Fill in the IOP equation below.

\[ \text{IOP} = \frac{\text{Aqueous Formation Rate (µL/min)}}{\text{Outflow Facility (µL/min/mmHg)}} + \text{Episcleral Venous Pressure (EVP)} \]
Fill in the IOP equation below.

\[
IOP = \frac{\text{Aqueous Formation Rate (}\mu\text{L/min})}{\text{Outflow Facility (}\mu\text{L/min/mmHg})} + \text{Episcleral Venous Pressure (mmHg)}
\]
Fill in the IOP equation below. What is its eponymous name?

The **Goldmann equation**

\[
\text{IOP} = \frac{\text{Aqueous Formation Rate (µL/min)}}{\text{Outflow Facility (µL/min/mmHg)}} + \text{Episceral Venous Pressure (mmHg)}
\]
Fill in the IOP equation below. What is its eponymous name?
The **Goldmann equation**

\[ IOP = \frac{\text{Aqueous Formation Rate (\(\mu\)L/min)}}{\text{Outflow Facility (\(\mu\)L/min/mmHg)}} + \text{Episceral Venous Pressure (mmHg)} \]
The Goldmann Equation

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

The Goldmann equation

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

Note how the \(\mu\text{L/min}\) cancel, leaving IOP in mmHg
Fill in the IOP equation below. What is its eponymous name? The Goldmann equation

\[ IOP = \frac{\text{Aqueous Formation Rate (µL/min)}}{\text{Outflow Facility (µL/min/mmHg)}} + \text{Episcleral Venous Pressure (mmHg)} \]

So to lower IOP, one must:

Three IOP-lowering maneuvers implied by the Goldmann equation:
- Decrease aqueous formation
- Increase outflow facility
- Decrease episcleral venous pressure
- Dehydrate the vitreous with a hyperosmotic agent
Fill in the IOP equation below. What is its eponymous name?

The Goldmann equation

\[ IOP = \frac{\text{Aqueous Formation Rate (µL/min)}}{\text{Outflow Facility (µL/min/mmHg)}} + \text{Episceral Venous Pressure (mmHg)} \]

So to lower IOP, one must:

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

Three IOP-lowering maneuvers implied by the Goldmann equation
Fill in the IOP equation below. What is its eponymous name?

The **Goldmann equation**

\[ IOP = \frac{\text{Aqueous Formation Rate (µL/min)}}{\text{Outflow Facility (µL/min/mmHg)}} + \text{Episcleral Venous Pressure (mmHg)} \]

So to lower IOP, one must:

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

---

Three IOP-lowering maneuvers implied by the Goldmann equation

Important IOP-lowering maneuver not implied by the Goldmann equation

Foreshadowing alert! Toward the end of the set we will address an important and oft-used IOP-lowering maneuver **not** implied by the Goldmann equation

No question—proceed when ready
IOP = Aqueous Formation Rate (µL/min) / Outflow Facility (µL/min/mmHg) + Episceral Venous Pressure (mmHg)

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

Let’s take a look at the process of aqueous formation...

So to lower IOP, one must:
-- decrease aqueous formation, and/or
-- increase outflow facility, and/or
-- decrease episcleral venous pressure

No question—proceed when ready
Speaking of Aqueous Formation…

Where is it formed? What cells specifically?
Speaking of Aqueous Formation...

Where is it formed? What cells specifically?

- Pigmented vs nonpigmented
- Epithelial cells of the pars plicata portion of the ciliary body

The Goldmann Equation
Speaking of Aqueous Formation...

Where is it formed? What cells specifically?

Nonpigmented epithelial cells of the pars plicata portion of the ciliary body
Nonpigmented epithelium of the pars plicata of the ciliary body
(note also the presence of a pigmented epithelial layer)
Speaking of Aqueous Formation…

Where is it formed? What cells specifically?

Nonpigmented epithelial cells of the pars plicata portion of the ciliary body

The ciliary body has two parts. One is the pars plicata; what is the other?
Speaking of Aqueous Formation...

- Where is it formed? What cells specifically?
- Nonpigmented epithelial cells of the pars plicata portion of the ciliary body

The ciliary body has two parts. One is the pars plicata; what is the other?
The pars plana
Ciliary body: One perspective, **two questions**
Ciliary body: One perspective, **two questions**
Speaking of Aqueous Formation...

- Where is it formed? What cells specifically?
  Nonpigmented epithelial cells of the pars plicata portion of the ciliary body

- What is the normal rate of production? $\#\# \mu\text{L/min}$
Speaking of Aqueous Formation…

- Where is it formed? What cells specifically?
  Nonpigmented epithelial cells of the pars plicata portion of the ciliary body

- What is the normal rate of production? 2-3 µL/min
Speaking of Aqueous Formation...

- Where is it formed? What cells specifically? *Nonpigmented epithelial cells of the pars plicata portion of the ciliary body*
- What is the normal rate of production? *2-3 µL/min*

An important clarification is needed regarding this figure—what is it?
Q/A

- Speaking of Aqueous Formation...
  - Where is it formed? What cells specifically?
    Nonpigmented epithelial cells of the pars plicata portion of the ciliary body
  - What is the normal rate of production? 2-3 \( \mu L/min \)

An important clarification is needed regarding this figure—what is it?
This is the rate of aqueous production while the individual is in a general state.
Speaking of Aqueous Formation...

- Where is it formed? What cells specifically?
  Nonpigmented epithelial cells of the pars plicata portion of the ciliary body

- What is the normal rate of production?
  2-3 \( \mu L/min \)

An important clarification is needed regarding this figure—what is it? This is the rate of aqueous production while the individual is awake.
Speaking of Aqueous Formation…

- Where is it formed? What cells specifically? Nonpigmented epithelial cells of the pars plicata portion of the ciliary body
- What is the normal rate of production? 2-3 μL/min

An important clarification is needed regarding this figure—what is it? This is the rate of aqueous production while the individual is awake.

Is the rate while sleeping higher, or lower?
Speaking of Aqueous Formation...

- Where is it formed? What cells specifically? Nonpigmented epithelial cells of the pars plicata portion of the ciliary body
- What is the normal rate of production? 2-3 µL/min

An important clarification is needed regarding this figure—what is it? This is the rate of aqueous production while the individual is awake.

Is the rate while sleeping higher, or lower? Lower
Speaking of Aqueous Formation...

- Where is it formed? What cells specifically? Nonpigmented epithelial cells of the pars plicata portion of the ciliary body
- What is the normal rate of production? 2-3 $\mu$L/min

An important clarification is needed regarding this figure—what is it? This is the rate of aqueous production while the individual is awake.

Is the rate while sleeping higher, or lower? How much lower? Lower
Q/A

Speaking of Aqueous Formation...

- Where is it formed? What cells specifically?
  Nonpigmented epithelial cells of the pars plicata portion of the ciliary body

- What is the normal rate of production?
  2-3 µL/min

An important clarification is needed regarding this figure—what is it? This is the rate of aqueous production while the individual is awake.

Is the rate while sleeping higher, or lower? How much lower?
Lower. Depends on which book you read—per the Glaucoma book, the rate drops “by about ___%” during sleep.
Speaking of Aqueous Formation…

Where is it formed? What cells specifically?
Nonpigmented epithelial cells of the pars plicata portion of the ciliary body

What is the normal rate of production?

2-3 µL/min

An important clarification is needed regarding this figure—what is it? This is the rate of aqueous production while the individual is awake

Is the rate while sleeping higher, or lower? How much lower? Lower. Depends on which book you read—per the Glaucoma book, the rate drops “by about 50% ” during sleep
Speaking of Aqueous Formation...

- Where is it formed? What cells specifically?
  Nonpigmented epithelial cells of the pars plicata portion of the ciliary body

- What is the normal rate of production?
  2-3 µL/min

An important clarification is needed regarding this figure—what is it? This is the rate of aqueous production while the individual is awake.

Is the rate while sleeping higher, or lower? How much lower?
Lower. Depends on which book you read—per the Glaucoma book, the rate drops “by about 50%” during sleep, whereas the Fundamentals book gives a sleep-production rate of # µl/min.
Speaking of Aqueous Formation...

- Where is it formed? What cells specifically?
  Nonpigmented epithelial cells of the pars plicata portion of the ciliary body

- What is the normal rate of production?
  2-3 µL/min

An important clarification is needed regarding this figure—what is it? This is the rate of aqueous production while the individual is awake.

Is the rate while sleeping higher, or lower? How much lower? Lower. Depends on which book you read—per the *Glaucoma* book, the rate drops “by about 50%” during sleep, whereas the *Fundamentals* book gives a sleep-production rate of 1.0 µl/min.
Speaking of Aqueous Formation...

- Where is it formed? What cells specifically? Nonpigmented epithelial cells of the pars plicata portion of the ciliary body
- What is the normal rate of production? 2-3 µL/min
- What is the AC aqueous volume? 200-300 µL
Speaking of Aqueous Formation...

- Where is it formed? What cells specifically? **Nonpigmented epithelial cells of the pars plicata portion of the ciliary body**
- What is the normal rate of production? 2-3 $\mu$L/min
- What is the AC aqueous volume? 200-300 $\mu$L
Speaking of Aqueous Formation...

- Where is it formed? What cells specifically? Nonpigmented epithelial cells of the pars plicata portion of the ciliary body
- What is the normal rate of production? 2-3 µL/min
- What is the AC aqueous volume? 200-300 µL
- So, what percent of AC volume is formed per minute?

The Goldmann Equation
Speaking of Aqueous Formation…

- Where is it formed? What cells specifically?
  Nonpigmented epithelial cells of the pars plicata portion of the ciliary body

- What is the normal rate of production? 2-3 µL/min

- What is the AC aqueous volume? 200-300 µL

- So, what percent of AC volume is formed per minute? ~1%
Speaking of Aqueous Formation…

- Where is it formed? What cells specifically? **Nonpigmented epithelial cells of the pars plicata portion of the ciliary body**
- What is the normal rate of production? **2-3 \( \mu \text{L/min} \)**
- What is the AC aqueous volume? **200-300 \( \mu \text{L} \)**
- So, what percent of AC volume is formed per minute? **\(~1\%\)**
- Given a \(1\%/\text{min}\) rate of aqueous formation, how long does it take to have a complete turnover of aqueous in the AC?
● Speaking of Aqueous Formation…
  ● Where is it formed? What cells specifically? Nonpigmented epithelial cells of the pars plicata portion of the ciliary body
  ● What is the normal rate of production? 2-3 μL/min
  ● What is the AC aqueous volume? 200-300 μL
  ● So, what percent of AC volume is formed per minute? ~1%
  ● Given a 1%/min rate of aqueous formation, how long does it take to have a complete turnover of aqueous in the AC? About 100 minutes
Speaking of Aqueous Formation…

- Other than keeping the globe inflated, what physiologic needs are met by aqueous?
Speaking of Aqueous Formation…

- Other than keeping the globe inflated, what physiologic needs are met by aqueous? It is the chief source of nutrients for the [structure] and [structure]. (Likewise, it [phrase].)
Speaking of Aqueous Formation…

- Other than keeping the globe inflated, what physiologic needs are met by aqueous? It is the chief source of nutrients for the lens and cornea. (Likewise, it removes their waste products.)
Speaking of Aqueous Formation...

- Other than keeping the globe inflated, what physiologic needs are met by aqueous? It is the chief source of nutrients for the lens and cornea. (Likewise, it removes their waste products.)
- Of the many constituents of aqueous, the Academy seems fixated on one class—what is it?
Speaking of Aqueous Formation...

- Other than keeping the globe inflated, what physiologic needs are met by aqueous? It is the chief source of nutrients for the lens and cornea. (Likewise, it removes their waste products.)

- Of the many constituents of aqueous, the Academy seems fixated on one class—what is it? Ions
What are the two general classes of ions in aqueous? (Note: Not ‘anions and cations.’)

Speaking of Aqueous Formation…

- Other than keeping the globe inflated, what physiologic needs are met by aqueous? It is the chief source of nutrients for the lens and cornea. (Likewise, it removes their waste products.)

- Of the many constituents of aqueous, the Academy seems fixated on one class—what is it? Ions

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

Inorganic and organic
Speaking of Aqueous Formation...

- Other than keeping the globe inflated, what physiologic needs are met by aqueous? It is the chief source of nutrients for the lens and cornea. (Likewise, it removes their waste products.)
- Of the many constituents of aqueous, the Academy seems fixated on one class—what is it? **Ions**

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

The BCSC fixates on four inorganic ions—which ones?

?? Inorganic and organic
Speaking of Aqueous Formation...

- Other than keeping the globe inflated, what physiologic needs are met by aqueous? It is the chief source of nutrients for the lens and cornea. (Likewise, it removes their waste products.)

- Of the many constituents of aqueous, the Academy seems fixated on one class—what is it? Ions

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

[The BCSC fixates on four inorganic ions—which ones? Na⁺, K²⁺, Mg²⁺, Ca²⁺]
Speaking of Aqueous Formation...

- Other than keeping the globe inflated, what physiologic needs are met by aqueous? It is the chief source of nutrients for the lens and cornea. (Likewise, it removes their waste products.)

- Of the many constituents of aqueous, the Academy seems fixated on one class—what is it?

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

Na⁺ ↔ Inorganic and organic → ?
K⁺
Mg²⁺
Ca²⁺

Likewise, it fixates on one organic ion— which one?
Speaking of Aqueous Formation...

- Other than keeping the globe inflated, what physiologic needs are met by aqueous? It is the chief source of nutrients for the lens and cornea. (Likewise, it removes their waste products.)

- Of the many constituents of aqueous, the Academy seems fixated on one class—what is it? **Ions**

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

Inorganic and organic

<table>
<thead>
<tr>
<th>Inorganic</th>
<th>Organic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Na⁺</td>
<td>Lactate</td>
</tr>
<tr>
<td>K⁺</td>
<td></td>
</tr>
<tr>
<td>Mg⁺</td>
<td></td>
</tr>
<tr>
<td>Ca⁺</td>
<td></td>
</tr>
</tbody>
</table>

Likewise, it fixates on one organic ion—**which one?**
Speaking of Aqueous Formation...

- Other than keeping the globe inflated, what physiologic needs are met by aqueous? It is the chief source of nutrients for the lens and cornea. (Likewise, it removes their waste products.)
- Of the many constituents of aqueous, the Academy seems fixated on one class—what is it? **Ions**

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

- **Na**⁺, **K**²⁺, **Mg**²⁺, **Ca**²⁺ (Inorganic)
- **Lactate** (Organic)

*The Glaucoma book states that the concentration of the inorganic ions are all “similar” to that of plasma, with one exception—which is it?*
Speaking of Aqueous Formation…

- Other than keeping the globe inflated, what physiologic needs are met by aqueous? It is the chief source of nutrients for the lens and cornea. (Likewise, it removes their waste products.)

- Of the many constituents of aqueous, the Academy seems fixated on one class—what is it? Ions

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

- Inorganic
- Organic

The Glaucoma book states that the concentration of the inorganic ions are all “similar” to that of plasma, with one exception—which is it? Ca²⁺
Speaking of Aqueous Formation…

- Other than keeping the globe inflated, what physiologic needs are met by aqueous? It is the chief source of nutrients for the lens and cornea. (Likewise, it removes their waste products.)
- Of the many constituents of aqueous, the Academy seems fixated on one class—what is it? **Ions**

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

- Inorganic
- Organic

The Glaucoma book states that the concentration of the inorganic ions are all “similar” to that of plasma, with one exception—which is it? **Ca^{2+}**

*Is [aqueous Ca^{2+}] significantly greater than, or less than, [plasma Ca^{2+}]*?
Speaking of Aqueous Formation…

Other than keeping the globe inflated, what physiologic needs are met by aqueous? It is the chief source of nutrients for the lens and cornea. (Likewise, it removes their waste products.)

Of the many constituents of aqueous, the Academy seems fixated on one class—what is it? **Ions**

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

- Na⁺ ← Inorganic and organic → Lactate
- K⁺
- Mg²⁺
- Ca²⁺

The Glaucoma book states that 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 % that of [plasma Ca²⁺]
Speaking of Aqueous Formation…

- Other than keeping the globe inflated, what physiologic needs are met by aqueous? It is the chief source of nutrients for the lens and cornea. (Likewise, it removes their waste products.)

- Of the many constituents of aqueous, the Academy seems fixated on one class—what is it? **Ions**

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

![The Goldmann Equation](image)

The Glaucoma book states that the concentration of the inorganic ions are all “similar” to that of plasma, with one exception—which is it? **Ca^{2+}**

Is [aqueous Ca^{2+}] significantly greater than, or less than, [plasma Ca^{2+}]?

Less than—it is about half that of [plasma Ca^{2+}]
Speaking of Aqueous Formation...

- Other than keeping the globe inflated, what physiologic needs are met by aqueous? It is the chief source of nutrients for the lens and cornea. (Likewise, it removes their waste products.)
- Of the many constituents of aqueous, the Academy seems fixated on one class—what is it? **Ions**

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

- Na$^+$ (Inorganic and organic)
- K$^{2+}$
- Mg$^{2+}$
- Ca$^{2+}$

Lactate

Per the BCSC, the presence of lactate in aqueous is due primarily to what physiologic fact?
Speaking of Aqueous Formation...

- Other than keeping the globe inflated, what physiologic needs are met by aqueous? It is the chief source of nutrients for the lens and cornea. (Likewise, it removes their waste products.)
- Of the many constituents of aqueous, the Academy seems fixated on one class—what is it? **Ions**

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

- Na⁺  
- K⁺  
- Mg²⁺  
- Ca²⁺  

Inorganic and **organic** Lactate

*Per the BCSC, the presence of lactate in aqueous is due primarily to what physiologic fact?*

The fact that **structure** metabolism is almost 100% (recall that lactate is the end-product of **two words** same two words)
Speaking of Aqueous Formation…

- Other than keeping the globe inflated, what physiologic needs are met by aqueous? It is the chief source of nutrients for the lens and cornea. (Likewise, it removes their waste products.)

- Of the many constituents of aqueous, the Academy seems fixated on one class—what is it?

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

- Inorganic and organic

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

Lactate

*Per the BCSC, the presence of lactate in aqueous is due primarily to what physiologic fact?*

The fact that lens metabolism is almost 100% anaerobic glycolysis (recall that lactate is the end-product of anaerobic glycolysis)
Speaking of Aqueous Formation...

- Other than keeping the globe inflated, what physiologic needs are met by aqueous? It is the chief source of nutrients for the lens and cornea. (Likewise, it removes their waste products.)

- Of the many constituents of aqueous, the Academy seems fixated on one class—what is it? **Ions**

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

- Inorganic and **organic**
- Lactate

Per the BCSC, the presence of lactate in aqueous is due primarily to what physiologic fact?

The fact that lens metabolism is almost 100% anaerobic glycolysis (recall that lactate is the end-product of anaerobic glycolysis)

*How is [aqueous lactate] related to [plasma lactate]?
Speaking of Aqueous Formation…

- Other than keeping the globe inflated, what physiologic needs are met by aqueous? It is the chief source of nutrients for the lens and cornea. (Likewise, it removes their waste products.)

- Of the many constituents of aqueous, the Academy seems fixated on one class—what is it?

Q/A

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

- Inorganic and organic

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

**Lactate**

---

Per the BCSC, the presence of lactate in aqueous is due primarily to **what physiologic fact?**

The fact that lens metabolism is almost 100% anaerobic glycolysis (recall that lactate is the end-product of anaerobic glycolysis)

---

\[ \text{[aqueous lactate]} \quad \text{[plasma lactate]} \]

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

[Aqueous lactate] is **always** greater than [plasma lactate]
Speaking of Aqueous Formation...

Other than keeping the globe inflated, what physiologic needs are met by aqueous? It is the chief source of nutrients for the **lens** and **cornea**. (Likewise, it **removes** their waste products.)

Of the many constituents of aqueous, the Academy seems fixated on one class—what is it? **Ions**

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

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

**The Goldmann Equation**

Per the BCSC, the presence of lactate in aqueous is due primarily to **what physiologic fact?**

The fact that **lens** metabolism is almost 100% anaerobic glycolysis (recall that lactate is the end-product of anaerobic glycolysis)

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

[Aqueous lactate] is **always** greater than [plasma lactate]*
Speaking of Aqueous Formation...

- Other than keeping the globe inflated, what physiologic needs are met by aqueous? *It is the chief source of nutrients for the lens and cornea.* (Likewise, it *removes their waste products.*)

- Of the many constituents of aqueous, the Academy seems fixated on one class—what is it? *Ions*

- Another, nonionic aqueous constituent also gets a lot of Academy love—which one?
Speaking of Aqueous Formation...

- Other than keeping the globe inflated, what physiologic needs are met by aqueous? It is the chief source of nutrients for the lens and cornea. (Likewise, it removes their waste products.)

- Of the many constituents of aqueous, the Academy seems fixated on one class—what is it? Ions

- Another, nonionic aqueous constituent also gets a lot of Academy love—which one? Ascorbate, aka

The Goldmann Equation
Speaking of Aqueous Formation...

- Other than keeping the globe inflated, what physiologic needs are met by aqueous? **It is the chief source of nutrients for the lens and cornea.** (Likewise, it **removes their waste products**.)
- Of the many constituents of aqueous, the Academy seems fixated on one class—what is it? **Ions**
- Another, nonionic aqueous constituent also gets a lot of Academy love—which one? **Ascorbate, aka Vitamin C**
Speaking of Aqueous Formation…

- Other than keeping the globe inflated, what physiologic needs are met by aqueous? It is the chief source of nutrients for the lens and cornea. (Likewise, it removes their waste products.)

- Of the many constituents of aqueous, the Academy seems fixated on one class—what is it? Ions

- Another, nonionic aqueous constituent also gets a lot of Academy love—which one? **Ascorbate**, aka Vitamin C

*Is [aqueous ascorbate] greater, or less than [plasma ascorbate]?
Speaking of Aqueous Formation...

- Other than keeping the globe inflated, what physiologic needs are met by aqueous? It is the chief source of nutrients for the lens and cornea. (Likewise, it removes their waste products.)

- Of the many constituents of aqueous, the Academy seems fixated on one class—what is it? Ions

- Another, nonionic aqueous constituent also gets a lot of Academy love—which one? Ascorbate, aka Vitamin C

**Q/A**

The Goldmann Equation

Is [aqueous ascorbate] greater, or less than [plasma ascorbate]? Greater—# to # times greater, in fact
Speaking of Aqueous Formation...

- Other than keeping the globe inflated, what physiologic needs are met by aqueous? It is the chief source of nutrients for the lens and cornea. (Likewise, it removes their waste products.)

- Of the many constituents of aqueous, the Academy seems fixated on one class—what is it? Ions

- Another, nonionic aqueous constituent also gets a lot of Academy love—which one? Ascorbate, aka Vitamin C

The Goldmann Equation

Is [aqueous ascorbate] greater, or less than [plasma ascorbate]?
Greater—10 to 50 times greater, in fact
Speaking of Aqueous Formation…

- Other than keeping the globe inflated, what physiologic needs are met by aqueous? It is the chief source of nutrients for the lens and cornea. (Likewise, it removes their waste products.)
- Of the many constituents of aqueous, the Academy seems fixated on one class—what is it? Ions
- Another, nonionic aqueous constituent also gets a lot of Academy love—which one? Ascorbate, aka Vitamin C

Is [aqueous ascorbate] greater, or less than [plasma ascorbate]? Greater—10 to 50 times greater, in fact

What role does aqueous ascorbate play in eye health?
Speaking of Aqueous Formation...

- Other than keeping the globe inflated, what physiologic needs are met by aqueous? It is the chief source of nutrients for the lens and cornea. (Likewise, it removes their waste products.)
- Of the many constituents of aqueous, the Academy seems fixated on one class—what is it? Ions
- Another, nonionic aqueous constituent also gets a lot of Academy love—which one? Ascorbate, aka Vitamin C

The Goldmann Equation

Is [aqueous ascorbate] greater, or less than [plasma ascorbate]?
Greater—10 to 50 times greater, in fact

What role does aqueous ascorbate play in eye health?
Ascorbate is an antioxidant property
Speaking of Aqueous Formation…

- Other than keeping the globe inflated, what physiologic needs are met by aqueous? It is the chief source of nutrients for the lens and cornea. (Likewise, it removes their waste products.)
- Of the many constituents of aqueous, the Academy seems fixated on one class—what is it? Ions
- Another, nonionic aqueous constituent also gets a lot of Academy love—which one? Ascorbate, aka Vitamin C

Is [aqueous ascorbate] greater, or less than [plasma ascorbate]? Greater—10 to 50 times greater, in fact

What role does aqueous ascorbate play in eye health? Ascorbate is an antioxidant
Speaking of Aqueous Formation...

- Other than keeping the globe inflated, what physiologic needs are met by aqueous? It is the chief source of nutrients for the lens and cornea. (Likewise, it removes their waste products.)

- Of the many constituents of aqueous, the Academy seems fixated on one class—what is it? Ions

- Another, nonionic aqueous constituent also gets a lot of Academy love—which one? Ascorbate, aka Vitamin C

Is [aqueous ascorbate] greater, or less than [plasma ascorbate]?
Greater—10 to 50 times greater, in fact

What role does aqueous ascorbate play in eye health?
Ascorbate is an antioxidant, and as such, its high aqueous levels prevent some light from reaching the lens and structures beyond
Speaking of Aqueous Formation…
- Other than keeping the globe inflated, what physiologic needs are met by aqueous? It is the chief source of nutrients for the lens and cornea. (Likewise, it removes their waste products.)
- Of the many constituents of aqueous, the Academy seems fixated on one class—what is it? Ions
- Another, nonionic aqueous constituent also gets a lot of Academy love—which one? **Ascorbate**, aka Vitamin C

*The Goldmann Equation*

Is [aqueous ascorbate] greater, or less than [plasma ascorbate]?
Greater—10 to 50 times greater, in fact

What role does aqueous ascorbate play in eye health? Ascorbate is an antioxidant, and as such, its high aqueous levels prevent some UV light from reaching the lens and structures beyond
Fill in the IOP equation below. What is its eponymous name? The Goldmann equation

\[ \text{IOP} = \frac{\text{Aqueous Formation Rate (µL/min)}}{\text{Outflow Facility (µL/min/mmHg)}} + \text{Episceral Venous Pressure (mmHg)} \]

Which three classes of meds decrease aqueous formation?

-- β blockers
-- CAIs
-- α agonists

So to lower IOP, one must:

-- decrease aqueous formation
-- increase outflow facility, and/or
-- decrease episcleral venous pressure
Which three classes of meds decrease aqueous formation?
--β blockers
--CAIs
--α agonists

So to lower IOP, one must:
--decrease aqueous formation and/or
--increase outflow facility, and/or
--decrease episcleral venous pressure
Which three classes of meds decrease aqueous formation?
--β blockers
--CAIs
--α agonists

So to lower IOP, one must:
--decrease aqueous formation
and/or
--increase outflow facility, and/or
--decrease episcleral venous pressure

Recall that aqueous production decreases significantly during sleep. What implication does this have for dosing aqueous suppressants?

The Goldmann equation

$IOP = \text{Aqueous Formation Rate (μL/min)} + \frac{\text{Outflow Facility (μL/min/mmHg)}}{\text{Episcleral Venous Pressure (mmHg)}}$
Which three classes of meds decrease aqueous formation?
--- β blockers
--- CAIs
--- α agonists

So to lower IOP, one must:
--- decrease aqueous formation and/or
--- increase outflow facility, and/or
--- decrease episcleral venous pressure

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

\[
\text{IOP} = \text{Aqueous Formation Rate (µL/min)} + \text{Outflow Facility (µL/min/mmHg)} + \text{Epischleral Venous Pressure (mmHg)}
\]

Recall that aqueous production decreases significantly during sleep. What implication does this have for dosing aqueous suppressants? It implies they will not be as effective if instilled at qHS (so be sure to inquire as to the specific time your pts take their PM dose of these!)
So to lower IOP, one must:

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

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

The Goldmann equation

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

Which three classes of meds decrease aqueous formation?

-- β blockers
-- CAIs
-- α agonists

Which two laser procedures decrease aqueous formation?

--?
--?
So to lower IOP, one must:

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

The Goldmann Equation

\[ IOP = \frac{\text{Aqueous Formation Rate (µL/min)}}{\text{Outflow Facility (µL/min/mmHg)}} + \text{Episceral Venous Pressure (mmHg)} \]

Which three classes of meds decrease aqueous formation?
- β blockers
- CAIs
- α agonists

Which two laser procedures decrease aqueous formation?
- Trans-scleral cyclophotocoagulation (TS-CPC)
- Endocyclophotocoagulation (ECP)
The Goldmann Equation

Trans-scleral

Endoscopic

Cyclophotocoagulation (CPC)
So to lower IOP, one must:
--decrease aqueous formation, and/or
--increase outflow facility, and/or
--decrease episcleral venous pressure

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

\[ \text{IOP} = \frac{\text{Aqueous Formation Rate (µL/min)}}{\text{Outflow Facility (µL/min/mmHg)}} + \text{Episcleral Venous Pressure (mmHg)} \]

What are the two types of outflow?
--?
--?
To lower IOP, one must:
--decrease aqueous formation, and/or
--increase outflow facility, and/or
--decrease episcleral venous pressure

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

The Goldmann equation

\[
IOP = \frac{\text{Aqueous Formation Rate (µL/min)}}{\text{Outflow Facility (µL/min/mmHg)}} + \text{Episcleral Venous Pressure (mmHg)}
\]

What are the two types of outflow?
--Trabecular meshwork (TM)
--Uveoscleral (U/S)
To lower IOP, one must:
--decrease aqueous formation, and/or
--increase outflow facility, and/or
--decrease episcleral venous pressure

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

\[ \text{IOP} = \frac{\text{Aqueous Formation Rate (µL/min)}}{\text{Outflow Facility (µL/min/mmHg)}} + \text{Episcleral Venous Pressure (mmHg)} \]

What are the two types of outflow?
--Trabecular meshwork (TM)
--Uveoscleral (U/S)

One of these is referred to as ‘conventional outflow,’ the other, ‘unconventional.’ Which is which?
TM = ?
U/S = ?
So to lower IOP, one must:
--decrease aqueous formation, and/or
--increase outflow facility, and/or
--decrease episcleral venous pressure

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

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

What are the two types of outflow?
--Trabecular meshwork (TM)
--Uveoscleral (U/S)

One of these is referred to as ‘conventional outflow,’ the other, ‘unconventional.’ Which is which?
TM = conventional
U/S = unconventional
So to lower IOP, one must:
--decrease aqueous formation,
and/or
--increase outflow facility,
and/or
--decrease episcleral venous pressure.

The Goldmann equation

\[ IOP = \frac{\text{Aqueous Formation Rate (µL/min)}}{\text{Outflow Facility (µL/min/mmHg)}} + \text{Episcleral Venous Pressure (mmHg)} \]

What are the two types of outflow?
--Trabecular meshwork (TM)
--Uveoscleral (U/S)

One of these is referred to as 'pressure-dependent outflow,' the other, 'pressure-independent.' Which is which?

TM = conventional
U/S = unconventional

One of these is referred to as 'conventional outflow,' the other, 'unconventional.' Which is which?

TM = conventional
U/S = unconventional
So to lower IOP, one must:
--decrease aqueous formation,
and/or
--increase outflow facility,
and/or
--decrease episcleral venous pressure.

The Goldmann Equation

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

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

What are the two types of outflow?
--Trabecular meshwork (TM)
--Uveoscleral (U/S)

One of these is referred to as ‘pressure-dependent outflow,’ the other, ‘pressure-independent.’ Which is which?
TM = conventional = pressure-dependent
U/S = unconventional = pressure-independent

One of these is referred to as ‘conventional outflow,’ the other, ‘unconventional.’ Which is which?
TM = conventional
U/S = unconventional
So to lower IOP, one must:
-- decrease aqueous formation,
and/or
-- increase outflow facility,
and/or
-- decrease episcleral venous pressure.

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

The Goldmann equation

\[
IOP = \frac{\text{Aqueous Formation Rate (µL/min)}}{\text{Outflow Facility (µL/min/mmHg)}} + \text{Episcleral Venous Pressure (mmHg)}
\]

What are the two types of outflow?
-- Trabecular meshwork (TM)
-- Uveoscleral (U/S)

One of these is referred to as 'pressure-dependent outflow,' the other, 'pressure-independent.' Which is which?

TM = conventional = pressure-dependent
U/S = unconventional = pressure-independent

To be clear, these constitute two sets of synonyms:

**TM outflow** is aka conventional outflow is aka pressure-dependent outflow
**U/S outflow** is aka unconventional outflow is aka pressure-independent outflow

**TM = conventional**
**U/S = unconventional**

No question—proceed when ready
So to lower IOP, one must:
--decrease aqueous formation,
and/or
--increase outflow facility,
and/or
--decrease episcleral venous pressure.

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

The Goldmann equation

\[ IOP = \frac{\text{Aqueous Formation Rate (µL/min)}}{\text{Outflow Facility (µL/min/mmHg)}} + \text{Episcleral Venous Pressure (mmHg)} \]

What are the two types of outflow?
--Trabecular meshwork (TM)
--Uveoscleral (U/S)

One of these is referred to as ‘pressure-dependent outflow,’ the other, ‘pressure-independent.’ Which is which?
TM = conventional = pressure-dependent
U/S = unconventional = pressure-independent

One of these is referred to as ‘conventional outflow,’ the other, ‘unconventional.’ Which is which?
TM = conventional
U/S = unconventional
So to lower IOP, one must:

--decrease aqueous formation,

and/or

--increase outflow facility,

and/or

--decrease episcleral venous pressure

The Goldmann equation

\[ IOP = \frac{\text{Aqueous Formation Rate (µL/min)}}{\text{Outflow Facility (µL/min/mmHg)}} + \text{Episcleral Venous Pressure (mmHg)} \]

What are the two types of outflow?

--Trabecular meshwork (TM)

--Uveoscleral (U/S)

One of these is referred to as ‘pressure-dependent outflow,’ the other, ‘pressure-independent.’ Which is which?

TM = conventional = pressure-dependent

U/S = unconventional = pressure-independent

One of these is referred to as ‘conventional outflow,’ the other, ‘unconventional.’ Which is which?

TM = conventional

U/S = unconventional
The Goldmann Equation

What does it mean to say outflow is ‘pressure-dependent’ or ‘pressure-independent’?
It refers to whether the rate of outflow is influenced by IOP. Take a closer look at the
denominator of the Goldmann equation. Note that, in it, outflow is a function of IOP
(hence the mmHg in the term). For pressure-dependent outflow (ie, outflow via the TM),
increases in IOP result in increased outflow facility.

IOP = Aqueous Formation Rate (µL/min) + Outflow Facility (µL/min/mmHg) + Episcleral Venous
Pressure (mmHg)

What are the two types of outflow?
--Trabecular meshwork (TM)
--Uveoscleral (U/S)

One of these is referred to as ‘pressure-dependent outflow,’
the other, ‘pressure-independent.’ Which is which?
TM = conventional = pressure-dependent
U/S = unconventional = pressure-independent

One of these is referred to as ‘conventional outflow,’
the other, ‘unconventional.’ Which is which?
TM = conventional
U/S = unconventional
So to lower IOP, one must:

--decrease aqueous formation,

and/or

--increase outflow facility,

and/or

--decrease episcleral venous pressure

What does it mean to say outflow is ‘pressure-dependent’ or ‘pressure-independent’?
It refers to whether the rate of outflow is influenced by IOP. Take a closer look at the denominator of the Goldmann equation. Note that, in it, outflow is a function of IOP (hence the mmHg in the term). For pressure-dependent outflow (ie, outflow via the TM), increases in IOP result in increased outflow facility. On the other hand, changes in IOP do not affect U/S outflow—it is pressure-independent. From this, it can be inferred (correctly) that Dr. Goldmann was unaware of uveoscleral outflow at the time he developed his equation.

What are the two types of outflow?
--Trabecular meshwork (TM)
--Uveoscleral (U/S)

One of these is referred to as ‘pressure-dependent outflow,’ the other, ‘pressure-independent.’ Which is which?
TM = conventional = pressure-dependent
U/S = unconventional = pressure-independent

One of these is referred to as ‘conventional outflow,’ the other, ‘unconventional.’ Which is which?
TM = conventional
U/S = unconventional
So to lower IOP, one must:

-- decrease aqueous formation,
-- increase outflow facility,
-- decrease episcleral venous pressure.

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

The Goldmann equation

\[ IOP = \frac{\text{Aqueous Formation Rate (µL/min)}}{\text{Outflow Facility (µL/min/mmHg)}} + \text{Episcleral Venous Pressure (mmHg)} \]

What are the two types of outflow?

-- Trabecular meshwork (TM)
-- Uveoscleral (U/S)

One of these is referred to as ‘pressure-dependent outflow,’ the other, ‘pressure-independent.’ Which is which?

TM = conventional = pressure-dependent
U/S = unconventional = pressure-independent

Next let’s take a closer look at the actual process of aqueous outflow...

One of these is referred to as ‘conventional outflow,’ the other, ‘unconventional.’ Which is which?

TM = conventional
U/S = unconventional
And Speaking of Aqueous Outflow...

What are the major structures aqueous encounters along the conventional outflow pathway?

- Start here—name the first structure crossed by aqueous on the way out via the conventional pathway
And Speaking of Aqueous Outflow...

What are the major structures aqueous encounters along the conventional outflow pathway?

- The TM
- Schlemm's canal
- Episcleral veins
- Anterior ciliary and superior ophthalmic veins
- Cavernous sinus
The Goldmann Equation

Canal of Schlemm (CS) and trabecular meshwork (TM) are located in anterior crotch of scleral spur (SS). Longitudinal ciliary muscle (CM) attaches to posterior aspect of spur.

The trabecular meshwork (TM)
And Speaking of Aqueous Outflow…

What are the major structures aqueous encounters along the conventional outflow pathway?

- The TM

*The TM has three layers. From innermost (i.e., nearest the anterior chamber) to outermost, what are they?
--?
--?
--?
And Speaking of Aqueous Outflow…

What are the major structures aqueous encounters along the conventional outflow pathway?

- The TM

The TM has three layers. From innermost (ie, nearest the anterior chamber) to outermost, what are they?

--Uveal layer
--Corneoscleral layer
--Juxtacanalicular layer

The Goldmann Equation
The Goldmann Equation

TM: Layers
And Speaking of Aqueous Outflow…

What are the major structures aqueous encounters along the conventional outflow pathway?

- The TM
- Schlemm’s canal
- Episcleral veins
- Anterior ciliary and superior ophthalmic veins
- Cavernous sinus

The TM has three layers. From innermost (i.e., nearest the anterior chamber) to outermost, what are they?

- Uveal layer?
- Corneoscleral layer?
- Juxtacanalicular layer?

Of the three, which is the major site of resistance to aqueous outflow?

The Goldmann Equation
And Speaking of Aqueous Outflow...

- What are the major structures aqueous encounters along the conventional outflow pathway?
  - The TM

The TM has three layers. From innermost (i.e., nearest the anterior chamber) to outermost, what are they?
- Uveal layer
- Corneoscleral layer
- Juxtacanalicular layer

Of the three, which is the major site of resistance to aqueous outflow?
The juxtacanalicular layer
And Speaking of Aqueous Outflow…

What are the major structures aqueous encounters along the conventional outflow pathway?

- The TM

Next structure—a space, of sorts
Q/A

And Speaking of Aqueous Outflow…

What are the major structures aqueous encounters along the conventional outflow pathway?

- The TM
- Schlemm’s canal
Schlemm’s canal
And Speaking of Aqueous Outflow…

What are the major structures aqueous encounters along the conventional outflow pathway?

- The TM
- Schlemm’s canal

Next—vascular structures
And Speaking of Aqueous Outflow…

What are the major structures aqueous encounters along the conventional outflow pathway?

- The TM
- Schlemm’s canal
- Episceral veins
The Goldmann Equation

Episceral veins
And Speaking of Aqueous Outflow…

What are the major structures aqueous encounters along the conventional outflow pathway?

- The TM
- Schlemm’s canal
- Episcleral veins

Next, more and larger vascular structures
And Speaking of Aqueous Outflow...

What are the major structures aqueous encounters along the conventional outflow pathway?

- The TM
- Schlemm’s canal
- Episceral veins
- Anterior ciliary vein…
The Goldmann Equation

Anterior ciliary vein
And Speaking of Aqueous Outflow…

What are the major structures aqueous encounters along the conventional outflow pathway?

- The TM
- Schlemm’s canal
- Episcleral veins
- Anterior ciliary vein…and superior ophthalmic vein

The Goldmann Equation
The Goldmann Equation

Superior ophthalmic vein
And Speaking of Aqueous Outflow…

What are the major structures aqueous encounters along the conventional outflow pathway?

- The TM
- Schlemm’s canal
- Episcleral veins
- Anterior ciliary vein…and superior opthalmic vein

Finally, a major vascular space
And Speaking of Aqueous Outflow…

What are the major structures aqueous encounters along the conventional outflow pathway?

- The TM
- Schlemm’s canal
- Episceral veins
- Anterior ciliary vein…and superior ophthalmic vein
- Cavernous sinus
The Goldmann Equation

Cavernous sinus
And Speaking of Aqueous Outflow…

What are the major structures aqueous encounters along the conventional outflow pathway?

- The TM
- Schlemm’s canal
- Episceral veins
- Anterior ciliary vein…and superior ophthalmic vein
- Cavernous sinus

What are the major structures aqueous encounters along the unconventional outflow pathway?

- Start here—name the first structure crossed by aqueous on the way out via the unconventional pathway
And Speaking of Aqueous Outflow…

- What are the major structures aqueous encounters along the conventional outflow pathway?
  - The TM
  - Schlemm’s canal
  - Episcleral veins
  - Anterior ciliary vein...and superior ophthalmic vein
  - Cavernous sinus

- What are the major structures aqueous encounters along the unconventional outflow pathway?
  - **Ciliary body**
  - *And next, a space(s) associated with the CB*
And Speaking of Aqueous Outflow…

- What are the major structures aqueous encounters along the conventional outflow pathway?
  - The TM
  - Schlemm’s canal
  - Episcleral veins
  - Anterior ciliary vein… and superior ophthalmic vein
  - Cavernous sinus

- What are the major structures aqueous encounters along the unconventional outflow pathway?
  - Ciliary body
  - Suprachorioidal spaces
  - And next, another major component of the eye
And Speaking of Aqueous Outflow…

What are the major structures aqueous encounters along the conventional outflow pathway?
- The TM
- Schlemm’s canal
- Episcleral veins
- Anterior ciliary vein…and superior ophthalmic vein
- Cavernous sinus

What are the major structures aqueous encounters along the unconventional outflow pathway?
- Ciliary body
- Suprachoroidal spaces
- Sclera

And finally…another major component of the eye
And Speaking of Aqueous Outflow…

What are the major structures aqueous encounters along the conventional outflow pathway?
- The TM
- Schlemm’s canal
- Episceral veins
- Anterior ciliary vein…and superior ophthalmic vein
- Cavernous sinus

What are the major structures aqueous encounters along the unconventional outflow pathway?
- Ciliary body
- Supraciliary/suprachoroidal spaces
- Sclera
- Conjunctiva
And Speaking of Aqueous Outflow…

- What are the major structures aqueous encounters along the conventional outflow pathway?
  - The TM
  - Schlemm’s canal
  - Episcleral veins
  - Anterior ciliary vein…and superior ophthalmic vein
  - Cavernous sinus

- What are the major structures aqueous encounters along the unconventional outflow pathway?
  - What proportion of egressed aqueous leaves via the unconventional pathway?

- Decrease

The Goldmann Equation
And Speaking of Aqueous Outflow…

What are the major structures aqueous encounters along the conventional outflow pathway?
- The TM
- Schlemm’s canal
- Episceral veins
- Anterior ciliary vein…and superior ophthalmic vein
- Cavernous sinus

What are the major structures aqueous encounters along the unconventional outflow pathway?
- What proportion of egressed aqueous leaves via the unconventional pathway?
  - The most recent version of the BCSC Glaucoma book in my possession puts it as high as 45%

Does the proportion leaving via this pathway increase, or decrease with age?
- Decrease
And Speaking of Aqueous Outflow...

What are the major structures aqueous encounters along the conventional outflow pathway?

- The TM
- Schlemm’s canal
- Episceral veins
- Anterior ciliary vein…and superior ophthalmic vein
- Cavernous sinus

What are the major structures aqueous encounters along the unconventional outflow pathway?

- What proportion of egressed aqueous leaves via the unconventional pathway? The most recent version of the BCSC Glaucoma book in my possession puts it as high as 45% (Note: The Fundamentals book puts the figure at 50%)

Decrease

The Goldmann Equation
And Speaking of Aqueous Outflow…

What are the major structures aqueous encounters along the conventional outflow pathway?

- The TM
- Schlemm’s canal
- Episceral veins
- Anterior ciliary vein…and superior ophthalmic vein
- Cavernous sinus

What are the major structures aqueous encounters along the unconventional outflow pathway?

- What proportion of egressed aqueous leaves via the unconventional pathway?
  - The most recent version of the BCSC Glaucoma book in my possession puts it as high as 45% (Note: The Fundamentals book puts the figure at 50%)
- Does the proportion leaving via this pathway increase, or decrease with age?
  - Decrease
And Speaking of Aqueous Outflow…

- What are the major structures aqueous encounters along the conventional outflow pathway?
  - The TM
  - Schlemm’s canal
  - Episcleral veins
  - Anterior ciliary vein…and superior ophthalmic vein
  - Cavernous sinus

- What are the major structures aqueous encounters along the unconventional outflow pathway?

  - What proportion of egressed aqueous leaves via the unconventional pathway?
    - The most recent version of the BCSC *Glaucoma* book in my possession puts it as high as 45% (Note: The *Fundamentals* book puts the figure at 50%)

  - Does the proportion leaving via this pathway increase, or decrease with age?
    - Decrease
So to lower IOP, one must:

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

**The Goldmann Equation**

\[ IOP = \text{Aqueous Formation Rate (µL/min)} + \text{Outflow Facility (µL/min/mmHg)} + \text{Episcleral Venous Pressure (mmHg)} \]

What are the two types of outflow?

--Trabecular meshwork (TM)
--Uveoscleral (U/S)

Which class of meds increases TM outflow?

Parasympathomimetics, ie, pilo...
So to lower IOP, one must:
--decrease aqueous formation,
and/or
--increase outflow facility,
and/or
--decrease episcleral venous pressure.

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

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

What are the two types of outflow?
--Trabecular meshwork (TM)
--Uveoscleral (U/S)

Which class of meds increases TM outflow?
Parasympathomimetics, ie, pilo

---
So to lower IOP, one must:
--decrease aqueous formation,
and/or
--increase outflow facility,
and/or
--decrease episcleral venous pressure.

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

\[
IOP = \text{Aqueous Formation Rate (µL/min)} + \text{Episcleral Venous Pressure (mmHg)}
\]

What are the two types of outflow?
--Trabecular meshwork (TM)
--Uveoscleral (U/S)

What laser procedure enhances TM outflow?
Laser trabeculoplasty

Microinvasive glaucoma surgery (MIGS) to enhance TM outflow takes one of three general approaches. What are they?
--Disruption or removal of a portion of the TM
--Creation of an artificial conduit through it with an implanted bypass stent
--Enlargement of Schlemm’s canal via cannulation and dilation

Which class of meds increases TM outflow?
Parasympathomimetics, ie, pilo
To lower IOP, one must:

--decrease aqueous formation,

and/or

--increase outflow facility,

and/or

--decrease episcleral venous pressure.

The Goldmann Equation

\[ IOP = \text{Aqueous Formation Rate (µL/min)} + \text{Outflow Facility (µL/min/mmHg)} + \text{Episcleral Venous Pressure (mmHg)} \]

What are the two types of outflow?

--Trabecular meshwork (TM)

--Uveoscleral (U/S)

What laser procedure enhances TM outflow?

Laser trabeculoplasty

Which class of meds increases TM outflow?

Parasympathomimetics, ie, pilo
The Goldmann Equation

Laser trabeculoplasty
So to lower IOP, one must:

--decrease aqueous formation,

and/or

--increase outflow facility,

and/or

--decrease episcleral venous pressure.

The Goldmann Equation

The Goldmann Equation

\[ IOP = \text{Aqueous Formation Rate (µL/min)} + \text{Episcleral Venous Pressure (mmHg)} \]

What surgery enhances TM outflow?

Laser trabeculoplasty

Microinvasive glaucoma surgery (MIGS) to enhance TM outflow takes one of three general approaches. What are they?

--?

--?

--?

What are the two types of outflow?

--Trabecular meshwork (TM)

--Uveoscleral (U/S)

Which class of meds increases TM outflow?

Parasympathomimetics, ie, pilo
So to lower IOP, one must:
--decrease aqueous formation,
and/or
--increase outflow facility,
and/or
--decrease episcleral venous pressure

**The Goldmann Equation**

\[ \text{IOP} = \text{Aqueous Formation Rate (µL/min)} + \text{Outflow Facility (µL/min/mmHg)} + \text{Episcleral Venous Pressure (mmHg)} \]

**What are the two types of outflow?**
--Trabecular meshwork (TM)
--Uveoscleral (U/S)

**What laser procedure enhances TM outflow?**
Laser trabeculoplasty

**Microinvasive glaucoma surgery (MIGS) to enhance TM outflow takes one of three general approaches. What are they?**
--Disruption or removal of a portion of the TM
--Creation of an artificial conduit through it with an implanted bypass stent
--Enlargement of Schlemm’s canal via cannulation and dilation

**Which class of meds increases TM outflow?**
Parasympathomimetics, ie, pilo
The Goldmann Equation

Disruption or removal of a portion of the TM

Creation of an artificial conduit through it with an implanted bypass stent

MIGS

Enlargement of Schlemm's canal via cannulation and dilation
So to lower IOP, one must:
--decrease aqueous formation,
and/or
--increase outflow facility,
and/or
--decrease episcleral venous pressure.

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

\[ \text{IOP} = \frac{\text{Aqueous Formation Rate (µL/min)}}{\text{Outflow Facility (µL/min/mmHg)}} + \text{Episcleral Venous Pressure (mmHg)} \]

What are the two types of outflow?
--Trabecular meshwork (T/M)
--Uveoscleral (U/S)

Which class of meds has as its main IOP-lowering effect an increase in U/S outflow?

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

The Goldmann Equation

Q
So to lower IOP, one must:
--decrease aqueous formation,
and/or
--increase outflow facility,
and/or
--decrease episcleral venous pressure.

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

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

What are the two types of outflow?
--Trabecular meshwork (T/M)
--Uveoscleral (U/S)

Which class of meds has as its main IOP-lowering effect an increase in U/S outflow?
Prostaglandin analogues

---decrease aqueous formation, and/or
---increase outflow facility, and/or
---decrease episcleral venous pressure
So to lower IOP, one must:

-- decrease aqueous formation,

and/or

-- increase outflow facility,

and/or

-- decrease episcleral venous pressure.

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

**The Goldmann equation**

\[
IOP = \frac{\text{Aqueous Formation Rate (µL/min)}}{\text{Outflow Facility (µL/min/mmHg)}} + \text{Episcleral Venous Pressure (mmHg)}
\]

What are the two types of outflow?

-- Trabecular meshwork (T/M)

-- Uveoscleral (U/S)

Which class of meds has as its main IOP-lowering effect an increase in U/S outflow?

Prostaglandin analogues

Is there a MIGS procedure that enhances U/S outflow?

As of this writing, no. An implantable bypass device that shunted aqueous into the suprachoroidal space was available for a time, but has since been withdrawn owing to corneal complications associated with it.
So to lower IOP, one must:

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

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

\[
IOP = \frac{\text{Aqueous Formation Rate (µL/min)}}{\text{Outflow Facility (µL/min/mmHg)}} + \text{Episcleral Venous Pressure (mmHg)}
\]

What are the two types of outflow?
--Trabecular meshwork (TM)
--Uveoscleral (U/S)

Which class of meds has as its main IOP-lowering effect an increase in U/S outflow?
Prostaglandin analogues

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

Is there a MIGS procedure that enhances U/S outflow?
As of this writing, no. An implantable bypass device that shunted aqueous into the suprachoroidal space was available for a time, but has since been withdrawn owing to corneal complications associated with it.
Fill in the IOP equation below. What is its eponymous name?
The Goldmann equation

\[
IOP = \frac{\text{Aqueous Formation Rate (µL/min)}}{\text{Outflow Facility (µL/min/mmHg)}} + \text{Episcleral Venous Pressure (mmHg)}
\]

Are there medical options for lowering EVP?
IOP = \frac{\text{Aqueous Formation Rate (µL/min)}}{\text{Outflow Facility (µL/min/mmHg)}} + \text{Episcleral Venous Pressure (mmHg)}

The Goldmann Equation

Q/A

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

The Goldmann equation

Are there medical options for lowering EVP?
The Glaucoma book indicates class of glaucoma med may lower EVP

Note how the µL/min cancel, leaving IOP in mmHg
Fill in the IOP equation below. What is its eponymous name? The **Goldmann equation**

\[
IOP = \frac{\text{Aqueous Formation Rate (µL/min)}}{\text{Outflow Facility (µL/min/mmHg)}} + \text{Episceral Venous Pressure (mmHg)}
\]

*Note how the µL/min cancel, leaving IOP in mmHg.*

Are there medical options for lowering EVP? The Glaucoma book indicates rho kinase inhibitors may lower EVP.
Fill in the IOP equation below. What is its eponymous name?
The Goldmann equation

\[ IOP = \frac{\text{Aqueous Formation Rate (\(\mu\)L/min)}}{\text{Outflow Facility (\(\mu\)L/min/mmHg)}} + \text{Episceral Venous Pressure (mmHg)} \]
Fill in the IOP equation below. What is its eponymous name?

The Goldmann equation

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

\[ \text{IOP in mmHg} \]

Are there medical options for lowering EVP?

The Glaucoma book indicates rho kinase inhibitors may lower EVP. Additionally, one selective \( \alpha \)-agonist—apraclonidine—may lower EVP to some extent by decreasing blood flow to the eye.
Fill in the IOP equation below. What is its eponymous name?

The **Goldmann equation**

\[
IOP = \frac{\text{Aqueous Formation Rate (μL/min)}}{\text{Outflow Facility (μL/min/mmHg)}} + \text{Episceral Venous Pressure (mmHg)}
\]

So to lower IOP, one must:

\[
\begin{align*}
&\text{--decrease aqueous formation, and/or} \\
&\text{--increase outflow facility, and/or} \\
&\text{--decrease episcleral venous pressure}
\end{align*}
\]

Three IOP-lowering maneuvers implied by the Goldmann equation

Important IOP-lowering maneuver not implied by the Goldmann equation

Time to address the important and oft-used IOP-lowering maneuver **not implied by the Goldmann equation** that was foreshadowed early in the set

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

The Goldmann equation

\[ IOP = \frac{\text{Aqueous Formation Rate (µL/min)}}{\text{Outflow Facility (µL/min/mmHg)}} + \text{Episcleral Venous Pressure (mmHg)} \]

So to lower IOP, one must:

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

Important IOP-lowering maneuver not implied by the Goldmann equation

- and/or... three words... with a
- one word... agent
Fill in the IOP equation below. What is its eponymous name?
The Goldmann equation

\[ IOP = \frac{\text{Aqueous Formation Rate (µL/min)}}{\text{Outflow Facility (µL/min/mmHg)}} + \text{Episcleral Venous Pressure (mmHg)} \]

So to lower IOP, one must:
- decrease aqueous formation, and/or
- increase outflow facility, and/or
- decrease episcleral venous pressure

Three IOP-lowering maneuvers implied by the Goldmann equation

Important IOP-lowering maneuver not implied by the Goldmann equation: ...and/or dehydrate the vitreous with a hyperosmotic agent
Fill in the IOP equation below. What is its eponymous name? The Goldmann equation

\[ IOP = \frac{\text{Aqueous Formation Rate (µL/min)}}{\text{Outflow Facility (µL/min/mmHg)}} + \text{Episceral Venous Pressure (mmHg)} \]

So to lower IOP, one must:

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

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

Important IOP-lowering maneuver not implied by the Goldmann equation

Three IOP-lowering maneuvers implied by the Goldmann equation

Which hyperosmotic agent is used most often?

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

The **Goldmann equation**

\[
IOP = \frac{\text{Aqueous Formation Rate (µL/min)}}{\text{Outflow Facility (µL/min/mmHg)}} + \text{Episcleral Venous Pressure (mmHg)}
\]

So to lower IOP, one must:

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

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

**Important IOP-lowering maneuver not implied by the Goldmann equation**

**Three IOP-lowering maneuvers implied by the Goldmann equation**

**Which hyperosmotic agent is used most often?**

Mannitol