

It's a Colorful Life

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General Atomics

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GENERAL ATOMICS

Color Confusion

- “The primary colors of paints, pigments, etc. are red, yellow, blue.” (Webster’s New World Dictionary)
- “There are three colors, however, which cannot be created from mixtures; these are the hues, red, yellow, and blue. They are called the primary color... A mixture of the three primaries should theoretically result in white; actually this mixture produces a neutral grey, which may be considered a darkened form of white.” (Art Fundamentals Theory and Practice)
- “They should identify the three colors needed to produce all the others as red, blue, and yellow. Most artists call these the fundamental colors. The correct subtractive colors, used by printers, for example, are cyan, magenta, and yellow.” (Journal of Chemical Education)
- “The primary process colors are: Yellow, Red (Magenta), and Blue (Cyan). (Color Printing Manual)
- “For this reason cyan, magenta, and yellow are called the subtractive primary colors. In painting or printing, the primaries are often said to be red, yellow, and blue. Here we are loosely speaking of magenta, yellow, and cyan.” (Conceptual Physics - Hewitt)
- “Mixing light colors:... yellow (the result of superimposing green and red), magenta (the result of superimposing red and intense blue), and cyan blue (the result of superimposing intense blue and green). The result of mixing pigment colors ... Mixing yellow and red together produces vermilion. Red and blue gives violet. By combining blue with yellow we get green.” (Barron’s Art Handbooks. Mixing Colors 1. Watercolor)



Color Confusion

- Disagreement: primary colors
 - “Primary colors of paint are Red, Yellow, Blue”
 - “Primary colors of paint are Magenta, Yellow, Cyan”
 - “Primary colors of paint are Red (magenta), Yellow, Cyan (blue) ”
 - “Primary colors of light are Red, Green, Blue”
 - “Primary colors of light are Red, Green, Blue-Violet”

How can red and blue be both primary colors of light and paint?

Why is yellow the 3rd primary of paint and green the 3rd primary of light?

Why can't anyone agree on primary colors?

- Agreement
 - Complementary colors of pigment yield black
 - Complementary colors of light yield white
 - Primary colors cannot be made from mixtures



Color Names

- Our society - computer programs, color ink-jet printers, etc. - has determined that there are distinct colors corresponding to:
 - Blue
 - Cyan
 - Red
 - Magenta
- However, in many books, blue, intense blue, cyan, blue-violet, and violet are often used interchangeably, as are red, magenta and vermilion, leading to misconceptions and much confusion.



Color is Complex

- Human color vision is complex and depends on:
 - Light illuminating the object
 - Object
 - Observer
 - Surrounding color
 - Size of color pixel
 - Field of view
 - Duration of viewing
- Paint colors are complex
 - Size, distribution, orientation of pigments
 - Nature of binder - oil, water, transparent, opaque, etc.
- *Need a simple, consistent, reproducible, understandable model that can explain and predict color mixing*



Let's do some experiments to determine the primary colors of paint as well as light.

We'll use the results of these experiments to construct a model that explains our results - the color wheel - and can be used to predict.



Ways to Explore Subtractive Color Mixing (Pigments: Ink or Paint)

- **Colored transparencies**
- Paint
- Colored water (food coloring/water colors)
- Simulation using CMY model on MAC
- Simulation using CMY model- web applet
- Zip lock bags



Definition of Primary Colors

- No combination of 2 primary colors can produce a third primary color
- Combinations of the 3 primary colors can produce a wider range of colors than using any other 3 colors



Subtractive Colors Experiment

R, Y, B Primaries

- Overlap R and Y transparencies on W paper
 - Resultant color?
- Overlap R and B transparencies on W paper
 - Resultant color?
- Overlap Y and B transparencies on W paper
 - Resultant color?



Subtractive Colors Experiment

R, Y, B Primaries

- Overlap R and Y transparencies on W paper
 - Red
- Overlap R and B transparencies on W paper
 - Black
- Overlap Y and B transparencies on W paper
 - Black

R, Y, B are not appropriate primaries

Traditional artist's color wheel is not appropriate model



Subtractive Colors Experiment

C, M, Y Primaries

- Overlap C and M transparencies on W paper
 - Resultant color?
- Overlap M and Y transparencies on W paper
 - Resultant color?
- Overlap Y and C transparencies on W paper
 - Resultant color?



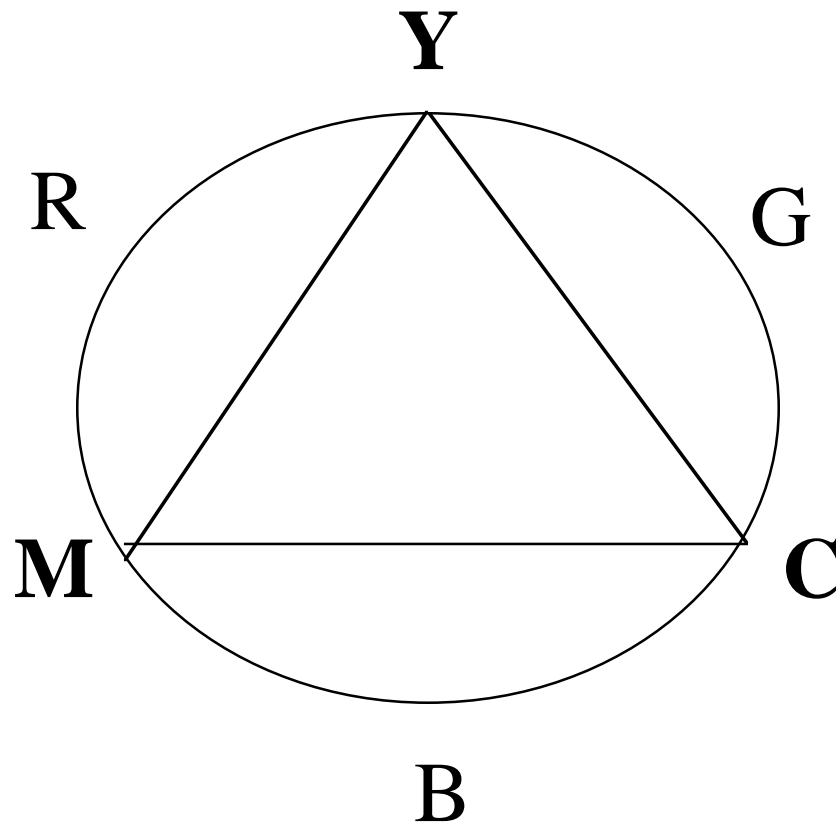
Subtractive Colors Experiment

C, M, Y Primaries

- Overlap C and M transparencies on W paper
 - Blue
- Overlap M and Y transparencies on W paper
 - Red
- Overlap Y and C transparencies on W paper
 - Green
- Red and blue can be made by mixing other colors
 - not subtractive primary colors
- CMY are correct subtractive primary colors



Color Wheel Model for Subtractive Colors (Pigments)



Complementary Colors Experiment

- Recall that overlapping complementary colors of pigment produce black
- Overlap C, R films
- Overlap M, G films
- Overlap Y, B films
- Complementary colors lie on opposite sides of the color wheel
- Demonstration using 2 identical color wheels



Color Wheel

- Nice discussion of the position of common artist's paints on the CMY color wheel :
www.goldenpaints.com/mixguide.htm
- GA Color Wheel Wall Chart
- Complementary colors can also be observed as after-image



Mixing colors of light

- Computer monitor or TV or slide projectors
 - Red light + green light = yellow light
 - Green light + blue light = cyan light
 - Blue light + red light = magenta light

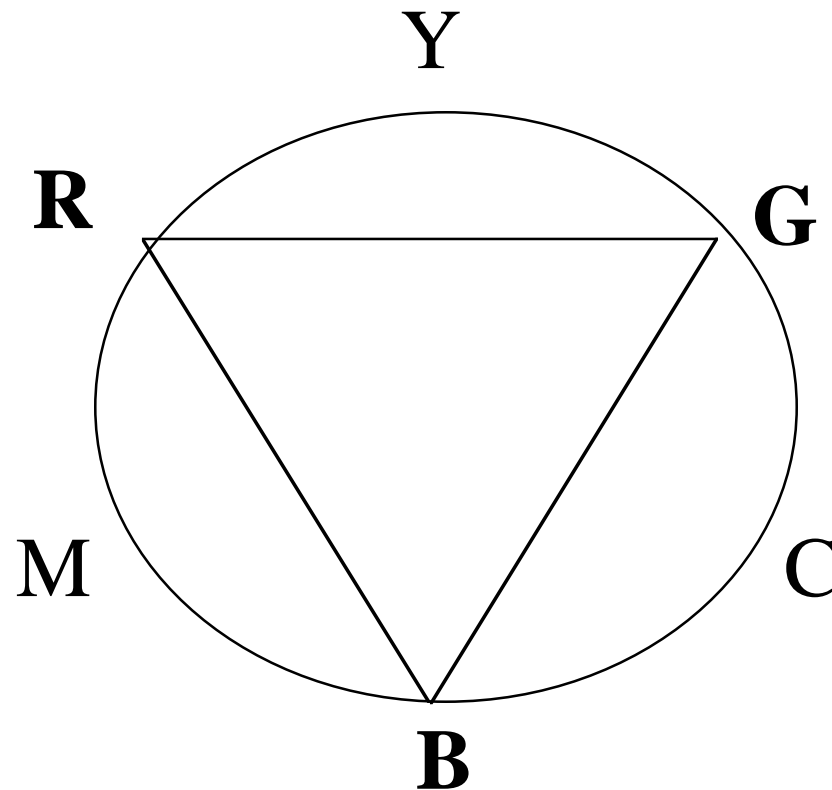
These combinations of light define a color wheel for light

- Complementary colors of light produce white light:
 - Red light + cyan light = white light
 - Green light + magenta light = white light
 - Blue light + yellow light = white light

Complementary colors of light are on opposite sides of the color wheel



Color Wheel Model for Additive Colors (Light)



Color wheel for light and pigments is the same!



Unique Materials to Explore Color

- CMYK Gradient Strips - demonstration
- Handheld microscope (Radio Shack)
 - 8x magnifier to look at computer monitor
 - 30x microscope to look at CMYK color printing
- Color cube
 - Another model for both additive and subtractive colors
- CMY color wheel components - demonstration
- “It’s a Colorful Life” module
 - Experiments, demonstrations, assessments, references

www.sci-ed-ga.org



Color Conclusion

- Primary colors of pigment (subtractive) are C, M, Y
- Primary colors of light (additive) are R, G, B
- Color wheels for pigment and light are the same
- Physics, chemistry, and color science communities generally use above color concepts
- Color is a complex subject - many other color models are used to describe color.

