$
- Mg$^{2+}$
- Ca$^{2+}$
- Lactate
Just as the structure and histology of the lens poses a challenge to meeting its metabolic needs, so too does it challenge the maintenance of lens transparency. Lens transparency is exquisitely sensitive to the water content of the lens’s intracellular and extracellular compartments—a touch too much water and the lens scatters light; a touch more and the lens becomes opaque.* Because of this, intralenticular water levels must be scrupulously maintained. And because water follows osmotic gradients, intralenticular ion levels must also be closely held.

important: The vitreous concentrations of these ions is roughly equivalent to their aqueous values

What are the two general classes of ions in vitreous? (Note: Not ‘anions and cations.’)

- \(\text{Na}^+\) \(\longleftarrow\) Inorganic
- \(\text{K}^{2+}\)
- \(\text{Mg}^{2+}\)
- \(\text{Ca}^{2+}\)
- Lactate
Lens/Cataracts Overview

Just as the structure and histology of the lens poses a challenge to meeting its metabolic needs, so too does it challenge the maintenance of lens transparency. Lens transparency is exquisitely sensitive to the water content of the lens’s intracellular and extracellular compartments—a touch too much water and the lens scatters light; a touch more and the lens becomes opaque.* Because of this, intralenticular water levels must be scrupulously maintained. And because water follows osmotic gradients, intralenticular ion levels must also be closely held.

What are the two general classes of ions in aqueous? (Note: Not ‘anions and cations.’)

\[ \text{Na}^+ \quad \text{Inorganic and} \quad \text{organic} \quad \text{Lactate} \]
\[ \text{K}^{2+} \]
\[ \text{Mg}^{2+} \]
\[ \text{Ca}^{2+} \]

* The presence of lactate in aqueous is due primarily to what physiologic fact?
Just as the structure and histology of the lens poses a challenge to meeting its metabolic needs, so too does it challenge the maintenance of lens transparency. Lens transparency is exquisitely sensitive to the water content of the lens’s intracellular and extracellular compartments—a touch too much water and the lens scatters light; a touch more and the lens becomes opaque.* Because of this, intralenticular water levels must be scrupulously maintained. And because water follows osmotic gradients, intralenticular ion levels must also be closely held.

What are the two general classes of ions in aqueous? (Note: Not ‘anions and cations.’)

\[
\begin{align*}
\text{Na}^+ & \longleftrightarrow \text{Inorganic and} \\
\text{K}^2+ & \text{organic} \\
\text{Mg}^2+ & \text{Lactate} \\
\text{Ca}^2+ & 
\end{align*}
\]

*The presence of lactate in aqueous is due primarily to what physiologic fact?*

The fact that metabolism is almost 100%
Just as the structure and histology of the lens poses a challenge to meeting its metabolic needs, so too does it challenge the maintenance of lens transparency. Lens transparency is exquisitely sensitive to the water content of the lens’s intracellular and extracellular compartments—a touch too much water and the lens scatters light; a touch more and the lens becomes opaque.* Because of this, intralenticular water levels must be scrupulously maintained. And because water follows osmotic gradients, intralenticular ion levels must also be closely held.

**intralenticular ion levels**

What are the two general classes of ions in aqueous? (Note: Not ‘anions and cations.’)

\[
\begin{align*}
\text{Na}^+ & \leftrightarrow \text{Inorganic and} \\
\text{K}^+ & \text{organic} \quad \rightarrow \quad \text{Lactate}
\end{align*}
\]

The presence of lactate in aqueous is due primarily to what physiologic fact?

The fact that lens metabolism is almost 100% anaerobic glycolysis
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What are the two general classes of ions in aqueous? (Note: Not ‘anions and cations.’)

Inorganic and organic

\[\text{Na}^+ \quad \text{K}^+ \quad \text{Mg}^2+ \quad \text{Ca}^2+ \quad \text{Lactate}\]

The presence of lactate in aqueous is due primarily to what physiologic fact?

The fact that lens metabolism is almost 100% anaerobic glycolysis

(How is [aqueous lactate] related to [plasma lactate]?)
Just as the structure and histology of the lens poses a challenge to meeting its metabolic needs, so too does it challenge the maintenance of lens transparency. Lens transparency is exquisitely sensitive to the water content of the lens’s intracellular and extracellular compartments—a touch too much water and the lens scatters light; a touch more and the lens becomes opaque.* Because of this, intralenticular water levels must be scrupulously maintained. And because water follows osmotic gradients, intralenticular ion levels must also be closely held.

What are the two general classes of ions in aqueous? (Note: Not ‘anions and cations.’)

\[\text{Na}^+ \leftrightarrow \text{Inorganic and organic} \rightarrow \text{Lactate}\]

The presence of lactate in aqueous is due primarily to what physiologic fact?

The fact that lens metabolism is almost 100% anaerobic glycolysis

How is [aqueous lactate] related to [plasma lactate]?

[Aqueous lactate] is \underline{usually} greater than [plasma lactate].
Just as the structure and histology of the lens poses a challenge to meeting its metabolic needs, so too does it challenge the maintenance of lens transparency. Lens transparency is exquisitely sensitive to the water content of the lens’s intracellular and extracellular compartments—a touch too much water and the lens scatters light; a touch more and the lens becomes opaque.* Because of this, intra-lenticular water levels must be scrupulously maintained. And because water follows osmotic gradients, intralenticular ion levels must also be closely held.

What are the two general classes of ions in aqueous? (Note: Not ‘anions and cations.’)

- Na⁺
- K⁺
- Mg²⁺
- Ca²⁺

Inorganic and organic

Lactate

The presence of lactate in aqueous is due primarily to what physiologic fact?

The fact that lens metabolism is almost 100% anaerobic glycolysis

How is [aqueous lactate] related to [plasma lactate]?

[Aqueous lactate] is always greater than [plasma lactate]
Just as the structure and histology of the lens poses a challenge to meeting its metabolic needs, so too does it challenge the maintenance of lens transparency. Lens transparency is exquisitely sensitive to the water content of the lens’s intracellular and extracellular compartments—a touch too much water and the lens scatters light; a touch more and the lens becomes opaque.* Because of this, intralenticular water levels must be scrupulously maintained. And because water follows osmotic gradients, intralenticular ion levels must also be closely held.

**What are the two general classes of ions in aqueous? (Note: Not ‘anions and cations.’)**

Na$^+$ ← Inorganic and organic → Lactate
K$^{2+}$
Mg$^{2+}$
Ca$^{2+}$

The presence of lactate in aqueous is due primarily to what physiologic fact?

The fact that lens metabolism is almost 100% anaerobic glycolysis

How is [aqueous lactate] related to [plasma lactate]?

[Aqueous lactate] is always greater than [plasma lactate]

*Note that ‘lens anaerobic glycolysis’ and ‘high aqueous lactate levels’ imply one another, so if you can remember one you can deduce the other.
But there’s a complicating factor regarding maintenance of appropriate intralenticular hydration: With the exception of the epithelium and the youngest cortical fibers, organelle loss means lens cells lack the membrane machinery required to regulate their ionic milieu.
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But there’s a complicating factor regarding maintenance of appropriate intralenticular hydration: With the exception of the epithelium and the youngest cortical fibers, organelle loss means lens cells lack the membrane machinery required to regulate their ionic milieu. Once again, the structure and histology of the lens creates a metabolic conundrum; once again, nature finds a way, this time via a process called the **pump-leak system.**
But there’s a complicating factor regarding maintenance of appropriate intralenticular hydration: With the exception of the epithelium and the youngest cortical fibers, organelle loss means lens cells lack the membrane machinery required to regulate their ionic milieu. Once again, the structure and histology of the lens creates a metabolic conundrum; once again, nature finds a way, this time via a process called the pump-leak system.*

*aka pump-leak theory, aka pump-leak hypothesis
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The Pump-Leak System
The lens sits between two fluids, both of which have high \([Na^{2+}]\) and low \([K^+]\).
The Pump-Leak System
The lens sits between two fluids, both of which have high $[Na^{2+}]$ and low $[K^+]$. However, to maintain transparency the intralenticular milieu must be the opposite: low $[Na^{2+}]$ and high $[K^+]$.

No question yet—proceed when ready
**The Pump-Leak System**

The lens sits between two fluids, both of which have high $[Na^{2+}]$ and low $[K^+]$. However, to maintain transparency the intralenticular milieu must be the opposite: low $[Na^{2+}]$ and high $[K^+]$. To achieve this, lens epithelial cells employ membrane-bound, $\text{ATP}$-powered, $\text{Na}^+$-$\text{K}^+$ transporters.

**Aqueous**
- $K^+$: Low
- $Na^{2+}$: High

**Lens**
- $K^+$: High
- $Na^{2+}$: Low

**Vitreous**
- $K^+$: Low
- $Na^{2+}$: High

The structure and histology of the lens create a metabolic conundrum; once again, nature finds a way, this time via a process called the **pump-leak system**. The **BCSC** refers to this as “perhaps the most important aspect of lens physiology,” so it’s worth paying attention to.
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---

**Aqueous**

- \(K^+\): Low
- \(Na^2+\): High

**Lens**

- \(K^+\): High
- \(Na^2+\): Low

- Pump

**Vitreous**

- \(K^+\): Low
- \(Na^2+\): High

---

Anterior capsule & epithelium

Posterior capsule
The Pump-Leak System
The lens sits between two fluids, both of which have high $[Na^{2+}]$ and low $[K^+]$. However, to maintain transparency the intralenticular milieu must be the opposite: low $[Na^{2+}]$ and high $[K^+]$. To achieve this, lens epithelial cells employ membrane-bound, ATP–powered, sodium-potassium transporters. The activity of these transporters is regulated by the enzyme ATPase to drive $Na^{2+}$ out of the lens and $K^+$ into it.
The Pump-Leak System

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The diagram illustrates the concentrations of ions: high \(K^+\) and low \(Na^{2+}\) in the aqueous humor, low \(K^+\) and high \(Na^{2+}\) in the lens, and high \(K^+\) and low \(Na^{2+}\) in the vitreous humor.
The Pump-Leak System

The lens sits between two fluids, both of which have high $[Na^{2+}]$ and low $[K^+]$. However, to maintain transparency the intralenticular milieu must be the opposite: low $[Na^{2+}]$ and high $[K^+]$. To achieve this, lens epithelial cells employ membrane-bound, ATP–powered, sodium-potassium transporters. The activity of these transporters is regulated by the enzyme ATPase to drive $Na^{2+}$ out of the lens and $K^+$ into it. This is the ‘pump’ portion of the pump-leak system. In contrast, at the epithelium-less posterior capsule, ions move passively down their concentration gradients—$Na^{2+}$ in, and $K^+$ out. This is the ‘leak’ portion of the pump-leak system.*

*Note that some leakage occurs across the anterior capsule as well.
The Pump-Leak System

The lens sits between two fluids, both of which have high \([Na^{2+}]\) and low \([K^+]\). However, to maintain transparency the intralenticular milieu must be the opposite: low \([Na^{2+}]\) and high \([K^+]\). To achieve this, lens epithelial cells employ membrane-bound, ATP-powered, sodium-potassium transporters. The activity of these transporters is regulated by the enzyme ATPase to drive \(Na^{2+}\) out of the lens and \(K^+\) into it. This is the ‘pump’ portion of the pump-leak system. In contrast, at the epithelium-less posterior capsule, ions move passively down their concentration gradients—\(Na^{2+}\) in, and \(K^+\) out. This is the ‘leak’ portion of the pump-leak system. (Finally, note that the epithelium uses similar active pumping mechanisms to move other critical molecules (e.g., amino acids) in and out of the lens.)
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

- **Nucleus**
  - Older fibers densely packed in central lens

- **Cortex**

- **Zonules**

**Lens/Cataracts Overview**

Next (no question, just a factoid)
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

- **Nucleus**
  - Older fibers densely packed in central lens

- **Cortex**

- **Zonules**

**Why are nuclear fibers more densely packed?**
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

- **Nucleus**
  - Older fibers densely packed in central lens

- **Cortex**

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

Why are nuclear fibers more densely packed? We’ll answer this very shortly.
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

- **Nucleus**
  - Older fibers densely packed in central lens

- **Cortex**
  - Newer fibers between and

- **Zonules**
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

- **Nucleus**
  - Older fibers densely packed in central lens

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

- **Zonules**

*Having recently developed in the bow region, as you know
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

- **Nucleus**
  - Older fibers densely packed in central lens

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

- **Zonules**

---

*Why are nuclear fibers more densely packed?*

*We’ll answer this very shortly*

---

*This is why the nucleus is densely packed—as new fibers are created around it, they compress the older fibers located more centrally*
Lens/Cataracts Overview

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

No question yet—proceed when ready.
Do cortical and nuclear fibers have unique properties that allow them to be differentiated histologically?

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

Do cortical and nuclear fibers have unique properties that allow them to be differentiated histologically?

Nope, they pretty much look the same at a microscope.
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

- **Nucleus**
  - Older fibers densely packed in central lens
  - Why are nuclear fibers more densely packed?
    - We’ll answer this very shortly

- **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
  - Three sets of fibers:
    - Anterior
    - Equatorial
    - Posterior

At what point in life do newly-created fibers not have time to get packed tight enough to be considered nuclear fibers?*

*Sorry, I know that question’s not worded goodly
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

- **Nucleus**
  - Older fibers **densely packed** in central lens

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

- **Zonules**

This is why the nucleus is densely packed—as new fibers are created around it, they compress the older fibers located more centrally.

At what point in life do newly-created fibers not have time to get packed tight enough to be considered nuclear fibers?

Age 20 years, give or take.
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

- **Nucleus**
  - Older fibers densely packed in central lens

- **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
  - Three sets of fibers:
    - Anterior
    - Equatorial
    - Posterior

**Lens/Cataracts Overview**

Why are nuclear fibers more densely packed? We’ll answer this very shortly

This is why the nucleus is densely packed—as new fibers are created around it, they compress the older fibers located more centrally.

At what point in life do newly-created fibers not have time to get packed tight enough to be considered nuclear fibers?
Age 20 years, give or take
**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
- **Nucleus**
  - Older fibers densely packed in central lens
  - Why are nuclear fibers more densely packed? We’ll answer this very shortly
- **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
  - Three sets of fibers:
    - Anterior
    - Equatorial
    - Posterior

**Lens/Cataracts Overview**

At what point in life do newly-created fibers not have time to get packed tight enough to be considered nuclear fibers?

Age 20 years, give or take. That is, fibers laid down from age embryo to age 20 form the adult nucleus, whereas fibers created after age 20 comprise the lens cortex.
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

- **Nucleus**
  - Older fibers densely packed in central lens

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

- **Zonules**
  - Originate from the very specific tissue of the pigmented vs nonpigmented epithelium of the specific portion 1 and specific portion 2 of the ciliary body
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

- **Nucleus**
  - Older fibers densely packed in central lens

- **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
Pars plicata
Pars plana
(Nevra you mind what these are pointing to)
Zonular origins
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

- **Nucleus**
  - Older fibers densely packed in central lens

- **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
  - Three sets of fibers:
    - ?
    - ?
    - ?
The anatomy of the mature lens includes:

- **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

- **Nucleus**
  - Older fibers densely packed in central lens

- **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
  - Three sets of fibers:
    - Anterior
    - Equatorial
    - Posterior
Anatomy of the mature lens

- **Capsule**
  - Type IV collagen

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  - Metabolically active; mitotically active
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- **Nucleus**
  - Older fibers densely packed in central lens

- **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

- **Three sets of fibers:**
  - Anterior?
  - Equatorial?
  - Posterior?

One set regresses (to the point of disappearing) throughout life—which one?
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

- **Nucleus**
  - Older fibers densely packed in central lens

- **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

- **Three sets of fibers:**
  - Anterior
  - **Equatorial!**
  - Posterior

---

**Lens/Cataracts Overview**

One set regresses (to the point of disappearing) throughout life—which one? The equatorial
Lens/Cataracts Overview

Zonular insertions on the lens
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

- **Nucleus**
  - Older fibers densely packed in central lens

- **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
  - Three sets of fibers:
    - **Anterior:** Insert # mm anterior to equator
    - **Equatorial**
    - **Posterior**
### 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

- **Nucleus**
  - Older fibers densely packed in central lens

- **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
  - Three sets of fibers:
    - **Anterior**: Insert 1.5 mm anterior to equator
    - **Equatorial**
    - **Posterior**
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

- **Nucleus**
  - Older fibers densely packed in central lens

- **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
  - Three sets of fibers:
    - **Anterior:** Insert 1.5 mm anterior to equator
    - **Equatorial**
    - **Posterior:** Insert # mm posterior to equator
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

- **Nucleus**
  - Older fibers densely packed in central lens

- **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
  - Three sets of fibers:
    - **Anterior**: Insert 1.5 mm anterior to equator
    - **Equatorial**
    - **Posterior**: Insert 1.25 mm posterior to equator
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

- **Nucleus**
  - Older fibers densely packed in central lens

- **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
  - Three sets of fibers:
    - **Anterior:** Insert 1.5 mm anterior to equator
    - **Equatorial**
    - **Posterior:** Insert 1.25 mm posterior to equator

**Lens/Cataracts Overview**

*Probably more important to remember the relative insertions of the anterior and posterior zonules rather than the specific distances*

- **Anterior:** Insert more centrally than the posterior
- **Equatorial**
- **Posterior:** Insert less centrally than the anterior
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 measurements
  - Birth: # mm equatorial, # mm anteroposterior
Lens/Cataracts Overview

- Lens measurements
  - Birth: 6.4 mm equatorial, 3.5 mm anteroposterior
- **Lens measurements**
  - Birth: **6.4** mm equatorial, **3.5** mm anteroposterior
  - Adult: [ ] mm equatorial, [ ] mm anteroposterior
Lens measurements

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

Cataract surgeons will sometimes employ an age-based rule of thumb for guesstimating the A-P depth of a lens—what is it?
● **Lens measurements**
  
  ● Birth: 6.4 mm equatorial, 3.5 mm anteroposterior
  
  ● Adult: 9-10 mm equatorial, 5.0 mm anteroposterior
  
  *Cataract surgeons will sometimes employ an age-based rule of thumb for guesstimating the A-P depth of a lens—what is it? A-P depth = ‘Four (point) pt age’ (eg, the A-P depth of the lens in a 65 y.o. is ~4.65 mm)*
Lens/Cataracts Overview

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(e.g., the A-P depth of the lens in a 65 y.o. is ~4.65 mm)

The fact that the magnitude of this number correlates with age implies that the lens never stops getting thicker. Is this the case?
Lens/Cataracts Overview

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*What is the cause of this thickening?*
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It is indeed

What is the cause of this thickening?
The never-ending creation of new fibers (via the process discussed a few slides ago)
Lens/Cataracts Overview

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

- **With age…**
  - Lens curvature increases or decreases → refractive power increases vs decreases
Lens/Cataracts Overview

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  - Refractive index **increases vs decreases** → ↑ or ↓ refractive power
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So which do people become with age—more myopic or more hyperopic?
Lens measurements

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With age...

- Lens curvature increases \( \rightarrow \) \( \uparrow \) refractive power
- Refractive index decreases \( \rightarrow \) \( \downarrow \) refractive power

So which do people become with age—more myopic or more hyperopic? As the change in an individual’s refraction is a function of the interplay between these, it can be either
Lens/Cataracts Overview

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Note: 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.”)
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Let’s drill down on the highly OKAPable topic of *Lens Proteins*
Let’s drill down on the highly OKAPable topic of Lens Proteins. What proportion of the lens by weight do Lens Proteins constitute?
Let’s drill down on the highly OKAPable topic of Lens Proteins. What proportion of the lens by weight do Lens Proteins constitute? 1/3
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**Lens Proteins** constitute what proportion of the lens by weight?

1/3

Um, cool story bro. Is that proportion supposed to be impressive?
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Alrighty then. Is it impressively high, or low?
Let’s drill down on the highly OKAPable topic of Lens Proteins constitute what proportion of the lens by weight (1/3).

Um, cool story bro. Is that proportion supposed to be impressive? Indeed it is.

Alrighty then. Is it impressively high, or low? High—no other tissue comes close (a content-by-weight of a third is 2 to 3 times the protein content of most other tissues!)
Lens proteins come in one of two basic types. What are they? (Hint: The types are divvied on the basis of a physical property of the proteins.)
Lens proteins come in one of two basic types. What are they? (Hint: The types are divvied on the basis of a physical property of the proteins.)
One of these types predominates in the lens of a young person— which one?
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which one?
Water soluble
One of these types predominates in the lens of a young person—
which one?
Water soluble
One of these types predominates in the lens of a young person— which one?
Water soluble

Water-soluble proteins comprise what percentage of proteins in the young lens?
80%
One of these types predominates in the lens of a young person—which one?
Water soluble

What happens to the relative proportions of water soluble vs insoluble proteins as the person ages?
One of these types predominates in the lens of a young person—
which one?
Water soluble

What happens to the relative proportions of water soluble vs
insoluble proteins as the person ages?
It reverses—water *insoluble* predominates
What accounts for this change in the proportion of water-soluble vs insoluble proteins?

It reverses—water insoluble predominates.
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What accounts for this change in the proportion of water-soluble vs insoluble proteins? It’s very straightforward—as the lens ages, water-soluble proteins aggregate, in the process forming particles that are water-insoluble.

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Is this fact of any clinical relevance, or are you just torturing me with minutiae?

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*Is this fact of any clinical relevance, or are you just torturing me with minutiae?* Unlike much of the esoterica in this slide-set, a straight line can be drawn from this fact to the exam room. These water-insoluble aggregates are very large and scatter light, thereby reducing acuity.

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It reverses—water insoluble predominates in an old, brunescent lens.
One of these types predominates in the lens of a young person—water soluble or water insoluble? What happens to the relative proportions of water soluble vs insoluble proteins as the person ages? It reverses—water insoluble predominates.

What accounts for this change in the proportion of water-soluble vs insoluble proteins? As the lens ages, water-soluble proteins aggregate, in the process forming particles that are water-insoluble.

Is this fact of any clinical relevance, or are you just torturing me with minutiae? Unlike much of the esoterica in this slide-set, a straight line can be drawn from this fact to the exam room. These water-insoluble aggregates are very large and scatter light, thereby reducing acuity. Further, there is a direct correlation between the proportion of water-insoluble proteins and how brunescent a cataract is.

It can be as high as 90%!
By what other name are the water-soluble proteins known?

Water Soluble *aka*… Water Insoluble

**Q**

Lens Proteins

Lens/Cataracts Overview
By what other name are the water-soluble proteins known?
‘Crystallins’
By what other name are the water-soluble proteins known? ‘Crystallins’

Crystallins come in three forms (two of which are grouped together). What are they?
By what other name are the water-soluble proteins known?
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Crystallins come in three forms (two of which are grouped together). What are they?

What vital role do crystallins play in lens function?
By what other name are the water-soluble proteins known? ‘Crystallins’

Crystallins come in three forms (two of which are grouped together). What are they?

What vital role do crystallins play in lens function? They are the proteins cranked out by elongating lens fibers that increase the lens’s refractive index enough to render it a viable refracting entity
Water-insoluble proteins come two basic types. What are they? (Hint: The types are divvied on the basis of a physical property of the proteins.)
Water-insoluble proteins come two basic types. What are they? (Hint: The types are divvied on the basis of a physical property of the proteins.)
What sort of protein comprises the majority of the urea-soluble fraction of the water-insoluble lens proteins?
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Cytoskeletal proteins
What sort of protein comprises the majority of the urea-soluble fraction of the water-insoluble lens proteins?
Cytoskeletal proteins

What function do cytoskeletal proteins serve?
What sort of protein comprises the majority of the urea-soluble fraction of the water-insoluble lens proteins?
Cytoskeletal proteins

What function do cytoskeletal proteins serve?
They are the primary component of the structural framework of lens cells
What sort of protein comprises the majority of the urea-insoluble fraction of the water-insoluble lens proteins?
Lens Proteins

Water Soluble

- α
- βγ

Water Insoluble

- Urea Soluble
- Cytoskeletal proteins

- Urea Insoluble
- MIP

What sort of protein comprises the majority of the urea-insoluble fraction of the water-insoluble lens proteins?

Major intrinsic protein (MIP)
Remember when we talked about the big bump in lens protein creation that occurs during fiber elongation?

(Rhetorical question)
Remember when we talked about the big bump in lens protein creation that occurs during fiber elongation? The Lens book states that the proteins thus created are primarily crystallins.
Remember when we talked about the big bump in lens protein creation that occurs during fiber elongation? The *Lens* book states that the proteins thus created are primarily crystallins. MIPs production goes up too.
Remember when we talked about the big bump in lens protein creation that occurs during fiber elongation? The *Lens* book states that the proteins thus created are primarily **crystallins**. MIPs production goes up too, **but it’s the crystallins that are responsible for the refractive index effect we discussed**.

No question yet—proceed when ready.
(This is a good point in the set to take a break)
What sort of protein comprises the majority of the urea-insoluble fraction of the water-insoluble lens proteins?

Major intrinsic protein (MIP)
Which embryologic cell line gives rise to all of the components of the lens?
Q/A

Which embryologic cell line gives rise to all of the components of the lens? *surface vs neuro-* **ectoderm**
Which embryologic cell line gives rise to all of the components of the lens? *Surface ectoderm*
Which embryologic cell line gives rise to all of the components of the lens? **Surface ectoderm**

T/F: The optic vesicle is the primordial structure that becomes the lens. It consists of a single layer of cuboidal cells encased within their basement membrane.
A

- Which embryologic cell line gives rise to all of the components of the lens? *Surface ectoderm*

- T/F: The optic vesicle is the primordial structure that becomes the lens. It consists of a single layer of cuboidal cells encased within their basement membrane  **F**
Re surface ectoderm and lens formation:

(No info yet—advance when ready)
Re **surface ectoderm** and lens formation:

*(Glance at this, then keep going to see the points being made)*
Surface ectoderm and lens formation:
--A portion of surface ectoderm thickens to form the lens placode
Re **surface ectoderm** and lens formation:
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Re **surface ectoderm** and lens formation: 
--A portion of **surface ectoderm** thickens to form the **lens placode** (aka the **lens plate**).
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Re surface ectoderm and lens formation:
--A portion of surface ectoderm thickens to form the lens placode (aka the lens plate)

It’s the contact from the optic vesicle that induces the overlying surface ectoderm to thicken and form the placode

No question yet—proceed when ready
Re surface ectoderm and lens formation:
--A portion of surface ectoderm thickens to form the lens placode (aka the lens plate)
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Note the presence of an indentation in the lens placode; this is called the lens pit.
Re surface ectoderm and lens formation:
--A portion of surface ectoderm thickens to form the lens placode (aka the lens plate)
--The placode invaginates to form the
Re surface ectoderm and lens formation:
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No question—proceed when ready
Re **surface ectoderm** and **lens formation:**

--A portion of **surface ectoderm** thickens to form the **lens placode** (aka the **lens plate**)

--The placode invaginates to form the **lens vesicle**

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

*No question—proceed when ready*
Re surface ectoderm and lens formation:
--A portion of surface ectoderm thickens to form the lens placode (aka the lens plate)
--The placode invaginates to form the lens vesicle
--The lens vesicle goes on to form (eventually; there are intervening steps) the mature lens.

Take note that 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.

No question—proceed when ready
Re surface ectoderm and lens formation
--A portion of surface ectoderm thickens to form the lens placode (aka the lens plate)
--The placode invaginates to form the lens vesicle
--The lens vesicle goes on to form (eventually; there are intervening steps) the mature lens

Finally: Note that optic vesicle and lens vesicle are different structures—don’t mix them up!
Q

- Which embryologic cell line gives rise to all of the components of the lens? **Surface ectoderm**
- T/F: The **optic vesicle** is the primordial structure that becomes the lens. It consists of a single layer of cuboidal cells encased within their basement membrane. **F**
- T/F: The anterior cells of the lens vesicle elongate and progressively obliterate the lumen, forming the embryonic nucleus
Which embryologic cell line gives rise to all of the components of the lens? **Surface ectoderm**

T/F: The optic vesicle is the primordial structure that becomes the lens. It consists of a single layer of cuboidal cells encased within their basement membrane  **F**

T/F: The posterior cells of the lens vesicle elongate and progressively obliterate the lumen, forming the embryonic nucleus  **F**
Posterior cells of the lens vesicle elongate to obliterate the vesicle's lumen, thus creating the embryonic nucleus.

No question—proceed when ready
Posterior cells of the lens vesicle elongate to obliterate the vesicle's lumen, thus creating the embryonic nucleus.

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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.

As they elongate, these cells lose their organelles and thereby transform into ‘fibers.’ They are known as the lens fibers.

s/p vesicle obliteration, the structure is now the embryonic nucleus.
Posterior cells of the lens vesicle elongate to obliterate the vesicle's lumen, thus creating the embryonic nucleus. As they elongate, these cells lose their organelles and thereby transform into ‘fibers.’ They are known as the primary lens fibers.

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

This is the lens vesicle getting obliterated by the elongating posterior cells.
Which embryologic cell line gives rise to all of the components of the lens? **Surface ectoderm**

T/F: The optic vesicle is the primordial structure that becomes the lens. It consists of a single layer of cuboidal cells encased within their basement membrane  **F**

T/F: The anterior cells of the lens vesicle elongate and progressively obliterate the lumen, forming the embryonic nucleus  **F**

The anterior cells become the **two words**
Which embryologic cell line gives rise to all of the components of the lens? *Surface ectoderm*

T/F: The optic vesicle is the primordial structure that becomes the lens. It consists of a single layer of cuboidal cells encased within their basement membrane  **F**

T/F: The anterior cells of the lens vesicle elongate and progressively obliterate the lumen, forming the embryonic nucleus  **F**

The anterior cells become the *lens epithelium*
We saw this image a few slides ago. Now take note of the anterior cells—they will/have become the lens epithelial cells.
We saw this image a few slides ago. Now take note of the anterior cells—they will/have become the lens epithelial cells. Note also that they extend around to the lens’ equatorial region.
Which embryologic cell line gives rise to all of the components of the lens? *Surface ectoderm*

T/F: The optic vesicle is the primordial structure that becomes the lens. It consists of a single layer of cuboidal cells encased within their basement membrane  **F**

T/F: The anterior cells of the lens vesicle elongate and progressively obliterate the lumen, forming the embryonic nucleus  **F**

The anterior cells become the *lens epithelium*

The equatorial epi cells become fibers that elongate both anteriorly and posteriorly, thereby forming the lens.
Which embryologic cell line gives rise to all of the components of the lens? *Surface ectoderm*

T/F: The optic vesicle is the primordial structure that becomes the lens. It consists of a single layer of cuboidal cells encased within their basement membrane  **F**

T/F: The anterior cells of the lens vesicle elongate and progressively obliterate the lumen, forming the embryonic nucleus  **F**

The anterior cells become the *lens epithelium*

The equatorial epi cells become fibers that elongate both anteriorly and posteriorly, thereby forming the *fetal nucleus*
As we’ve seen, the **embryonic nucleus** is formed when the elongating posterior (aka *primary*) lens fibers obliterate the vesicle.
As we've seen, the **embryonic nucleus** is formed when the elongating posterior (aka primary) 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 primary lens fibers of the embryonic nucleus) and posteriorly (insinuating themselves between the originations of the primary lens fibers and the underlying capsule).
As we’ve seen, the **embryonic nucleus** is formed when the elongating posterior (aka *primary*) 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 primary lens fibers of the embryonic nucleus) and posteriorly (insinuating themselves between the origins of the primary lens fibers and the underlying capsule). These fibers constitute the **secondary lens fibers**.
As we’ve seen, the **embryonic nucleus** is formed when the elongating posterior (aka primary) 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 primary lens fibers of the embryonic nucleus) and posteriorly (insinuating themselves between the originations of the primary lens fibers and the underlying capsule). These fibers constitute the **secondary lens fibers**. When these fibers run into each other at the anterior and posterior poles, they interdigitate to form **lens sutures**. (We will have more to say about these shortly.)
As we’ve seen, the **embryonic nucleus** is formed when the elongating posterior (aka **primary**) 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 primary lens fibers of the embryonic nucleus) and posteriorly (insinuating themselves between the originations of the primary lens fibers and the underlying capsule). When these elongating fibers run into each other at the anterior and posterior poles, they interdigitate to form lens sutures. (We will have more to say about these shortly.)
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 `{` . Put another way: The fetal nucleus *surrounds* the embryonic nucleus.

As we’ve seen, the **embryonic nucleus** is formed when the elongating posterior (aka primary) 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 primary lens fibers of the embryonic nucleus) and posteriorly (insinuating themselves between the originations of the primary lens fibers and the underlying capsule). When these elongating fibers run into each other at the anterior and posterior poles, they interdigitate to form lens sutures. (We will have more to say about these shortly.)
Lens/Cataracts Overview

- Lens vesicle
- Primary fibers (Degrading nuclei)
- Secondary lens fibers
- Epithelium
- Embryonic nucleus
- Lens suture
- Fetal nucleus

Another illustration making the same set of points
Which embryologic cell line gives rise to all of the components of the lens? *Surface ectoderm*

T/F: The *optic vesicle* is the primordial structure that becomes the lens. It consists of a single layer of cuboidal cells encased within their basement membrane  **F**

T/F: The *anterior* cells of the lens vesicle elongate and progressively obliterate the lumen, forming the embryonic nucleus  **F**

The anterior cells become the *lens epithelium*

The equatorial epi cells become fibers that elongate both anteriorly and posteriorly, thereby forming the *fetal nucleus*

The *Y sutures* are formed by the anterior and posterior interdigitations of fetal nucleus fibers
Which embryologic cell line gives rise to all of the components of the lens? **Surface ectoderm**

T/F: The optic vesicle is the primordial structure that becomes the lens. It consists of a single layer of cuboidal cells encased within their basement membrane  **F**

T/F: The anterior cells of the lens vesicle elongate and progressively obliterate the lumen, forming the embryonic nucleus  **F**

The anterior cells become the **lens epithelium**

The equatorial epi cells become fibers that elongate both anteriorly and posteriorly, thereby forming the **fetal nucleus**

The **Y sutures** are formed by the anterior and posterior interdigitations of fetal nucleus fibers
Q

- Which embryologic cell line gives rise to all of the components of the lens? Surface ectoderm

- T/F: The optic vesicle is the primordial structure that becomes the lens. It consists of a single layer of cuboidal cells encased within their basement membrane. F

- T/F: The anterior cells of the lens vesicle elongate and progressively obliterate the lumen, forming the embryonic nucleus. F

- The anterior cells become the lens epithelium.

- The equatorial epi cells become fibers that elongate both anteriorly and posteriorly, thereby forming the fetal nucleus.

- The Y sutures are formed by the anterior and posterior interdigitations of fetal nucleus fibers.

(Here begins the ‘more to say about the lens sutures’ alluded to previously.)

Why are they called the ‘Y sutures’?
A

Lens/Cataracts Overview

- Which embryologic cell line gives rise to all of the components of the lens? *Surface ectoderm*
- T/F: The optic vesicle is the primordial structure that becomes the lens. It consists of a single layer of cuboidal cells encased within their basement membrane. **F**
- T/F: The anterior cells of the lens vesicle elongate and progressively obliterate the lumen, forming the embryonic nucleus. **F**
- Why are they called the ‘Y sutures’? Because they look like the letter Y
- The *Y sutures* are formed by the anterior and posterior interdigitations of fetal nucleus fibers.
Q

- Which embryologic cell line gives rise to all of the components of the lens? *Surface ectoderm*
- T/F: The optic vesicle is the primordial structure that becomes the lens. It consists of a single layer of cuboidal cells encased within their basement membrane. **F**
- T/F: The anterior cells of the lens vesicle elongate and progressively obliterate the lumen, forming the embryonic nucleus. **F**
- The anterior cells become the *lens epithelium*.
- The equatorial epi cells become fibers that elongate both anteriorly and posteriorly, thereby forming the *fetal nucleus*.
- The *Y sutures* are formed by the anterior and posterior interdigitations of fetal nucleus fibers.

(Here begins the ‘more to say about the lens sutures’ alluded to previously.)

Why are they called the ‘Y sutures’?
Because they look like the letter Y

How many Y sutures are there?
A

Lens/Cataracts Overview

- Which embryologic cell line gives rise to all of the components of the lens? *Surface ectoderm*
- T/F: The optic vesicle is the primordial structure that becomes the lens. It consists of a single layer of cuboidal cells encased within their basement membrane  
  - posterior
  - anterior
- T/F: The anterior cells of the lens vesicle elongate and progressively obliterate the lumen, forming the embryonic nucleus.  
  - posterior
  - anterior

(Here begins the ‘more to say about the lens sutures’ alluded to previously.)

*Y sutures*

Why are they called the ‘Y sutures’?
Because they look like the letter Y

How many Y sutures are there?
Just the two—one anterior, one posterior
Which embryologic cell line gives rise to all of the components of the lens? *Surface ectoderm*

T/F: The optic vesicle is the primordial structure that becomes the lens. It consists of a single layer of cuboidal cells encased within their basement membrane  

T/F: The anterior cells of the lens vesicle elongate and progressively obliterate the lumen, forming the embryonic nucleus  

The anterior cells become the *lens epithelium*  

The equatorial epitel cells become fibers that elongate both anteriorly and posteriorly, thereby forming the *fetal nucleus*  

The *Y sutures* are formed by the anterior and posterior interdigitations of fetal nucleus fibers.

(Here begins the ‘more to say about the lens sutures’ alluded to previously.)

Why are they called the ‘Y sutures’?

Because they look like the letter Y

How many Y sutures are there?

Just the two—one anterior, one posterior

How are they oriented?
Which embryologic cell line gives rise to all of the components of the lens? Surface ectoderm

T/F: The optic vesicle is the primordial structure that becomes the lens. It consists of a single layer of cuboidal cells encased within their basement membrane  F

T/F: The anterior cells of the lens vesicle elongate and progressively obliterate the lumen, forming the embryonic nucleus  F

The anterior cells become the lens epithelium

The equatorial epi cells become fibers that elongate both anteriorly and posteriorly, thereby forming the fetal nucleus

The Y sutures are formed by the anterior and posterior interdigitations of fetal nucleus fibers

(Here begins the ‘more to say about the lens sutures’ alluded to previously.)

Why are they called the ‘Y sutures’? Because they look like the letter Y

How many Y sutures are there? Just the two—one anterior, one posterior

How are they oriented? The anterior one is right-side up; the posterior one, upside down
A

Which embryologic cell line gives rise to all of the components of the lens? *Surface ectoderm*

T/F: The optic vesicle is the primordial structure that becomes the lens. It consists of a single layer of cuboidal cells encased within their basement membrane. **False**

T/F: The anterior cells of the lens vesicle elongate and progressively obliterate the lumen, forming the embryonic nucleus. **False**

The anterior cells become the lens epithelium.

The equatorial epi cells become fibers that elongate both anteriorly and posteriorly, thereby forming the fetal nucleus.

The **Y sutures** are formed by the anterior and posterior interdigitations of fetal nucleus fibers.

(Here begins the ‘more to say about the lens sutures’ alluded to previously.)

Why are they called the ‘Y sutures’?
Because they look like the letter Y

How many Y sutures are there?
Just the two—one anterior, one posterior

How are they oriented?
The anterior one is right-side up; the posterior one, upside down
Lens/Cataracts Overview

Lens: Y suture formation
Y sutures as they might be seen at the slit lamp
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; this 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 primary 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. These secondary lens fibers comprise the fetal nucleus.
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; this 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 primary 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. These secondary lens fibers comprise the fetal nucleus.

Now let’s look at the fetal vasculature of the lens.
The vascular supply encapsulating the developing lens is called the **tunica vasculosa lentis**.
The vascular supply encapsulating the developing lens is called the **tunica vasculosa lentis**.
The vascular supply encapsulating the developing lens is called the **tunica vasculosa lentis**. It has three sections:

1) ?

2) ?

3) ?
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
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)
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](https://www.ncbi.nlm.nih.gov/pubmed/312)

2) The *anterior vascular capsule* 

3) The *capsulopupillary portion*
The vascular supply encapsulating the developing lens is called the \textit{tunica vasculosa lentis}. \textit{It has three sections:}

1) The \textit{posterior vascular capsule} arises from the \textit{hyaloid} artery

2) The \textit{anterior vascular capsule}

3) The \textit{capsulopupillary portion}
Lens/Cataracts Overview

Tunica vasculosa lentis: Posterior vascular capsule
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).
2) The anterior vascular capsule derives from the long ciliary arteries.

- A common, clinically insignificant (usually) remnant is a persistent pupillary membrane.
- Another common remnant is the epicapsular star, colloquially referred to as 'chicken feet' on the anterior capsule.

3) The capsulopupillary portion

- 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.

The hyaloid artery runs from where to where?

- From the optic nerve head to the back of the fetal lens.
- Does it survive into post-fetal life? It is supposed to regress prior to birth (but doesn't always, as we are about to see).

3) The capsulopupillary portion
Lens/Cataracts Overview

2) The anterior vascular capsule

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

3) The capsulopupillary portion

The hyaloid artery runs from where to where? From the optic nerve head to the back of the fetal lens.
2) The anterior vascular capsule derives from the long ciliary arteries.

A common, clinically insignificant (usually) remnant is a persistent pupillary membrane.

Another common remnant is the epicapsular star, colloquially referred to as 'chicken feet' on the anterior capsule.

3) The capsulopupillary portion

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.

The hyaloid artery runs from where to where?

From the optic nerve head to the back of the fetal lens.

Does it survive into post-fetal life?

It is supposed to regress prior to birth (but doesn't always, as we are about to see).

Q
2) The anterior vascular capsule

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

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

The hyaloid artery runs from where to where?
From the optic nerve head to the back of the fetal lens

Does it survive into post-fetal life?
It is supposed to regress prior to birth (but doesn’t always, as we are about to see)

2) The anterior vascular capsule

3) The capsulopupillary portion
Single loop of a persistent hyaloid artery extending anteriorly within Cloquet's canal to insert on the posterior capsule of the lens.
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
   - A common, clinically insignificant remnant is the **Mittendorf dot**

2) The *anterior vascular capsule*

3) The *capsulopupillary portion*
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
   - A common, clinically insignificant remnant is the Mittendorf dot

2) The *anterior vascular capsule*

3) The *capsulopupillary portion*
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**
   - A common, clinically insignificant remnant is the **Mittendorf dot**

2) The *anterior vascular capsule*

3) The *capsulopupillary portion*
2) The anterior vascular capsule derives from the long ciliary arteries. A common, clinically insignificant (usually) remnant is a persistent pupillary membrane. Another common remnant is the epicapsular star, colloquially referred to as 'chicken feet' on the anterior capsule.

3) The capsulopupillary portion

- 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. 
     - A common, clinically insignificant remnant is the Mittendorf dot. 

  2) The *anterior vascular capsule*

  3) The *capsulopupillary portion*
The anterior vascular capsule derives from the long ciliary arteries.

A common, clinically insignificant (usually) remnant is a persistent pupillary membrane. Another common remnant is the epicapsular star, colloquially referred to as 'chicken feet' on the anterior capsule.

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.

How does a Mittendorf dot present clinically?

2) The anterior vascular capsule

3) The capsulopupillary portion
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.

*How does a Mittendorf dot present clinically?*

As a small white dot on the posterior capsule of the lens is the **Mittendorf dot**.

2) The anterior vascular capsule

3) The capsulopupillary portion
Mittendorf dot
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. 

   - *How does a Bergmeister papilla present clinically?*

2) The *anterior vascular capsule*

3) The *capsulopupillary portion*
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.

   - How does a Bergmeister papilla present clinically? As a tuft of glial-like tissue extending veil-like from the optic nerve head vs posterior capsule.

2) The anterior vascular capsule.

3) The capsulopupillary portion.
The anterior vascular capsule derives from the long ciliary arteries. A common, clinically insignificant (usually) remnant is a persistent pupillary membrane. Another common remnant is the epicapsular star, colloquially referred to as 'chicken feet' on the anterior capsule.

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. A common, clinically insignificant remnant is the Mittendorf dot.

2) The anterior vascular capsule

3) The capsulopupillary portion

How does a Bergmeister papilla present clinically? As a tuft of glial-like tissue extending veil-like from the optic nerve head a short distance into the vitreous.
Bergmeister papillae

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). **Notice the glial sheath of the hyaloid artery** (arrow 3).
2) The anterior vascular capsule derives from the long ciliary arteries. A common, clinically insignificant (usually) remnant is a persistent pupillary membrane. Another common remnant is the epicapsular star, colloquially referred to as ‘chicken feet’ on the anterior capsule.

3) The capsulopupillary portion

***It has three sections:***

1) The *posterior vascular capsule* arises from the *hyaloid* artery:
   - A common, clinically insignificant remnant is the *Mittendorf dot*.
   - A less common, clinically devastating remnant is PFV.

2) The *anterior vascular capsule*
The anterior vascular capsule derives from the long ciliary arteries.

A common, clinically insignificant (usually) remnant is a persistent pupillary membrane.

Another common remnant is the epicapsular star, colloquially referred to as ‘chicken feet’ on the anterior capsule.

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.
   - A common, clinically insignificant remnant is the *Mittendorf dot*.
   - A less common, clinically devastating remnant is *PFV*.

2) The *anterior vascular capsule*.

3) The *capsulopupillary portion*.
The anterior vascular capsule derives from the long ciliary arteries. A common, clinically insignificant (usually) remnant is a persistent pupillary membrane. Another common remnant is the epicapsular star, colloquially referred to as 'chicken feet' on the anterior capsule.

The capsulopupillary portion

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. A common, clinically insignificant remnant is the Mittendorf dot. A less common, clinically devastating remnant is PFV.

2) The anterior vascular capsule

What does PFV stand for in this context?

3) The capsulopupillary portion
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
   - A common, clinically insignificant remnant is the Mittendorf dot
   - A less common, clinically devastating remnant is PFV
2) The anterior vascular capsule
3) The capsulopupillary portion

What does PFV stand for in this context? Persistent fetal vasculature
Q

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  
   - A common, clinically insignificant remnant is the **Mittendorf dot**  
   - A less common, clinically devastating remnant is **PFV**
2) The *anterior vascular capsule*

*What does PFV stand for in this context?*  
Persistent fetal vasculature

*By what name was this condition known previously?*

3) The *capsulopupillary portion*
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
   - A common, clinically insignificant remnant is the Mittendorf dot
   - A less common, clinically devastating remnant is **PFV**

2) The *anterior vascular capsule*

   *What does PFV stand for in this context?*
   Persistent fetal vasculature

   *By what name was this condition known previously?*
   Persistent hyperplastic primary vitreous (PHPV)

3) The *capsulopupillary portion*
2) The anterior vascular capsule derives from the long ciliary arteries.

- A common, clinically insignificant (usually) remnant is a persistent pupillary membrane.
- Another common remnant is the epicapsular star, colloquially referred to as 'chicken feet' on the anterior capsule.

3) The capsulopupillary portion

- 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.
     - A common, clinically insignificant remnant is the Mittendorf dot.
     - A less common, clinically devastating remnant is **PFV**.

  2) The *anterior vascular capsule*.

 3) The *capsulopupillary portion*.

*In a nutshell, what is PFV?*
The anterior vascular capsule derives from the long ciliary arteries.

A common, clinically insignificant (usually) remnant is a persistent pupillary membrane.

Another common remnant is the epicapsular star, colloquially referred to as 'chicken feet' on the anterior capsule.

The capsulopupillary portion

1) The posterior vascular capsule arises from the hyaloid artery.
   - A common, clinically insignificant remnant is the Mittendorf dot.
   - A less common, clinically devastating remnant is **PFV**.

2) The anterior vascular capsule

   *In a nutshell, what is PFV?*

   **A** retrolental fibrovascular membrane that induces a variety of sight-threatening problems.

3) The capsulopupillary portion

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.
  - A common, clinically insignificant remnant is the **Mittendorf dot**.
  - A less common, clinically devastating remnant is **PFV**.

- **2)** The **anterior vascular capsule**
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
   - A common, clinically insignificant remnant is the Mittendorf dot
   - A less common, clinically devastating remnant is PFV

2) The anterior vascular capsule

In a nutshell, what is PFV? A retrolental fibrovascular membrane that induces a variety of sight-threatening problems

3) The capsulopupillary portion
PFV: Retrolental fibrovascular membrane
The anterior vascular capsule derives from the long ciliary arteries. A common, clinically insignificant (usually) remnant is a persistent pupillary membrane. Another common remnant is the epicapsular star, colloquially referred to as 'chicken feet' on the anterior capsule.

The capsulopupillary portion

- 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.
     - A common, clinically insignificant remnant is the Mittendorf dot.
     - A less common, clinically devastating remnant is PFV.
  2. The anterior vascular capsule

In a nutshell, what is PFV?
A retrolental fibrovascular membrane that induces a variety of sight-threatening problems.

What are the sight-threatening manifestations of PFV?
--?
--?
--?

3. The capsulopupillary portion
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
   - A common, clinically insignificant remnant is the **Mittendorf dot**
   - A less common, clinically devastating remnant is **PFV**

2) The *anterior vascular capsule*

   *In a nutshell, what is PFV?*
   A retrolental fibrovascular membrane that induces a **variety of sight-threatening problems**

   **What are the sight-threatening manifestations of PFV?**
   -- Cataract
   -- Progressive AC shallowing → closed-angle glaucoma
   -- Retinal detachment

3) The *capsulopupillary portion*
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
   - A common, clinically insignificant remnant is the Mittendorf dot
   - A less common, clinically devastating remnant is PFV

2) The *anterior vascular capsule* derives from the long ciliary arteries

3) The *capsulopupillary portion*
• 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**
   - A common, clinically insignificant remnant is the **Mittendorf dot**
   - A less common, clinically devastating remnant is **PFV**

2) The *anterior vascular capsule* derives from the **long ciliary arteries**

3) The *capsulopupillary portion*
Tunica vasculosa lentis: Anterior vascular capsule
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
   - A common, clinically insignificant remnant is the **Mittendorf dot**
   - A less common, clinically devastating remnant is **PFV**
2) The *anterior vascular capsule* derives from the **long ciliary** arteries
   - A common, clinically insignificant (usually) remnant is a

3) The *capsulopupillary portion*
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**
   - A common, clinically insignificant remnant is the **Mittendorf dot**
   - A less common, clinically devastating remnant is **PFV**
2) The *anterior vascular capsule* derives from the **long ciliary arteries**
   - A common, clinically insignificant (usually) remnant is a **persistent pupillary membrane**
3) The *capsulopupillary portion*
Persistent pupillary membrane

Trivial case

Hey now
2) The anterior vascular capsule derives from the long ciliary arteries. A common, clinically insignificant (usually) remnant is a persistent pupillary membrane. Another common remnant is the epicapsular star, colloquially referred to as ‘chicken feet’ on the anterior capsule.

3) The capsulopupillary portion

It has three sections:

1) The posterior vascular capsule arises from the hyaloid artery.
   - A common, clinically insignificant remnant is the Mittendorf dot.
   - A less common, clinically devastating remnant is PFV.

2) The anterior vascular capsule derives from the long ciliary arteries.
   - A common, clinically insignificant (usually) remnant is a persistent pupillary membrane.
   - Another common remnant is the two words.

3) The capsulopupillary portion
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*
   - A common, clinically insignificant remnant is the *Mittendorf dot*
   - A less common, clinically devastating remnant is *PFV*

2) The *anterior vascular capsule* derives from the *long ciliary arteries*
   - A common, clinically insignificant (usually) remnant is a *persistent pupillary membrane*
   - Another common remnant is the *epicapsular star*

3) The *capsulopupillary portion*
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**
   - A common, clinically insignificant remnant is the **Mittendorf dot**
   - A less common, clinically devastating remnant is **PFV**
2) The *anterior vascular capsule* derives from the **long ciliary arteries**
   - A common, clinically insignificant (usually) remnant is a **persistent pupillary membrane**
   - Another common remnant is the **epicapsular star,** colloquially referred to as **cluck** on the anterior capsule
3) The *capsulopupillary portion*
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
   - A common, clinically insignificant remnant is the Mittendorf dot
   - A less common, clinically devastating remnant is PFV

2) The *anterior vascular capsule* derives from the long ciliary arteries
   - A common, clinically insignificant (usually) remnant is a persistent pupillary membrane
   - 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
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
   - A common, clinically insignificant remnant is the **Mittendorf dot**
   - A less common, clinically devastating remnant is **PFV**

2) The *anterior vascular capsule* derives from the **long ciliary arteries**
   - A common, clinically insignificant (usually) remnant is a **persistent pupillary membrane**
   - Another common remnant is the **epicapsular star**, colloquially referred to as ‘**chicken feet**’ on the anterior capsule

3) The *capsulopupillary portion* anastomoses the anterior and posterior sections of the tunica
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*:
   - A common, clinically insignificant remnant is the *Mittendorf dot*
   - A less common, clinically devastating remnant is *PFV*

2) The *anterior vascular capsule* derives from the *long ciliary arteries*:
   - A common, clinically insignificant (usually) remnant is a *persistent pupillary membrane*
   - Another common remnant is the *epicapsular star*, colloquially referred to as ‘*chicken feet*’ on the anterior capsule

3) The *capsulopupillary portion* *anastomoses* the anterior and posterior sections of the tunica
Tunica vasculosa lentis: Capsulopupillary portion
Zonules are secreted by the specific structure near the end of the third month of gestation.
Zonules are secreted by the ciliary epithelium near the end of the third month of gestation.
Zonules are secreted by the ciliary epithelium near the end of the third month of gestation.
Zonules are secreted by the ciliary epithelium near the end of the third month of gestation. Zonules comprise the so-called vitreous.
- Zonules are secreted by the **ciliary epithelium** near the end of the third month of gestation.
- Zonules comprise the so-called **tertiary vitreous**.
Zonules are secreted by the ciliary epithelium near the end of the third month of gestation. Zonules comprise the so-called tertiary vitreous. This begs the question: What are the primary and secondary vitreous? (Vitrei?)

Primary vitreous: The two words.
Zonules are secreted by the ciliary epithelium near the end of the third month of gestation.

Zonules comprise the so-called tertiary vitreous.

This begs the question: What are the primary and secondary vitreous? (Vitrei?)

Primary vitreous: The hyaloid vasculature.
Zonules are secreted by the ciliary epithelium near the end of the third month of gestation.

Zonules comprise the so-called tertiary vitreous.

This begs the question: What are the primary and secondary vitreous? (Vitrei?)

- Primary vitreous: The hyaloid vasculature
- Hence PFV is aka...
Zonules are secreted by the ciliary epithelium near the end of the third month of gestation.

Zonules comprise the so-called tertiary vitreous.

This begs the question: What are the primary and secondary vitreous? (Vitrei?)

- Primary vitreous: The hyaloid vasculature
  - Hence PFV is aka persistent hyperplastic primary vitreous.
Primary vitreous
Zonules are secreted by the ciliary epithelium near the end of the third month of gestation.

Zonules comprise the so-called tertiary vitreous.

This begs the question: What are the primary and secondary vitreous? (Vitrei?)

- **Primary vitreous**: The hyaloid vasculature
  - Hence PFV is aka persistent hyperplastic primary vitreous

- **Secondary vitreous**: The
Zonules are secreted by the ciliary epithelium near the end of the third month of gestation.

Zonules comprise the so-called tertiary vitreous.

This begs the question: What are the primary and secondary vitreous? (Vitrei?)

- **Primary vitreous**: The hyaloid vasculature
  - Hence PFV is aka persistent hyperplastic primary vitreous

- **Secondary vitreous**: The main vitreous body
Secondary vitreous

(Tertiary vitreous will form the zonules)
(This is a good point in the set to take a break)
At long last we’re ready to address the *cataract* portion of our lens/cataract overview. Obviously, cataracts and their extraction are central to the practice of ophthalmology.
At long last we’re ready to address the *cataract* portion of our lens/cataract overview. Obviously, cataracts and their extraction are central to the practice of ophthalmology. In fact, CE is so central to ophthalmology that the motto of the American Board of Ophthalmology, *Ex obscuris lux*, is Latin for ‘No one dies with a natural lens.’
Where does cataracts rank as a cause of blindness worldwide?
Where does cataracts rank as a cause of blindness worldwide?
It is #1
Lens/Cataracts Overview

Where does cataracts rank as a cause of blindness worldwide?
It is #1

What proportion of worldwide blindness does cataracts account for?
Lens/Cataracts Overview

Where does cataracts rank as a cause of blindness worldwide?
It is #1

What proportion of worldwide blindness does cataracts account for?
An astonishing 1/2!
Where does cataracts rank as a cause of blindness worldwide? It is #1.

What proportion of worldwide blindness does cataracts account for? An astonishing 1/2!

What proportion of the world’s population has some degree of visual impairment 2ndry to cataracts?
Where does cataracts rank as a cause of blindness worldwide? It is #1.

What proportion of worldwide blindness does cataracts account for? An astonishing 1/2!

What proportion of the world’s population has some degree of visual impairment 2ndry to cataracts? A third.
**Lens/Cataracts Overview**

*Where does cataracts rank as a cause of blindness worldwide?*
It is #1

*What proportion of worldwide blindness does cataracts account for?*
An astonishing 1/2!

*What proportion of the world’s population has some degree of visual impairment secondary to cataracts?*
A third. To be clear: The assertion here is not that a third of visual impairment cases are due to cataracts; rather, it’s that a full one-third of the world’s population has some degree of visual impairment owing to cataracts!
Where does cataracts rank as a cause of blindness worldwide?
It is #1

What proportion of worldwide blindness does cataracts account for?
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Is it safe to assume that cataracts are the #1 cause of visual impairment worldwide?
Where does cataracts rank as a cause of blindness worldwide? It is #1.

What proportion of worldwide blindness does cataracts account for? An astonishing 1/2!

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Is it safe to assume that cataracts are the #1 cause of visual impairment worldwide? You’d think so, but no—it ranks second behind
Where does cataracts rank as a cause of blindness worldwide?
It is #1

What proportion of worldwide blindness does cataracts account for?
An astonishing 1/2!

What proportion of the world’s population has some degree of visual impairment 2ndry to cataracts?
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Is it safe to assume that cataracts are the #1 cause of visual impairment worldwide?
You’d think so, but no—it ranks second behind refractive error
Where does cataracts rank as a cause of blindness worldwide?
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Is it safe to assume that cataracts are the #1 cause of visual impairment worldwide?
You’d think so, but no—it ranks second behind refractive error

How many cataract surgeries are performed worldwide on a yearly basis?
Where does cataracts rank as a cause of blindness worldwide? It is #1.

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Is it safe to assume that cataracts are the #1 cause of visual impairment worldwide? You’d think so, but no—it ranks second behind refractive error.

How many cataract surgeries are performed worldwide on a yearly basis? 10 million (and we’re still falling behind)
Per the Lens book, how many categories of cataracts are there?
Per the Lens book, how many categories of cataracts are there? Four
What are the four categories of cataracts?
What are the four categories of cataracts?

- Congenital
- Metabolic
- Age-related
- Traumatic
What are the four categories of cataracts?

- Congenital
- Metabolic
- Age-related
- Traumatic

The remainder of this slide-set will focus on age-related cataracts
How many ‘age-related’ types of cataracts are there?
How many ‘age-related’ types of cataracts are there? Three
What are the three age-related types of cataracts?
What are the three age-related types of cataracts?

- **NSC** (Nuclear sclerotic cataract)
- **Cortical**
- **PSC** (Posterior subcapsular cataract)
What are the three age-related types of cataracts?

NSC

Cortical

PSC

What is the typical color of an NSC?
What are the three age-related types of cataracts?

NSC

Cortical

PSC

What is the typical color of an NSC?
Somewhere on the amber-to-brown spectrum
What are the three age-related types of cataracts?

- NSC
- Cortical
- PSC

What is the typical color of an NSC?  
Somewhere on the amber-to-brown spectrum

What is the pathogenesis of NSC discoloration?
What are the three age-related types of cataracts?

NSC

Cortical

PSC

What is the typical color of an NSC?
Somewhere on the amber-to-brown spectrum

What is the pathogenesis of NSC discoloration?
Per the Lens book, it is “poorly understood” at this time
What are the three age-related types of cataracts?

- NSC
- Cortical
- PSC

What is the typical color of an NSC?
Somewhere on the amber-to-brown spectrum

What is the pathogenesis of NSC discoloration?
Per the Lens book, it is “poorly understood” at this time

What is the typical consistency of an NSC?
What are the three age-related types of cataracts?

- **NSC**
- Cortical
- PSC

**What is the typical color of an NSC?**
Somewhere on the *amber-to-brown* spectrum

**What is the pathogenesis of NSC discoloration?**
Per the *Lens* book, it is “poorly understood” at this time

**What is the typical consistency of an NSC?**
Firm to hard
What are the three age-related types of cataracts?

NSC

What is the typical color of an NSC?
Somewhere on the amber-to-brown spectrum

What is the pathogenesis of NSC discoloration?
Per the Lens book, it is “poorly understood” at this time

What is the typical consistency of an NSC?
Firm to hard

What is the pathogenesis of NSC hardness?
What are the three age-related types of cataracts?

**NSC**

*What is the typical color of an NSC?*
Somewhere on the *amber-to-brown* spectrum

*What is the pathogenesis of NSC discoloration?*
Per the *Lens* book, it is “poorly understood” at this time

*What is the typical consistency of an NSC?*
Firm to hard

*What is the pathogenesis of NSC hardness?*
The never-ending creation of new fibers progressively compresses the nucleus, causing it to become progressively denser (and harder) over time

**Cortical**

**PSC**
What are the three age-related types of cataracts?

- **NSC**
- **Cortical**
- **PSC**

**What is the typical color of an NSC?**
Somewhere on the amber-to-brown spectrum.

**What is the pathogenesis of NSC discoloration?**
Per the Lens book, it is “poorly understood” at this time.

**What is the typical consistency of an NSC?**
Firm to hard.

**What is the pathogenesis of NSC hardness?**
The never-ending creation of new fibers progressively compresses the nucleus, causing it to become progressively denser (and harder) over time.
What are the three age-related types of cataracts?

- **NSC**
  - What is the typical color of an NSC?
    - Somewhere on the *amber-to-brown* spectrum
  - What is the pathogenesis of NSC discoloration?
    - Per the *Lens* book, it is “poorly understood” at this time
  - What is the typical consistency of an NSC?
    - Firm to hard
    - *What’s the formal term for this progressive compression and hardening?*
    - Sclerosis (as in, a ‘nuclear sclerotic cataract’)
    - The never-ending creation of new fibers *progressively compresses the nucleus, causing it to become progressively denser* (and harder) over time
Nuclear cataract viewed with diffuse illumination (A) and with a slit beam (B). C, Schematic of nuclear cataract
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.
What are the three age-related types of cataracts?

Next let’s look at cortical cataracts
What are the first manifestations of a cortical cataract?
What are the first manifestations of a cortical cataract? The presence of water clefts and vacuoles in the cortical region of the lens.
What are the first manifestations of a cortical cataract?
The presence of water clefts and vacuoles in the cortical region of the lens

**Important:** The opacification in this area is not representative of cortical changes, but rather is a.
Early cortical cataract development as viewed at the slit lamp using retroillumination. A, Vacuoles. B, Typical cortical spokes

**Important:** The opacification in this area is not representative of cortical changes, but rather is a PSC. (Just as a dog can have both ticks and fleas, so too can an eye have >1 form of cataract.)
Lens/Cataracts Overview

What are the first manifestations of a cortical cataract?
The presence of water clefts and vacuoles in the cortical region of the lens

What manifestation typically follows water clefts and vacuoles?
What are the first manifestations of a cortical cataract?
The presence of water clefts and vacuoles in the cortical region of the lens

What manifestation typically follows water clefts and vacuoles?
The appearance of wedge-shaped opacifications (called...two words) at the lens periphery
What are the first manifestations of a cortical cataract? 
The presence of water clefts and vacuoles in the cortical region of the lens

What manifestation typically follows water clefts and vacuoles? 
The appearance of wedge-shaped opacifications (‘cortical spokes’) at the lens periphery
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
What are the first manifestations of a cortical cataract?
The presence of water clefts and vacuoles in the cortical region of the lens

What manifestation typically follows water clefts and vacuoles?
The appearance of wedge-shaped opacifications (‘cortical spokes’) at the lens periphery

Eventually, these spokes will turn white and comprise the entire lens. What is the name for such a cataract?
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A mature cataract
Cortical cataract: Mature
What are the first manifestations of a cortical cataract?
The presence of water clefts and vacuoles in the cortical region of the lens.

What manifestation typically follows water clefts and vacuoles?
The appearance of wedge-shaped opacifications (‘cortical spokes’) at the lens periphery.

Eventually, these spokes will turn white and comprise the entire lens. What is the name for such a cataract?
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Occasionally, a mature cataract will absorb a clinically significant amount of water. What is the name for such a cataract?
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An intumescent 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)
What are the first manifestations of a cortical cataract?
The presence of water clefts and vacuoles in the cortical region of the lens

What manifestation typically follows water clefts and vacuoles?
The appearance of wedge-shaped opacifications (‘cortical spokes’) at the lens periphery

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Occasionally, the cortical material of an intumescent or mature cortical cataract will begin to degenerate and leach through the lens capsule. The accompanying loss of cataract mass will leave the anterior capsule with a wrinkled appearance.
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A hypermature cataract
Hypermature cataract. Note the capsular wrinkling.
What are the first manifestations of a cortical cataract?
The presence of water clefts and vacuoles in the cortical region of the lens

What manifestation typically follows water clefts and vacuoles?
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Occasionally, the entire hypermature cataract liquefies, leaving only a wrinkled bag with an NSC resting at its bottom. What is the name for such a cataract?
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A morgagnian cataract
Morgagnian cataract
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**Take note of the stages:**

Mature cataract
What are the first manifestations of a cortical cataract? The presence of water clefts and vacuoles in the cortical region of the lens.

What manifestation typically follows water clefts and vacuoles? The appearance of wedge-shaped opacifications (‘cortical spokes’) at the lens periphery.

Eventually, these spokes will turn white and comprise the entire lens. What is the name for such a cataract? A mature cataract.

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Occasionally, the entire hypermature cataract liquefies, leaving only a wrinkled bag with an NSC resting at its bottom. What is the name for such a cataract? A morgagnian cataract.

**Take note of the stages:**

Mature cataract → intumescent cataract → ?
Lens/Cataracts Overview

What are the first manifestations of a cortical cataract?
The presence of water clefts and vacuoles in the cortical region of the lens

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Take note of the stages:

Mature cataract → intumescent cataract → hypermature cataract
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Mature cataract → **intumescent** cataract → **hypermature** cataract
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**Take note of the stages:**

Mature cataract  >  intumescent cataract  >  hypermature cataract

Cataract absorbs water  ➔  What happens
What are the first manifestations of a cortical cataract?
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**Take note of the stages:**

Mature cataract $\xrightarrow{absorbs}$ intumescent cataract $\xrightarrow{leaks}$ hypermature cataract

Cataract absorbs water $\xleftarrow{What \ happens}$ Cataract leaks water
What are the first manifestations of a cortical cataract?
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Take note of the stages:

Mature cataract \(\xrightarrow{\text{absorbs water}}\) intumescent cataract \(\xrightarrow{\text{leaks water}^*}\) hypermature cataract

*(and proteins)*
What are the first manifestations of a cortical cataract?
The presence of water clefts and vacuoles in the cortical region of the lens

What manifestation typically follows water clefts and vacuoles?
The appearance of wedge-shaped opacifications ('cortical spokes') at the lens periphery

Eventually, these spokes will turn white and comprise the entire lens. What is the name for such a cataract? A mature cataract

Occasionally, a mature cataract will absorb a clinically significant amount of water. What is the name for such a cataract? An intumescent cataract

All three of these pose a particular challenge during an early, crucial step in cataract surgery. What step, and what challenge?

They stain the anterior capsule with trypan blue

Take note of the stages:

Mature cataract → intumescent cataract → hypermature cataract
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All three of these pose a particular challenge during an early, crucial step in cataract surgery. What step, and what challenge?
For all three stages, the red reflex 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.

Take note of the stages:

Mature cataract  intumescent cataract  hypermature cataract
What are the first manifestations of a cortical cataract?
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What step do most surgeons take to facilitate capsulorrhexis in these cases?

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What are the first manifestations of a cortical cataract?
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What step do most surgeons take to facilitate capsulorrhexis in these cases?
They stain the anterior capsule with trypan blue.
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Take note of the stages:
- Mature cataract
- Intumescent cataract
- Hypermature cataract
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**Let’s drill down on intumescent cataracts for a moment. In this context, what does intumescent mean?**

It means ‘swollen.’ As mentioned a few slides ago, the event that transforms a mature cataract into an intumescent cataract is absorption of water, and this absorption results in swelling of the lens.

What effect does swelling have on the internal dynamics of the lens?
It increases the pressure within the lens.

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What step do most surgeons take to facilitate capsulorrhexis in these cases?
They stain the anterior capsule with trypan blue.

*Take note of the stages:*

Mature cataract \(\rightarrow\) **intumescent cataract** \(\rightarrow\) hypermature cataract
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What manifestation typically follows water clefts and vacuoles?
The appearance of wedge-shaped opacifications ('cortical spokes') at the lens periphery.

Eventually, these spokes will turn white and comprise the entire lens. What is the name for such a cataract?
A mature cataract.

Occasionally, a mature candidate will absorb a clinically significant amount of water. What is the name for such a cataract?
An intumescent cataract.

Occasionally, the cortical material of an intumescent or mature cortical cataract will begin to degenerate and leach through the lens capsule. The accompanying loss of cataract mass will leave the anterior capsule with a wrinkled appearance. What is the name for such a cataract?
A hypermature cataract.

Occasionally, the entire hypermature cataract liquefies, leaving only a wrinkled bag with an NSC resting at its bottom. What is the name for such a cataract?
A Morgagnian cataract.

Let's drill down on intumescent cataracts for a moment. In this context, what does intumescent mean?
It means 'swollen.' As mentioned a few slides ago, the event that transforms a mature cataract into an intumescent cataract is absorption of water, and this absorption results in swelling of the lens.

What effect does swelling have on the internal dynamics of the lens?
It increases the pressure within the lens.

What step do most surgeons take to facilitate capsulorrhexis in these cases?
They stain the anterior capsule with trypan blue.

Take note of the stages:
Mature cataract → intumescent cataract → hypermature cataract.
What are the first manifestations of a cortical cataract?
The presence of water clefts and vacuoles in the cortical region of the lens.

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Take note of the stages:

Mature cataract \[\rightarrow\] \textbf{intumescent cataract} \[\rightarrow\] hypermature cataract
**Q**

**Lens/Cataracts Overview**

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**Take note of the stages:**

Mature cataract ➔ intumescent cataract ➔ hypermature cataract

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**Let’s drill down on intumescent cataracts for a moment. In this context, what does intumescent mean?**
As if obscuration of the red reflex wasn’t enough, the increased intralenticular pressure of an intumescent cataract poses an additional challenge during capsulorrhexis—what is it?
When the surgeon makes the initial rent in the capsule, the increased pressure within an intumescent cataract may cause the rent to suddenly and uncontrollably extend to the periphery.

**If/when the rent runs peripherally, what is the resulting appearance of the lens?**
Recall that, because of red-reflex obscuration, trypan blue is used in all these cases. Thus, after the rent runs out, the surgeon sees a white stripe (the cataract) between two areas of blue (the undisturbed, trypan blue-stained capsule).
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As if obscuration of the red reflex wasn’t enough, the increased intralenticular pressure of an intumescent cataract poses an additional challenge during capsulorrhexis—what is it?

When the surgeon makes the initial rent in the capsule, the increased pressure within an intumescent cataract may cause the rent to suddenly and uncontrollably extend to the periphery. This can make it difficult to perform a capsulorrhexis.

If/when the rent runs peripherally, what is the resulting appearance of the lens?

Recall that, because of red-reflex obscuration, trypan blue is used in all these cases. They stain the anterior capsule with trypan blue.

Take note of the stages:

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What is a mature cataract?
A cortical cataract that has progressed to involve the entire lens cortex.

What is a hypermature cataract?
Mature cataracts may absorb water, transforming them into an intumescent cortical cataract. A hypermature cataract results when an intumescent cataract begins leaking water and denatured proteins through its intact anterior capsule.

Take note of the stages:
Mature cataract → intumescent cataract → hypermature cataract.

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They stain the anterior capsule with trypan blue.

Trypan blue
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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 rent is made in the capsule, the increased pressure within an intumescent cataract may cause the rent to suddenly and uncontrollably extend to the periphery.

If/when the rent runs peripherally, what is the resulting appearance of the lens?
Recall that, because of red-reflex obscuration, trypan blue is used in all these cases. When the rent runs out, the surgeon sees a white stripe (the cataract) between two areas of blue (the undisturbed, trypan blue-stained capsule). They stain the anterior capsule with trypan blue.

This appearance has led to a memorable name for this finding. What is it?
It is known as 'Argentinian flag sign.'
What are the first manifestations of a cortical cataract?

The presence of water clefts and vacuoles in the cortical region of the lens.

What manifestation typically follows water clefts and vacuoles?

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Q

When faced with an intumescent cataract, what can the surgeon do to minimize the likelihood of seeing an Argentinian flag?

When the surgeon makes the initial rent in the capsule, the increased pressure within an intumescent cataract may cause the rent to suddenly and uncontrollably extend to the periphery.

When the rent runs peripherally, what is the resulting appearance of the lens? Recall that, because of red-reflex obscuration, trypan blue is used in all these cases. Thus, after the rent runs out, the surgeon sees a white stripe (the cataract) between two areas of blue (the undisturbed, trypan blue-stained capsule).

They stain the anterior capsule with trypan blue and perform capsulorrhexis with a laser.

Take note of the stages:

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

Lens/Cataracts Overview

What is a mature cataract? A cortical cataract that has progressed to involve the entire lens cortex.

What is a hypermature cataract? Mature cataracts may absorb water, transforming them into an intumescent cortical cataract. A hypermature cataract results when an intumescent cataract begins leaking water and denatured proteins through its intact anterior capsule.

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Take note of the stages:

- Mature cataract
- Intumescent cataract
- Hypermature cataract

All three of these pose a particular challenge during an early, crucial step in cataract surgery.

What step, and what challenge?
For all three stages, the red reflex 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.

What step do most surgeons take to facilitate capsulorrhexis in these cases?
They stain the anterior capsule with trypan blue.

Let’s drill down on intumescent cataracts for a moment. In this context, what does intumescent mean?
It means ‘swollen.’ As mentioned a few slides ago, the event that transforms a mature cataract into an intumescent cataract is absorption of water, and this absorption results in swelling of the lens.

What effect does swelling have on the internal dynamics of the lens?
It increases the pressure within the lens.

As if obscuration of the red reflex wasn’t enough, the increased intralenticular pressure of an intumescent cataract poses an additional challenge during capsulorrhexis—what is it?
When the surgeon makes the initial rent in the capsule, the increased pressure within an intumescent cataract may cause the rent to suddenly and uncontrollably extend to the periphery.

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When faced with an intumescent cataract, what can the surgeon do to minimize the likelihood of seeing an Argentinian flag?
--Counteract the positive pressure within the lens by filling the AC with a high-viscosity OVD
--Reduce intralenticular pressure by aspirating cortical material immediately upon creating the initial rent

When the surgeon makes the initial rent in the capsule, the increased pressure within an intumescent cataract may cause the rent to suddenly and uncontrollably extend to the periphery.
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And as a review: What stage occurs after the hypermature stage?

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Are hypermature and/or morgagnian cataracts susceptible to an Argentinian flag-sign event?
Not at all.

Why not?
Because the loss of water removes the hydrostatic pressure that causes it.

**Take note of the stages:**
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Take note of the stages:
- Mature cataract
- Intumescent cataract
- Hypermature cataract

Morgagnian cataract: Cataract leaks water.
What are the three age-related types of cataracts?

NSC

Cortical

PSC

All PSCs are not visually significant. What attribute is needed to make them so?
What are the three age-related types of cataracts?

NSC  
Cortical  
PSC

All PSCs are not visually significant. What attribute is needed to make them so? Being located in the two words
What are the three age-related types of cataracts?

NSC

Cortical

PSC

All PSCs are not visually significant. What attribute is needed to make them so? Being located in the visual axis
Lens/Cataracts Overview

Posterior subcapsular cataract
Posterior subcapsular cataract as seen at the slit lamp
What are the three age-related types of cataracts?

NSC

Cortical

PSC

All PSCs are not visually significant. What attribute is needed to make them so?
Being located in the visual axis

What is the first, basic step in PSC pathophysiology?
What are the three age-related types of cataracts?

- NSC (Nuclear Sclerotic Cataract)
- Cortical Cataract
- PSC (Posterior Subcapsular Cataract)

All PSCs are not visually significant. What attribute is needed to make them so?

Being located in the visual axis

What is the first, basic step in PSC pathophysiology?

Migration of cells to the posterior capsule
What are the three age-related types of cataracts?

NSC  Cortical  PSC

All PSCs are not visually significant. What attribute is needed to make them so?

Being located in the visual axis

What is the first, basic step in PSC pathophysiology?

Migration of equatorial epithelial cells to the posterior capsule
What are the three age-related types of cataracts?

NSC | Cortical | PSC

All PSCs are not visually significant. What attribute is needed to make them so? Being located in the visual axis

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Posterior subcapsular cataract. Oval to round nucleated Wedl cells (arrows) and smaller lens epithelial cells line the posterior lens capsule (arrowhead).
What are the three age-related types of cataracts?

Relevant sidebar: In eye-dentistry, what does PCO stand for?

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Up to half (unless we’re talking about peds CE, wherein essentially all develop a PCO)

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It is indeed. In fact, it is the most common post-op complication associated with cataract surgery.

Are we talking about PCOs at this juncture because they have something in common with PSCs?

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Understanding Pathophysiology

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- **NSC**
  - Risk factors:
  - For each risk factor, identify which type of cataract it is associated with (some will be associated with more than one):

- **Cortical**
  - Risk factors:

- **PSC**
  - Risk factors:

**Steroids**
What are the three age-related types of cataracts?

- **NSC**
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For each risk factor, identify which type of cataract it is associated with (some will be associated with more than one):

*Steroids*
Which of the following routes of steroid administration have been associated with cataract formation:
--Topical?
--Subconjunctival?
--Sub-Tenon’s?
--Intravitreal?
--PO?
--IV?
--Inhaled?
--Intranasal?
What are the three age-related types of cataracts?

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All have been associated with PSC formation!

Steroids

Risk factors:

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Pts with a propensity to develop a steroid-induced PSC are susceptible to another steroid-related complication—what is it?

Ocular hypertension

Steroid-induced PSCs in children differ in an important way from steroid-induced PSCs in adults. What is it?

Cessation of steroid therapy in children may result in regression and resolution of the PSC; this does not occur in adults.

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### Risk factors:
- Steroids

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What are the three age-related types of cataracts?

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What are the three age-related types of cataracts?

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

- **PSC**
  - Risk factors:
    - Steroids

For each risk factor, identify which type of cataract it is associated with (some will be associated with more than one):

**UV radiation**
What are the three age-related types of cataracts?

- **NSC (Nuclear Sclerotic Cataract)**
  - Risk factors:
    - Miotics
    - Statins

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

- **PSC (Posterior Subcapsular Cataract)**
  - Risk factors:
    - Steroids

For each risk factor, identify which type of cataract it is associated with (some will be associated with more than one):

**UV radiation**
What are the three age-related types of cataracts?

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

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

- **PSC**
  - Risk factors:
    - Steroids

For each risk factor, identify which type of cataract it is associated with (some will be associated with more than one):

*Diabetes mellitus*
What are the three age-related types of cataracts?

- **NSC (Cortical)**
  - Risk factors:
    - Miotics
    - Statins
    - DM

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

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

For each risk factor, identify which type of cataract it is associated with (some will be associated with more than one):

*Diabetes mellitus*
What are the 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

How do diabetes-related NSCs, cortical cataracts, and PSCs differ from those associated with age?

For each risk factor, identify which type of cataract it is associated with (some will be associated with more than one):

*Diabetes mellitus*
What are the 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

How do diabetes-related NSCs, cortical cataracts, and PSCs differ from those associated with age? They don’t; rather, DM seems to cause age-related cataracts to occur at an earlier age.

For each risk factor, identify which type of cataract it is associated with (some will be associated with more than one):

*Diabetes mellitus*
What are the three age-related types of cataracts?

- **NSC (Nuclear Sclerotic Cataract)**
  - Risk factors:
    - Miotics
    - Statins
    - DM

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

- **PSC (Posterior Subcapsular Cataract)**
  - Risk factors:
    - Steroids
    - DM

For each risk factor, identify which type of cataract it is associated with (some will be associated with more than one):

- **Smoking**
What are the three age-related types of cataracts?

NSC
Risk factors:
--Miotics
--Statins
--DM
--Smoking

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

PSC
Risk factors:
--Steroids
--DM
--Smoking

For each risk factor, identify which type of cataract it is associated with (some will be associated with more than one):

Smoking
What are the three age-related types of cataracts?

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

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

**PSC**
Risk factors:
--Steroids
--DM
--Smoking

What about smokeless—does it convey an increased risk of cataracts as well?

Smok**eless** tobacco?
What are the three age-related types of cataracts?

**NSC**
- Miotics
- Statins
- DM
- Smoking

**Cortical**
- Miotics
- Infrared radiation
- UV radiation
- DM

**PSC**
- Steroids
- DM
- Smoking

For each risk factor, identify which type of cataract it is associated with (some will be associated with more than one):

*What about smokeless—does it convey an increased risk of cataracts as well?*
- Yes (although the *Lens* book does not say which type)

*Smokless tobacco? Yes*
What are the three age-related types of cataracts?

NSC
Risk factors:
--Miotics
--Statins
--DM
--Smoking

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

PSC
Risk factors:
--Steroids
--DM
--Smoking

For each risk factor, identify which type of cataract it is associated with (some will be associated with more than one):

High myopia
What are the three age-related types of cataracts?

**NSC**
- Miotics
- Statins
- DM
- Smoking
- High myopia

**Cortical**
- Miotics
- Infrared radiation
- UV radiation
- DM

**PSC**
- Steroids
- DM
- Smoking

For each risk factor, identify which type of cataract it is associated with (some will be associated with more than one): 

*High myopia*
What are the three age-related types of cataracts?

**NSC**
- Miotics
- Statins
- DM
- Smoking
- High myopia

**Cortical**
- Miotics
- Infrared radiation
- UV radiation
- DM

**PSC**
- Steroids
- DM
- Smoking

For each risk factor, identify which type of cataract it is associated with (some will be associated with more than one):

*Heavy EtOH consumption*
What are the three age-related types of cataracts?

**NSC**
- Miotics
- Statins
- DM
- Smoking
- High myopia
- Heavy EtOH

**Cortical**
- Miotics
- Infrared radiation
- UV radiation
- DM
- Heavy EtOH

**PSC**
- Steroids
- DM
- Smoking
- Heavy EtOH

For each risk factor, identify which type of cataract it is associated with (some will be associated with more than one):

*Heavy EtOH consumption*
What are the three age-related types of cataracts?

- **NSC (Nuclear Sclerotic Cataract)**
  - Risk factors:
    - Miotics
    - Statins
    - DM
    - Smoking
    - High myopia
    - Heavy EtOH

- **Cortical Cataract**
  - Risk factors:
    - Miotics
    - Infrared radiation
    - UV radiation
    - DM
    - Heavy EtOH

- **PSC (Posterior Subcapsular Cataract)**
  - Risk factors:
    - Steroids
    - DM
    - Smoking
    - Heavy EtOH

What about moderate amount of alcohol—does it convey an increased risk of cataracts as well? **Moderate EtOH consumption?**
What are the three age-related types of cataracts?

**NSC (Nuclear Sclerotic Cataract)**
- Miotics
- Statins
- DM
- Smoking
- High myopia
- Heavy EtOH

**Cortical Cataract**
- Miotics
- Steroids
- DM
- Smoking
- Infrared radiation
- UV radiation
- Heavy EtOH

**PSC (Posterior Subcapsular Cataract)**
- Steroids
- DM
- Smoking
- Heavy EtOH

For each risk factor, identify which type of cataract it is associated with (some will be associated with more than one):

What about moderate amount of alcohol—does it convey an increased risk of cataracts as well? No—in fact, it may convey a reduced risk.

Moderate EtOH consumption? No! In fact...
For each statement, identify the associated type of cataract: **nuclear sclerotic (NSC); cortical; posterior subcapsular (PSC)**
For each statement, identify the associated type of cataract: nuclear sclerotic (NSC); cortical; posterior subcapsular (PSC)

- Associated with the second sight phenomenon:
For each statement, identify the associated type of cataract:
- nuclear sclerotic (NSC);
- cortical;
- posterior subcapsular (PSC)

- Associated with the *second sight* phenomenon: NSC
For each statement, identify the associated type of cataract: 
- nuclear sclerotic (NSC); cortical; posterior subcapsular (PSC)

- Associated with the *second sight* phenomenon: **NSC**

*What is the second sight phenomenon?*
For each statement, identify the associated type of cataract: nuclear sclerotic (NSC); cortical; posterior subcapsular (PSC)

- Associated with the *second sight* phenomenon: NSC

*What is the* second sight phenomenon? NSC progression often produces lenticular myopia. In some patients this myopia rehabilitates the near vision loss they experienced due to presbyopia, thus restoring the ability to read without glasses.
For each statement, identify the associated type of cataract: nuclear sclerotic (NSC); cortical; posterior subcapsular (PSC)

- Associated with the second sight phenomenon: NSC
- Related to lens hydration status:
For each statement, identify the associated type of cataract:
- nuclear sclerotic (NSC)
- cortical
- posterior subcapsular (PSC)

- Associated with the *second sight* phenomenon: **NSC**
- Related to lens hydration status: **Cortical**
For each statement, identify the associated type of cataract: nuclear sclerotic (NSC); cortical; posterior subcapsular (PSC)

- Associated with the *second sight* phenomenon: NSC
- Related to lens hydration status: Cortical
- Affects scotopic > photopic vision:
For each statement, identify the associated type of cataract: nuclear sclerotic (NSC); cortical; posterior subcapsular (PSC)

- Associated with the *second sight* phenomenon: NSC
- Related to lens hydration status: Cortical
- Affects scotopic > photopic vision: NSC
For each statement, identify the associated type of cataract: nuclear sclerotic (NSC); cortical; posterior subcapsular (PSC)

- Associated with the *second sight* phenomenon: **NSC**
- Related to lens hydration status: **Cortical**
- Affects scotopic > photopic vision: **NSC**
- Affects photopic > scotopic vision:
For each statement, identify the associated type of cataract:
nuclear sclerotic (NSC); cortical; posterior subcapsular (PSC)

- Associated with the *second sight* phenomenon: **NSC**
- Related to lens hydration status: **Cortical**
- Affects scotopic > photopic vision: **NSC**
- Affects photopic > scotopic vision: **PSC**
For each statement, identify the associated type of cataract: nuclear sclerotic (NSC); cortical; posterior subcapsular (PSC)

- Associated with the second sight phenomenon: NSC
- Related to lens hydration status: Cortical
- Affects scotopic > photopic vision: NSC
- Affects photopic > scotopic vision: PSC

Define these terms:
Scotopic: Related to vision in...
Photopic
For each statement, identify the associated type of cataract: nuclear sclerotic (NSC); cortical; posterior subcapsular (PSC)

- Associated with the second sight phenomenon: NSC
- Related to lens hydration status: Cortical
- Affects scotopic > photopic vision: NSC
- Affects photopic > scotopic vision: PSC

Define these terms:
Scotopic: Related to vision in... *dim illumination*
Photopic
For each statement, identify the associated type of cataract: nuclear sclerotic (NSC); cortical; posterior subcapsular (PSC)

- Associated with the *second sight* phenomenon: NSC
- Related to lens hydration status: Cortical
- Affects scotopic > photopic vision: NSC
- Affects photopic > scotopic vision: PSC

*Define these terms:*

*Scotopic:* Related to vision in... *dim illumination*

*Photopic:* Related to vision in...
For each statement, identify the associated type of cataract: 
nuclear sclerotic (NSC); cortical; posterior subcapsular (PSC)

- Associated with the *second sight* phenomenon: NSC
- Related to lens hydration status: Cortical
- Affects scotopic > photopic vision: NSC
- Affects photopic > scotopic vision: PSC

Define these terms:
Scotopic: Related to vision in…*dim illumination*
Photopic: Related to vision in…*bright illumination*
For each statement, identify the associated type of cataract: nuclear sclerotic (NSC); cortical; posterior subcapsular (PSC)

- Associated with the *second sight* phenomenon: NSC
- Related to lens hydration status: Cortical
- Affects scotopic > photopic vision: NSC
- Affects photopic > scotopic vision: PSC

Define these terms:

- **Scotopic**: Related to vision in…*dim* illumination
- **Photopic**: Related to vision in…*bright* illumination

As an aside: What is the term describing vision under low (e.g., twilight) illumination conditions?
For each statement, identify the associated type of cataract: nuclear sclerotic (NSC); cortical; posterior subcapsular (PSC)

- Associated with the *second sight* phenomenon: NSC
- Related to lens hydration status: Cortical
- Affects scotopic > photopic vision: NSC
- Affects photopic > scotopic vision: PSC

**Define these terms:**
- Scotopic: Related to vision in… *dim* illumination
- Photopic: Related to vision in… *bright* illumination

*As an aside: What is the term describing vision under low (e.g., twilight) illumination conditions?*
*Mesopic vision*
For each statement, identify the associated type of cataract: nuclear sclerotic (NSC); cortical; posterior subcapsular (PSC)

- Associated with the *second sight* phenomenon: NSC
- Related to lens hydration status: Cortical
- Affects scotopic > photopic vision: NSC
- Affects photopic > scotopic vision: PSC
- Affects near > distance vision:
Associated with the *second sight* phenomenon: **NSC**

- Related to lens hydration status: **Cortical**
- Affects scotopic > photopic vision: **NSC**
- Affects photopic > scotopic vision: **PSC**
- Affects near > distance vision: **PSC**
For each statement, identify the associated type of cataract:

- Associated with the *second sight* phenomenon: NSC
- Related to lens hydration status: Cortical
- Affects scotopic > photopic vision: NSC
- **Affects photopic > scotopic vision:** PSC
- Affects near > distance vision: PSC

*Photopic vision, near vision—what eye-state do these have in common?*
For each statement, identify the associated type of cataract: 
- **nuclear sclerotic (NSC)**;  
- **cortical**;  
- **posterior subcapsular (PSC)**

- Associated with the *second sight* phenomenon: **NSC**
- Related to lens hydration status: **Cortical**
- Affects scotopic > photopic vision: **NSC**
- **Affects photopic > scotopic vision: PSC**
- **Affects near > distance vision: PSC**

*Photopic vision, near vision—what eye-state do these have in common?*  
The pupil is relatively **miosis** in both
For each statement, identify the associated type of cataract:
nuclear sclerotic (NSC); cortical; posterior subcapsular (PSC)

- Associated with the second sight phenomenon: NSC
- Related to lens hydration status: Cortical
- Affects scotopic > photopic vision: NSC
- **Affects photopic > scotopic vision: PSC**
- Affects near > distance vision: PSC

Photopic vision, near vision—what eye-state do these have in common? The pupil is relatively miosis in both
For each statement, identify the associated type of cataract:
nuclear sclerotic (NSC); cortical; posterior subcapsular (PSC)

- Associated with the *second sight* phenomenon: NSC
- Related to lens hydration status: Cortical
- Affects scotopic > photopic vision: NSC
- **Affects photopic > scotopic vision: PSC**
- **Affects near > distance vision: PSC**

*Photopic vision, near vision—what eye-state do these have in common?*
The pupil is relatively miosed in both

*Why is vision through a PSC worse when the pupil is miosed?*
For each statement, identify the associated type of cataract: nuclear sclerotic (NSC); cortical; posterior subcapsular (PSC)

- Associated with the *second sight* phenomenon: NSC
- Related to lens hydration status: Cortical
- Affects scotopic > photopic vision: NSC
- **Affects photopic > scotopic vision:** PSC
- **Affects near > distance vision:** PSC

*Photopic vision, near vision*—*what eye-state do these have in common?*
The pupil is relatively miosed in both

*Why is vision through a PSC worse when the pupil is miosed?*
Visually significant PSCs are centrally vs peripherally located.
For each statement, identify the associated type of cataract:
nuclear sclerotic (NSC); cortical; posterior subcapsular (PSC)

- Associated with the second sight phenomenon: NSC
- Related to lens hydration status: Cortical
- Affects scotopic > photopic vision: NSC
- **Affects photopic > scotopic vision: PSC**
- Affects near > distance vision: PSC

Photopic vision, near vision—what eye-state do these have in common?
The pupil is relatively miosed in both

Why is vision through a PSC worse when the pupil is miosed?
Visually significant PSCs are centrally located.
For each statement, identify the associated type of cataract: nuclear sclerotic (NSC); cortical; posterior subcapsular (PSC)

- Associated with the *second sight* phenomenon: NSC
- Related to lens hydration status: Cortical
- Affects scotopic > photopic vision: NSC

**Affects photopic > scotopic vision:** PSC

- Affects near > distance vision: PSC

*Photopic vision, near vision—what eye-state do these have in common?*

The pupil is relatively miosed in both

*Why is vision through a PSC worse when the pupil is miosed?*

Visually significant PSCs are centrally located. When the pupil is dilated, incoming light can ‘go around’ the PSC, and vision is less affected.
For each statement, identify the associated type of cataract: 
nuclear sclerotic (NSC); cortical; posterior subcapsular (PSC)

- Associated with the second sight phenomenon: NSC
- Related to lens hydration status: Cortical
- Affects scotopic > photopic vision: NSC
- **Affects photopic > scotopic vision: PSC**
- Affects near > distance vision: PSC

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Photopic vision, near vision—what eye-state do these have in common?
The pupil is relatively miosed in both

Why is vision through a PSC worse when the pupil is miosed?
Visually significant PSCs are centrally located. When the pupil is dilated, incoming light can ‘go around’ the PSC, and vision is less affected. However, when the pupil is miosed, incoming light is limited to that which is passing through the densest portion of the PSC, and thus results in maximally-degraded visual acuity.
For each statement, identify the associated type of cataract: nuclear sclerotic (NSC); cortical; posterior subcapsular (PSC)

- Associated with the *second sight* phenomenon: **NSC**
- Related to lens hydration status: **Cortical**
- Affects scotopic > photopic vision: **NSC**
- Affects photopic > scotopic vision: **PSC**
- Affects near > distance vision: **PSC**
- Associated with monocular diplopia:
Associated with the second sight phenomenon: NSC
Related to lens hydration status: Cortical
Affects scotopic > photopic vision: NSC
Affects photopic > scotopic vision: PSC
Affects near > distance vision: PSC
Associated with monocular diplopia: All
For each statement, identify the associated type of cataract: nuclear sclerotic (NSC); cortical; posterior subcapsular (PSC)

- Associated with the *second sight* phenomenon: **NSC**
- Related to lens hydration status: **Cortical**
- Affects scotopic > photopic vision: **NSC**
- Affects photopic > scotopic vision: **PSC**
- Affects near > distance vision: **PSC**
- Associated with monocular diplopia: **All**
- Most likely to c/o glare:
For each statement, identify the associated type of cataract: nuclear sclerotic (NSC); cortical; posterior subcapsular (PSC)

- Associated with the *second sight* phenomenon: NSC
- Related to lens hydration status: Cortical
- Affects scotopic > photopic vision: NSC
- Affects photopic > scotopic vision: PSC
- Affects near > distance vision: PSC
- Associated with monocular diplopia: All
- Most likely to c/o glare: Cortical
For each statement, identify the associated type of cataract: nuclear sclerotic (NSC); cortical; posterior subcapsular (PSC)

- Associated with the *second sight* phenomenon: **NSC**
- Related to lens hydration status: **Cortical**
- Affects scotopic > photopic vision: **NSC**
- Affects photopic > scotopic vision: **PSC**
- Affects near > distance vision: **PSC**
- Associated with monocular diplopia: **All**
- Most likely to c/o glare: **Cortical**
- Least likely to c/o glare:
For each statement, identify the associated type of cataract: nuclear sclerotic (NSC); cortical; posterior subcapsular (PSC)

- Associated with the second sight phenomenon: NSC
- Related to lens hydration status: Cortical
- Affects scotopic > photopic vision: NSC
- Affects photopic > scotopic vision: PSC
- Affects near > distance vision: PSC
- Associated with monocular diplopia: All
- Most likely to c/o glare: Cortical
- Least likely to c/o glare: NSC
For each statement, identify the associated type of cataract:

- Associated with the *second sight* phenomenon: **NSC**
- Related to lens hydration status: **Cortical**
- Affects scotopic > photopic vision: **NSC**
- Affects photopic > scotopic vision: **PSC**
- Affects near > distance vision: **PSC**
- Associated with monocular diplopia: **All**
- Most likely to c/o glare: **Cortical**
- Least likely to c/o glare: **NSC**
- Most likely in a younger adult:
For each statement, identify the associated type of cataract: nuclear sclerotic (NSC); cortical; posterior subcapsular (PSC)

- Associated with the *second sight* phenomenon: **NSC**
- Related to lens hydration status: **Cortical**
- Affects scotopic > photopic vision: **NSC**
- Affects photopic > scotopic vision: **PSC**
- Affects near > distance vision: **PSC**
- Associated with monocular diplopia: **All**
- Most likely to c/o glare: **Cortical**
- Least likely to c/o glare: **NSC**
- Most likely in a younger adult: **PSC**
For each statement, identify the associated type of cataract: nuclear sclerotic (NSC); cortical; posterior subcapsular (PSC)

- Associated with the *second sight* phenomenon: **NSC**
- Related to lens hydration status: **Cortical**
- Affects scotopic > photopic vision: **NSC**
- Affects photopic > scotopic vision: **PSC**
- Affects near > distance vision: **PSC**
- Associated with monocular diplopia: **All**
- Most likely to c/o glare: **Cortical**
- Least likely to c/o glare: **NSC**
- Most likely in a younger adult: **PSC**
- Cause: Migration of equatorial epithelial cells:
For each statement, identify the associated type of cataract: nuclear sclerotic (NSC); cortical; posterior subcapsular (PSC)

- Associated with the second sight phenomenon: NSC
- Related to lens hydration status: Cortical
- Affects scotopic > photopic vision: NSC
- Affects photopic > scotopic vision: PSC
- Affects near > distance vision: PSC
- Associated with monocular diplopia: All
- Most likely to c/o glare: Cortical
- Least likely to c/o glare: NSC
- Most likely in a younger adult: PSC
- Cause: Migration of equatorial epithelial cells: PSC
For each statement, identify the associated type of cataract: 

- Nuclear sclerotic (NSC); cortical; posterior subcapsular (PSC)

- Associated with the *second sight* phenomenon: NSC
- Related to lens hydration status: Cortical
- Affects scotopic > photopic vision: NSC
- Affects photopic > scotopic vision: PSC
- Affects near > distance vision: PSC
- Associated with monocular diplopia: All
- Most likely to c/o glare: Cortical
- Least likely to c/o glare: NSC
- Most likely in a younger adult: PSC
- Cause: Migration of equatorial epithelial cells: PSC
- Associated with altered color perception:
For each statement, identify the associated type of cataract: nuclear sclerotic (NSC); cortical; posterior subcapsular (PSC)

- Associated with the *second sight* phenomenon: **NSC**
- Related to lens hydration status: **Cortical**
- Affects scotopic > photopic vision: **NSC**
- Affects photopic > scotopic vision: **PSC**
- Affects near > distance vision: **PSC**
- Associated with monocular diplopia: **All**
- Most likely to c/o glare: **Cortical**
- Least likely to c/o glare: **NSC**
- Most likely in a younger adult: **PSC**
- Cause: Migration of equatorial epithelial cells: **PSC**
- Associated with altered color perception: **NSC**
For each statement, identify the associated type of cataract: nuclear sclerotic (NSC); cortical; posterior subcapsular (PSC)

- Associated with the *second sight* phenomenon: NSC
- Related to lens hydration status: Cortical
- Affects scotopic > photopic vision: NSC
- Affects photopic > scotopic vision: PSC
- Affects near > distance vision: PSC
- Associated with monocular diplopia: All
- Most likely to c/o glare: Cortical
- Least likely to c/o glare: NSC

- Progressive yellowing or browning of the lens causes patients to have poor color discrimination, especially at the *red* end of the visible-light spectrum
- Associated with *altered color perception*: NSC
A

For each statement, identify the associated type of cataract: nuclear sclerotic (NSC); cortical; posterior subcapsular (PSC)

- Associated with the second sight phenomenon: NSC
- Related to lens hydration status: Cortical
- Affects scotopic > photopic vision: NSC
- Affects photopic > scotopic vision: PSC
- Affects near > distance vision: PSC
- Associated with monocular diplopia: All
- Most likely to c/o glare: Cortical
- Least likely to c/o glare: NSC
- Most likely in a younger adult: PSC
- Cause: Migration of equatorial epithelial cells: PSC
- Associated with altered color perception: NSC

Progressive yellowing or browning of the lens causes patients to have poor color discrimination, especially at the blue end of the visible-light spectrum.
 Associates with the second sight phenomenon: NSC
- Related to lens hydration status: Cortical
- Affects scotopic > photopic vision: NSC
- Affects photopic > scotopic vision: PSC
- Affects near > distance vision: PSC
- Associated with monocular diplopia: All
- Most likely to c/o glare: Cortical
- Least likely to c/o glare: NSC
- Progressive yellowing or browning of the lens causes patients to have poor color discrimination, especially at the blue end of the visible-light spectrum. In bilateral cases, patients are acutely aware vs frequently unaware of their altered color discrimination.
- Associated with altered color perception: NSC
For each statement, identify the associated type of cataract: nuclear sclerotic (NSC); cortical; posterior subcapsular (PSC)

- Associated with the *second sight* phenomenon: NSC
- Related to lens hydration status: Cortical
- Affects scotopic > photopic vision: NSC
- Affects photopic > scotopic vision: PSC
- Affects near > distance vision: PSC
- Associated with monocular diplopia: All
- Most likely to c/o glare: Cortical
- Least likely to c/o glare: NSC
- Most likely in a younger adult: PSC
- Cause: Migration of equatorial epithelial cells: PSC
- Associated with altered color perception: NSC

Progressive yellowing or browning of the lens causes patients to have poor color discrimination, especially at the blue end of the visible-light spectrum. In bilateral cases, patients are frequently unaware of their altered color discrimination.
Finally: Circling back to something touched upon at the beginning of the slide-set...
Finally: Circling back to something touched upon at the beginning of the slide-set…

- **What are the three lens/cataract layers as encountered in cataract surgery?**
  - ?
  - ?
  - ?
What are the three lens/cataract layers as encountered in cataract surgery?

- Nucleus
- Epinucleus
- Cortex
Layers of the lens:

- Lens capsule
- Cortex
- Epinucleus
- Nucleus (aka the endonucleus)

Surgical
What are the three lens/cataract layers as encountered in cataract surgery? How do these layers differ from one another histologically?

- Nucleus: ?
- Epinucleus: ?
- Cortex: ?
What are the three lens/cataract layers as encountered in cataract surgery? How do these layers differ from one another histologically?

- Nucleus:
- Epinucleus:
- Cortex:

Trick question—they don’t! These terms refer to differences in appearance and behavior of lens material encountered during cataract surgery. They are descriptive terms, not histological.
What are the three lens/cataract layers as encountered in cataract surgery?

Briefly, how does each layer look and behave during cataract surgery?

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

**Epinucleus:**
Clear to cloudy. The epinucleus is soft, and can be aspirated without emulsification (although emulsifying energy is often employed during epinucleus removal in order to make the process faster/more efficient).

**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.

They are *descriptive* terms, not histological.
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Briefly, how does each layer look and behave during cataract surgery?

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**Q**

**Lens/Cataracts Overview**

**Difference in appearance and behavior**

Differences in appearance and behavior of lens material encountered during cataract surgery. They are descriptive terms, not histological.
Slide depicting the basic anatomy of the adult lens
Basic components of the mature lens: Photomicrograph
What are the three lens/cataract layers encountered in cataract surgery?

How do these layers differ from one another histologically?

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Lens/Cataracts Overview

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