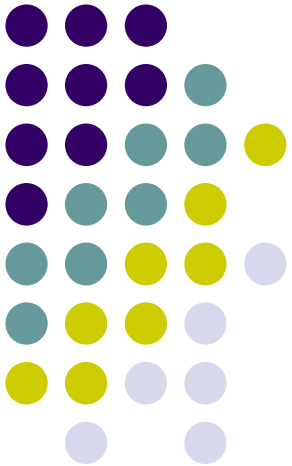
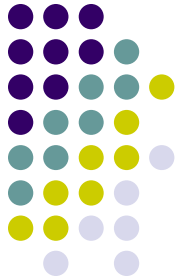
Chromatic Aberration

Basic Optics, Chapter 26



Aberrations



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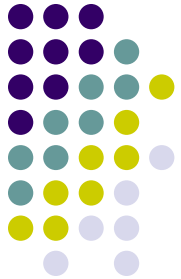

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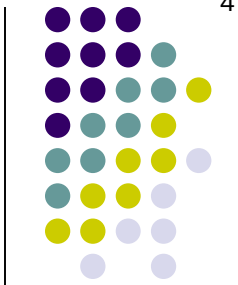

- *Aberrations* are phenomena that degrade the quality of the image formed by an optical system
- Degradation results when light rays from a given object-point fail to form a single sharp image-point
- *It's important to recognize that aberrations are the rule, not the exception*
  - Aberration-free vision essentially never occurs

Aberrations

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    - Spherical error (myopia/hyperopia)
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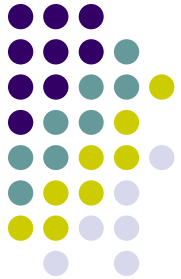
  - Among the others, one of the more important is **Chromatic aberration**



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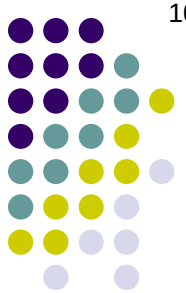

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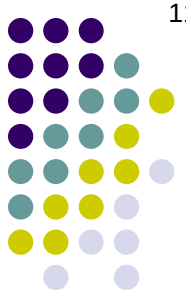

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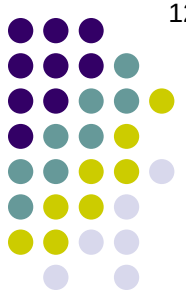

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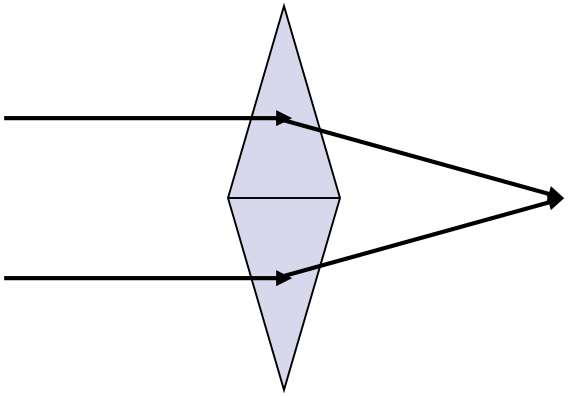
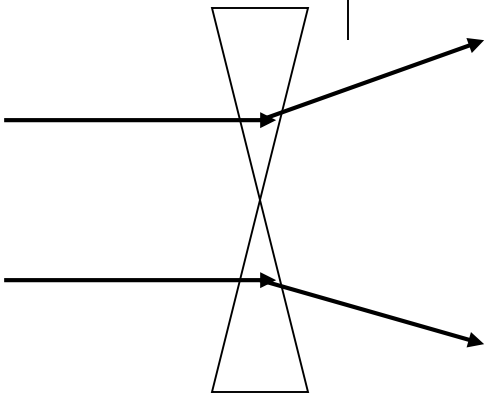


If we placed two prisms base-to-base or apex-to-apex, we could get light to converge and diverge, respectively



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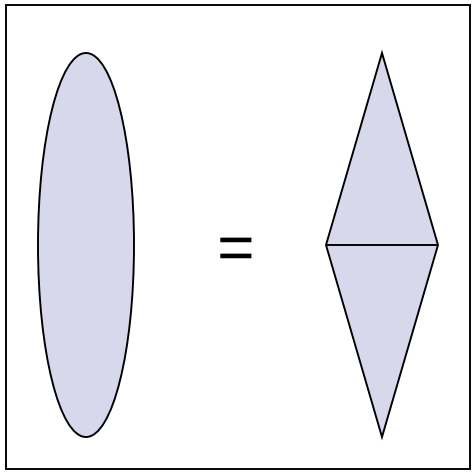

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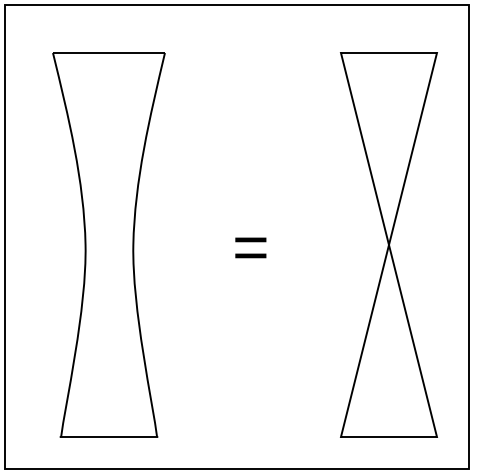

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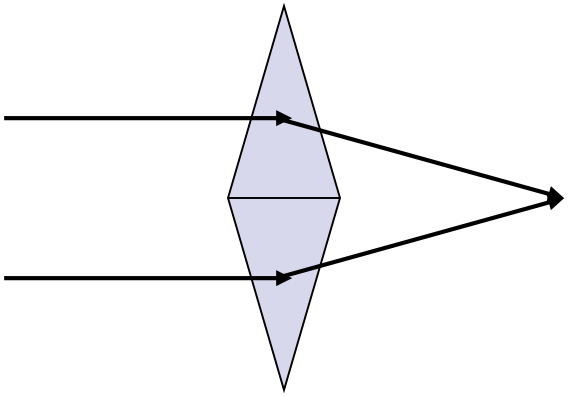

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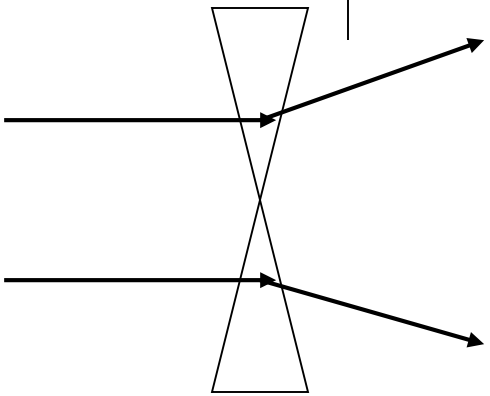

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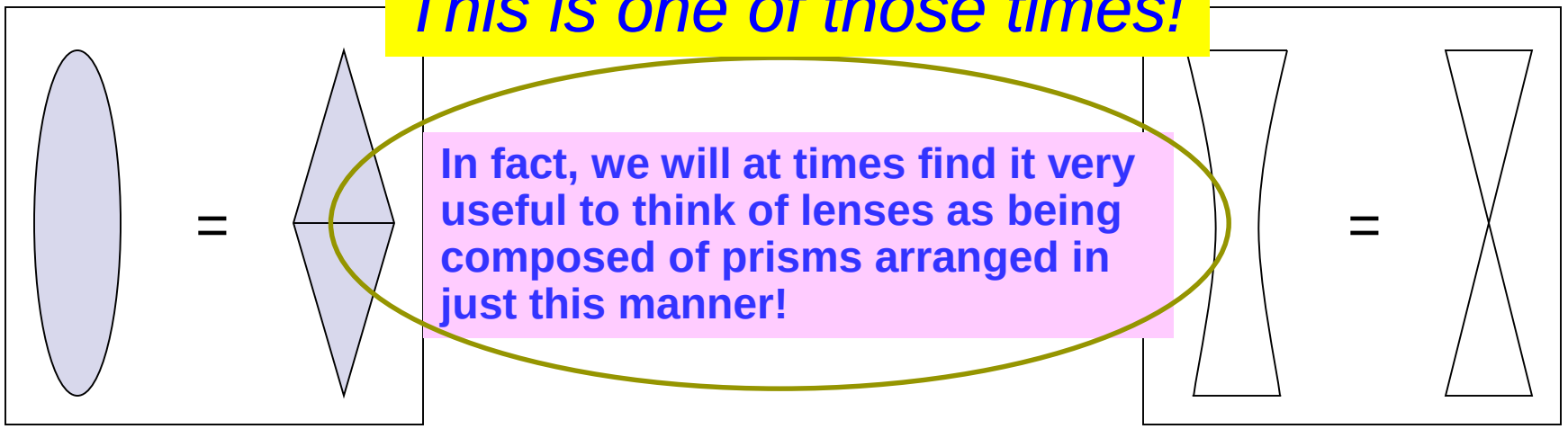

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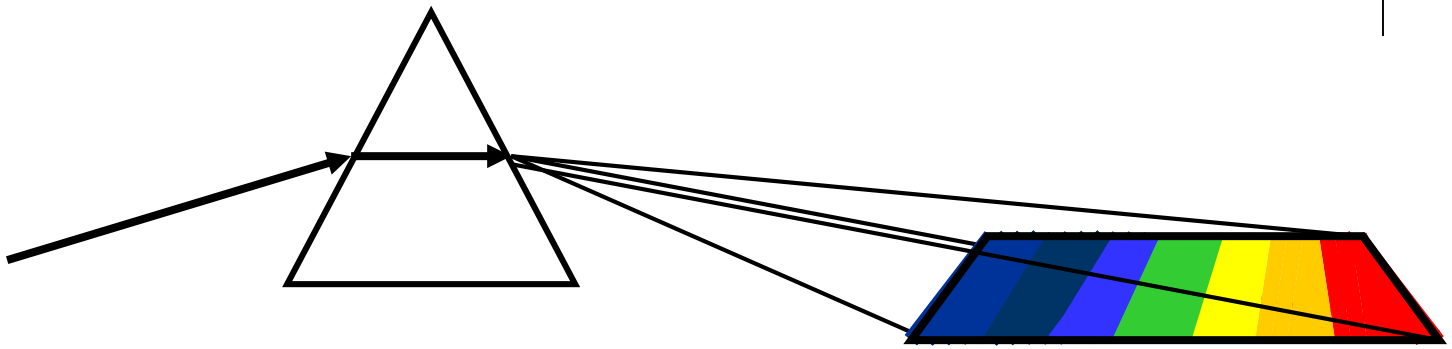

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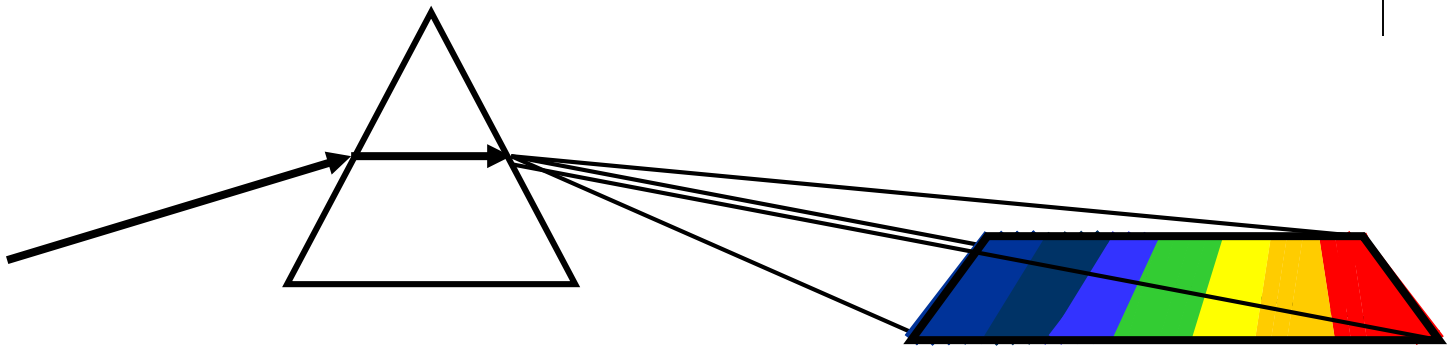

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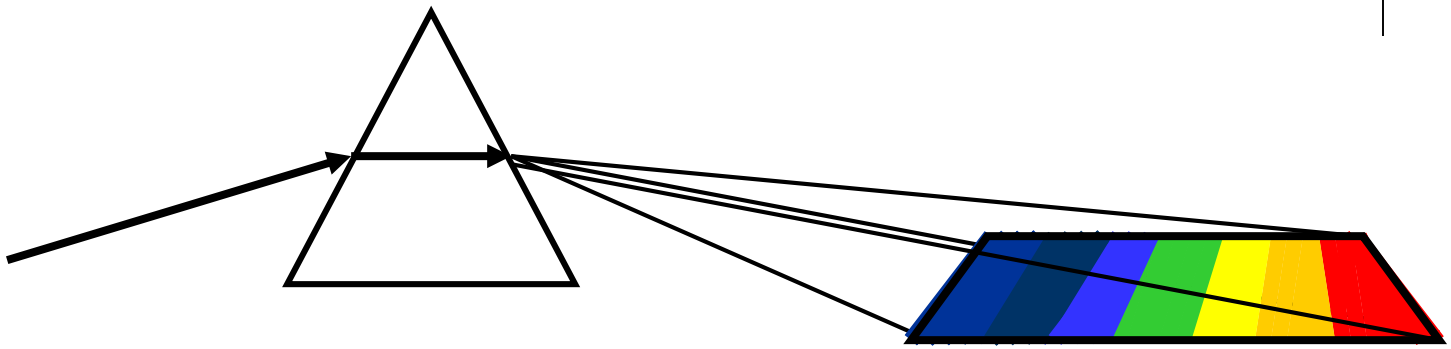

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Snell's Law

$$n_i \sin \theta_i = n_t \sin \theta_t$$

- n_i: Refractive index of the material light is leaving
- θ_t: Angle of transmission with respect to the Normal
- θ_i: Angle of incidence with respect to the Normal
- n_t: Refractive index of the material light is entering

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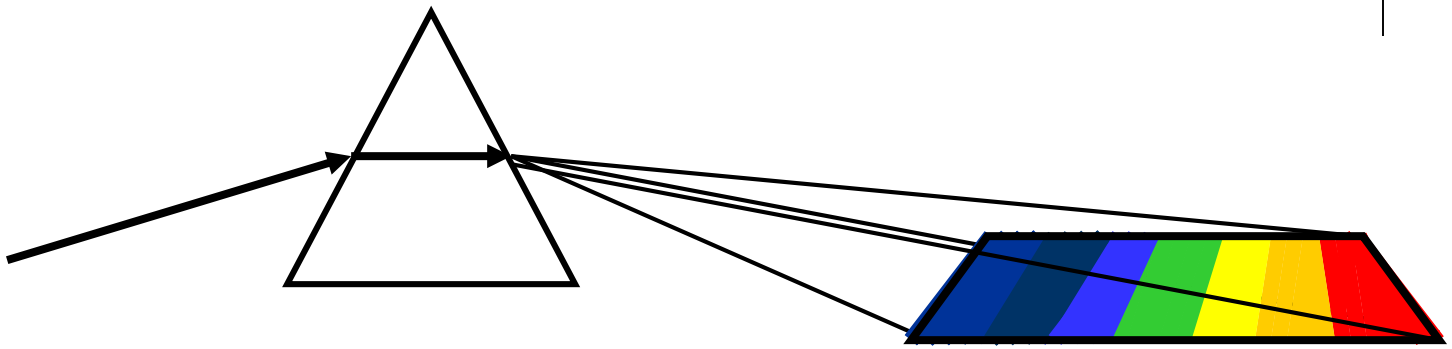

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Because of this, for a given angle of incidence θ_i, each wavelength will be refracted a different amount (ie, will have a different angle of transmission, θ_t).

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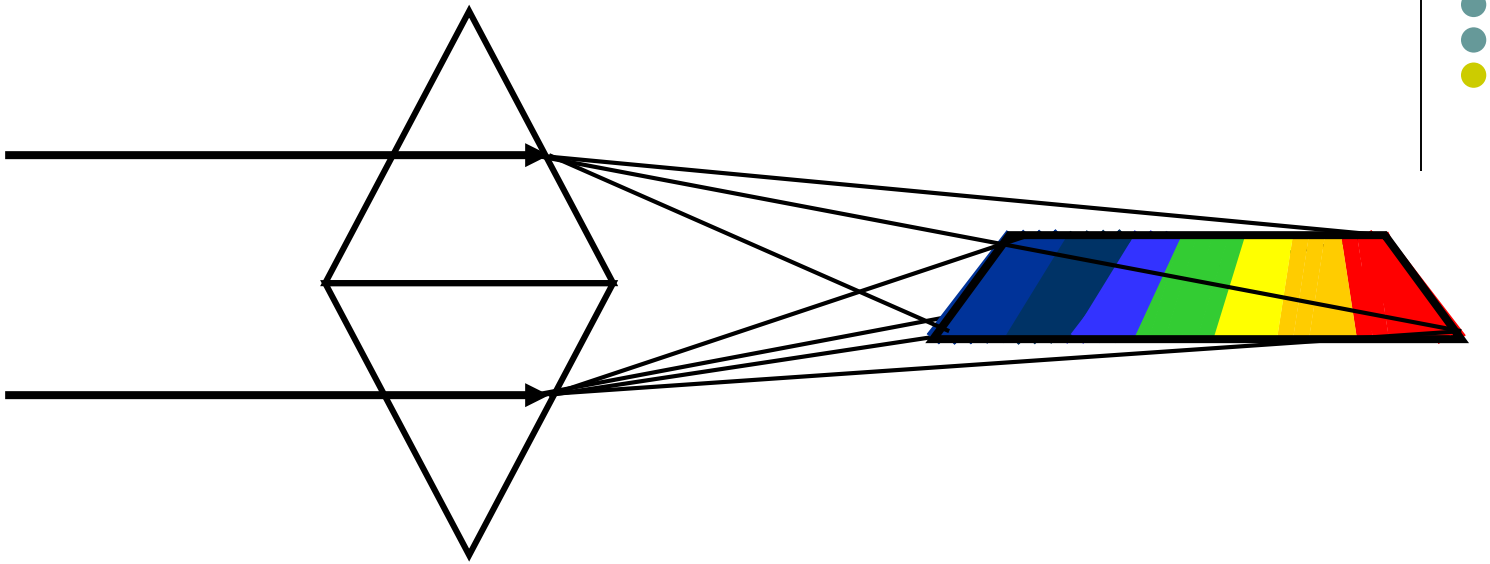

Prisms working in tandem would do the same thing.

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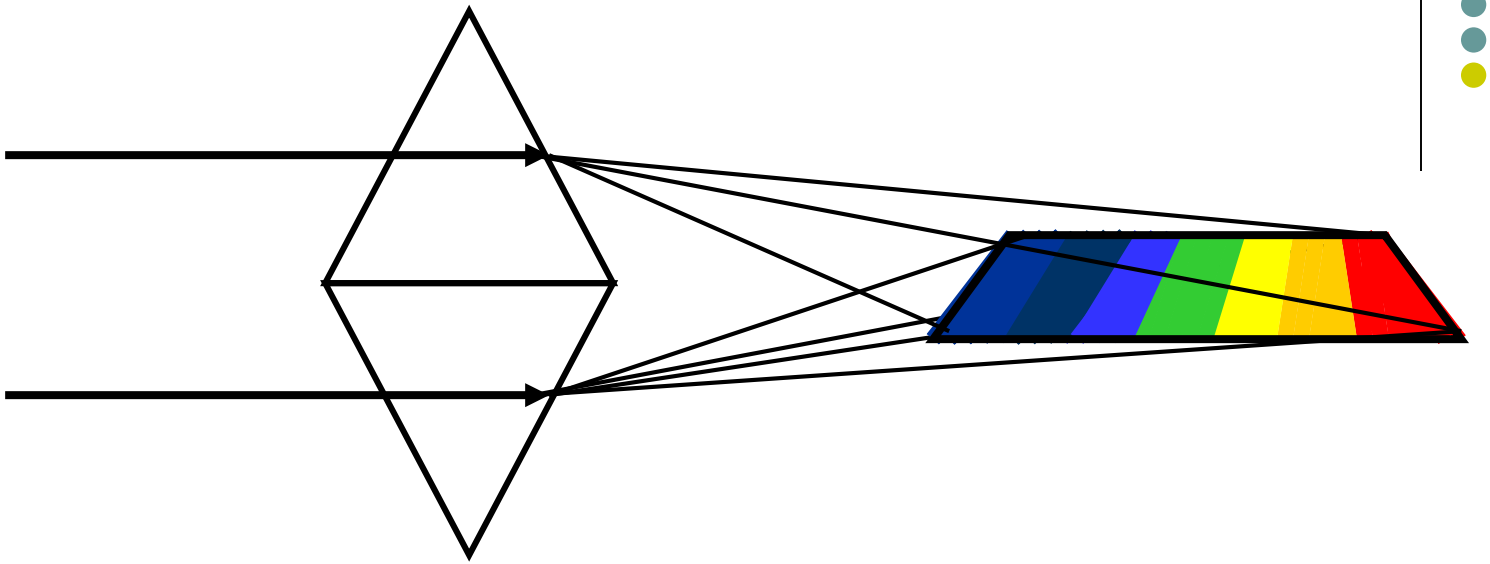
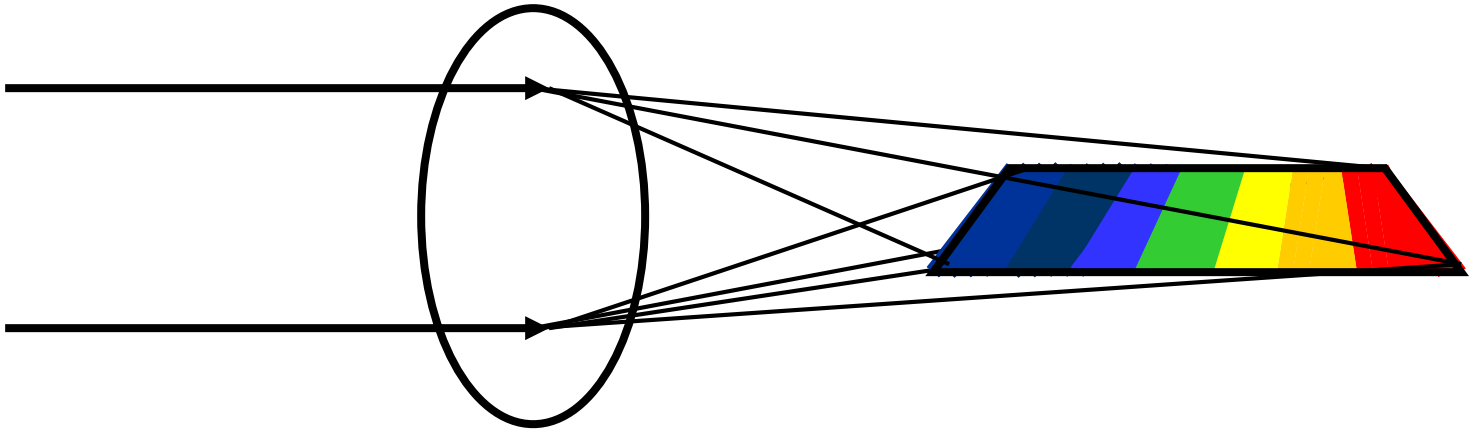


And because lenses are essentially prisms working in tandem, they do the same as well.



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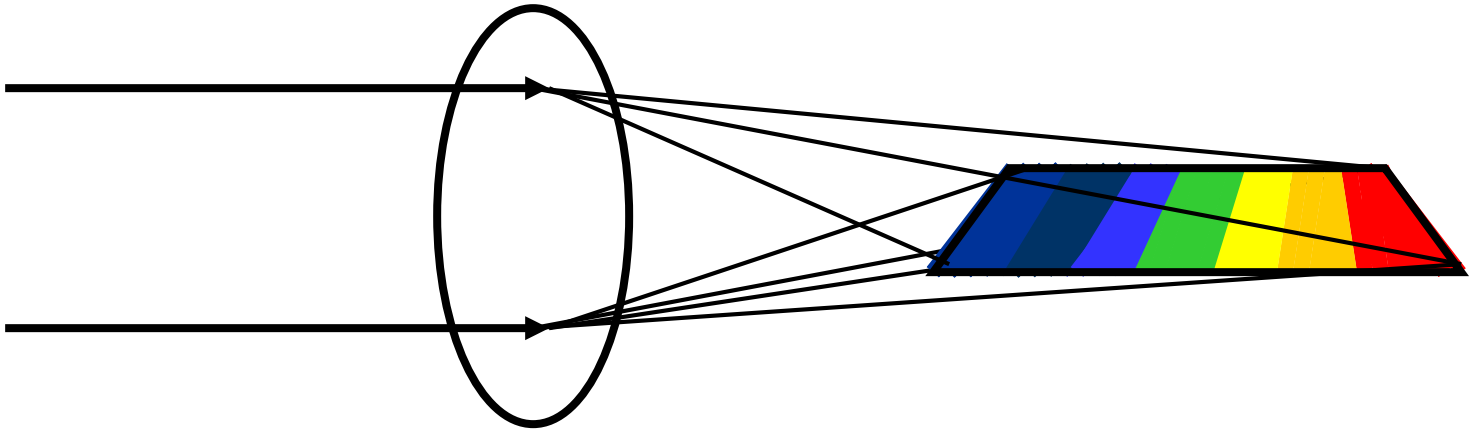

And finally, because the cornea/lens of the eye act like one big lens…

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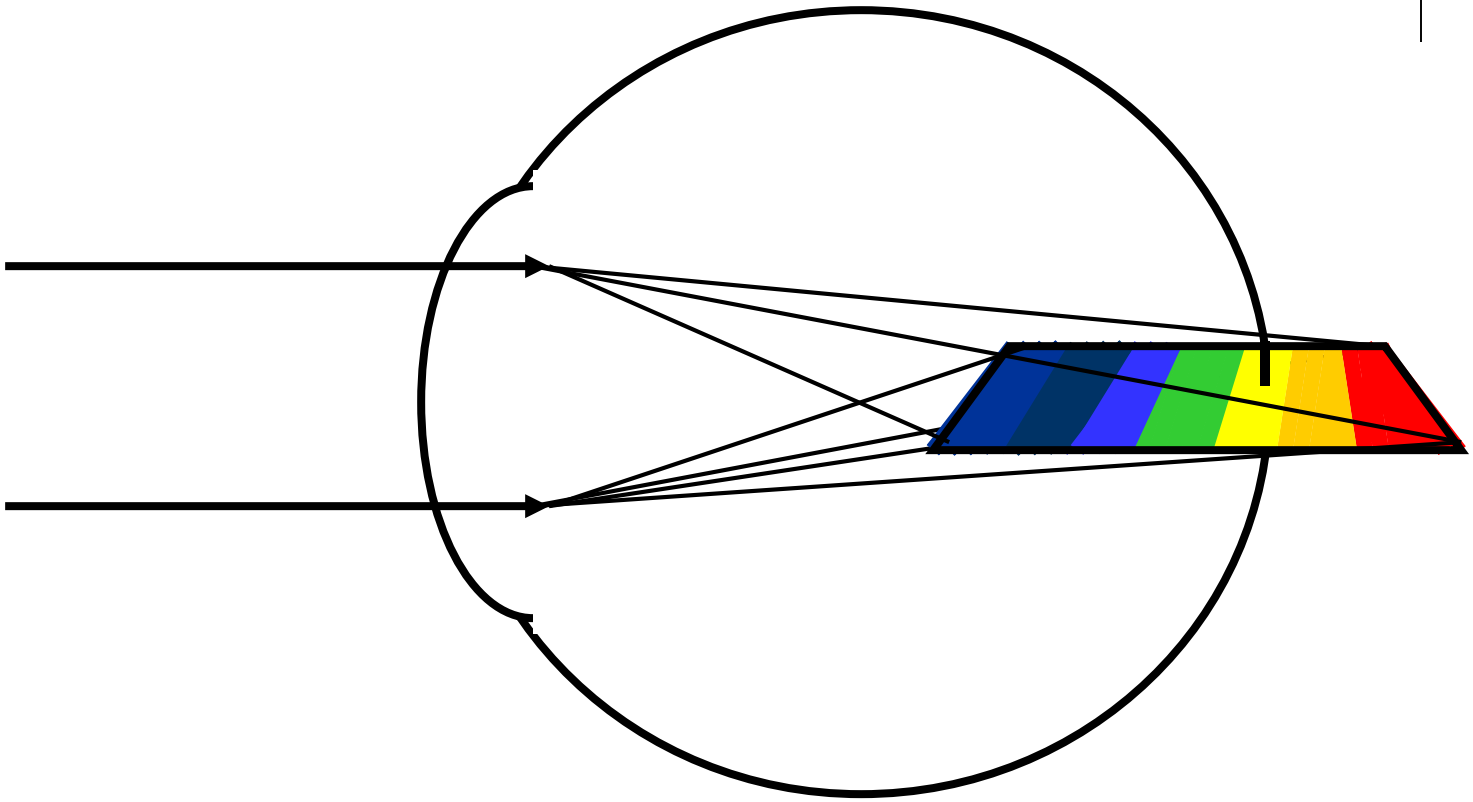

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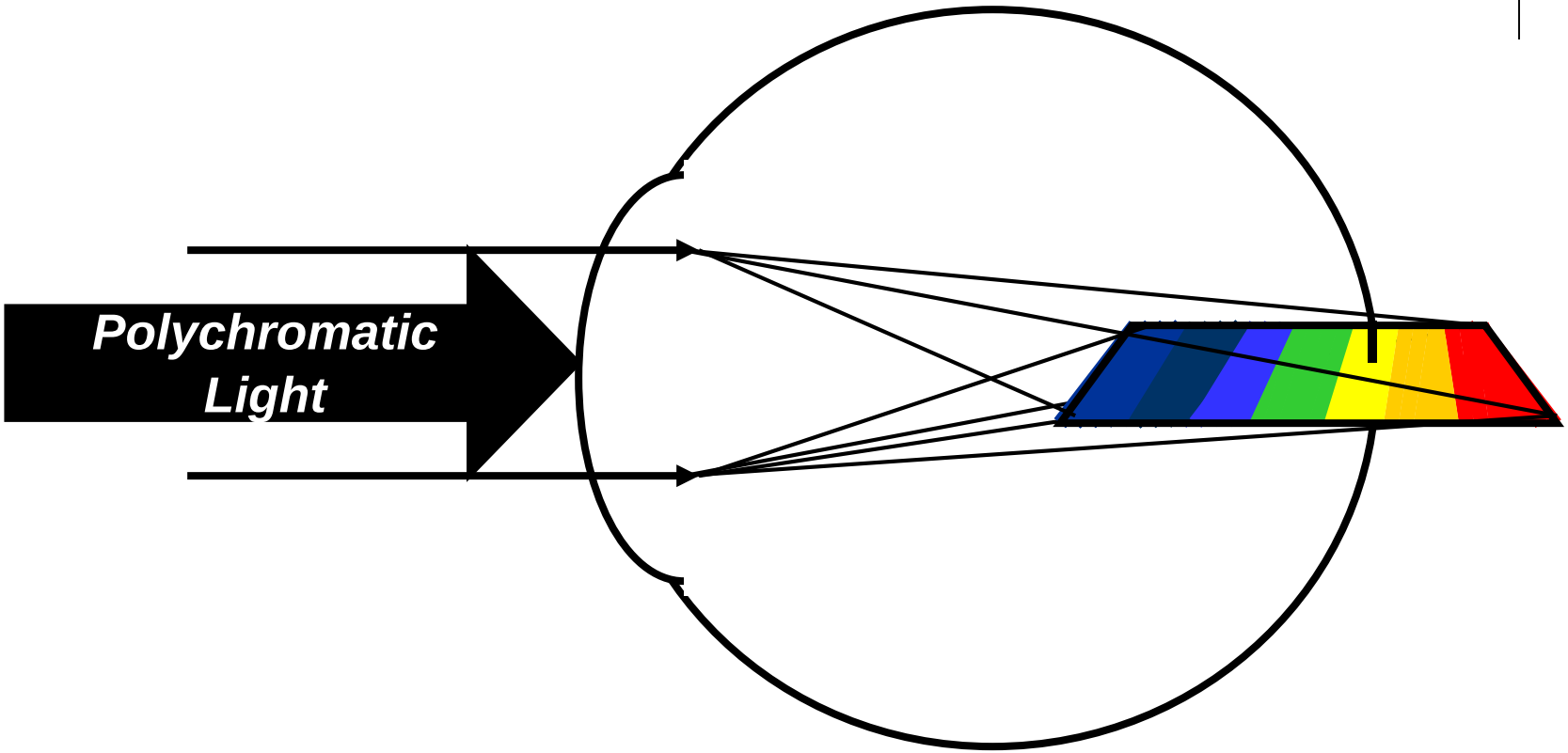
Thus, when ***polychromatic light*** strikes the eye, it is refracted into a ***chromatic interval***



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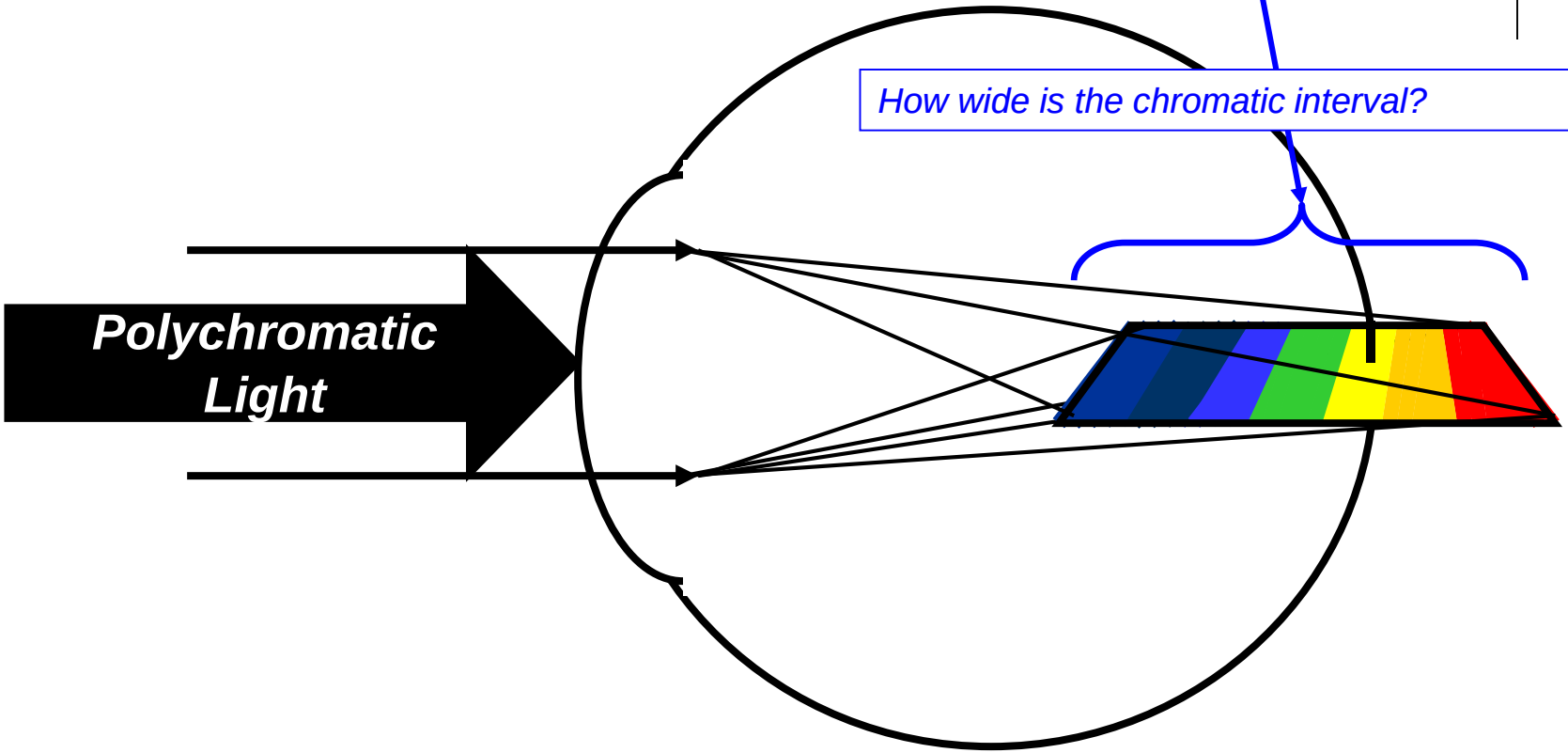
How wide is the chromatic interval?



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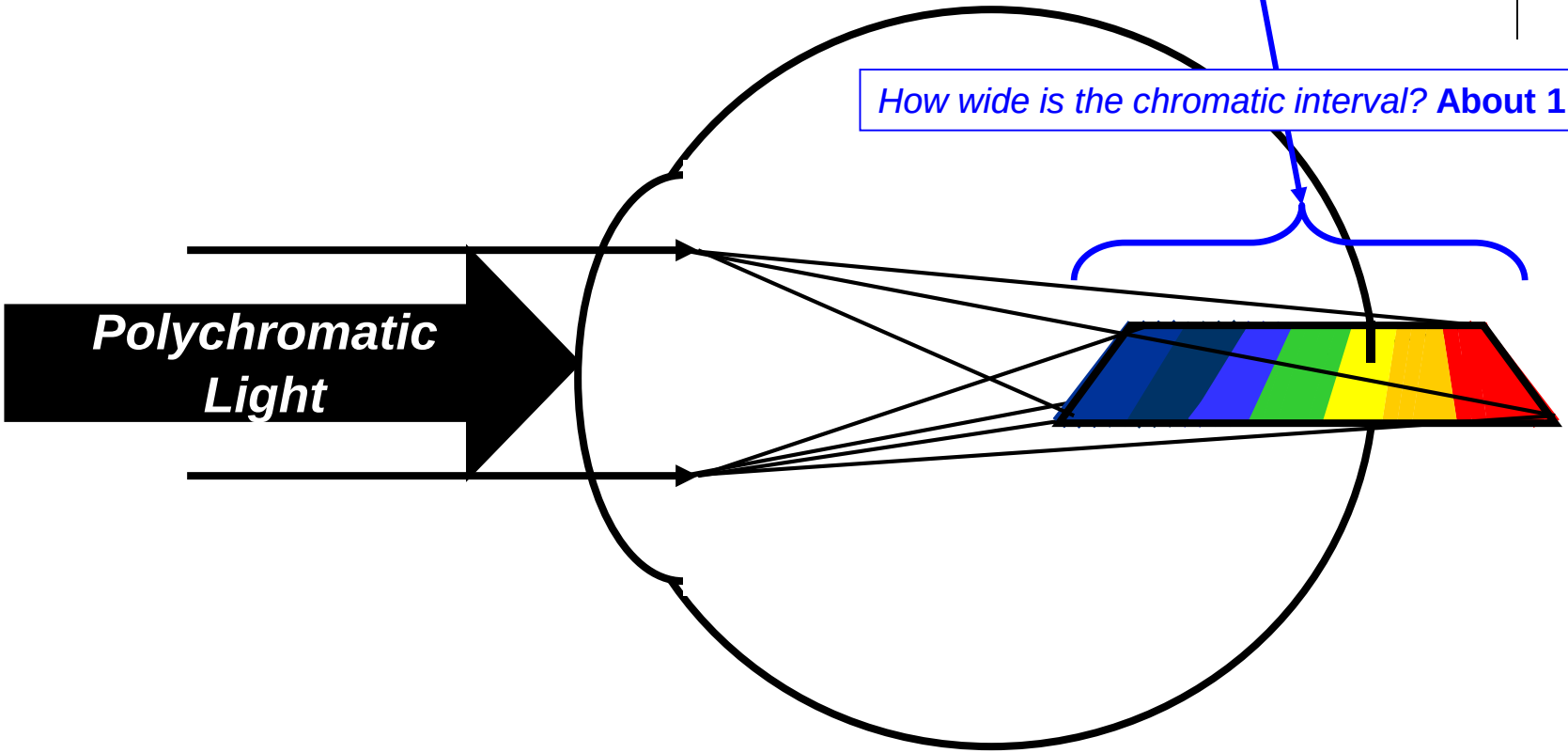
How wide is the chromatic interval? **About 1.25D!**



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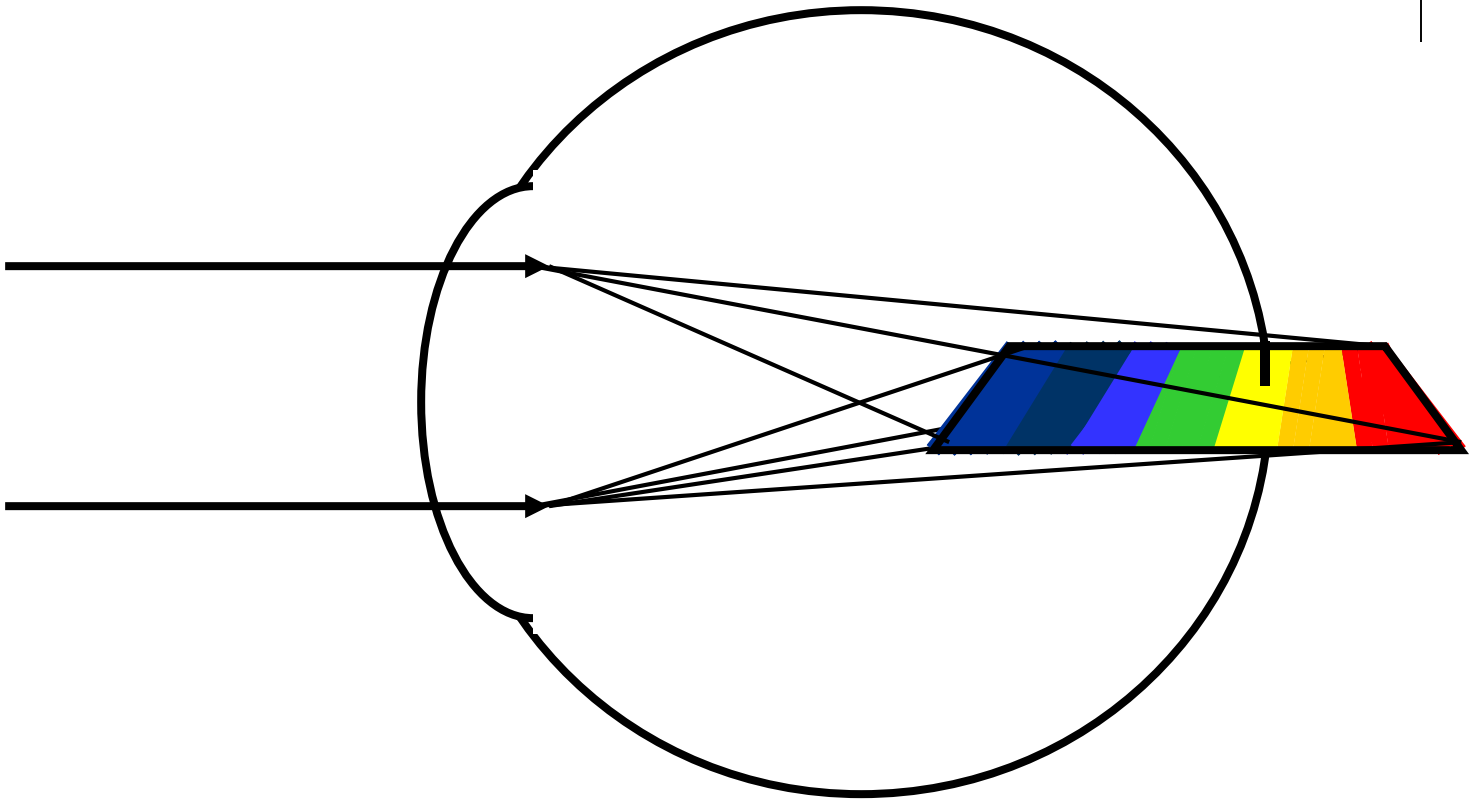
Chromatic aberration contributes to a phenomenon called ***night myopia***.



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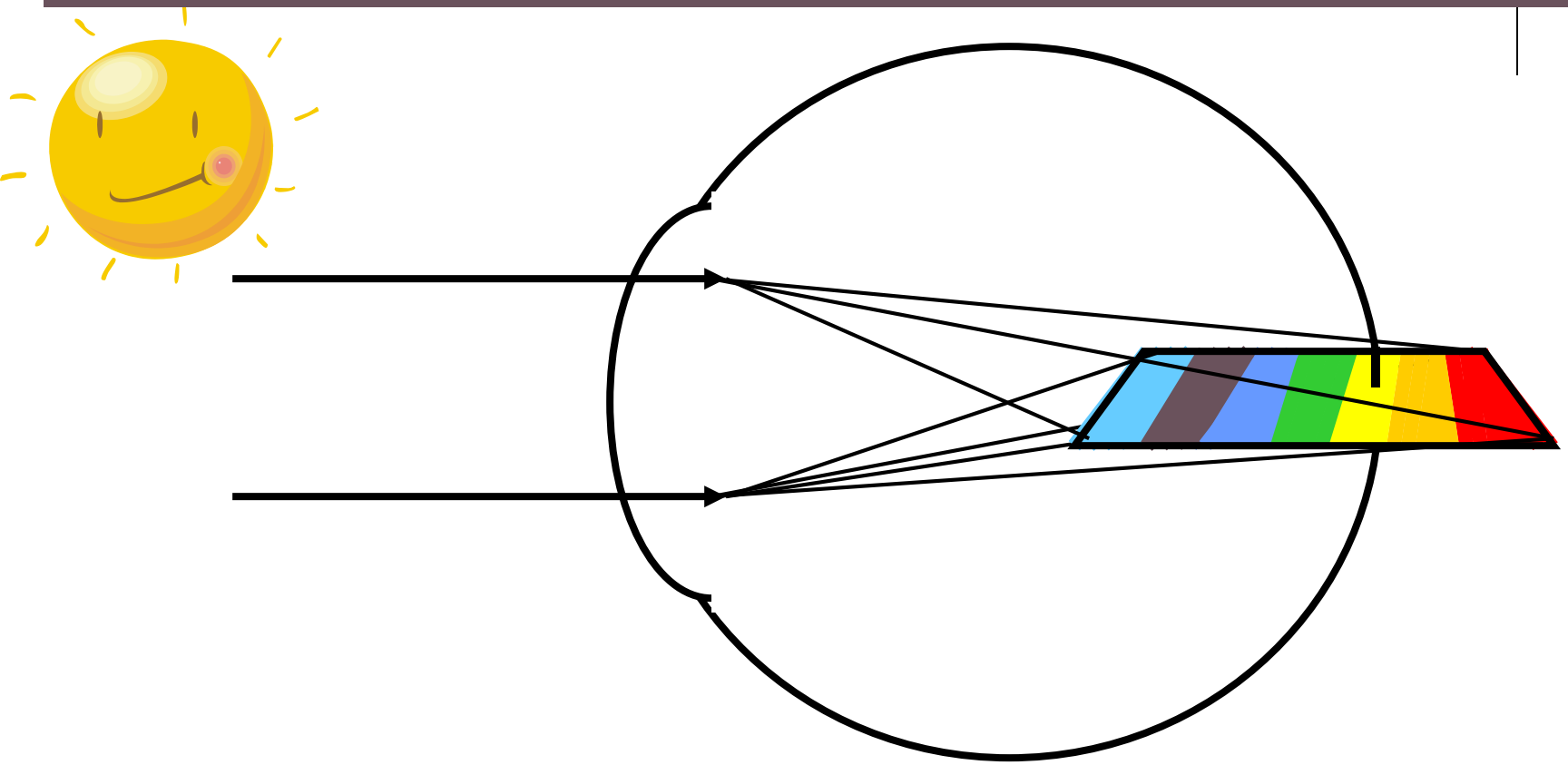

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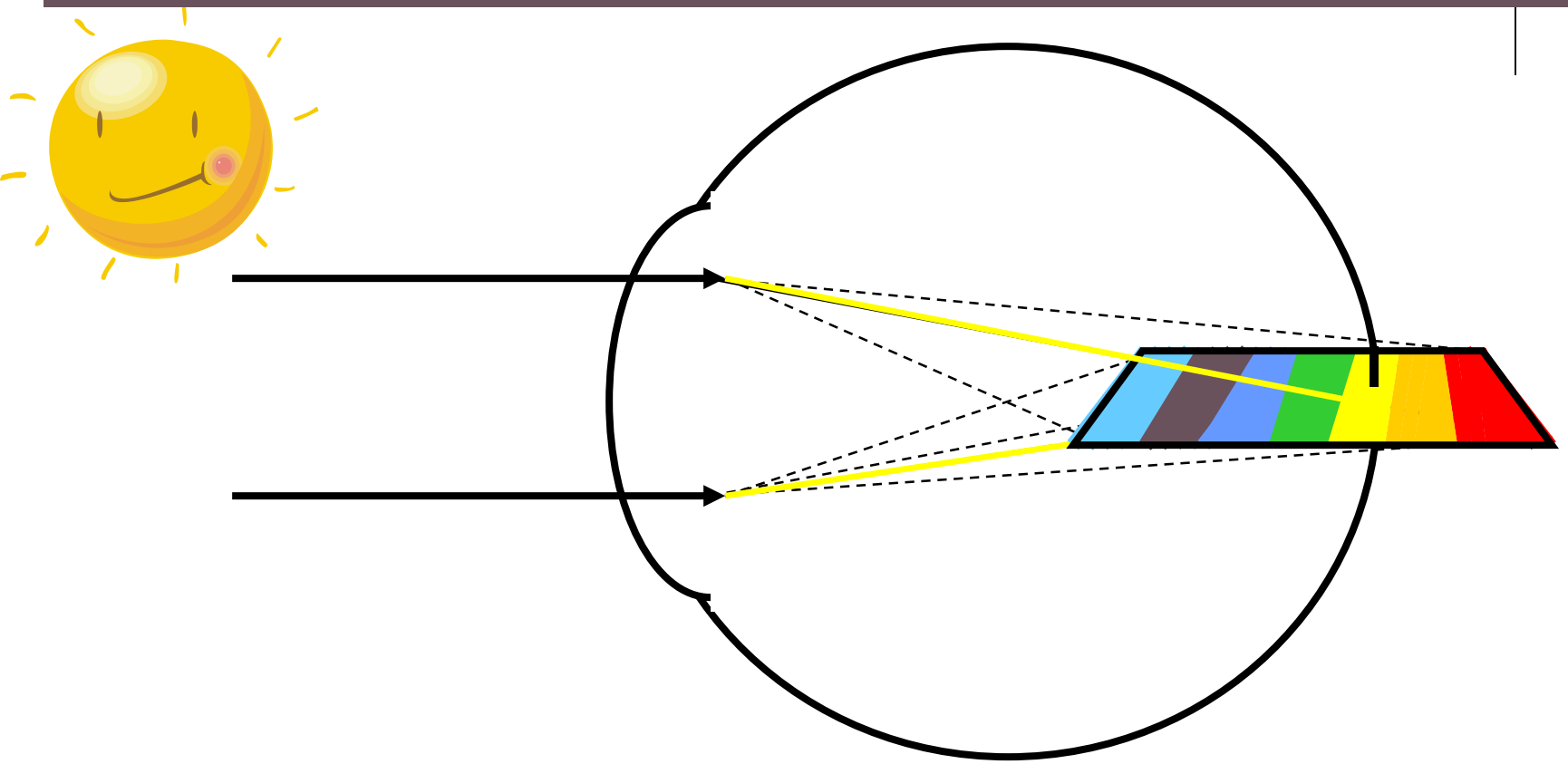

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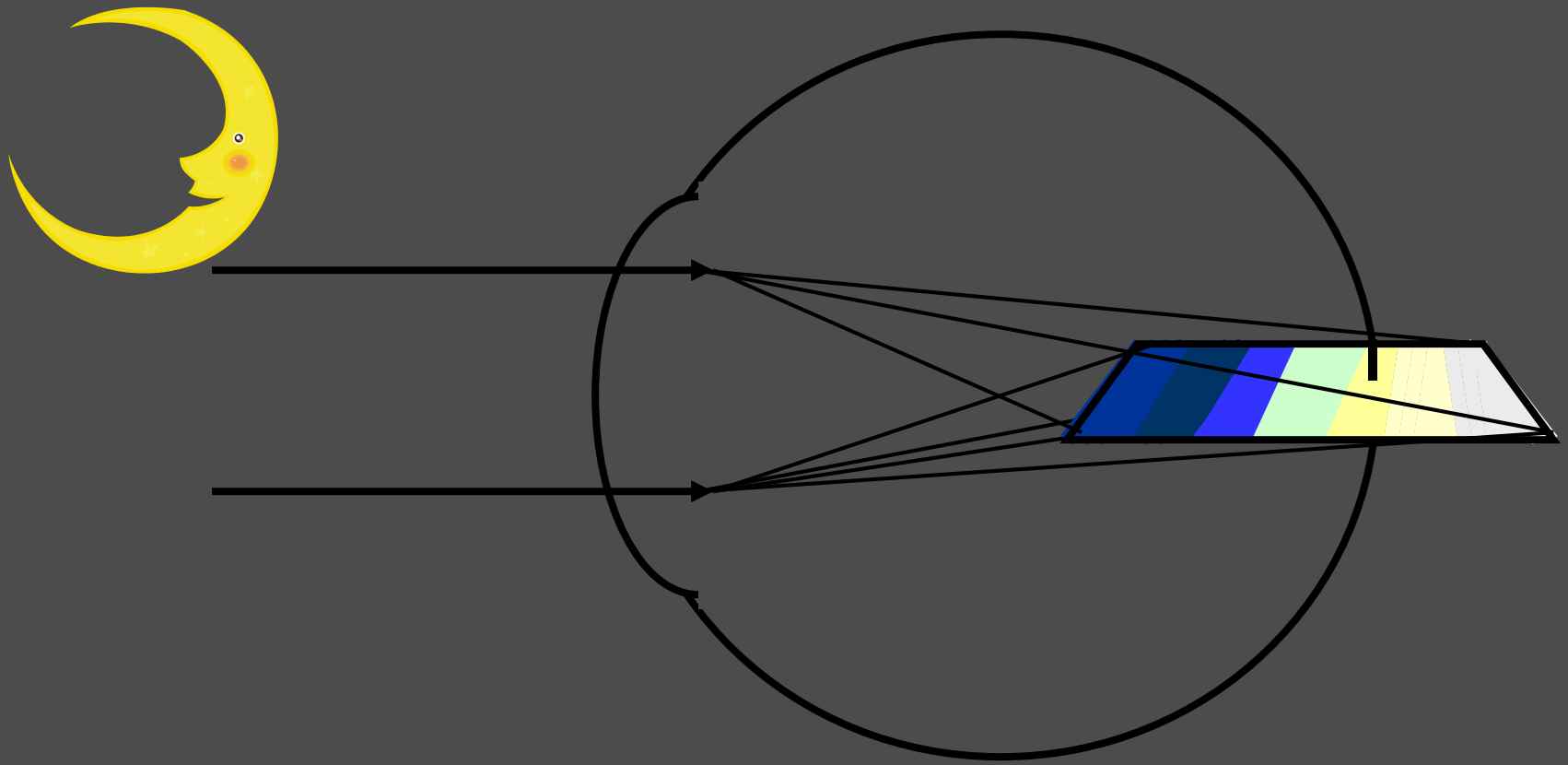

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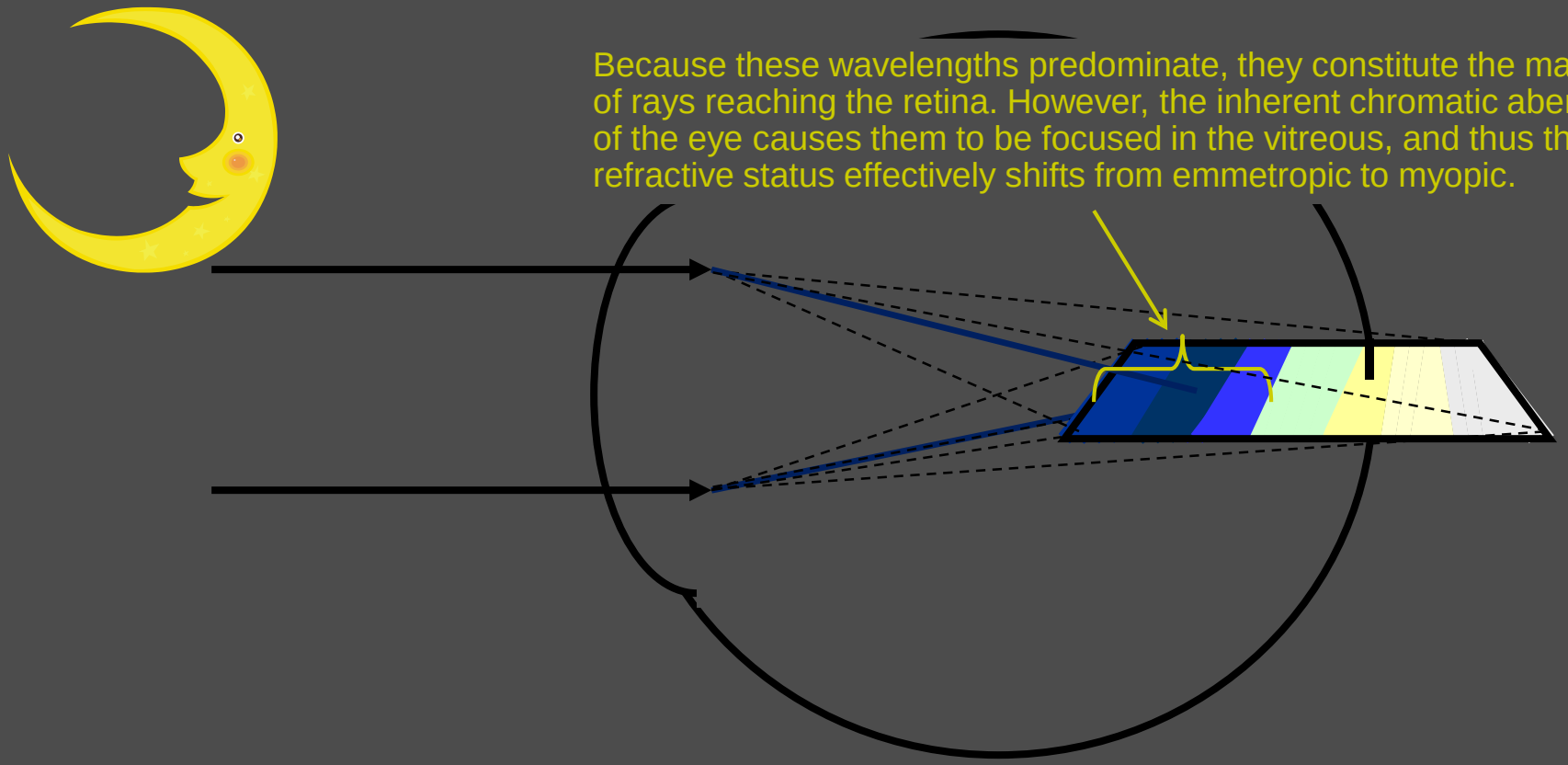

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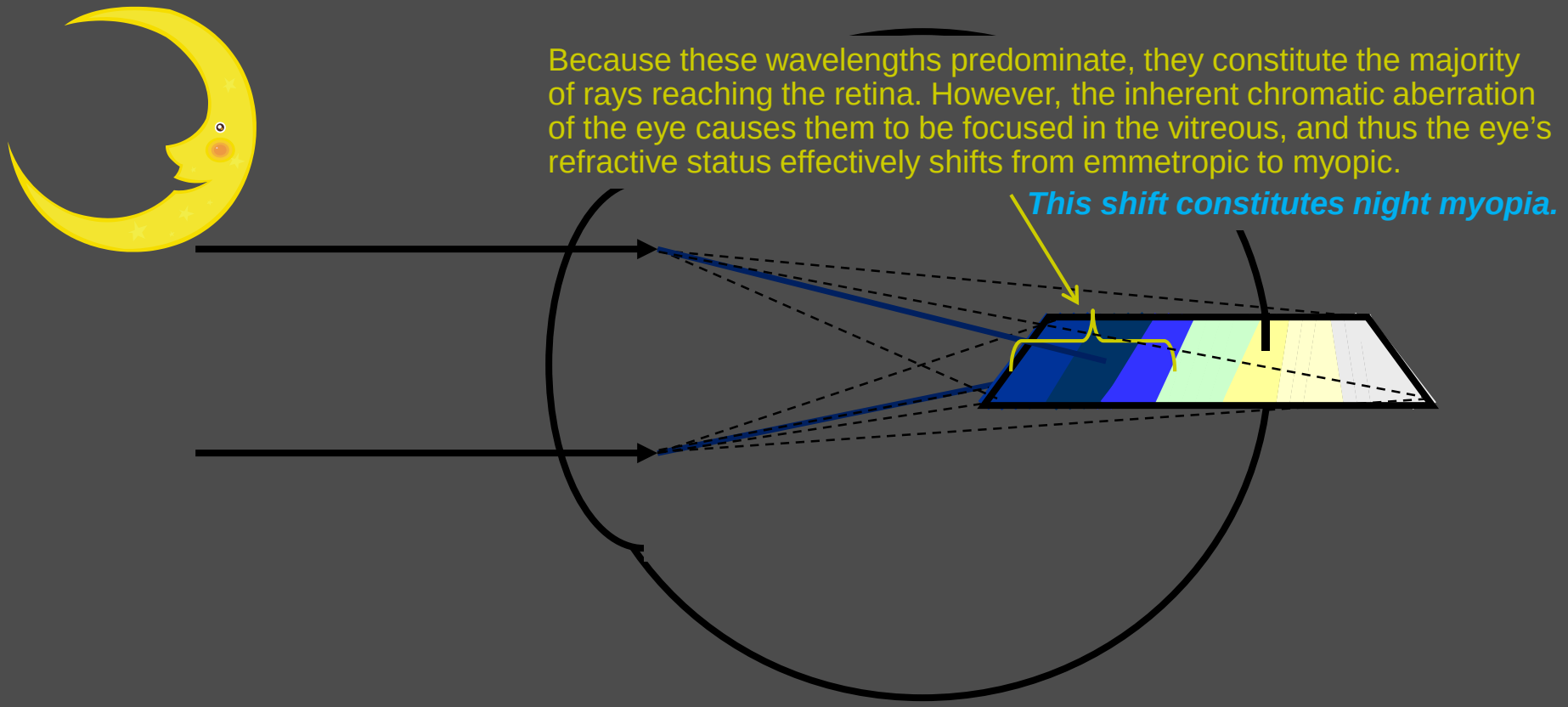

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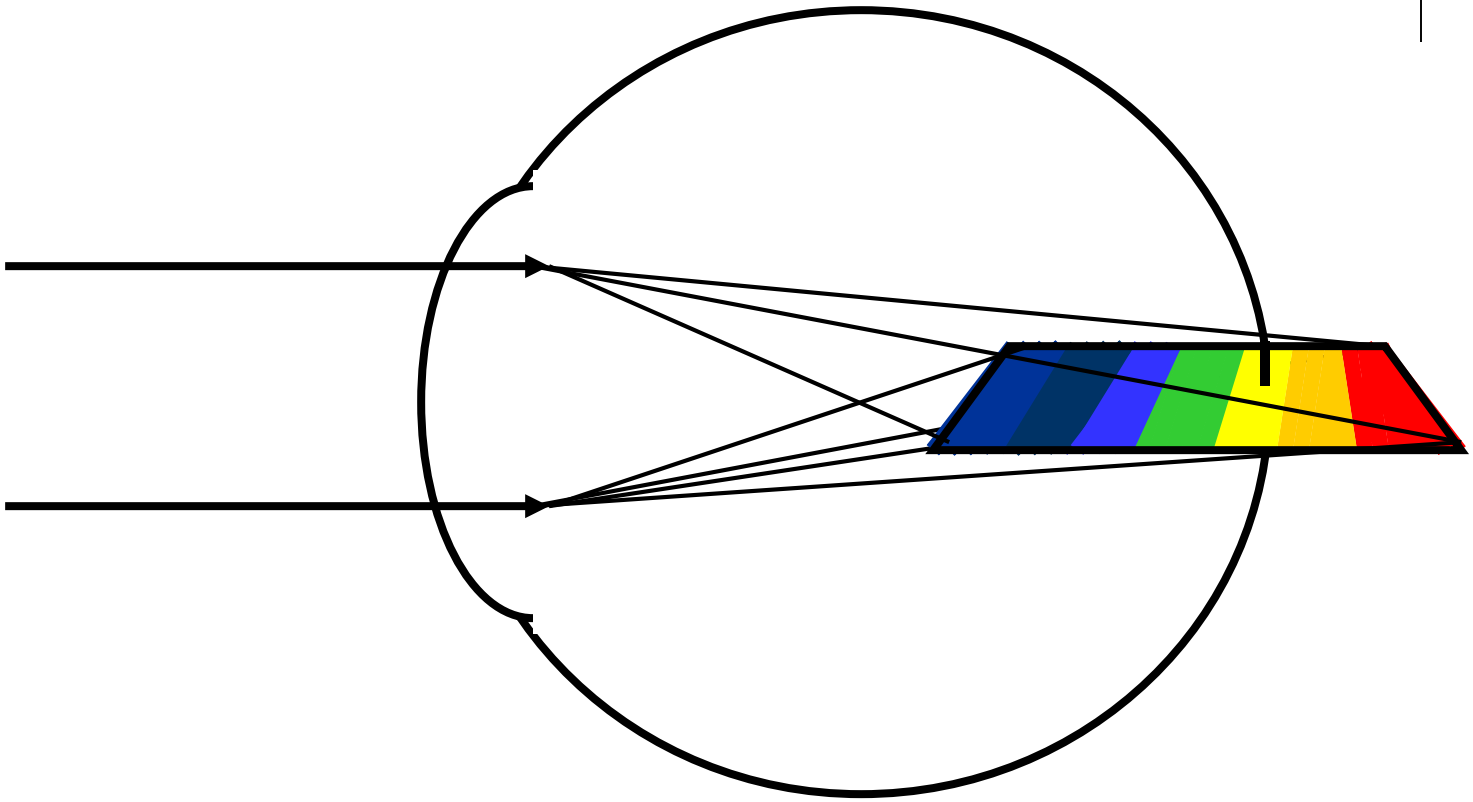

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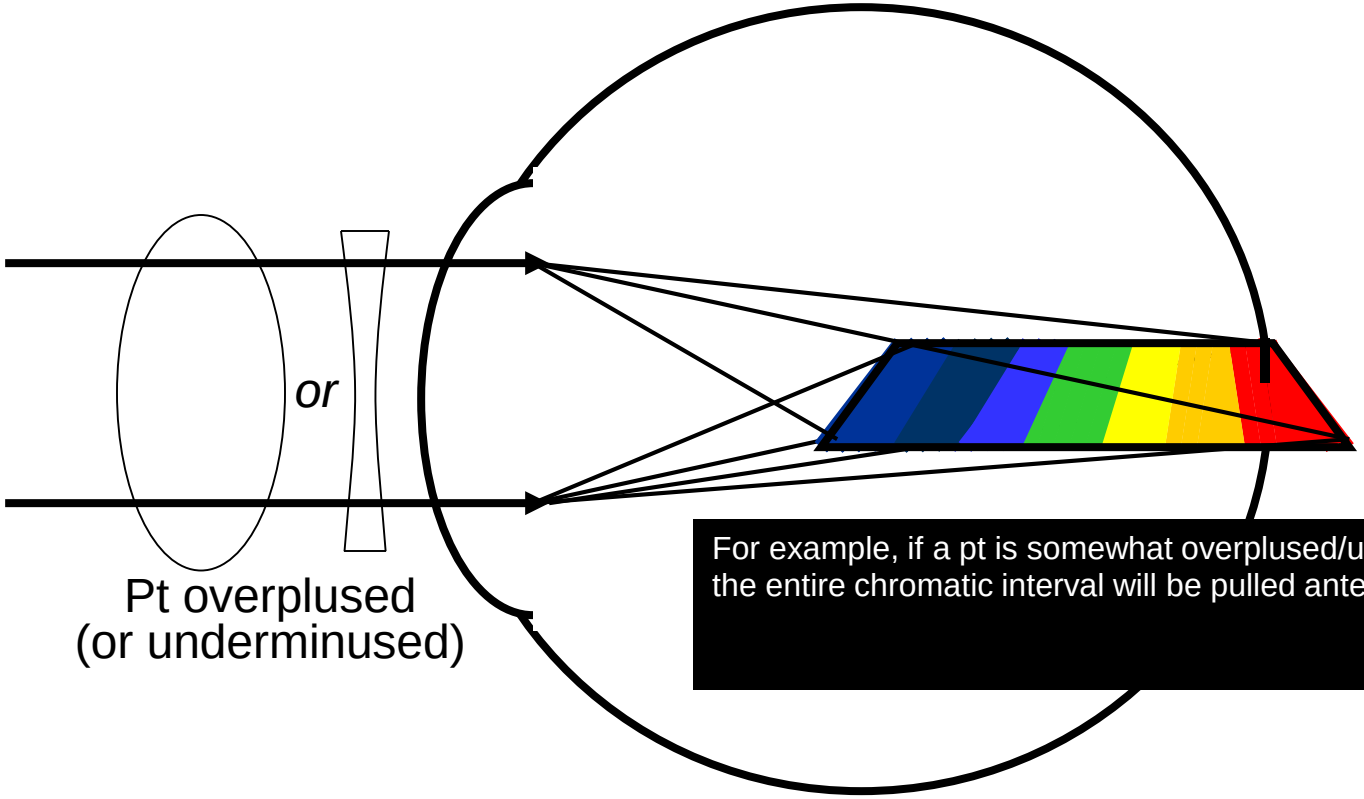

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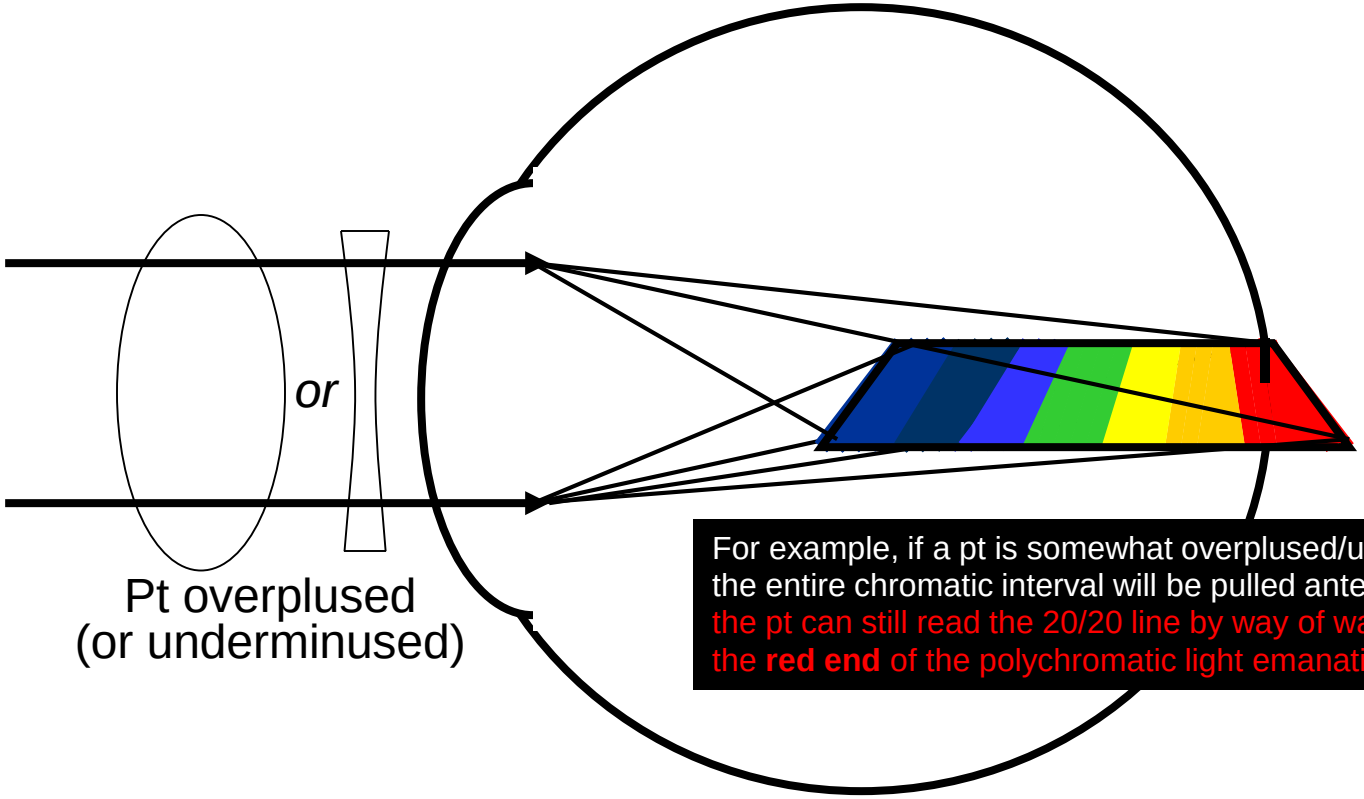

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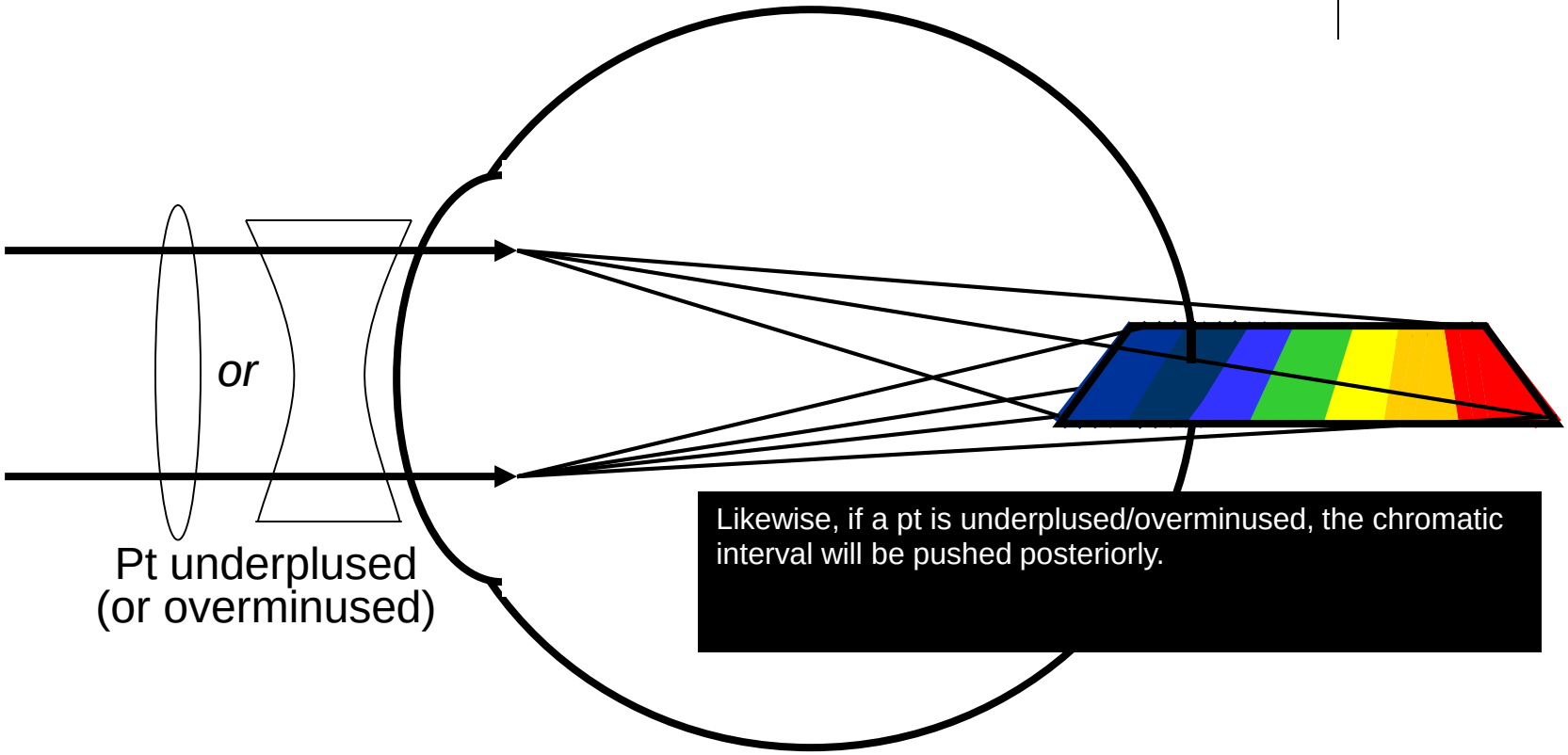

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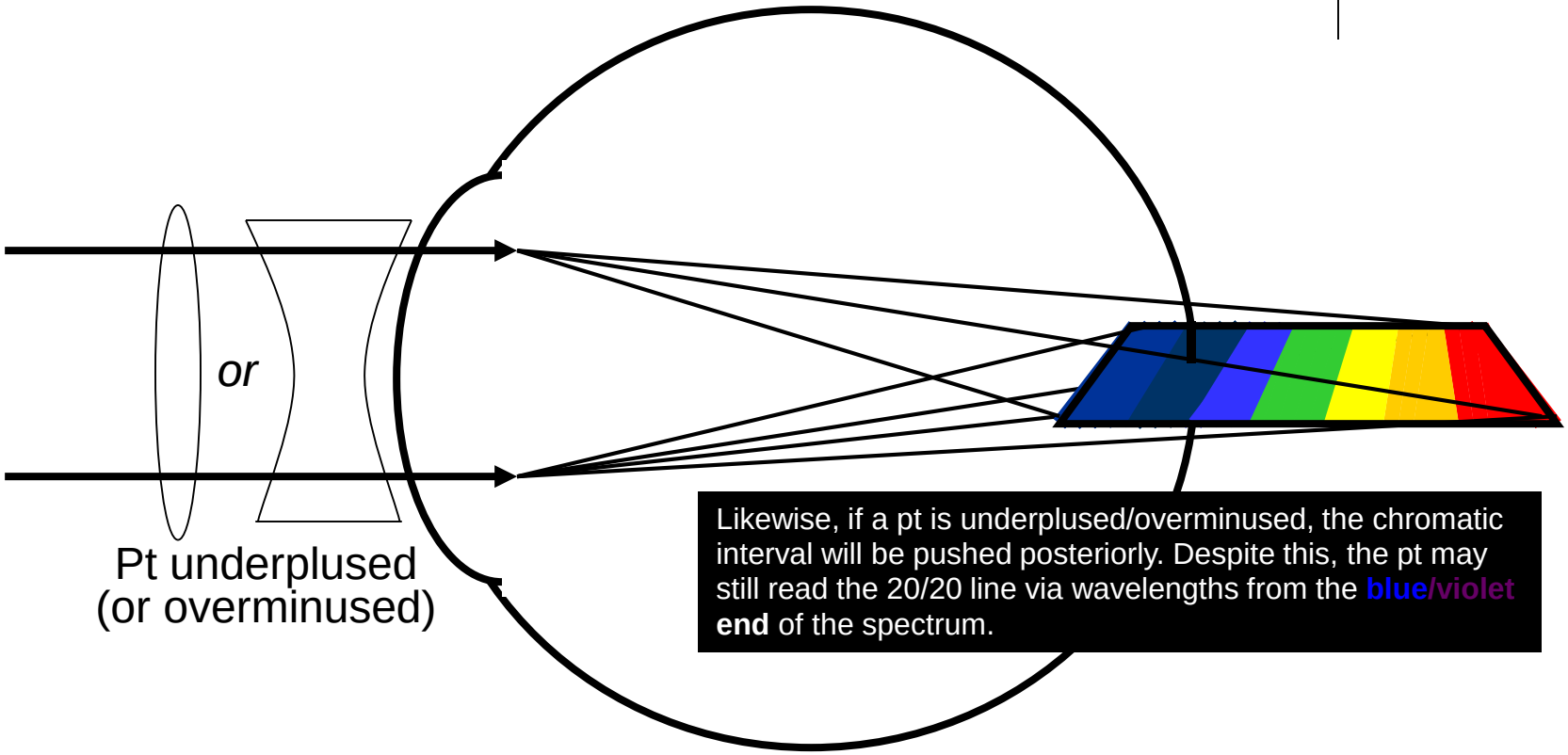

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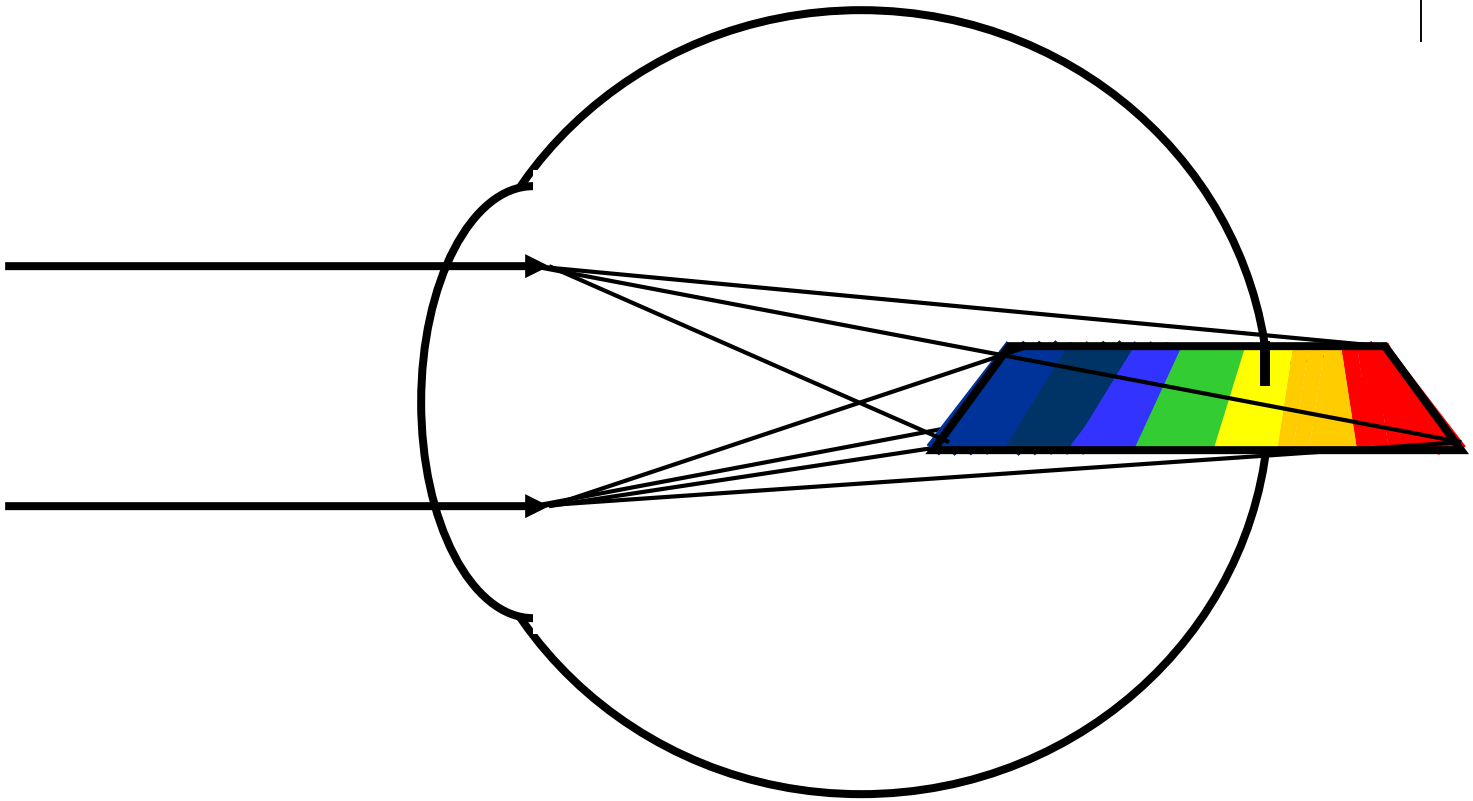

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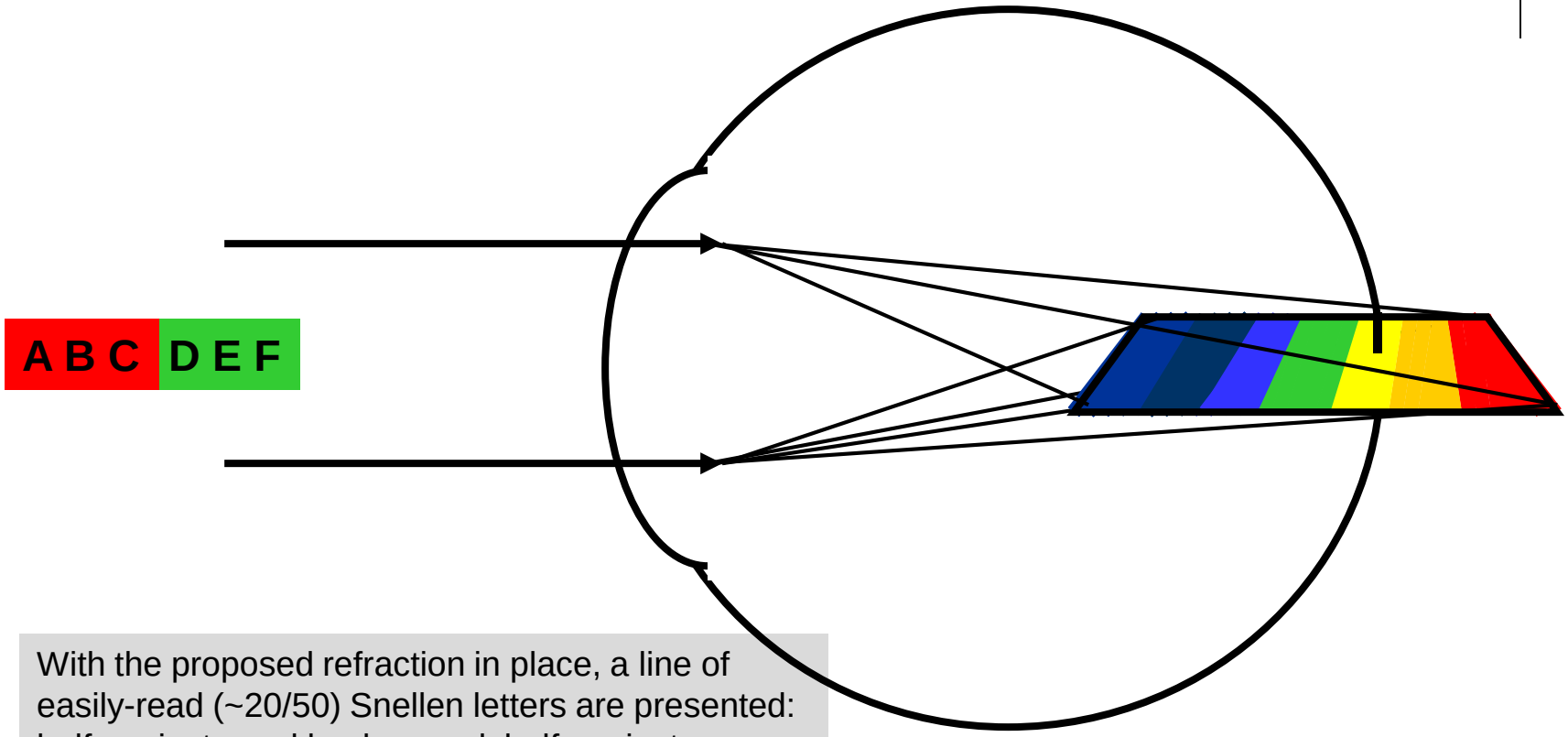

With the proposed refraction in place, a line of easily-read (~20/50) Snellen letters are presented: half against a red background, half against green. (The test is done monocularly.) The pt is asked if one group of letters appears clearer than the other.

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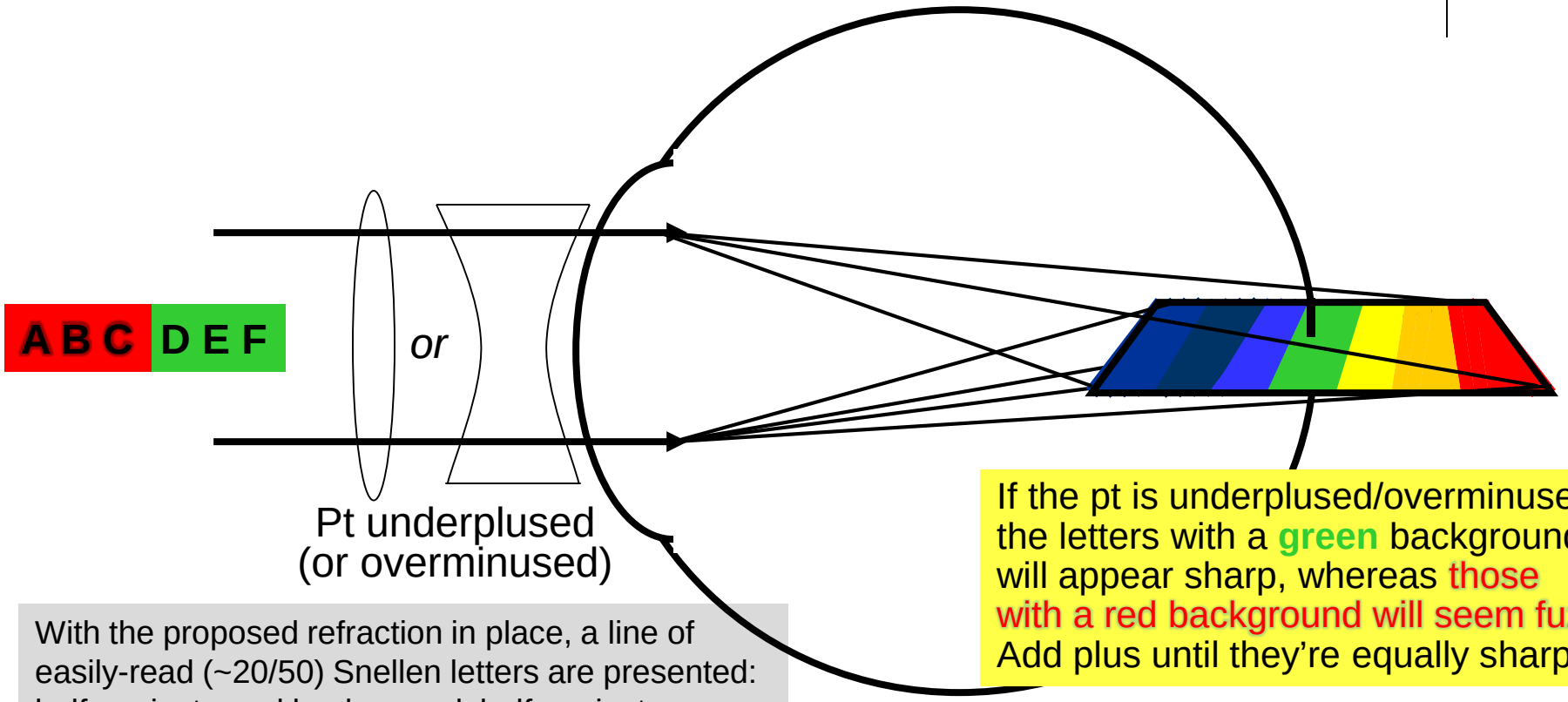

If the pt is underplused/overminused, the letters with a **green** background will appear sharp, whereas those with a red background will seem fuzzy. Add plus until they're equally sharp.

With the proposed refraction in place, a line of easily-read (~20/50) Snellen letters are presented: half against a red background, half against green. (The test is done monocularly.) The pt is asked if one group of letters appears clearer than the other.

The duochrome test works by pitting the two ends of the chromatic interval against one another.

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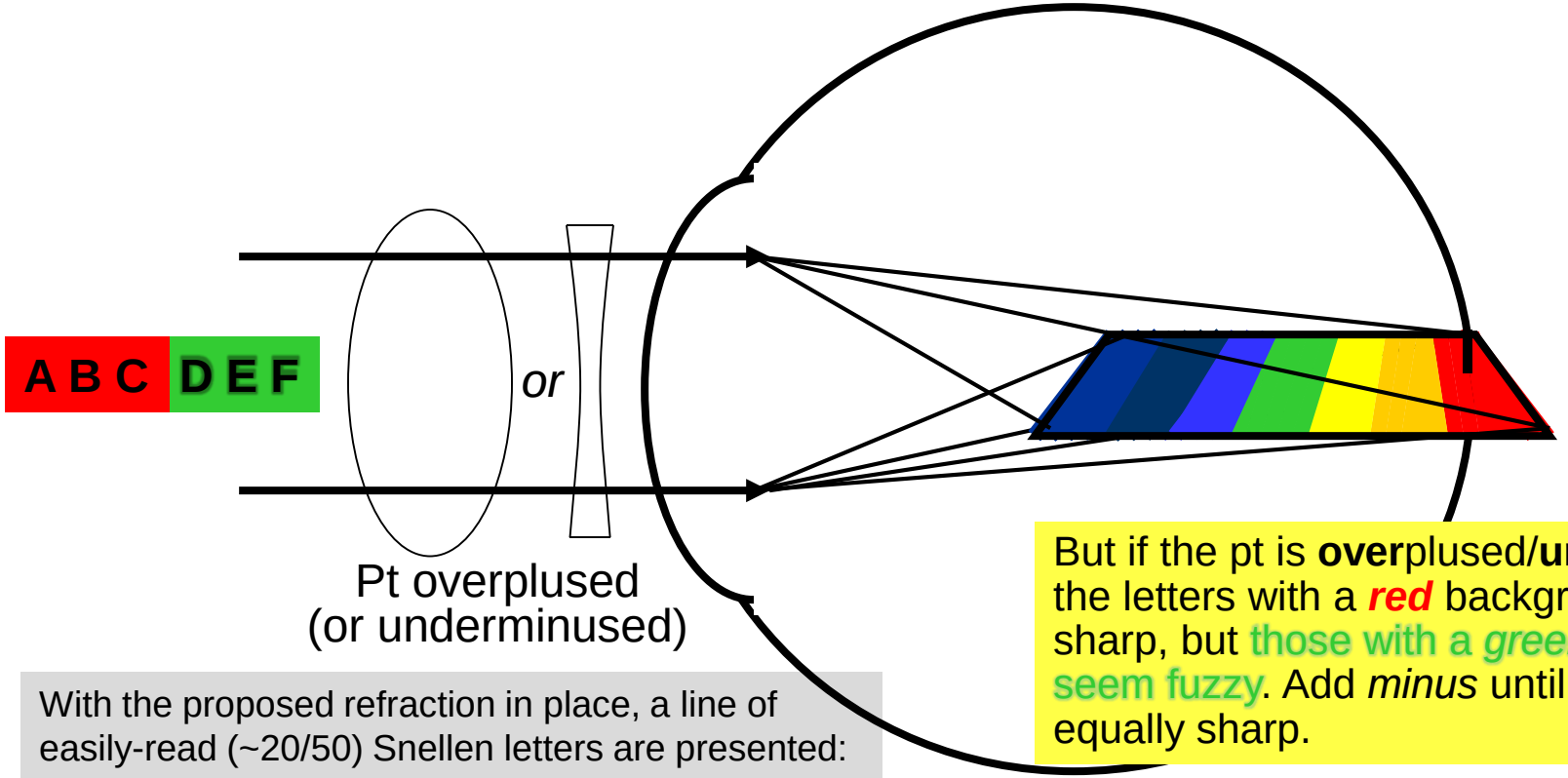

But if the pt is **over**plused/**under**minused, the letters with a ***red*** background appear sharp, but those with a *green* background seem fuzzy. Add *minus* until they're equally sharp.

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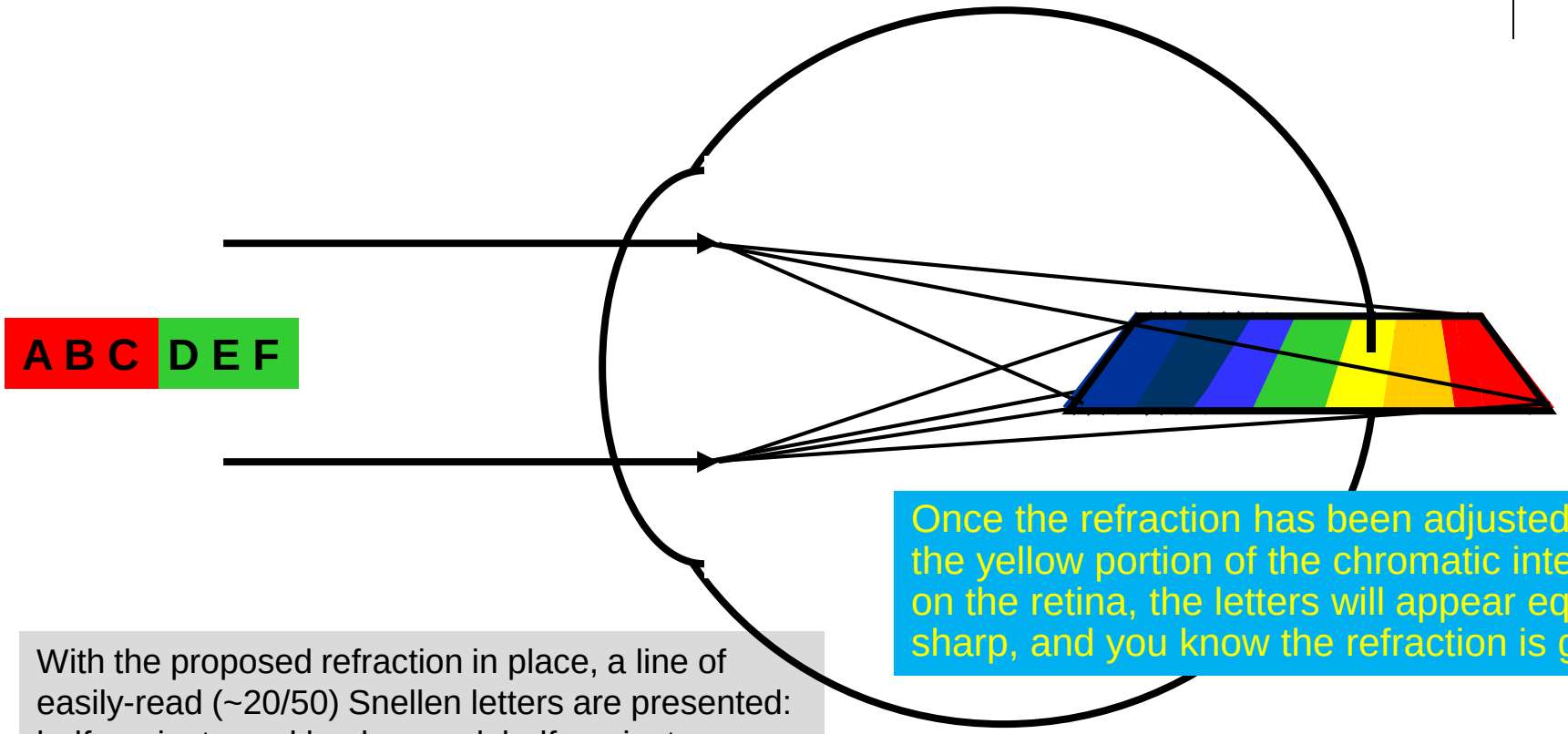

Once the refraction has been adjusted so that the yellow portion of the chromatic interval is on the retina, the letters will appear equally sharp, and you know the refraction is good!*

With the proposed refraction in place, a line of easily-read (~20/50) Snellen letters are presented: half against a red background, half against green. (The test is done monocularly.) The pt is asked if one group of letters appears clearer than the other.

**For that eye; don't forget to test the other one!*

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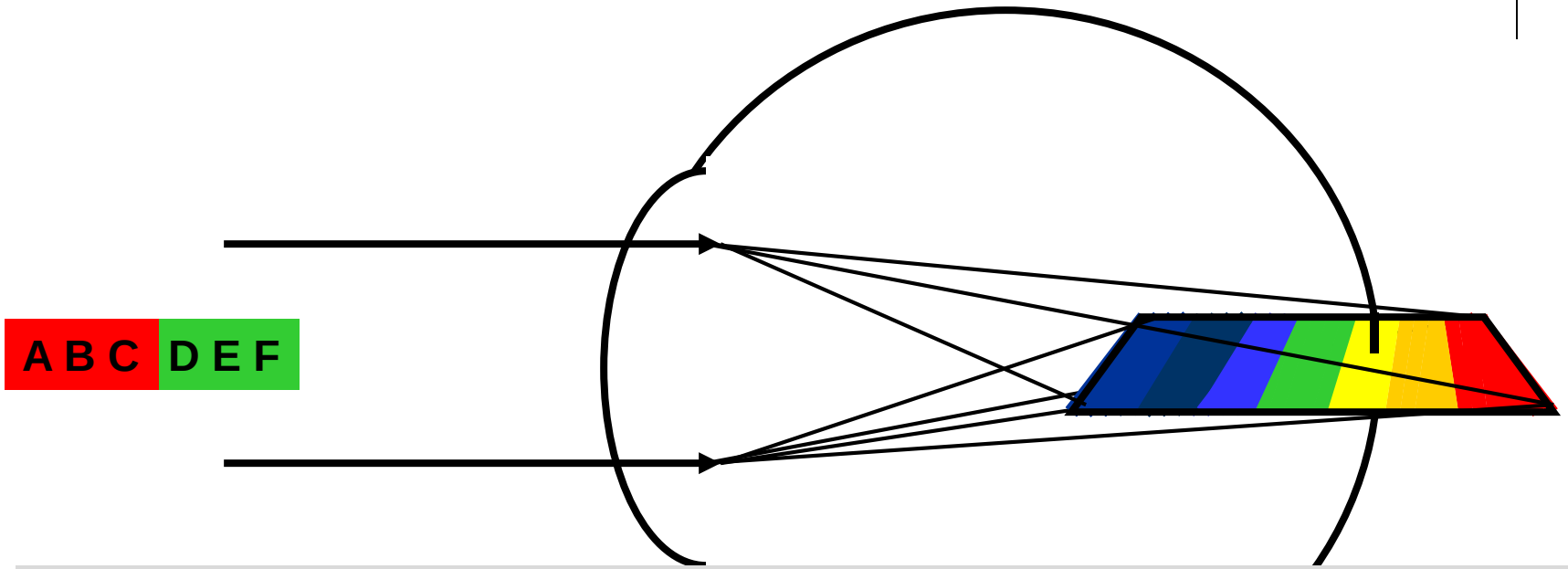

*Why use **red** and **green** as the test colors? Why not **red** and **violet**, which would cover the whole interval?*

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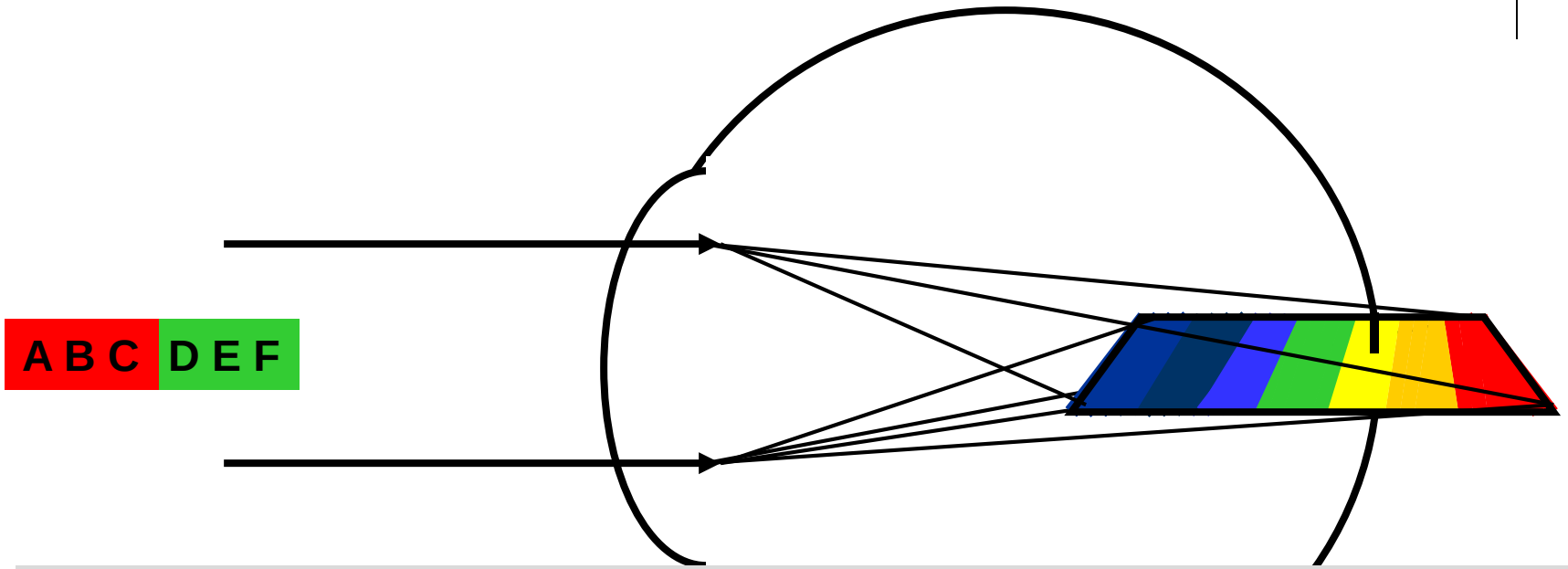

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1)

2)

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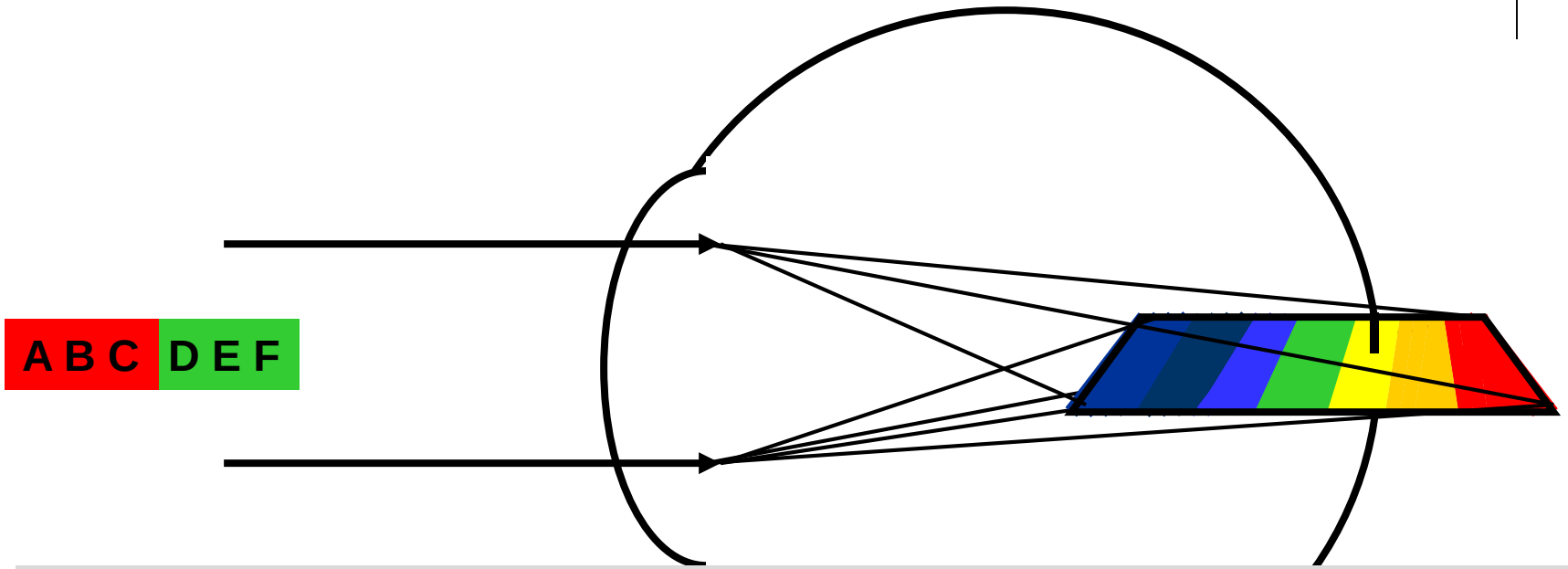

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2)

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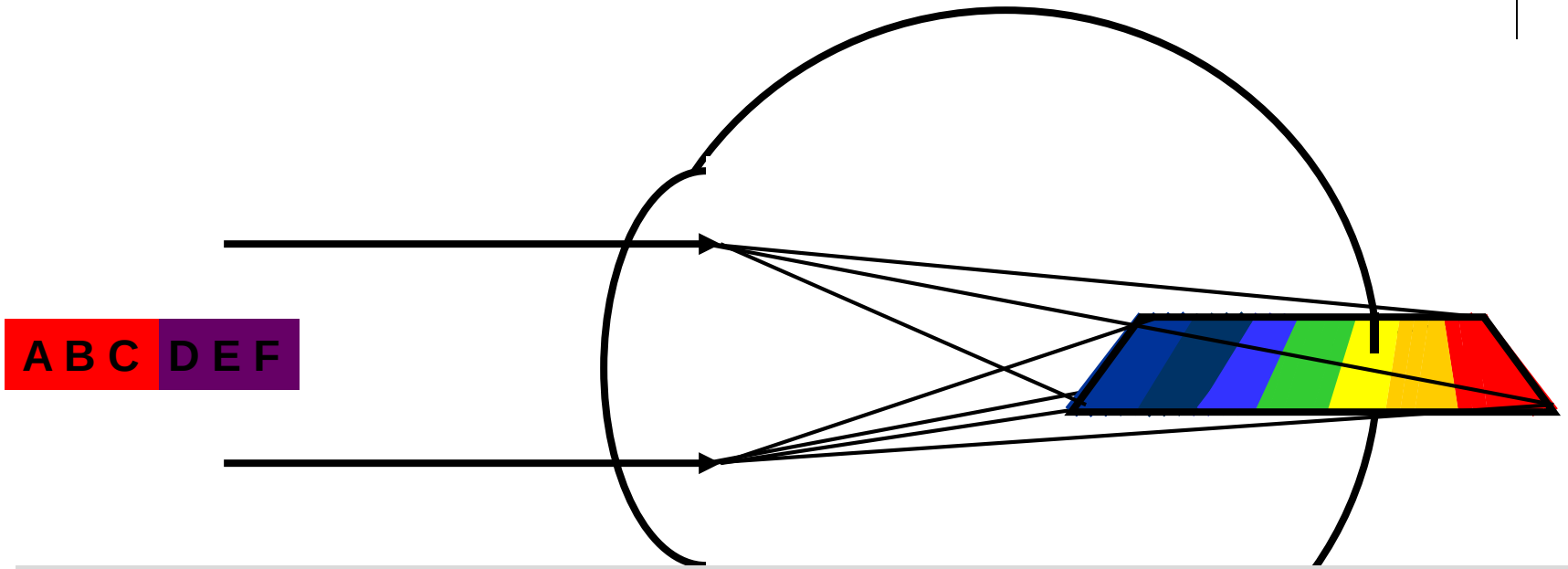

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2) If **violet** were used, the contrast with the black letters would be poor, and might influence the test.

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  1) Spherical error (ie, myopia/hyperopia)
  2) Regular astigmatism
     - *Regular* meaning 'that which can be corrected with cylindrical lenses'
  3) Irregular astigmatism
     - *Irregular* meaning 'that which **can't** be corrected with cylindrical lenses'

Essentially, *irregular astigmatism* was a wastebasket term for aberrations that:
1) could not be measured in the clinic; and
2) could not be corrected (by glasses) even if they had been measureable

Aberrations

Old Lingo

Sphere
Myopia
Hyperopia

‘Regular Astigmatism’ — Cylinder

‘Irregular Astigmatism’ — Any component of refractive error that could not be remediated with spherical and/or cylindrical lenses

This is how we thought of aberrations back in the day

Aberrations

- *Wavefront analysis* did away with the first problem
  - Allows clinicians to identify/quantify many of the refractive problems previously consigned to the irregular-astigmatism wastebasket

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Aberrations

Old Lingo		***New Lingo*** (from wavefront analysis)
Sphere Myopia Hyperopia	⟷ = ⟷	Defocus
‘Regular Astigmatism’		Cylinder
‘Irregular Astigmatism’		Any component of refractive error that could not be remediated with spherical and/or cylindrical lenses

Aberrations

Old Lingo	***New Lingo*** (from wavefront analysis)
Sphere	Defocus
Myopia	*Positive* defocus
Hyperopia	*Negative* defocus

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Aberrations

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Aberrations

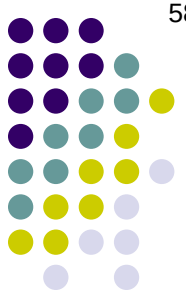
Old Lingo		***New Lingo*** (from wavefront analysis)	
Sphere	=	Defocus	‘Lower-order Aberrations’
Myopia	=	*Positive* defocus	
Hyperopia	=	*Negative* defocus	
Cylinder	=	Cylinder	

‘Regular Astigmatism’

‘Irregular Astigmatism’

Any component of refractive error that could not be remediated with spherical and/or cylindrical lenses

Aberrations



Old Lingo ***New Lingo***

(from wavefront analysis)

Sphere ⟵ = ⟶ Defocus

Myopia ⟵ = ⟶ *Positive* defocus

Hyperopia ⟵ = ⟶ *Negative* defocus

‘Lower-order Aberrations’

‘Regular Astigmatism’ — Cylinder ⟵ = ⟶ Cylinder

‘Irregular Astigmatism’ — Any component of refractive error that could not be remediated with spherical and/or cylindrical lenses ⟵ =

- Spherical aberration
- Coma
- Trefoil
- (Others, less clinically relevant)

Aberrations

Old Lingo		***New Lingo*** (from wavefront analysis)	
Sphere	=	Defocus	‘Lower-order Aberrations’
Myopia	=	*Positive* defocus	
Hyperopia	=	*Negative* defocus	
‘Regular Astigmatism’ Cylinder	=	Cylinder	
‘Irregular Astigmatism’ Any component of refractive error that could not be remediated with spherical and/or cylindrical lenses	=	Spherical aberration Coma Trefoil (Others, less clinically relevant)	‘Higher-order Aberrations’

Aberrations

- *Wavefront-guided keratorefractive surgery* did away with the second problem

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  - We will address higher-order aberrations in detail in the *Refractive Surgery* subsection (slide-set *RS6*)

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