

# Q

## Applanation Tonometry



1

(*P* is for *Pressure*)

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



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



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

*I-F Principle in words* → Pressure inside a sphere equals what the...  
...*F* stands for divided by the what the *A* stands for



- Based on the *Imbert-Fick* principle:  $P = F / A$ 
  - Pressure inside a sphere equals force needed to flatten its surface divided by the area of flattening

I-F Principle  
in words



- Based on the *Imbert-Fick* principle:  $P = F / A$ 
  - Pressure inside a sphere equals force needed to flatten its surface divided by the area of flattening
  - Assumes surface is , and  (cornea is neither, obviously)



- Based on the *Imbert-Fick* principle:  $P = F / A$ 
  - Pressure inside a sphere equals force needed to flatten its surface divided by the area of flattening
  - Assumes surface is infinitely thin, and dry (cornea is neither, obviously)



- Based on the *Imbert-Fick* principle:  $P = F / A$ 
  - Pressure inside a sphere equals force needed to flatten its surface divided by the area of flattening
  - Assumes surface is infinitely thin, and dry (cornea is neither, obviously)
    - K thickness → resists applanation → increase vs decrease IOP reading



- Based on the *Imbert-Fick* principle:  $P = F / A$ 
  - Pressure inside a sphere equals force needed to flatten its surface divided by the area of flattening
  - Assumes surface is infinitely thin, and dry (cornea is neither, obviously)
    - K thickness → resists applanation → increases IOP reading





- Based on the *Imbert-Fick* principle:  $P = F / A$ 
  - Pressure inside a sphere equals force needed to flatten its surface divided by the area of flattening
  - Assumes surface is infinitely thin, and dry (cornea is neither, obviously)
    - K thickness → resists applanation → increases IOP reading

For the Imbert-Fick principle to hold, the **only** force resisting applanation should be the pressure within the sphere. However, real objects such as the cornea have *intrinsic* resistance to deformation owing to their physical nature, ie, because they're made of 'stuff.'

## Applanation Tonometry



- Based on the *Imbert-Fick* principle:  $P = F / A$ 
  - Pressure inside a sphere equals force needed to flatten its surface divided by the area of flattening
  - Assumes surface is infinitely thin, and dry (cornea is neither, obviously)
    - K thickness → resists applanation → *increases* IOP reading

For the Imbert-Fick principle to hold, the **only** force resisting applanation should be the pressure within the sphere. However, real objects such as the cornea have *intrinsic* resistance to deformation owing to their physical nature, ie, because they're made of 'stuff.' This inherent structural resistance of the cornea will be additive to whatever pressure is inside the eye, thereby causing the pressure reading to be falsely **high**. (And the thicker the cornea is, the higher the reading will be.)



- Based on the *Imbert-Fick* principle:  $P = F / A$ 
  - Pressure inside a sphere equals force needed to flatten its surface divided by the area of flattening
  - Assumes surface is infinitely thin, and dry (cornea is neither, obviously)
    - K thickness → resists applanation → increases IOP reading
    - Tear film → capillary attraction → 

increase vs decrease

 IOP reading



- Based on the *Imbert-Fick* principle:  $P = F / A$ 
  - Pressure inside a sphere equals force needed to flatten its surface divided by the area of flattening
  - Assumes surface is infinitely thin, and dry (cornea is neither, obviously)
    - K thickness → resists applanation → increases IOP reading
    - Tear film → capillary attraction → decreases IOP reading

## Applanation Tonometry



- Based on the *Imbert-Fick* principle:  $P = F / A$ 
  - Pressure inside a sphere equals force needed to flatten its surface divided by the area of flattening
  - Assumes surface is infinitely thin, and dry (cornea is neither, obviously)
    - K thickness → resists applanation → increases IOP reading
    - Tear film → capillary attraction → decreases IOP reading

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

## Applanation Tonometry



- Based on the *Imbert-Fick* principle:  $P = F / A$ 
  - Pressure inside a sphere equals force needed to flatten its surface divided by the area of flattening
  - Assumes surface is infinitely thin, and dry (cornea is neither, obviously)
    - K thickness → resists applanation → increases IOP reading
    - Tear film → capillary attraction → decreases IOP reading

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

## Applanation Tonometry



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

- Pressure inside a sphere equals force needed to

*To be useful, an applanator-type device has to account for these factors.*

neither, obviously)

- K thickness → resists applanation → *increases* IOP reading
- Tear film → capillary attraction → *decreases* IOP reading

## Applanation Tonometry



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

- Pressure inside a sphere equals force needed to

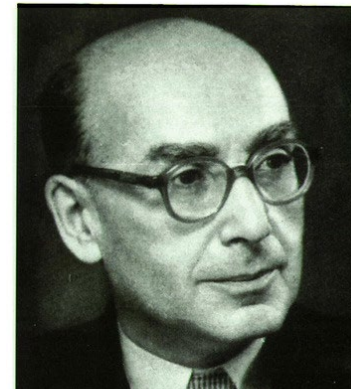
*To be useful, an applanator-type device has to account for these factors. Fortunately, the brilliant Dr. Goldman was (mostly) up to the challenge...*

*(neither, obviously)*

- K thickness → resists applanation → *increases* IOP reading
- Tear film → capillary attraction → *decreases* IOP reading



Stan an eye king!



Hans Goldman  
1899-1991

*No question—pay your respects, then proceed*





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



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

## Applanation Tonometry



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

## Applanation Tonometry



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

(We now know that CCT averages about 550, with wide variation among individuals)

## Applanation Tonometry



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

*No question—proceed when ready*

Q

*This implies that applanation IOP measurements will be off if CCT is not 520. Is that the case?*

• Ba

•

•

•

applanated by the device is 0.00 mm, capillary  
attractive forces between the mires cancel each  
other out

**(assuming CCT is 520  $\mu\text{m}$ )**

- Goldmann believed CCT was 520, with little variation
- When the mires line up, the diameter of the applanated area is 3.06 mm

# A

*This implies that applanation IOP measurements will be off if CCT is not 520.  
Is that the case?  
Indeed it is*

- Ba

- 

- 

- 

applanated by the device is 0.00 mm, capillary  
attraction between the two tips cancel each  
other out

**(assuming CCT is 520  $\mu\text{m}$ )**

- Goldmann perimeter CCT was 520, with little variation
- When the mires line up, the diameter of the applanated area is 3.06 mm

Q

*This implies that applanation IOP measurements will be off if CCT is not 520.  
Is that the case?*

Indeed it is

*Off in which direction, ie, too high or too low?*

**(assuming CCT is 520  $\mu\text{m}$ )**

- Goldmann perimeter CCT was 520, with little variation
- When the mires line up, the diameter of the applanated area is 3.06 mm



Q/ This implies that applanation IOP measurements will be off if CCT is not 520.  
Is that the case?  
Indeed it is

Off in which direction, ie, too high or too low?

Depends—if CCT > 520, the reading will be        than actual IOP, whereas if it's < 520 it will be       

(assuming CCT is 520  $\mu\text{m}$ )

- Goldmann perimeter CCT was 520, with little variation
- When the mires line up, the diameter of the applanated area is 3.06 mm

A

*This implies that applanation IOP measurements will be off if CCT is not 520.  
Is that the case?*

Indeed it is

*Off in which direction, ie, too high or too low?*

Depends—if CCT > 520, the reading will be higher than actual IOP, whereas if it's < 520 it will be lower

**(assuming CCT is 520  $\mu\text{m}$ )**

- Goldmann perimeter CCT was 520, with little variation
- When the mires line up, the diameter of the applanated area is 3.06 mm

Q

*This implies that applanation IOP measurements will be off if CCT is not 520. Is that the case?*

Indeed it is

*Off in which direction, ie, too high or too low?*

Depends—if  $CCT > 520$ , the reading will be higher than actual IOP, whereas if it's  $< 520$  it will be lower

*So why don't we just use a 'CCT correction factor' to adjust the IOP obtained via applanation?*

**(assuming CCT is 520  $\mu\text{m}$ )**

- Goldmann believed CCT was 520, with little variation
- When the mires line up, the diameter of the applanated area is 3.06 mm

A

*This implies that applanation IOP measurements will be off if CCT is not 520. Is that the case?*

Indeed it is

*Off in which direction, ie, too high or too low?*

Depends—if CCT > 520, the reading will be higher than actual IOP, whereas if it's < 520 it will be lower

*So why don't we just use a 'CCT correction factor' to adjust the IOP obtained via applanation?*

Because unfortunately for us, the relationship between CCT and applanated IOP is nonlinear, and not completely understood

**(assuming CCT is 520  $\mu\text{m}$ )**

- Goldmann believed CCT was 520, with little variation
- When the mires line up, the diameter of the applanated area is 3.06 mm

A

*This implies that applanation IOP measurements will be off if CCT is not 520. Is that the case?*

Indeed it is

*Off in which direction, ie, too high or too low?*

Depends—if CCT > 520, the reading will be higher than actual IOP, whereas if it's < 520 it will be lower

*So why don't we just use a 'CCT correction factor' to adjust the IOP obtained via applanation?*

Because unfortunately for us, the relationship between CCT and applanated IOP is nonlinear, and not completely understood. Thus, as of the latest (2022) version of the *Glaucoma* book, "there is no validated correction factor for the effect of CCT on applanation tonometers."

**(assuming CCT is 520  $\mu\text{m}$ )**

- Goldmann believed CCT was 520, with little variation
- When the mires line up, the diameter of the applanated area is 3.06 mm

Q

*This implies that applanation IOP measurements will be off if CCT is not 520. Is that the case?*

Indeed it is

*Off in which direction, ie, too high or too low?*

Depends—if CCT > 520, the reading will be higher than actual IOP, whereas if it's < 520 it will be lower

*So why don't we just use a 'CCT correction factor' to adjust the IOP obtained via applanation?*

Because unfortunately for us, the relationship between CCT and applanated IOP is nonlinear, and not completely understood. Thus, as of the latest (2022) version of the *Glaucoma* book, "there is no validated correction factor for the effect of CCT on applanation tonometers."

*Are there ways of measuring IOP that aren't affected by CCT?*

**(assuming CCT is 520  $\mu\text{m}$ )**

- Goldmann believed CCT was 520, with little variation
- When the mires line up, the diameter of the applanated area is 3.06 mm

A

*This implies that applanation IOP measurements will be off if CCT is not 520. Is that the case?*

Indeed it is

*Off in which direction, ie, too high or too low?*

Depends—if CCT > 520, the reading will be higher than actual IOP, whereas if it's < 520 it will be lower

*So why don't we just use a 'CCT correction factor' to adjust the IOP obtained via applanation?*

Because unfortunately for us, the relationship between CCT and applanated IOP is nonlinear, and not completely understood. Thus, as of the latest (2022) version of the *Glaucoma* book, "there is no validated correction factor for the effect of CCT on applanation tonometers."

*Are there ways of measuring IOP that aren't affected by CCT?*

Yep

**(assuming CCT is 520  $\mu\text{m}$ )**

- Goldmann believed CCT was 520, with little variation
- When the mires line up, the diameter of the applanated area is 3.06 mm

Q

*This implies that applanation IOP measurements will be off if CCT is not 520. Is that the case?*

Indeed it is

*Off in which direction, ie, too high or too low?*

Depends—if CCT > 520, the reading will be higher than actual IOP, whereas if it's < 520 it will be lower

*So why don't we just use a 'CCT correction factor' to adjust the IOP obtained via applanation?*

Because unfortunately for us, the relationship between CCT and applanated IOP is nonlinear, and not completely understood. Thus, as of the latest (2022) version of the *Glaucoma* book, "there is no validated correction factor for the effect of CCT on applanation tonometers."

*Are there ways of measuring IOP that aren't affected by CCT? Why aren't they considered the 'gold standard,' and in widespread use?*

Yep

**(assuming CCT is 520  $\mu\text{m}$ )**

- Goldmann believed CCT was 520, with little variation
- When the mires line up, the diameter of the applanated area is 3.06 mm



A

*This implies that applanation IOP measurements will be off if CCT is not 520. Is that the case?*

Indeed it is

*Off in which direction, ie, too high or too low?*

Depends—if CCT > 520, the reading will be higher than actual IOP, whereas if it's < 520 it will be lower

*So why don't we just use a 'CCT correction factor' to adjust the IOP obtained via applanation?*

Because unfortunately for us, the relationship between CCT and applanated IOP is nonlinear, and not completely understood. Thus, as of the latest (2022) version of the *Glaucoma* book, "there is no validated correction factor for the effect of CCT on applanation tonometers."

*Are there ways of measuring IOP that aren't affected by CCT? Why aren't they considered the 'gold standard,' and in widespread use?*

Yep. Beats me.

**(assuming CCT is 520  $\mu\text{m}$ )**

- Goldmann believed CCT was 520, with little variation
- When the mires line up, the diameter of the applanated area is 3.06 mm

## Applanation Tonometry

*What happens during applanation tonometry, and how does it measure IOP?*

- When the mires line up, the diameter of the applanated area is 3.06 mm



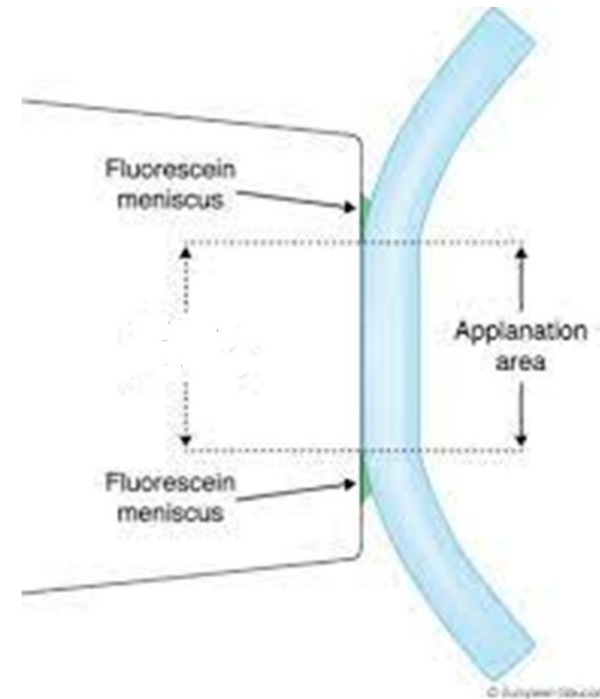
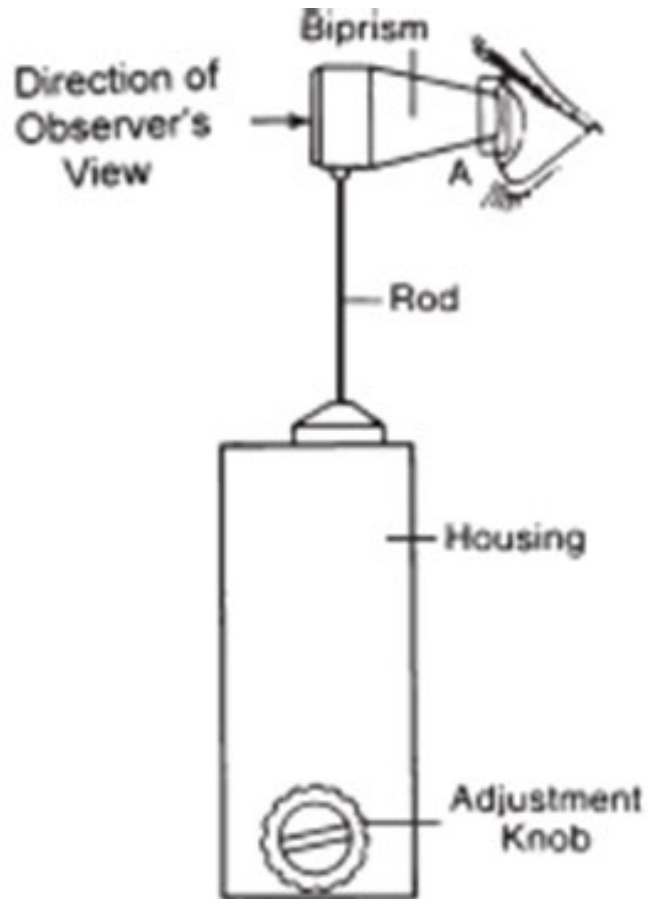
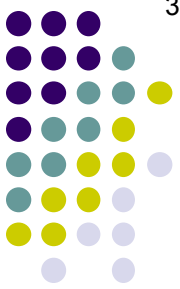
## Applanation Tonometry

*What happens during applanation tonometry, and how does it measure IOP?*

During applanation tonometry, the tip of the applanator pushes against the cornea, flattening it. As the tip flattens the cornea, fluorescein flows into and fills the rim-area between the cornea and the applanator tip, forming a 'meniscus ring.'

- When the mires line up, the diameter of the applanated area is 3.06 mm

# Applanation Tonometry





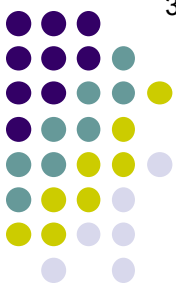
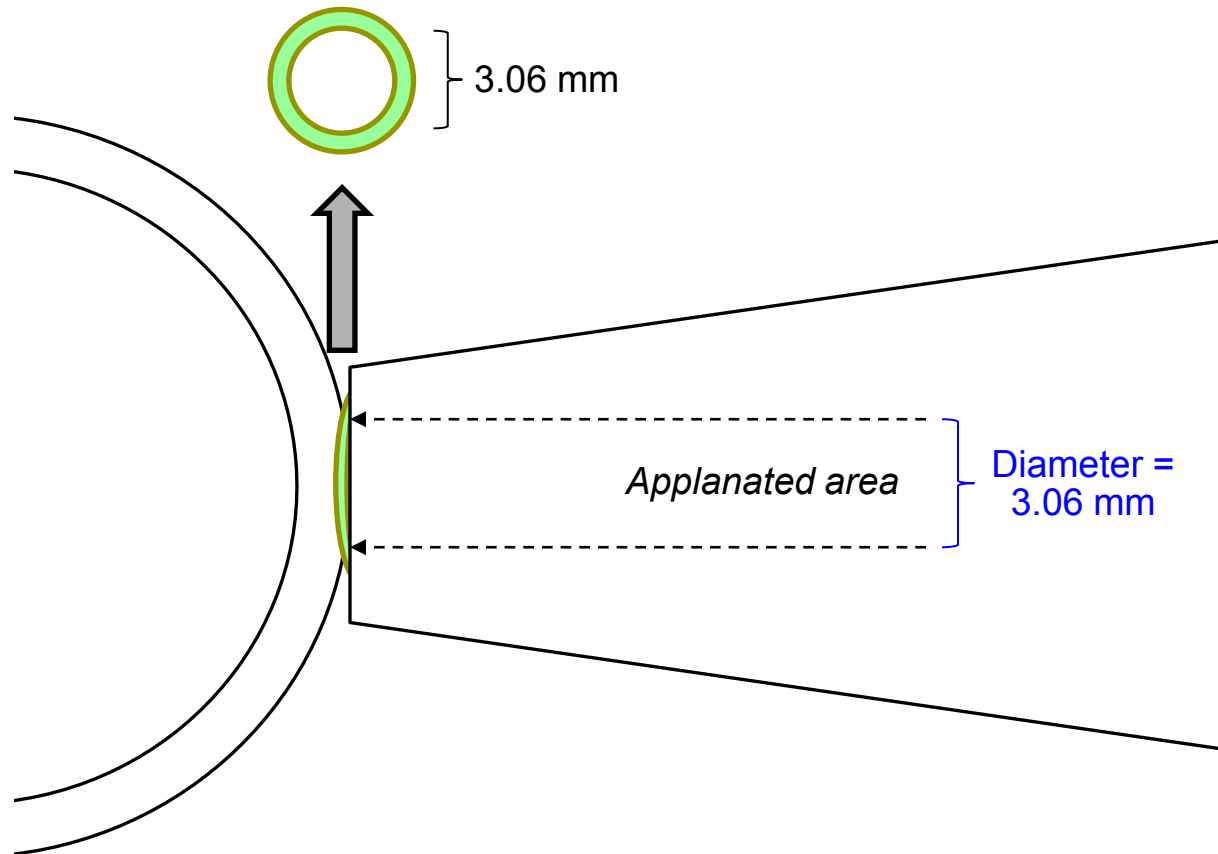
## Applanation Tonometry

*What happens during applanation tonometry, and how does it measure IOP?*

During applanation tonometry, the tip of the applanator pushes against the cornea, flattening it. As the tip flattens the cornea, fluorescein flows into and fills the rim-area between the cornea and the applanator tip, forming a 'meniscus ring.' The size of this ring is a function of how much the tip is flattening the cornea—if the tip is flattening a large area, the ring will be large; if it's flattening a small area, it will be small. To measure IOP, you must adjust the pressure being applied by the device (ie, turn the knob) until the diameter of the fluorescein circle is exactly 3.06 mm. When this is done, the force being applied by the applanator exactly matches the force on the inside of the cornea—that is, the IOP.

- When the mires line up, the diameter of the applanated area is 3.06 mm

## Applanation Tonometry



Applanation tonometry: When the diameter of the flattened area is 3.06 mm, the force being applied by the tip equals the pressure inside the eye

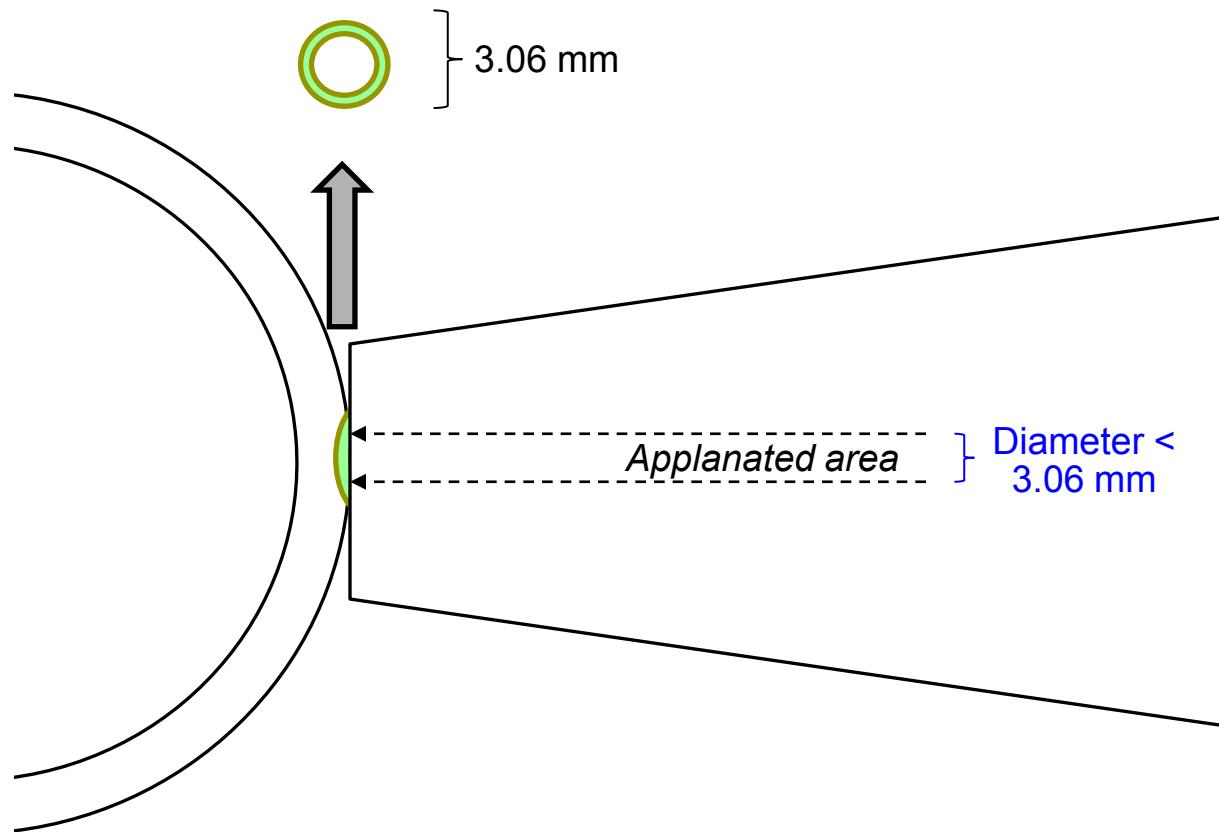
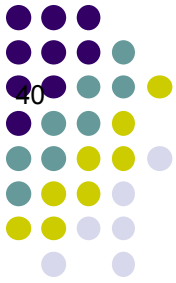


*What happens during applanation tonometry, and how does it measure IOP?*

During applanation tonometry, the tip of the applanator pushes against the cornea, flattening it. As the tip flattens the cornea, fluorescein flows into and fills the rim-area between the cornea and the applanator tip, forming a 'meniscus ring.' The size of this ring is a function of how much the tip is flattening the cornea—if the tip is flattening a large area, the ring will be large; if it's flattening a small area, it will be small. To measure IOP, you must adjust the pressure being applied by the device (ie, turn the knob) until the diameter of the fluorescein circle is exactly 3.06 mm. When this is done, the force being applied by the applanator exactly matches the force on the inside of the cornea—that is, the IOP. When the pressure inside the eye is higher than the force applied by the tip, the area of flattened cornea will have a diameter less than 3.06 mm, and thus so will the meniscus.

- When the mires line up, the diameter of the applanated area is 3.06 mm

# Applanation Tonometry



When the diameter of the flattened area is less than 3.06 mm, the force being applied by the tip is less than the pressure inside the eye



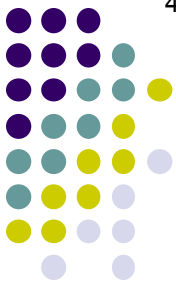
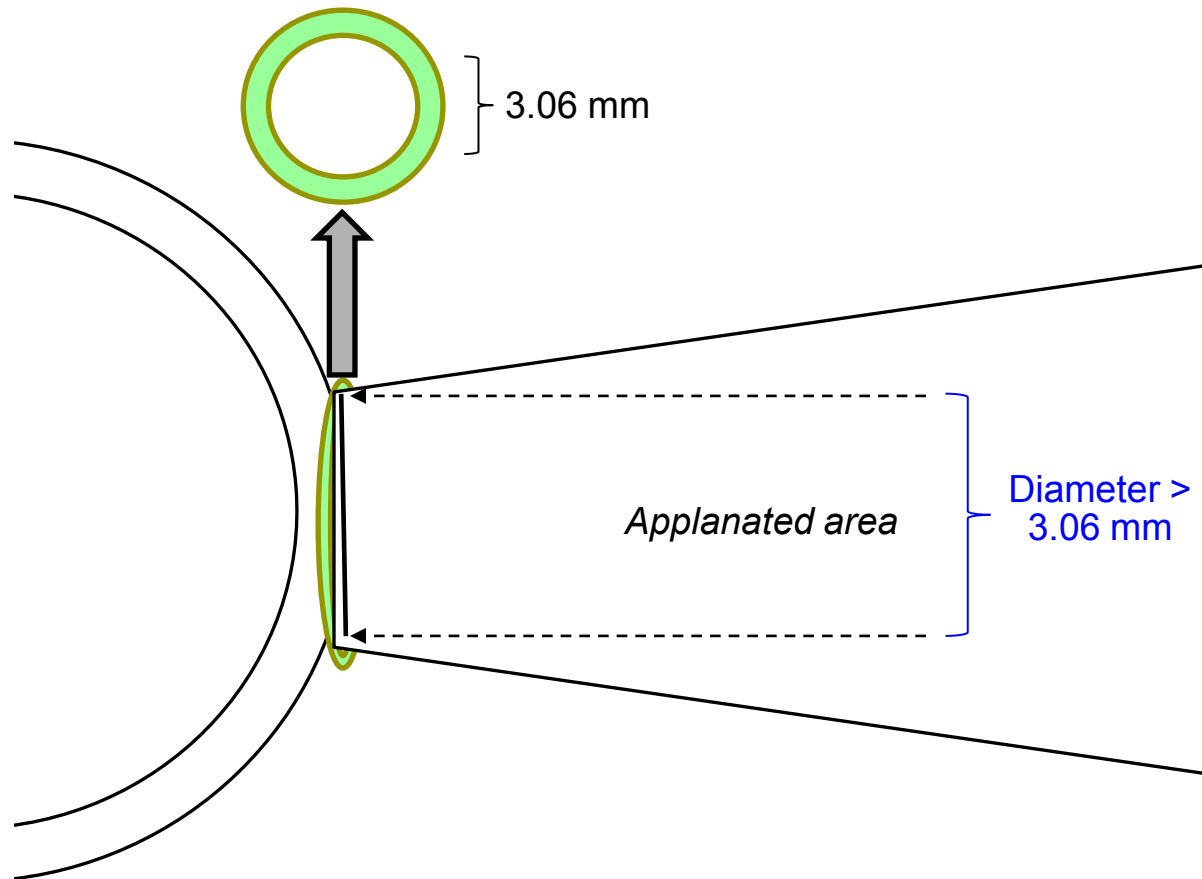


*What happens during applanation tonometry, and how does it measure IOP?*

During applanation tonometry, the tip of the applanator pushes against the cornea, flattening it. As the tip flattens the cornea, fluorescein flows into and fills the rim-area between the cornea and the applanator tip, forming a 'meniscus ring.' The size of this ring is a function of how much the tip is flattening the cornea—if the tip is flattening a large area, the ring will be large; if it's flattening a small area, it will be small. To measure IOP, you must adjust the pressure being applied by the device (ie, turn the knob) until the diameter of the fluorescein circle is exactly 3.06 mm. When this is done, the force being applied by the applanator exactly matches the force on the inside of the cornea—that is, the IOP. When the pressure inside the eye is higher than the force applied by the tip, the area of flattened cornea will have a diameter less than 3.06 mm, and thus so will the meniscus. Likewise, when the pressure inside the eye is lower than the force applied by the tip, the area of cornea flattened will have a diameter greater than 3.06 mm, and so too will the meniscus.

- When the mires line up, the diameter of the applanated area is 3.06 mm

## Applanation Tonometry



When the diameter of the flattened area is greater than 3.06 mm, the force being applied by the tip is greater than the pressure inside the eye

## Applanation Tonometry

*What happens during applanation tonometry, and how does it measure IOP?*

During applanation tonometry, the tip of the applanator pushes against the cornea, flattening it. As the tip flattens the cornea, fluorescein flows into and fills the rim-area between the cornea and the applanator tip, forming a 'meniscus ring.' The size of this ring is a function of how much the tip is flattening the cornea—if the tip is flattening a large area, the ring will be large; if it's flattening a small area, it will be small. To measure IOP, you must adjust the pressure being applied by the device (ie, turn the knob) until the diameter of the fluorescein circle is exactly 3.06 mm. When this is done, the force being applied by the applanator exactly matches the force on the inside of the cornea—that is, the IOP. When the pressure inside the eye is higher than the force applied by the tip, the area of flattened cornea will have a diameter less than 3.06 mm, and thus so will the meniscus. Likewise, when the pressure inside the eye is lower than the force applied by the tip, the area of cornea flattened will have a diameter greater than 3.06 mm, and so too will the meniscus.

*OK, but why does the applanator use a prism to split the circle?*

- **When the mires line up, the diameter of the applanated area is 3.06 mm**



## Applanation Tonometry

*What happens during applanation tonometry, and how does it measure IOP?*

During applanation tonometry, the tip of the applanator pushes against the cornea, flattening it. As the tip flattens the cornea, fluorescein flows into and fills the rim-area between the cornea and the applanator tip, forming a 'meniscus ring.' The size of this ring is a function of how much the tip is flattening the cornea—if the tip is flattening a large area, the ring will be large; if it's flattening a small area, it will be small. To measure IOP, you must adjust the pressure being applied by the device (ie, turn the knob) until the diameter of the fluorescein circle is exactly 3.06 mm. When this is done, the force being applied by the applanator exactly matches the force on the inside of the cornea—that is, the IOP. When the pressure inside the eye is higher than the force applied by the tip, the area of flattened cornea will have a diameter less than 3.06 mm, and thus so will the meniscus. Likewise, when the pressure inside the eye is lower than the force applied by the tip, the area of cornea flattened will have a diameter greater than 3.06 mm, and so too will the meniscus.

*OK, but why does the applanator use a prism to split the circle?*

Consider if the applanator didn't contain a prism. The tip would press against the cornea, and you would adjust the knob until the diameter of the circle was 3.06 mm. Seems straightforward enough, until you consider this: How would you know when the diameter is 3.06 mm? One way would be to simply etch a 3.06 mm line into the optics of the slit-lamp. This would provide an easy-to-use measurement tool. OTOH, the line would be visible during the rest of the exam—not good. What else you got?

- **When the mires line up, the diameter of the applanated area is 3.06 mm**



*What happens during applanation tonometry, and how does it measure IOP?*

During applanation tonometry, the tip of the applanator pushes against the cornea, flattening it. As the tip flattens the cornea, fluorescein flows into and fills the rim-area between the cornea and the applanator tip, forming a 'meniscus ring.' The size of this ring is a function of how much the tip is flattening the cornea—if the tip is flattening a large area, the ring will be large; if it's flattening a small area, it will be small. To measure IOP, you must adjust the pressure being applied by the device (ie, turn the knob) until the diameter of the fluorescein circle is exactly 3.06 mm. When this is done, the force being applied by the applanator exactly matches the force on the inside of the cornea—that is, the IOP. When the pressure inside the eye is higher than the force applied by the tip, the area of flattened cornea will have a diameter less than 3.06 mm, and thus so will the meniscus. Likewise, when the pressure inside the eye is lower than the force applied by the tip, the area of cornea flattened will have a diameter greater than 3.06 mm, and so too will the meniscus.

*OK, but why does the applanator use a prism to split the circle?*

Consider if the applanator didn't contain a prism. The tip would press against the cornea, and you would adjust the knob until the diameter of the circle was 3.06 mm. Seems straightforward enough, until you consider this: How would you know when the diameter is 3.06 mm? One way would be to simply etch a 3.06 mm line into the optics of the slit-lamp. This would provide an easy-to-use measurement tool. OTOH, the line would be visible during the rest of the exam—not good. What else you got?

Enter the prism. The prism splits the image of the circle in half, but not in a random way. Rather, the prism is powered so that *the two half-circles will exactly overlap when the diameter of the circle is 3.06 mm.* Thus, as the pressure applied by the tip is manipulated (ie, as you turn the knob on the applanator), it *looks* like the mires are moving toward or away from one another—but *they're not*. What's **actually** happening is *the circle is getting larger or smaller.*

- **When the mires line up, the diameter of the applanated area is 3.06 mm**



*What happens during applanation tonometry, and how does it measure IOP?*

During applanation tonometry, the tip of the applanator pushes against the cornea, flattening it. As the tip flattens the cornea, fluorescein flows into and fills the rim-area between the cornea and the applanator tip, forming a 'meniscus ring.' The size of this ring is a function of how much the tip is flattening the cornea—if the tip is flattening a large area, the ring will be large; if it's flattening a small area, it will be small. To measure IOP, you must adjust the pressure being applied by the device (ie, turn the knob) until the diameter of the fluorescein circle is exactly 3.06 mm. When this is done, the force being applied by the applanator exactly matches the force on the inside of the cornea—that is, the IOP. When the pressure inside the eye is higher than the force applied by the tip, the area of flattened cornea will have a diameter less than 3.06 mm, and thus so will the meniscus. Likewise, when the pressure inside the eye is lower than the force applied by the tip, the area of cornea flattened will have a diameter greater than 3.06 mm, and so too will the meniscus.

*OK, but why does the applanator use a prism to split the circle?*

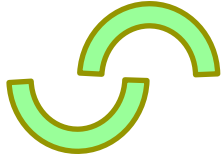
Consider if the applanator didn't contain a prism. The tip would press against the cornea, and you would adjust the knob until the diameter of the circle was 3.06 mm. Seems straightforward enough, until you consider this: How would you know when the diameter is 3.06 mm? One way would be to simply etch a 3.06 mm line into the optics of the slit-lamp. This would provide an easy-to-use measurement tool. OTOH, the line would be visible during the rest of the exam—not good. What else you got?

Enter the prism. The prism splits the image of the circle in half, but not in a random way. Rather, the prism is powered so that *the two half-circles will exactly overlap when the diameter of the circle is 3.06 mm.* Thus, as the pressure applied by the tip is manipulated (ie, as you turn the knob on the applanator), it *looks* like the mires are moving toward or away from one another—but *they're not*. What's **actually** happening is *the circle is getting larger or smaller*. (Next time you applanate someone, take note of the heights of the mires as you adjust the knob, and you'll be better able to appreciate the fact that it's the *size* of the circle that's actually changing, not the distance between the segments).

- **When the mires line up, the diameter of the applanated area is 3.06 mm**

## Applanation Tonometry

Dia. of applanated  
area  $> 3.06$  mm



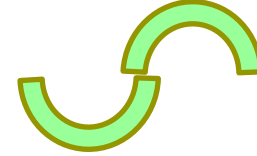
Number on dial is too *high*

Dia. of applanated  
area  $< 3.06$  mm

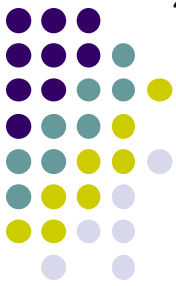


Number on dial is too *low*

Dia. of applanated  
area  $= 3.06$  mm



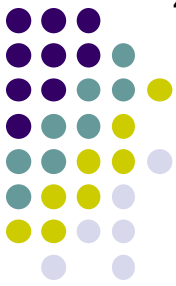
Number on dial = IOP



*What you **think** you're seeing when you turn the knob: One size of ring segment moving closer and farther apart*

*No question—proceed when ready*

# Applanation Tonometry



Dia. of applanated area  $> 3.06$  mm



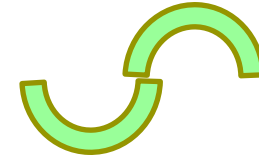
Number on dial is too *high*

Dia. of applanated area  $< 3.06$  mm



Number on dial is too *low*

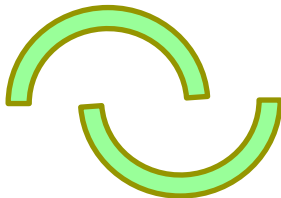
Dia. of applanated area = 3.06 mm



Number on dial = IOP

*What you **think** you're seeing when you turn the knob: One size of ring segment moving closer and farther apart*

Dia. of applanated area  $> 3.06$  mm



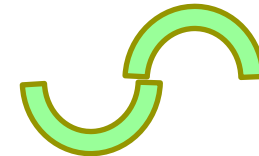
Number on dial is too *high*

Dia. of applanated area  $< 3.06$  mm



Number on dial is too *low*

Dia. of applanated area = 3.06 mm

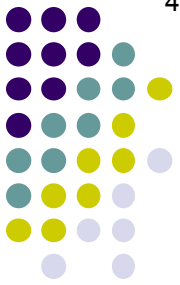


Number on dial = IOP

*What you're **actually** seeing: The size of the ring segment getting larger and smaller*

*No question—proceed when ready*





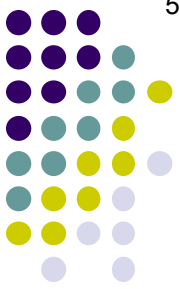
# Q

## *Applanation Tonometry*

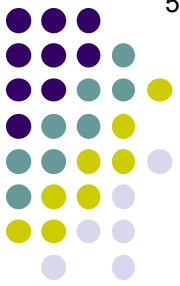
- **More on Applanation Tonometry**
  - Reading will be falsely **LOW** if:
    - Cornea is pathologic state

# A

## *Applanation Tonometry*



- **More on Applanation Tonometry**
  - Reading will be falsely **LOW** if:
    - Cornea is edematous

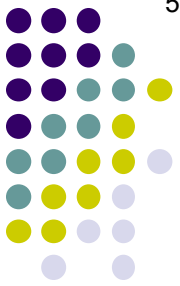


# Q

## Applanation Tonometry

- **More on Applanation Tonometry**
  - Reading will be falsely **LOW** if:
    - Cornea is **edematous**

*But an edematous cornea is a thick cornea, and we all know that thicker corneas yield falsely **high** applanation pressures. What gives?*



# A

## Applanation Tonometry

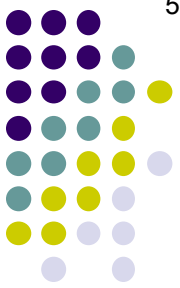
- **More on Applanation Tonometry**
  - Reading will be falsely **LOW** if:
    - Cornea is **edematous**

*But an edematous cornea is a thick cornea, and we all know that thicker corneas yield falsely **high** applanation pressures. What gives?*

Not all thick corneas are biomechanically equivalent. A 'naturally thick' (i.e., thicker-than-normal in the non-pathologic state) cornea yields falsely high applanation readings because it has greater intrinsic biomechanical resistance compared with thinner corneas.

# A

## Applanation Tonometry

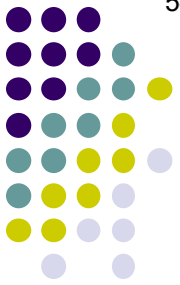


- **More on Applanation Tonometry**

- Reading will be falsely **LOW** if:
  - Cornea is **edematous**

*But an edematous cornea is a thick cornea, and we all know that thicker corneas yield falsely **high** applanation pressures. What gives?*

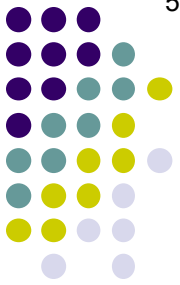
Not all thick corneas are biomechanically equivalent. A 'naturally thick' (i.e., thicker-than-normal in the non-pathologic state) cornea yields falsely high applanation readings because it has greater intrinsic biomechanical resistance compared with thinner corneas. On the other hand, an edematous cornea undergoes a **decrease** in its native biomechanical resistance (think of it as being 'goeey'). Thickness *per se* is not the issue.



# Q

## *Applanation Tonometry*

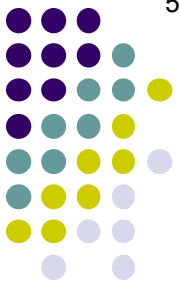
- **More on Applanation Tonometry**
  - Reading will be falsely **LOW** if:
    - Cornea is **edematous**
    - Applanation performed over a **oops**



# A

## *Applanation Tonometry*

- **More on Applanation Tonometry**
  - Reading will be falsely **LOW** if:
    - Cornea is **edematous**
    - Applanation performed over a **soft CL**



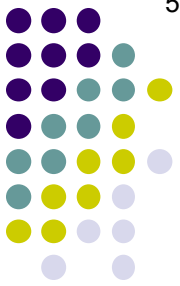
# Q

## *Applanation Tonometry*

### ● More on Applanation Tonometry

- Reading will be falsely **LOW** if:
  - Cornea is edematous
  - Applanation performed over a soft CL
  - After two words surgery (changes scleral rigidity)



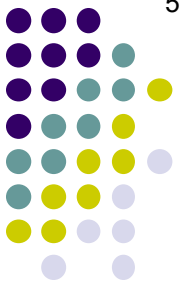


# A

## *Applanation Tonometry*

- **More on Applanation Tonometry**

- Reading will be falsely **LOW** if:
  - Cornea is edematous
  - Applanation performed over a soft CL
  - After scleral buckling surgery (changes scleral rigidity)



# Q

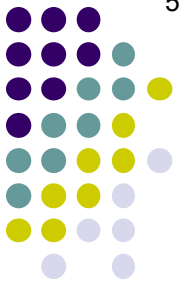
## Applanation Tonometry

### ● More on Applanation Tonometry

- Reading will be falsely **LOW** if:
  - Cornea is edematous
  - Applanation performed over a soft CL
  - After scleral buckling surgery (changes scleral rigidity)
  - Too 

much vs  
little

 fluorescein in tear film

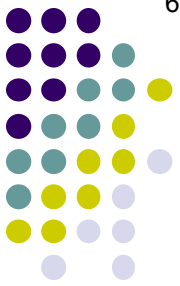


# A

## *Applanation Tonometry*

- **More on Applanation Tonometry**

- Reading will be falsely **LOW** if:
  - Cornea is edematous
  - Applanation performed over a soft CL
  - After scleral buckling surgery (changes scleral rigidity)
  - Too little fluorescein in tear film



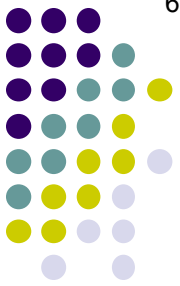
# Q

## Applanation Tonometry

### ● More on Applanation Tonometry

- Reading will be falsely **LOW** if:
  - Cornea is edematous
  - Applanation performed over a soft CL
  - After scleral buckling surgery (changes scleral rigidity)
  - Too little fluorescein in tear film

*Why would too little fluorescein make the reading falsely low?*



# A

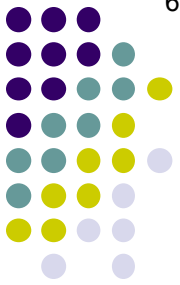
## Applanation Tonometry

### ● More on Applanation Tonometry

- Reading will be falsely **LOW** if:
  - Cornea is edematous
  - Applanation performed over a soft CL
  - After scleral buckling surgery (changes scleral rigidity)
  - Too little fluorescein in tear film

*Why would too little fluorescein make the reading falsely low?*

Mainly because it makes the inner edge of the mires difficult to appreciate, so the knob isn't turned up as it needs to be



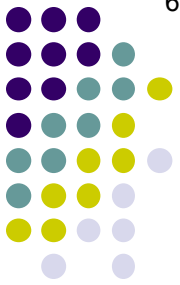
# Q

## Applanation Tonometry

### ● More on Applanation Tonometry

- Reading will be falsely **LOW** if:
  - Cornea is edematous
  - Applanation performed over a soft CL
  - After scleral buckling surgery (changes scleral rigidity)
  - Too little fluorescein in tear film
- Reading will be falsely **HIGH** if:
  - Performed over a 

two words

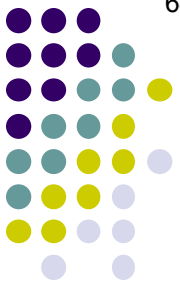


# A

## Applanation Tonometry

### ● More on Applanation Tonometry

- Reading will be falsely **LOW** if:
  - Cornea is edematous
  - Applanation performed over a soft CL
  - After scleral buckling surgery (changes scleral rigidity)
  - Too little fluorescein in tear film
- Reading will be falsely **HIGH** if:
  - Performed over a corneal scar



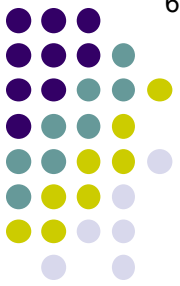
# Q

## Applanation Tonometry

### • More on Applanation Tonometry

- Reading will be falsely **LOW** if:
  - Cornea is edematous
  - Applanation performed over a soft CL
  - After scleral buckling surgery (changes scleral rigidity)
  - Too little fluorescein in tear film
- Reading will be falsely **HIGH** if:
  - Performed over a corneal scar
  - Too duh fluorescein in tear film



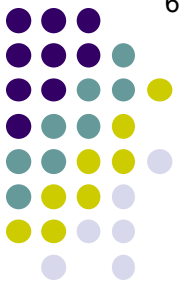


# A

## Applanation Tonometry

### ● More on Applanation Tonometry

- Reading will be falsely **LOW** if:
  - Cornea is edematous
  - Applanation performed over a soft CL
  - After scleral buckling surgery (changes scleral rigidity)
  - Too little fluorescein in tear film
- Reading will be falsely **HIGH** if:
  - Performed over a corneal scar
  - Too much fluorescein in tear film



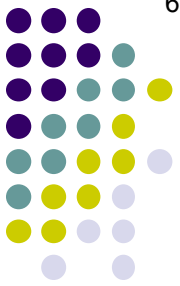
# Q

## Applanation Tonometry

### • More on Applanation Tonometry

- Reading will be falsely **LOW** if:
  - Cornea is edematous
  - Applanation performed over a soft CL
  - After scleral buckling surgery (changes scleral rigidity)
  - Too little fluorescein in tear film
- Reading will be falsely **HIGH** if:
  - Performed over a corneal scar
  - Too much fluorescein in tear film

*Why does too much fluess make the reading falsely high? Does it make the mires **too** easy to see?*



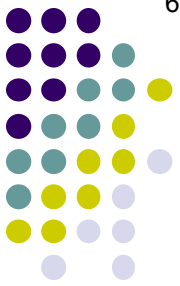
# A

## Applanation Tonometry

### ● More on Applanation Tonometry

- Reading will be falsely **LOW** if:
  - Cornea is edematous
  - Applanation performed over a soft CL
  - After scleral buckling surgery (changes scleral rigidity)
  - Too little fluorescein in tear film
- Reading will be falsely **HIGH** if:
  - Performed over a corneal scar
  - Too much fluorescein in tear film

*Why does too much fluess make the reading falsely high? Does it make the mires **too** easy to see?*  
No, smart AGAB\*



# Q

## Applanation Tonometry

### • More on Applanation Tonometry

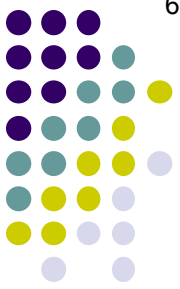
- Reading will be falsely **LOW** if:
  - Cornea is edematous
  - Applanation performed over a soft CL
  - After scleral buckling surgery (changes scleral rigidity)
  - Too little fluorescein in tear film
- Reading will be falsely **HIGH** if:
  - Performed over a corneal scar
  - Too much fluorescein in tear film

*Why does too much fluess make the reading falsely high? Does it make the mires **too** easy to see?*  
No, smart AGAB\*

*OK seriously, I've been told it's because the extra fluess makes the mires too thick. Is that the case?*

# Q/A

## Applanation Tonometry

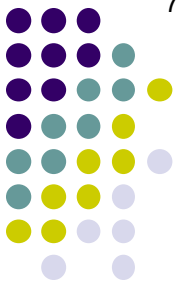


### • More on Applanation Tonometry

- Reading will be falsely **LOW** if:
  - Cornea is edematous
  - Applanation performed over a soft CL
  - After scleral buckling surgery (changes scleral rigidity)
  - Too little fluorescein in tear film
- Reading will be falsely **HIGH** if:
  - Performed over a corneal scar
  - Too **much** fluorescein in tear film

*Why does too much fluess make the reading falsely high? Does it make the mires **too** easy to see?*  
 No, smart AGAB\*

*OK seriously, I've been told it's because the extra fluess makes the mires too thick. Is that the case?*  
 You'd think so, but no. No matter how much fluess is in the tear film, overlap of the inner aspect of the mires means the flattened circle's diameter is exactly Ya gotta know this number! mm.



# A

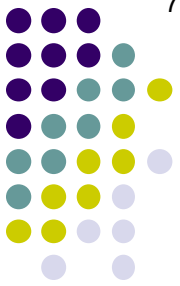
## Applanation Tonometry

### ● More on Applanation Tonometry

- Reading will be falsely **LOW** if:
  - Cornea is edematous
  - Applanation performed over a soft CL
  - After scleral buckling surgery (changes scleral rigidity)
  - Too little fluorescein in tear film
- Reading will be falsely **HIGH** if:
  - Performed over a corneal scar
  - Too much fluorescein in tear film

*Why does too much fluess make the reading falsely high? Does it make the mires **too** easy to see?*  
 No, smart AGAB\*

*OK seriously, I've been told it's because the extra fluess makes the mires too thick. Is that the case?*  
 You'd think so, but no. No matter how much fluess is in the tear film, overlap of the inner aspect of the mires means the flattened circle's diameter is exactly 3.06 mm.



# Q

## Applanation Tonometry

### • More on Applanation Tonometry

- Reading will be falsely **LOW** if:
  - Cornea is edematous
  - Applanation performed over a soft CL
  - After scleral buckling surgery (changes scleral rigidity)
  - Too little fluorescein in tear film
- Reading will be falsely **HIGH** if:
  - Performed over a corneal scar
  - Too **much** fluorescein in tear film

*Why does too much fluess make the reading falsely high? Does it make the mires too easy to see?*

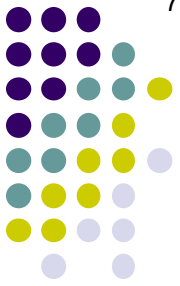
No, smart AGAR\*

*OK, then why does too much fluess make the reading falsely high?*

OK  
You  
the

# Q/A

## Applanation Tonometry



### • More on Applanation Tonometry

- Reading will be falsely **LOW** if:
  - Cornea is **edematous**
  - Applanation performed over a **soft CL**
  - After **scleral buckling** surgery (changes scleral rigidity)
  - Too **little** fluorescein in tear film
- Reading will be falsely **HIGH** if:
  - Performed over a **corneal scar**
  - Too **much** fluorescein in tear film

*Why does too much fluess make the reading falsely high? Does it make the mires too easy to see?*

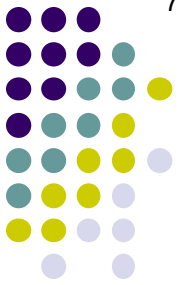
No, smart AGAR\*

*OK, then why does too much fluess make the reading falsely high?*

Too much fluess makes the tear film extra thick. An extra-thick tear film renders the radius-of-curvature of the tear film **longer vs shorter**, which in turn **increases vs decreases** its surface tension.

OK  
You  
the





# A

## Applanation Tonometry

### • More on Applanation Tonometry

- Reading will be falsely **LOW** if:
  - Cornea is edematous
  - Applanation performed over a soft CL
  - After scleral buckling surgery (changes scleral rigidity)
  - Too little fluorescein in tear film
- Reading will be falsely **HIGH** if:
  - Performed over a corneal scar
  - Too **much** fluorescein in tear film

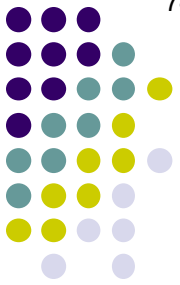
*Why does too much fluess make the reading falsely high? Does it make the mires too easy to see?*

No, smart AGAR\*

*OK, then why does too much fluess make the reading falsely high?*

Too much fluess makes the tear film extra thick. An extra-thick tear film renders the radius-of-curvature of the tear film longer, which in turn decreases its surface tension.

OK  
You  
the



# A

## Applanation Tonometry

### • More on Applanation Tonometry

- Reading will be falsely **LOW** if:
  - Cornea is edematous
  - Applanation performed over a soft CL
  - After scleral buckling surgery (changes scleral rigidity)
  - Too little fluorescein in tear film
- Reading will be falsely **HIGH** if:
  - Performed over a corneal scar
  - Too **much** fluorescein in tear film

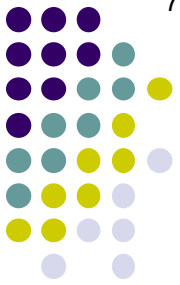
*Why does too much fluess make the reading falsely high? Does it make the mires too easy to see?*

No, smart AGAR\*

*OK, then why does too much fluess make the reading falsely high?*

Too much fluess makes the tear film extra thick. An extra-thick tear film renders the radius-of-curvature of the tear film longer, which in turn decreases its surface tension. The decrease in surface tension means there's less of the 'pull' on the applanation tip that's assumed to be present, and so the knob has to be cranked more to compensate—thereby producing a falsely high reading.

OK  
You  
the

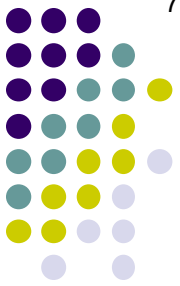


# Q

## Applanation Tonometry

### • More on Applanation Tonometry

- Reading will be falsely **LOW** if:
  - Cornea is edematous
  - Applanation performed over a soft CL
  - After scleral buckling surgery (changes scleral rigidity)
  - Too little fluorescein in tear film
- Reading will be falsely **HIGH** if:
  - Performed over a corneal scar
  - Too much fluorescein in tear film
- Reading will be just plain **WEIRD** if the eye has significant corneal

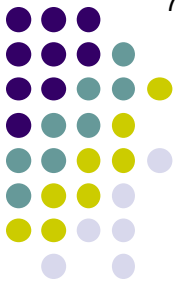


# A

## Applanation Tonometry

### ● More on Applanation Tonometry

- Reading will be falsely **LOW** if:
  - Cornea is edematous
  - Applanation performed over a soft CL
  - After scleral buckling surgery (changes scleral rigidity)
  - Too little fluorescein in tear film
- Reading will be falsely **HIGH** if:
  - Performed over a corneal scar
  - Too much fluorescein in tear film
- Reading will be just plain **WEIRD** if the eye has significant corneal astigmatism



# Q

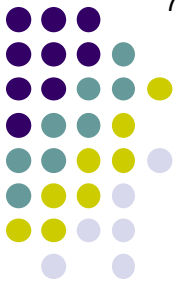
## Applanation Tonometry

- More on Applanation Tonometry

- Reading will be falsely **LOW** if:

*What will be weird when applanating an eye with a lot of corneal astigmatism?*

- Reading will be just plain **WEIRD** if the eye has significant corneal astigmatism



# Q/A

## Applanation Tonometry

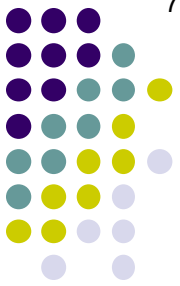
- More on Applanation Tonometry

- Reading will be falsely **LOW** if:

*What will be weird when applanating an eye with a lot of corneal astigmatism?*

The mires won't be round; rather, they'll be

- Reading will be just plain **WEIRD** if the eye has significant corneal astigmatism



# A

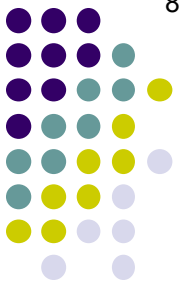
## Applanation Tonometry

- More on Applanation Tonometry

- Reading will be falsely **LOW** if:

*What will be weird when applanating an eye with a lot of corneal astigmatism?*  
The mires won't be round; rather, they'll be ovoid

- Reading will be just plain **WEIRD** if the eye has significant corneal astigmatism



# Q

## Applanation Tonometry

- More on Applanation Tonometry

- Reading will be falsely **LOW** if:

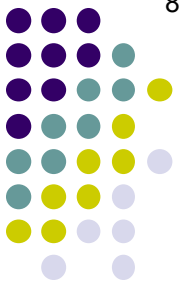
*What will be weird when applanating an eye with a lot of corneal astigmatism?*

The mires won't be round; rather, they'll be ovoid

*That **is** weird. How do oval mires impact IOP reading?*

- Reading will be just plain **WEIRD** if the eye has significant corneal astigmatism





# A

## Applanation Tonometry

- More on Applanation Tonometry

- Reading will be falsely **LOW** if:

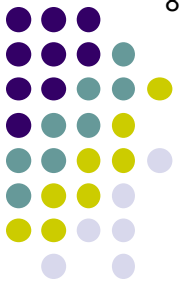
*What will be weird when applanating an eye with a lot of corneal astigmatism?*

The mires won't be round; rather, they'll be ovoid

*That **is** weird. How do oval mires impact IOP reading?*

The IOP reading will be different depending upon whether you align the mires along the short vs long axis of the ellipse

- Reading will be just plain **WEIRD** if the eye has significant corneal astigmatism



# Q

## Applanation Tonometry

- More on Applanation Tonometry

- Reading will be falsely **LOW** if:

*What will be weird when applanating an eye with a lot of corneal astigmatism?*

The mires won't be round; rather, they'll be ovoid

*That **is** weird. How do oval mires impact IOP reading?*

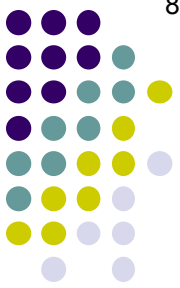
The IOP reading will be different depending upon whether you align the mires along the short vs long axis of the ellipse

*What can be done to get an accurate IOP reading in this situation?*

- Reading will be just plain **WEIRD** if the eye has significant corneal astigmatism

# Q/A

## Applanation Tonometry



### • More on Applanation Tonometry

#### • Reading will be falsely **LOW** if:

*What will be weird when applanating an eye with a lot of corneal astigmatism?*  
The mires won't be round; rather, they'll be ovoid

*That **is** weird. How do oval mires impact IOP reading?*

The IOP reading will be different depending upon whether you align the mires along the short vs long axis of the ellipse

*What can be done to get an accurate IOP reading in this situation?*

Align the mark on the prism so that it's pointing at the middle of the meridian that is

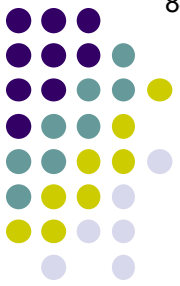
most v  
least

curved, ie, the

steeper v  
flatter

meridian—that value will be accurate

- Reading will be just plain **WEIRD** if the eye has significant corneal astigmatism



# A

## Applanation Tonometry

### • More on Applanation Tonometry

#### • Reading will be falsely **LOW** if:

*What will be weird when applanating an eye with a lot of corneal astigmatism?*  
The mires won't be round; rather, they'll be ovoid

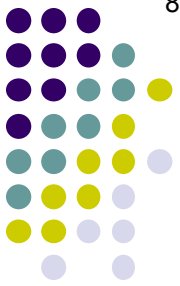
*That **is** weird. How do oval mires impact IOP reading?*

The IOP reading will be different depending upon whether you align the mires along the short vs long axis of the ellipse

*What can be done to get an accurate IOP reading in this situation?*

Align the mark on the prism so that it's pointing at the middle of the meridian that is least curved, ie, the flatter meridian—that value will be accurate

- Reading will be just plain **WEIRD** if the eye has significant corneal astigmatism



# Q

## Applanation Tonometry

### • More on Applanation Tonometry

#### • Reading will be falsely **LOW** if:

*What will be weird when applanating an eye with a lot of corneal astigmatism?*  
The mires won't be round; rather, they'll be ovoid

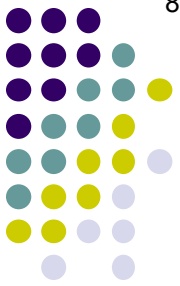
*That **is** weird. How do oval mires impact IOP reading?*

The IOP reading will be different depending upon whether you align the mires along the short vs long axis of the ellipse

*What can be done to get an accurate IOP reading in this situation?*

Align the mark on the prism so that it's pointing at the middle of the meridian that is least curved, ie, the flatter meridian—that value will be accurate. Or if you can't remember which axis to check, you can check IOP at *any* # meridia that are deg apart and average the readings.

- Reading will be just plain **WEIRD** if the eye has significant corneal astigmatism



# A

## Applanation Tonometry

### • More on Applanation Tonometry

#### • Reading will be falsely **LOW** if:

*What will be weird when applanating an eye with a lot of corneal astigmatism?*

The mires won't be round; rather, they'll be ovoid

*That **is** weird. How do oval mires impact IOP reading?*

The IOP reading will be different depending upon whether you align the mires along the short vs long axis of the ellipse

*What can be done to get an accurate IOP reading in this situation?*

Align the mark on the prism so that it's pointing at the middle of the meridian that is least curved, ie, the flatter meridian—that value will be accurate. Or if you can't remember which axis to check, you can check IOP at *any* two meridians that are 90° apart and average the readings.

- Reading will be just plain **WEIRD** if the eye has significant corneal astigmatism