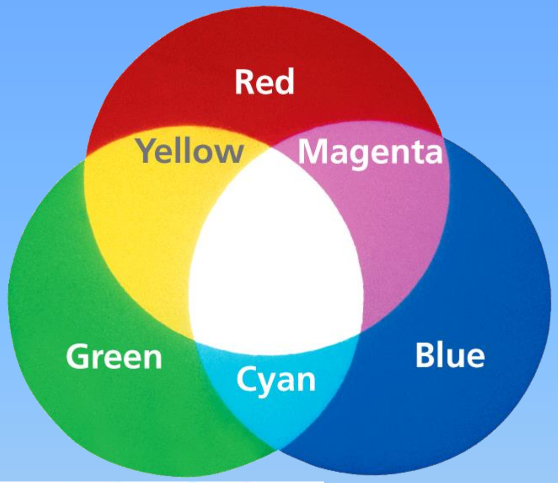
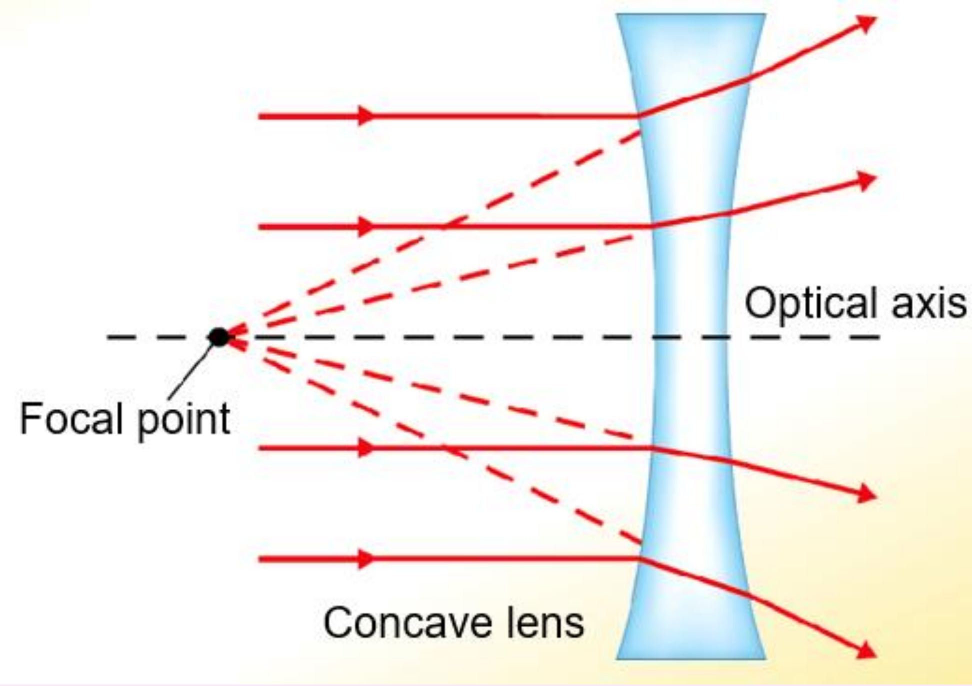
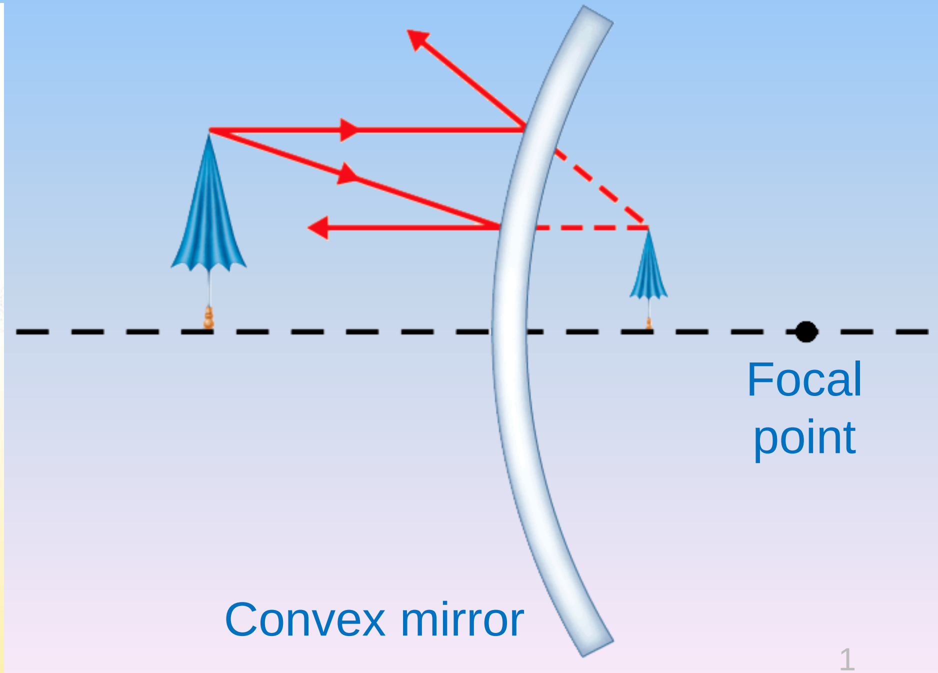
Optics Chapter 19



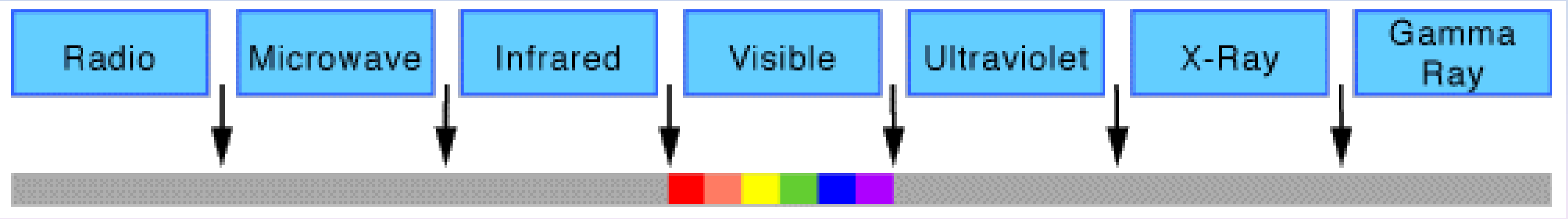




What is the relationship between frequency and wavelength: $c = f \lambda$?

Do radio waves have lower or higher frequency than visible light? What about X-rays compared to visible light?

Order the colors of the rainbow from highest to lowest frequency.



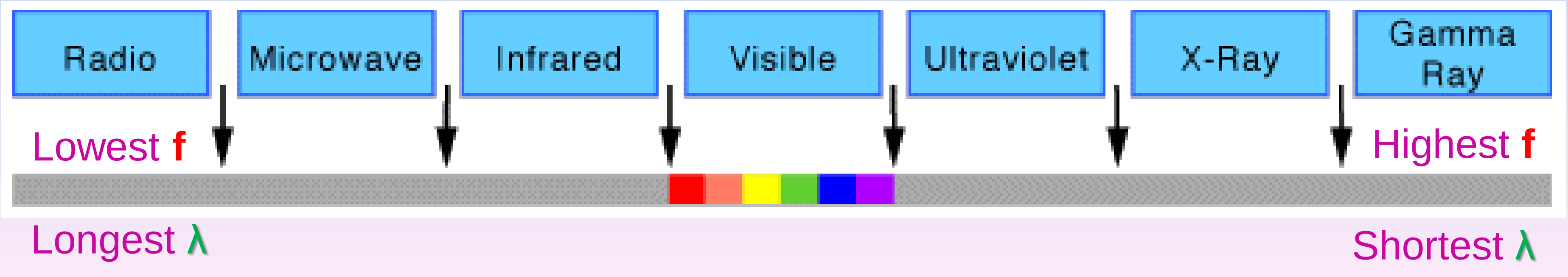
What is the relationship between frequency and wavelength: c = f λ? inverse

WARM-UP

Radio waves have lower frequency than visible light. X-rays have higher frequency than visible light.

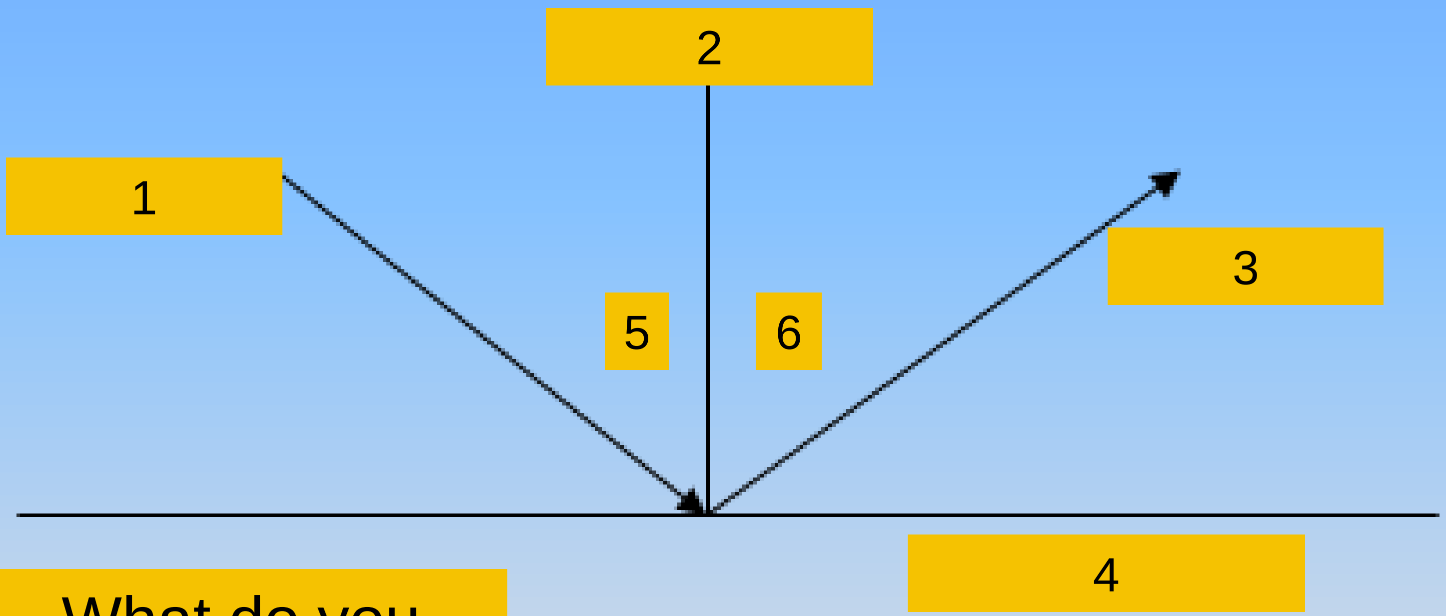
Order the colors of the rainbow from highest to lowest frequency. VIBGYOR

ROYBIV (longest to shortest wavelength)



WARM-UP

Title and label the following diagram:

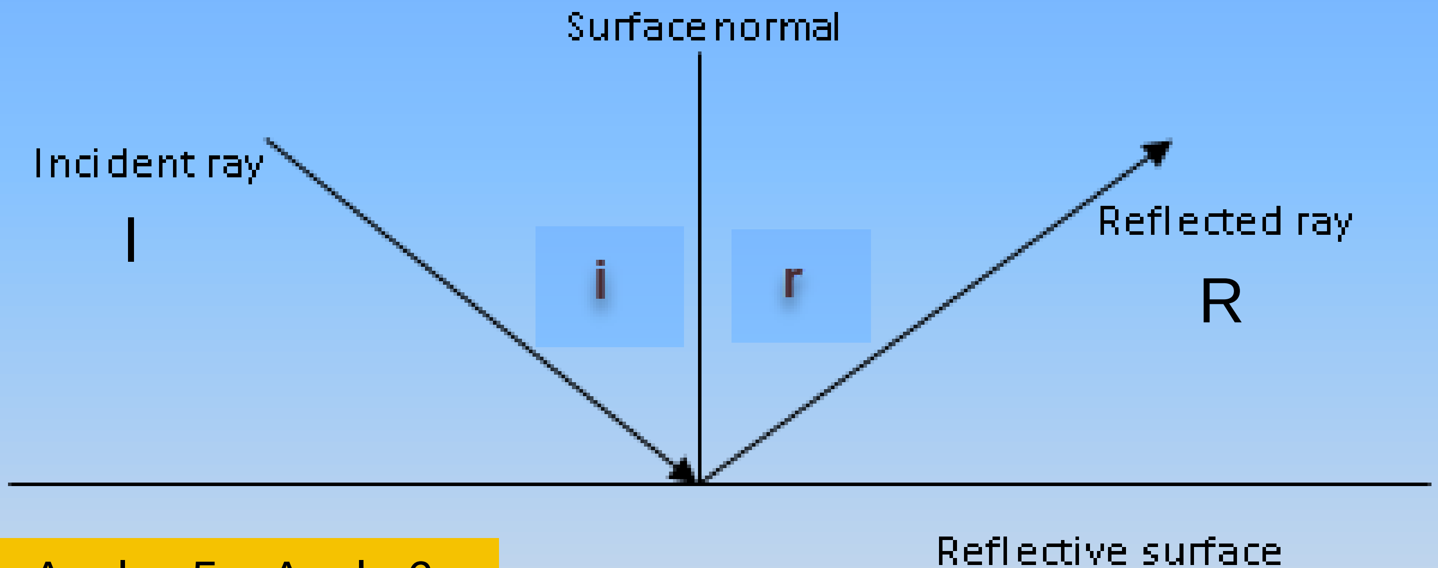


What do you know about angles 5 & 6?

WARM-UP

Label the following diagram:

Specular Reflection



Angles 5 = Angle 6

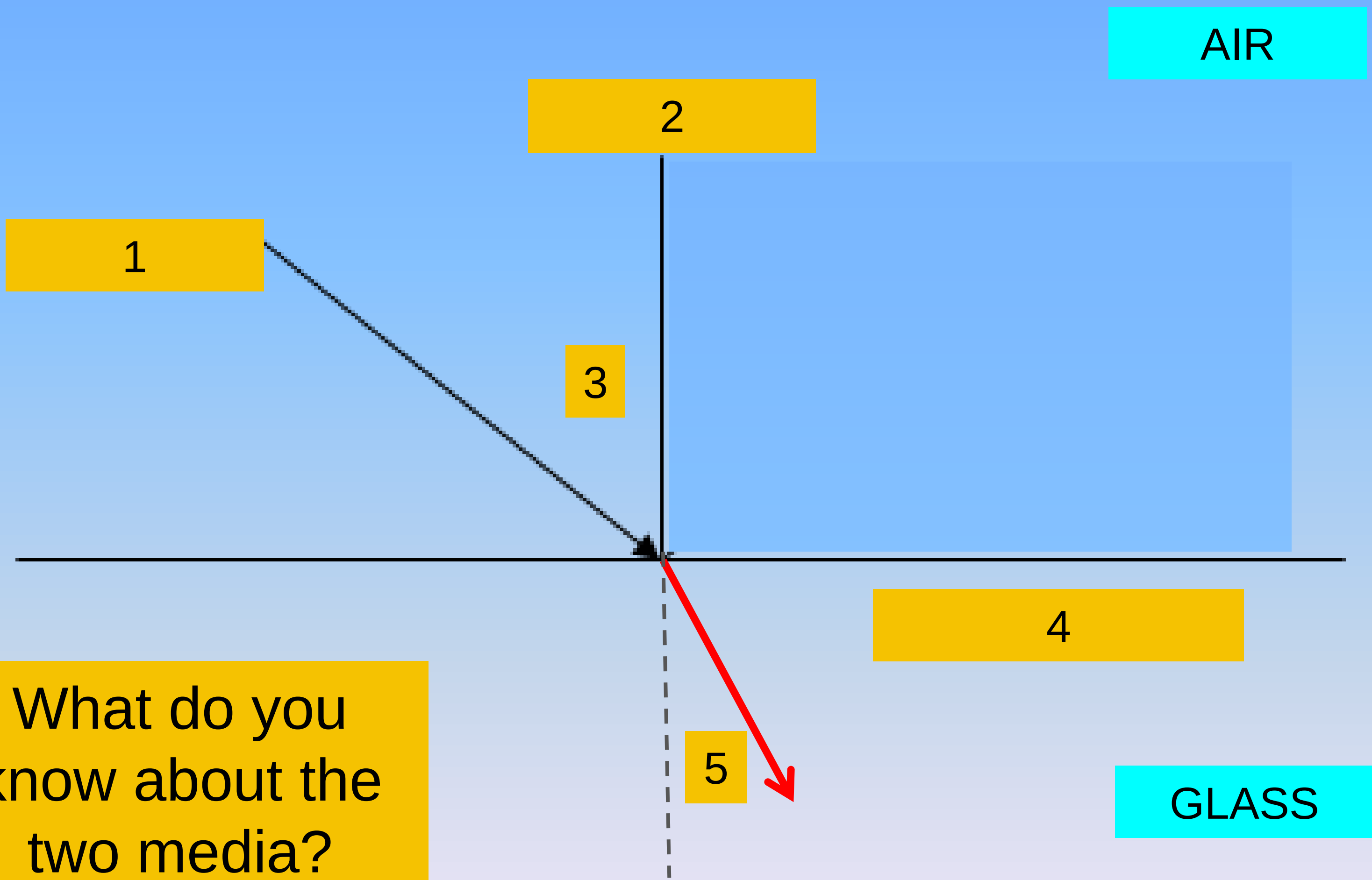
i = r

i = incident angle

r = refracted angle

WARM-UP

Air is the top medium and glass is the bottom medium. **Title and label the following diagram:**



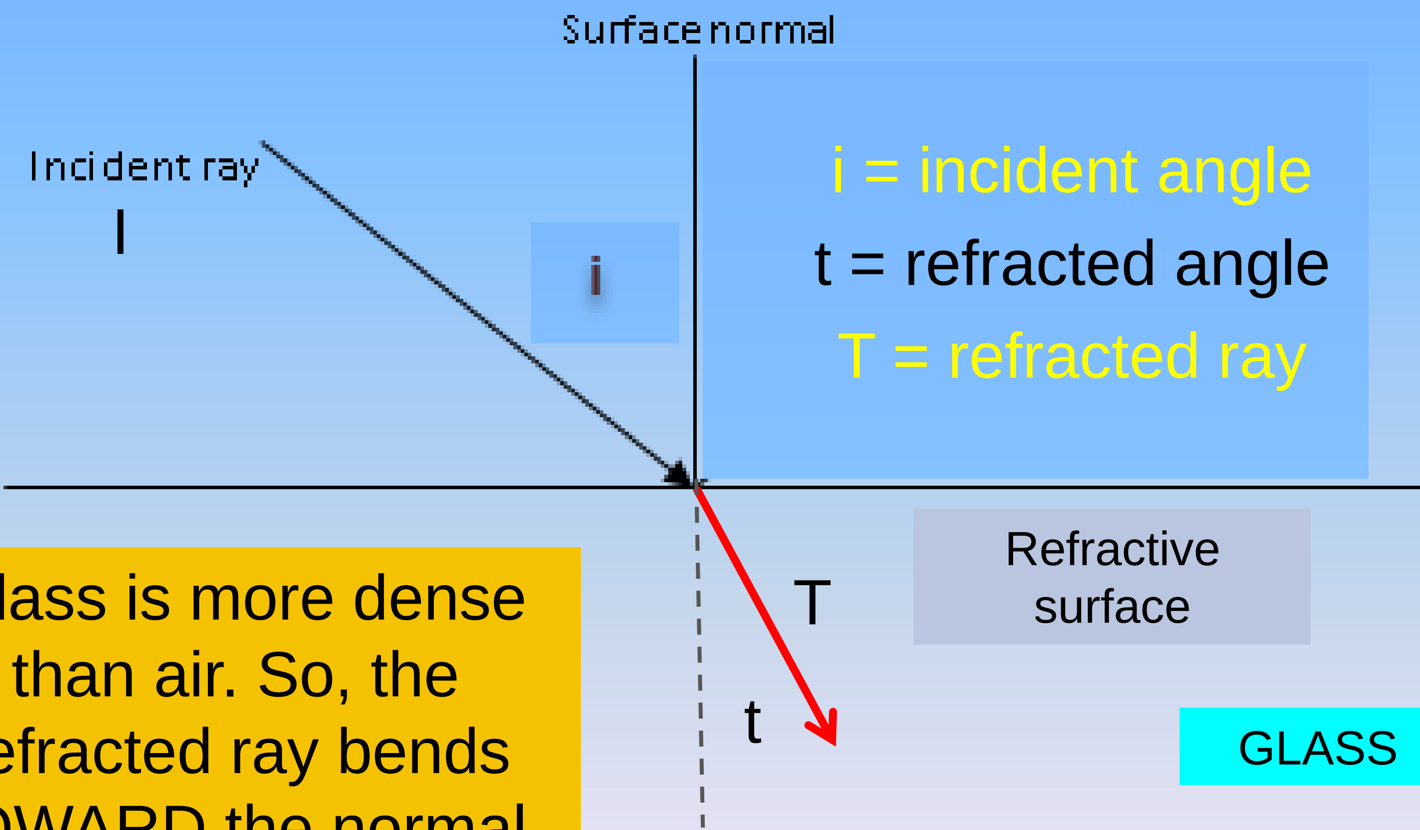
What do you know about the two media?

WARM-UP

Air is the top medium and glass is the bottom medium. **Label the following diagram:**

Refraction

AIR



i = incident angle

t = refracted angle

T = refracted ray

GLASS

Glass is more dense than air. So, the refracted ray bends TOWARD the normal.

Focus Questions

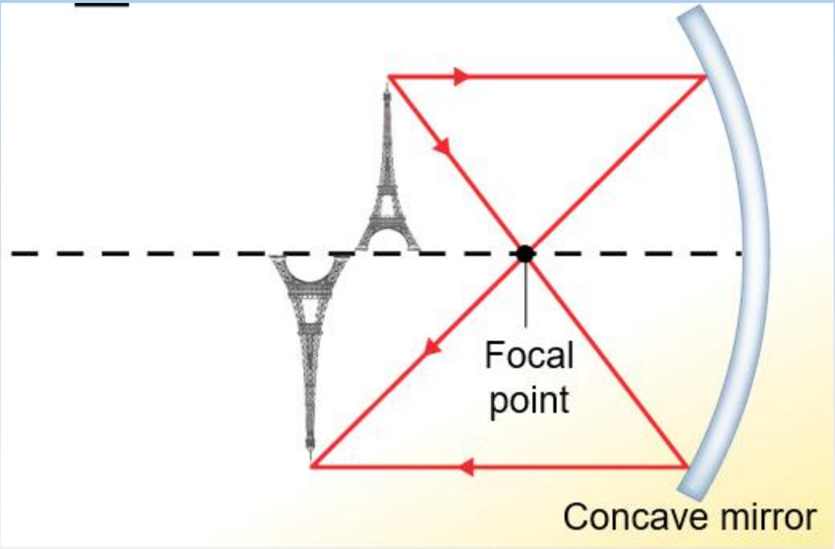
LESSON QUESTION

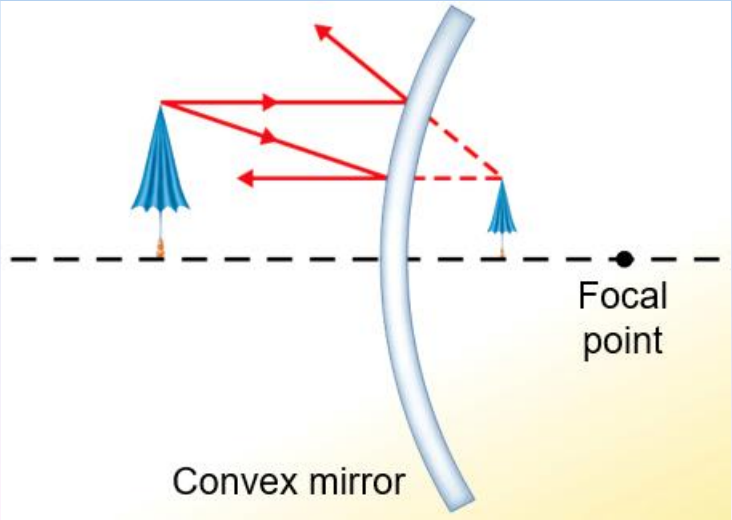
1. Name the two major types of mirrors and lenses, and describe & draw how light is transmitted through them.
2. Identify and define the parts of the human eye responsible for vision. Discuss vision problems and how to correct them.
3. Explain how white light is separated into colors. Distinguish between primary additive, primary subtractive, and complementary colors of LIGHT. Be able to define how each color is created.

Mirrors

There are three types of mirrors that all operate according to the law of reflection:

1. Plane Mirrors
2. Concave Mirrors
3. Convex Mirrors

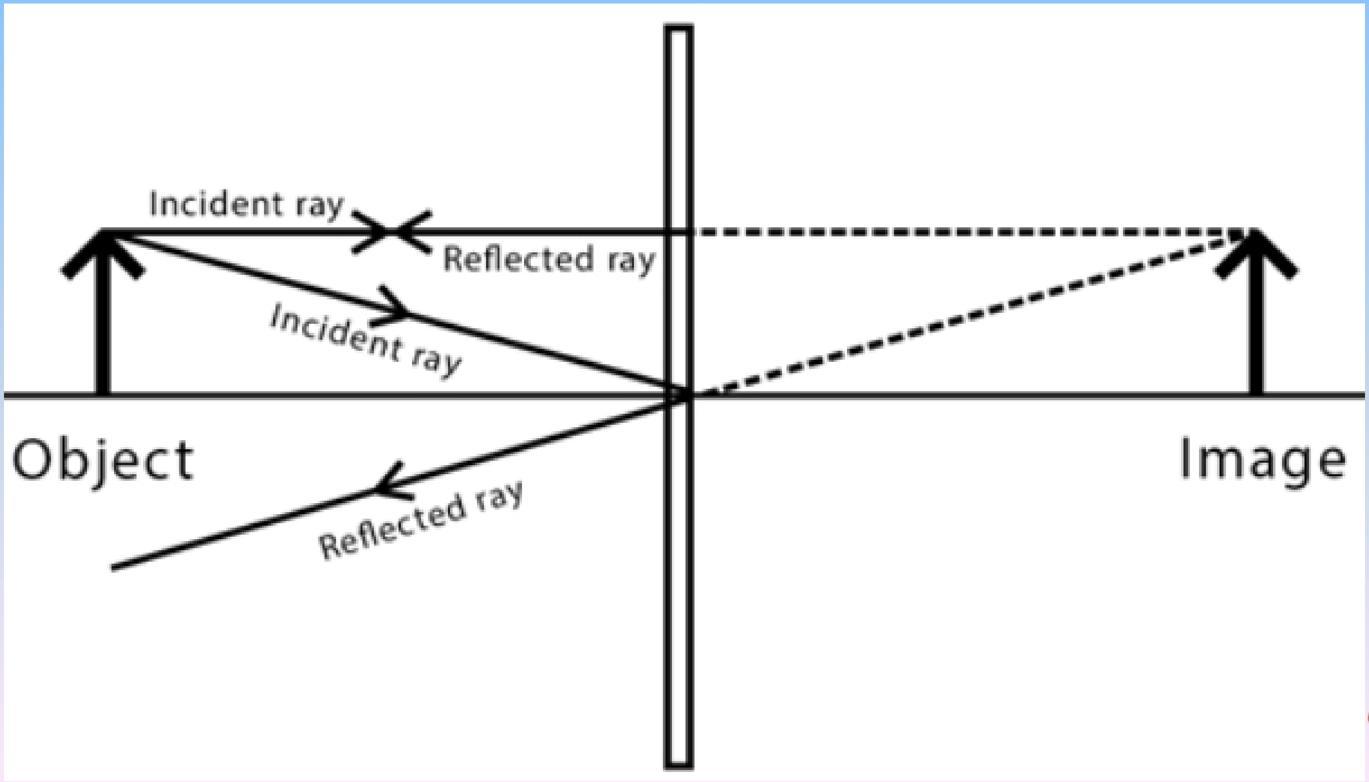




Plane Mirrors

Plane mirrors produce VIRTUAL images, meaning they cannot be projected onto a screen.

The image appears the same distance behind the mirror as it is in front, and the image is right side up.



Concave Mirrors

When the inside surface of a curved mirror is the reflecting surface, the mirror is a **concave mirror.**

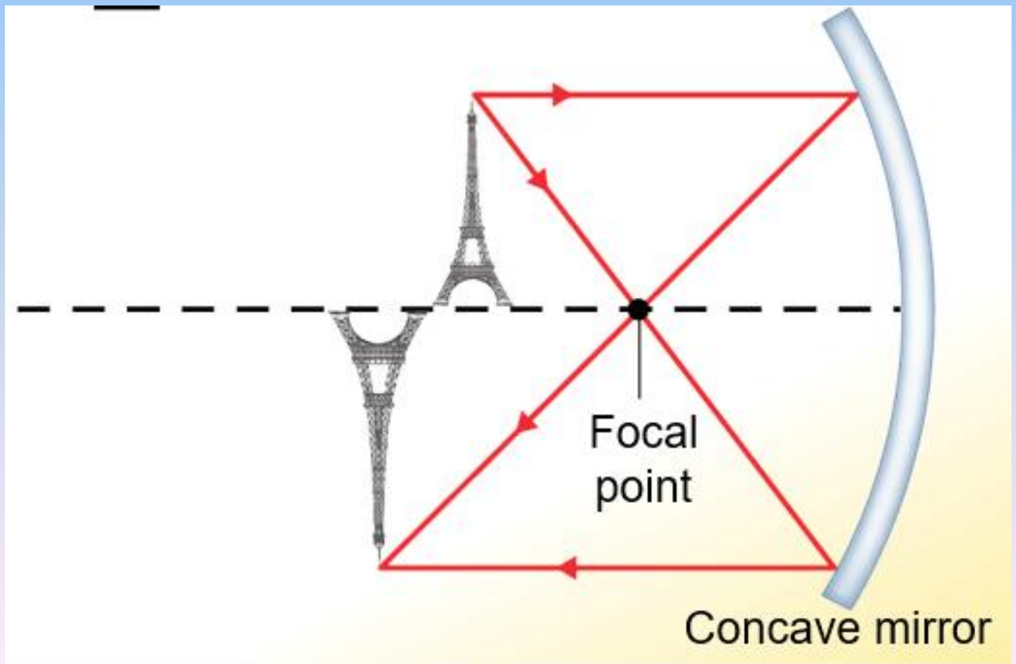
- The curvature of the reflecting surface causes the rays to come together.
- The point at which the light rays meet is called the **focal point**.

Concave mirrors in automobile headlights and flashlights direct the illumination from a light bulb into a beam.

Concave Mirrors

Concave mirrors can form "real" or "virtual" images.

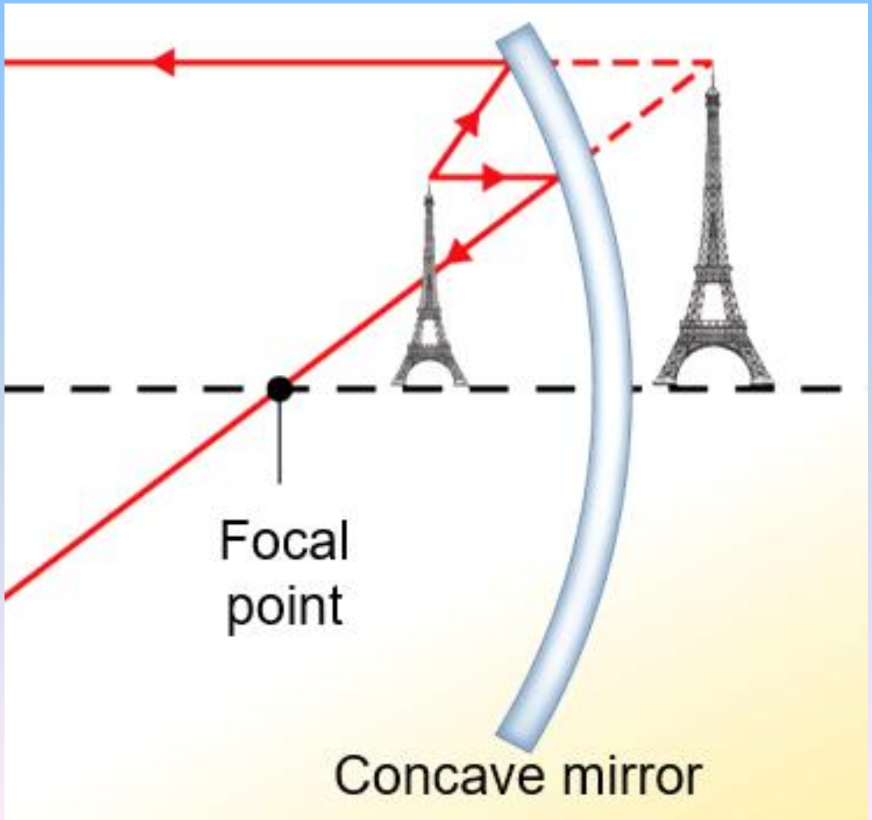
- A **real image** is a copy of an object formed at the point where light rays actually meet. This occurs when the object is farther from the mirror than the focal point as shown.
- A real image can be viewed on a surface such as a screen.



Concave Mirrors

Concave mirrors can form "real" or "virtual" images.

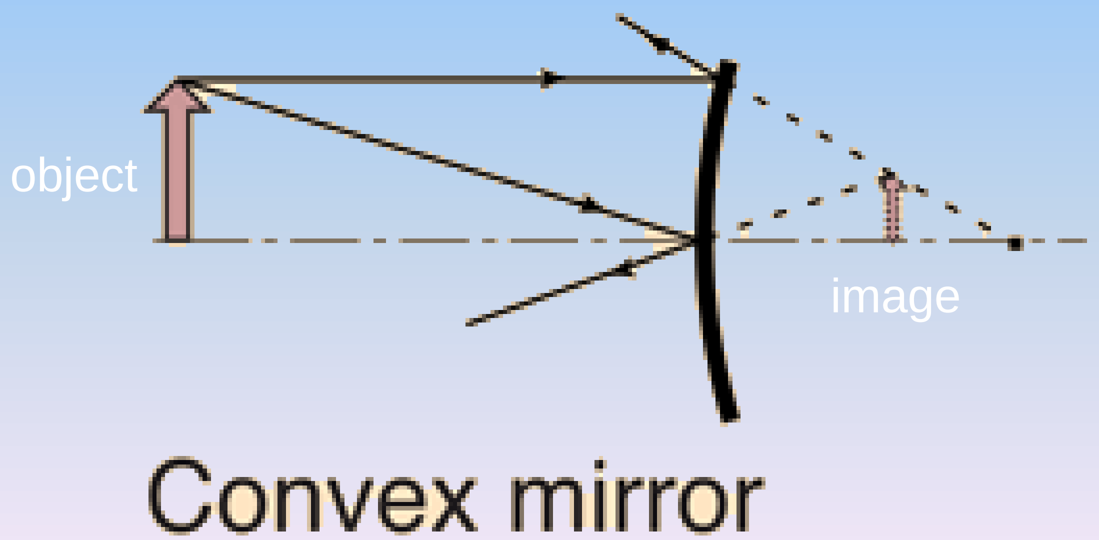
- A **virtual image** forms when the object is closer to the mirror than the focal point is, the reflected rays spread out and appear to come from behind the mirror to form a virtual image.



Convex Mirrors

Convex mirrors ONLY form "virtual" images.

- The **virtual image** forms **BEHIND** the mirror because the reflected rays off the mirror do NOT converge to a focus (no real image formed).
- The image is **REDUCED** and **ERECT**.



QUICK CHECK

A real image formed by a mirror is

a. always right-side up.
b. always smaller than the object.
c. able to be projected on a screen.
d. only formed by convex mirrors.

According to the law of reflection, the angle of reflection is (*greater than, less than, equal to*) the angle of incidence.

An image of an object, formed by a convex mirror, is always

a. upright and smaller than the object.
b. upside down and smaller than the object.
c. upright and larger than the object.
d. upside down and larger than the object.

A real image formed by a mirror is

a. always right-side up.
b. always smaller than the object.
c. **able to be projected on a screen.**
d. only formed by convex mirrors.

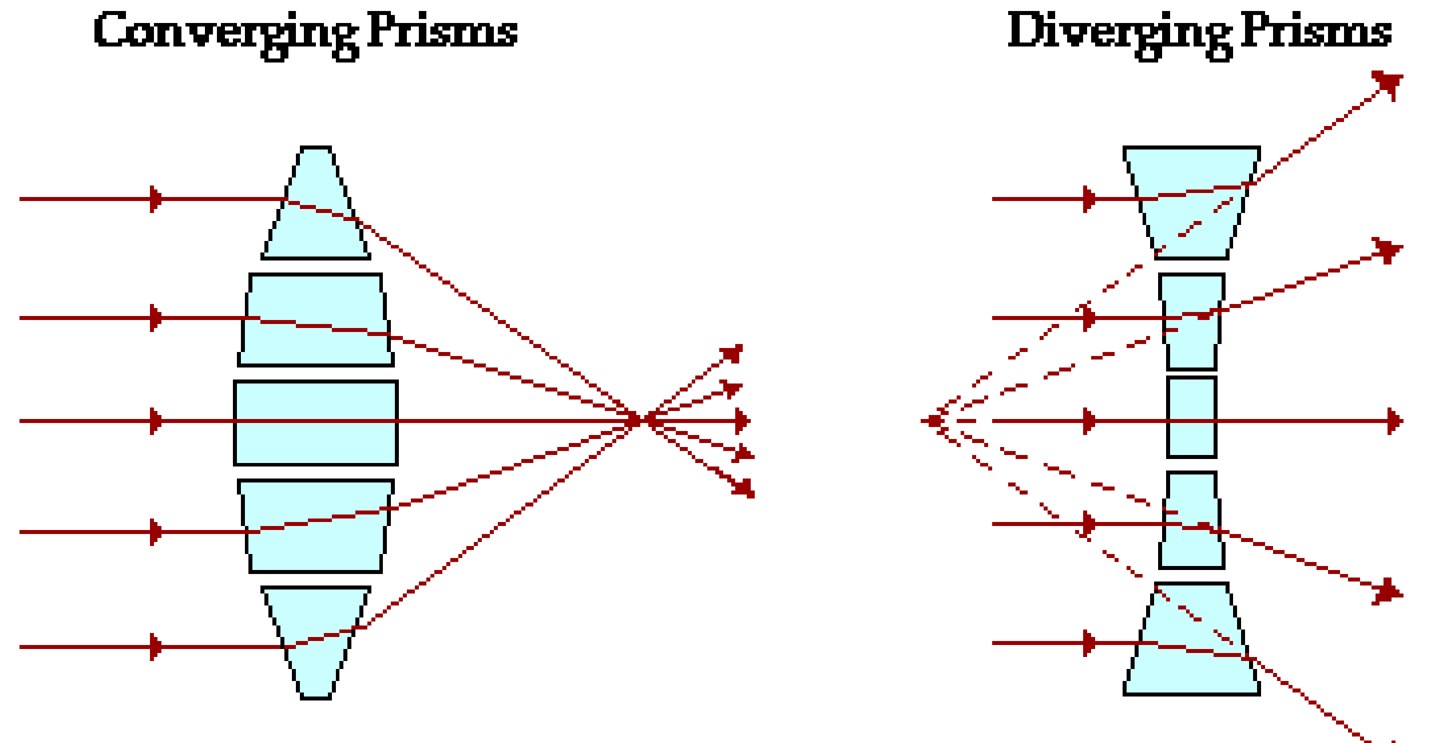
According to the law of reflection, the angle of reflection is **equal** to the angle of incidence.

An image of an object, formed by a convex mirror, is always

a. **upright and smaller than the object.**
b. upside down and smaller than the object.
c. upright and larger than the object.
d. upside down and larger than the object.

Lenses

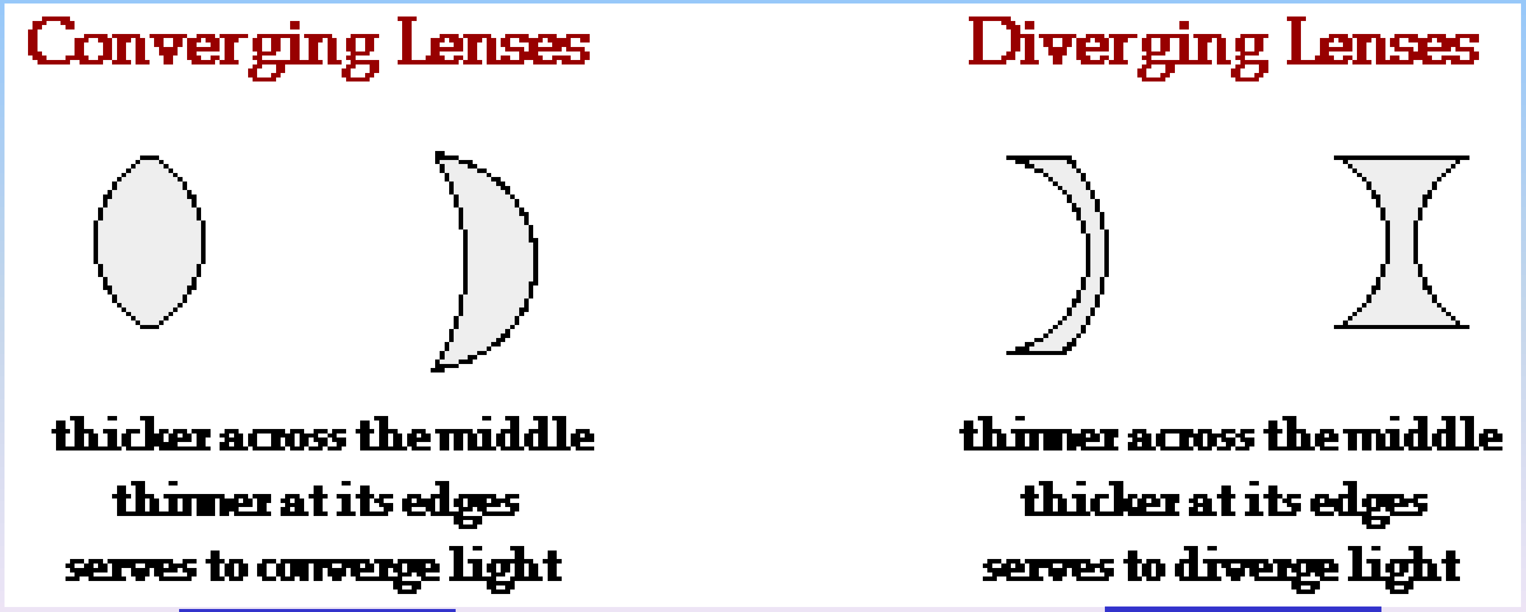
If a piece of glass or other transparent material takes on the appropriate shape, it will be capable of taking parallel rays of incident light and either converging them to a point or appear to diverge them from a point. Such a piece of glass is referred to as a lens.



A set of prisms acting as a converging and diverging lens.

Lenses

A **lens** is a carefully ground or molded piece of transparent material which refracts light rays in such a way as to form an image. Lenses can be thought of as a series of tiny refracting prisms or lenses, each of which refracts light to produce their own image. When these prisms act together, they produce a bright enough image focused at a point.



convex

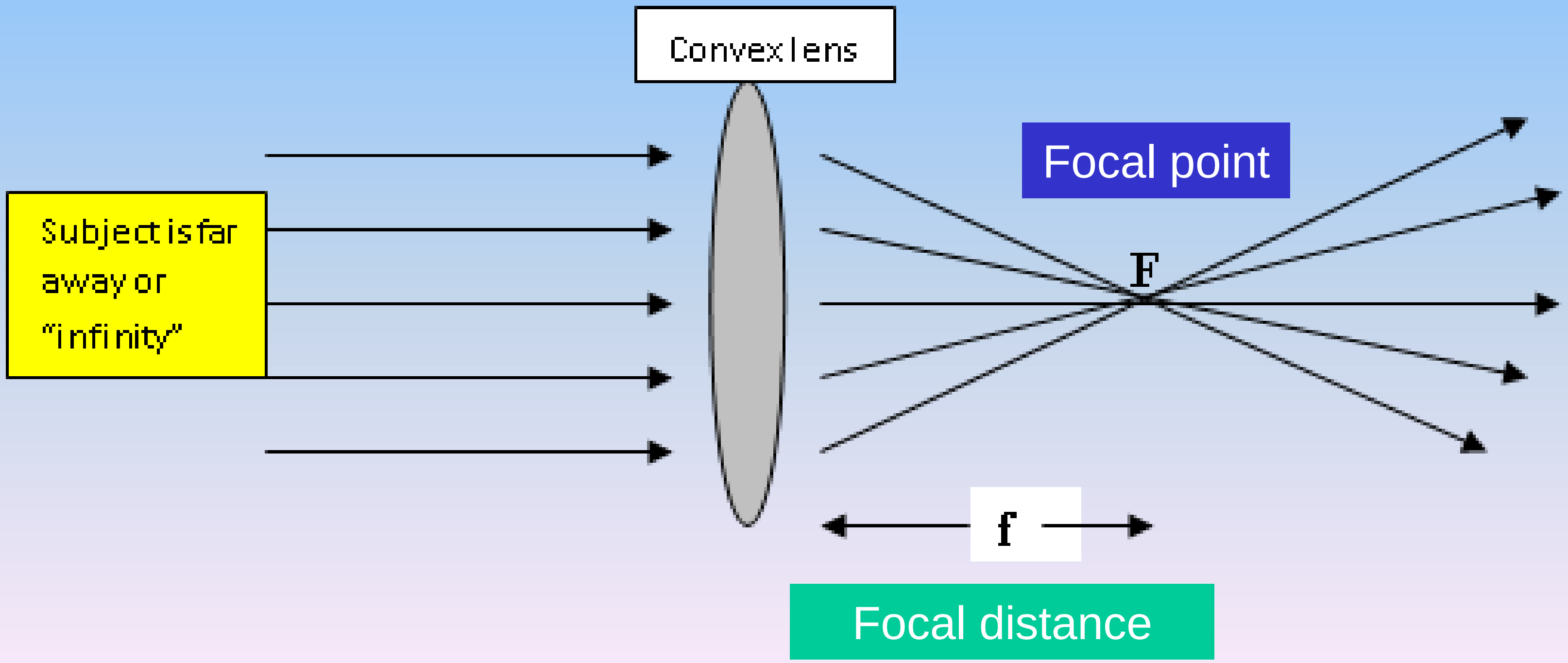
concave

Converging Lenses

Convex lenses (converging) are always thicker in the center than the ends and normally produce an image by focusing light rays on the other side of the lens.

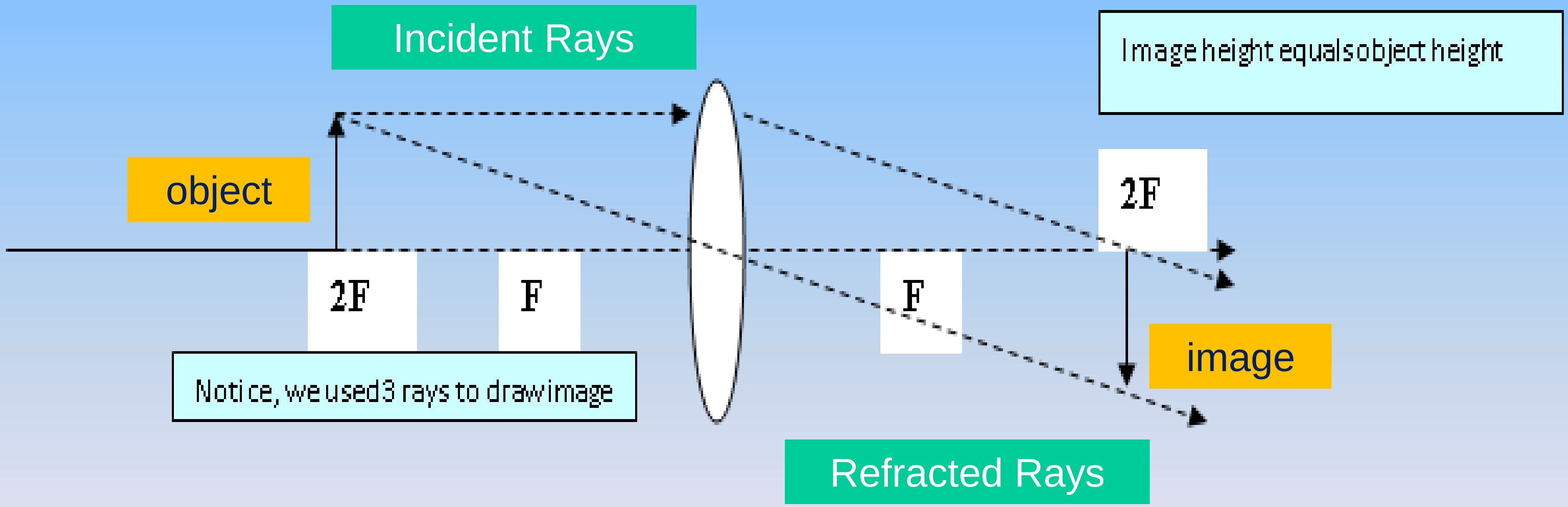
The image formed is INVERTED (upside down).

All lenses produce a REVERSED image.



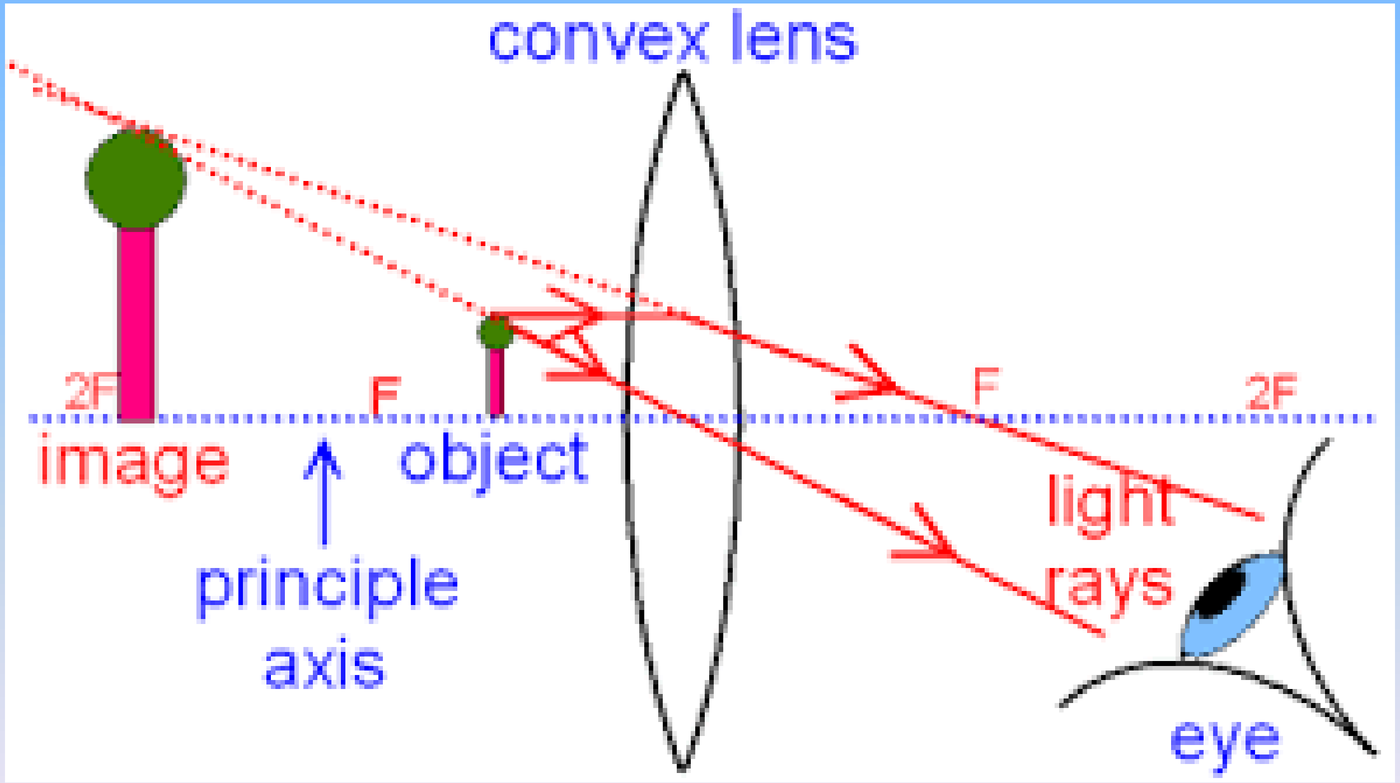
Converging Lenses

Convex lenses produce "**REAL**" images – **light rays actually pass through the lens by convergence and can be projected** (e.g. overhead projector or movie projector).



Converging Lenses

Convex lenses can also become MAGNIFYING glasses if the object is placed between the focal point and the lens.



Converging (convex) Lenses

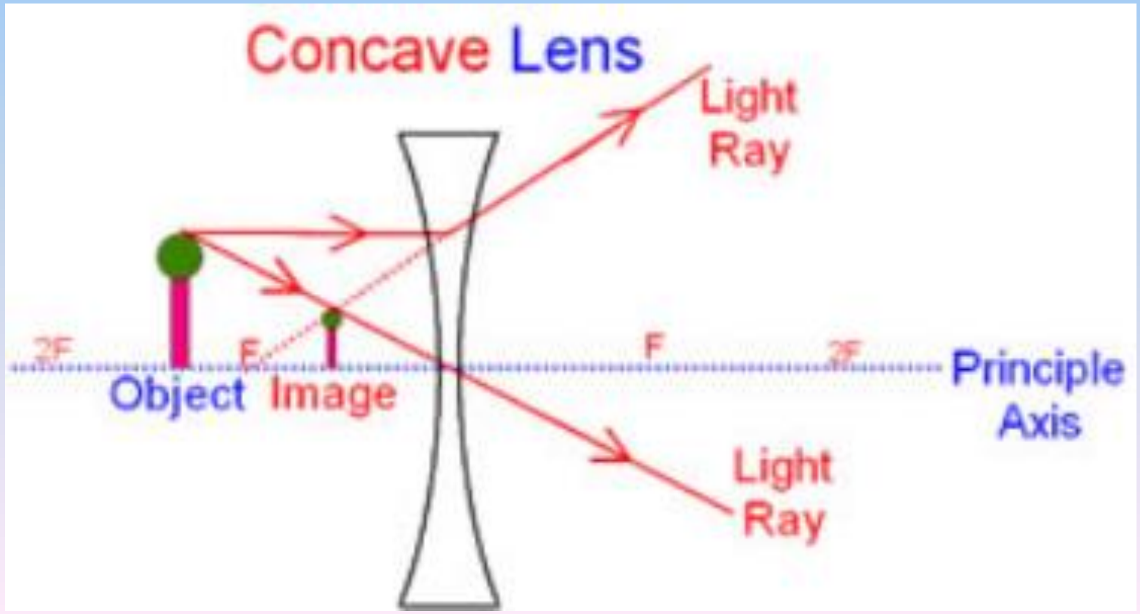
Watch video:

http://somup.com/c0f3oL44Mm (2:08)

Diverging Lenses

Concave lenses (diverging) are thinner in the center than at the ends and ALWAYS produce a VIRTUAL image.

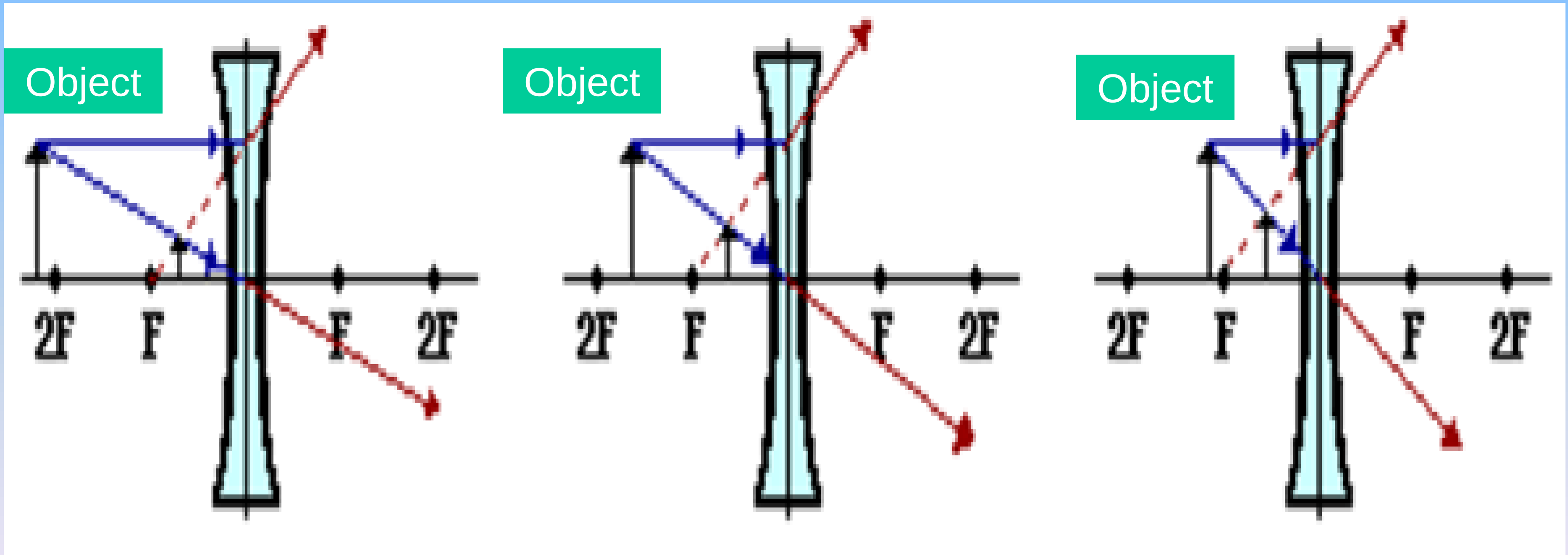
The VIRTUAL image is like an "optical illusion" to our brain. It is ERECT (upright), REDUCED in size, and on the SAME SIDE of the lens as the object.



Diverging Lenses

All lenses produce a REVERSED image.

Concave lenses are used in peep holes in doors, rearview mirrors, and in lens systems for cameras and binoculars.



Diverging (concave) Lenses

Watch video:

http://somup.com/cFf0FsV5Gl (1:37)

Which type(s) of lens can form a real image?

a. concave lens only
b. convex lens only
c. both concave and convex lenses
d. neither concave nor convex lenses

The ____ is the ratio of the speed of light in a vacuum to the speed of light in a material.

A virtual image is formed by

a. concave lens only
b. convex lens only
c. both concave and convex lenses
d. neither concave nor convex lenses

QUICK CHECK

QUICK CHECK

Which type(s) of lens can form a real image?

a. concave lens only

b. **convex lens only**

c. both concave and convex lenses

d. neither concave nor convex lenses

The index of refraction is the ratio of the speed of light in a vacuum to the speed of light in a material.

A virtual image is formed by

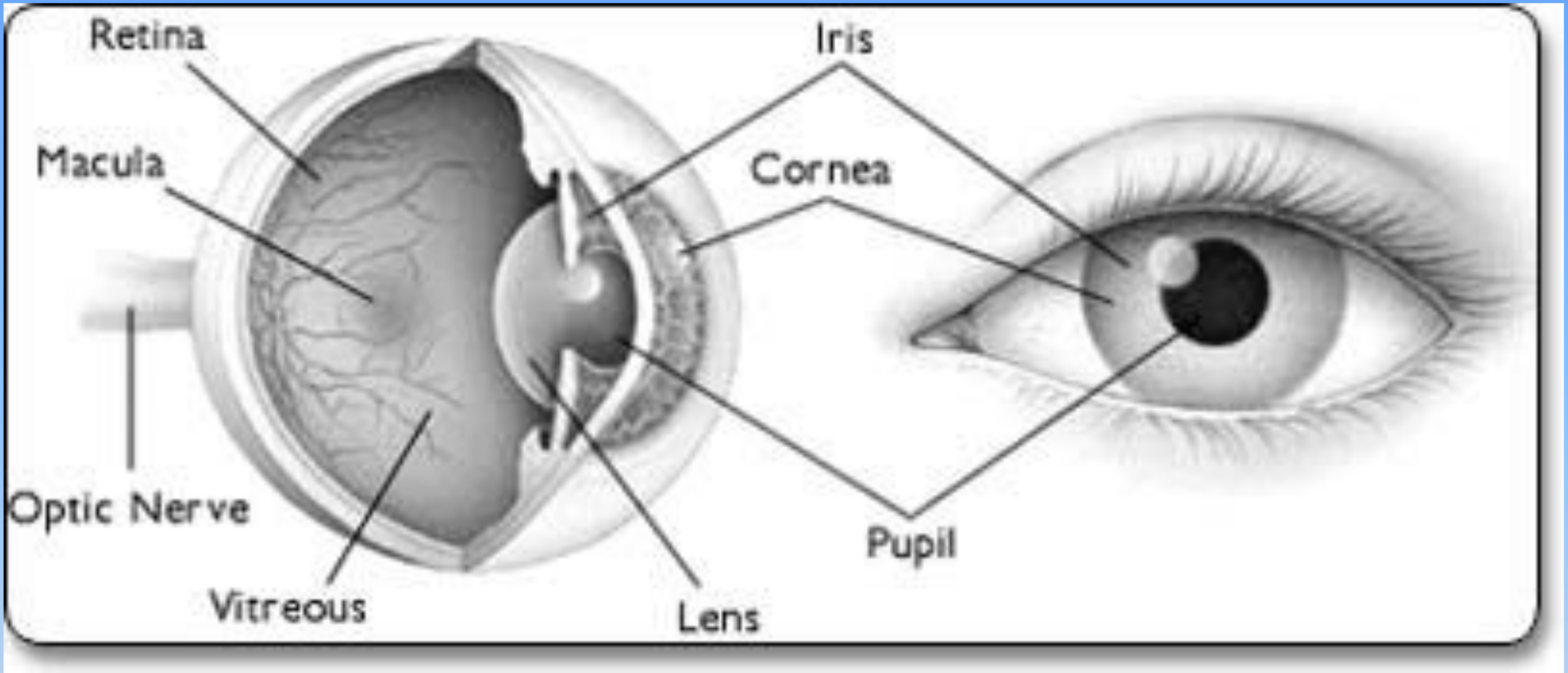
a. concave lens only

b. convex lens only

c. **both concave and convex lenses**

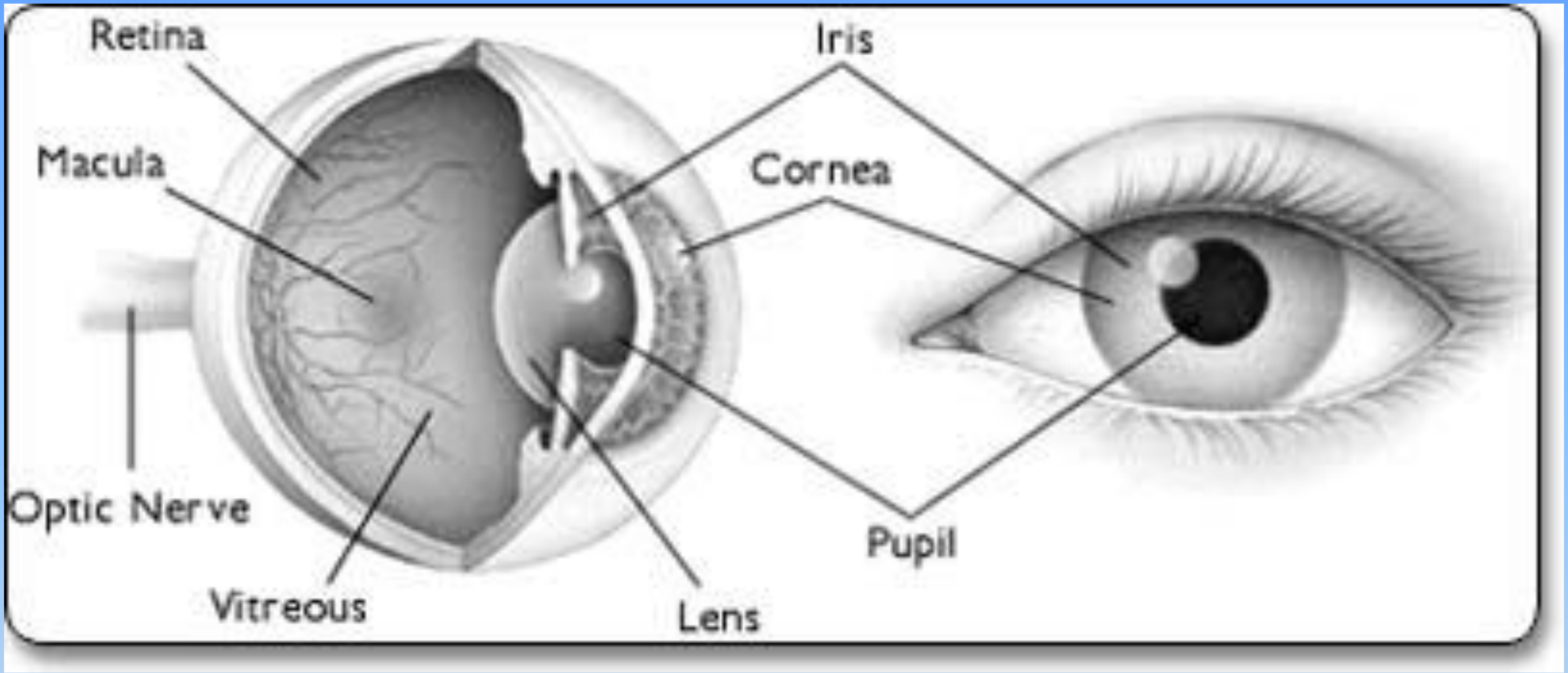
d. neither concave nor convex lenses

Anatomy of the Human Eye



Cornea	45% of the focal power of sight; transparent; protective
Iris	muscle surrounding pupil, giving eye color
Pupil	like the diaphragm of a camera regulating light
Lens	25% of the focal power of sight; convex

Anatomy of the Human Eye



Retina receives light impulses & sends them to the optic nerve

Macula blood vessels come together (nourish eye)

Vitreous solution; 30% of the focal power of sight; nutrition

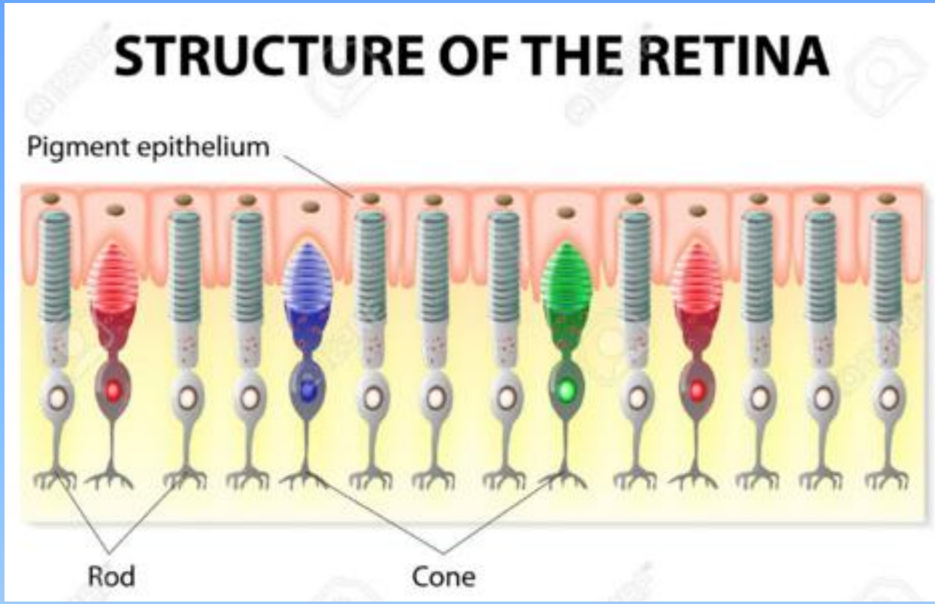
Optic Nerve receives nerve impulses from the retina and sends them to the brain

Anatomy of the Human Eye

The eye is an utterly amazing creation of God. Even Darwin was quoted as saying that to think the eye was formed by random natural selection is absurd in the highest degree (London: Penguin Classics, 1985, p. 217). Yet, he still advocated evolution as the source.????

13 This is why I speak to them in parables: "Though seeing, they do not see; though hearing, they do not hear or understand.
14 In them is fulfilled the prophecy of Isaiah: "'You will be ever hearing but never understanding; you will be ever seeing but never perceiving. Matthew 13:13-14

Anatomy of the Retina



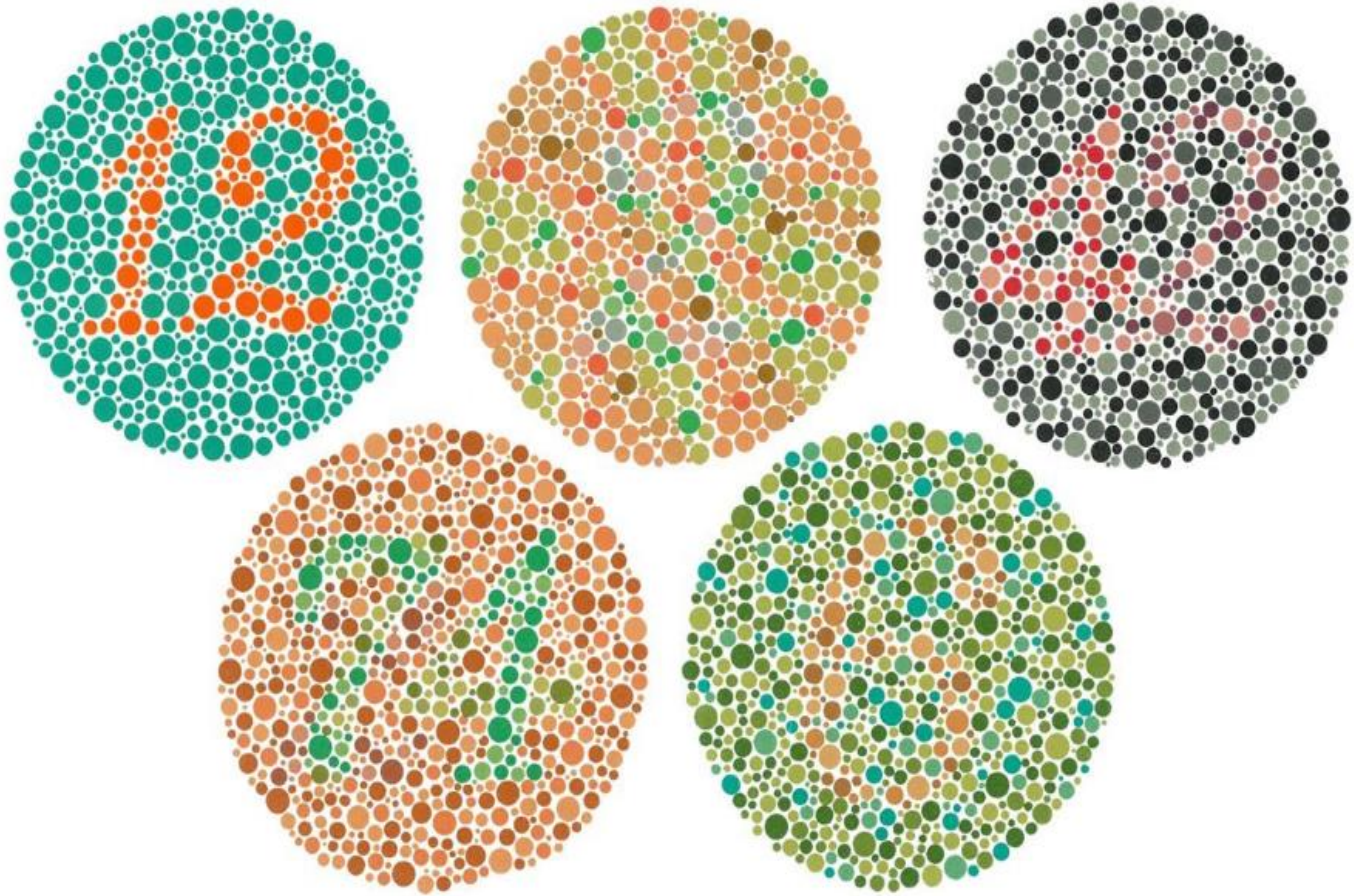
There are two types of photoreceptors in the human retina: rods and cones.

Rods are responsible for vision at low light levels and specialize in light and dark contrast (sensitivity).

Cones are active at higher light levels and specialize in color vision. There are 3 main "cone" cells corresponding to Red, Green, and Blue light.

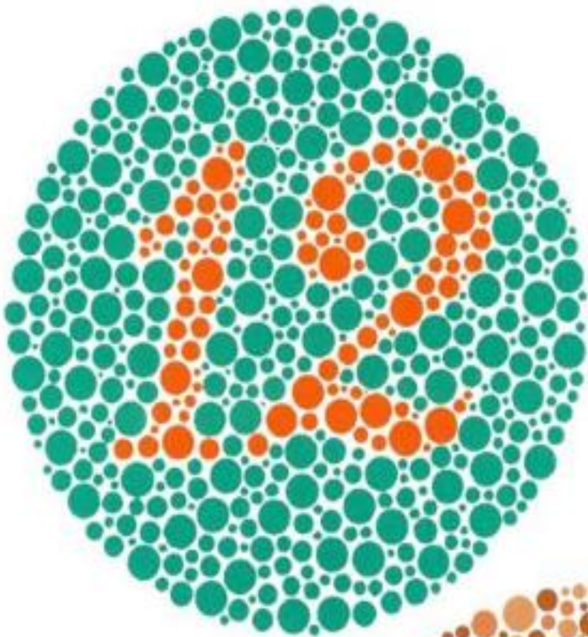
Color Blindness

?



Color Blindness

12



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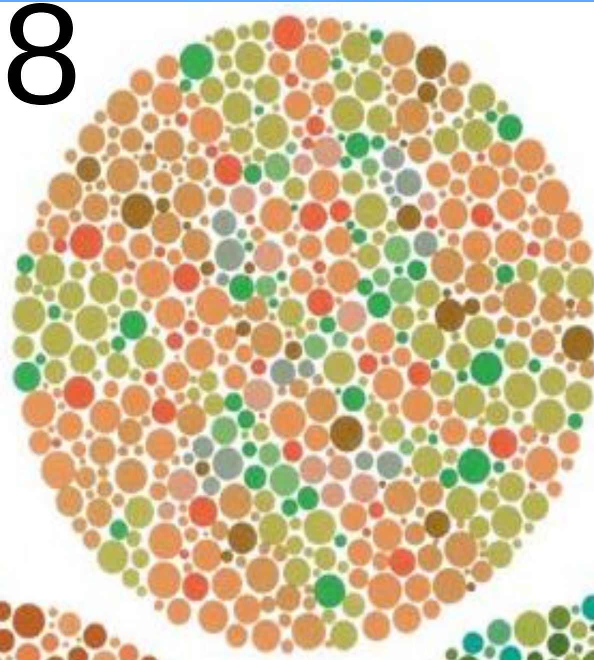

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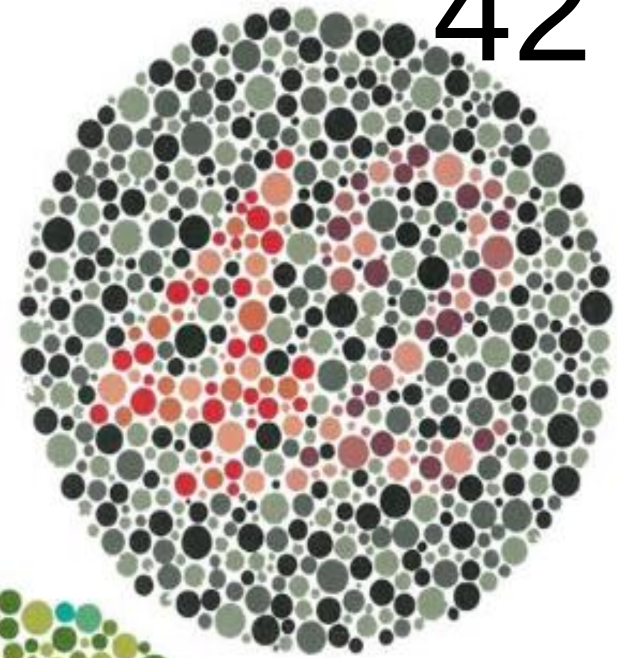

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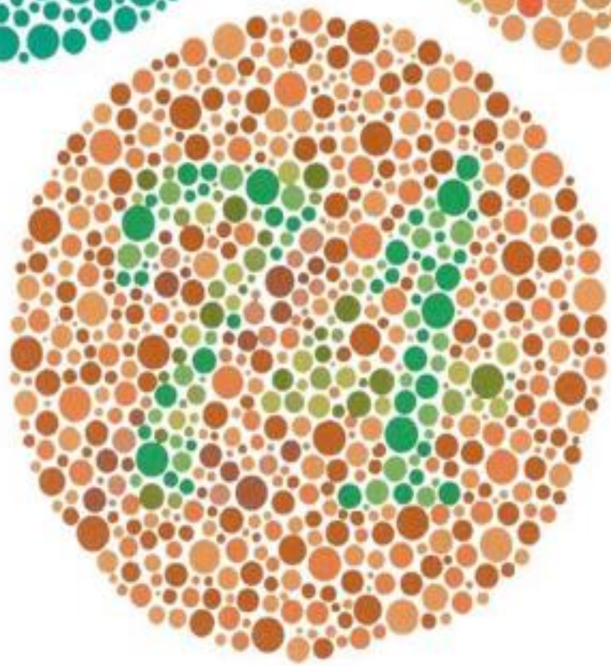

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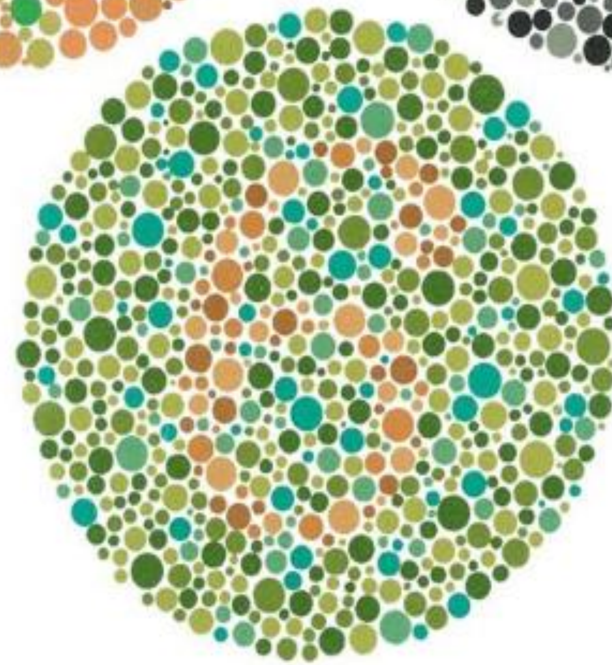
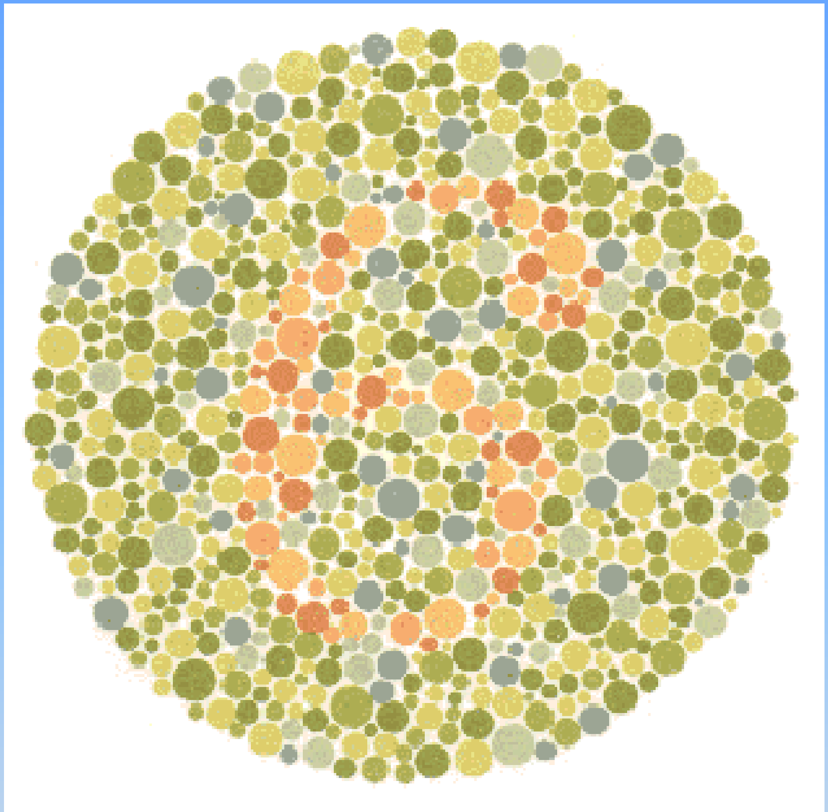
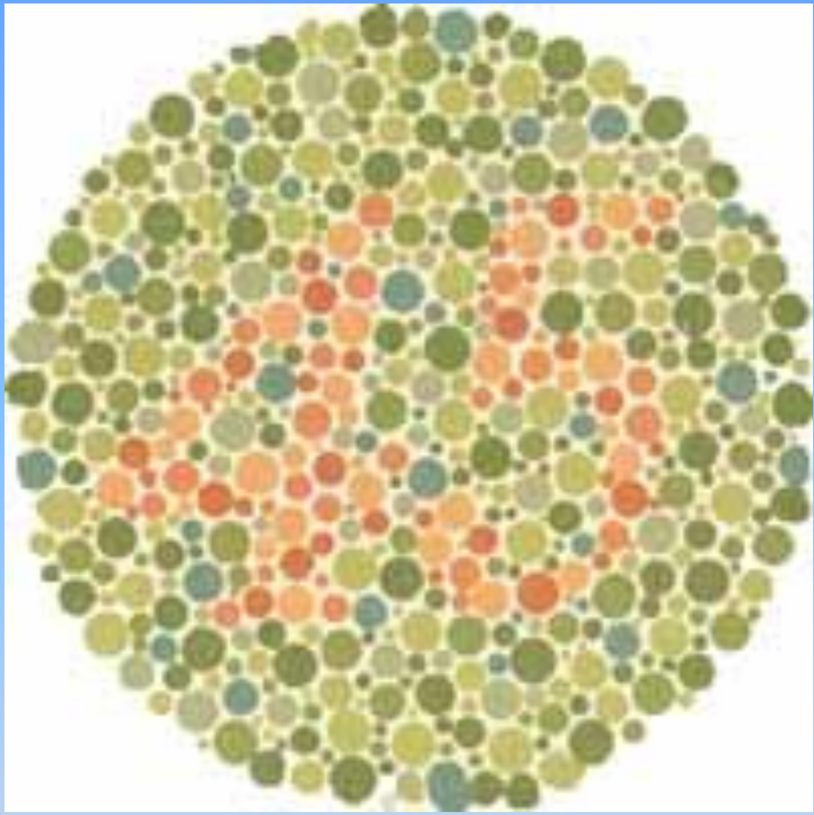


Color Blindness

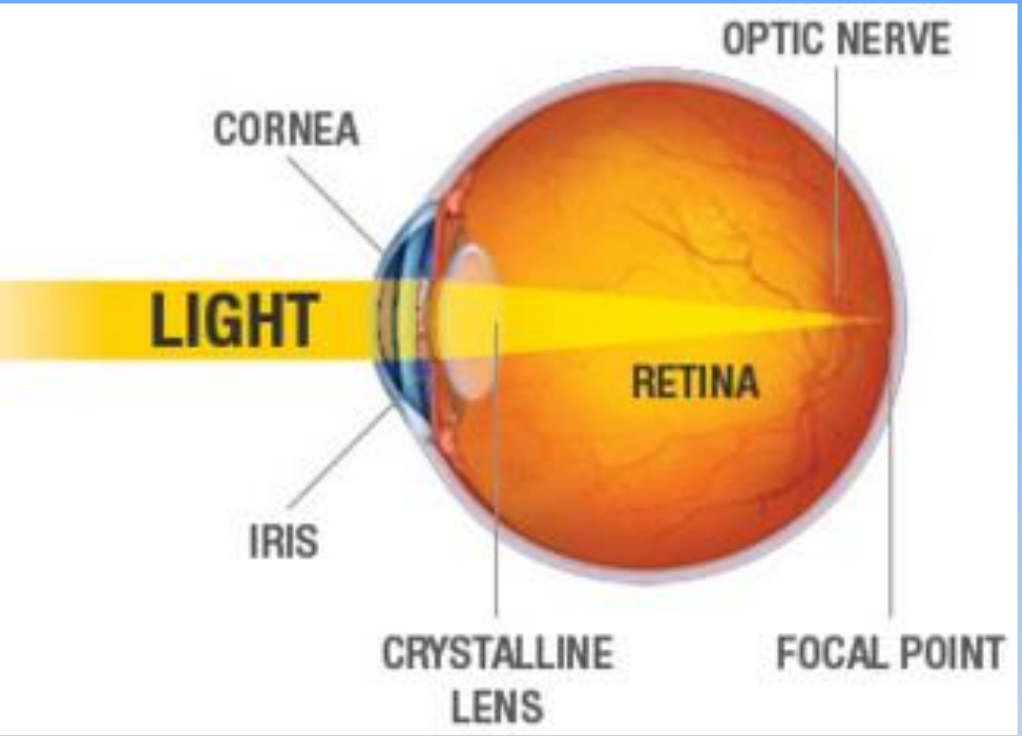


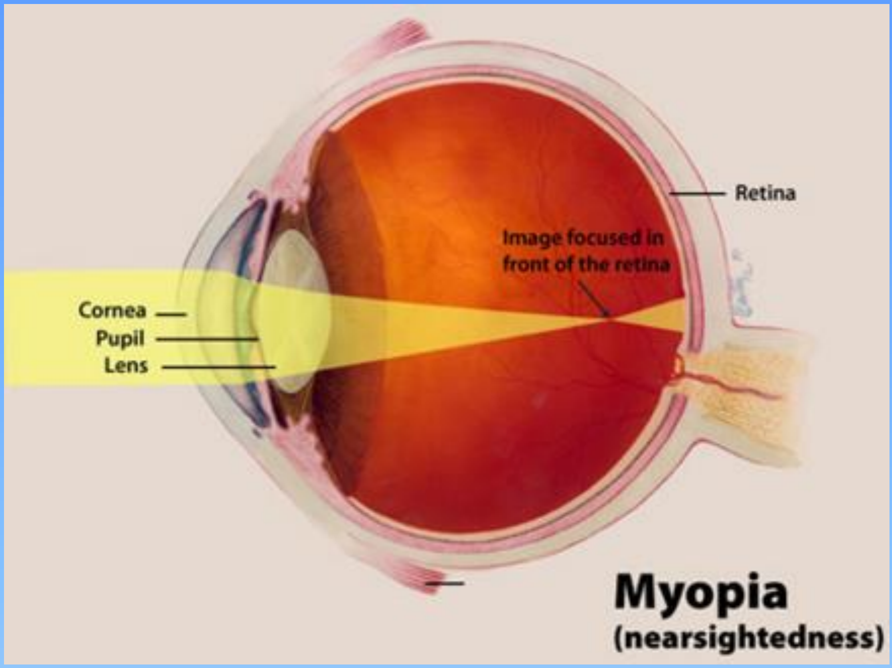
?

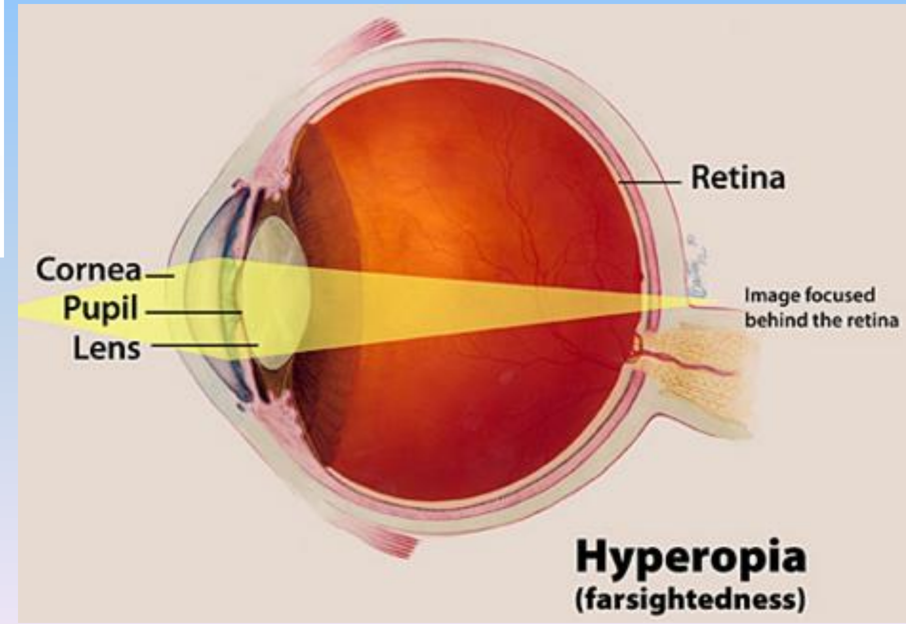


Red – Green color blindness is the most common deficiency in human vision. In the case of Red – Green color blindness people struggle with shades of color, especially related to blue.

Eyesight





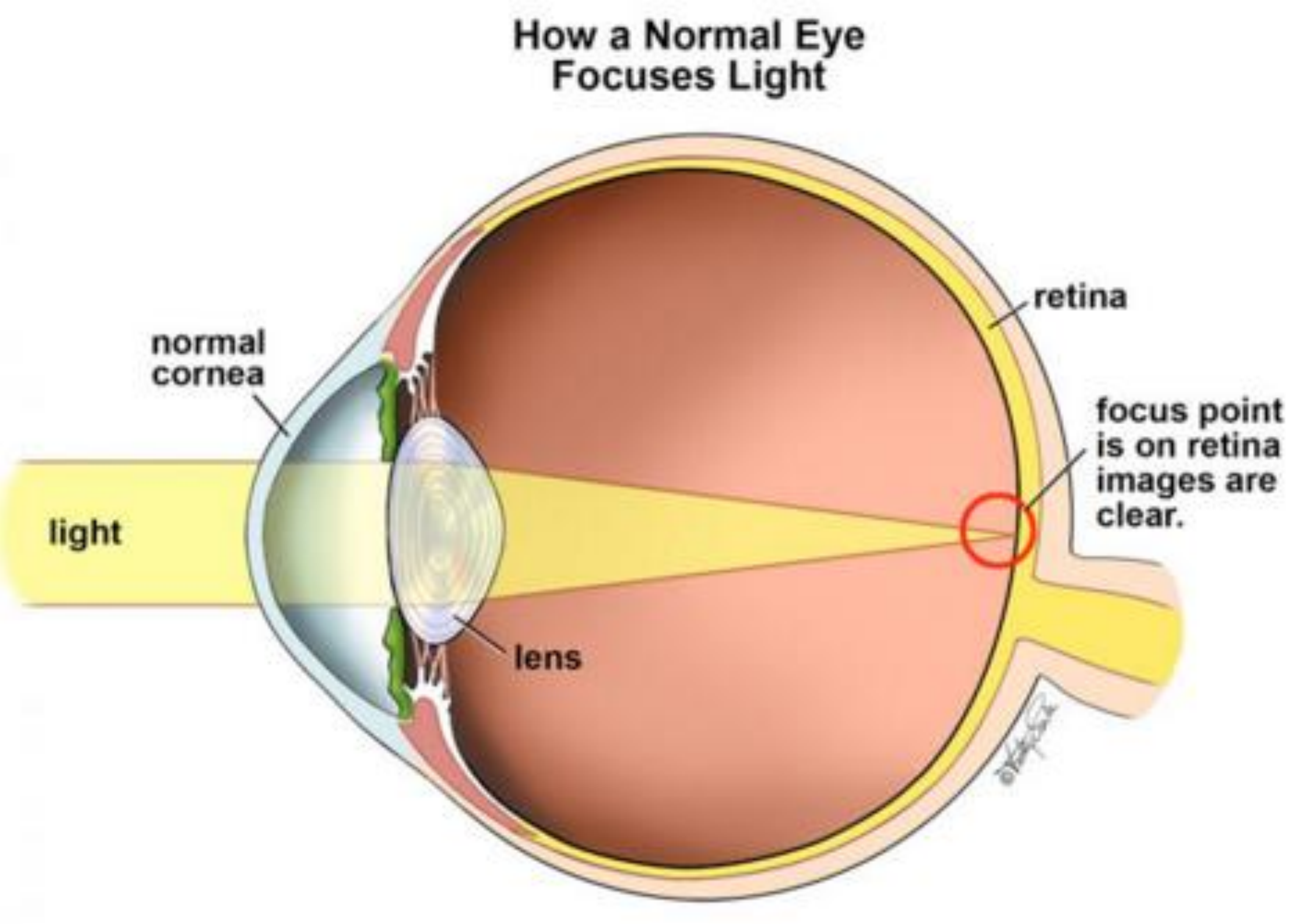


What produces nearsighted vision?

What produces farsighted vision?

Normal Vision

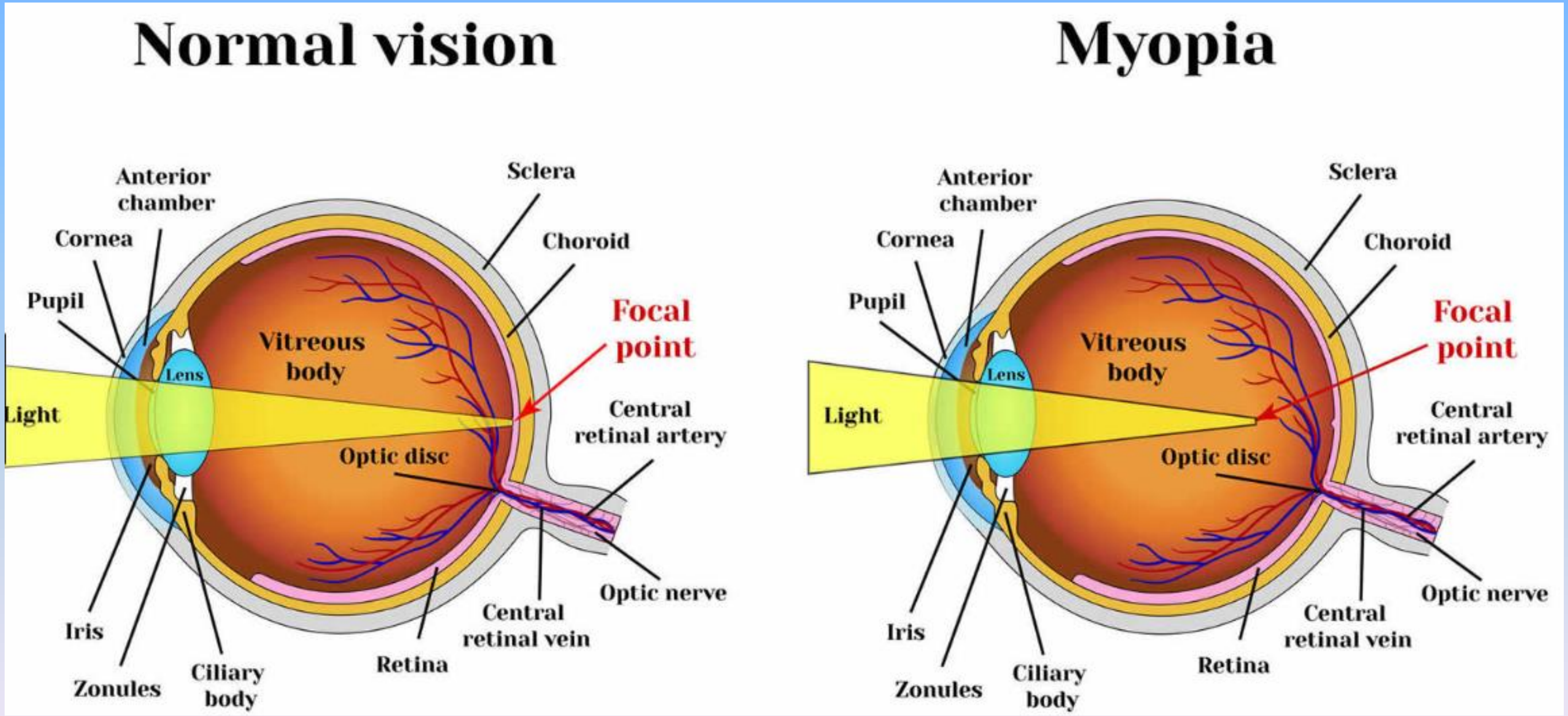
In normal vision, light rays from an object entering the eye are focused by the *lens*



(*transparent tissue that changes shape to help focus incoming light*) onto the *retina* (*the membrane at the back of the eye that transmits images of external objects to the optic nerve*).

NEARsightedness

Also called **myopia**; impaired vision in which a person sees near objects clearly while distant objects appear blurred.

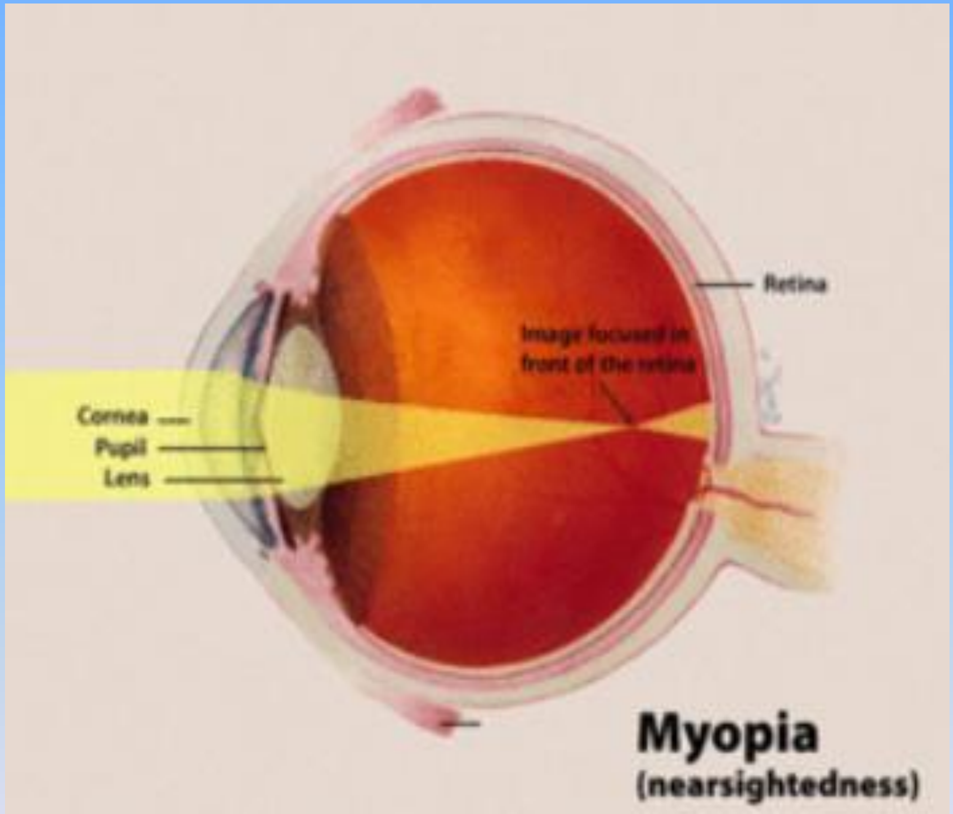


NEARsightedness

The distance between the lens and the retina is too long.

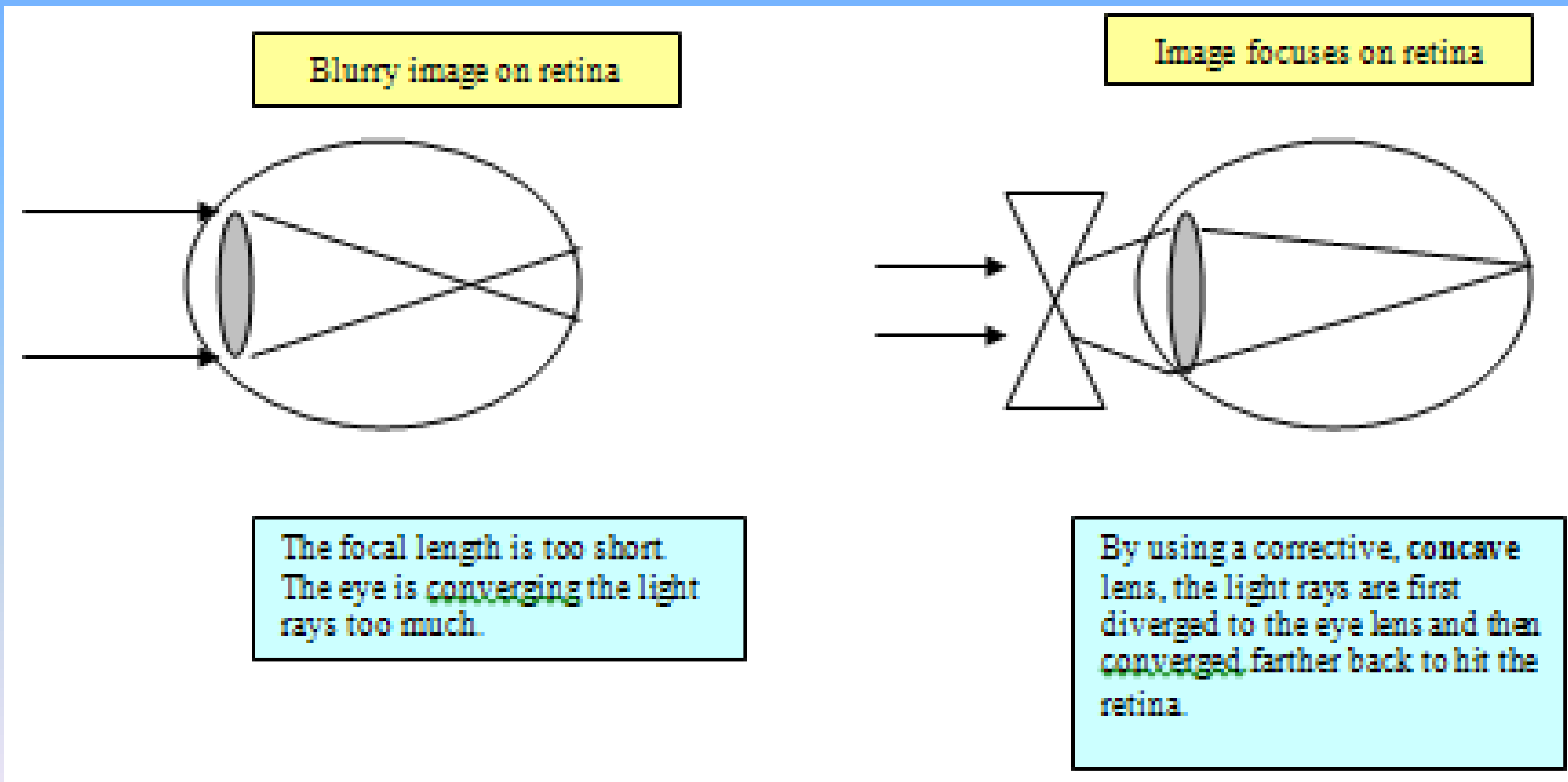
As a result, light rays from distant objects focus before they strike the retina.

Near objects appear clearly because light rays from them focus correctly on the retina.



NEARsightedness

Nearsighted people need eyeglasses that are concave lenses.



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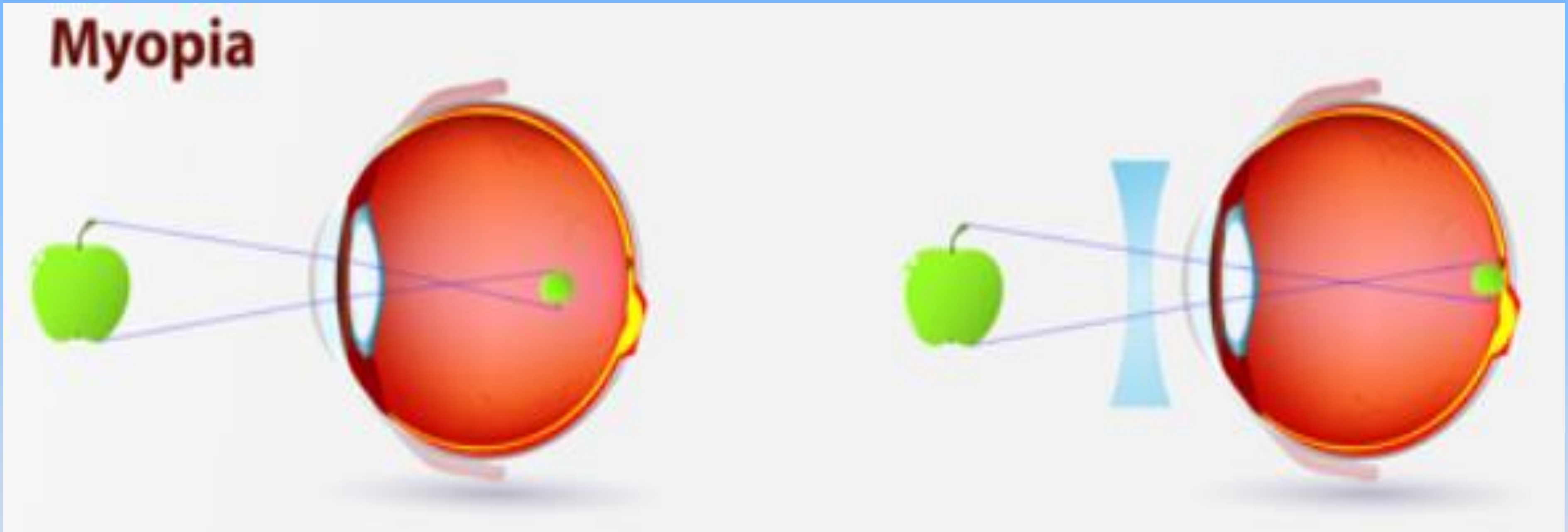


NearSighted Vision (myopia)

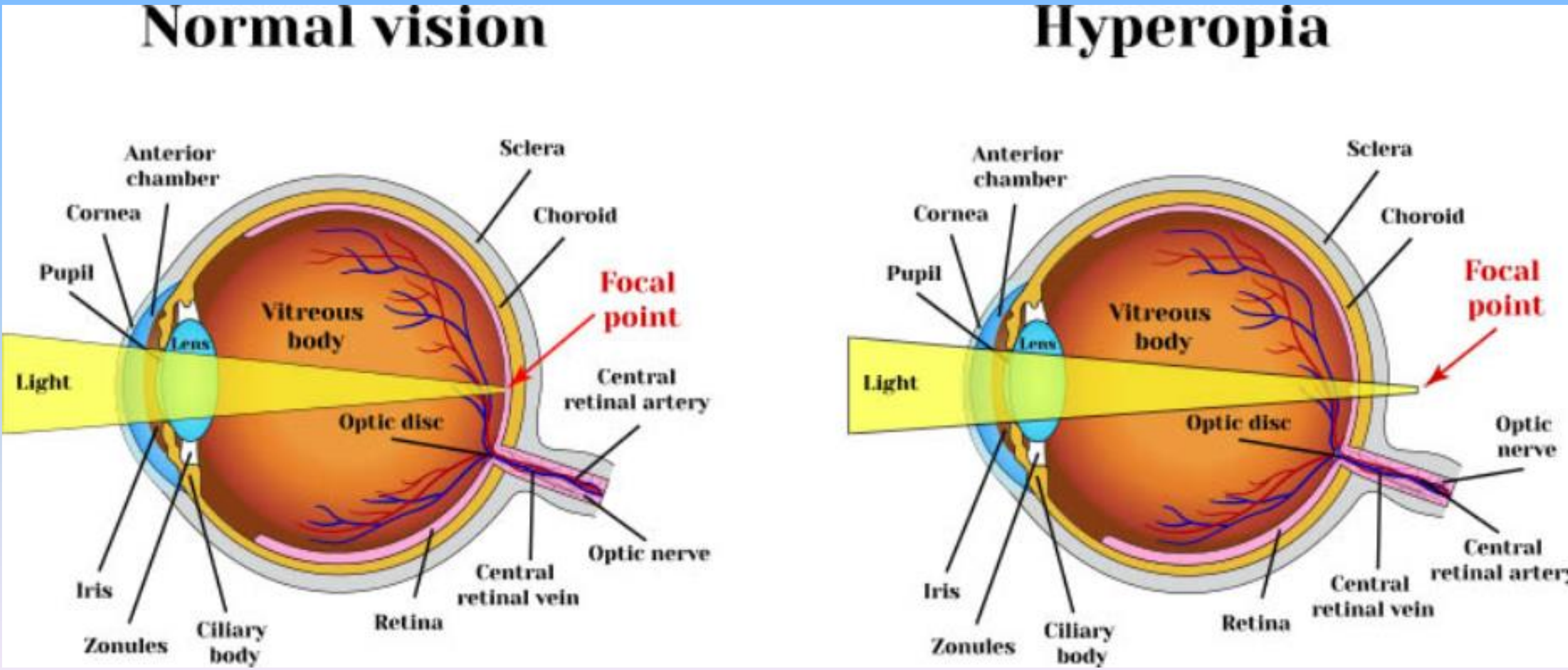
Watch video:

http://somup.com/cFfhb7VpOt (2:05)

What is myopia? How is it corrected?

FARsightedness

Also called **hyperopia**; impaired vision in which a person sees near objects with blurred vision, while distant objects appear in sharp focus.



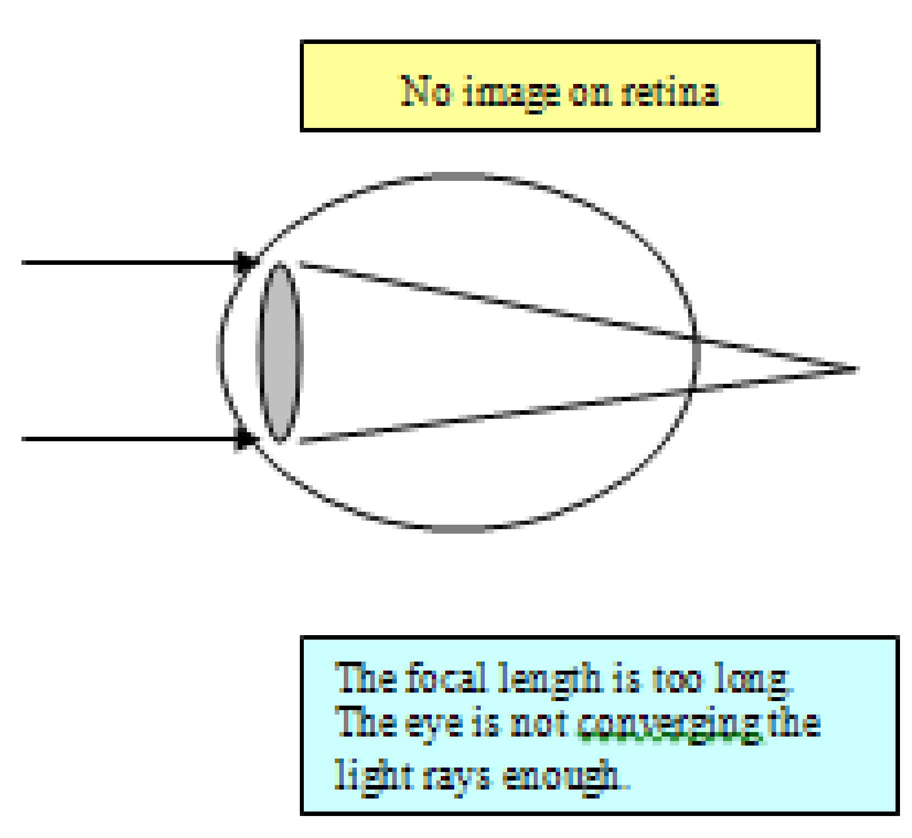
FARsightedness

The distance between the lens and the retina is too short.

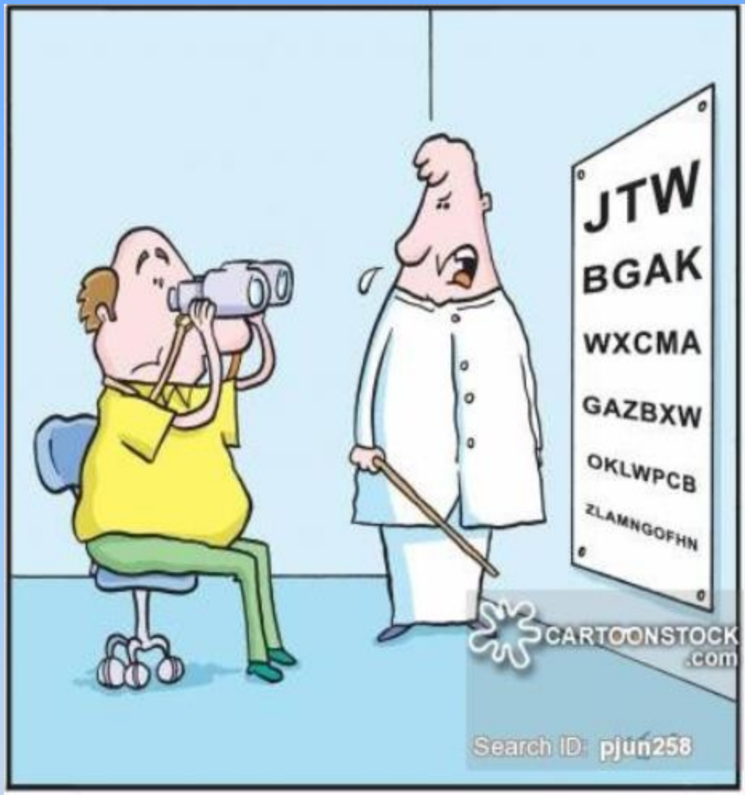
As a result, light rays from near objects strike the retina before they are in focus, which causes blurred vision.

Distant objects appear clearly because light rays from them focus correctly on the retina.

Picture is exaggerated for simplicity.



*FAR*sightedness

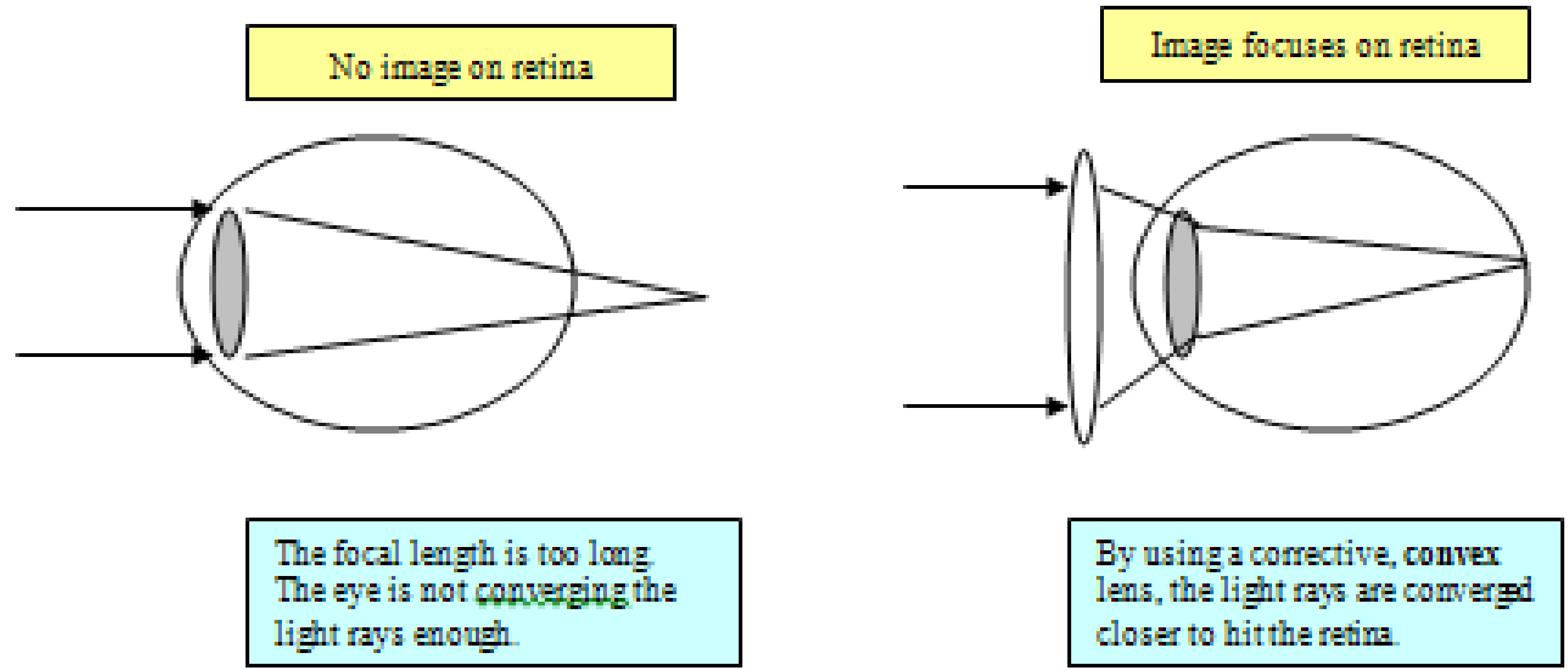


"No cheating!"

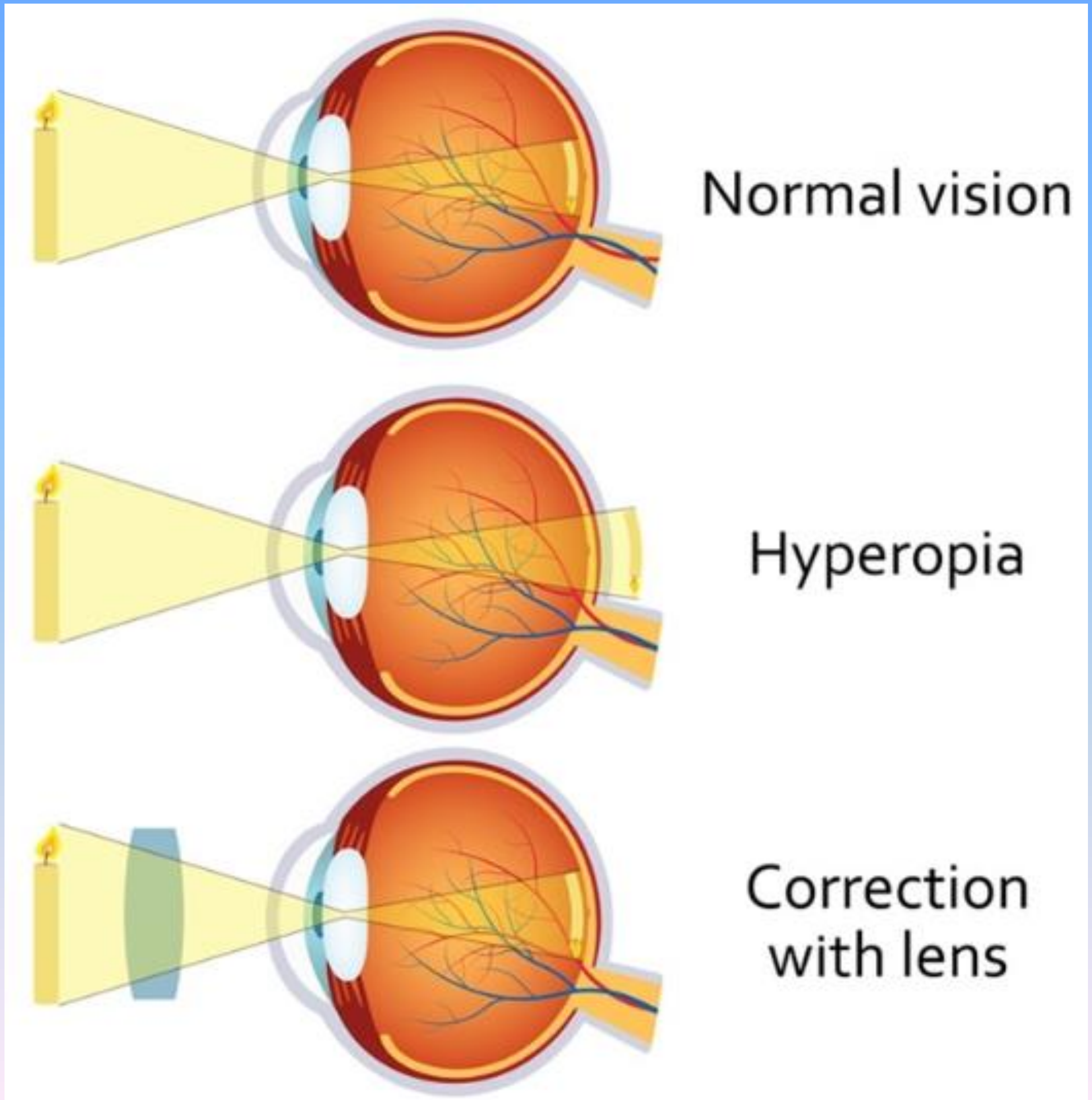
FARsightedness

Farsighted people need eyeglasses that are convex lenses.

Most corrective issues are due to farsightedness.



FARsightedness



Farsighted people need eyeglasses that are convex lenses. Most corrective issues are due to farsightedness.

Far Sighted Vision (hyperopia)

Watch video:

http://somup.com/cFfO3EVEo7 (0:58)

What is hyperopia? How is it corrected?

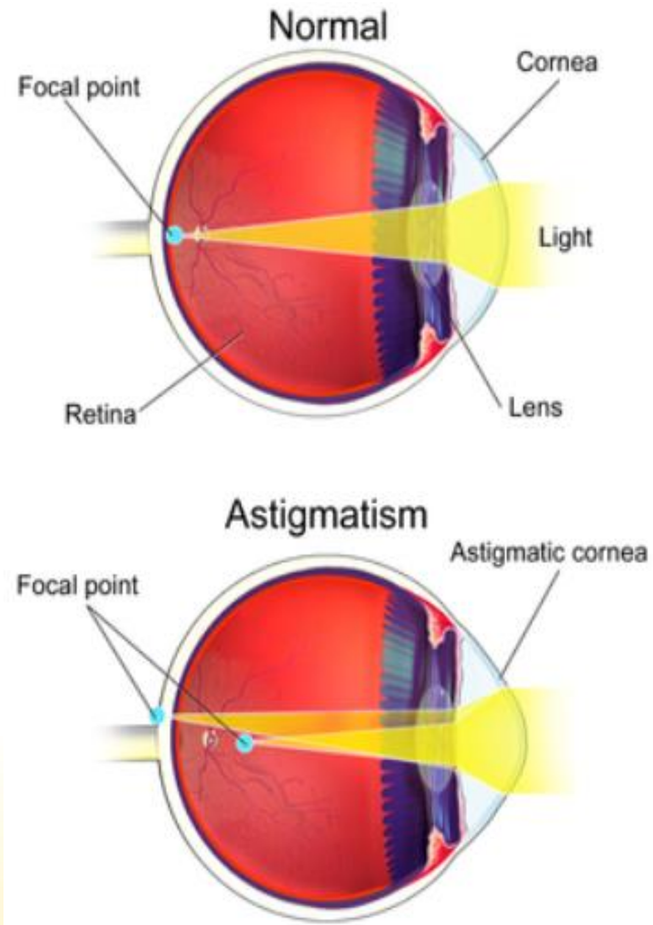
Correcting Vision Problems

Astigmatism

When the cornea or lens is misshapen, a defect in vision called astigmatism results.

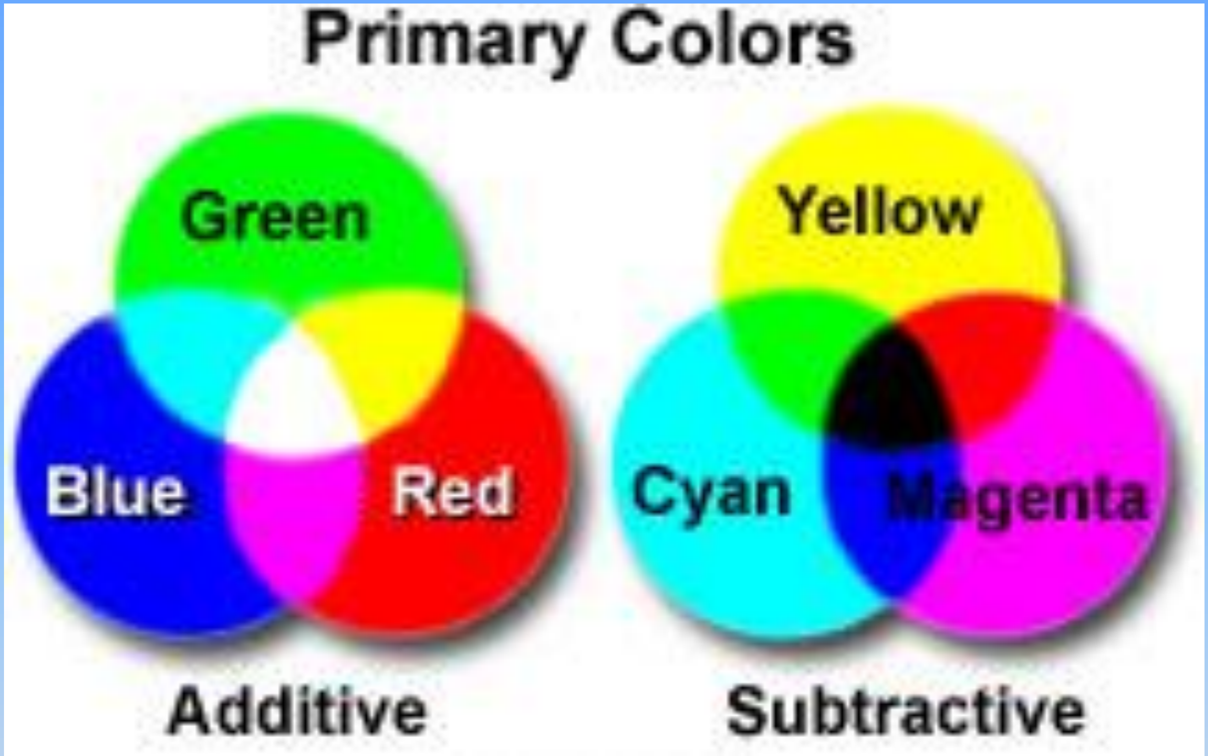
Astigmatism is a condition in which objects at any distance appear blurry because the cornea or lens is misshapen.

Specialized eyeglass lens shapes are used to correct astigmatism.



Astigmatic cornea distorts the focal point of light in front of and/or behind the retina

Color of Light



How important is color in our lives?

Name ways we use color to enrich our lives.

Importance of Color of Light

Colors make us happy (**red**, **blue**, **yellow**)

Colors can put us in a sad, gloomy, bad mood (**black**, **gray**).

Color in clothing is also important to how we appear.

- Make you look thinner or not (**one color** versus multi-)
- Make you look healthy or unhealthy (**lighter, more yellow**)
- Make you feel happy or unhappy (greens, blues)

Color can change the look of your skin (rosy cheeks).

Color combinations change the look of other colors you wear.

- *Yellow, orange and red are associated with the heat / warmth of sun and fire*
- *Blue, green and violet are associated with the coolness of leaves, sea, and the sky.*
- *Red has been shown to stimulate the senses and raise the blood pressure, while blue has the opposite effect and calms the mind.*

Importance of Color of Light

Cosmetics Eye shadow, lipstick, blush, facial creams, facial cleansers, facial scrubs and strippers, eye brow size and colors

Food many foods add coloring for appeal – Coke/soft drinks, gravies, toppings, ice cream, jello, meats, desserts, etc.

Vehicle colors (e.g. the "bad" guys drive dark colored cars and the "good" guys drive bright and light colored cars)

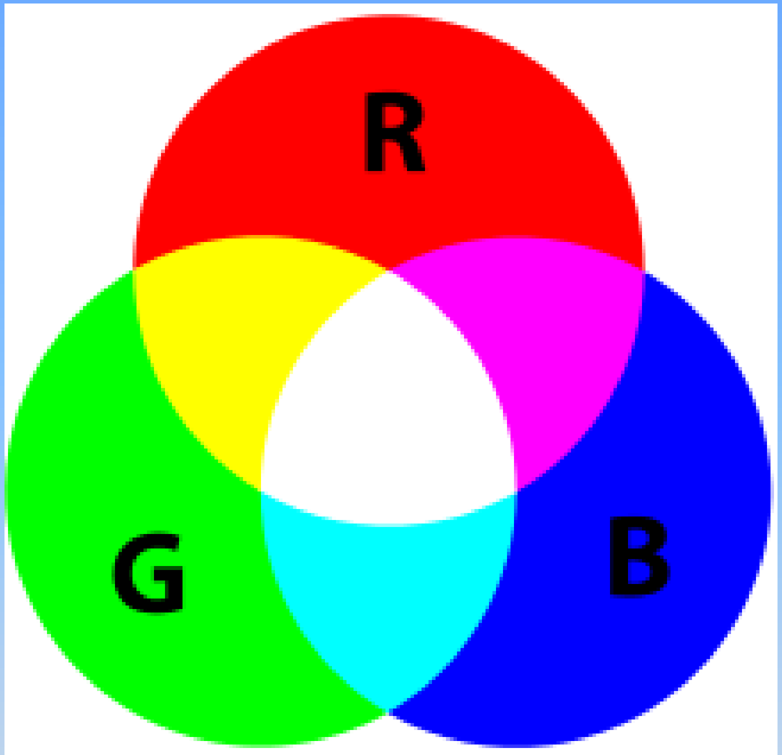
Multi-media color is so critical to setting mood; (*e.g. scary movies use a lot of grays and dark colors with bright red blood and gory parts*) *lights, costumes, props, stage settings, cosmetics have particular colors to gain a specific effect*

Rooms Classrooms, offices, meeting rooms, interior decorating, our homes, etc.

Child care facilities are brightly colored with lots of blues, reds and yellows – making the children happier, more active – giving the appearance of a fun, clean environment

Jewelry

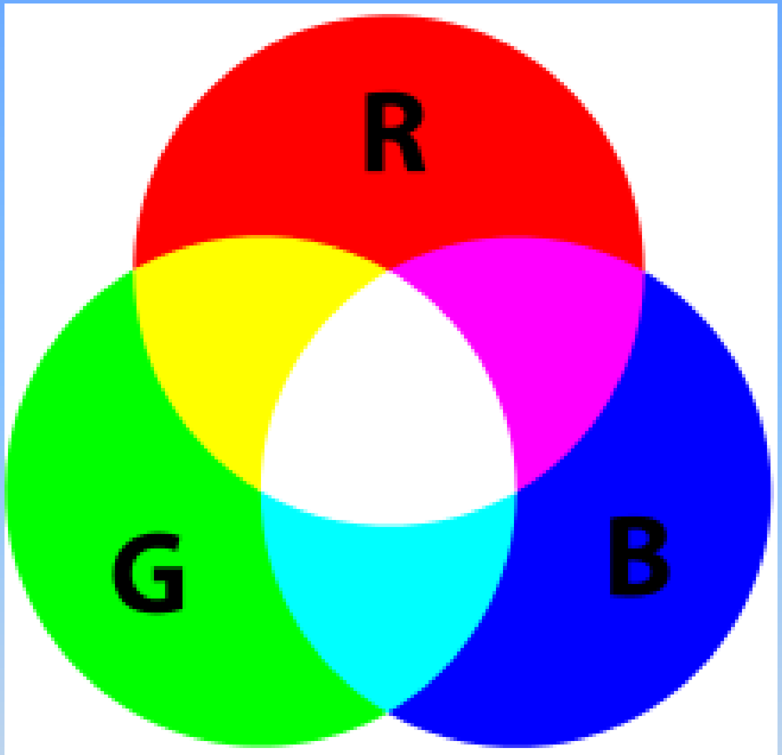
Additive Primary Colors of Light



Additive color processes, such as in television and multi-media presentations, work by having the capability to generate an image composed of red, green, and blue light.

Overlapping all three Additive Primary Colors (red, Green, Blue) of Light in equal intensities, yields white light as shown at the center.

Additive Primary Colors of Light



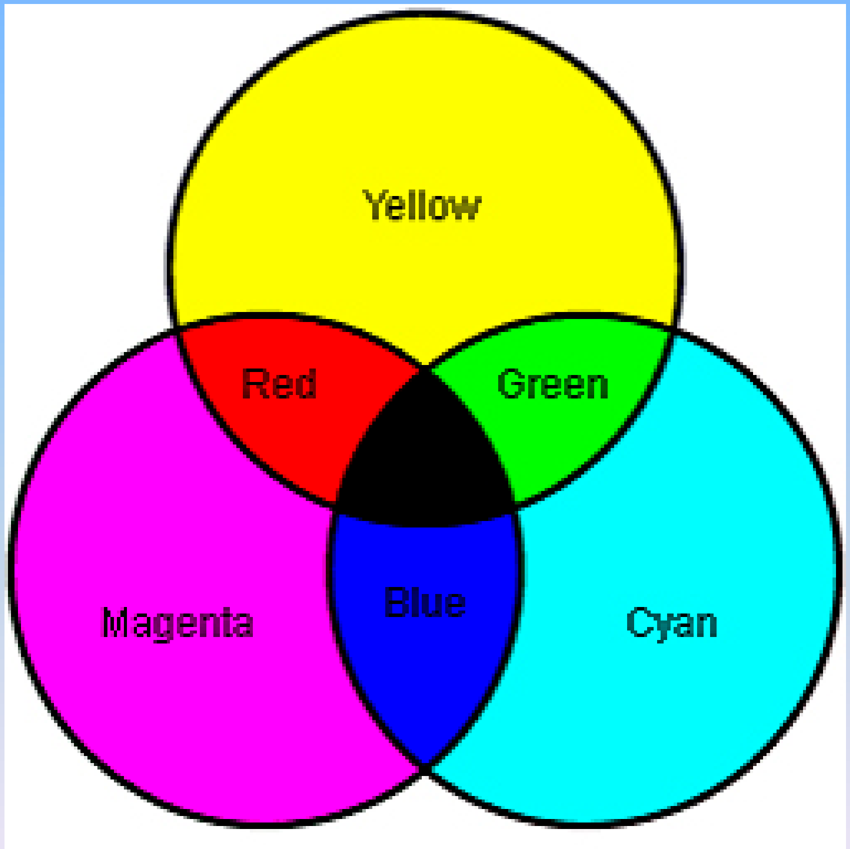
The combination of TWO of the three additive primary colors in equal proportions produces an additive secondary color — cyan, magenta or yellow.

White contains all the colors.

Red + Green + Blue = White

Mixing pigments produces different results than combining light.

Subtractive Primary Colors when mixing dyes, paint, or ink



Each subtractive primary color absorbs one of the additive primary colors and reflects the rest.

Cyan absorbs Red, reflecting green and blue.

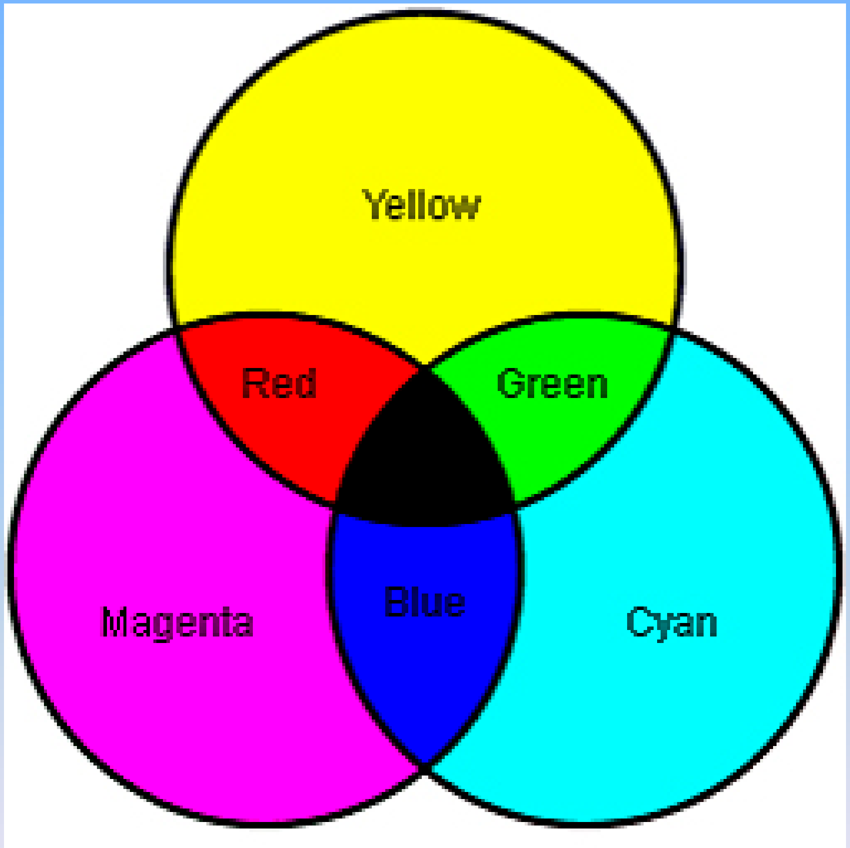
Magenta absorbs Green, reflecting red and blue.

Yellow absorbs Blue, reflecting red and green.

Subtractive Primary Colors when mixing dyes, paint, or ink

We see reflected light. White light (which contains all colors of light) shines on the shirt and shorts. Red is reflected from the shirt, meaning that all the other colors are absorbed into the shirt. Blue is reflected from the shirt, meaning that all the other colors are absorbed into the shirt.

Subtractive Primary Colors when mixing dyes, paint, or ink



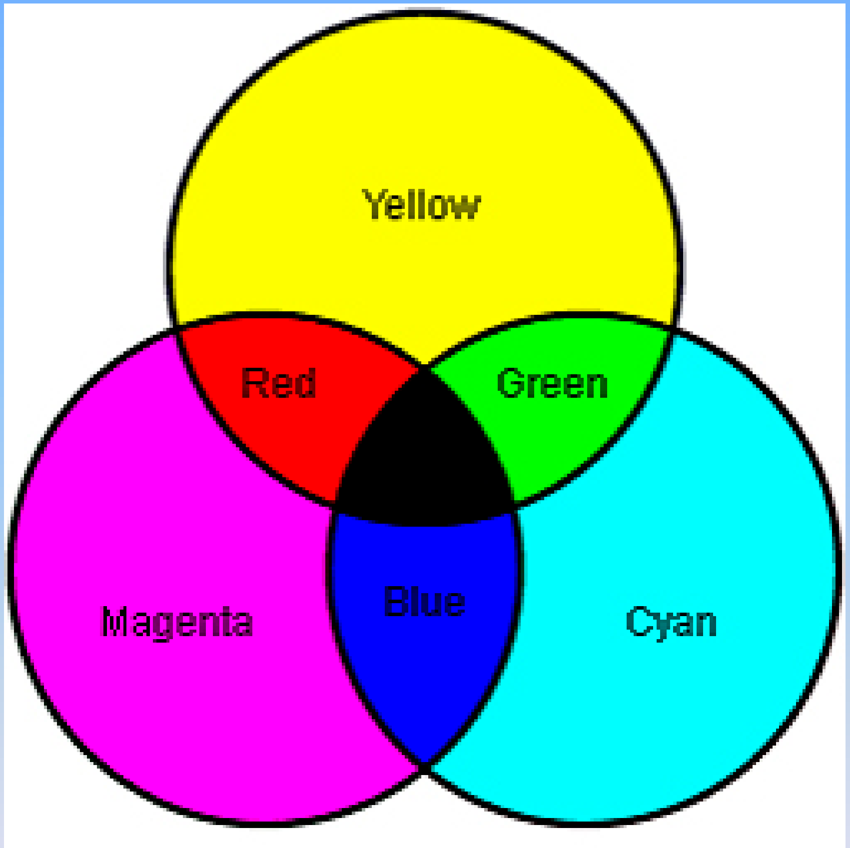
Adding TWO subtractive primary colors together will transmit one of the primary additive colors.

Yellow plus Cyan reflects Green to our eyes, absorbing the rest.

Magenta plus Yellow reflects Red, absorbing the rest.

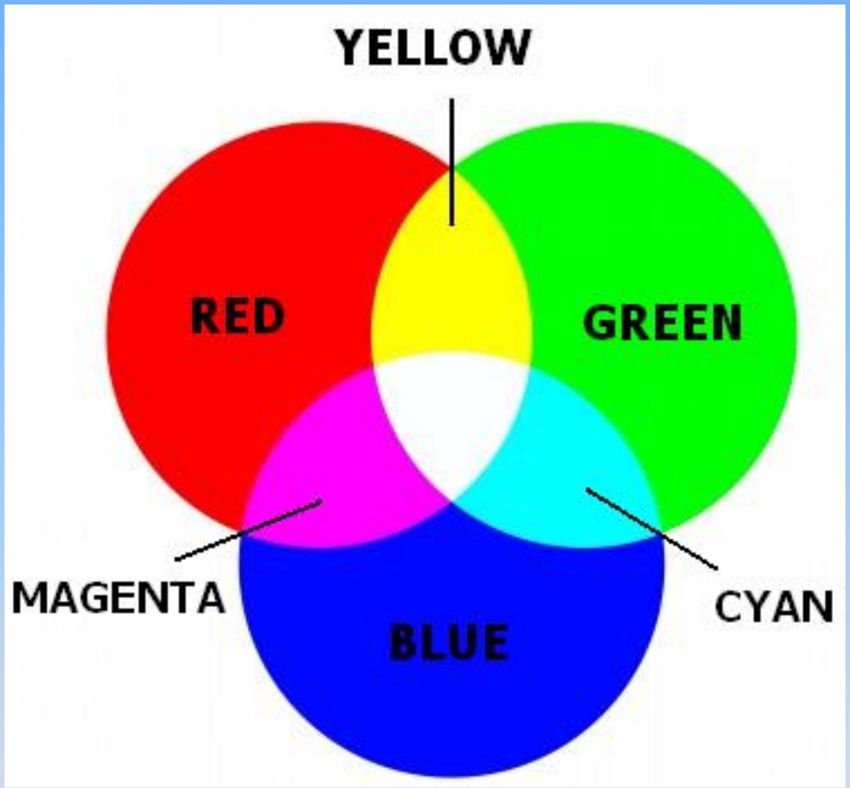
Cyan plus Magenta reflects Blue, absorbing the rest.

Subtractive Primary Colors when mixing dyes, paint, or ink



Adding all three subtractive primary colors together will absorb all the colors of the white light, leaving no color (interpreted as “black” by our brain).

Complementary Colors of Light

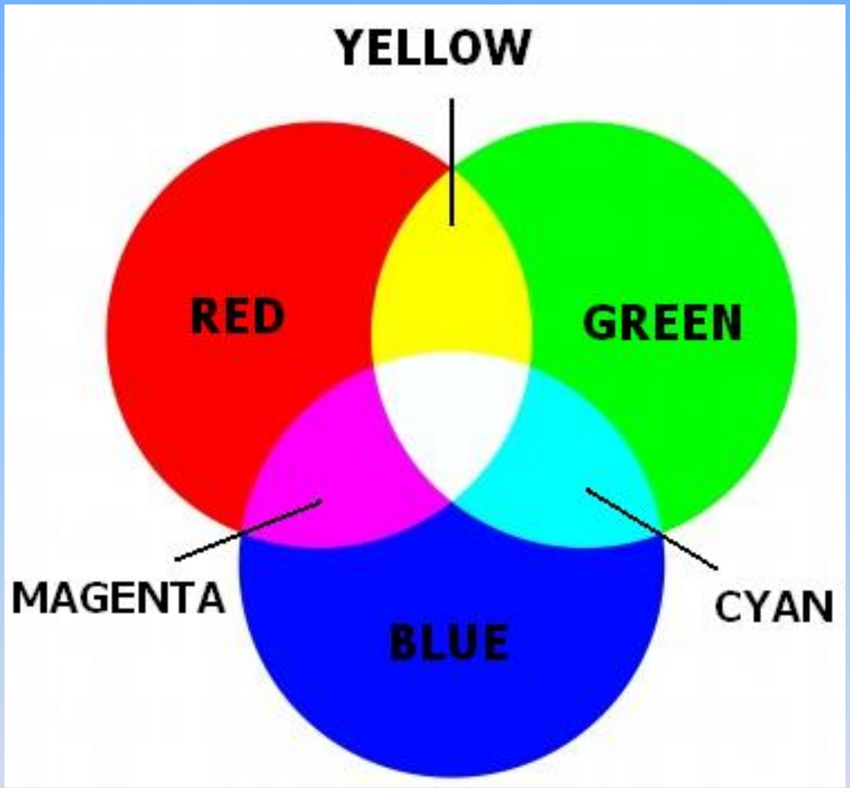


Two colors that produce white when added together are called complementary.

The color complementary to a primary color is called a secondary color.

The complementary or secondary colors for red, green and blue are cyan, magenta and yellow respectively.

Complementary Colors of Light



Complementary colors are also called "Color Opposites" …

Red is "opposite" cyan.

Blue is "opposite" yellow.

Green is "opposite" magenta.

Addition of complementary colors (color "opposites") produce white.

Complementary Colors of Light

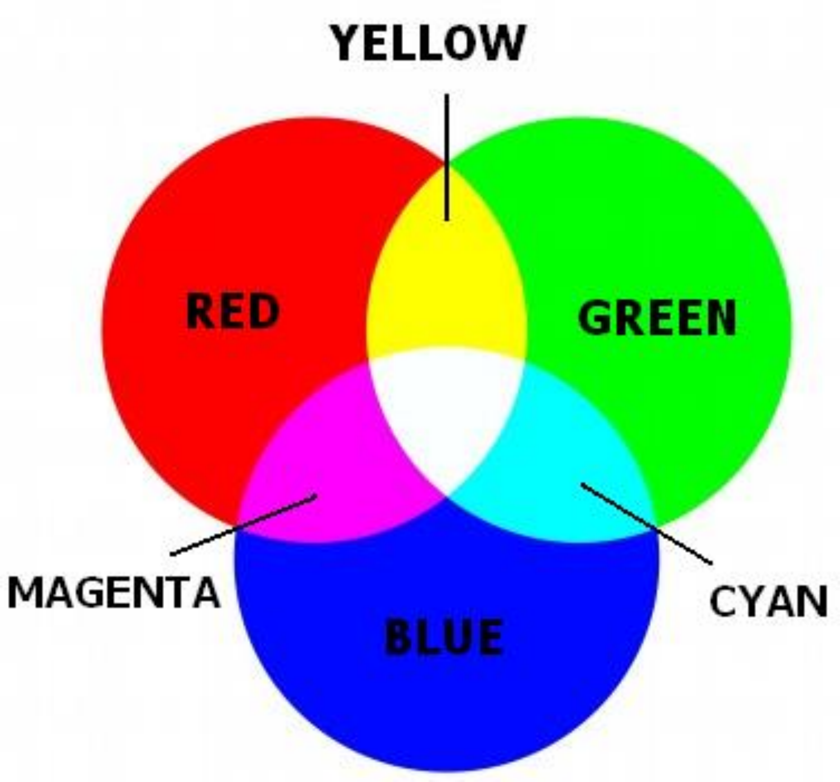
Red plus cyan (green & blue)

Green plus magenta (red & blue)

Blue plus yellow (green & red)

"Color Opposites"

Red + Green + Blue = White



Colors of Light - fill in the chart

QUICK CHECK

Primary Additives	Red	Blue	Green
Red			
Blue			
Green			
R + B + G =			

Subtractive Primary Colors	Yellow (R + G)	Cyan (B + G)	Magenta (B + R)
Yellow (R + G)			
Cyan (B + G)			
Magenta (B + R)			
Y + C + M =			

Complementary Colors	Complement	Result
Red		
Green		
Blue		

Colors of Light

STRATEGY

Primary Additives	Red	Blue	Green
Red	red	Magenta	Yellow
Blue	Magenta	Blue	Cyan
Green	Yellow	Cyan	Green
R + B + G = white			

Subtractive Primary Colors	Yellow (R + G)	Cyan (B + G)	Magenta (B + R)
Yellow (R + G)	yellow	Green	Red
Cyan (B + G)	Green	cyan	Blue
Magenta (B + R)	Red	Blue	magenta
Y + C + M = black			

Complementary Colors	Complement	Result
Red	Cyan (B + G)	White
Green	Magenta (B + R)	White
Blue	Yellow (R + G)	White

Assessment Questions

1. A prism separates white light into the visible spectrum because
   a. longer wavelengths are absorbed more than shorter wavelengths.
   b. shorter wavelengths refract more than longer wavelengths.
   c. shorter wavelengths reflect more than longer wavelengths.
   d. longer wavelengths experience more interference.

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   a. longer wavelengths are absorbed more than shorter wavelengths.
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   ANS: B

Assessment Questions

2. The color of an object depends on what the object is made of and on
   a. the intensity of light that strikes the object.
   b. the color of light that strikes the object.
   c. the direction of the light that strikes the object.
   d. the speed of the light that strikes the object.

Assessment Questions

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Assessment Questions

3. Which of these colors is one of the primary colors of light?
   a. green
   b. magenta
   c. yellow
   d. white

Assessment Questions

3. Which of these colors is one of the primary colors of light?
   a. green
   b. magenta
   c. yellow
   d. white

   ANS: A (red, green, blue)