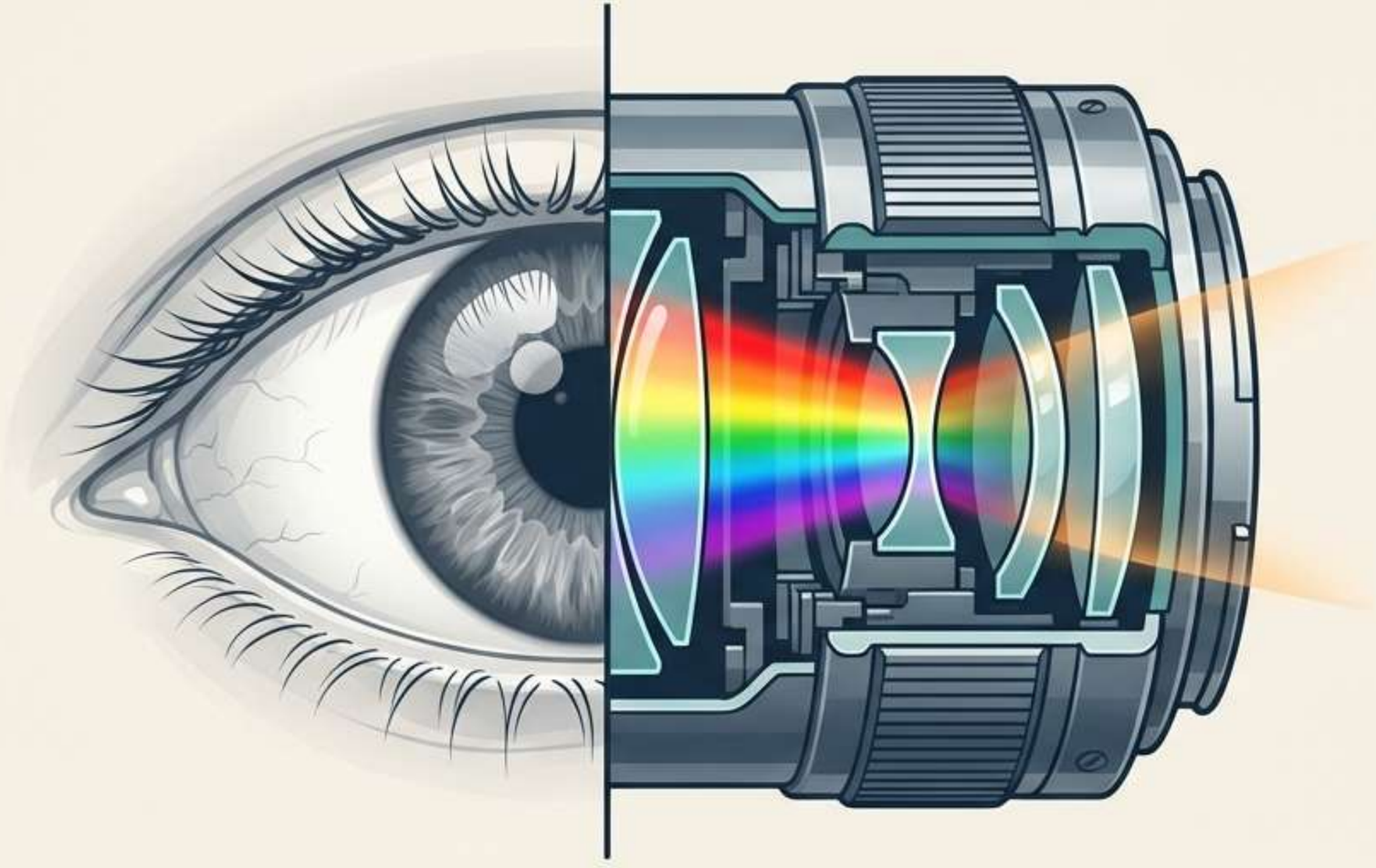
Light & The Human Eye

Nature’s Ultimate Optical Instrument



The Anatomy of Vision

Cornea & Aqueous Humor

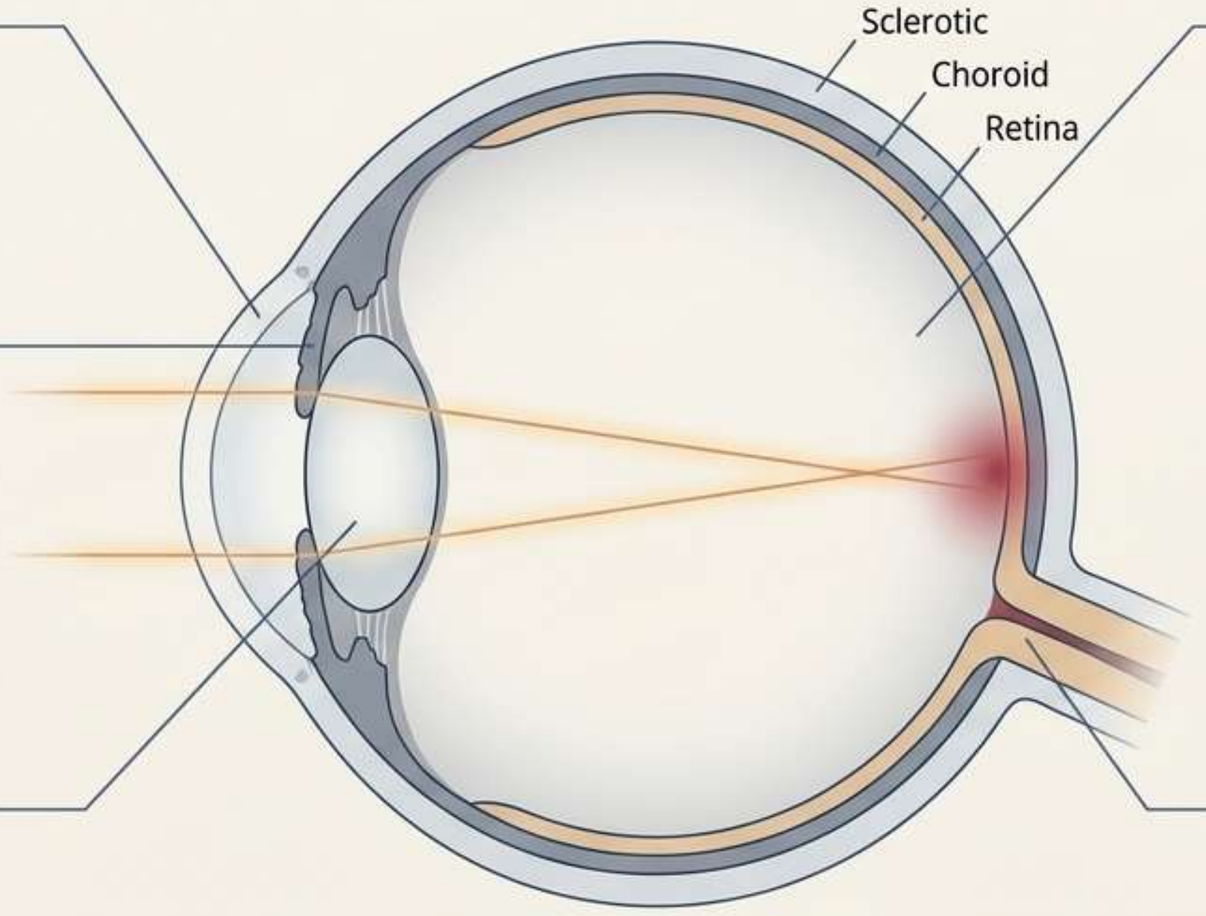
The transparent front shield where light first enters, backed by a clear liquid. (Lora)

Iris & Pupil

A variable aperture system. The muscular iris adjusts the pupil size—contracting in bright sunlight and expanding in dim rooms. (Lora)

Eye Lens

A convex, jelly-like proteinaceous material held by ciliary muscles.



Retina & Vitreous Humor

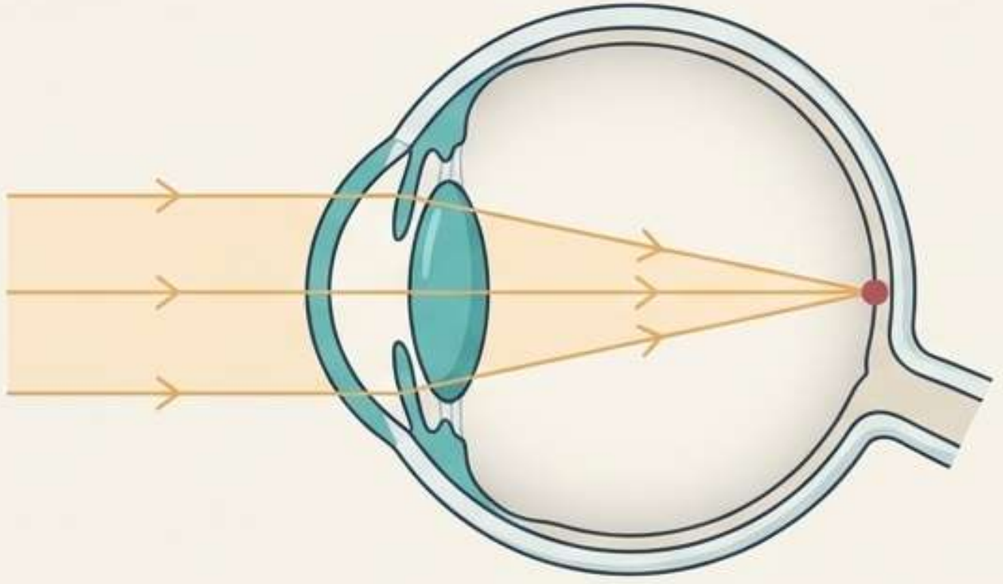
The rear surface housing 125 million light-sensitive receptors. (Lora)

Optic Nerve & Blind Spot

The data cable to the brain. Features a blind spot where no receptors exist. (Lora)

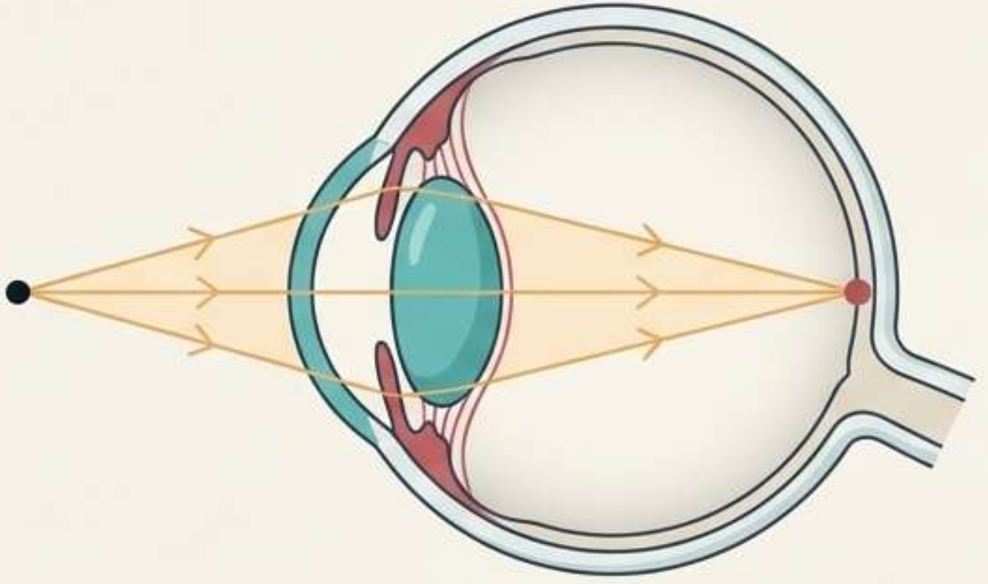
The Mechanics of Focus: Power of Accommodation

Relaxed Ciliary Muscles



- Distant Vision: The eye lens becomes thin, maximizing focal length.

Tensed Ciliary Muscles



- Near Vision: Muscles contract, increasing lens thickness and shortening the focal length.

Metrics of Human Sight

25 cm

The Near Point

The least distance of distinct vision. Objects closer than this produce blurred images for a healthy adult.

∞

The Far Point

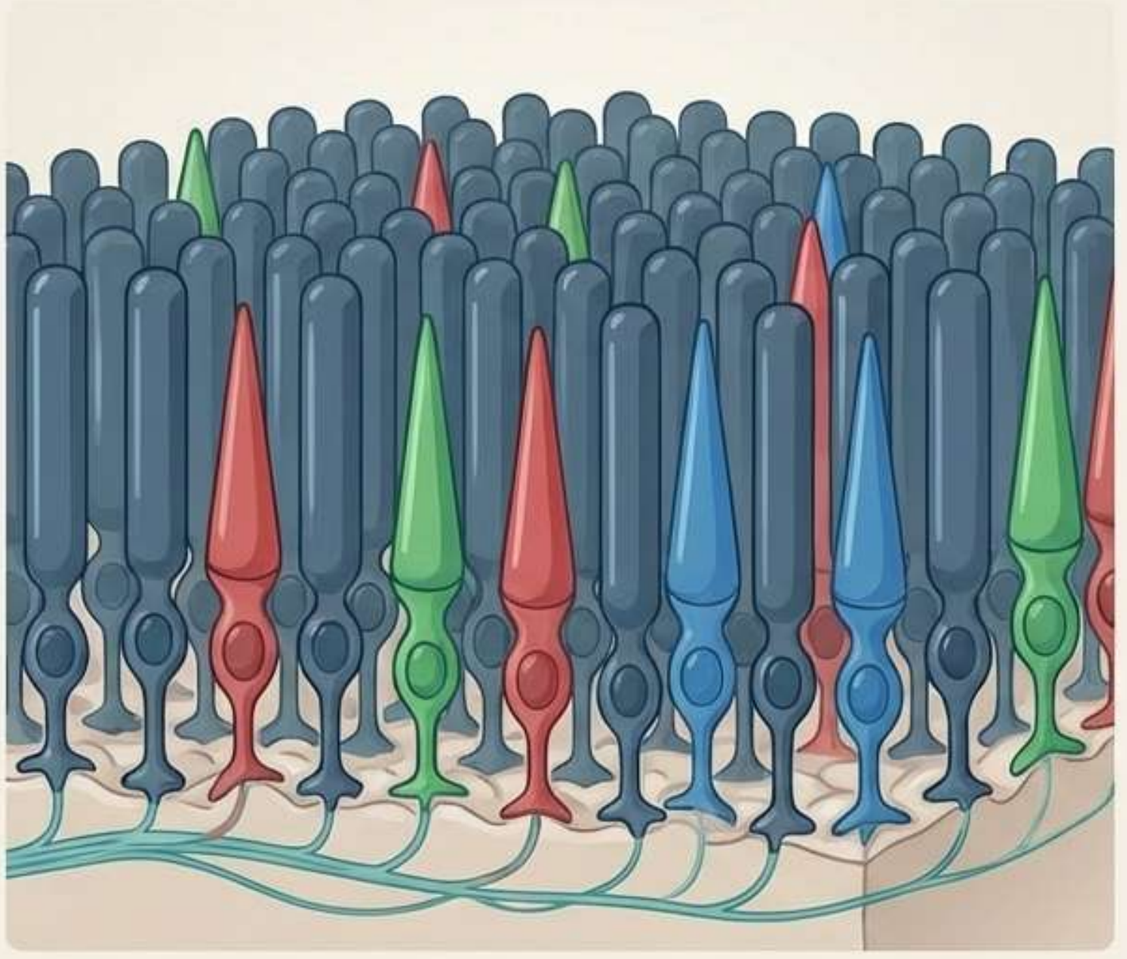
The maximum range of vision for a normal, healthy eye.

1/16th sec

Persistence of Vision

The time an image is retained on the retina. This biological delay allows cinematography to work by projecting 24 still pictures per second, creating the illusion of smooth motion.

The Color Sensors



Rods

- Respond to light intensity (brightness/darkness).
- Active in dim light.

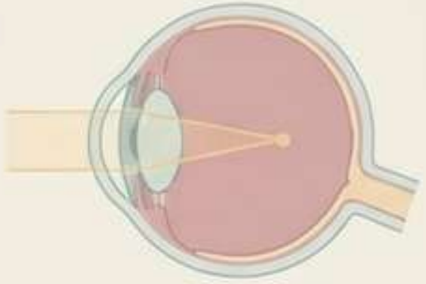
Cones

- Respond to color (Red, Green, Blue).
- Only active in bright light.
- Colour Blindness occurs genetically when a person lacks specific cone types.

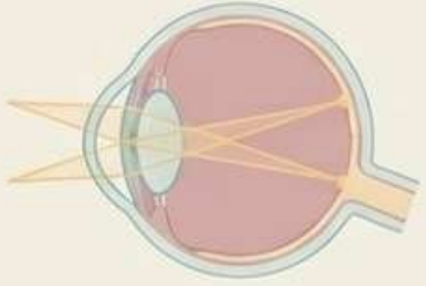
Animal Vision

- **Bees:** Possess cones sensitive to ultraviolet (UV) light.
- **Chickens:** Retinas are almost exclusively cones with very few rods. They can only see in bright light, waking at sunrise and sleeping at sunset.

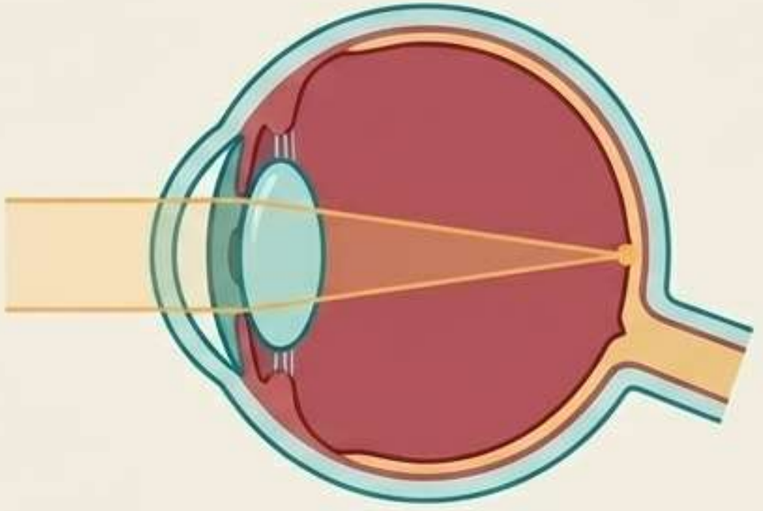
Troubleshooting the System: Vision Defects



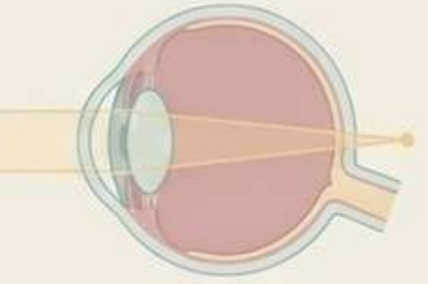
Myopia



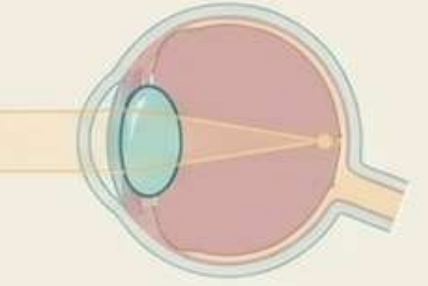
Astigmatism



Normal Eye



Hypermetropia



Presbyopia

Abnormalities in vision occur when the focal point of the eye lens misses the retina. The eye accommodates to a limit, but physical changes to the lens or eyeball require external correction.

Shortsightedness (Myopia)

The Experience

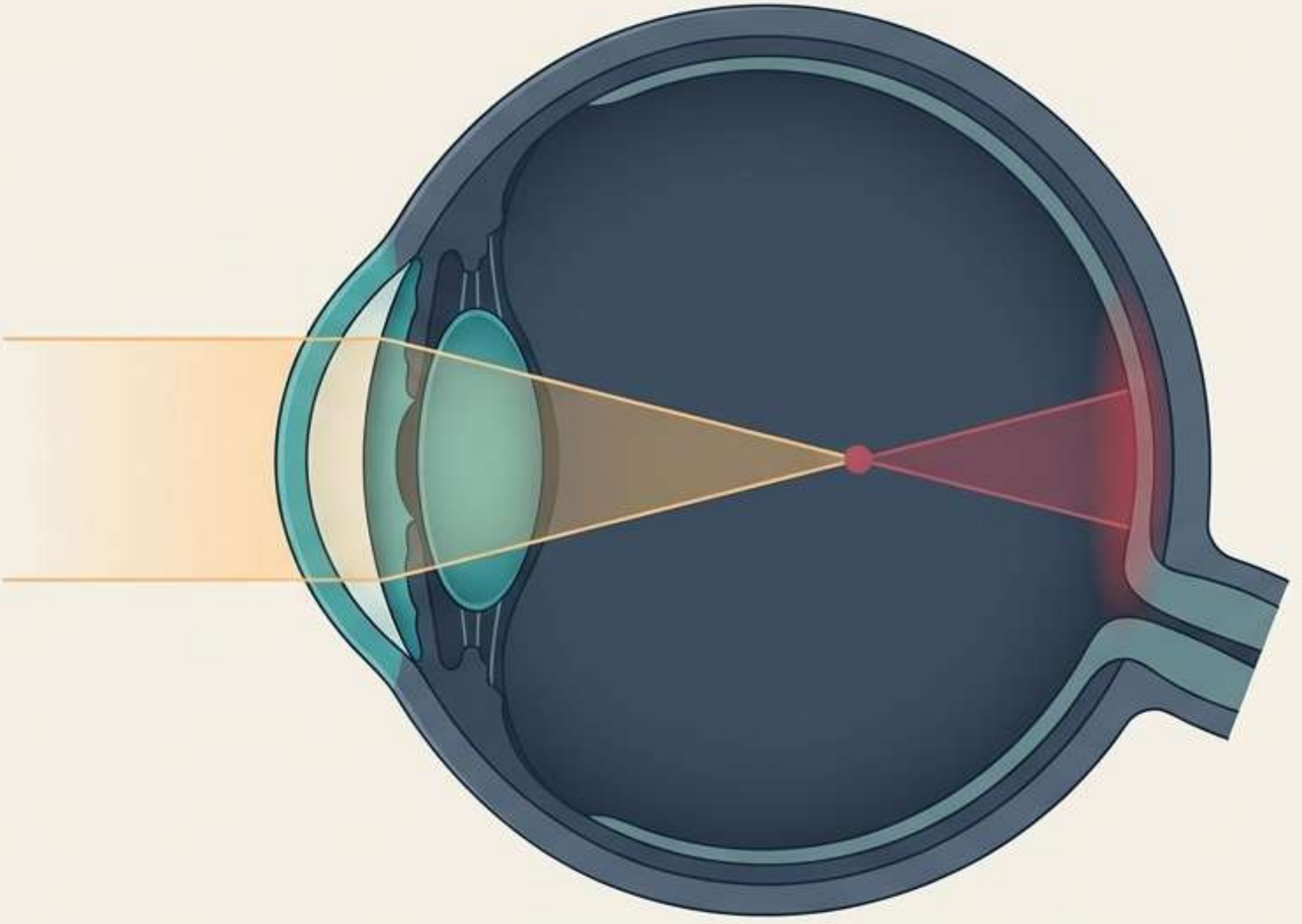
Can see nearby objects clearly, but distant objects are blurry.

The Cause

1. The eye lens is too convergent (decreased focal length).
2. The eyeball is elongated.

The Result

The image forms in front of the retina.



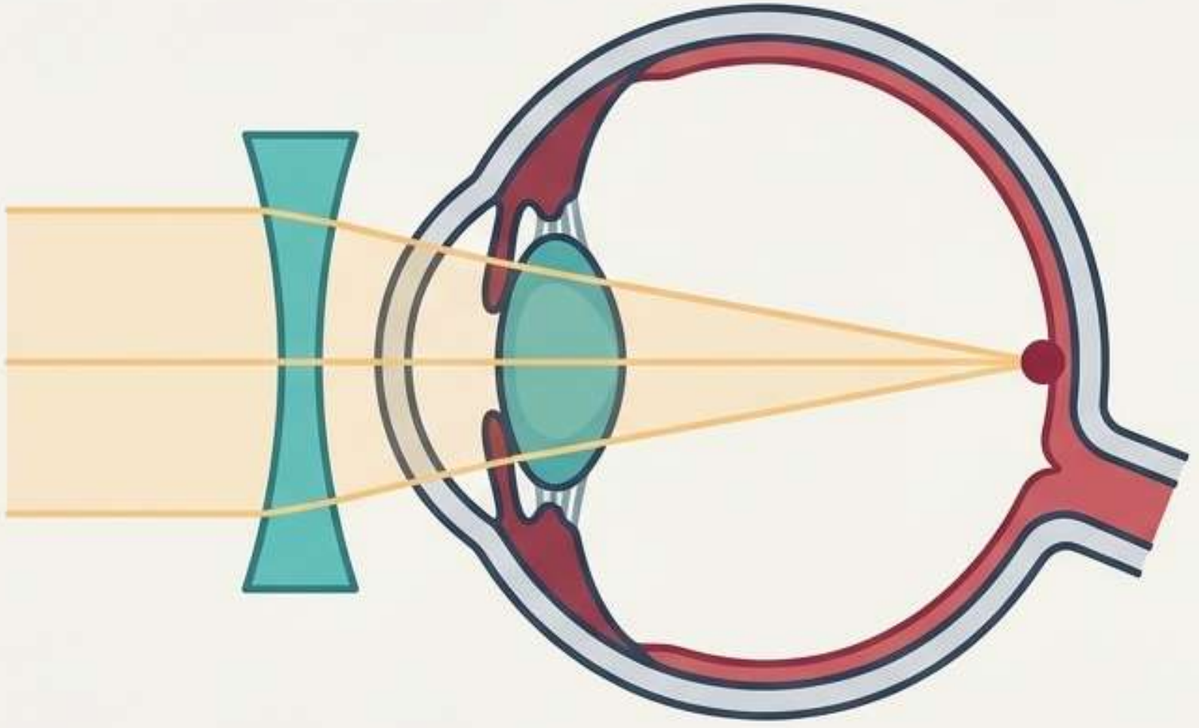
Correcting Myopia

The Fix

A Concave (Divergent) Lens.

How it Works

The lens slightly diverges incoming light, making rays appear to come from the myopic eye's actual far point.



The Math

$$f = -d$$

Longsightedness (Hypermetropia)

The Experience

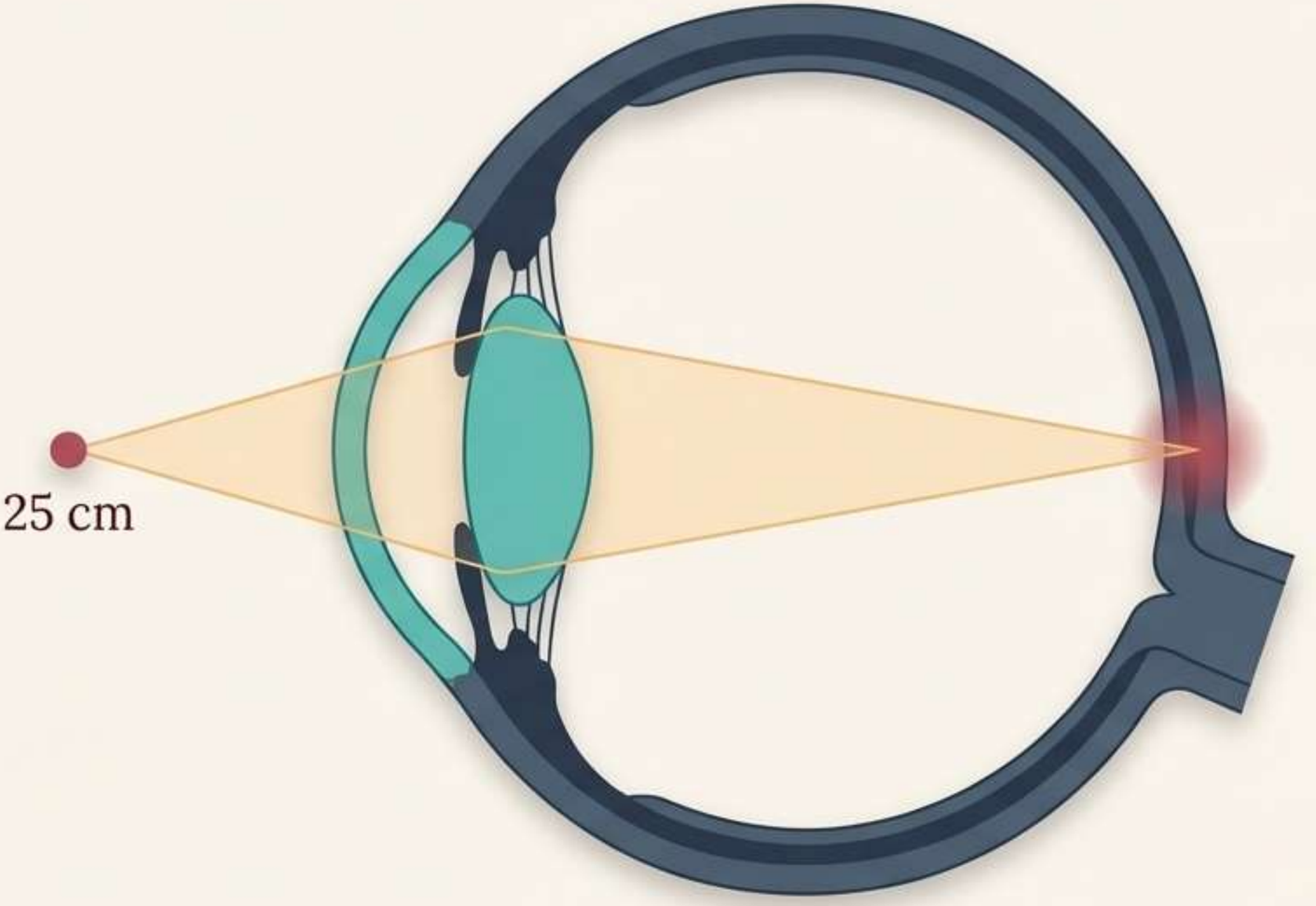
- Can see distant objects clearly, but nearby objects are blurry.

The Cause

1. The eye lens is less convergent (increased focal length).
2. The eyeball is shortened.

The Result

The image forms behind the retina.



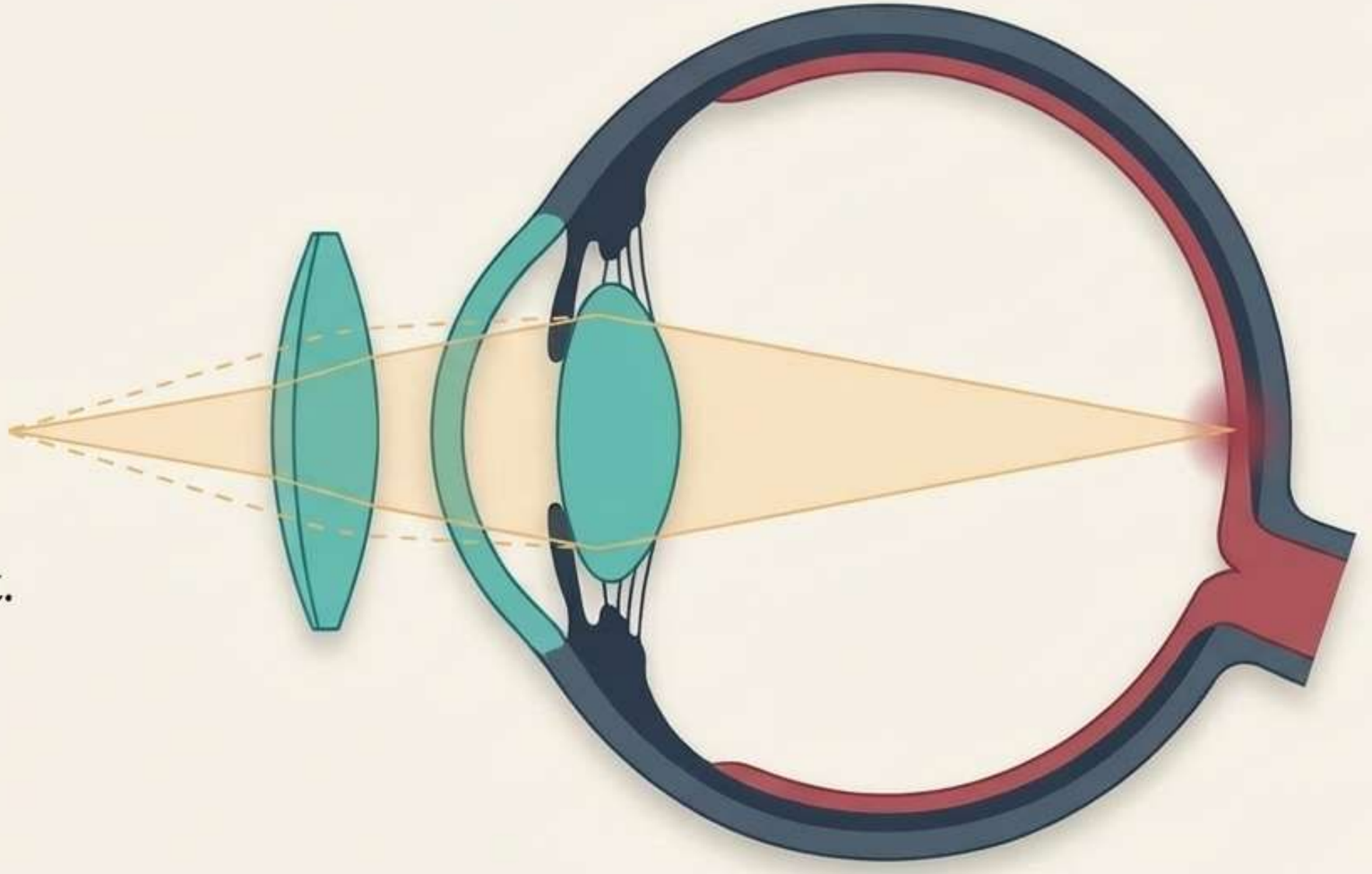
Correcting Hypermetropia

The Fix

A Convex (Convergent) Lens.

How it Works

The lens pre-converges incoming light, making rays appear to come from the defective eye's actual near point.



The Math

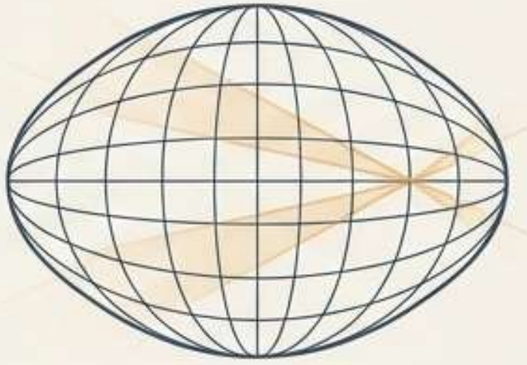
$$1/f = 1/v - 1/u$$

Age & Asymmetry

Presbyopia

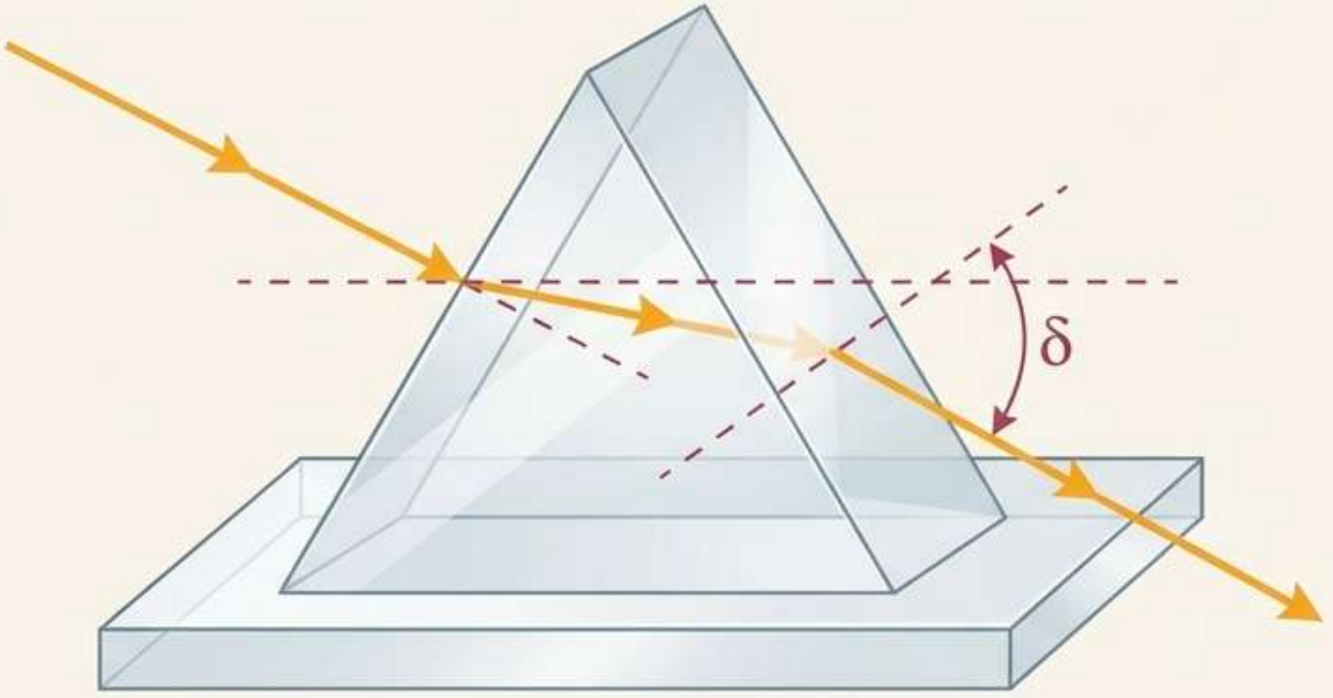
- Concept: The aging eye.
- Mechanism: Gradual weakening of ciliary muscles and diminishing flexibility of the crystalline lens.
- Result: Loss of accommodation power. People suffering from both Myopia and Hypermetropia require bi-focal lenses.

Astigmatism



- Concept: Asymmetrical focus.
- Mechanism: Cornea or eye lens is not perfectly spherical (more curved in one plane than another).
- Result: Horizontal and vertical views lack uniform clarity. Corrected using cylindrical lenses.

Bending Light: The Glass Prism



- The Phenomenon: Refraction. A prism is a transparent medium bound by two inclined plane surfaces.
- Angle of Deviation (δ): The specific angle through which the incident ray bends.
- Minimum Deviation: Occurs when the angle of emergence equals the angle of incidence.

Dispersion of White Light

The Cause

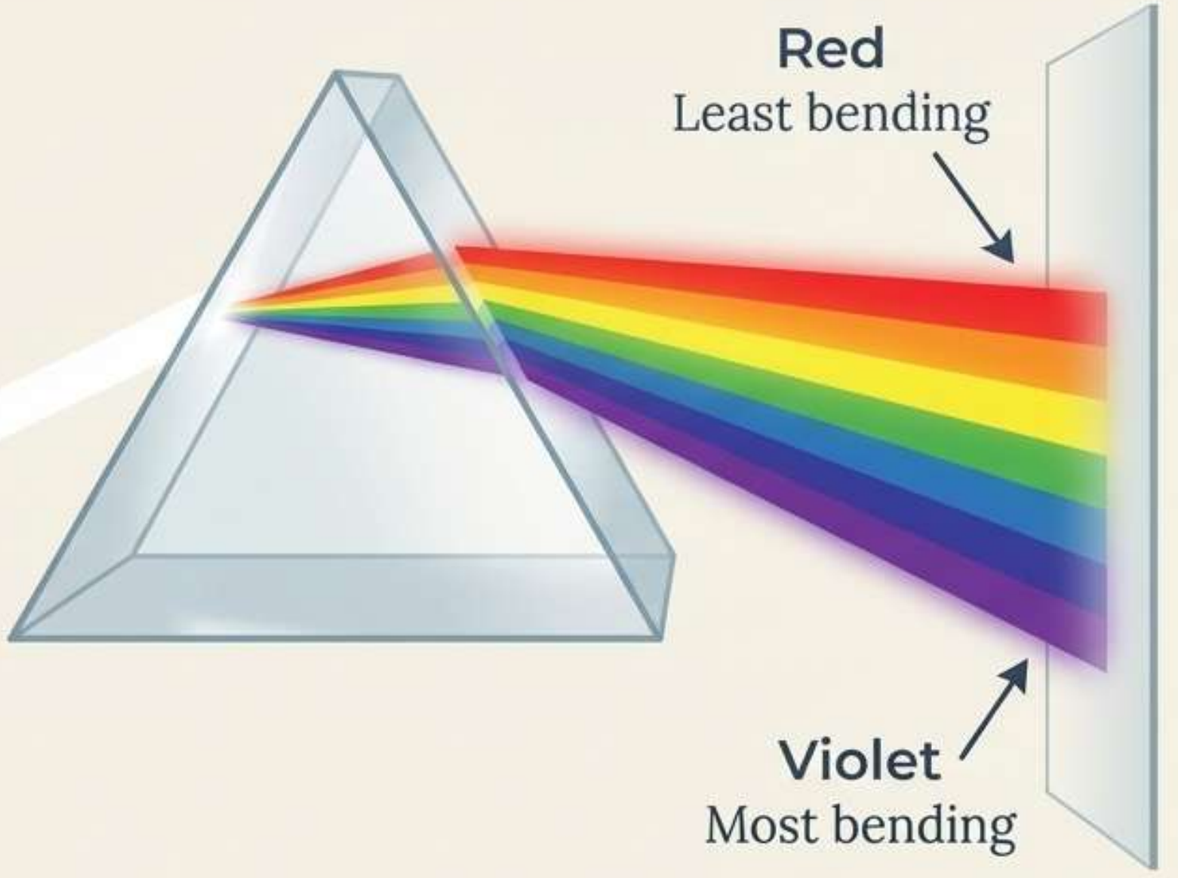
Different colors have different wavelengths and travel at different speeds in transparent mediums like glass.

Red Light

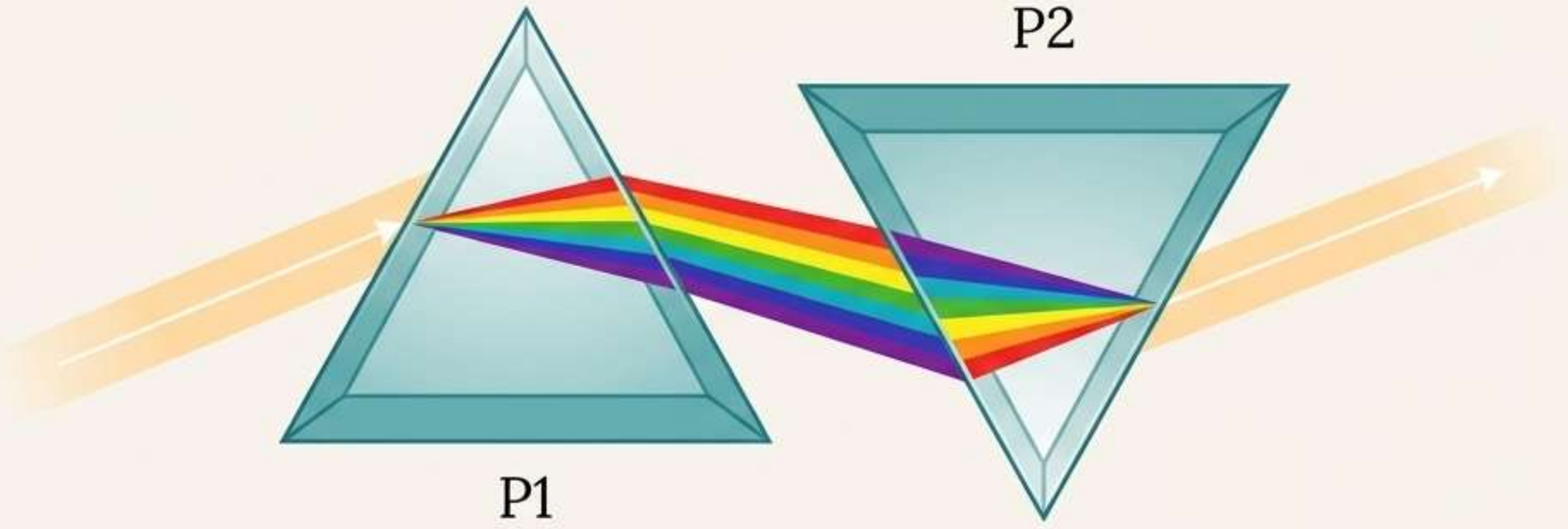
Longest wavelength, travels fastest in glass -> Bends the least.

Violet Light

Shortest wavelength, travels slowest in glass -> Bends the most.



Recomposing Light



Recombination. By passing the dispersed spectrum through an identical, inverted glass prism, the varying angles of deviation are perfectly reversed, recomposing the separated wavelengths back into pure white light.

Nature’s Prism: The Rainbow

Step 1: Refraction & Dispersion

Sunlight enters the droplet (rarer to denser medium) and splits into colors.

Step 2: Total Internal Reflection

The spectrum bounces off the inside back wall of the water droplet.

Step 3: Refraction

The light exits the droplet (denser to rarer medium), bending one last time to project the continuous colored band to the observer.