Define the term *macula*…

...anatomically: The retinal area in which the ganglion-cell layer is ≥ 2 cells thick.
Define the term *macula*…

…*anatomically*: The retinal area in which the ganglion-cell layer is ≥ 2 cells thick
Changes in retinal thickness. Two sections through the central (A) and peripheral (B) regions of the retina, aligned at the retinal pigment epithelium. The peripheral retina is thinner and has only rare cell nuclei in the ganglion cell layer (the uppermost layer of nuclei).
Define the term *macula*…

- **anatomically**: The retinal area in which the ganglion-cell layer is ≥ 2 cells thick.
- **histologically**: The retinal area containing...
Define the term *macula*...

- **anatomically**: The retinal area in which the ganglion-cell layer is ≥ 2 cells thick.
- **histologically**: The retinal area containing xanthophyll pigment.
Define the term *macula*...

- **anatomically**: The retinal area in which the ganglion-cell layer is ≥ 2 cells thick.
- **histologically**: The retinal area containing *xanthophyll pigment*.

The latest iteration of the *Retina* book refers to this pigment as “oxygenated carotenoids, in particular lutein and zeaxanthin”.
Define the term *macula*...

- **Anatomically**: The retinal area in which the ganglion-cell layer is ≥ 2 cells thick.
- **Histologically**: The retinal area containing xanthophyll pigment.
- **Clinically**: The retinal area bounded by...
Define the term *macula*…

- **Anatomically**: The retinal area in which the ganglion-cell layer is ≥ 2 cells thick.
- **Histologically**: The retinal area containing xanthophyll pigment.
- **Clinically**: The retinal area bounded by the temporal vascular arcades.
Retinal Anatomy and Histology

Macula
Define the term *macula*…

- **anatomically**: The retinal area in which the ganglion-cell layer is ≥ 2 cells thick
- **histologically**: The retinal area containing xanthophyll pigment
- **clinically**: The retinal area bounded by the temporal vascular arcades

*What is the full name of the macula (ie, what is its ‘last name’)?*
Define the term *macula...lutea*

*...anatomically:* The retinal area in which the ganglion-cell layer is $\geq 2$ cells thick

*...histologically:* The retinal area containing xanthophyll pigment

*...clinically:* The retinal area bounded by the temporal vascular arcades

*What is the full name of the macula (ie, what is its ‘last name’)?*

The macula *lutea*
Define the term *macula...lutea*

- **anatomically**: The retinal area in which the ganglion-cell layer is ≥ 2 cells thick
- **histologically**: The retinal area containing xanthophyll pigment
- **clinically**: The retinal area bounded by the temporal vascular arcades

*What is the full name of the macula (ie, what is its ‘last name’)?*

The macula *lutea*

*What does the word lutea mean?*
Define the term **macula**...**lutea**

- **anatomically:** The retinal area in which the ganglion-cell layer is ≥ 2 cells thick
- **histologically:** The retinal area containing **xanthophyll pigment**
- **clinically:** The retinal area bounded by the temporal vascular arcades

What is the full name of the macula (ie, what is its ‘last name’)?
The macula **lutea**

What does the word **lutea** mean?
It means ‘**yellow**’
Macula lutea: If you use your imagination, you can sort of see that the macula has a yellow tint.
Define the term **macula...lutea**

- **anatomically**: The retinal area in which the ganglion-cell layer is ≥ 2 cells thick
- **histologically**: The retinal area containing **xanthophyll pigment**
- **clinically**: The retinal area bounded by the temporal vascular arcades

*What is the full name of the macula (ie, what is its ‘last name’)?*

The macula **lutea**

*What does the word *lutea* mean?*

It means ‘yellow’
Define the term **macula...lutea**

- **anatomically**: The retinal area in which the ganglion-cell layer is ≥ 2 cells thick

- **histologically**: The retinal area containing **xanthophyll pigment**

- **clinically**: The retinal area bounded by the temporal vascular arcades

What is the full name of the macula (i.e., what is its ‘last name’)?

The macula **lutea**

What does the word **lutea** mean?

It means ‘**yellow**’
Define the term *macula...lutea*

- **anatomically**: The retinal area in which the ganglion-cell layer is ≥ 2 cells thick
- **histologically**: The retinal area containing xanthophyll pigment
- **clinically**: The retinal area bounded by the temporal vascular arcades

**What is the full name of the macula (ie, what is its ‘last name’)?**
The macula *lutea*

**What does the word *lutea* mean?**
It means ‘yellow’
What is the full name of the macula (ie, what is its ‘last name’)?
The macula lutea

What does the word lutea mean?
It means ‘yellow’
Let’s define some terms

Retinal Anatomy and Histology

What does FAZ stand for in this context?
Retinal Anatomy and Histology

Let’s define some terms

FAZ

What does FAZ stand for in this context?
Foveal avascular zone
Let’s define some terms

FAZ

What does FAZ stand for in this context?
Foveal avascular zone

GCL/INL

How about GCL and INL?
GCL =
INL =
Retinal Anatomy and Histology

Let's define some terms

What does FAZ stand for in this context?
Foveal avascular zone

How about GCL and INL?
GCL = Ganglion cell layer
INL = Inner nuclear layer
Retinal Anatomy and Histology

With that out of the way, let's do some…

What does FAZ stand for in this context?
Foveal avascular zone

How about GCL and INL?
GCL = Ganglion cell layer
INL = Inner nuclear layer
Retinal Anatomy and Histology

Matching! (some on the left have more than one answer)

With that out of the way, let’s do some…

Fovea
- Ring 1.5 mm diameter
- Ring 0.5 mm diameter
- ~1 DD in size (1.5mm)
- Just within the FAZ
- Thickest portion of retina
- ~1 cup in diameter (0.35mm)
- GCL/INL absent from here on in
- Very center of fovea
- All cones from here on in
- Farthest from center

Foveola

Umbo

Perifoveal zone

Parafoveal zone
Retinal Anatomy and Histology

Matching! (some on the left have more than one answer)

- **Fovea**
  - Ring 1.5 mm diameter
  - Ring 0.5 mm diameter
  - ~1 DD in size (1.5mm)
  - Just within the FAZ
  - Thickest portion of retina
  - ~1 cup in diameter (0.35mm)
  - GCL/INL absent from here on in
  - Very center of fovea
  - All cones from here on in
  - Farthest from center

- **Foveola**

- **Umbo**

- **Perifoveal zone**

- **Parafoveal zone**
Like the macula, the fovea has a last name. What is its full name?

- Ring 1.5 mm diameter
- Ring 0.5 mm diameter
- ~1 DD in size (1.5mm)
- Just within the FAZ
- Thickest portion of retina
- ~1 cup in diameter (0.35mm)
- GCL/INL absent from here on in
- Very center of fovea
- All cones from here on in
- Farthest from center
Like the macula, the fovea has a last name. What is its full name?
The fovea centralis

Retinal Anatomy and Histology

Matching! (some on the left have more than one answer)

- Ring 1.5 mm diameter
- Ring 0.5 mm diameter
- ~1 DD in size (1.5mm)
- Just within the FAZ
- Thickest portion of retina
- ~1 cup in diameter (0.35mm)
- GCL/INL absent from here on in
- Very center of fovea
- All cones from here on in
- Farthest from center
Fovea centralis (black circle)
Matching! (some on the left have more than one answer)

- Ring 1.5 mm diameter
- Ring 0.5 mm diameter
- ~1 DD in size (1.5mm)
- Just within the FAZ
- Thickest portion of retina
- ~1 cup in diameter (0.35mm)
- GCL/INL absent from here on in
- Very center of fovea
- All cones from here on in
- Farthest from center
Matching! (some on the left have more than one answer)

- Ring 1.5 mm diameter
- Ring 0.5 mm diameter
- ~1 DD in size (1.5mm)
- Just within the FAZ
- Thickest portion of retina
- ~1 cup in diameter (0.35mm)
- GCL/INL absent from here on in
- Very center of fovea
- All cones from here on in
- Farthest from center
Retinal Anatomy and Histology

Foveola
Retinal Anatomy and Histology

Foveola is within the foveal avascular zone (FAZ)
Retinal Anatomy and Histology

Matching! (some on the left have more than one answer)

- Ring 1.5 mm diameter
- Ring 0.5 mm diameter
- ~1 DD in size (1.5mm)
- Just within the FAZ
- Thickest portion of retina
- ~1 cup in diameter (0.35mm)
- GCL/INL absent from here on in
- Very center of fovea
- All cones from here on in
- Farthest from center
Retinal Anatomy and Histology

Matching! (some on the left have more than one answer)

- Ring 1.5 mm diameter
- Ring 0.5 mm diameter
- ~1 DD in size (1.5mm)
- Just within the FAZ
- Thickest portion of retina
- ~1 cup in diameter (0.35mm)
- GCL/INL absent from here on in
- Very center of fovea
- All cones from here on in
- Farthest from center
What very common DFE finding is directly attributable to the umbo?

- Ring 1.5 mm diameter
- Ring 0.5 mm diameter
- ~1 DD in size (1.5mm)
- Just within the FAZ
- Thickest portion of retina
- ~1 cup in diameter (0.35mm)
- GCL/INL absent from here on in
- Very center of fovea
- All cones from here on in
- Farthest from center
Retinal Anatomy and Histology

Matching! (some on the left have more than one answer)

Fovea
- Ring 1.5 mm diameter
- Ring 0.5 mm diameter
- ~1 DD in size (1.5mm)
- Just within the FAZ
- Thickest portion of retina on in
- GCL/INL absent from here on in
- Very center of fovea
- All cones from here on in
- Farthest from center

Foveola

Umbo

What very common DFE finding is directly attributable to the umbo?
The so-called ‘foveal reflex’
Matching! (some on the left have more than one answer)

- Ring 1.5 mm diameter
- Ring 0.5 mm diameter
- ~1 DD in size (1.5 mm)
- Just within the FAZ
- Thickest portion of retina
- ~1 cup in diameter (0.35 mm)
- GCL/INL absent from here on in
- Very center of fovea
- All cones from here on in
- Farthest from center
Matching! (some on the left have more than one answer)

- Fovea
- Foveola
- Umbo
- Perifoveal zone
- Parafoveal zone

- Ring 1.5 mm diameter
- Ring 0.5 mm diameter
- ~1 DD in size (1.5mm)
- Just within the FAZ
- Thickest portion of retina
- ~1 cup in diameter (0.35mm)
- GCL/INL absent from here on in
- Very center of fovea
- All cones from here on in
- Farthest from center
Fovea

Foveola

Umbo

Perifoveal zone

Parafoveal zone

- Ring 1.5 mm diameter
- Ring 0.5 mm diameter
- ~1 DD in size (1.5mm)
- Just within the FAZ
- Thickest portion of retina
- ~1 cup in diameter (0.35mm)
- GCL/INL absent from here on in
- Very center of fovea
- All cones from here on in
- Farthest from center
Matching! (some on the left have more than one answer)

- Ring 1.5 mm diameter
- Ring 0.5 mm diameter
- ~1 DD in size (1.5mm)
- Just within the FAZ
- Thickest portion of retina
- ~1 cup in diameter (0.35mm)
- GCL/INL absent from here on in
- Very center of fovea
- All cones from here on in
- Farthest from center
How are the fovea, perifoveal zone and parafoveal zone spatially related to one another?

- **Fovea**
  - Ring 1.5 mm diameter
  - Ring 0.5 mm diameter
  - ~1 DD in size (1.5mm)
  - Thickest portion of retina
  - ~1 cup in diameter (0.35mm)
  - GCL/INL absent from here on in
  - Very center of fovea
  - All cones from here on in
  - Farthest from center

- **Umbo**

- **Perifoveal zone**

- **Parafoveal zone**

Matching! (some on the left have more than one answer)
A/Q

Matching! (some on the left have more than one answer)

Retinal Anatomy and Histology

- Ring 1.5 mm diameter
- Ring 0.5 mm diameter
- ~1 DD in size (1.5mm)
- Thickest portion of retina
- ~1 cup in diameter (0.35mm)
- GCL/INL absent from here on in
- Very center of fovea
- All cones from here on in
- Farthest from center

How are the fovea, perifoveal zone and parafoveal zone spatially related to one another?
The para- vs peri- zone is a ring around the fovea, whereas the para- vs peri- zone is a ring around the para- vs peri- zone
How are the fovea, perifoveal zone and parafoveal zone spatially related to one another?
The parafoveal zone is a ring around the fovea, whereas the perifoveal zone is a ring around the parafoveal zone.

- **Fovea**
  - Ring 1.5 mm diameter
  - Ring 0.5 mm diameter
  - ~1 DD in size (1.5mm)
- **Umbo**
  - Thickest portion of retina
  - ~1 cup in diameter (0.35mm)
  - GCL/INL absent from here on in
- **Perifoveal zone**
  - Very center of fovea
- **Parafoveal zone**
  - All cones from here on in
  - Farthest from center
Macula: The zones
Macula: The zones, another view
Retinal Layers
- Internal limiting membrane
- Nerve fiber layer
- Ganglion cell layer
- Inner plexiform layer
- Inner nuclear layer
- Outer plexiform layer
- Outer nuclear layer
- External limiting membrane
- Rod & cone inner and outer segments
- RPE
- Bruch’s membrane
● Retinal Layers
  ● Internal limiting membrane
  ● Nerve fiber layer
  ● (Next?)
  ●
  ●
  ●
  ●
  ●
  ● External limiting membrane

● RPE
● Bruch’s membrane
A

Retinal Anatomy and Histology

● Retinal Layers
  ● Internal limiting membrane
  ● Nerve fiber layer
  ● Ganglion cell layer
  ● Rod & cone inner and outer segments
  ● External limiting membrane

● RPE
● Bruch’s membrane
Histologically speaking, the NFL is composed of what specific structures?
Retinal Layers
- Internal limiting membrane
- Nerve fiber layer
- Ganglion cell layer
- Inner plexiform layer
- Inner nuclear layer
- Outer plexiform layer
- Outer nuclear layer
- External limiting membrane
- Rod & cone inner and outer segments
- RPE
- Bruch’s membrane

Histologically speaking, the NFL is composed of what specific structures?
Axons of the ganglion cells
Retinal Anatomy and Histology

- Retinal Layers
  - Internal limiting membrane
  - Nerve fiber layer
  - Ganglion cell layer
  - Inner plexiform layer
  - Inner nuclear layer
  - Outer plexiform layer
  - Outer nuclear layer
  - External limiting membrane
  - RPE
  - Bruch’s membrane

**Histologically speaking, the NFL is composed of what specific structures?**
Axons of the ganglion cells

**Where are the ganglion-cell bodies located?**
Retinal Anatomy and Histology

- **Retinal Layers**
  - Internal limiting membrane
  - **Nerve fiber layer**
  - Ganglion cell layer
  - Inner plexiform layer
  - Inner nuclear layer
  - Outer plexiform layer
  - Outer nuclear layer
  - External limiting membrane

- **RPE**
- Bruch’s membrane

---

*Histologically speaking, the NFL is composed of what specific structures?*
Axons of the ganglion cells

*Where are the ganglion-cell bodies located?*
In the **ganglion cell layer**
Retinal Anatomy and Histology

- Retinal Layers
  - Internal limiting membrane
  - Nerve fiber layer
  - Ganglion cell layer
  - Inner plexiform layer
  - Inner nuclear layer
  - Outer plexiform layer
  - Outer nuclear layer
  - External limiting membrane

- RPE
- Bruch’s membrane

**Histologically speaking, the NFL is composed of what specific structures?**
Axons of the ganglion cells

**Where are the ganglion-cell bodies located?**
In the **ganglion cell layer**

**Anatomically speaking, what structure will the axons go on to form?**
Retinal Layers

- Internal limiting membrane
- Nerve fiber layer
- Ganglion cell layer
- Inner plexiform layer
- Inner nuclear layer
- Outer plexiform layer
- Outer nuclear layer
- External limiting membrane

- RPE
- Bruch’s membrane

Histologically speaking, the NFL is composed of what specific structures?
Axons of the ganglion cells

Where are the ganglion-cell bodies located?
In the ganglion cell layer

Anatomically speaking, what structure will the axons go on to form?
The optic nerve
Retinal Layers

- Internal limiting membrane
- Nerve fiber layer
- Ganglion cell layer
- Inner plexiform layer
- Inner nuclear layer
- Outer plexiform layer
- Outer nuclear layer
- External limiting membrane

- RPE
- Bruch’s membrane

Histologically speaking, the NFL is composed of what specific structures?
Axons of the ganglion cells

Where are the ganglion-cell bodies located?
In the ganglion cell layer

Anatomically speaking, what structure will the axons go on to form?
The optic nerve

Where will most of these fibers eventually synapse?
Retinal Anatomy and Histology

- **Retinal Layers**
  - Internal limiting membrane
  - **Nerve fiber layer**
  - **Ganglion cell layer**
  - Inner plexiform layer
  - Inner nuclear layer
  - Outer plexiform layer
  - Outer nuclear layer
  - External limiting membrane
  - **RPE**
  - Bruch’s membrane

**Histologically speaking, the NFL is composed of what specific structures?**
Axons of the ganglion cells

**Where are the ganglion-cell bodies located?**
In the **ganglion cell layer**

**Anatomically speaking, what structure will the axons go on to form?**
The optic nerve

**Where will most of these fibers eventually synapse?**
The lateral geniculate nucleus (LGN)
● Retinal Layers
  ● Internal limiting membrane
  ● Nerve fiber layer
  ● Ganglion cell layer
  ● (Next?)
  ● 
  ● 
  ● 
  ● External limiting membrane
  ● 

● RPE
● Bruch’s membrane
Retinal Anatomy and Histology

- Retinal Layers
  - Internal limiting membrane
  - Nerve fiber layer
  - Ganglion cell layer
  - Inner plexiform layer
  - (Next?)
  - ... (Further list items)
  - External limiting membrane

- RPE
- Bruch’s membrane
Retinal Layers
- Internal limiting membrane
- Nerve fiber layer
- Ganglion cell layer
- Inner plexiform layer
- Inner nuclear layer
- (Next?)

- External limiting membrane

RPE
Bruch’s membrane
Retinal Anatomy and Histology

- **Retinal Layers**
  - Internal limiting membrane
  - Nerve fiber layer
  - Ganglion cell layer
  - Inner plexiform layer
  - Inner nuclear layer
  - Outer plexiform layer
  - External limiting membrane

- **RPE**
- **Bruch’s membrane**
Retinal Anatomy and Histology

Q

- Retinal Layers
  - Internal limiting membrane
  - Nerve fiber layer
  - Ganglion cell layer
  - Inner plexiform layer
  - Inner nuclear layer
  - Outer plexiform layer
  - Outer nuclear layer
  - External limiting membrane

- RPE

- Bruch’s membrane

What does plexiform mean?

Plexus-like

OK then, what is a plexus?

An interlaced group of fibers

What does this indicate about the composition of the inner and outer plexiform layers?

That they are composed of cell processes (i.e., axons and dendrites)

Processes of what specific cells comprise these layers?

IPL: Bipolar, amacrine and ganglion cells

OPL: Photoreceptor, bipolar and horizontal cells
● Retinal Layers
  ● Internal limiting membrane
  ● Nerve fiber layer
  ● Ganglion cell layer
  ● **Inner plexiform layer**
  ● Inner nuclear layer
  ● **Outer plexiform layer**
  ● External limiting membrane

● RPE

● Bruch’s membrane

**What does plexiform mean?**

Plexus-like
Retinal Anatomy and Histology

- **Retinal Layers**
  - Internal limiting membrane
  - Nerve fiber layer
  - Ganglion cell layer
  - **Inner plexiform layer**
  - Inner nuclear layer
  - **Outer plexiform layer**
  - External limiting membrane

- **RPE**
- **Bruch’s membrane**

**What does plexiform mean?**
Plexus-like

**OK then, what is a plexus?**
Retinal Layers

- Internal limiting membrane
- Nerve fiber layer
- Ganglion cell layer
- Inner plexiform layer
- Inner nuclear layer
- Outer plexiform layer
- Outer nuclear layer
- External limiting membrane

RPE

Bruch’s membrane

What does plexiform mean?
Plexus-like

OK then, what is a plexus?
An interlaced group of fibers
Retinal Anatomy and Histology

Retinal Layers
- Internal limiting membrane
- Nerve fiber layer
- Ganglion cell layer
- **Inner plexiform layer**
- Inner nuclear layer
- **Outer plexiform layer**
- External limiting membrane

**RPE**

**Bruch’s membrane**

*What does plexiform mean?*
Plexus-like

*OK then, what is a plexus?*
An interlaced group of fibers

*What does this indicate about the composition of the inner and outer plexiform layers?*
Retinal Layers
- Internal limiting membrane
- Nerve fiber layer
- Ganglion cell layer
- **Inner plexiform layer**
- Inner nuclear layer
- **Outer plexiform layer**
- Outer nuclear layer
- External limiting membrane

RPE
Bruch's membrane

**What does plexiform mean?**
Plexus-like

**OK then, what is a plexus?**
An interlaced group of fibers

**What does this indicate about the composition of the inner and outer plexiform layers?**
That they are composed of cell processes (i.e., axons and dendrites)
Retinal Anatomy and Histology

- Retinal Layers
  - Internal limiting membrane
  - Nerve fiber layer
  - Ganglion cell layer
  - **Inner plexiform layer**
  - Inner nuclear layer
  - **Outer plexiform layer**
  - Outer nuclear layer
  - External limiting membrane
  - RPE
  - Bruch’s membrane

*What does plexiform mean?*
Plexus-like

*OK then, what is a plexus?*
An interlaced group of fibers

*What does this indicate about the composition of the inner and outer plexiform layers?*
That they are composed of cell processes (i.e., axons and dendrites)

*Processes of what specific cells comprise these layers?*
**IPL:**
**OPL:**
Retinal Layers
- Internal limiting membrane
- Nerve fiber layer
- Ganglion cell layer
- Inner plexiform layer
- Inner nuclear layer
- Outer plexiform layer
- Outer nuclear layer
- External limiting membrane
- RPE
- Bruch’s membrane

What does plexiform mean?
Plexus-like

OK then, what is a plexus?
An interlaced group of fibers

What does this indicate about the composition of the inner and outer plexiform layers?
That they are composed of cell processes (i.e., axons and dendrites)

Processes of what specific cells comprise these layers?
**IPL:** Bipolar, amacrine and ganglion cells
**OPL:** Photoreceptor, bipolar and horizontal cells
The outer plexiform layer is often referred to by an eponym. What is its eponymous name?
Retinal Layers
- Internal limiting membrane
- Nerve fiber layer
- Ganglion cell layer
- Inner plexiform layer
- Inner nuclear layer
- **Outer plexiform layer (Henle’s layer)**
- Outer nuclear layer
- External limiting membrane

RPE
- Bruch’s membrane
Retinal Anatomy and Histology

● Retinal Layers
  ● Internal limiting membrane
  ● Nerve fiber layer
  ● Ganglion cell layer
  ● Inner plexiform layer
  ● Inner nuclear layer
  ● Outer plexiform layer *(Henle’s layer)*
  ● *(Next?)*
  ● External limiting membrane

● RPE

● Bruch’s membrane


- Retinal Layers
  - Internal limiting membrane
  - Nerve fiber layer
  - Ganglion cell layer
  - Inner plexiform layer
  - Inner nuclear layer
  - Outer plexiform layer *(Henle’s layer)*
  - Outer nuclear layer
  - External limiting membrane

- RPE
- Bruch’s membrane
Q

- Retinal Layers
  - Internal limiting membrane
  - Nerve fiber layer
  - Ganglion cell layer
  - Inner plexiform layer
  - **Inner nuclear layer**
  - Outer plexiform layer *(Henle's layer)*
  - **Outer nuclear layer**
  - External limiting membrane

- RPE
- Bruch’s membrane

*If the plexiform layers are composed of cell axons, what are the nuclear layers composed of?*
Retinal Layers

- Internal limiting membrane
- Nerve fiber layer
- Ganglion cell layer
- Inner plexiform layer
- **Inner nuclear layer**
- Outer plexiform layer (Henle's layer)
- **Outer nuclear layer**
- External limiting membrane

- RPE
- Bruch’s membrane

*If the plexiform layers are composed of cell axons, what are the nuclear layers composed of?*

- Cell bodies
Q

- **Retinal Layers**
  - Internal limiting membrane
  - Nerve fiber layer
  - Ganglion cell layer
  - Inner plexiform layer
  - **Inner nuclear layer**
  - Outer plexiform layer (Henle's layer)
  - **Outer nuclear layer**
  - External limiting membrane

- **RPE**
- **Bruch’s membrane**

*If the plexiform layers are composed of cell axons, what are the nuclear layers composed of?*  
**Cell bodies**

*What cell types have their bodies in these layers?*  
**INL:**  
**ONL:**
Retinal Anatomy and Histology

- Retinal Layers
  - Internal limiting membrane
  - Nerve fiber layer
  - Ganglion cell layer
  - Inner plexiform layer
  - Inner nuclear layer
  - Outer plexiform layer (Henle's layer)
  - Outer nuclear layer
  - External limiting membrane

- RPE
- Bruch’s membrane

If the plexiform layers are composed of cell axons, what are the nuclear layers composed of?
- Cell bodies

What cell types have their bodies in these layers?
- **INL**: Bipolar, amacrine and horizontal cells
- **ONL**: Photoreceptors
Retinal Layers

- Internal limiting membrane
- Nerve fiber layer
- Ganglion cell layer
- Inner plexiform layer
- Inner nuclear layer
- Outer plexiform layer
- Outer nuclear layer
- External limiting membrane

- RPE
- Bruch’s membrane

Note that this section of the retina consists simply of alternating layers of cell processes and cell bodies. This can help you remember which layer is next to which!
Retinal Layers
- Internal limiting membrane
- Nerve fiber layer
- Ganglion cell layer
- Inner plexiform layer
- Inner nuclear layer
- Outer plexiform layer (*Henle’s layer*)
- Outer nuclear layer
- External limiting membrane
- *(Next?)*

RPE

Bruch’s membrane
Retinal Anatomy and Histology

- **Retinal Layers**
  - Internal limiting membrane
  - Nerve fiber layer
  - Ganglion cell layer
  - Inner plexiform layer
  - Inner nuclear layer
  - Outer plexiform layer (*Henle’s layer*)
  - Outer nuclear layer
  - External limiting membrane
  - Rod & cone inner and outer segments
- **RPE**
- **Bruch’s membrane**
Retinal Anatomy and Histology

- **Retinal Layers**
  - Internal limiting membrane
  - Nerve fiber layer
  - Ganglion cell layer
  - Inner plexiform layer
  - Inner nuclear layer
  - Outer plexiform layer (*Henle’s layer*)
  - Outer nuclear layer
  - External limiting membrane
  - Rod & cone inner and outer segments

- **RPE**
- **Bruch’s membrane**

We’ll have more to say about the RPE and Bruch’s shortly
Retinal Layers

- Internal limiting membrane
- Nerve fiber layer
- Ganglion cell layer
- Inner plexiform layer
- Inner nuclear layer
- Outer plexiform layer (Henle’s layer)
- Outer nuclear layer
- External limiting membrane
- Rod & cone inner and outer segments

- RPE
- Bruch’s membrane

Review slide—no questions
Retinal Anatomy and Histology

- **Retinal Layers**
  - Internal limiting membrane
  - Nerve fiber layer
  - Ganglion cell layer
  - Inner plexiform layer
  - Inner nuclear layer
  - Outer plexiform layer (Henle’s layer)
  - Outer nuclear layer
  - External limiting membrane
  - Rod & cone inner and outer segments

- **RPE**
- **Bruch’s membrane**
Retinal Layers
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- Outer nuclear layer
- External limiting membrane
- Rod & cone inner and outer segments

RPE

Bruch’s membrane

What cell extends the entire breadth of the retina?
Müller cells
Retinal Anatomy and Histology

Müller cells

choroid
pigment epithelium

photoreceptors

bipolar cells

ganglion cells

Müller cells
Retinal Anatomy and Histology

- **Retinal Layers**
  - Internal limiting membrane
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- **RPE**
- **Bruch’s membrane**
Retinal Anatomy and Histology

- Retinal Layers
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- RPE
- Bruch’s membrane

What cell extends the entire breadth of the retina?
Müller cells

What do their foot processes create?
The internal limiting membrane
Retinal Anatomy and Histology

- **Retinal Layers**
  - Internal limiting membrane
  - Nerve fiber layer
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  - Inner plexiform layer
  - Inner nuclear layer
  - Outer plexiform layer (Henle's layer)
  - Outer nuclear layer
  - External limiting membrane

  **What about the external limiting membrane?**

- **External limiting membrane**
  - Rod & cone inner and outer segments

- **RPE**

- **Bruch’s membrane**

**What cell extends the entire breadth of the retina?**
Müller cells

**What do their foot processes create?**
The internal limiting membrane
Q/A

- **Retinal Layers**
  - Internal limiting membrane
  - Nerve fiber layer
  - Ganglion cell layer
  - Inner plexiform layer
  - Inner nuclear layer
  - Outer plexiform layer (Henle's layer)
  - Outer nuclear layer
  - External limiting membrane

  *What about the external limiting membrane?*
  It’s not really a membrane. Rather, it’s a series of connections between and among photoreceptor and Müller cells.

- **RPE**
- **Bruch’s membrane**
Retinal Anatomy and Histology

Retinal Layers
- Internal limiting membrane
- Nerve fiber layer
- Ganglion cell layer
- Inner plexiform layer
- Inner nuclear layer
- Outer plexiform layer (Henle's layer)
- Outer nuclear layer
- External limiting membrane

What about the external limiting membrane?
It’s not really a membrane. Rather, it’s a series of connections between photoreceptor and Müller cells, and among Müller cells.

- External limiting membrane
- Rod & cone inner and outer segments

RPE
- Bruch’s membrane
Retinal Layers
- Internal limiting membrane
- Nerve fiber layer
- Ganglion cell layer
- Inner plexiform layer
- Inner nuclear layer
- Outer plexiform layer (Henle’s layer)
- Outer nuclear layer
- External limiting membrane
- Rod & cone inner and outer segments

RPE

Bruch’s membrane

Which cells comprise the retinal vertical pathway? (And what is meant by vertical pathway, anyway)?
Which cells comprise the retinal vertical pathway? (And what is meant by vertical pathway, anyway)? The photoreceptors, bipolar and ganglion cells comprise the vertical retinal pathway. This pathway is vertical in the sense that it is the direct path from photic stimulation to the CNS processing centers.
**Retinal Layers**
- Internal limiting membrane
- Nerve fiber layer
- Ganglion cell layer
- Inner plexiform layer
- Inner nuclear layer
- Outer plexiform layer (Henle’s layer)
- Outer nuclear layer
- External limiting membrane
- Rod & cone inner and outer segments

**RPE**

**Bruch’s membrane**

---

Which cells comprise the retinal **vertical pathway**? (And what is meant by vertical pathway, anyway)? The **photoreceptors**, **bipolar** and **ganglion cells** comprise the vertical retinal pathway. This pathway is vertical in the sense that it is the direct path from photic stimulation to the CNS processing centers. Other retinal cells form the **horizontal pathway**, connecting cells to one another, but not directly getting impulses out of the eye and on their way to the CNS.
Retinal Anatomy and Histology

- Retinal Layers
  - Internal limiting membrane
  - Nerve fiber layer
  - Ganglion cell layer
  - Inner plexiform layer
  - Inner nuclear layer
  - Outer plexiform layer (Henle’s layer)
  - Outer nuclear layer
  - External limiting membrane
  - Rod & cone inner and outer segments

- RPE

- Bruch’s membrane

Blood supply:

What are the retina’s two blood supplies?

Blood supply:
Retinal Anatomy and Histology

- **Retinal Layers**
  - Internal limiting membrane
  - Nerve fiber layer
  - Ganglion cell layer
  - Inner plexiform layer
  - Inner nuclear layer
  - Outer plexiform layer (Henle’s layer)
  - Outer nuclear layer
  - External limiting membrane
  - Rod & cone inner and outer segments

- **RPE**

- **Bruch’s membrane**

(CRA = Central retinal artery)

- **Blood supply:**
  - **CRA**

- **What are the retina’s two blood supplies?**
  - **Choriocapillaris**
Retinal Anatomy and Histology

- Retinal Layers
  - Internal limiting membrane
  - Nerve fiber layer
  - Ganglion cell layer
  - Inner plexiform layer
  - Inner nuclear layer
  - Outer plexiform layer (Henle’s layer)
  - Outer nuclear layer
  - External limiting membrane
  - Rod & cone inner and outer segments

- RPE
- Bruch’s membrane

Blood supply:
- CRA

Which layers are supplied by each blood supply?

Blood supply:
- Choriocapillaris
- **Retinal Layers**
  - Internal limiting membrane
  - Nerve fiber layer
  - Ganglion cell layer
  - Inner plexiform layer
  - Inner nuclear layer
  - Outer plexiform layer (Henle’s layer)
  - Outer nuclear layer
  - External limiting membrane
  - Rod & cone inner and outer segments

- **RPE**
- **Bruch’s membrane**

**Blood supply:**
- **CRA**
  - Which layers are supplied by each blood supply?
  - **Choriocapillaris**

**Blood supply:**
Here is a photomicrograph of the normal human retina.

- Internal limiting membrane
- Nerve fiber layer
- Ganglion cell layer
- Inner plexiform layer
- Inner nuclear layer
- Outer plexiform layer
- Outer nuclear layer
- Layer of Rods and Cones
- Retinal pigmented epithelium
- Choroid

(No question—proceed when ready)
Here is a photomicrograph of the normal human retina. Here, approximately, is the demarcation between the layers perfused by the CRA vs the choriocapillaris.
Here is a photomicrograph of the normal human retina. Here, approximately, is the demarcation between the layers perfused by the CRA vs the choriocapillaris.

Standard (ie, dye-based) FA allows visualization of the retinal and choroidal vasculatures, but the layers are all superimposed upon one another, making it impossible to distinguish among them.

(No question—proceed when ready)
Here is a photomicrograph of the normal human retina

Here, approximately, is the demarcation between the layers perfused by the CRA vs the choriocapillaris

Instead, let’s use *en face* OCTA to look at the ultrastructure of the circulatory system (for illustration purposes, in the foveal region)

Optical coherence tomography (OCT) through the fovea (cross-sectional, not *en face*)

(No question—proceed when ready)
Retinal Anatomy and Histology

Pics A, B and C depict the parafoveal vasculature as we progress deeper into the retina

(No question—proceed when ready)
Pics A, B and C depict the parafoveal vasculature as we progress deeper into the retina.
Pics A, B and C depict the parafoveal vasculature as we progress deeper into the retina.
Note the foveal avascular zone (FAZ) is present in all three layers.
As expected, imaging of the deeper retina (D) reveals the absence of intraretinal vasculature.
Imaging of the choriocapillaris (E) indicates it contains a dense, robust vasculature.
Imaging of the choriocapillaris (E) indicates it contains a dense, robust vasculature. As expected, note the absence of a void corresponding to the FAZ.

(No question—proceed when ready)
Q

● **RPE: Functions**

1)

2)

3)
RPE: Functions

1) Outer blood-ocular barrier

three words

2)

3)
RPE: Functions

1) Outer blood-ocular barrier

2)

3)
RPE: Functions

1) **Outer blood-ocular barrier**
   - Formed by inter-cellular structures near cell apices

2) 

3)
RPE: Functions

1) **Outer blood-ocular barrier**
   - Formed by *zonulae occludens* near cell apices

2)

3)
Retinal Anatomy and Histology

RPE: Functions

1) *Outer blood-ocular barrier*
   - Formed by *zonulae occludens* near cell apices

As a result of this barrier, the photoreceptor environment is determined by the transport properties of the RPE—bringing *metabolites* in, and carrying *waste products* out. The RPE also *dehydrates* the subretinal space, thereby maintaining structural integrity of the retina.
RPE: Functions

1) **Outer blood-ocular barrier**
   - Formed by *zonulae occludens* near cell apices

As a result of this barrier, the photoreceptor environment is determined by the transport properties of the RPE—bringing metabolites in, and carrying waste products out. The RPE also dehydrates the subretinal space, thereby maintaining structural integrity of the retina.
RPE: Functions

1) Outer blood-ocular barrier
   - Formed by zonulae occludens near cell apices

2) Phagocytosis of four words

3)
RPE: Functions

1) Outer **blood-ocular barrier**
   - Formed by **zonulae occludens** near cell apices

2) **Phagocytosis of rod/cone outer segments**

3)
**RPE: Functions**

1. **Outer blood-ocular barrier**
   - Formed by *zonulae occludens* near cell apices

2. **Phagocytosis of rod/cone outer segments**

3. **Vitamin metabolism**
**RPE: Functions**

1) **Outer blood-ocular barrier**
   - Formed by *zonulae occludens* near cell apices
2) **Phagocytosis of rod/cone outer segments**
3) **Vitamin A metabolism**
RPE: Functions

1) Outer blood-ocular barrier
   - Formed by zonulae occludens near cell apices

2) Phagocytosis of rod/cone outer segments

3) Vitamin A metabolism
   - Specific substance acquired, stored and transported by RPE
RPE: Functions

1) Outer blood-ocular barrier
   - Formed by zonulae occludens near cell apices

2) Phagocytosis of rod/cone outer segments

3) Vitamin A metabolism
   - Retinol acquired, stored and transported by RPE
What are the five layers of Bruch’s membrane?
What are the five layers of Bruch’s membrane?

1) [two words] of RPE
What are the five layers of Bruch’s membrane?

1) **Basement membrane** of RPE
2) (Next)
3)
4)
5)
What are the five layers of Bruch’s membrane?

1) **Basement membrane** of RPE
2) Inner layer
3) 
4) 
5) 

**Innermost**

**Outermost**
What are the five layers of Bruch’s membrane?

1) **Basement membrane** of RPE
2) Inner **collagenous** layer
3) (Next)
4)
5)
What are the five layers of Bruch’s membrane?

1) **Basement membrane** of RPE
2) Inner **collagenous** layer
3) [Diff one word]
4) [Diff one word]
5) [Diff one word]

**Innermost**

**Outermost**
What are the five layers of Bruch’s membrane?

1. **Basement membrane** of RPE
2. Inner **collagenous** layer
3. **Elastic** layer
4. *(Next)*
5. **(Next)*
What are the five layers of Bruch’s membrane?

1) **Basement membrane** of RPE
2) Inner **collagenous** layer
3) **Elastic** layer
4) Outer layer
5) **one familiar word**

**Innermost**

**Outermost**
What are the five layers of Bruch’s membrane?

1) **Basement membrane** of RPE
2) Inner **collagenous** layer
3) **Elastic** layer
4) Outer **collagenous** layer
5) (Next)
What are the five layers of Bruch’s membrane?

1) **Basement membrane** of RPE
2) Inner **collagenous** layer
3) **Elastic** layer
4) Outer **collagenous** layer
5) [two familiar words] of choriocapillaris
What are the five layers of Bruch’s membrane?

1) **Basement membrane** of RPE
2) Inner **collagenous** layer
3) **Elastic** layer
4) Outer **collagenous** layer
5) **Basement membrane** of choriocapillaris

**Innermost**

**Outermost**
What are the five layers of Bruch’s membrane?

1) **Basement membrane** of RPE
2) Inner **collagenous** layer
3) Elastic layer
4) Outer **collagenous** layer
5) **Basement membrane** of choriocapillaris

What (non-Bruch’s) structure goes here?

1) ?

Innermost

Outermost
What are the five layers of Bruch’s membrane?

0) RPE cells

1) Basement membrane of RPE
2) Inner collagenous layer
3) Elastic layer
4) Outer collagenous layer
5) Basement membrane of choriocapillaris

What (non-Bruch’s) structure goes here? The RPE cells themselves

Innermost

Outermost
What are the five layers of Bruch’s membrane?

0) RPE cells

1) **Basement membrane** of RPE

2) Inner **collagenous layer**

3) **Elastic layer**

4) Outer **collagenous layer**

5) **Basement membrane** of choriocapillaris

So, the plasma membranes of the RPE cells...
What are the five layers of Bruch’s membrane?

0) RPE cells RPE cells
1) Basement membrane of RPE
2) Inner collagenous layer
3) Elastic layer
4) Outer collagenous layer
5) Basement membrane of choriocapillaris

So, the plasma membranes of the RPE cells... sit directly on their BM
What are the five layers of Bruch's membrane?

- Basement membrane of RPE
- Inner collagenous layer
- Elastic layer
- Outer collagenous layer
- Basement membrane of choriocapillaris

What (non-RPE) structures go here?

Innermost

Outermost
What are the five layers of Bruch's membrane?

- Baseline membrane of RPE
- Inner collagenous layer
- Elastic layer
- Outer collagenous layer
- Baseline membrane of choriocapillaris

What (non-RPE) structures go here?
The photoreceptor outer segments
What are the five layers of Bruch's membrane?

1. Basement membrane of RPE
2. Inner collagenous layer
3. Elastic layer
4. Outer collagenous layer
5. Basement membrane of choriocapillaris

Note that both the RPE apical membranes…
What are the five layers of Bruch’s membrane?

- Basement membrane of RPE
- Inner collagenous layer
- Elastic layer
- Outer collagenous layer
- Basement membrane of choriocapillaris

Note that both the RPE apical membranes... and their basal membranes...
What are the five layers of Bruch’s membrane?

- Basement membrane of RPE
- Inner collagenous layer
- Elastic layer
- Outer collagenous layer
- Basement membrane of choriocapillaris

Note that both the RPE apical membranes and their basal membranes are highly infolded.
What are the five layers of Bruch’s membrane?

1. Basement membrane of RPE
2. Inner collagenous layer
3. Elastic layer
4. Outer collagenous layer
5. Basement membrane of choriocapillaris

Retinal Anatomy and Histology

But note further that, while the PRs closely interdigitate with these infoldings…
What are the five layers of Bruch’s membrane?

- 1) PR outer segments
- 0) RPE cells
- 1) Basement membrane of RPE
- 2) Inner collagenous layer
- 3) Elastic layer
- 4) Outer collagenous layer
- 5) Basement membrane of choriocapillaris

But note further that, while the PRs closely interdigitate with these infoldings…

the BM does not.

Innermost

Outermost
What are the five layers of Bruch’s membrane?

- 1) Basement membrane of RPE
- 2) Inner collagenous layer
- 3) Elastic layer
- 4) Outer collagenous layer
- 5) Basement membrane of choriocapillaris

Why does it make sense that the PRs and RPE cells would be highly interdigitated?

Recall that a central function of the RPE is to provide metabolic support for the PRs. The interdigitations greatly increase the total surface area of PR-RPE contact, thereby facilitating these metabolic efforts.

But note further that, while the PRs closely interdigitate with these infoldings…
What are the five layers of Bruch’s membrane?

- 1) Basement membrane of RPE
- 2) Inner collagenous layer
- 3) Elastic layer
- 4) Outer collagenous layer
- 5) Basement membrane of choriocapillaris

But note further that, while the PRs closely interdigitate with these infoldings...

Why does it make sense that the PRs and RPE cells would be highly interdigitated? Recall that a central function of the RPE is to provide metabolic support for the PRs. The interdigitations greatly increase the total surface area of PR-RPE contact, thereby facilitating these metabolic efforts.

Retinal Anatomy and Histology
What are the five layers of Bruch’s membrane?

1) Basement membrane of RPE
2) Inner collagenous layer
3) Elastic layer
4) Outer collagenous layer
5) Basement membrane of choriocapillaris

What cell type is this?

Bipolar cells
What are the five layers of Bruch’s membrane?

1) Basement membrane of RPE
2) Inner collagenous layer
3) Elastic layer
4) Outer collagenous layer
5) Basement membrane of choriocapillaris

What cell type is this? Bipolar cells

Retinal Anatomy and Histology
What are the five layers of Bruch’s membrane?

1. Basement membrane of RPE
2. Inner collagenous layer
3. Elastic layer
4. Outer collagenous layer
5. Basement membrane of choriocapillaris

What structure is this?
What are the five layers of Bruch’s membrane?

- Baseline membrane of RPE
- Inner collagenous layer
- Elastic layer
- Outer collagenous layer
- Baseline membrane of choriocapillaris

What structure is this? The choriocapillaris
What are the five layers of Bruch’s membrane?

- 0) RPE cells
- 1) Basement membrane of RPE
- 2) Inner collagenous layer
- 3) Elastic layer
- 4) Outer collagenous layer
- 5) Basement membrane of choriocapillaris
- 6) Choriocapillaris
- 7) ?

What structure is this? 

The choroid
What structure is this? The choroid

What are the five layers of Bruch’s membrane?

- **Basement membrane of RPE**
- **Inner collagenous layer**
- **Elastic layer**
- **Outer collagenous layer**
- **Basement membrane of choriocapillaris**

**A**

1) **Basement membrane** of RPE
2) Inner **collagenous** layer
3) **Elastic layer**
4) Outer **collagenous** layer
5) **Basement membrane** of choriocapillaris
6) **Choriocapillaris**
7) **Choroid**