

Technology and digital images



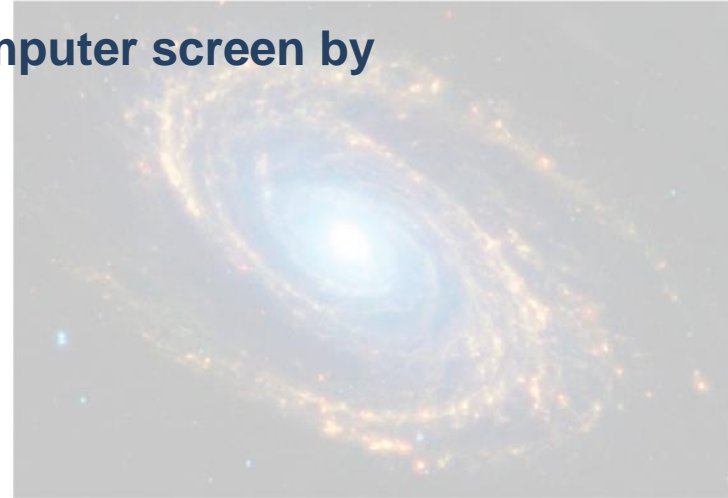
Objectives

- Describe how the characteristics and behaviors of white light allow us to see colored objects.
- Describe the connection between physics and *technology*.
- Describe how the characteristics and behaviors of light are used in technology, such as in the creation of digital images.



Assessment

1. Explain how you can see ordinary, non-luminous objects in the classroom.
2. What kind of light is represented on a computer screen by an RGB value of:
 - A. (255, 255, 255)
 - B. (0, 0, 0)
 - C. (100, 100, 100)
 - D. (255, 0, 0)
 - E. (255, 0, 255)



Assessment

3. List two technologies that use RGB color display.

4. Describe how the eye combines colors to see.



Physics terms

- quantitative
- qualitative
- engineering
- technology
- pixel
- RGB
- additive primary colors
- subtractive primary colors
- rods
- cones



The language of physics

Mathematics is the language of physics.

English:

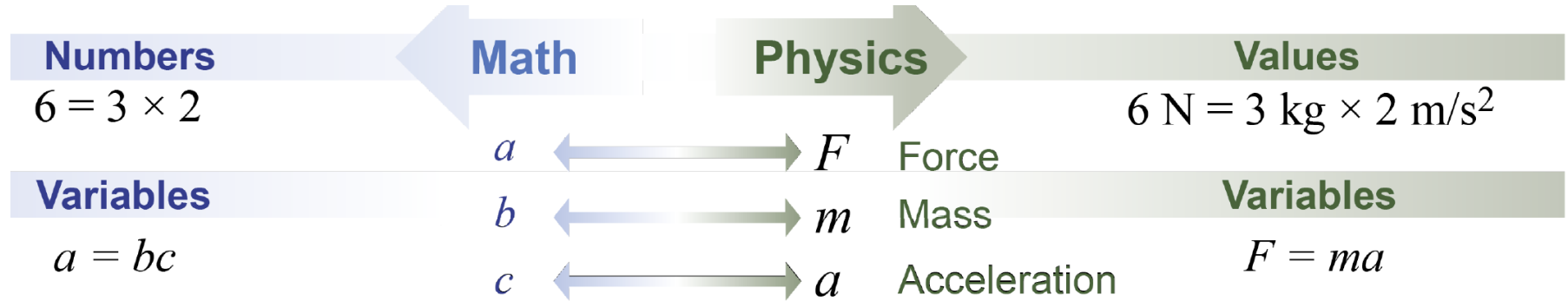
The speed is the distance traveled
divided by the time taken.

Mathematics:

$$v = \frac{d}{t}$$

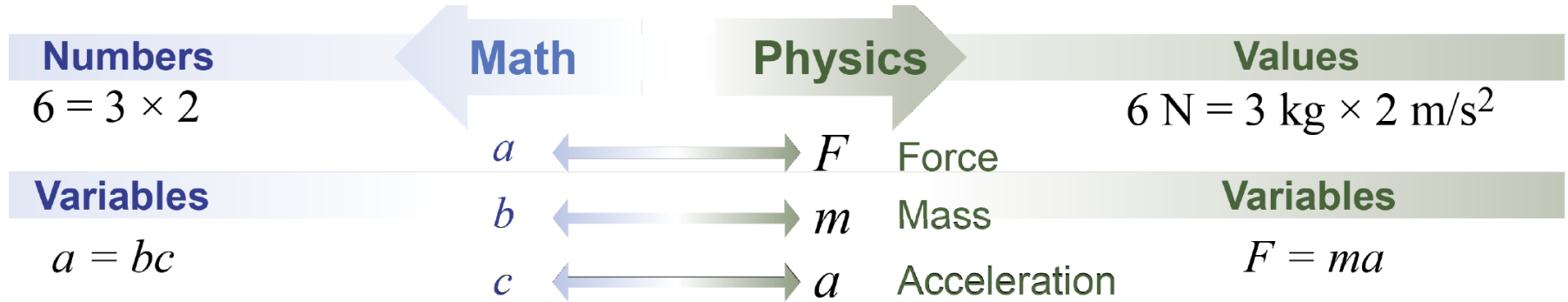
Equations

Physics teaches you how to use math to understand the physical world.



Equations

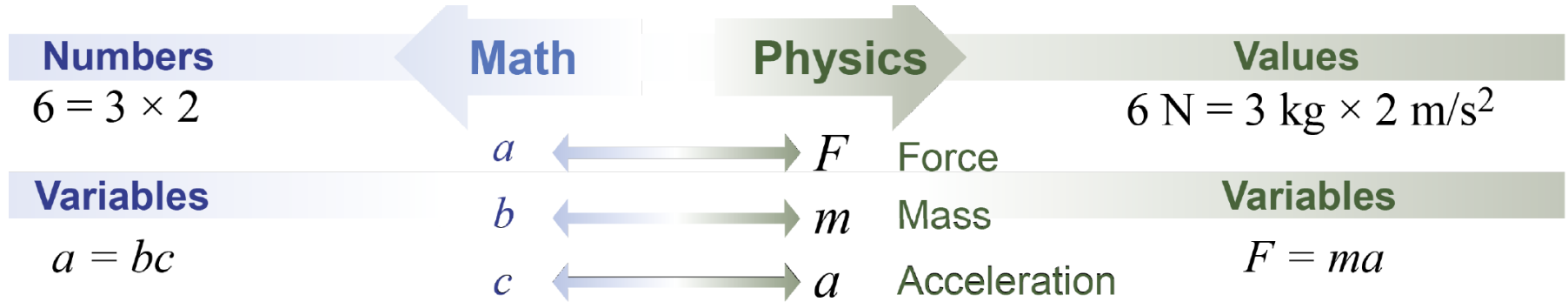
Physics teaches you how to use math to understand the physical world.



Equations allow us to write the natural laws of physics in *quantitative* rather than *qualitative* language.

Equations

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Equations allow us to write the natural laws of physics in *quantitative* rather than *qualitative* language.

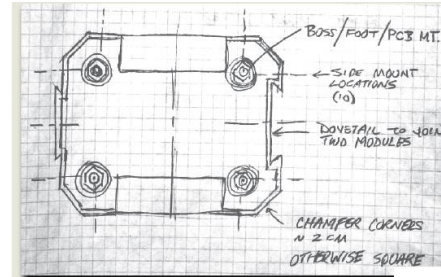
Click the math icon at the top of an e-Book page to see examples of math concepts matched with real-world physics applications.



The math icon

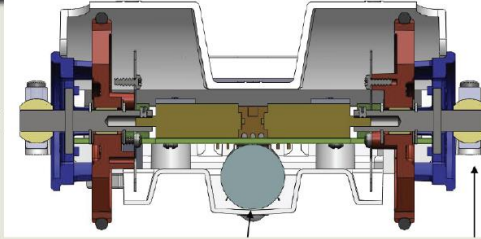
Engineering

Engineering is the application of science to the design of products or inventions to meet human needs.



Design

Rechargeable
Wireless communication
 ± 1 mm position sensing
0 - 1.5 m/s speed
0 - 0.5 m/s² acceleration



Technology

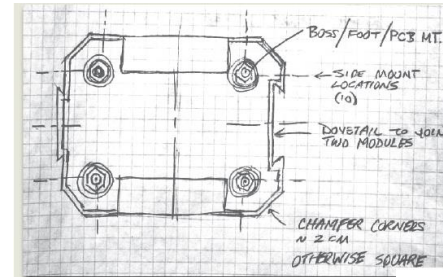


Engineering

Engineering is the application of science to the design of products or inventions to meet human needs.

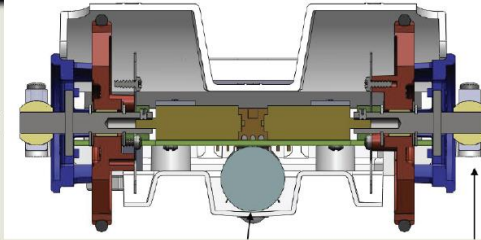
Engineers invent *technologies* such as cell phones and computers.

This course will feature many *case studies* that relate physics directly to the design of technology.



Design

Rechargeable
Wireless communication
 ± 1 mm position sensing
0 - 1.5 m/s speed
0 - 0.5 m/s² acceleration

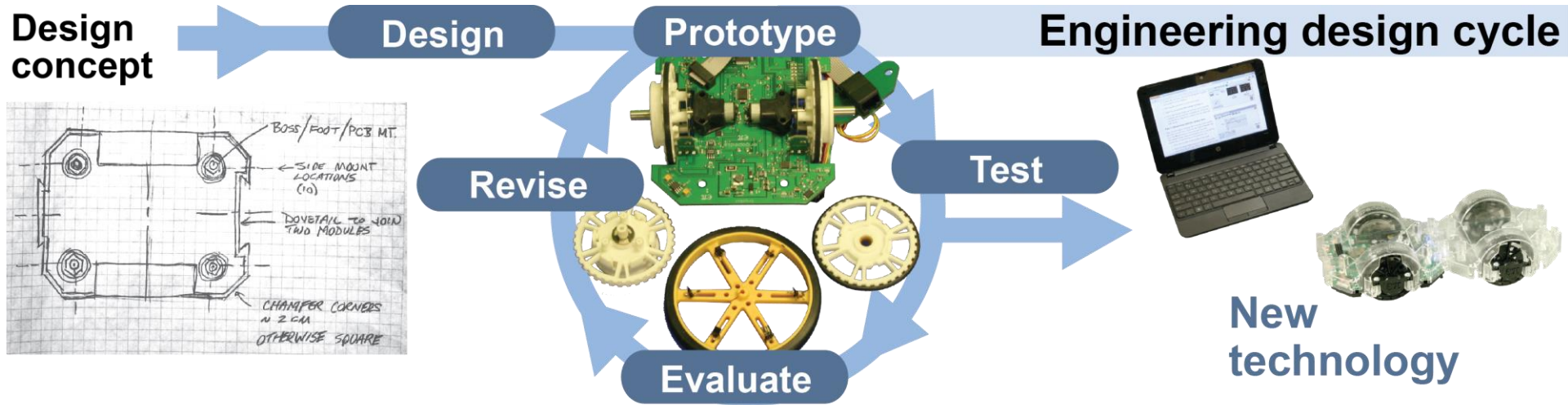


Technology



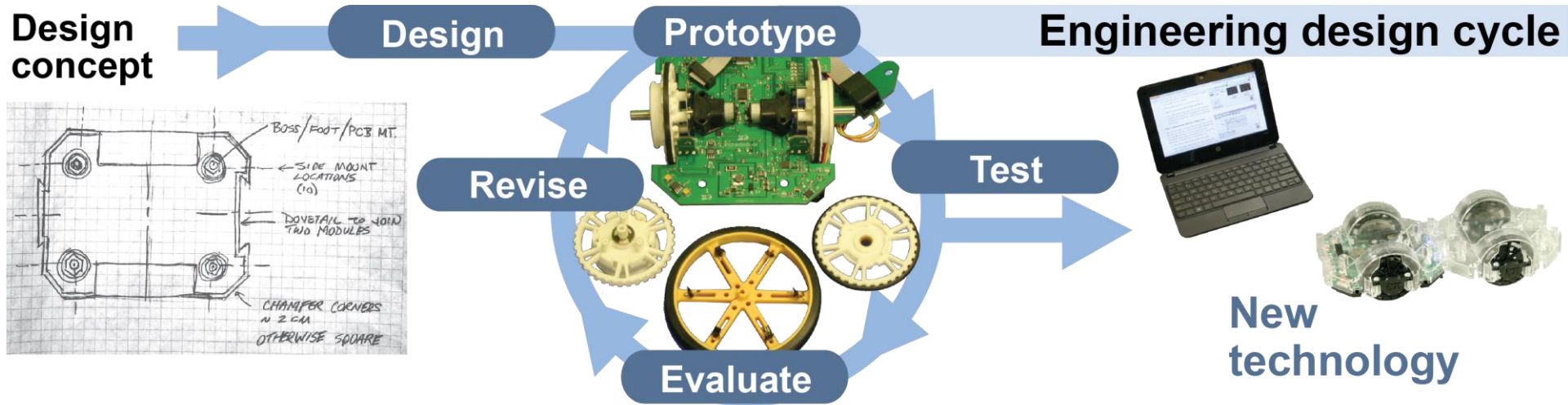
Engineering design cycle

Engineering involves designing devices to perform a function, within the limits of constraints such as cost, energy consumption or longevity.



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The design cycle is iterative. It continues until it finds the best solution.

Technology

Technology is everything built in the human-constructed world.



Technology

Technology is everything built in the human-constructed world.

In this course we will examine the fundamental physics behind many interesting technologies.



Subsystem

Communication
Display
Touchscreen
Processor
Memory
Battery
Case

Physics

Electromagnetic waves
Optics, diodes
Capacitance
Semiconductors
Semiconductors
Electrons, atoms
Force, strength, mass

Technology applications in the text

Technology and *engineering* icons in each chapter are a quick way to see how physics concepts are applied to various technologies.



R
G
B



Technology
Inventions
and techniques



Engineering
The design
of technology

Technology of digital images

Digital devices like this camera can display colorful images.

How do these devices read and display the all the thousands of possible colors?



R
G
B



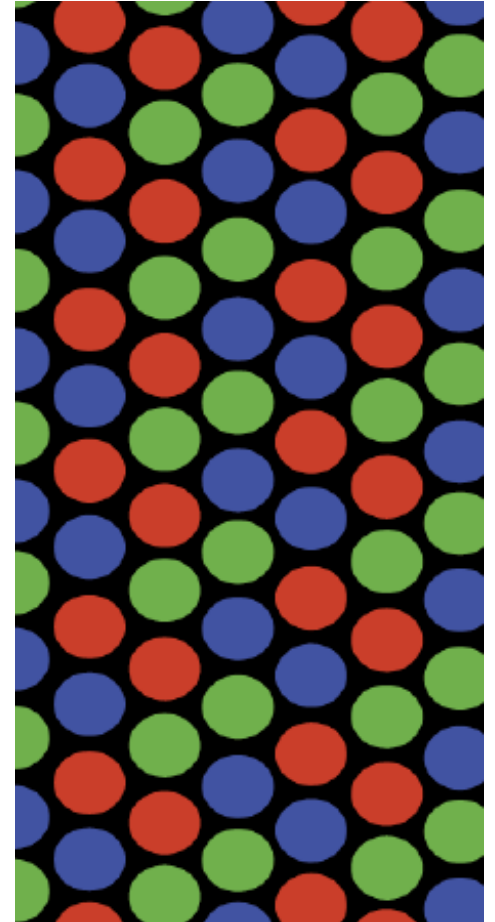
Technology
Inventions
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Engineering
The design
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Digital images

A digital image tricks the brain into seeing a full range of colors by adding together varying amounts of red, green, and blue.



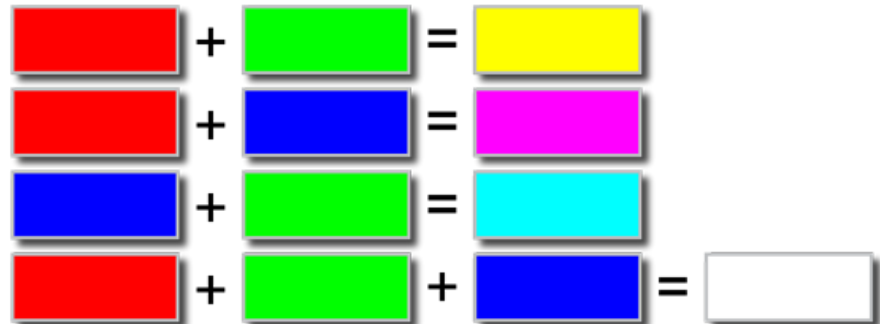
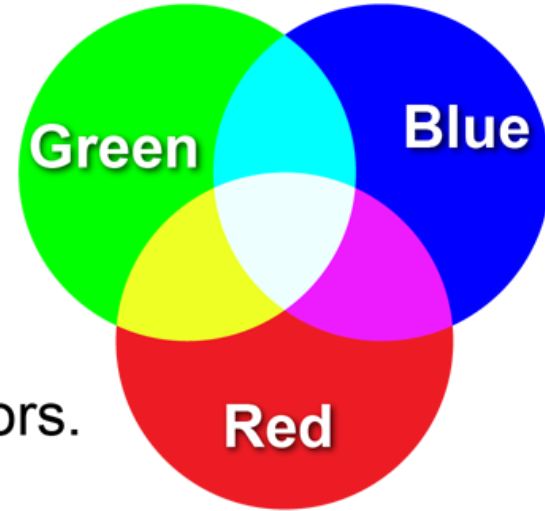
Additive colors

RGB = “Red, Green, Blue”

When combinations of RGB are *added* together, you can create many different colors.

RGB additive primary colors

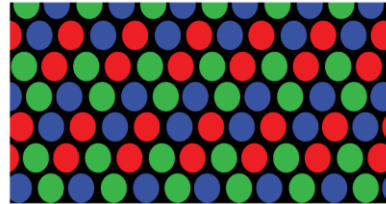
On your computer screen, RGB primary colors add together to make other colors.



Additive colors and technology

RGB additive colors are used in many technologies to create digital images.

- television
- computer screens
- digital cameras
- computer projectors

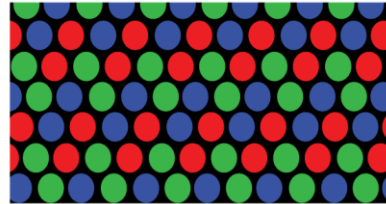


Pixels in a digital image fool the eye into seeing all colors using only red, green and blue.

Additive colors and technology

A digital image is made up of tiny dots called *pixels*.

- Each pixel is created by combining the three RGB colors.
- A one megapixel image has one million dots.



Pixels in a digital image fool the eye into seeing all colors using only red, green and blue.

Additive colors in digital cameras

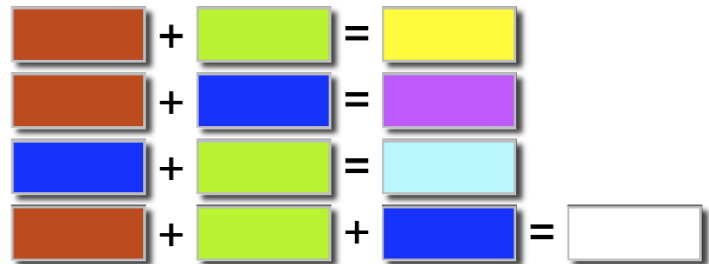
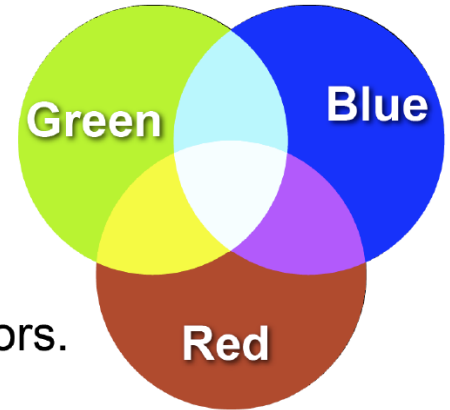
In a digital camera, each *pixel* is captured by tiny red, green and blue sensors.

Each sensor records a number from 0 to 255 corresponding to the light intensity for that color.

A one megapixel digital image is a string of three million numbers which prescribe the intensity of red, green and blue for each *pixel*.

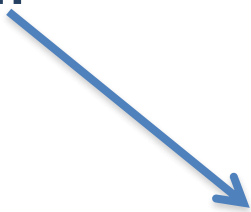
RGB additive primary colors

On your computer screen, RGB primary colors add together to make other colors.



Exploring the ideas

Click this
interactive
simulation on
page 26.



1C: RGB color matching

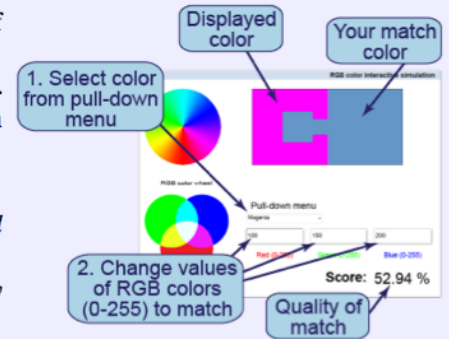
Essential questions

How do computers and TV screens create color using only red, green, and blue?

A computer or television screen produces a wide variety of colors using combinations only of red, green, and blue. RGB colors are used in HTML to create webpages, including this one. A color wheel is a simplified way of representing combinations of *two* of these primary colors. In this interactive simulation, you will construction combinations of all three in order to match various colors in a palette. What RGB color combination is needed to create aquamarine?

Part 1: Creating simple colors

1. Match the first few colors only using values of either zero or 255 for each primary color.
2. Select the color *magenta* in the pull-down menu. Enter values for red, green, and/or blue to match it.
3. Repeat to match cyan, yellow, white, and black.
 - a. What are the RGB colors for magenta, cyan, and yellow?
 - b. What is the RGB color for white? Explain why by referring to a prism.
 - c. What is the RGB color for black?



In this interactive simulation, you will change the values of the colors red, green, and blue in order to try to match the displayed color. In Part 1, only set the value of each color to zero or 255; in Part 2, set each color to any value from zero to 255. For each

Investigation

Part 1: Creating simple colors

1. Launch the application.
2. Match the first few colors using only values of zero or 255 for each primary color.
3. Select *magenta* in the pull-down menu. Enter values for red, green and/or blue to match it.
4. Repeat to match cyan, yellow, white and black.

The screenshot shows an "RGB color interactive simulation" interface. It includes an "RGB color wheel" and an "RGB color wheel" diagram. A "Pull-down menu" is set to "Magenta". Below the menu are three input fields for "Red (0-255)", "Green (0-255)", and "Blue (0-255)". The "Red" field is set to 100, "Green" to 150, and "Blue" to 200. A "Score: 52.94 %" is displayed. A "Quality of match" box points to the score. A "Displayed color" box points to a purple square on the right. A "Your match color" box points to a blue square on the right. A callout box "1. Select color from pull-down menu" points to the "Magenta" selection. Another callout box "2. Change values of RGB colors (0-255) to match" points to the input fields.

Investigation

Questions for Part 1

- What are the RGB colors for magenta? Cyan? Yellow?
- What is the RGB color for white? Explain why by referring to a prism.
- What is the RGB color for black?

The image shows a screenshot of an "RGB color interactive simulation" interface. The interface includes an "RGB color wheel" and an "RGB color wheel" (two labels pointing to the same wheel), a "Pull-down menu" currently set to "Magenta", and three input fields for "Red (0-255)", "Green (0-255)", and "Blue (0-255)". The "Red" field is set to 100, "Green" to 150, and "Blue" to 200. A "Score: 52.94 %" is displayed. The interface also shows a "Displayed color" (a purple square) and a "Your match color" (a blue square). Annotations in blue boxes with arrows point to these elements:

- "1. Select color from pull-down menu" points to the "Magenta" selection in the pull-down menu.
- "2. Change values of RGB colors (0-255) to match" points to the input fields for Red, Green, and Blue.
- "Quality of match" points to the "Score: 52.94 %" display.
- "Displayed color" points to the purple square on the right.
- "Your match color" points to the blue square on the right.

Investigation

Part 2: Creating complicated colors

1. Use any value from zero to 255 for each color.
2. Start by matching light gray and dark gray.
A good match has a “score” of greater than 95%.
3. Pick five different colors from further down the pull-down menu and find a good match for each one.

Answer questions on your assignment sheet.

What are the RGB colors for these?

Light gray

Dark gray

Salmon

Goldenrod

Turquoise

Olive drab

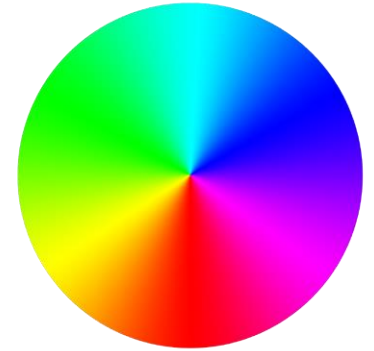
Hot pink

Gold

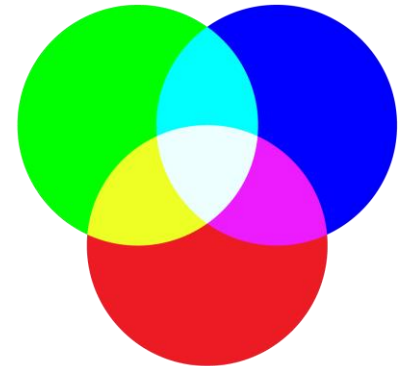
RGB color wheel representations

Each of these color wheels are *explanations* of how colors of light combine to form new colors.

1. **Analyze** each visual representation and describe in words how each explains how colors of light combine to create new colors.
2. **Critique** how well each color wheel explains how colors combine, based on your experiments and experience with the interactive element.
3. **Evaluate** these two representations. Which is more useful in helping you to determine the red, green, and blue values to match various colors during the investigation.



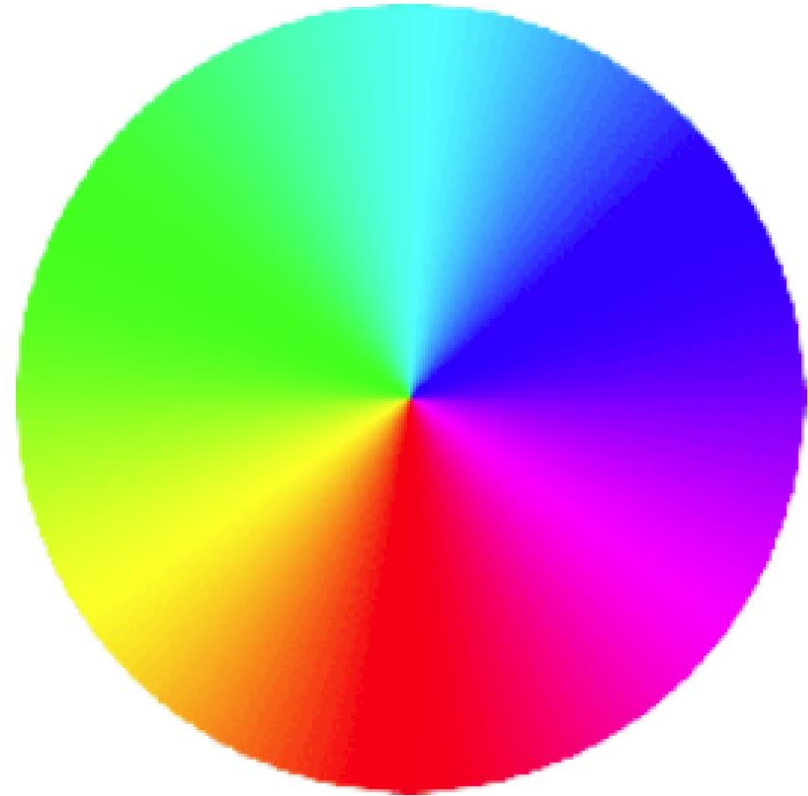
RGB color wheel



The technology of color

We use two different methods for creating different colors.

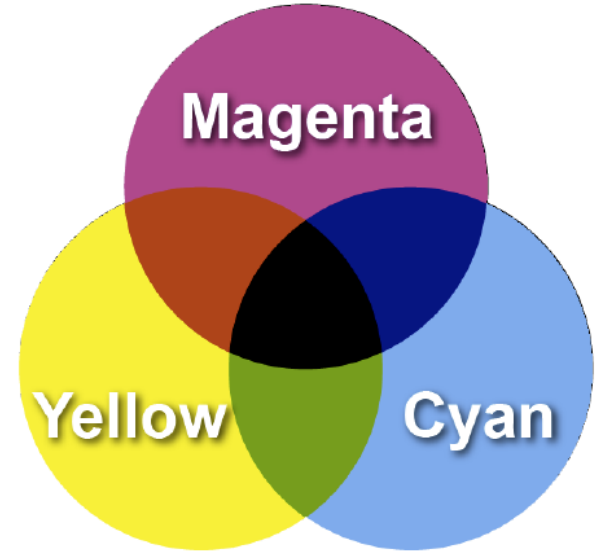
- Digital devices create colors using *emitted light* in an additive process.
- Print images in books and newspapers use *reflected light* in a subtractive process.



Printed images

Screens display color by emitting light.
The pages of a book reflect light instead.

Subtractive primary colors (CMYK)

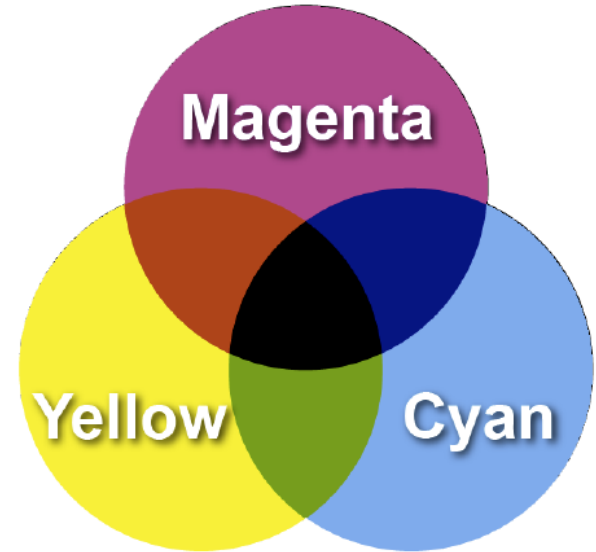


Printed images

Screens display color by emitting light.
The pages of a book reflect light instead.

When you view a color page, you see
the colors it reflects. Other colors have
been absorbed.

Subtractive primary colors (CMYK)



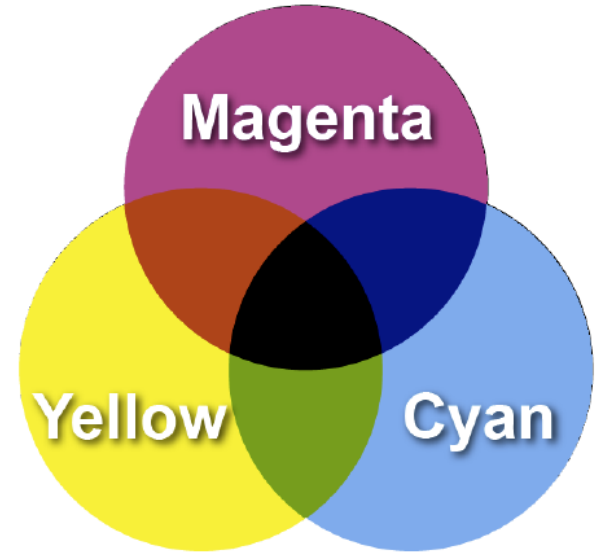
Printed images

Screens display color by emitting light. The pages of a book reflect light instead.

When you view a color page, you see the colors it reflects. Other colors have been absorbed.

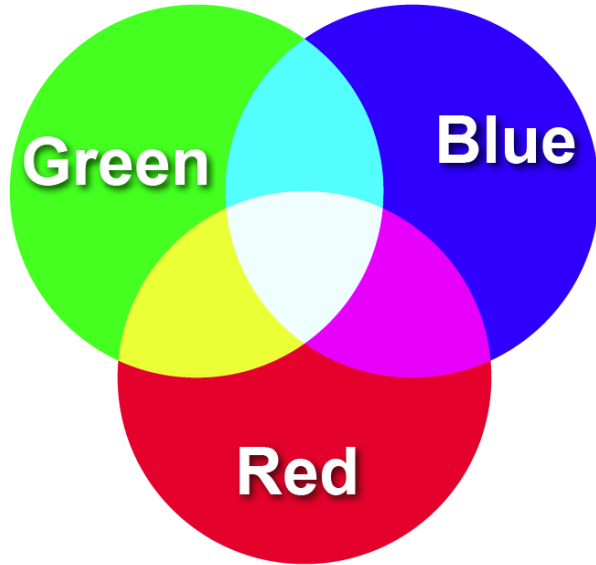
Cyan, magenta and yellow pigments are used in this *subtractive* process to remove light upon reflection.

Subtractive primary colors (CMYK)

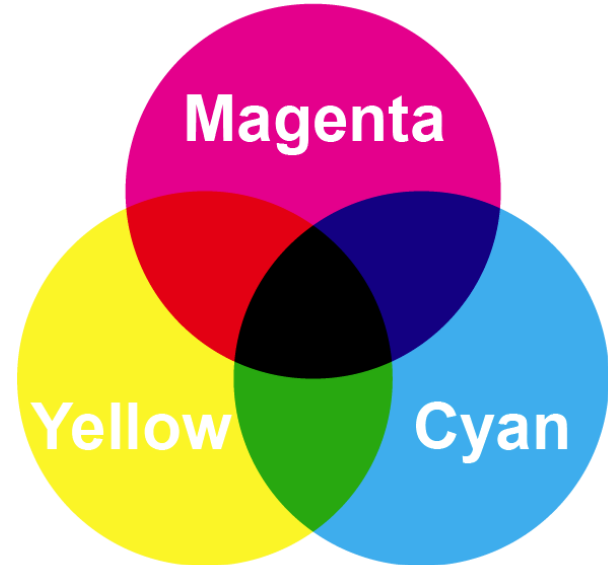


Compare color wheels

RGB additive primary colors



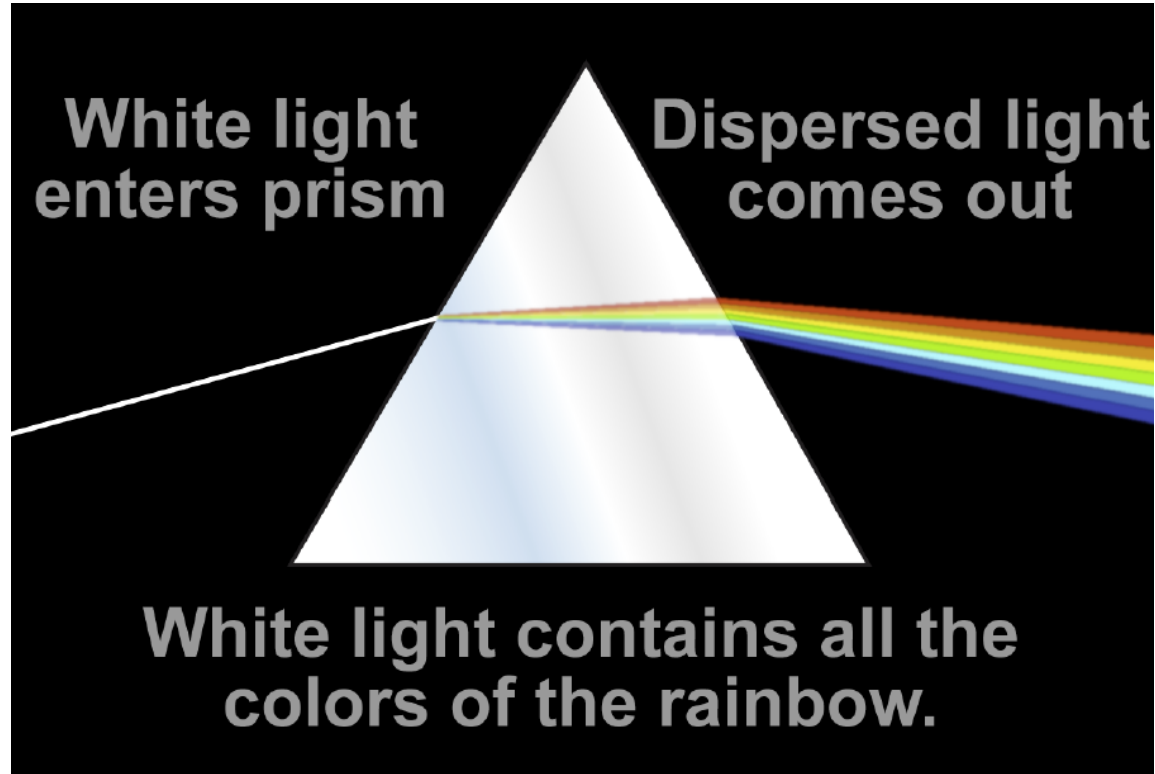
CMYK subtractive primary colors



Each set of colors can be created from the other!

Light and color

Where do the colors of a rainbow come from?

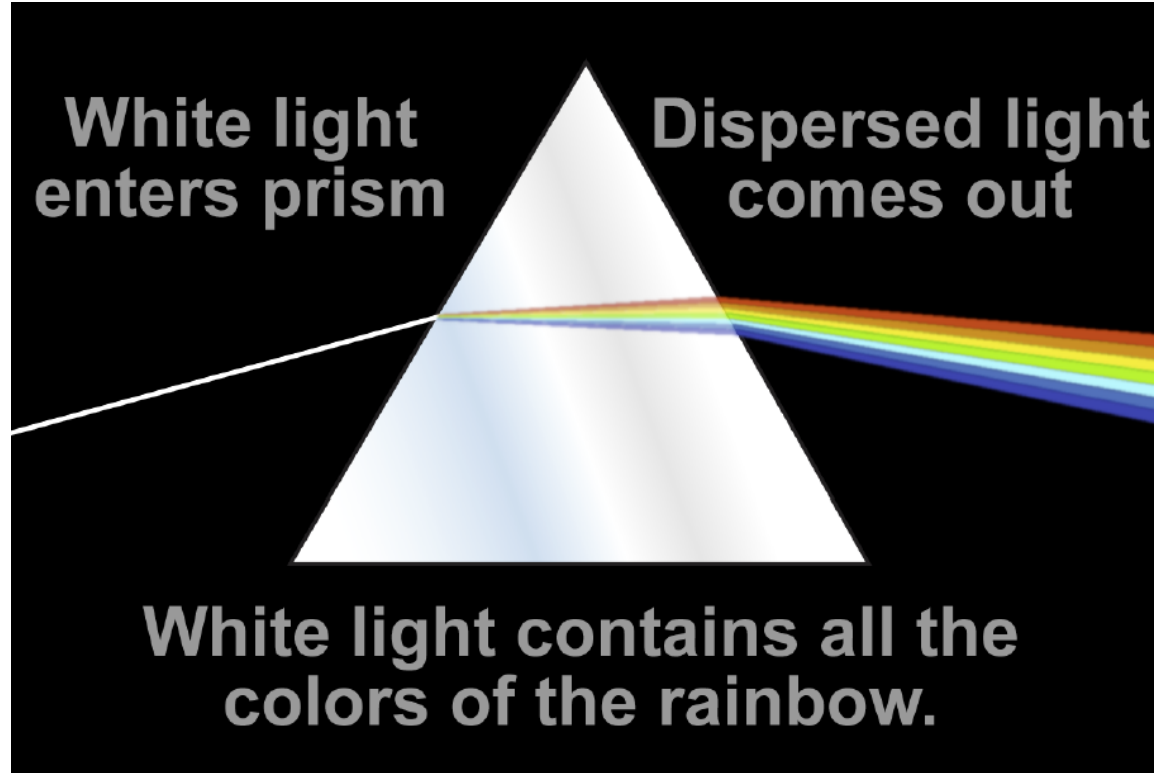


Light and color

All the colors of the rainbow are contained in white light from the Sun.

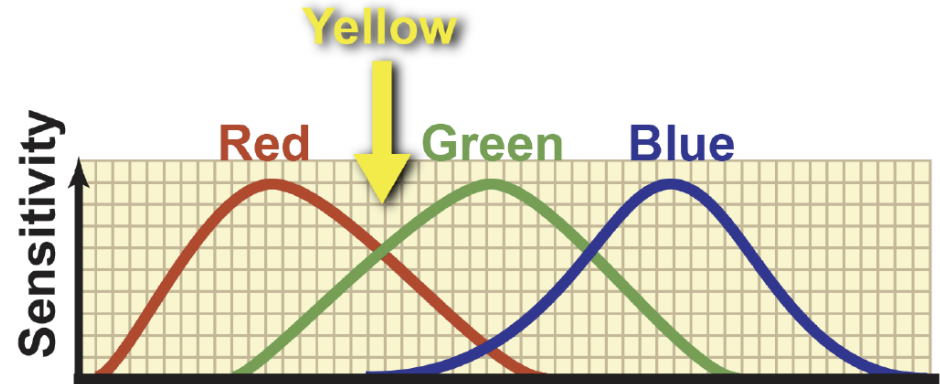
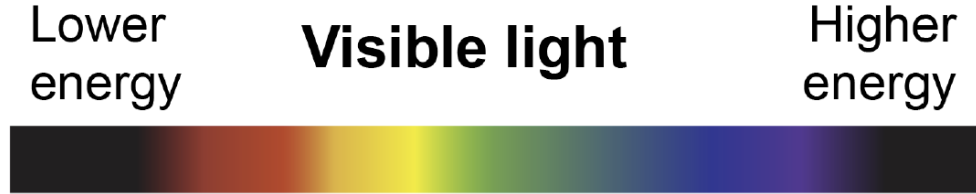
Raindrops disperse the white light into its colors.

A glass prism can also disperse white light into its colors.



How do we sense color?

The sensation of color is a perception of the *energy* in light.

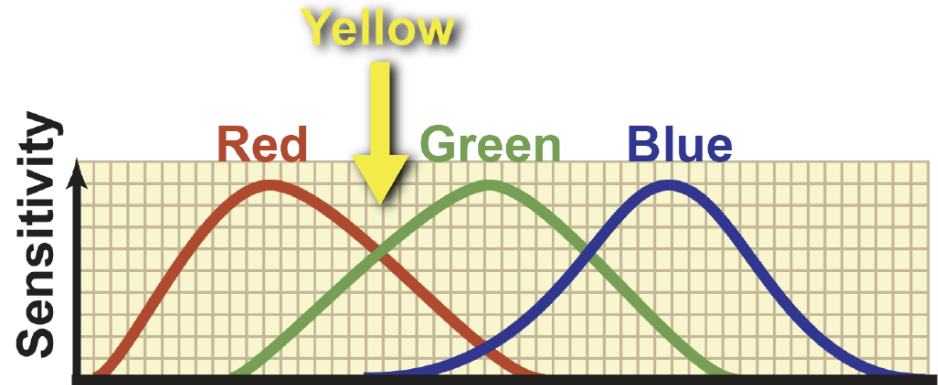
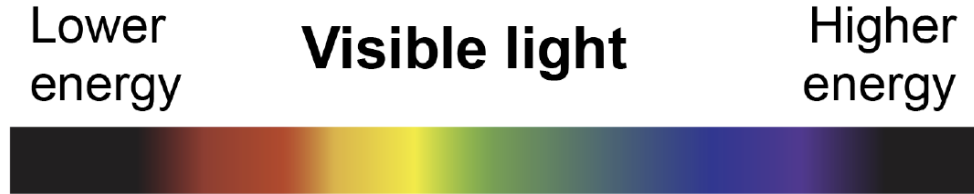


Schematic of the response for the three sensors in a human eye

How do we sense color?

The sensation of color is a perception of the *energy* in light.

Within the visible spectrum, lower energy light appears red to us, and higher energy appears blue.



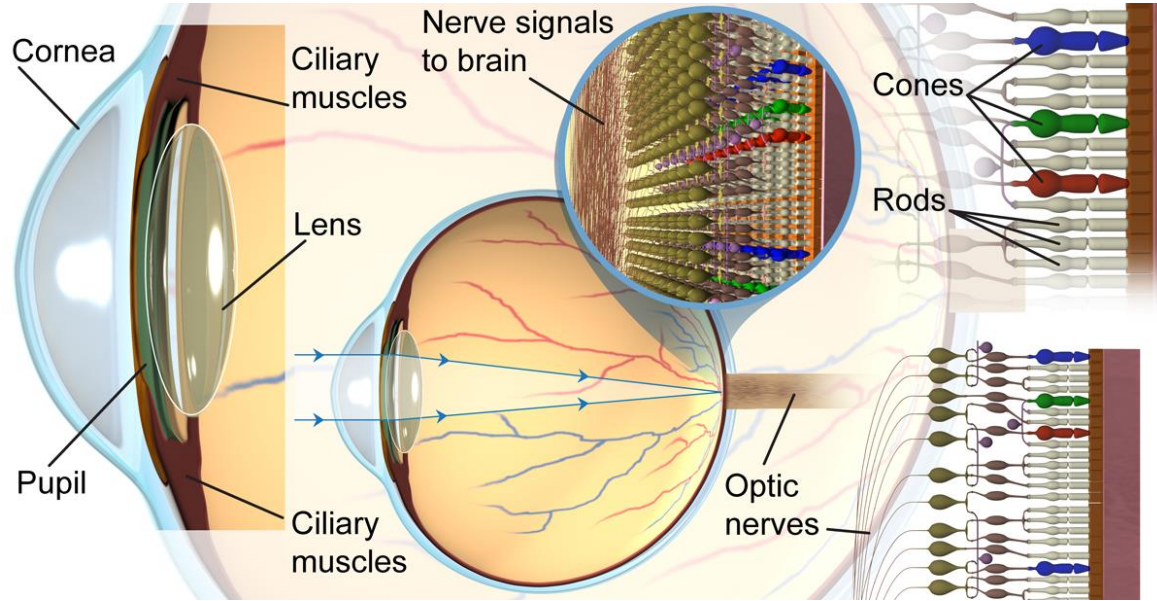
Schematic of the response for the three sensors in a human eye

How the eye sees color

The eye's retina has two kinds of light sensors.

- *Rods* detect the *intensity* of light.

- *Cones* detect the *color* of light.

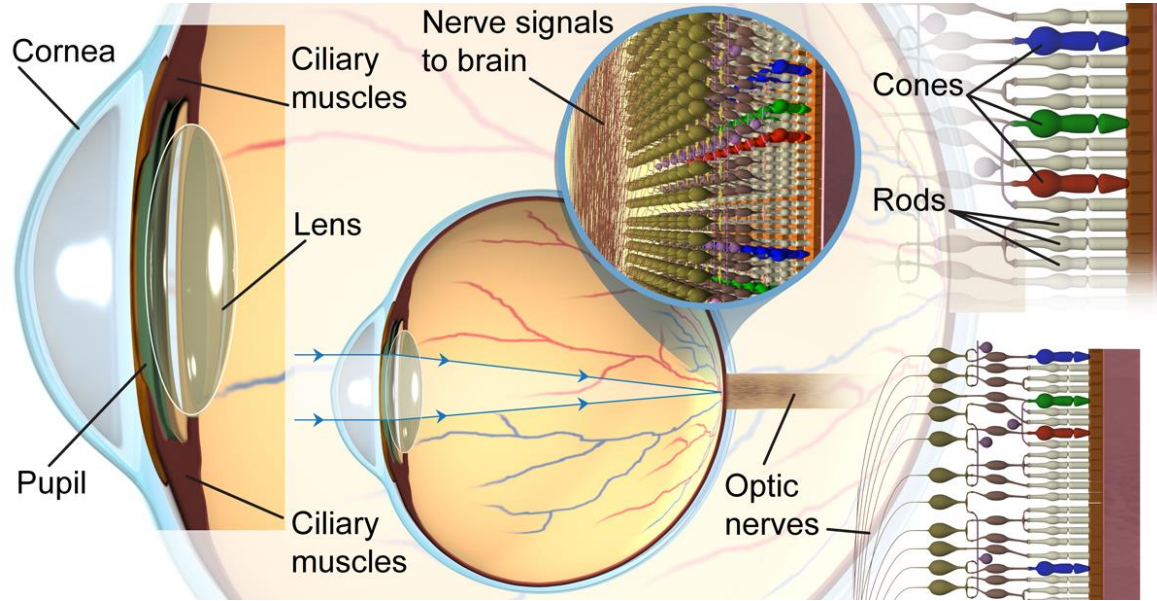


How the eye sees color

The eye's retina has two kinds of light sensors.

- *Rods* detect the *intensity* of light.

- *Cones* detect the *color* of light.



There are 3 types of cones: cones that detect **red** light, **green** light, and **blue** light. The brain combines these intensities and colors into an image.

How the eye sees color

Our eyes work like a digital camera.

In a digital camera, each *pixel* is captured by tiny red, green and blue sensors.

In our eyes, the three types of cones are sensors corresponding to the three primary colors.



Assessment

1. Explain how you can see ordinary, non-luminous objects in the classroom.



Assessment

1. Explain how you can see ordinary, non-luminous objects in the classroom.

Non-luminous objects in the classroom absorb or reflect particular colors. The colors we see are the ones that are reflected.



Assessment

2. What kind of light is represented on a computer screen by an RGB value of:

A. (255, 255, 255)

B. (0, 0, 0)

C. (100, 100, 100)

D. (255, 0, 0)

E. (255, 0, 255)



Assessment

2. What kind of light is represented on a computer screen by an RGB value of:

- A. (255, 255, 255) **white**
- B. (0, 0, 0) **black**
- C. (100, 100, 100) **grey**
- D. (255, 0, 0) **red**
- E. (255, 0, 255) **magenta**



Assessment

3. List two or more technologies that use RGB color display.



Assessment

3. List two or more technologies that use RGB color display.

computer screen

laptop projector

digital camera

cell phone



Assessment

4. Describe how the eye combines colors to see.



Assessment

4. Describe how the eye combines colors to see.

The eye has three types of *cones* that detect either red, green, or blue light.

The brain combines these RGB additive primary colors to create an image.

