Rose Colored Glasses

How Our Eyes Perceive Color and How You Can Manipulate Color Like a Wizard

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- Sorted into House Opticianry 17 years ago
- Corporate and Private Practice
- Dispenser, Buyer and Vendor
- NAO Fellow, Member of State Associations
- Master of Public Health, International Health and Development – Tulane University
- Returned Peace Corps Volunteer

Class Overview

Color Perception

- Brief Review of the Anatomy of Color Perception
- Dig Deeper into Cones and Electric Impulses to Brain
- Understand how the brain interprets color
- Understand how culture interprets color

Color Manipulation: Wizardry

- Filters: Tints and Polarization
- Mirrors

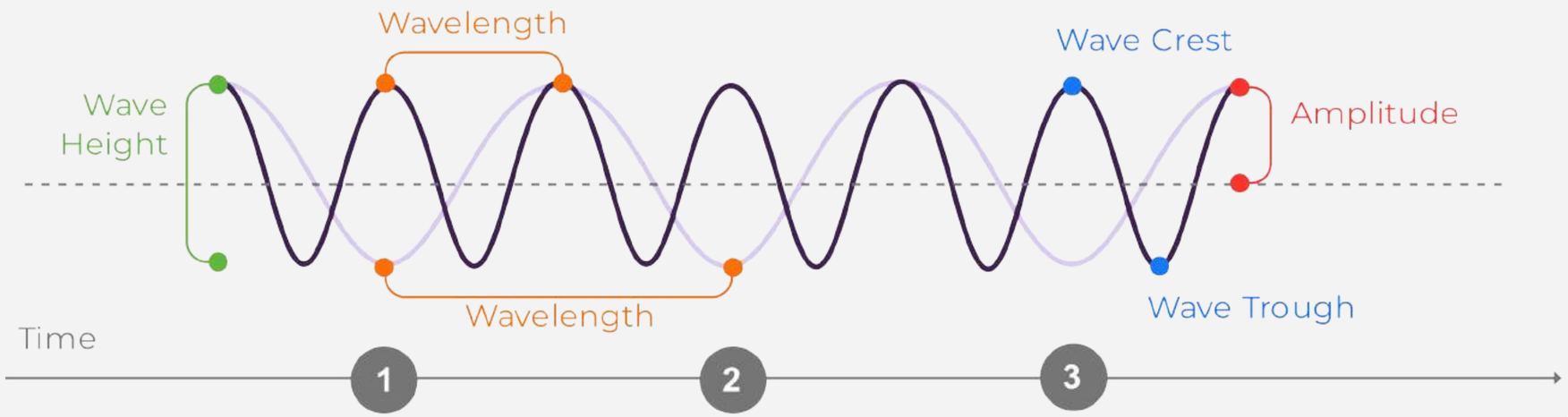
Why?

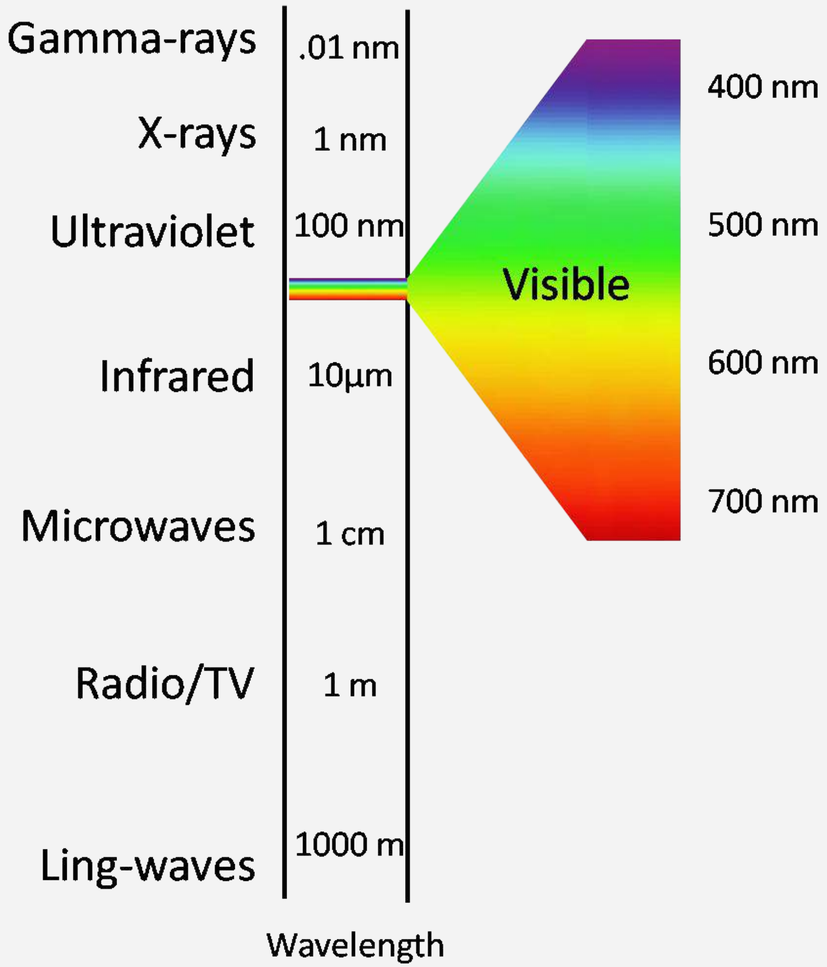
When we understand how we perceive color and then learn to manipulate color, we can better understand the tools that we already use (mirrors, polarization, tints) to improve the cosmetic outcomes of the eyewear we make and address real patient problems.

Understanding Light and Color

Wavelength & Frequency

- The distance between two consecutive crests or troughs, or light waves, is measured in wavelength.
- Wavelength and frequency are inversely proportional to each other. The higher the value of wavelength, the lesser the frequency and vice versa.
- The number of times light waves recur per unit of time is referred to as frequency.
- *Example* – Amplitude of wave, Frequency of wave (how many waves in a given period), Wavelength (how long it took to make a wave)





Visible Light

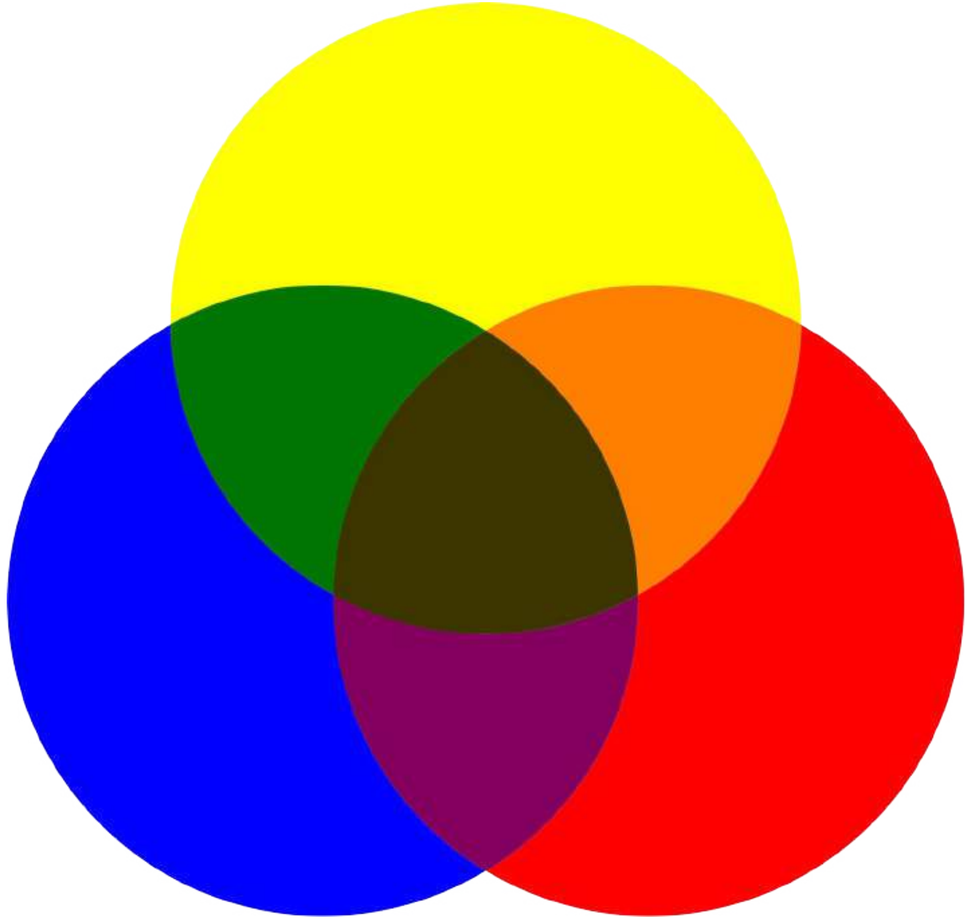
- 400-700 nm
- Short wavelengths have highest energy, most potential to do harm
- Long wavelengths are least likely to penetrate lids, ocular structures
- Each wavelength in the visible light spectrum corresponds to a color in the electromagnetic spectrum
- The human eye can perceive more than 2 Million colors with a sensitivity greater than one nanometer!

Color Models

Additive and Subtractive Color Mixing

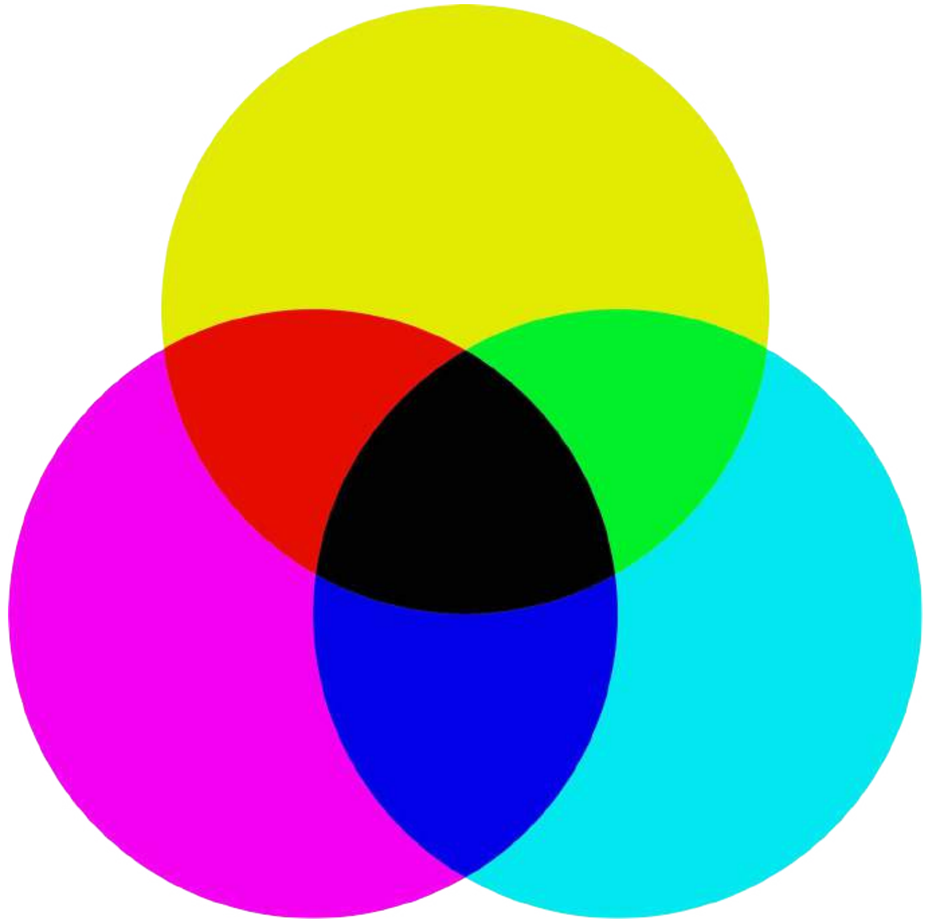
RYB Red, Yellow, Blue

- Subtractive – Think of light reflective off the subject to create color.
- Reflected Light – Chromophores absorb light in matter (usually in molecules as double bonds)
- Painting, etc. (pigments)
- Combine all colors, get Brown or Black



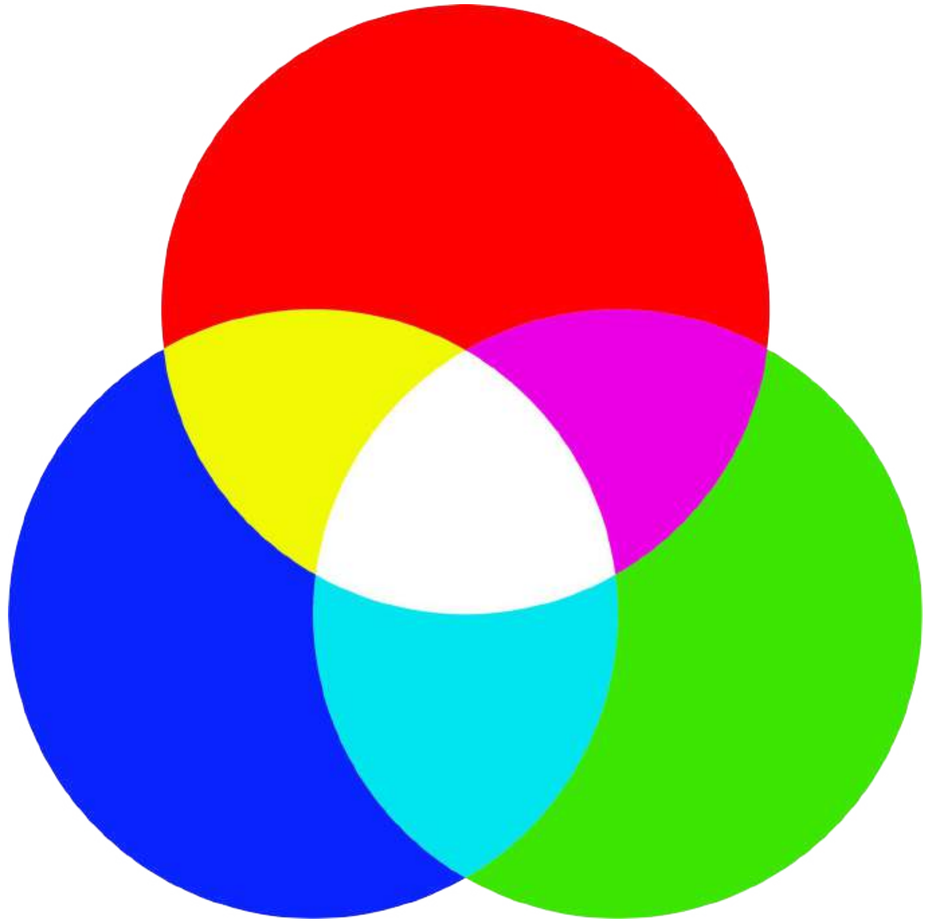
CMYK
Cyan, Magenta, Yellow, Black

- Subtractive – Removes Light
- Reflective Light – We start with White and subtract colors out (think white page)
- Printing
- Combine all colors, get black
- K is Black which is added to achieve pure black

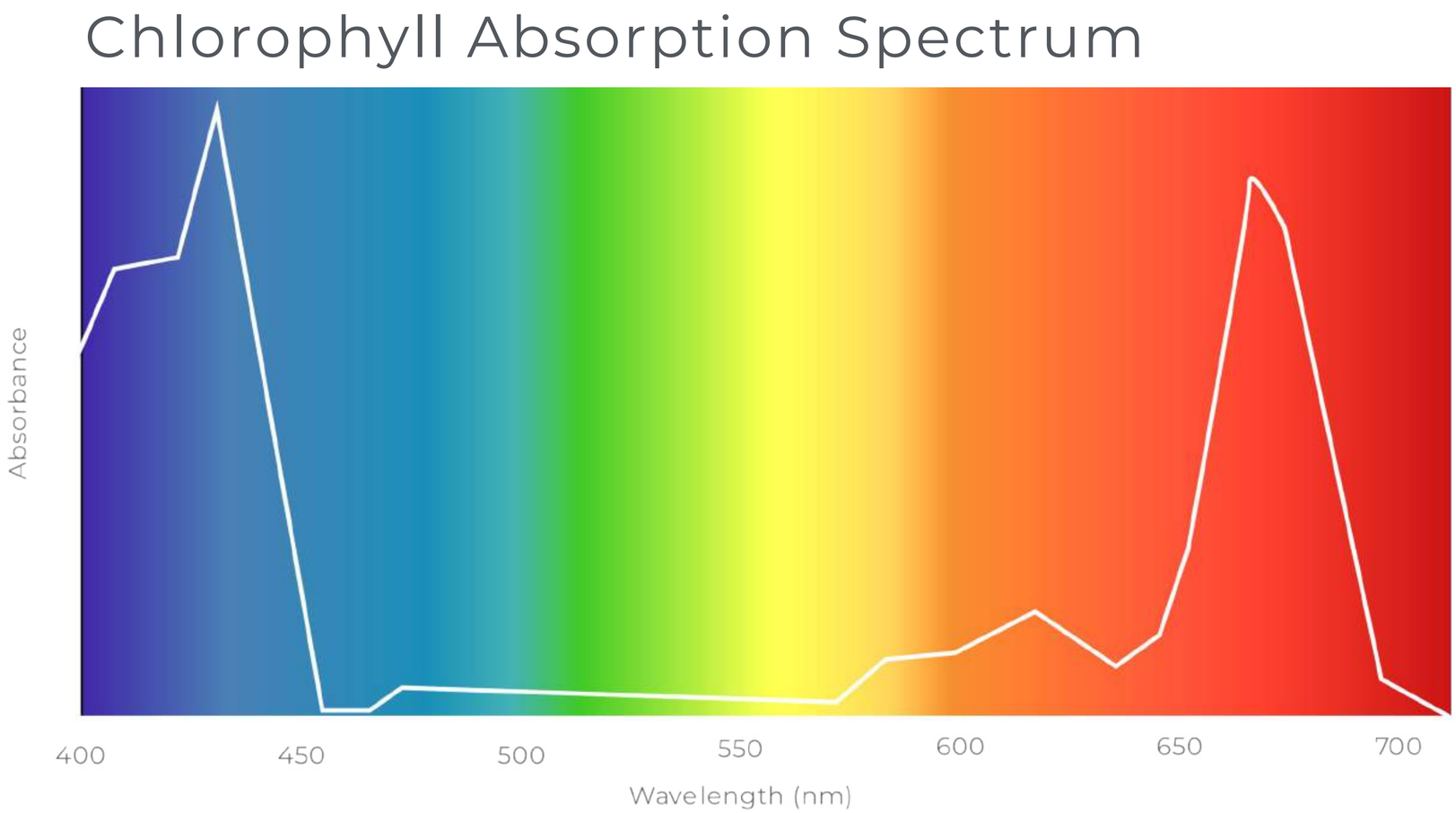


RGB
Red,
Green,
Blue

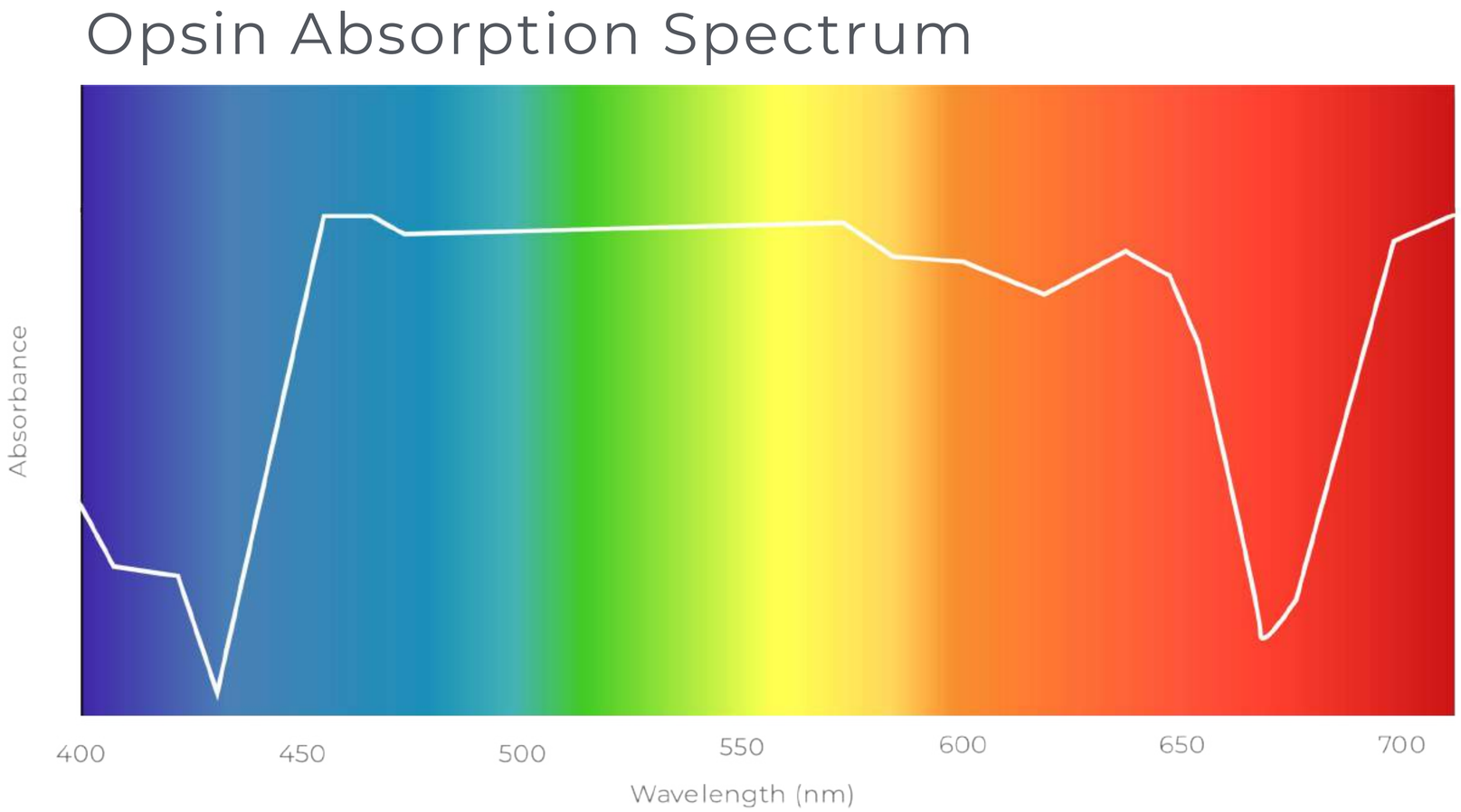
- Additive – By adding colors of LIGHT
- Absorbed Light
- Digital Media (screens)
- Combine all Colors, get WHITE
- Red + Green = Yellow
- Red + Blue = Magenta
- Blue + Green = Cyan



Reflected Light – Chromophore Absorption



Reflected Light – Human Eye Absorption



All colors are a combination of RGB Light

Yellow = Red + Green

Orange = Also Red + Green with more Red

Black = Absence of all Light

White = Presence of all Light

Brown = Presence of some level of specific colors

Pink = Presence of a lot of red light and a little of all else

Anatomy of Color Perception

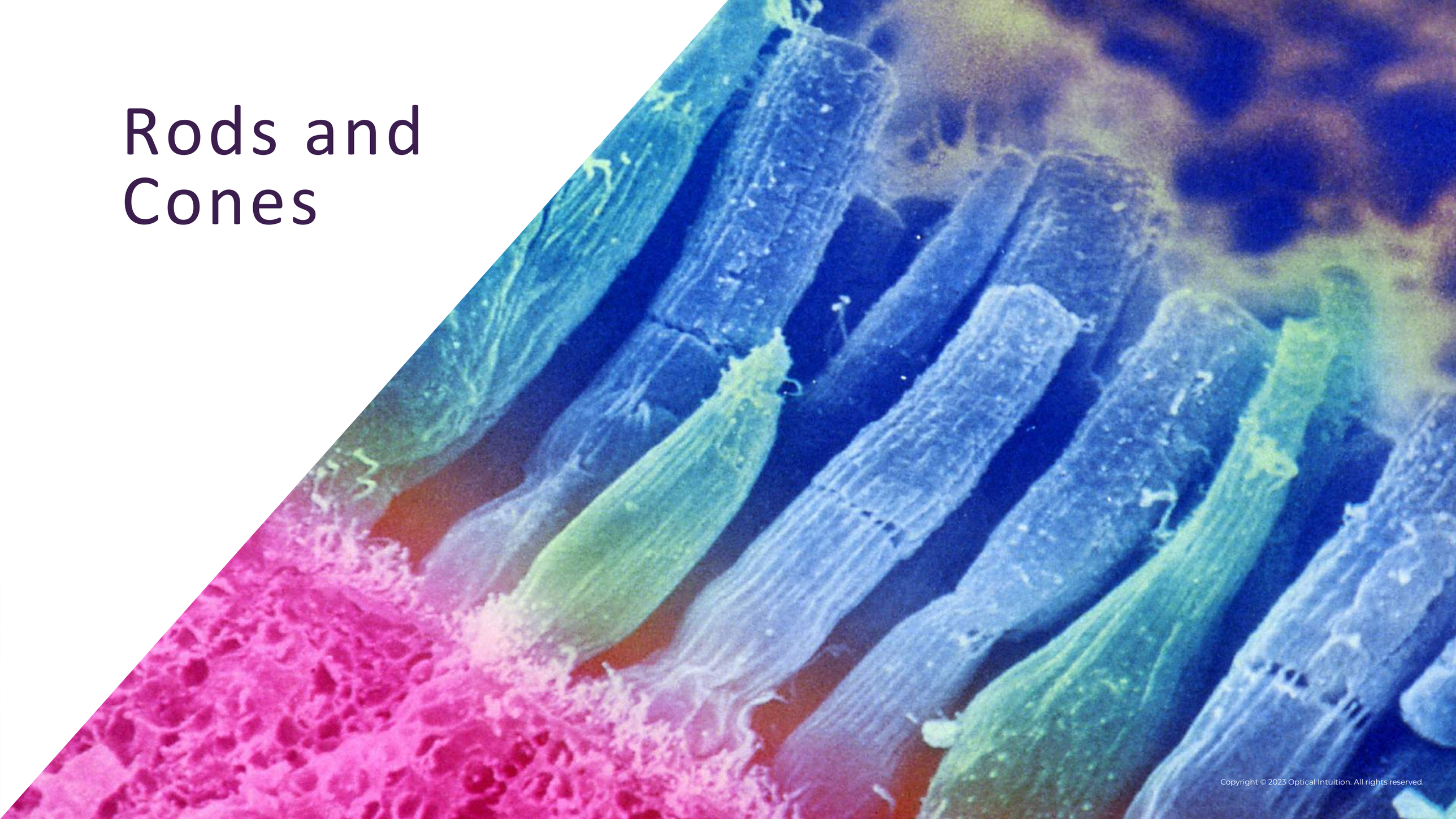
Scotopic vs. Photopic

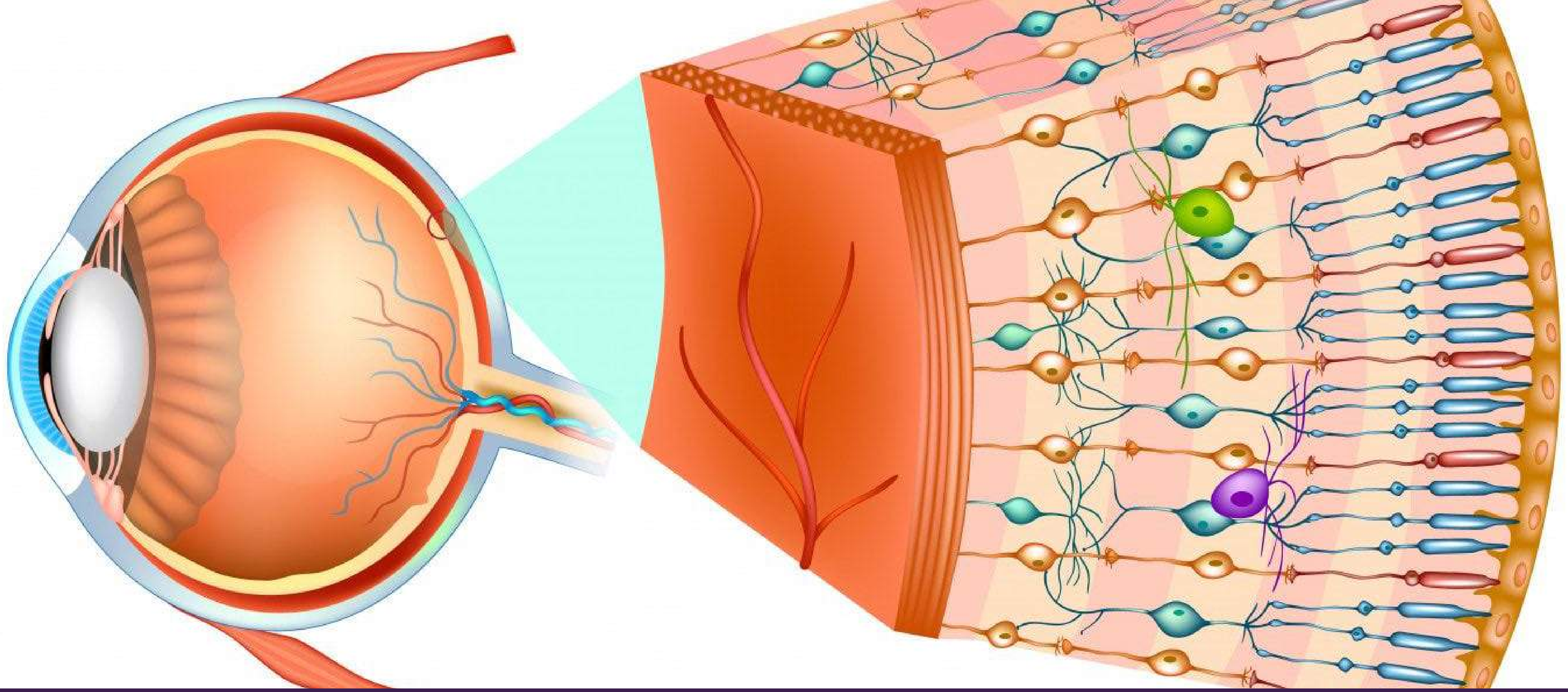
BE CREATIVE

- Black and White
- Motion
- Rhodopsins
- 120 Million + Rods, mostly in periphery
- Bleached – Broken down into All Trans Retinal and Opsin
- Regenerated

- Color
- Tremendous Acuity
- Photopsins
- 6-7 Million Cones
- Mostly in Macula Lutea and Fovea Centralis
- Fewer Blue (Short) Cones than Green (Medium) or Red (Long)

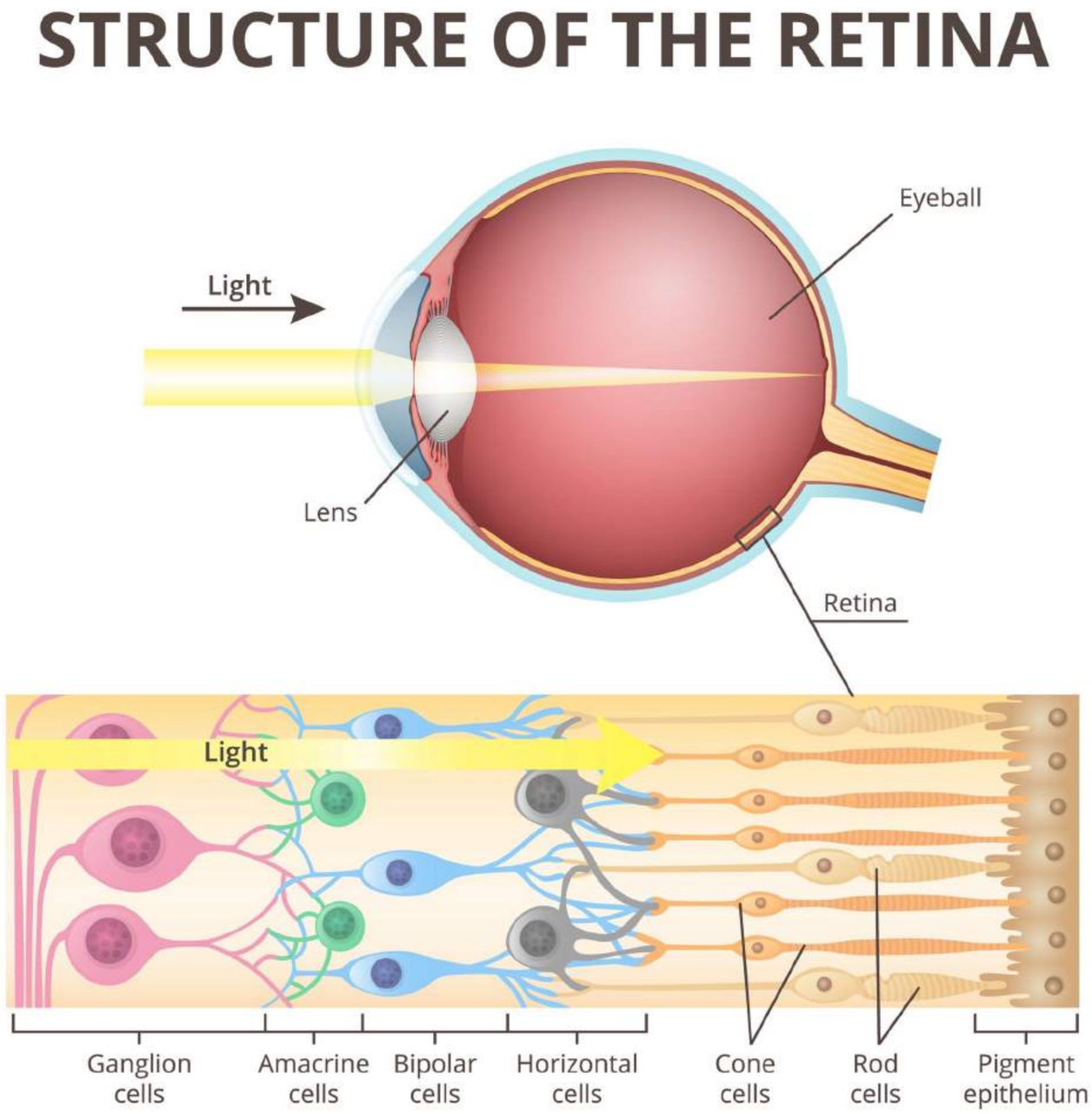
Rods and Cones





Anatomy of Color Perception

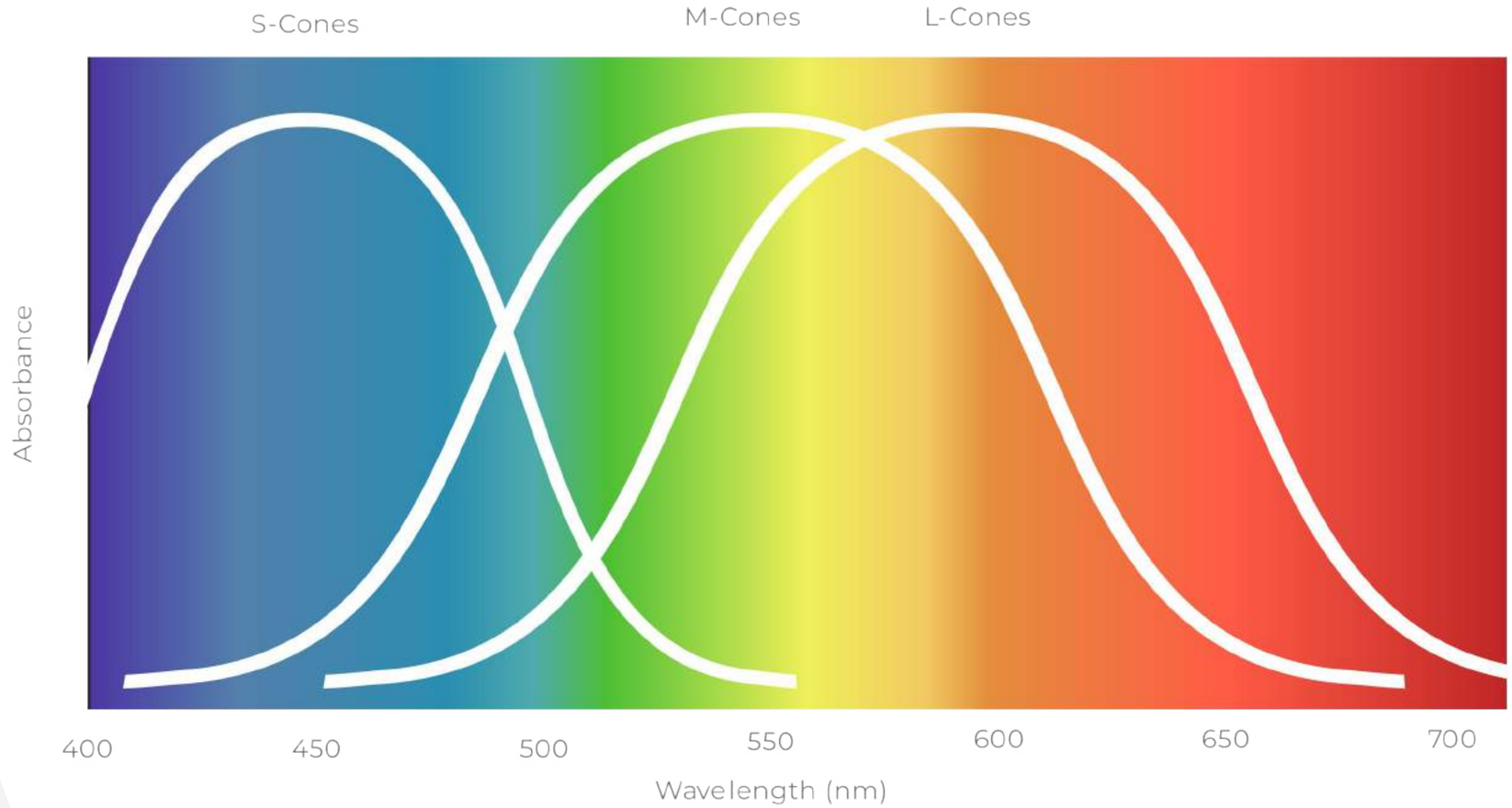
Movement of Light to the Cones



Cone and Rod Cells

- Opsins – Light sensitive and reactive compounds
- Photopsins are found in the Disks at the top of the cell.
- The type of photopsin determines the wavelength of light (Short, Medium or Long, i.e Blue, Green or Red) that the cone will be.
- Cone opsins, called iodopsins, use the same 11-cis-retinal as rhodopsin in rods but have very different spectral sensitivity.

Cone Photoreceptivity



Opsins are Photoreactive Proteins

Rhodopsin

- Found in Rods
- Requires Vitamin A
- Converts light to electricity
- Most sensitive at about 498nm

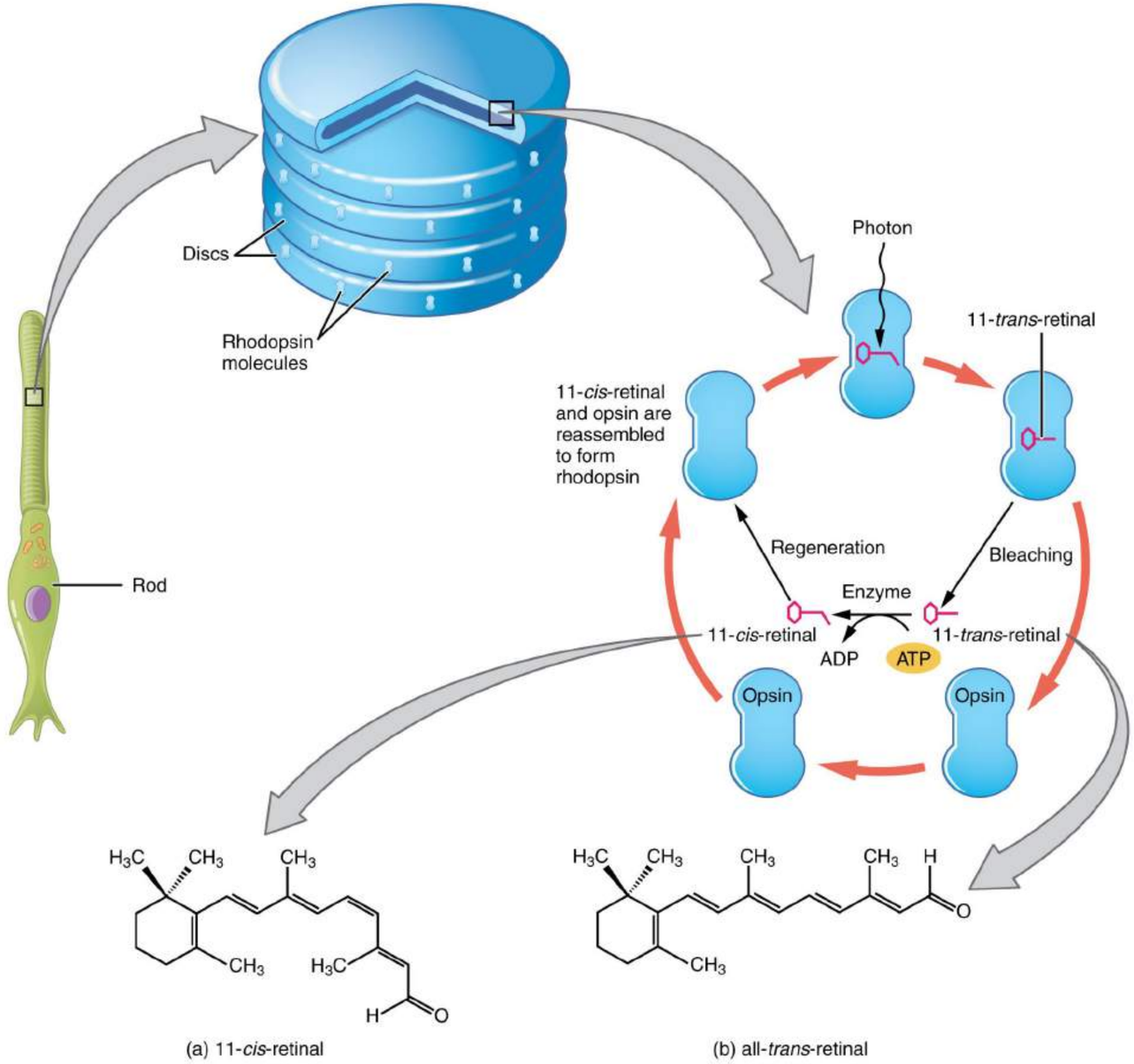
Iodopsins

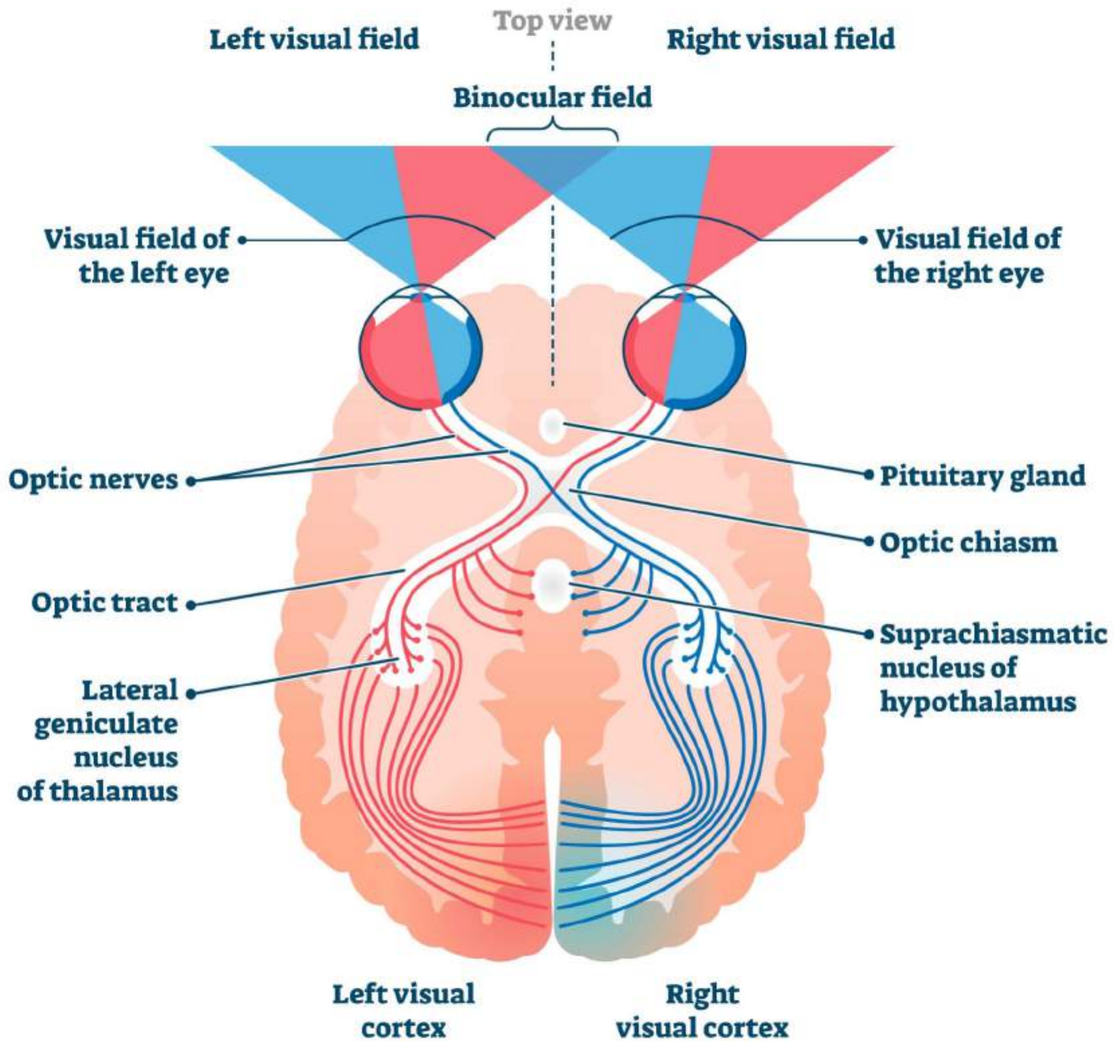
- L Cone Opsin – Red 557 - 564nm (Called OPN3)
- M Cone Opsin – Green 527- 533 nm (Called OPN2)
- S Cone Opsin – Blue 420 - 437 nm (Called OPN1SW)

The three cone opsins are similar in mechanism but differ in sensitivity.

Phototransduction Cascade

- How the eye translates light into chemicals
- Opsins – are Photoreceptor Compounds.
- Vitamin A Gets Broken down into 11 Cis Retinal, then Transducin and Hydrogen Ions – Ions, Sodium and sometimes Calcium, Magnesium and Potassium, are used to send electrical signal to brain by turning off channels of ion flow.
- Charged ions travel via the ganglion cells, back to the cranial nerve II (Optic Nerve) and to the brain.





Pathway to the Brain

- Retina Ganglion Cells send electricity to the brain
- Eye via Cranial Nerve II (Optic Nerve)
- Thalmus
- Midbrain (temporal lobe and perietal lobe)
- Occipital Lobe, near the back of the skull
- Interpreted in the Striate Cortex in what we call VISUAL PERCEPTION.

Melanopsin Retinal Ganglion Cells

Intrinsically Photosensitive Cells

In the RPE, we have melanocytes that contain MELANOPSIN (5 of 9)

Melanopsin triggers the chemical cascade that creates Melatonin, controlling Wakefulness

Controls:

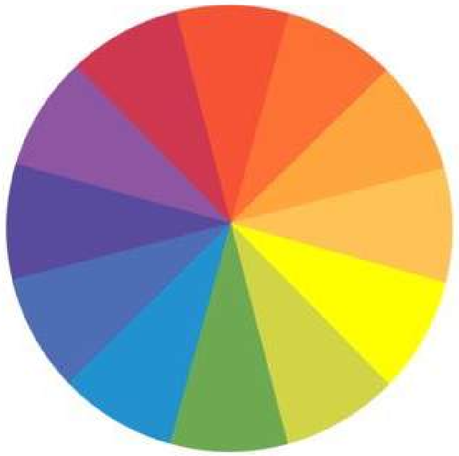
- Wakefulness, Blood Sugar Levels, Dopamine Levels, Pain Receptors

Analogous to frog skin,

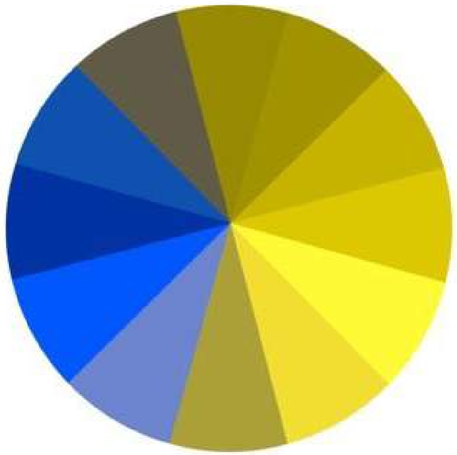
- Especially dense below macula
- Ten Minutes of being outside when the sun is low in the sky each day can help regulate all the above as a result, even in people with no vision.

Color Blindness - Cones lack photopsins/iodopsins

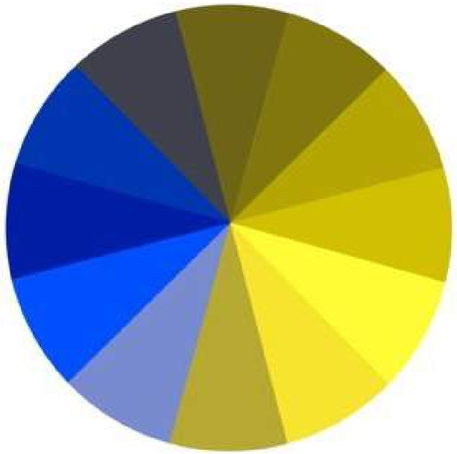
Normal vision



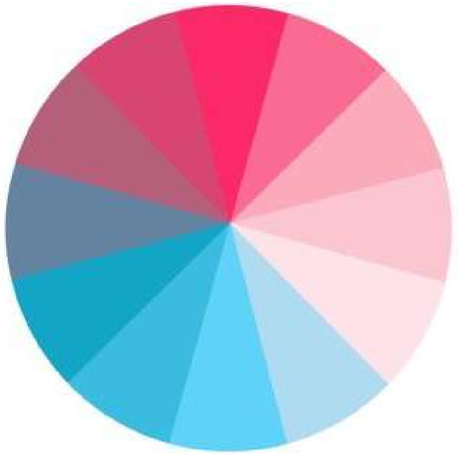
Deuteranopia



Protanopia

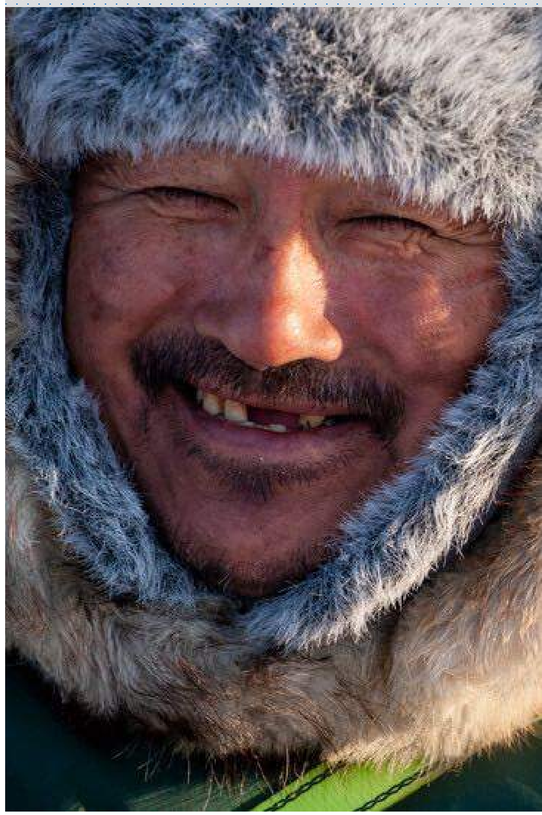


Tritanopia



Visual perception is context specific

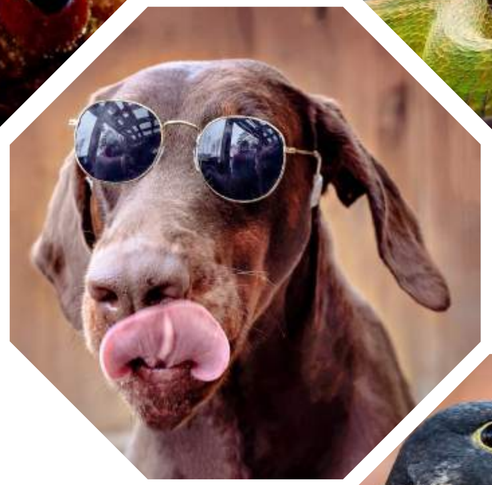
Color Language is CULTURALLY Specific



Color attaches to our emotion culturally

Color	Western Europe & North America	Asia	Middle East
	danger, anger, love, passion, excitement, action, adventure	joy, happiness, celebration, luck, prosperity	danger, evil, caution
	nature, progress, regeneration, eco-friendliness, luck, money, jealousy	youth, eternity, future, energy, exorcism, infidelity	fertility, strength, luck, wealth, prestige, spirituality
	masculinity, calm, authority, trust, peace, sadness, calm, loyalty	femininity, immortality, wealth	protection, safety, heaven, immortality, spirituality

Color is SPECIES Specific



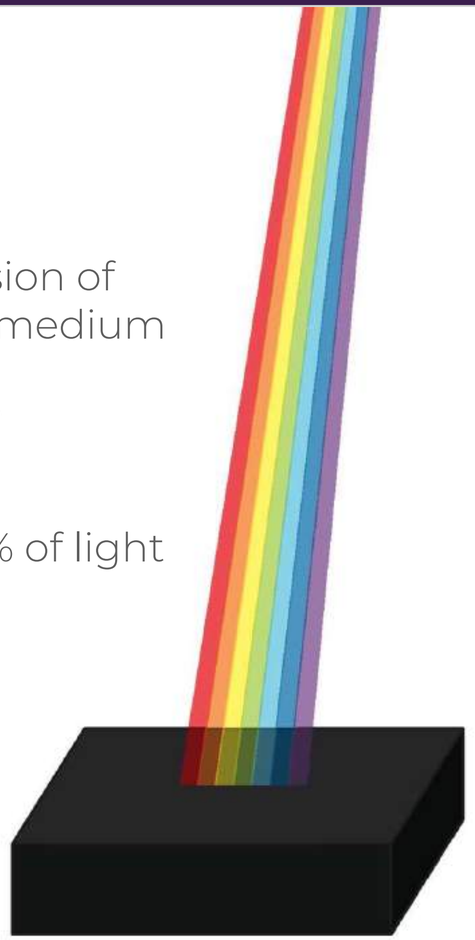
- Dogs and cats lack red and green cones. Green lawns look brown or orange.
- Mantis Shrimp see hundreds of colors we cannot see.
- Pit vipers can SEE heat emissions
- Ground Squirrel can see UV light.
- Diving Birds have bisected pupils and their brains can calculate the refractive properties of water.

Wizardry!

Absorption and Transmission

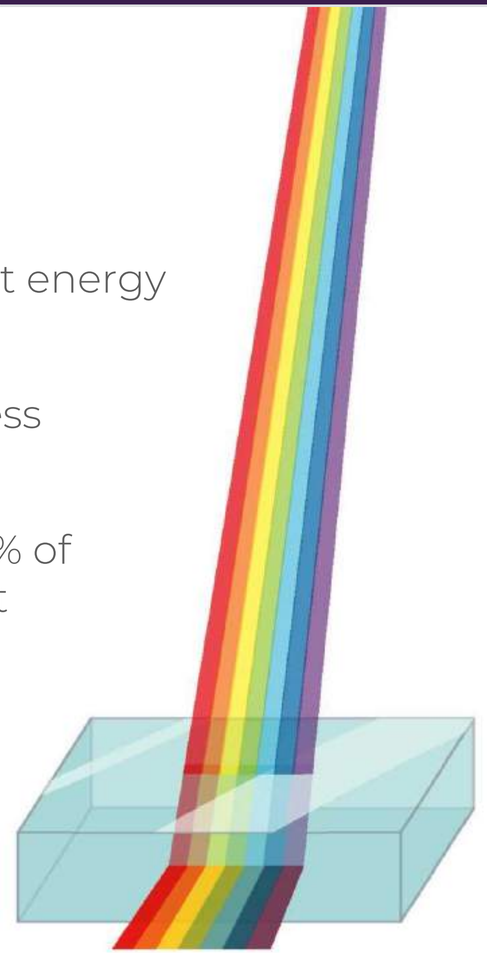
Absorption

- the reduction of transmission of radiant energy through a medium
- The more dense a tint, the more absorption
- Example: G-15 absorbs 85% of light



Transmission

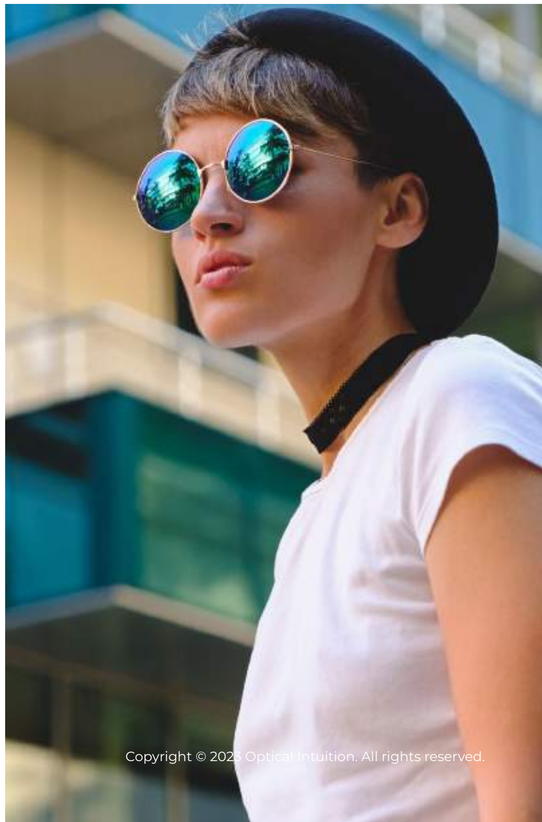
- the transit or passing of radiant energy through a medium
- The more dense the tint, the less transmission
- Sun Lenses should allow 15-30% of transmission, absolute darkest about 8%



Polarization

Mirrors

- Mirrors reflect back the color that you see on the outside, letting complementary colors through the lens more vibrantly.
- Think of Blue Mirrors used for fishing glasses: The water's surface is absorbing everything but blue and shooting it at you, your mirror lens reflects blue back, making the image you see look warmer, more yellow.
- Mirrors, like tints, do not reflect 100% of any color.
- Mirrors do reflect heat as well.
- Less scratch resistant, more often used for fashion.



Color Wheel

- Tints block the color of light that is across the color wheel and make you feel like you are perceiving more in the color of the tint.

- For example, a red lens is opposite Cyan on the RGB Color Wheel, thus Cyan, in addition to the red, will appear dark brown or black and seem to disappear.

Gray Lenses

- Reduce transmission of all wavelengths of colors, mostly uniformly*, thus, is truest in color
- Good for: Photographers, color enthusiasts, getting darkest lenses
- Conditions: Optic Neuropathy, Albinism, Photophobia, Parkinson’s Disease, Blinking Spasms in bright light.

Brown Lenses

- Enhances Contrast
- Most closely mimics Melanin
- Conditions: Sun Lenses for people with cataracts, glaucoma, low vision
- Glaucoma typically causes a decrease in blue and green cones first, then red later in the disease progression.

Red Lenses

- Conditions: Retinitis Pigmentosa, Low Vision, Light-Induced Migraines, AMD, Brain Trauma, Color Blindness (Deuteranomoly), Dyslexia
- Macular Degeneration (AMD) typically results in a decrease of red cone viability.

Orange or Amber Lenses

- Conditions: AMD, Optic Neuropathy, Brain Trauma, Contrast Sensitivity, Computer Related Eyestrain, Dyslexia, Light-Induced Migraine, Low Vision, Retinitis Pigmentosa

Yellow Lenses

- The best starter lens for many comfort-related conditions but may be cosmetically less appealing.
- These block blue but it is only a partial blocker. It is very difficult to get a deeply absorptive yellow.
- Adored by truckers, shooters and gamers, but little evidence to support improved performance.
- Conditions: AMD, Autism, Cataracts, Computer-Related Eyestrain, Contrast Sensitivity, Glaucoma, Insomnia, Multiple Sclerosis, Visual Snow Syndrome.

Green Lenses

- Conditions: Light-Induced Migraine, Visual Snow Syndrome, Dyslexia, Optic Neuropathy, Autism

Blue Lenses

- Conditions: Think Blue = Brain. Soothes agitated brains
- Brain Trauma, Autism, Dyslexia, Parkinson’s Disease, Light Induced Epilepsies, Strabismic Amblyopia (Lazy Eye), Visual Snow Syndrome

Purple, Plum, Magenta Lenses

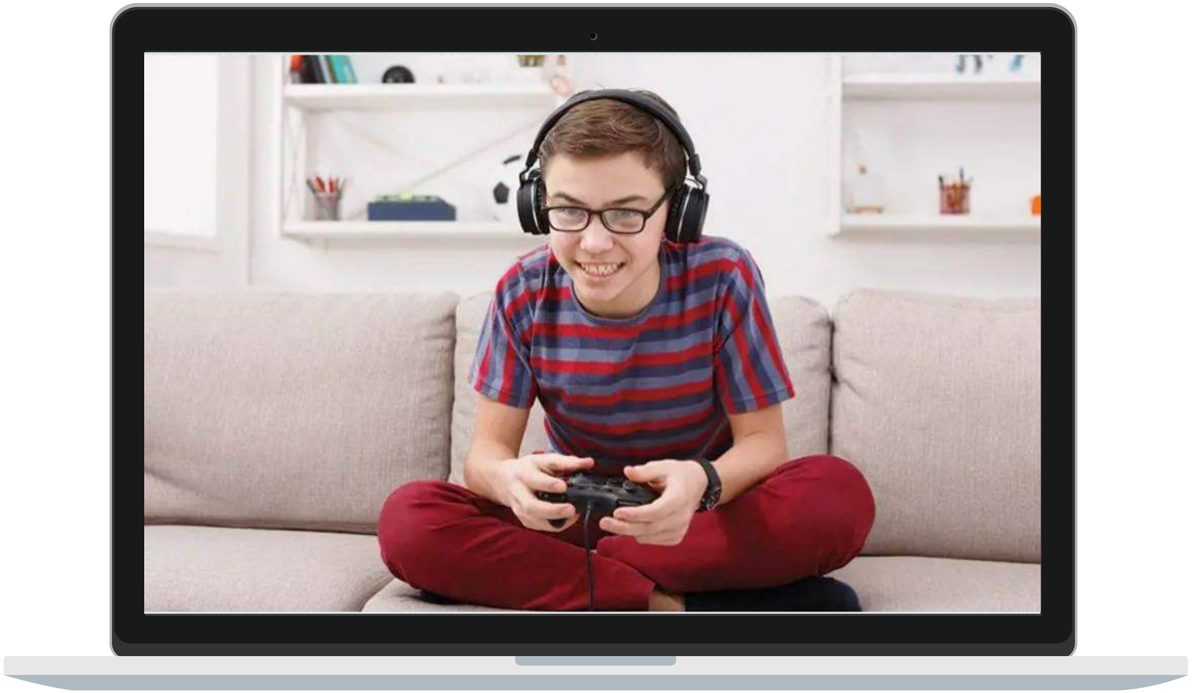
- Color Blindness, Especially Protanomoly: Enchroma Lenses

Pink Lenses

- Surprisingly True Color!
- Conditions: Dyslexia, Computer-Related Eyestrain

You Try It

Troy is a gamer. His favorite game is Fortnite where the screen has lots of blues and purples. He is neurodivergent and is sensitive to bright lights and struggles especially at school under fluorescent lights. He is being evaluated for dyslexia as well.



You Try It

Bono is a performer; he is constantly under really **bright lights** and in and out of crowds. He plays music, so **needs to be able to ready black notes on a white page easily**. He feels extremely light sensitive and is being treated for **glaucoma**. What color lenses should Bono consider?

Photo: Daniel Hazard, CC BY-SA 4.0 <https://creativecommons.org/licenses/by-sa/4.0>, via Wikimedia Commons

Whatever tint he prefers when given options!

Bono should have many pairs. But he will probably prefer his yellow tints indoors and dark lenses like grey outdoors.

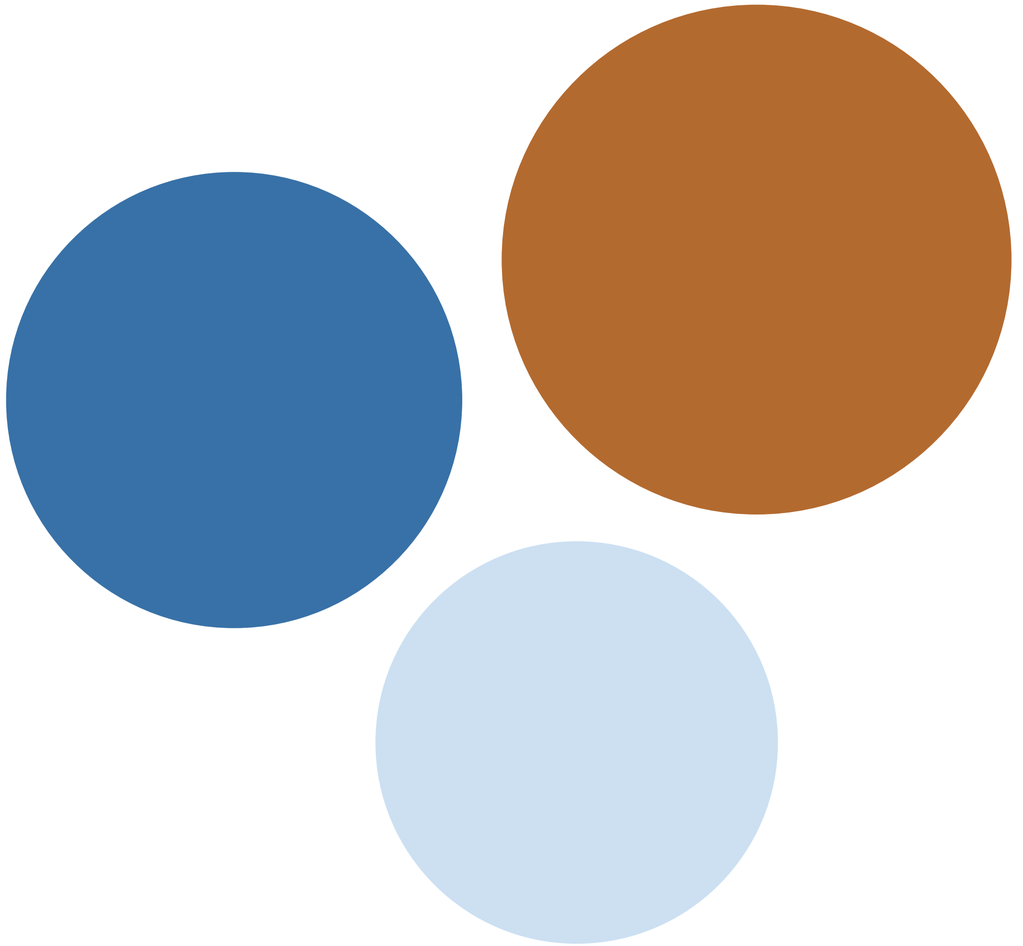
Tints can help you sell multiple pairs of eyewear.
And they are HOT!

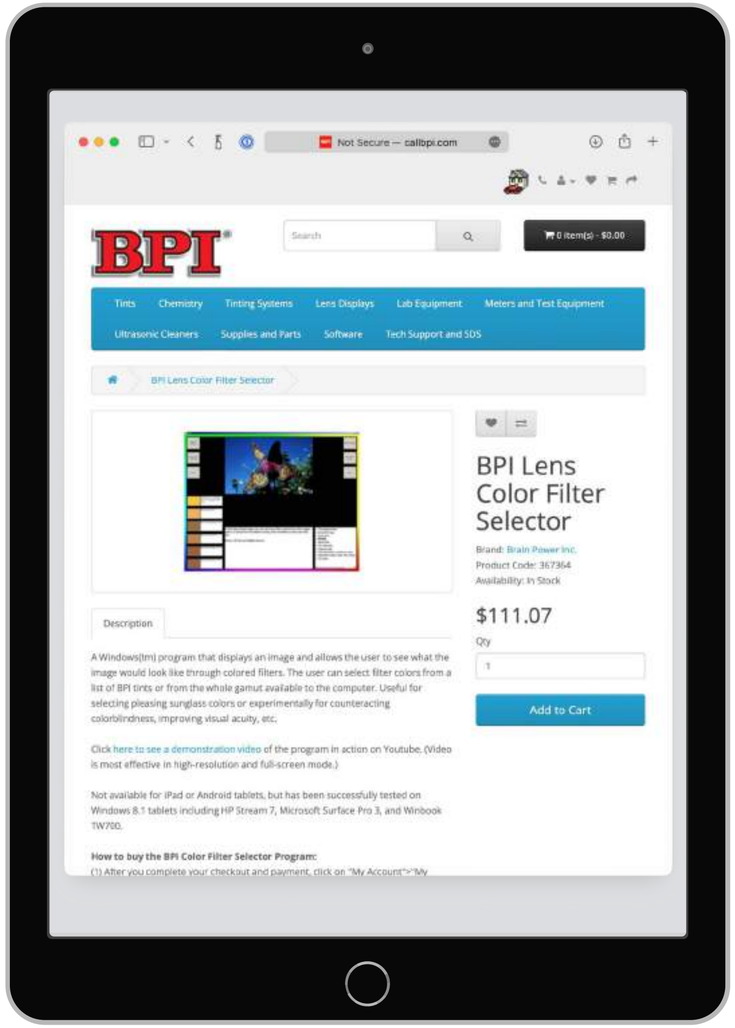
Specialty Tints: Expensive but Therapeutically Significant

- FL-41: A deep, orange/brown color. Used for: Photophobia, Light-Induced Migraine, Color Blindness, Brain Trauma, Lid Spasms.

- Deep Blue Zee: A very deep blue color, blocks a LOT of light. Used for: Photosensitive Epilepsy, Parkinson's, Strabismic Amblyopia

- Omega: Light Blue, similar to Maui Jim Opthalmics High Contrast Lens, Used for: Brain Trauma, Dyslexia, Autism





No Tint is a Cure All for Everyone

Use tint samples to assess comfort of the wearer or Filter Simulators

BPI Lens Color Filter Selector

https://www.callbpi.com/golf/index.php?route=product/product&product_id=851

A word about Syntonics

Syntonics is an optometric phototherapy dealing with the application of selected light frequencies through the eyes.

It has been used clinically for over 70 years in the field of optometry with continued success in the treatment of visual dysfunctions.

Effective for: Focusing issues, strabismus, amblyopia, convergence problems, learning disorders, affects of stress and trauma, brain injuries, emotional disorders, jet lag, PMS, sleep disorders, mood and behavior disorders.

Please make sure to provide feedback in the course evaluation. You help make me better!

Reach out at cira@cira.me