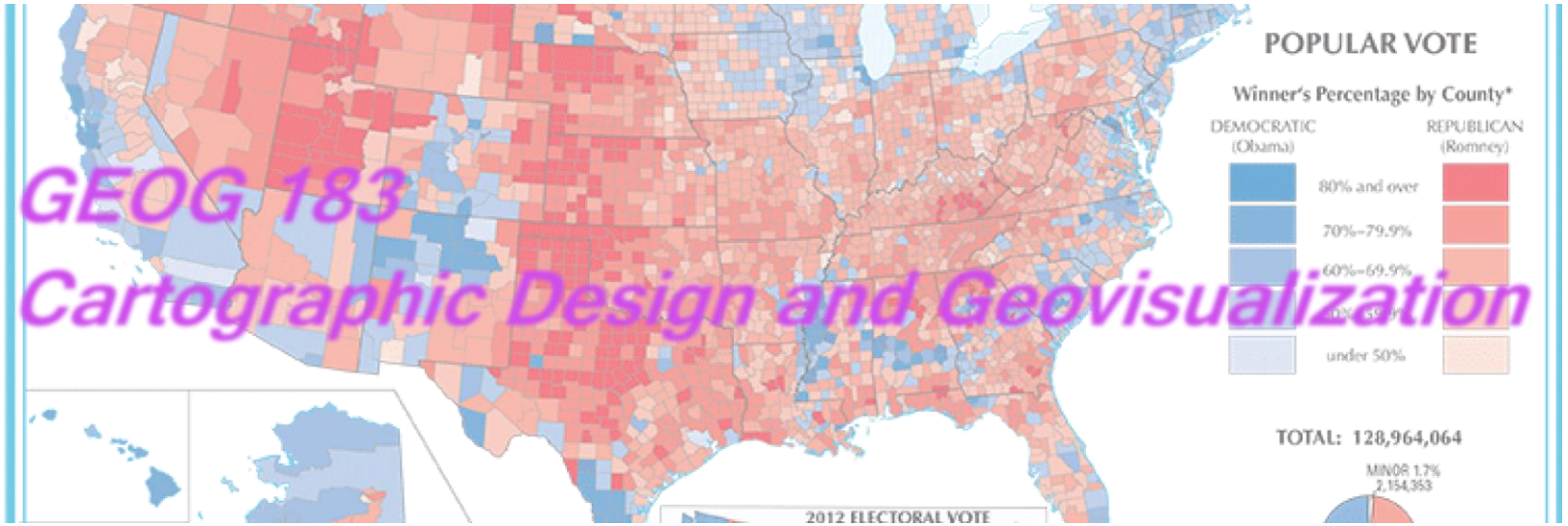
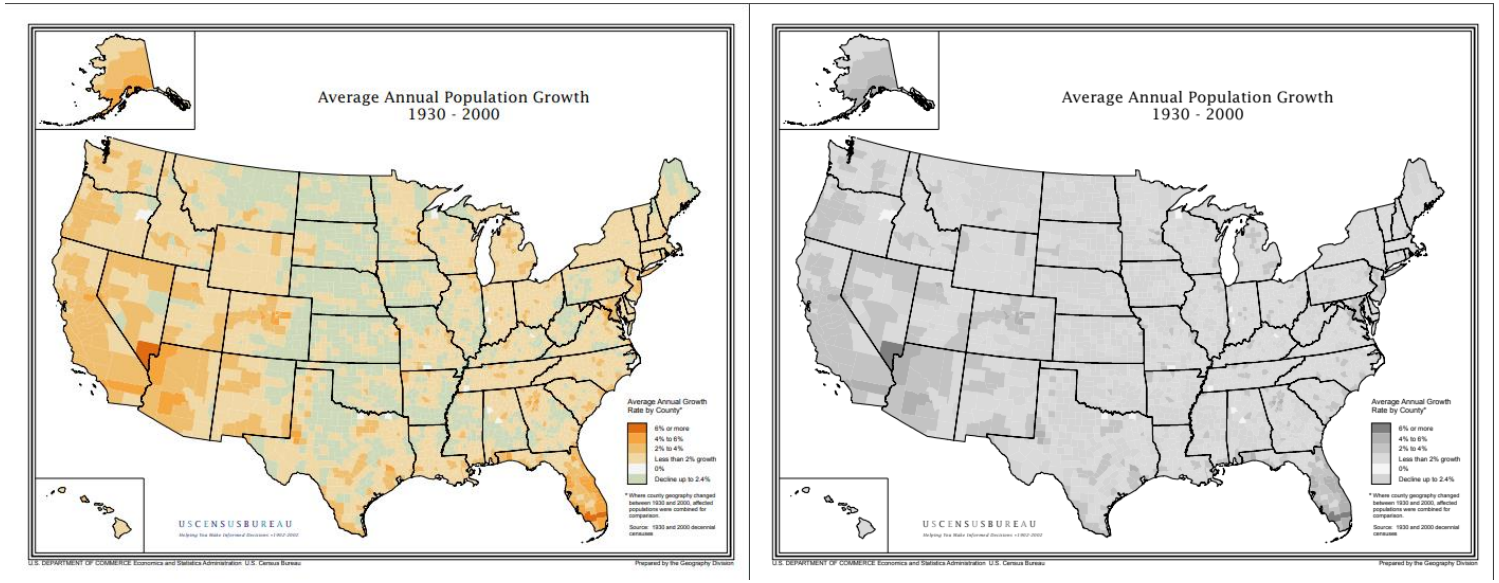


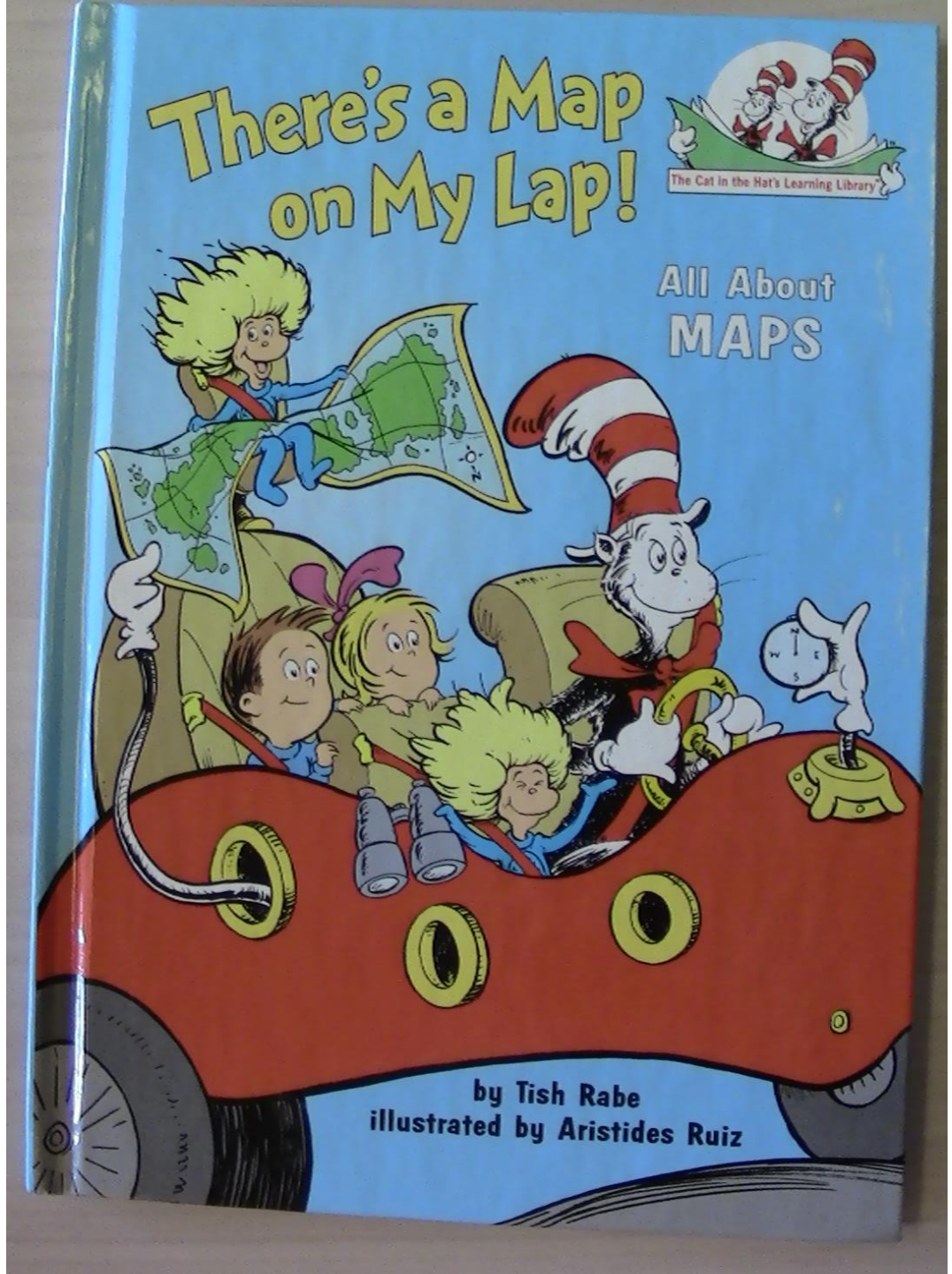
Geog183: Cartographic Design and Geovisualization Spring Quarter 2020

Lecture 7: Color and its use

Color

- Most powerful element in map symbolization
- Invokes unconscious, perceptual and cognitive responses
- Both input (eye) and output (video) concern in cartography
- Color rendering methods use additive and subtractive color
- Color models
  - Hardware
    - RGB
    - CMYK
  - User-oriented
    - HSV
    - Munsell
    - HVC

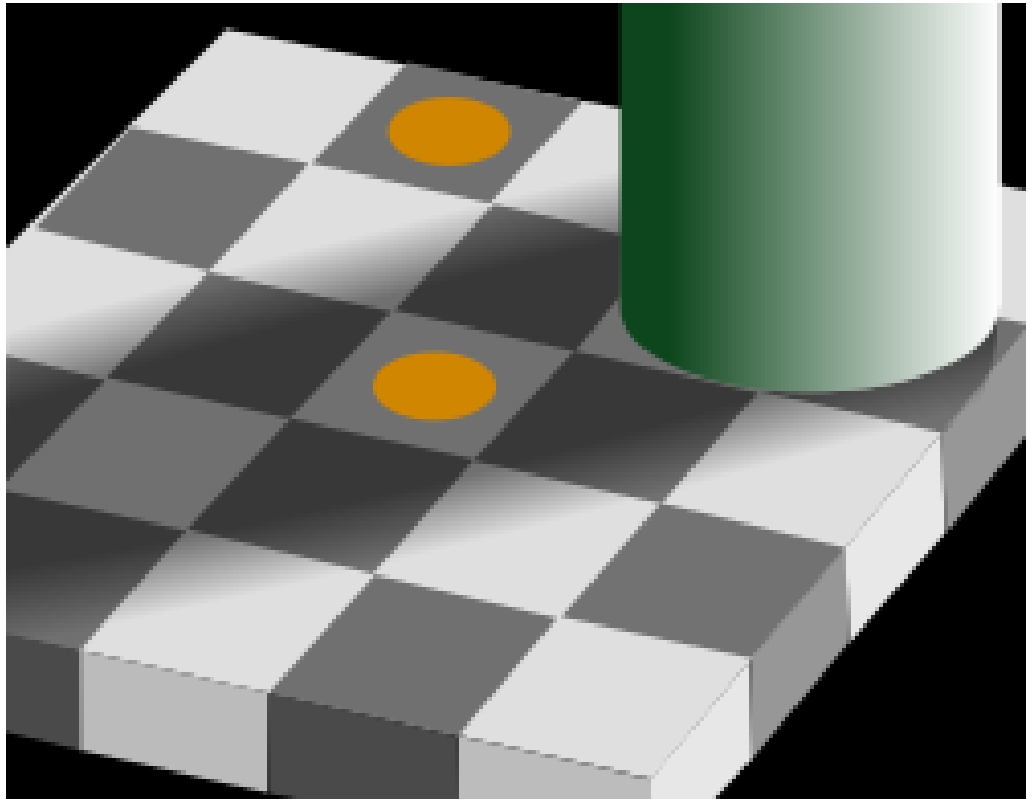


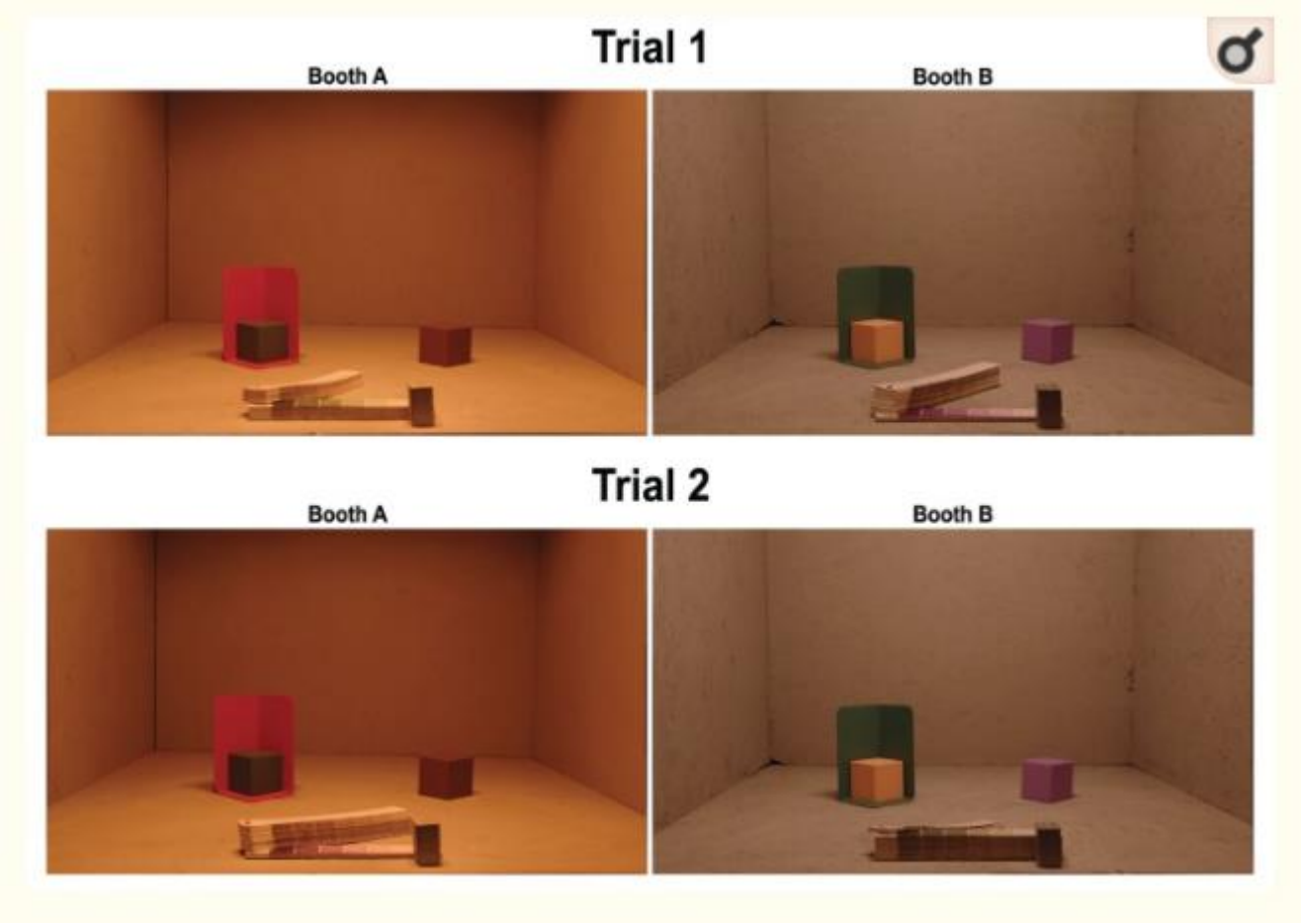

There's a Map on My Lap!
The Cat in the Hat's Learning Library
All About MAPS
by Tish Rabe
illustrated by Aristides Ruiz


Some maps use colors
to tell you a lot.
I used blue where it's cold
and red where it's hot.
FRAZEE
COLD
HOT
FRAZODE
LEGEND
= COLD
= HOT

Color context

Context and illumination



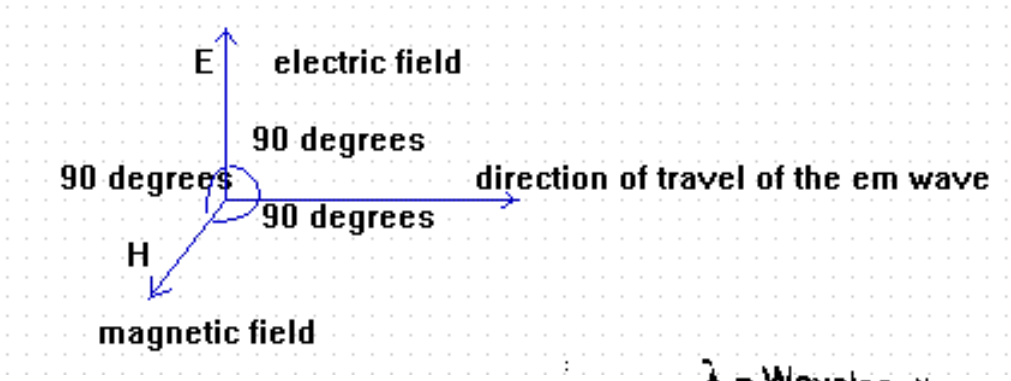


Allred, Sarah R., and Maria Olkkonen. “The Effect of Background and Illumination on Color Identification of Real, 3D Objects.” *Frontiers in Psychology* 4 (2013): 821. *PMC*. Web. 25 Apr. 2018.

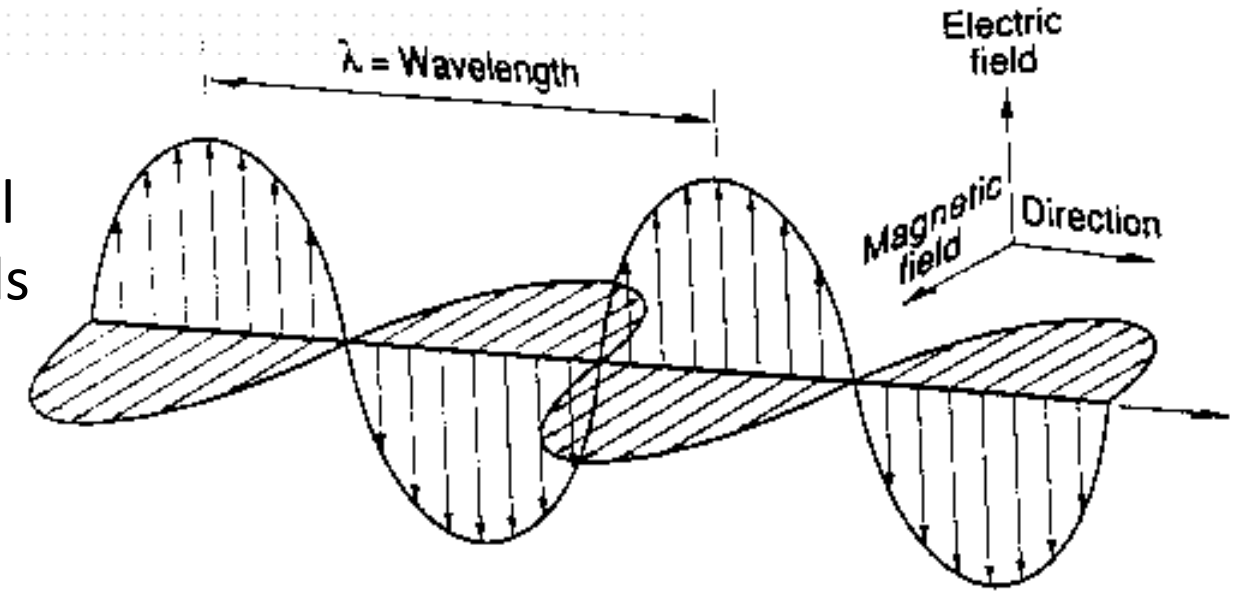
Not just a good idea, it's the law

- c = 299 792 458 m/ s
- c= 670 444 951 miles per hour
- Eye can process up to
  - Movies run at 24 FPS
  - TV runs at 30 FPS = 33 milliseconds/frame
  - Using 50 FPS, light can travel 5,995,849m between frames
- Effect on light is motion blur at high velocities

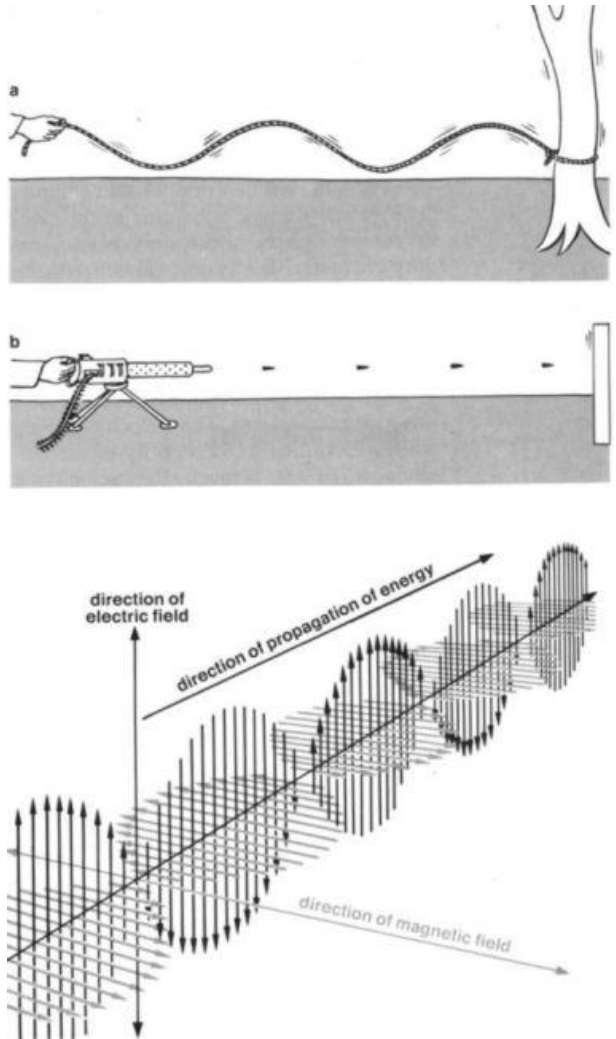
Wave theory of EMR: Polarization



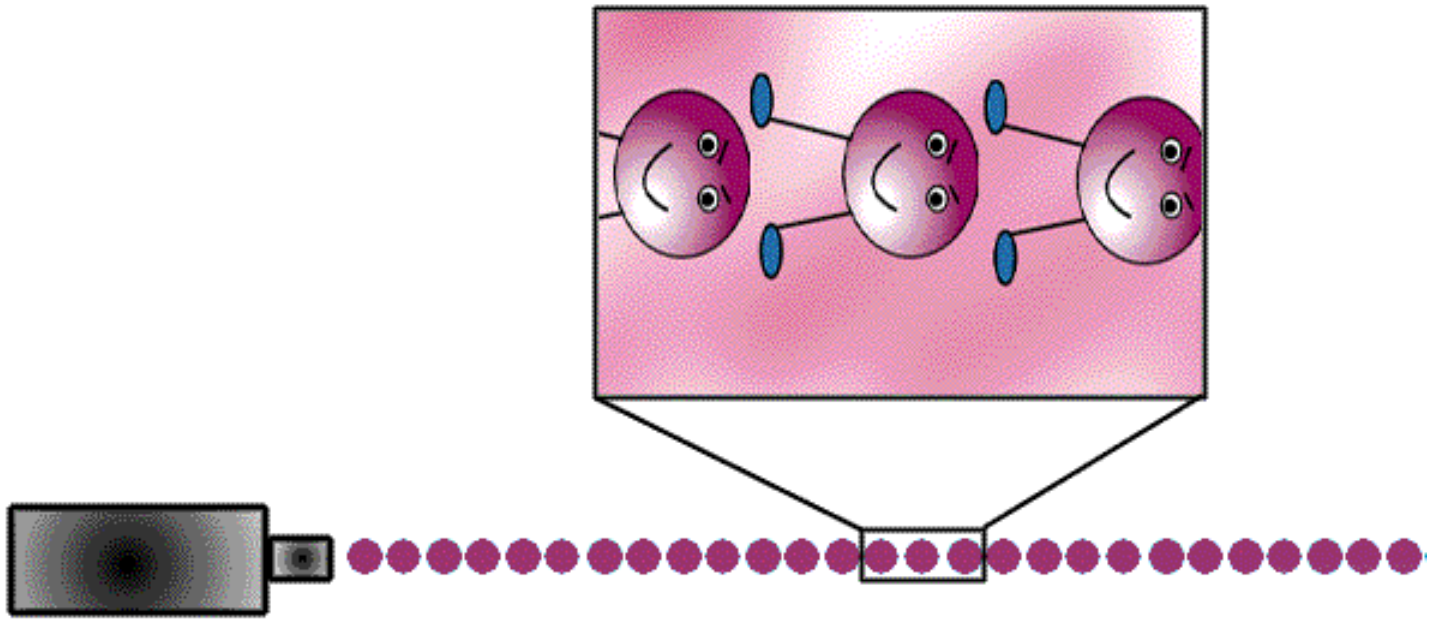
Dual Orthogonal
Fluctuating fields



EMR Theory: A Duality

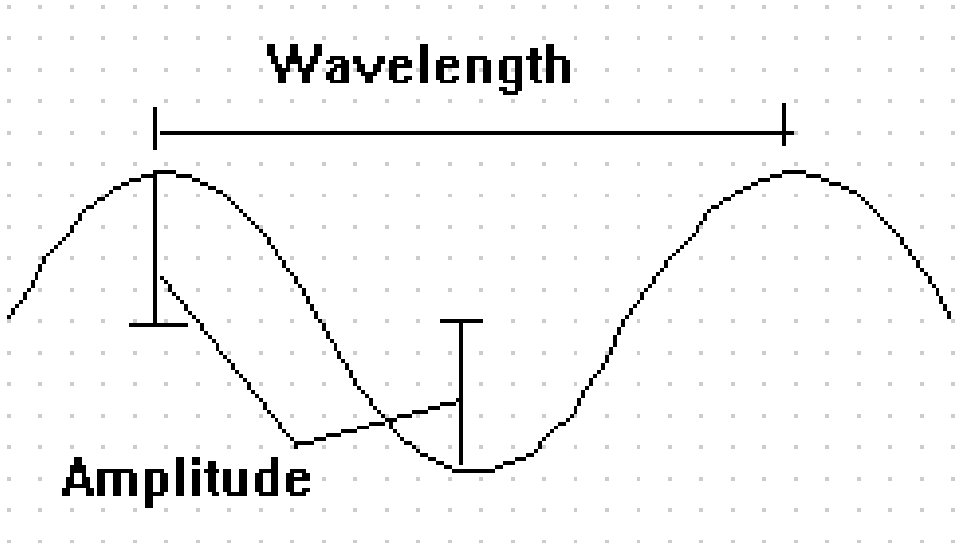


Particle Theory of EMR Photons



EMR has a wavelength

- Wavelength (λ) = c / v
- Frequency (f) = $1/\lambda$
- Amplitude (A)

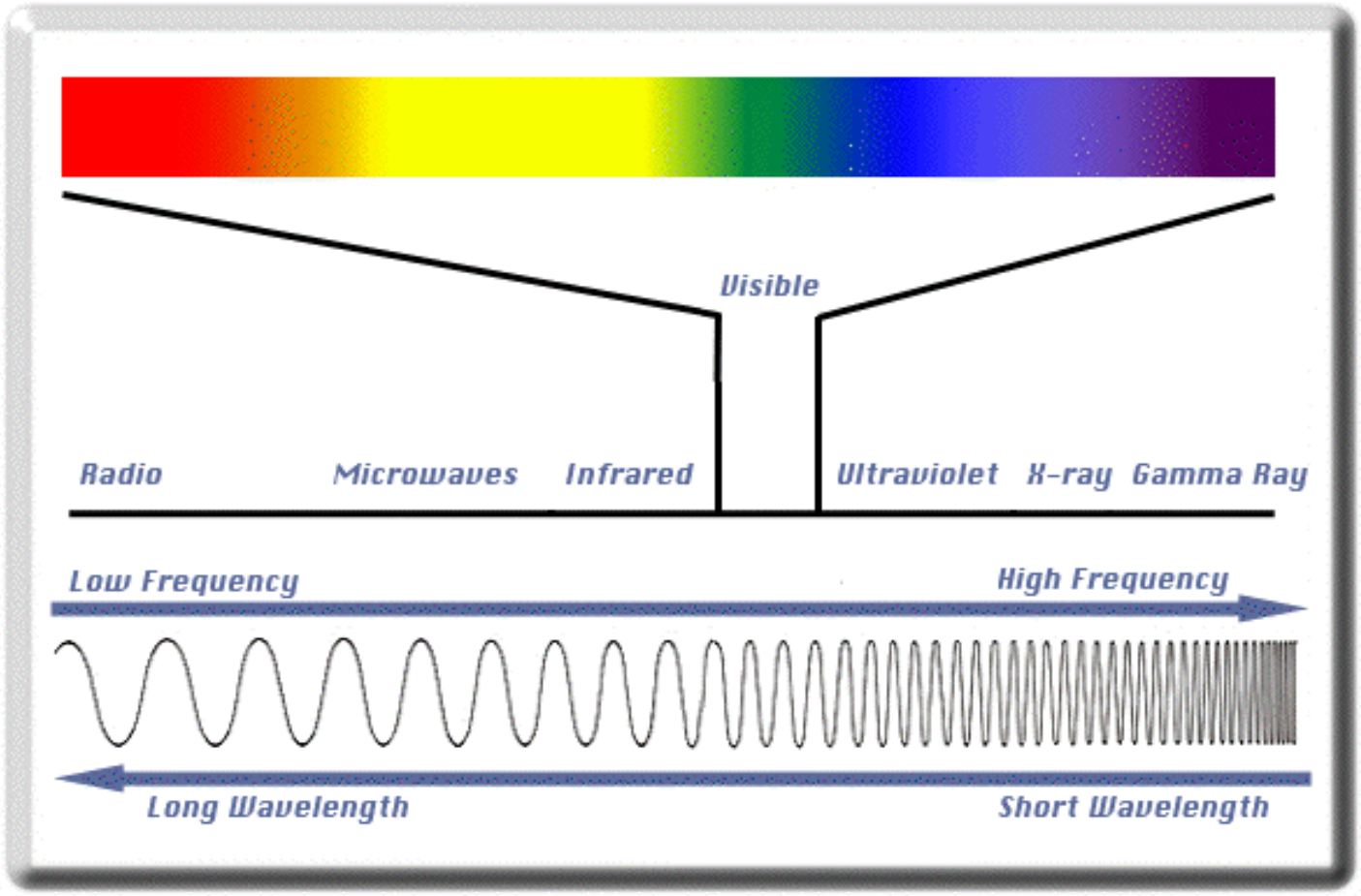


Intensity of EMR = Brightness

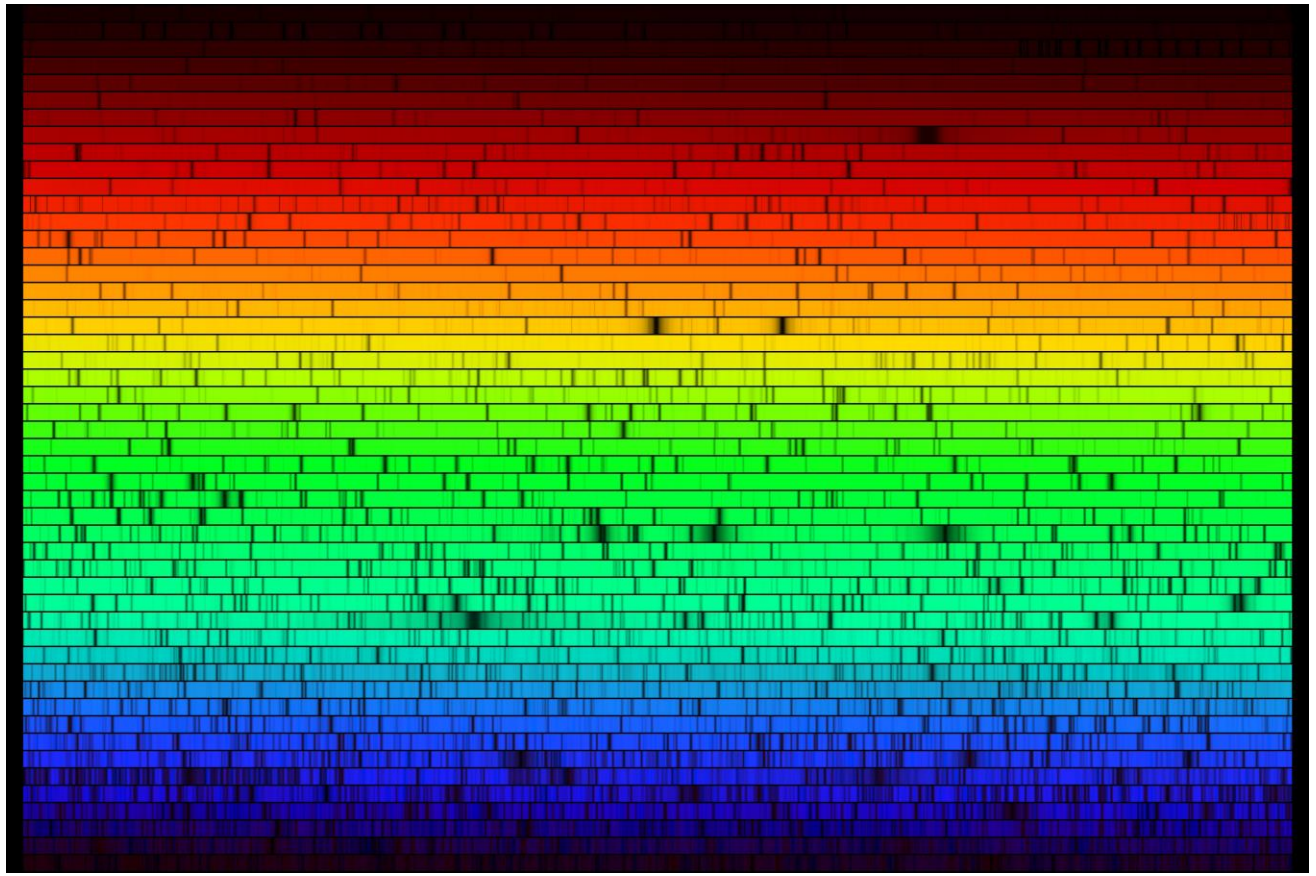
- Energy content = E = f(# photons)
- E = hc / λ

  Planck's constant (h)
- 6.626 x 10^-34 Joules/second
- Basic energy equation
- E.g. UV and visible light on skin
- UV shorter λ

Electromagnetic spectrum



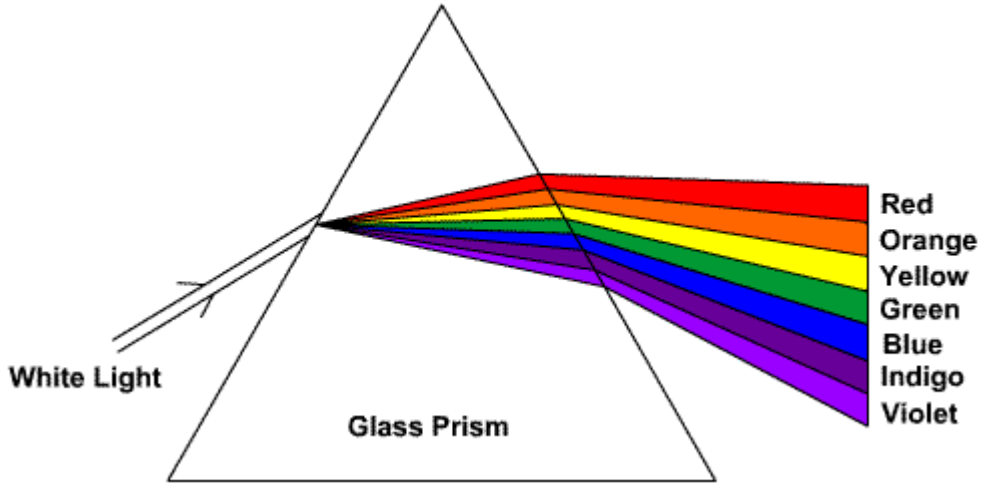
“Pure” sunlight: absorption features



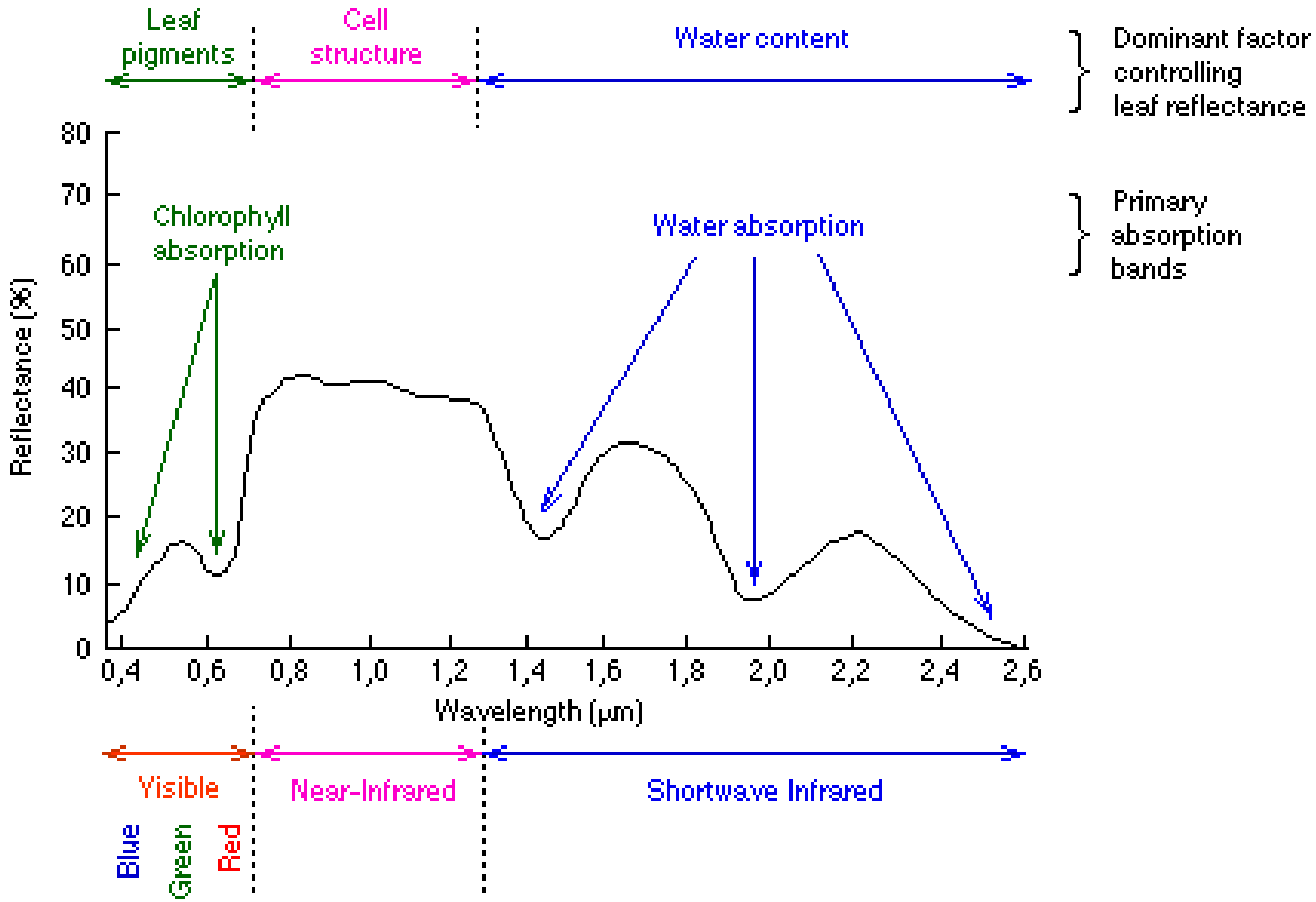
‘Solar Flux Atlas from 296 to 1300 nm’ by Robert L. Kurucz, Ingemar Furenlid, James Brault, and Larry Testerman: National Solar Observatory Atlas No. 1, June 1984.

Light interactions

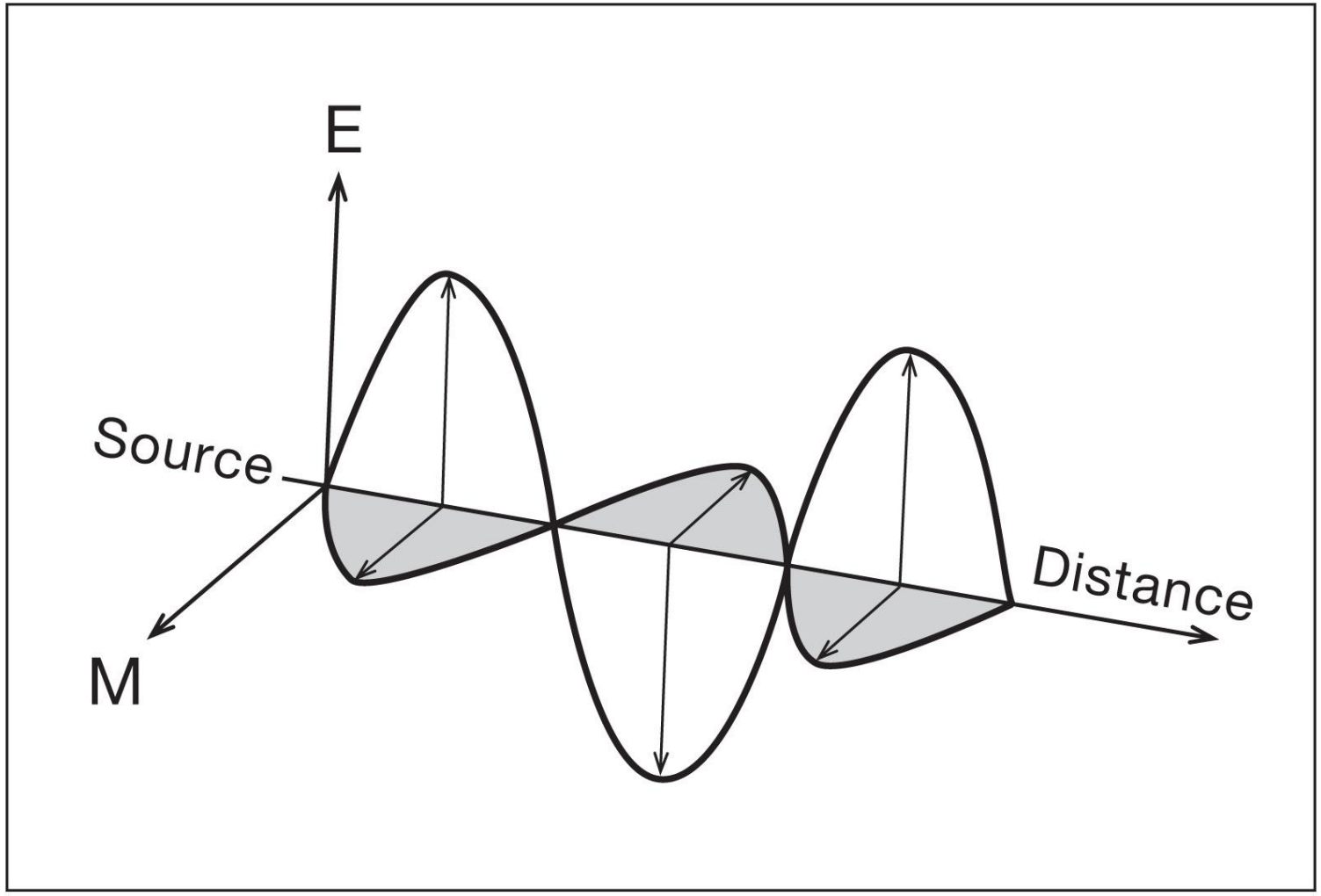
- Shadowing (depth)
- Reflection
- Refraction
- Scattering
- Absorption
- Re-emission



Spectrum and Absorption



Light: Electrical and magnetic dimensions (Polarization)



Rods and cones

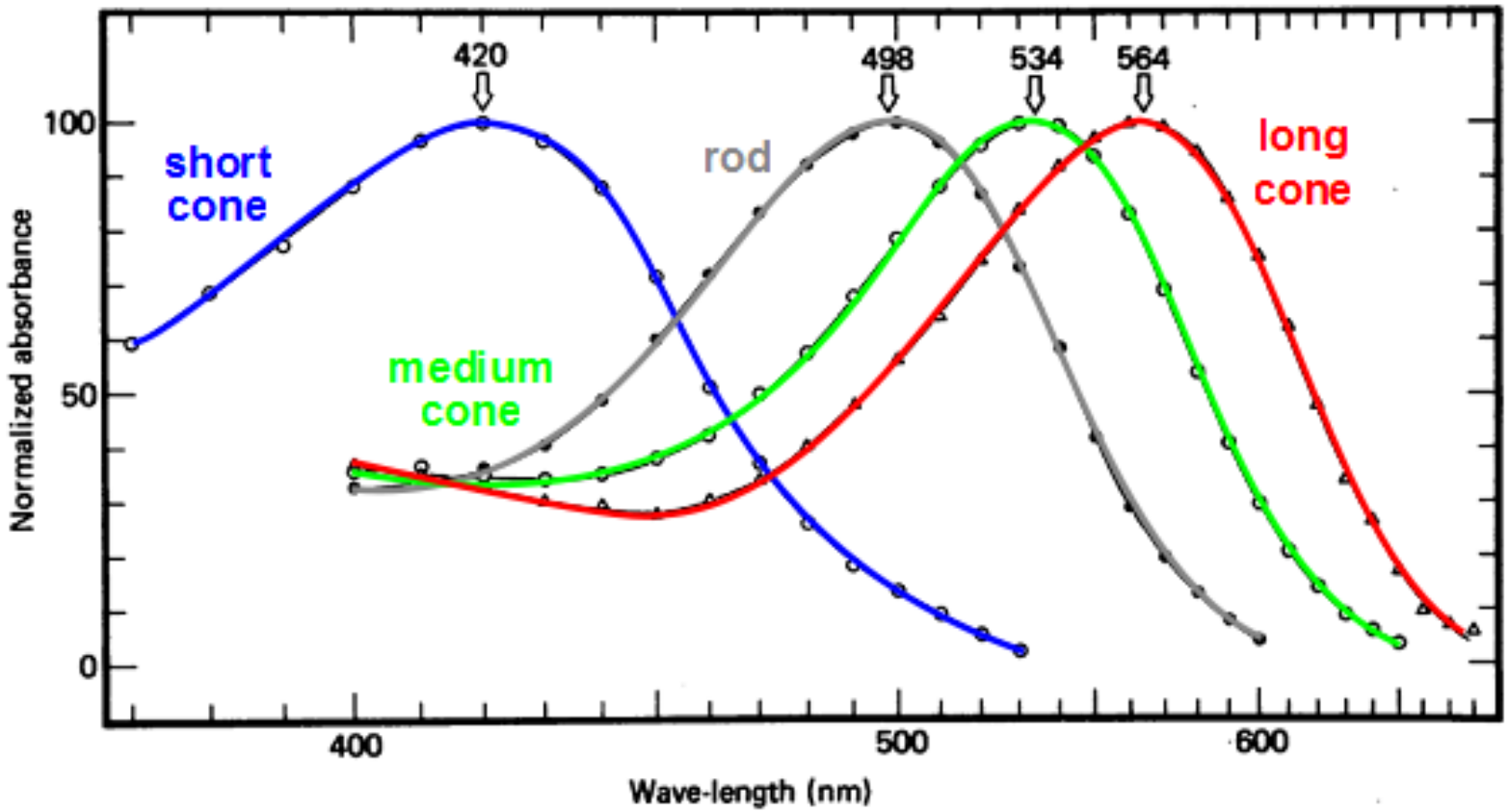
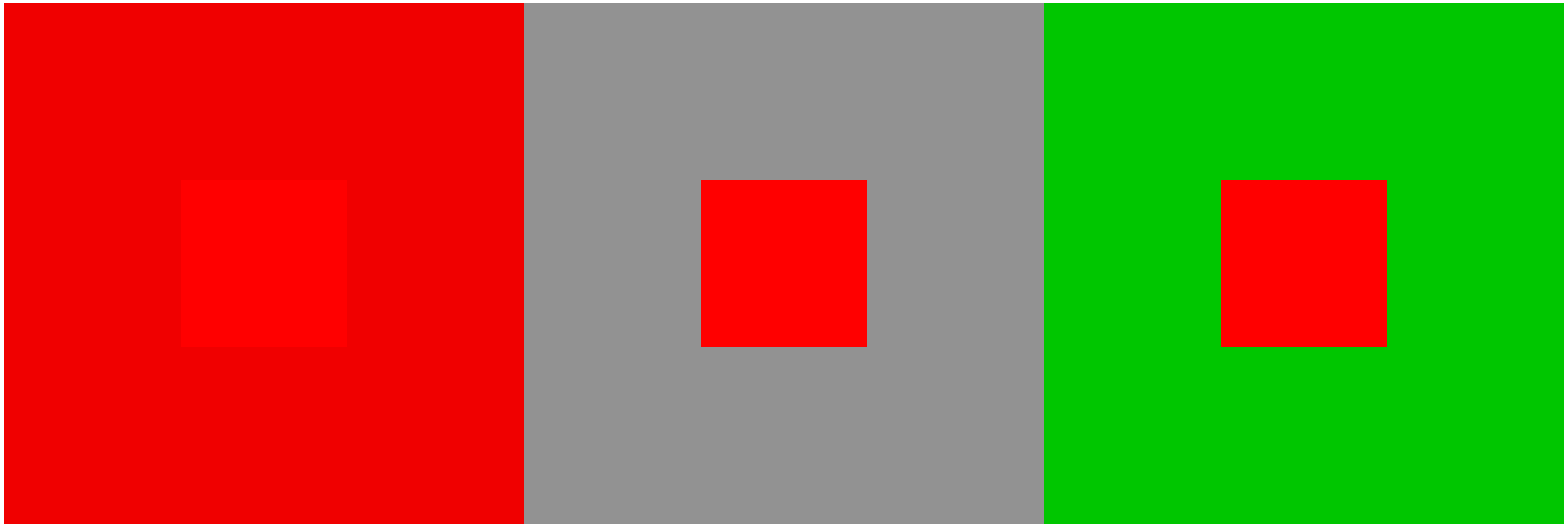


Fig. 2. The mean absorbance spectra of outer segments of the four classes of human photoreceptors. Curves labelled as follows: '498', mean of eleven rods; '420', mean of three blue-sensitive cones; '534', mean of eleven green-sensitive cones; '564', mean of nineteen red-sensitive cones.

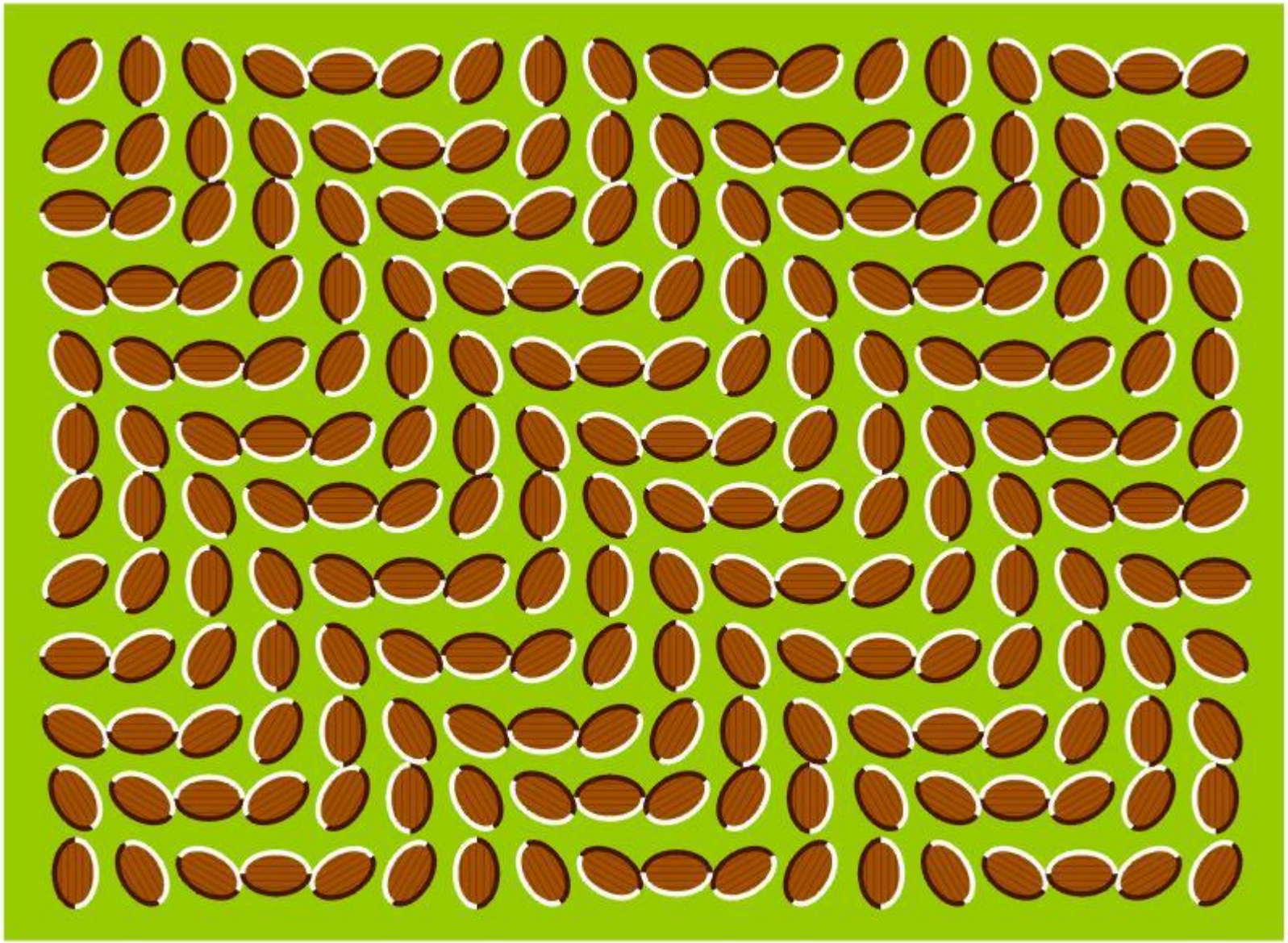
Theories of color perception

- Trichromatic theory
  - RGB cones
- Opponent-process theory
  - Light-dark and two color scales, red-green and blue-yellow
- Both theories have value
- Nerves fire at a constant rate
- Above standard is excitation, below is inhibition

Simultaneous contrast

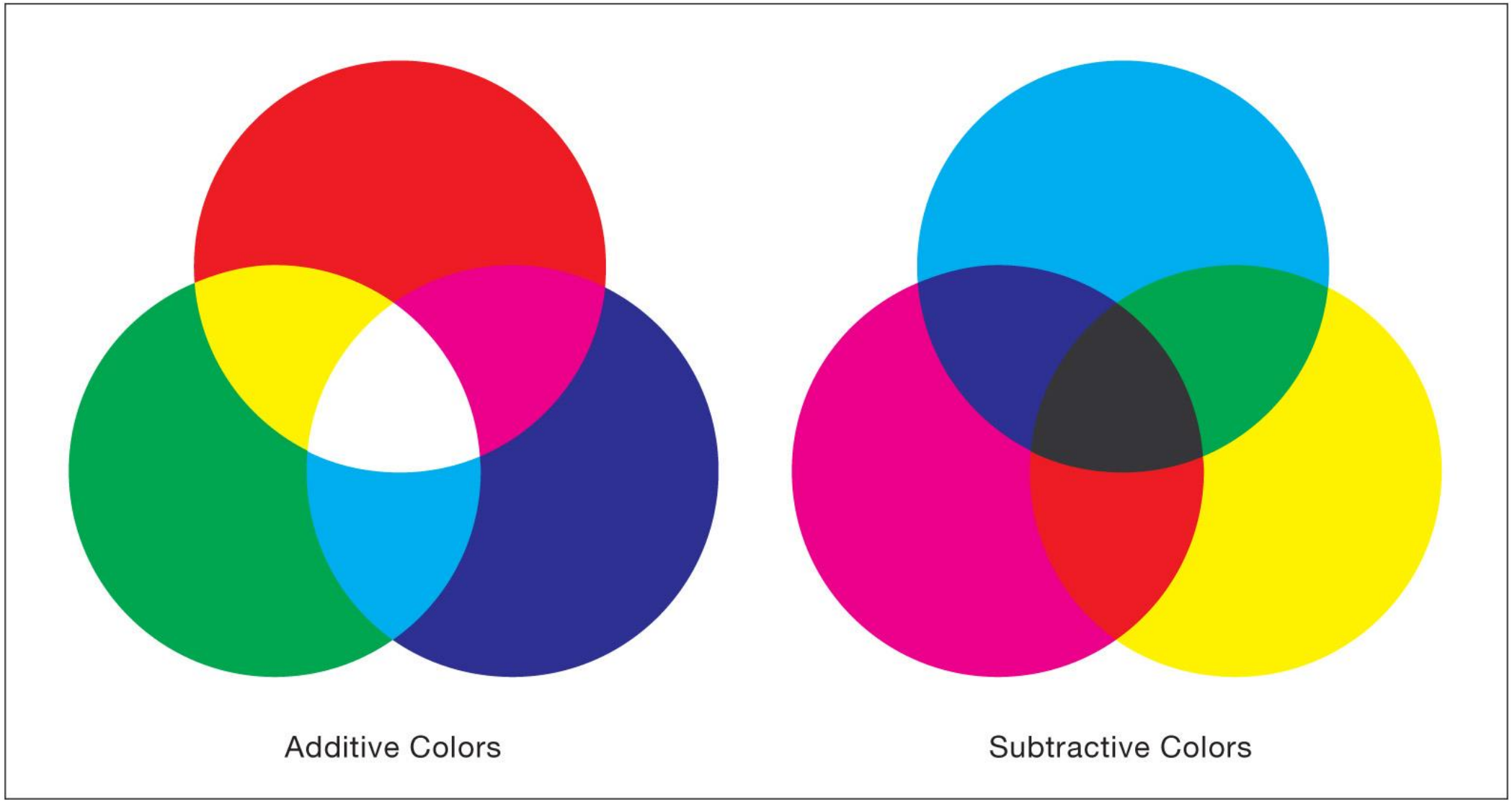


Almond illusion



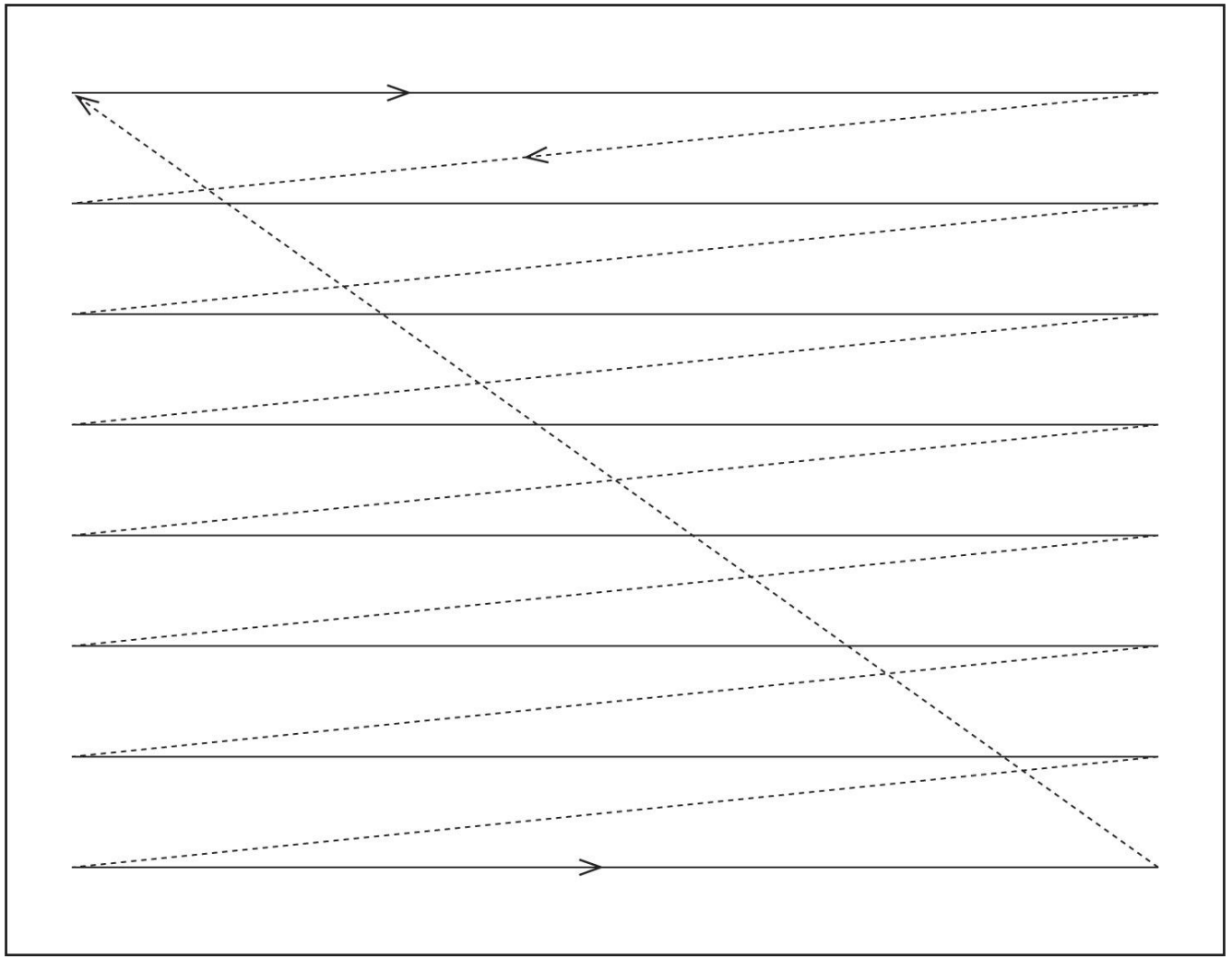
Rendering color

- Depends on medium, but one major contrast
- Subtractive color
  - Assumes background color is white, uses filtering pigments to add to surface to create color
  - Add little color, unsaturated and light
  - Add full color, saturated and darker
  - Non-primary colors are blends of MCY
- Additive color
  - Assumes background is black
  - Adds illumination to achieve color
  - More color more saturated, more light brighter
  - Non-primary colors are blends of RGB

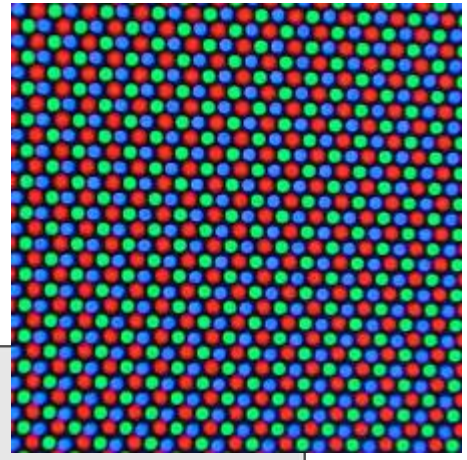


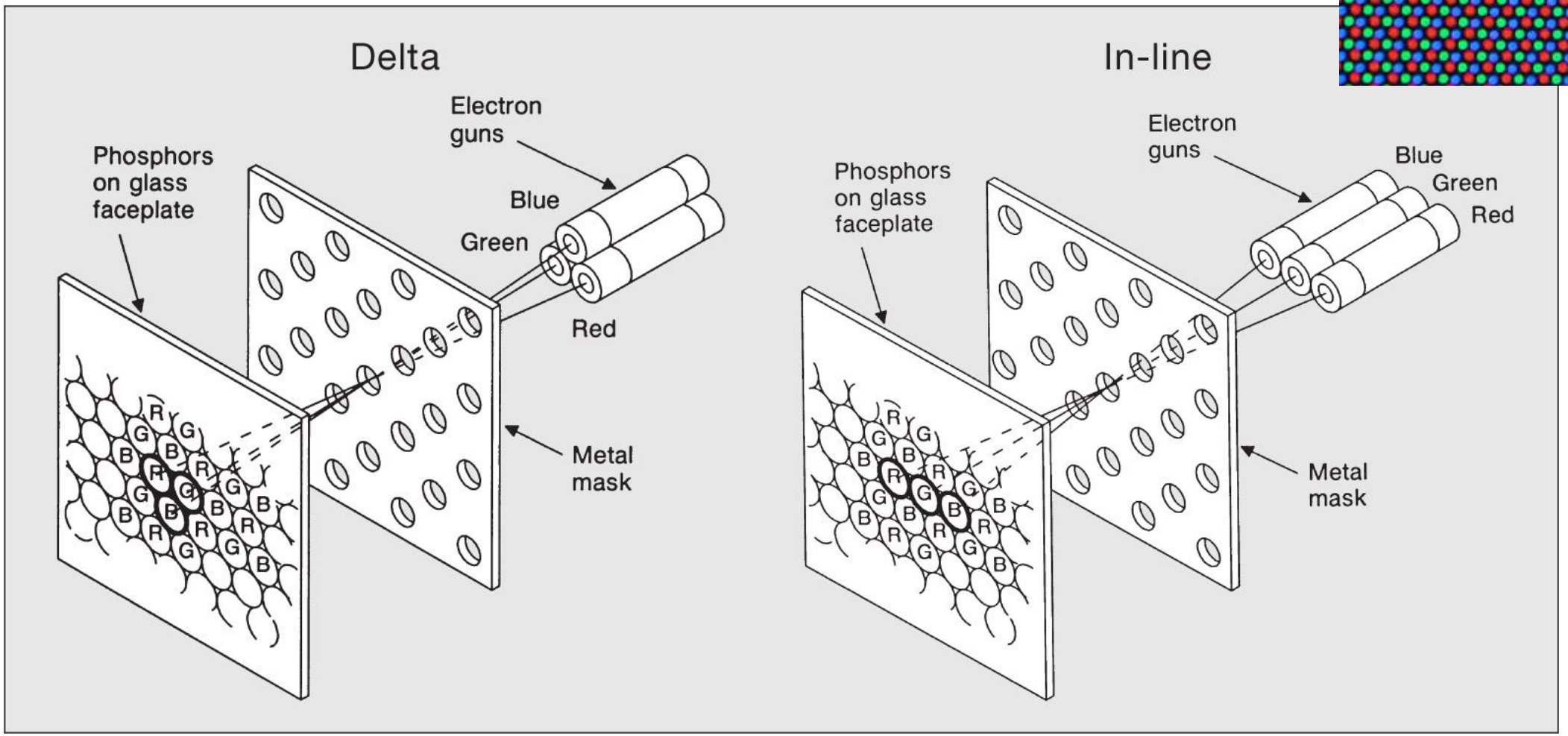
Offset color lithographic printing

Raster graphics



Raster imaging technologies

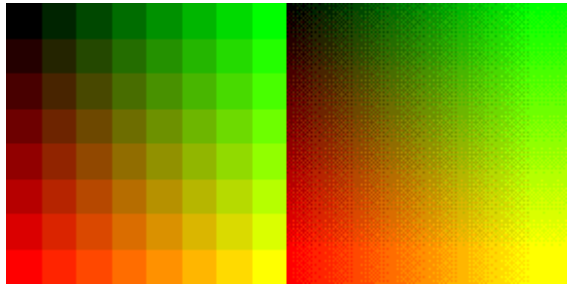




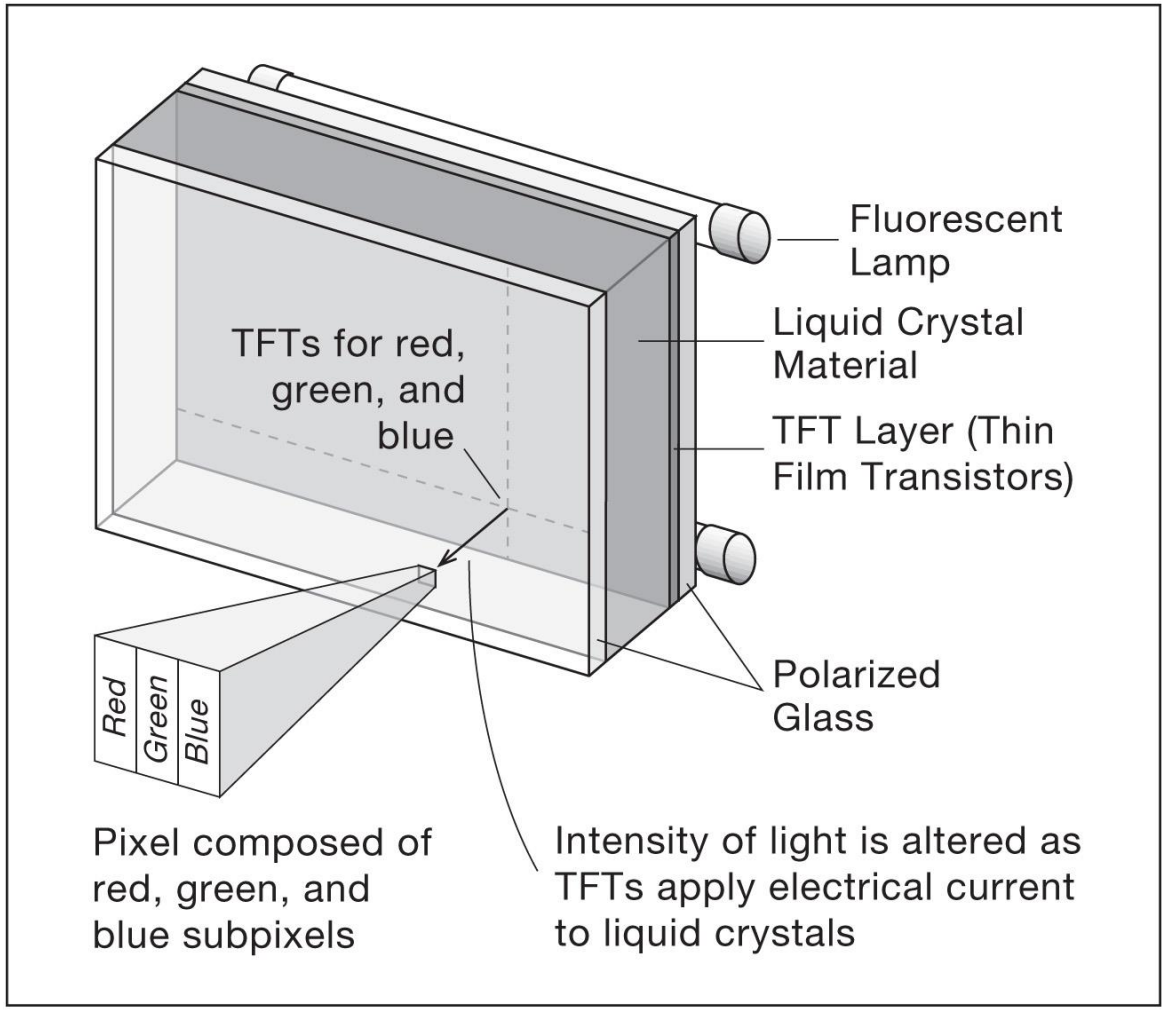
Display details

- Pixelization
- Aliasing and anti-aliasing
- Dithering
- Frame buffers and the refresh rate
- Movement periodicity

https://www.youtube.com/watch?v=smDpCsVVgPA



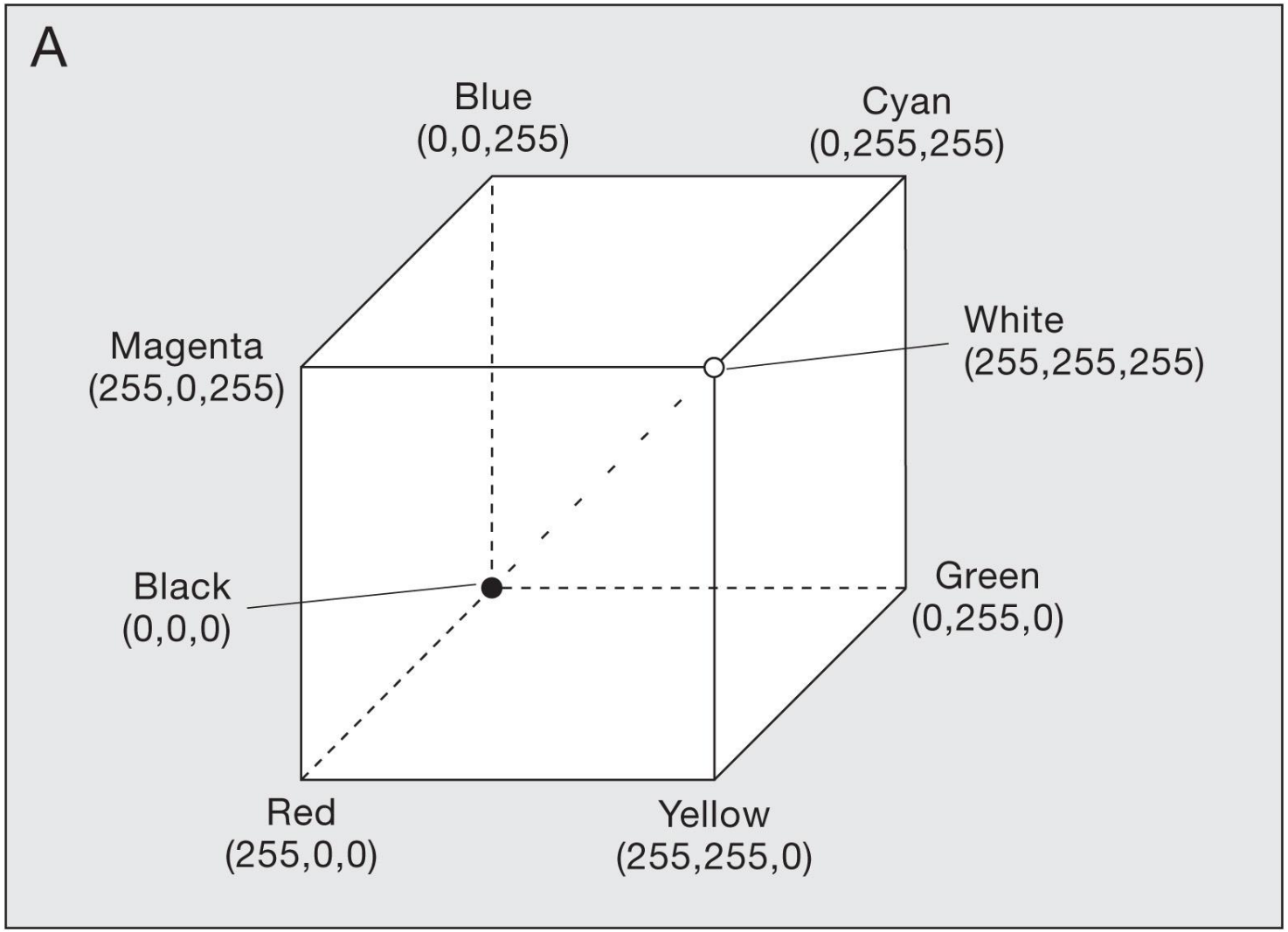
Liquid Crystal Display



Light Emitting Diodes

- LED panels: conventional (using discrete LEDs) and surface-mounted device (SMD) panels
- A cluster of red, green, and blue diodes is driven together to form a full-color pixel, usually square
- Pixels are spaced evenly apart and are measured from center to center for absolute pixel resolution
- Largest LED display in the world is over 500 meters long in Suzhou, China
- Largest LED television in the world is the Center Hung Video Display at Cowboys Stadium, which is 49 m × 22 m
- LED TVs using SMD pixels of red, green, and blue diodes mounted in a single package, which is then mounted on the driver PC board
- Individual diodes are smaller than a pinhead and are set very close together
- Reduces maximum viewing distance by 25% from the discrete diode screen at the same resolution

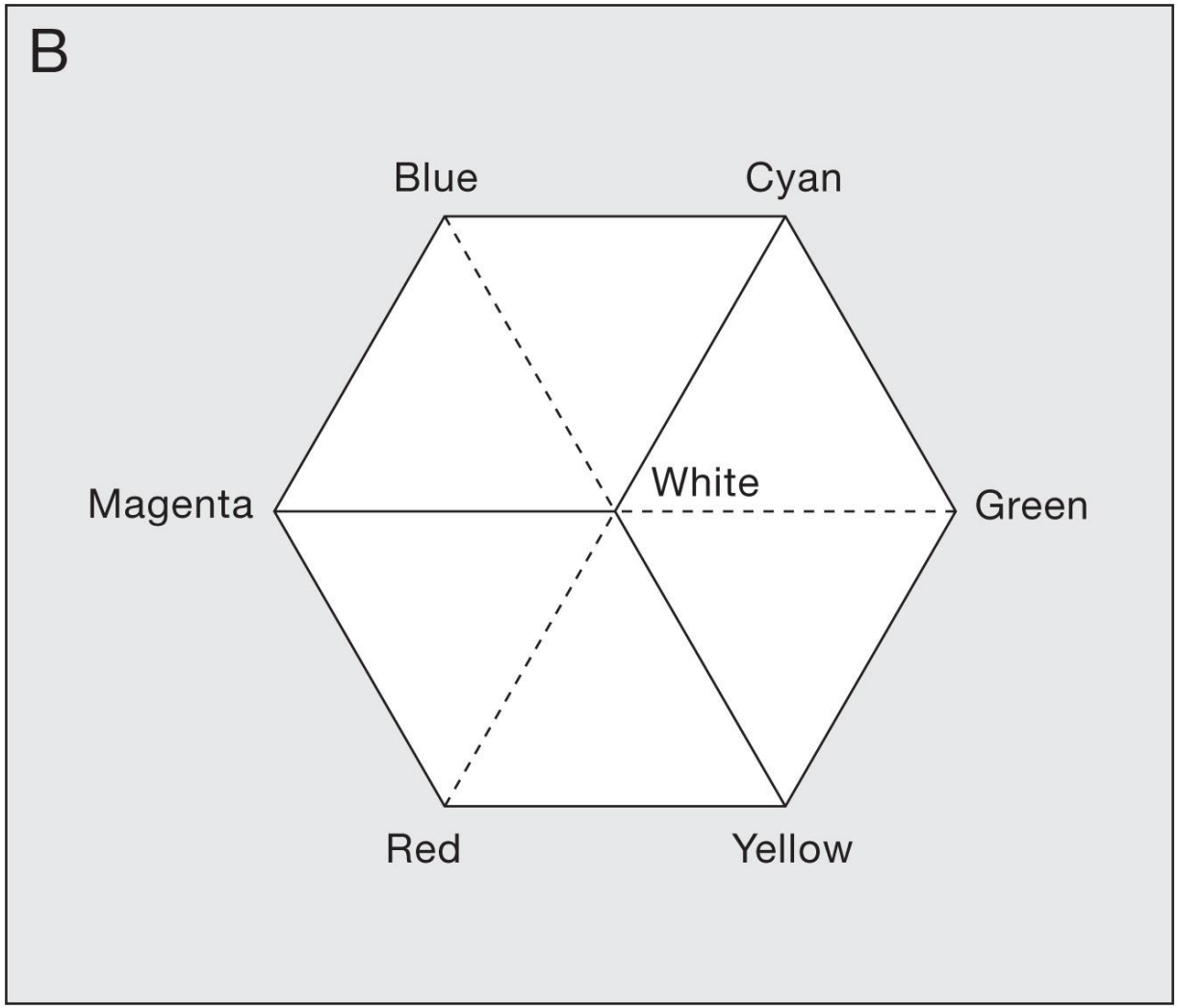
Color models: Cube



Color production and reproduction

- Requires measurement
- Based on standards
- Names are subjective
- Applies to foveal zone only
- Requires color MODEL

Color models: Wheel (Hue and Saturation)



CMYK: Subtractive primaries
Cyan, magenta, yellow, black

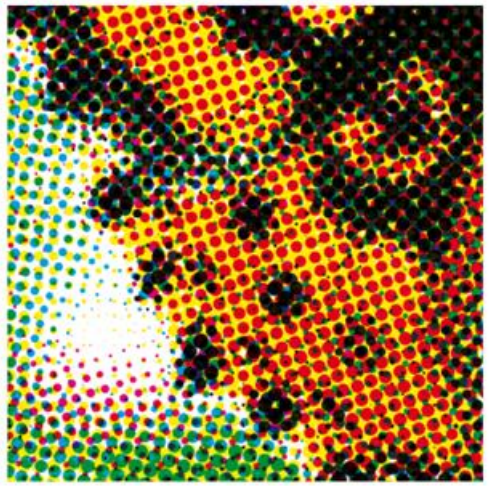
CYAN

MAGENTA

YELLOW

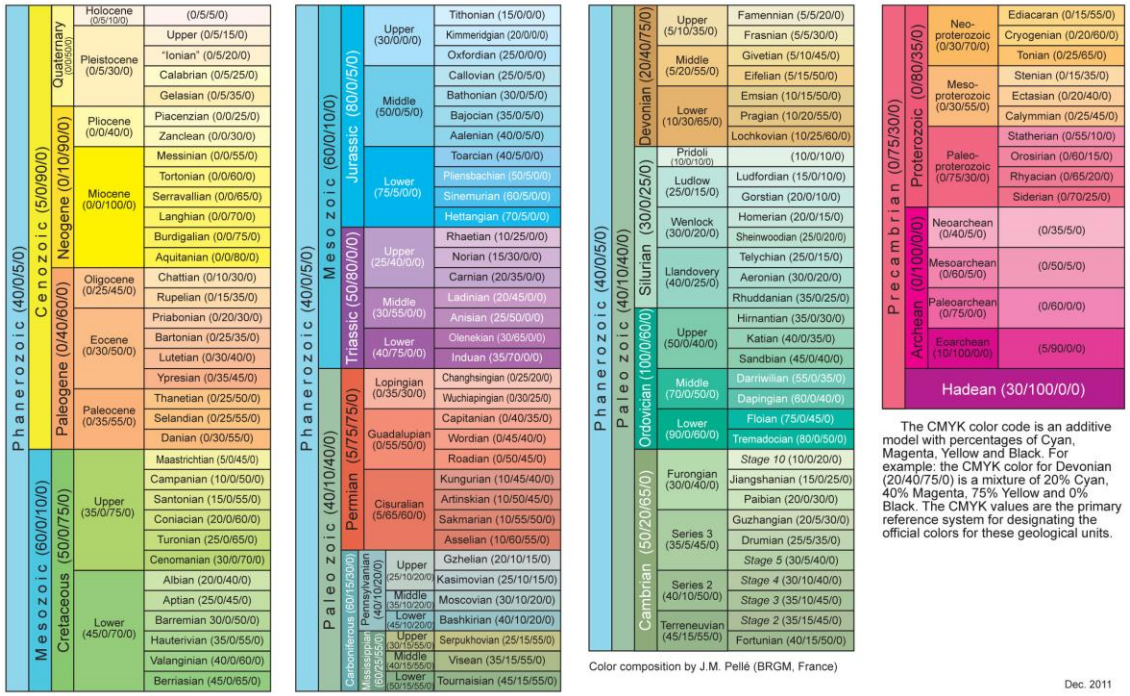
BLACK

FINAL CMYK



DETAIL VIEW

CMYK Color Code according to the Commission for the Geological Map of the World (CGMW), Paris, France

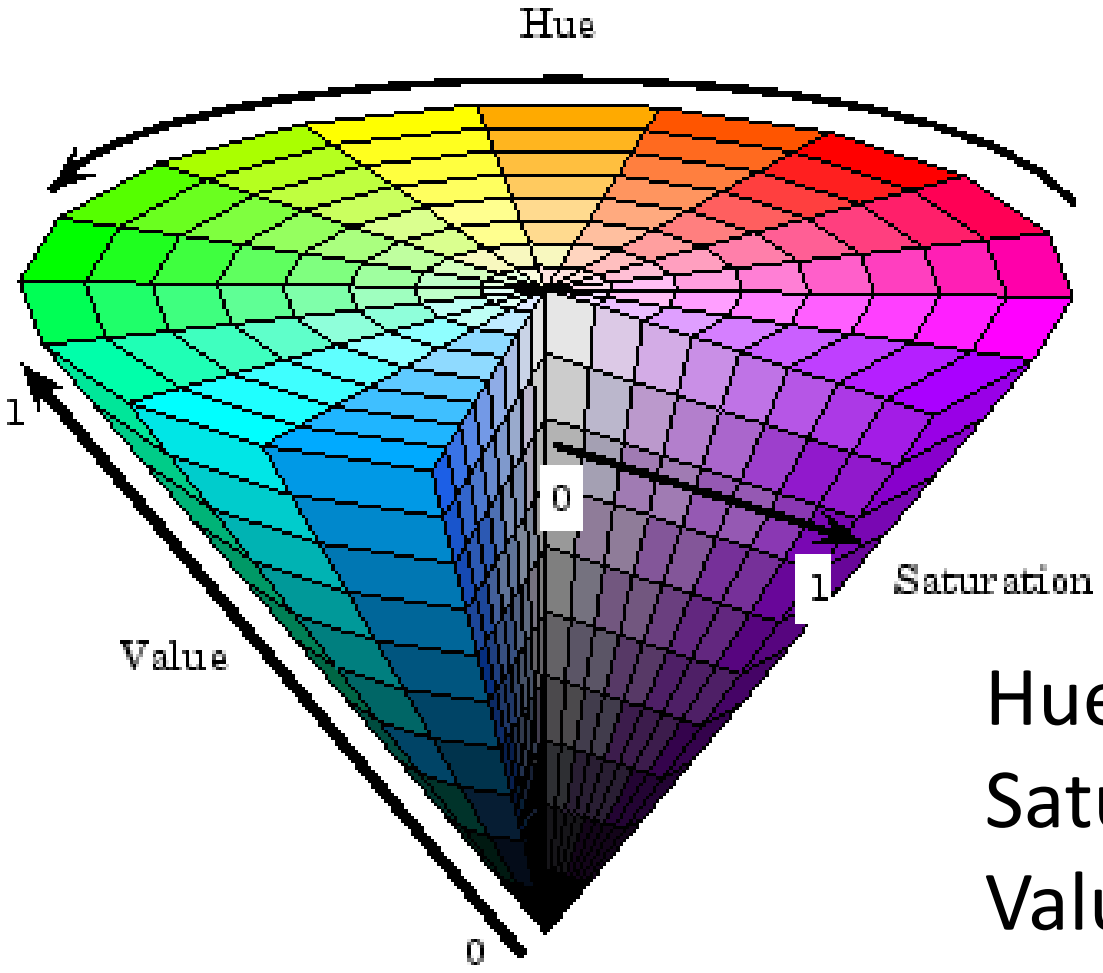


Color composition by J.M. Pellé (BRGM, France)

The CMYK color code is an additive model with percentages of Cyan, Magenta, Yellow and Black. For example: the CMYK color for Devonian (20/40/75/0) is a mixture of 20% Cyan, 40% Magenta, 75% Yellow and 0% Black. The CMYK values are the primary reference system for designating the official colors for these geological units.

Dec. 2011

HSV color model: Perceptual, but not all equal value

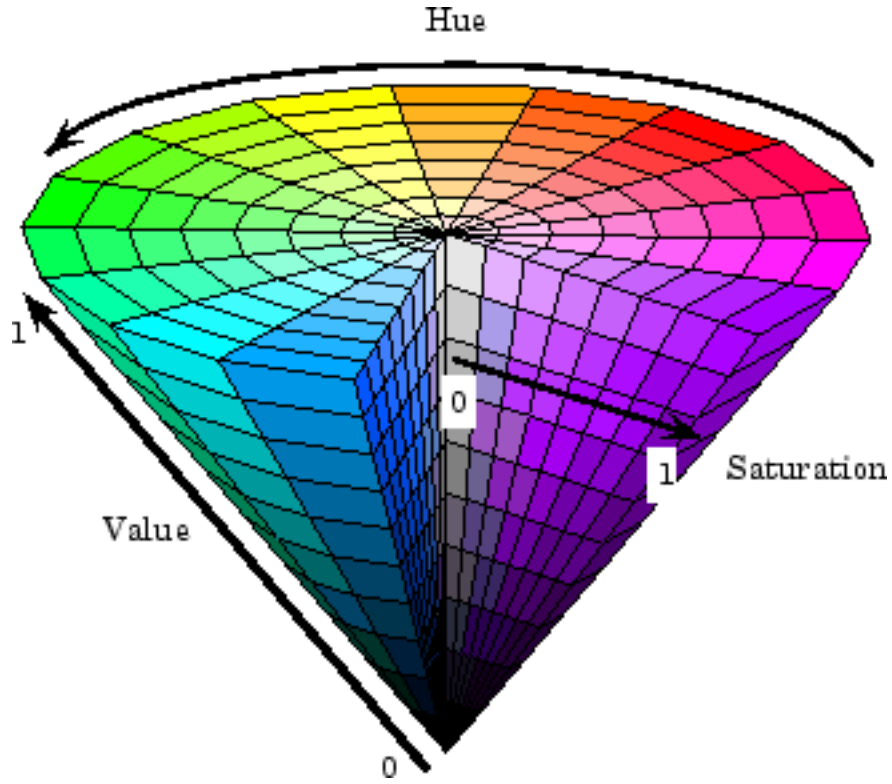


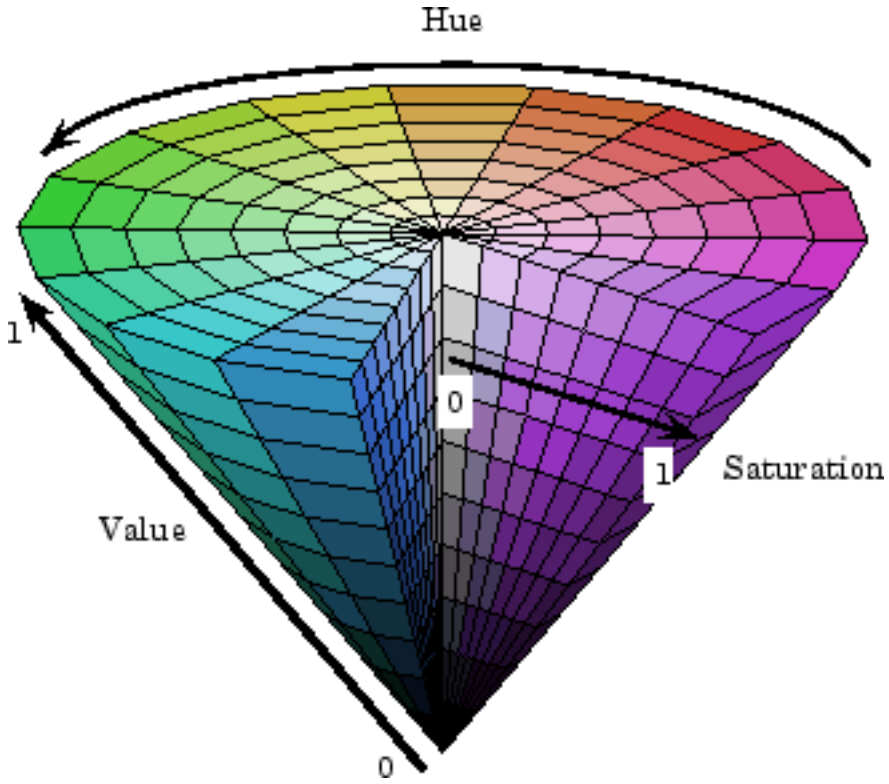
Hue: Wavelength

Saturation: Amount of pigment

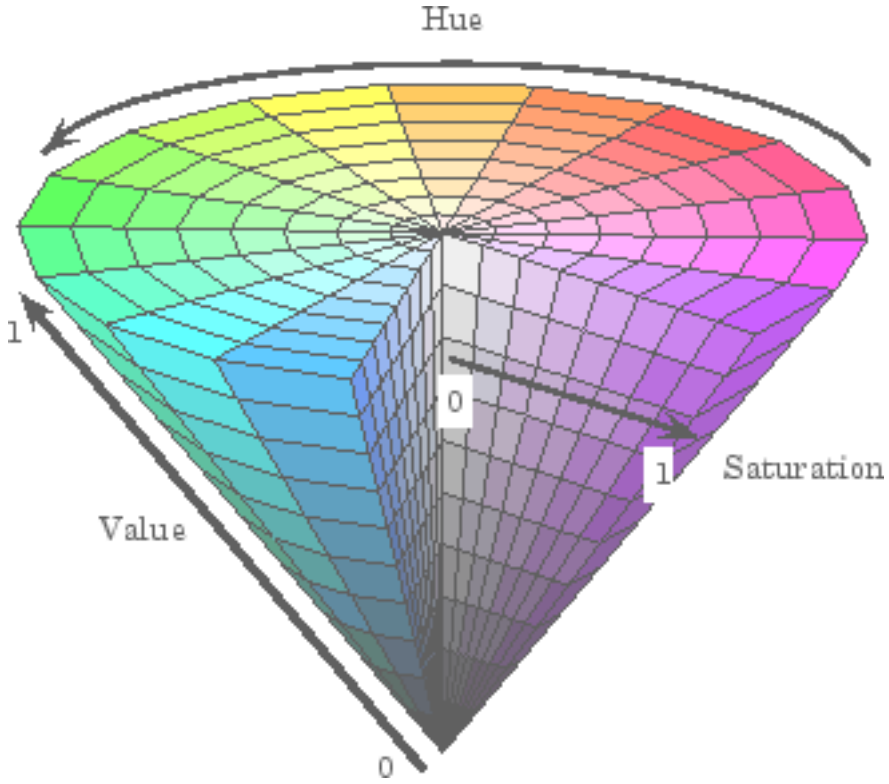
Value: Intensity or brightness

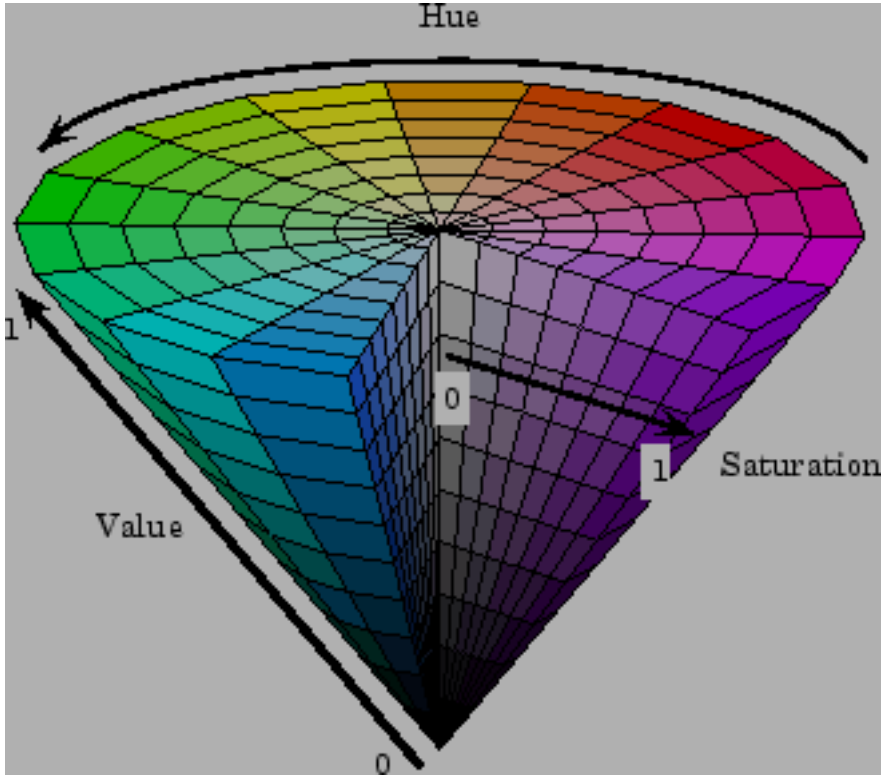
Saturation





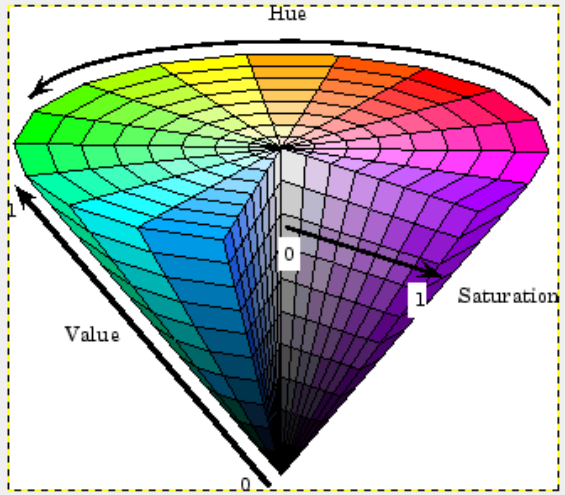
Intensity





*[Untitled]-1.0 (RGB color, 1 layer) 328x289 – GIMP

File Edit Select View Image Layer Colors Tools Filters Windows Help



-263, 18 px 100 % Pasted Layer (976.2 kB)

Hue-Saturation

Adjust Hue / Lightness / Saturation

Pasted Layer-2 ([Untitled])

Presets:

Select Primary Color to Adjust

R Y M Master G B C

Overlap: 0

Adjust Selected Color

Hue: 0

Lightness: 0

Saturation: 0

Reset Color

Preview

Help Reset OK Cancel

Sign in

Find Replace Select Editing

74%

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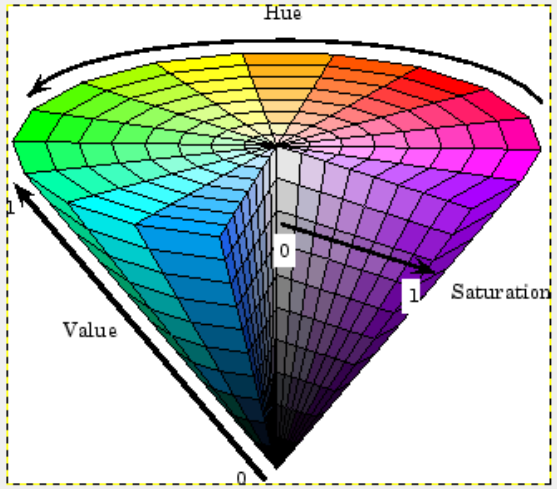
*[Untitled]-1.0 (RGB color, 1 layer) 328x289 – GIMP

File Edit Select View Image Layer Colors Tools Filters Windows Help



Brightness-Contrast

Adjust Brightness and Contrast

Pasted Layer-2 ([Untitled])

Presets:

Brightness: 0

Contrast: 0

Edit these Settings as Levels

Preview

Help Reset OK Cancel

483, 198 px 100 % Pasted Layer (976.2 kB)

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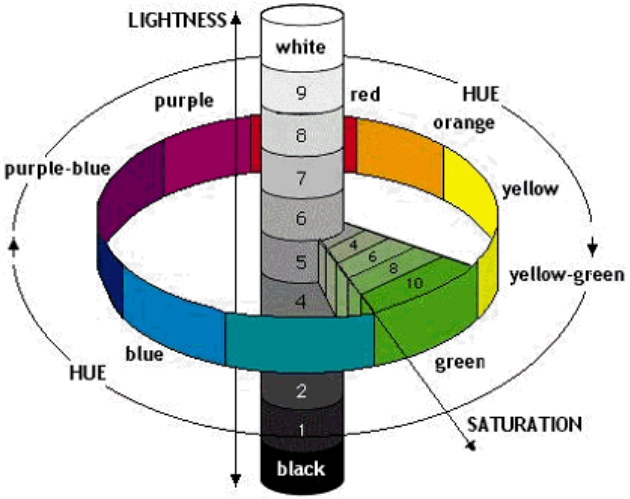
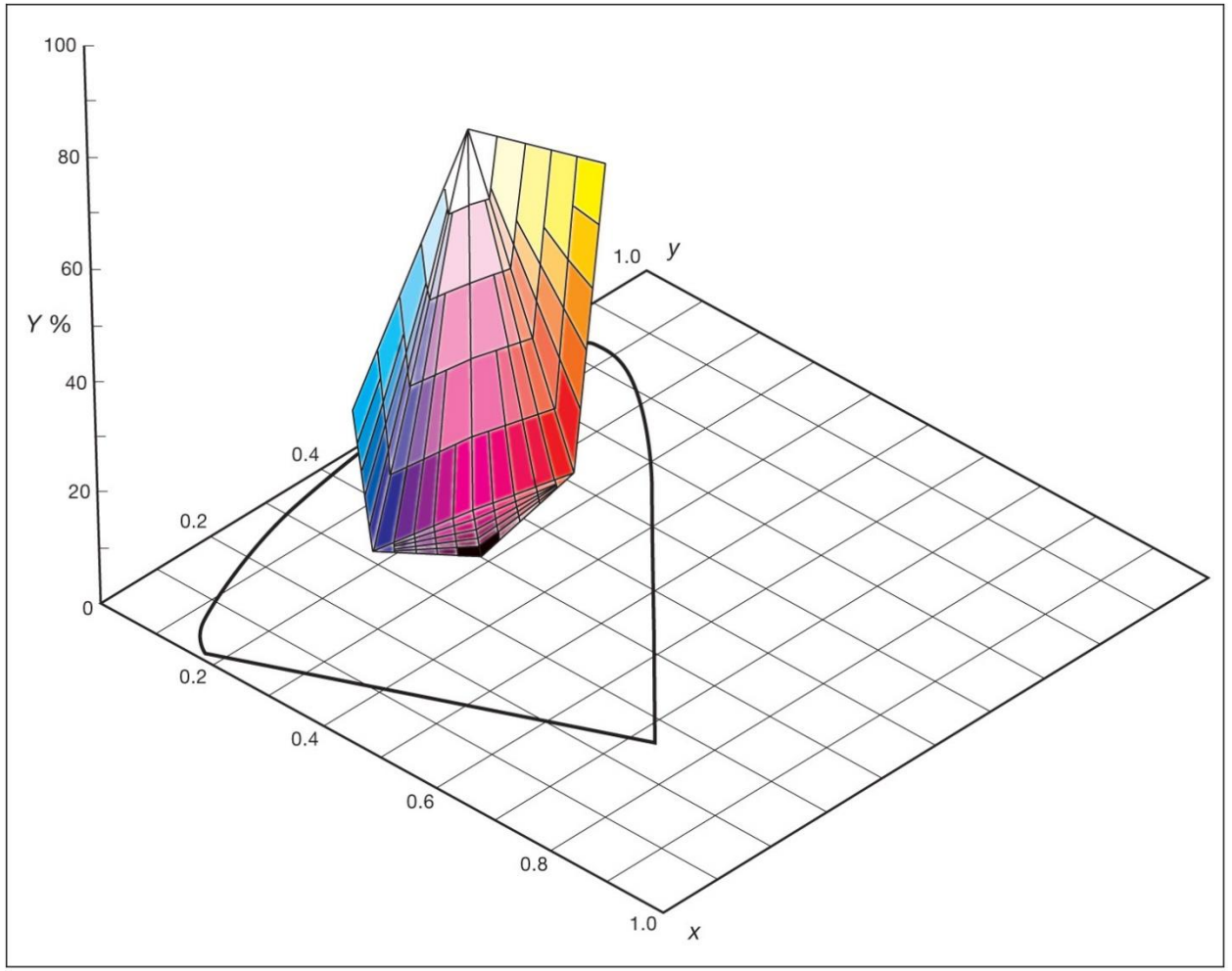
1/22/2015

Munsell color model



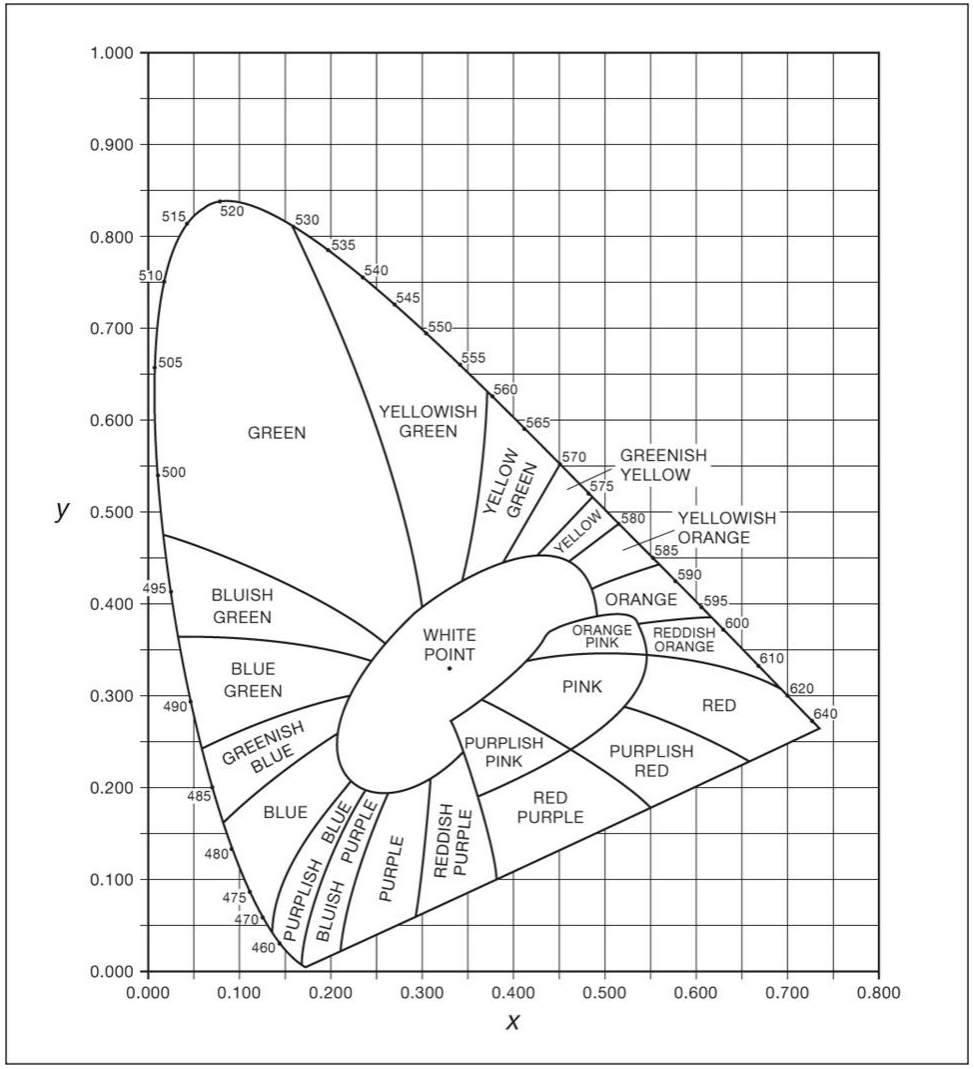
Munsell layers

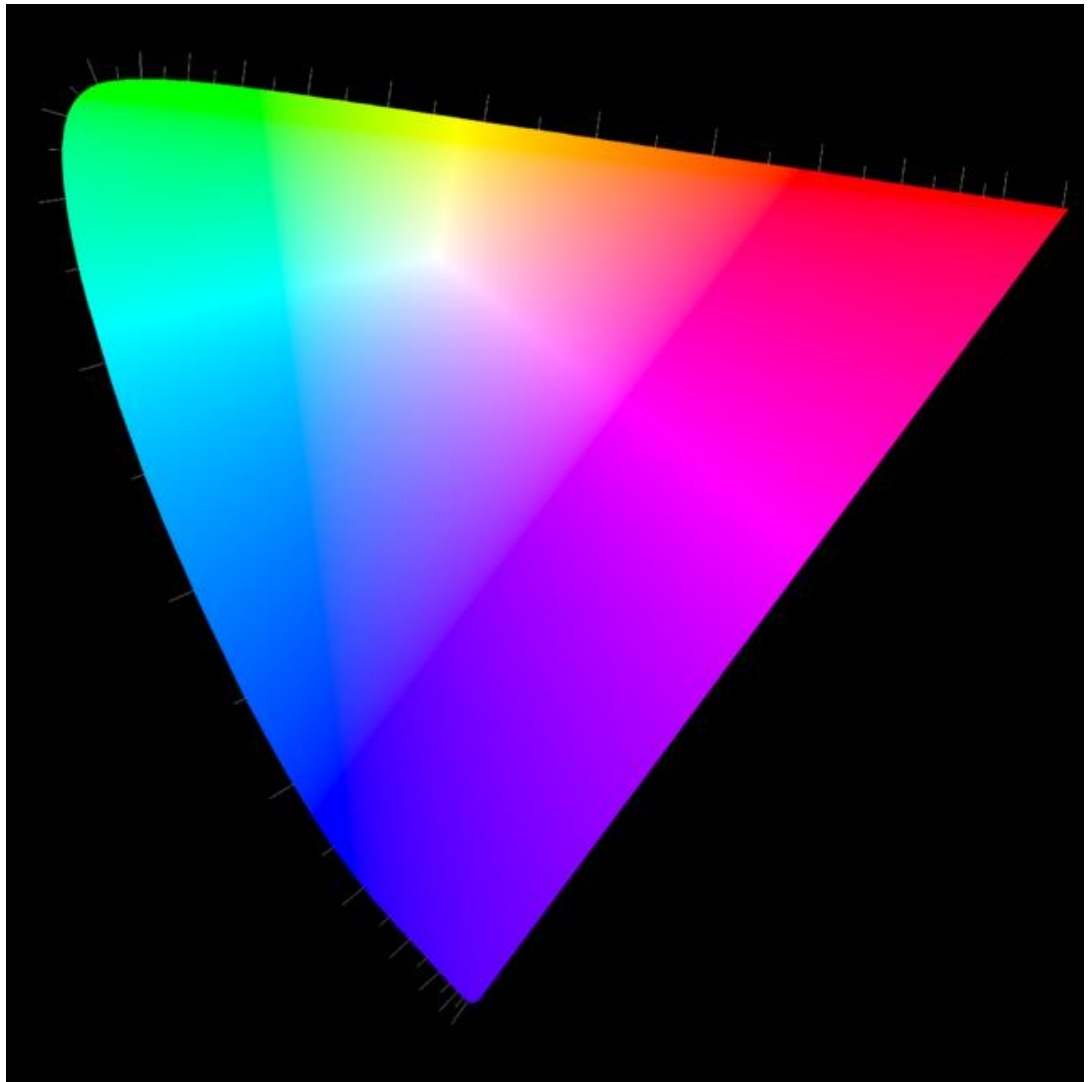


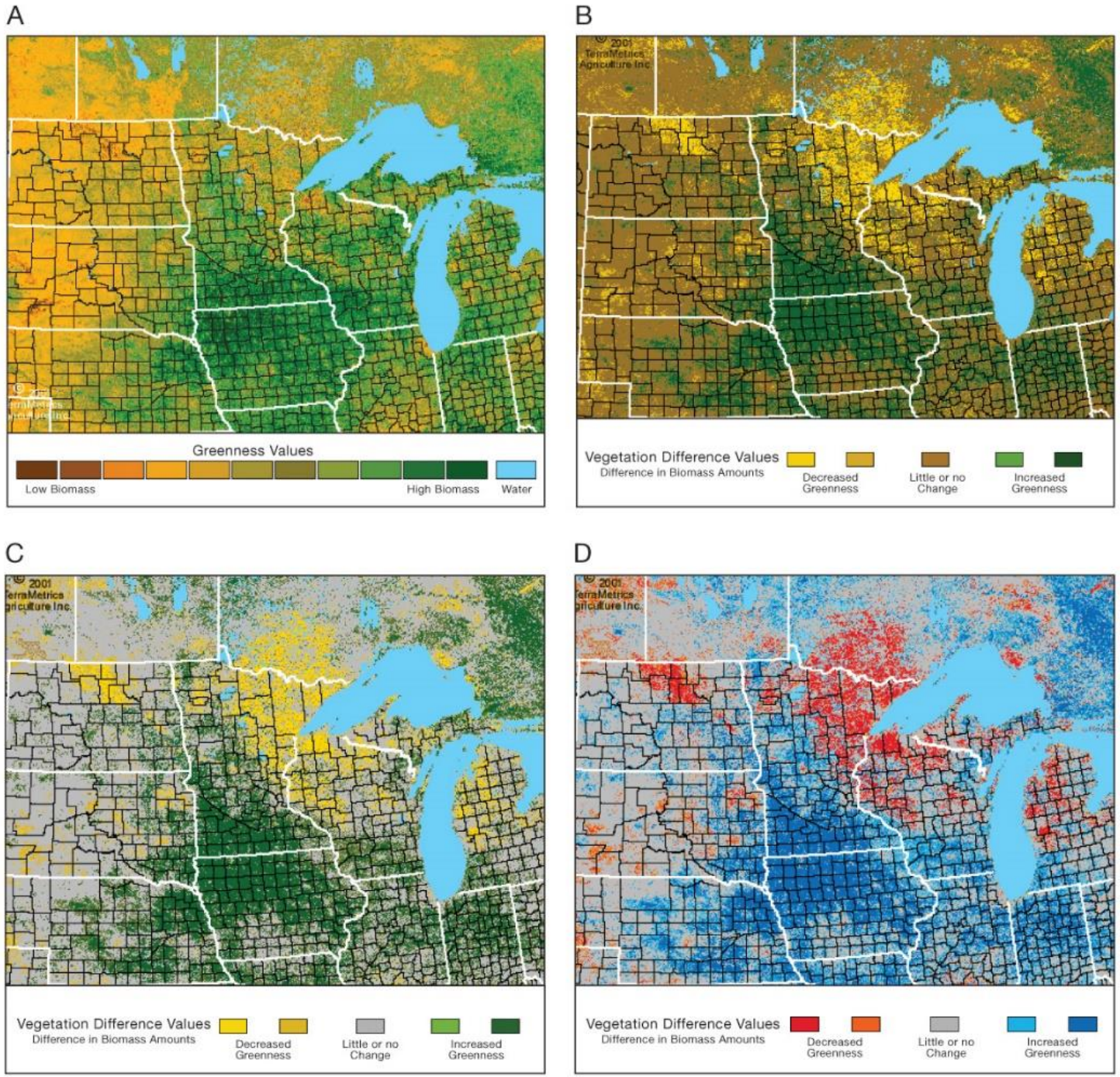
CIE color model

- Commission Internationale de l’Eclairage
- Objective way to specify color
- Based on three numbers Yxy
- Two dimensional space for range of hue and saturation
- Central white-point (or equal energy)
- Uses RGB theory, color combinations and human subjects for color repetition
- Attempt to rectify perceptual difference in luminescence as a function of hue

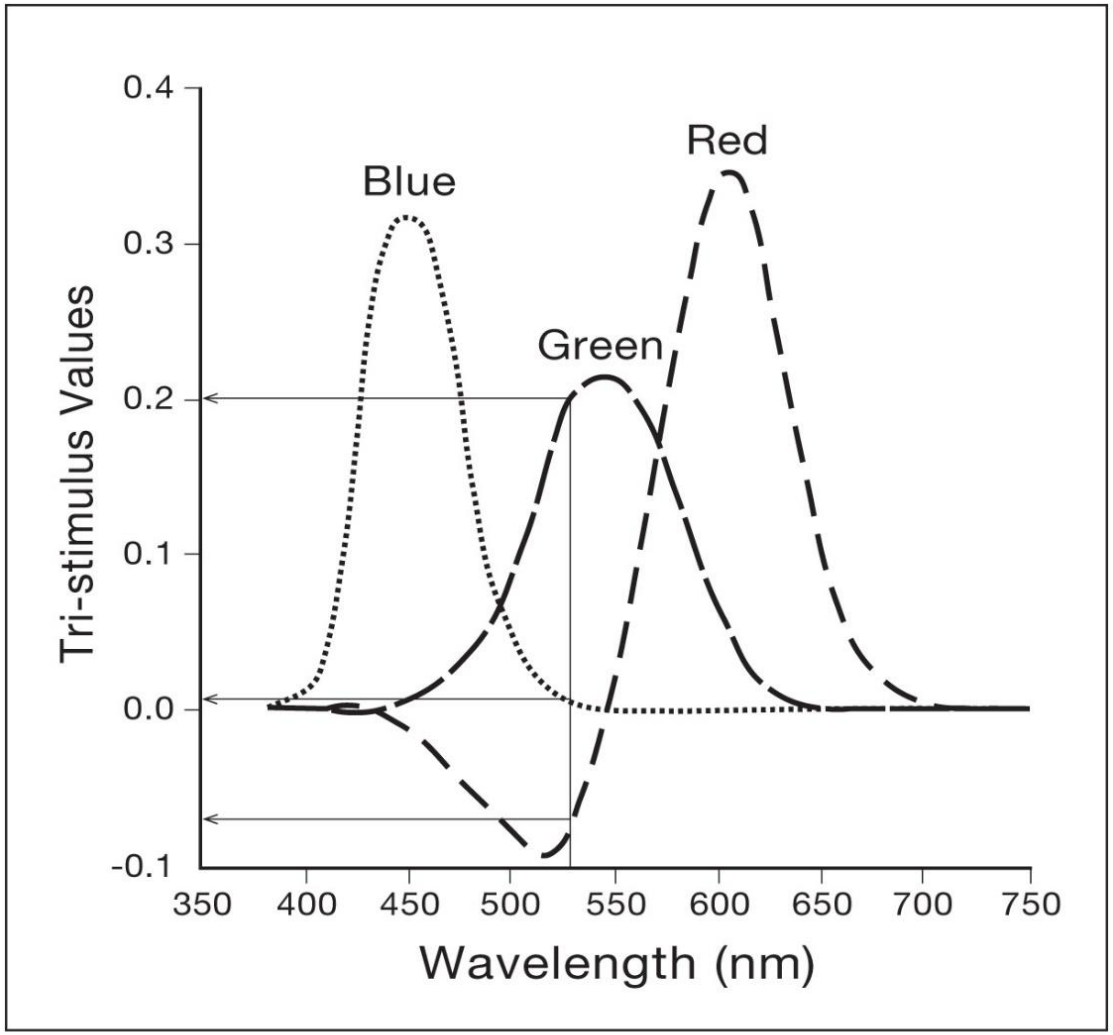
CIE color spaces

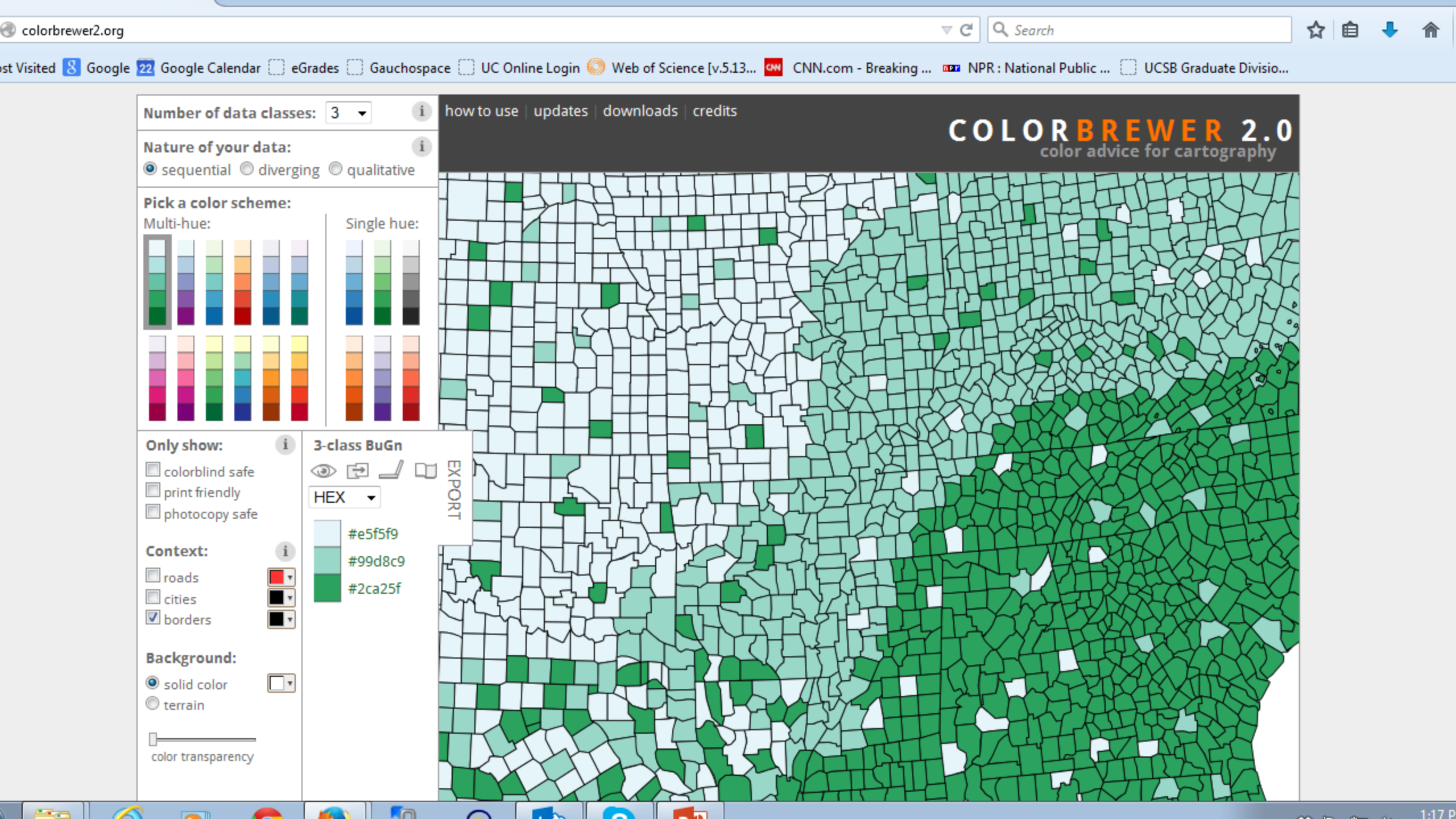






CIE stimulus adjustment

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CNN.com - Breaking ...
NPR : National Public ...
UCSB Graduate Divisio...
Number of data classes: 3
Nature of your data:
sequential
diverging
qualitative
Pick a color scheme:
Multi-hue:
Single hue:
Only show:
colorblind safe
print friendly
photocopy safe
Context:
roads
cities
borders
Background:
solid color
terrain
color transparency
3-class BuGn
HEX
EXPORT
#e5f5f9
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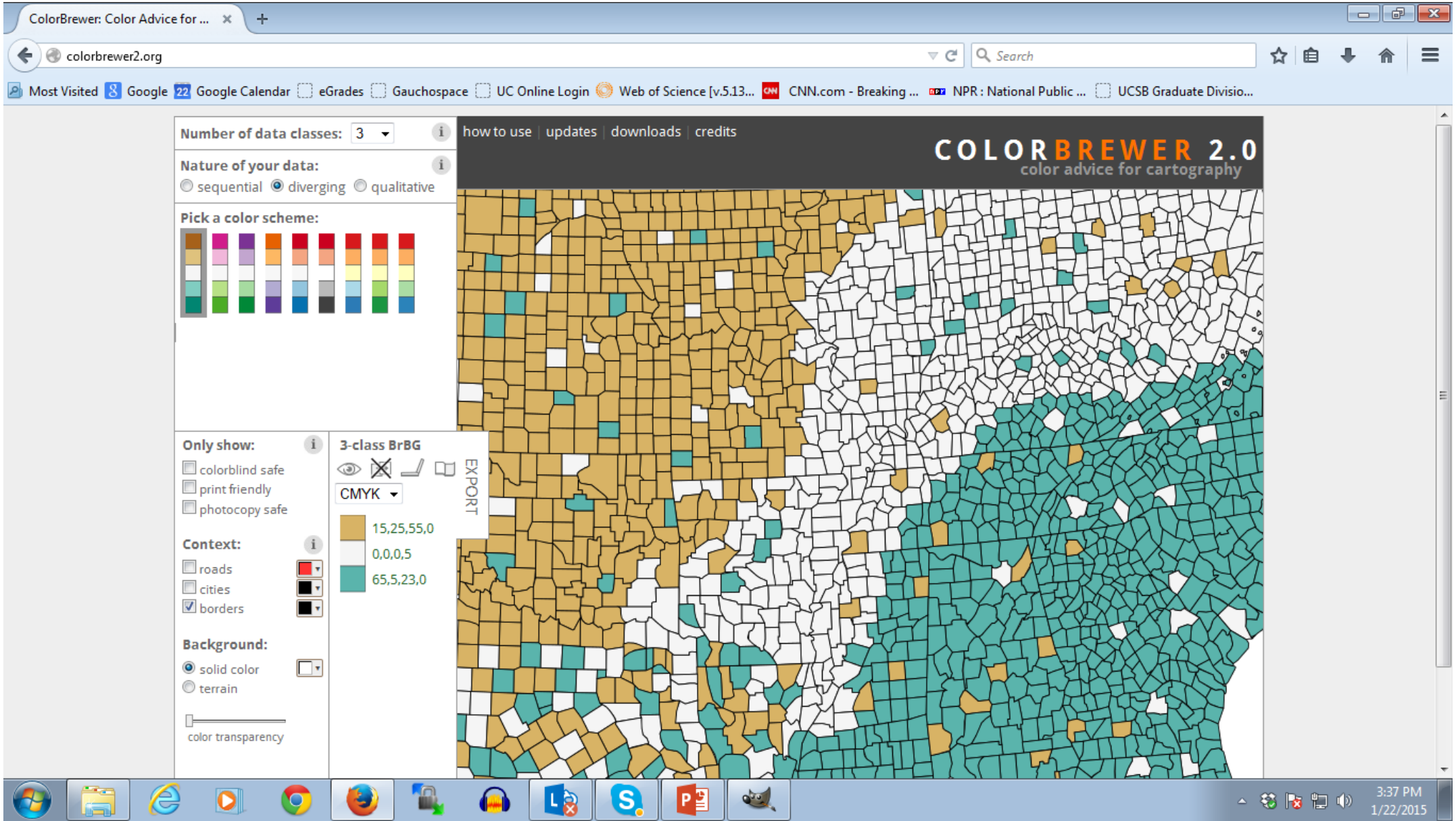
#2ca25f
how to use
updates
downloads
credits
COLORBREWER 2.0
color advice for cartography

Diverging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colorbrewer2.org
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Most Visited
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Gauchospace
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CNN.com - Breaking ...
NPR : National Public ...
UCSB Graduate Divisio...
Number of data classes: 3
Nature of your data:
sequential
diverging
qualitative
Pick a color scheme:
how to use | updates | downloads | credits
COLORBREWER 2.0
color advice for cartography
Only show:
colorblind safe
print friendly
photocopy safe
Context:
roads
cities
borders
Background:
solid color
terrain
color transparency
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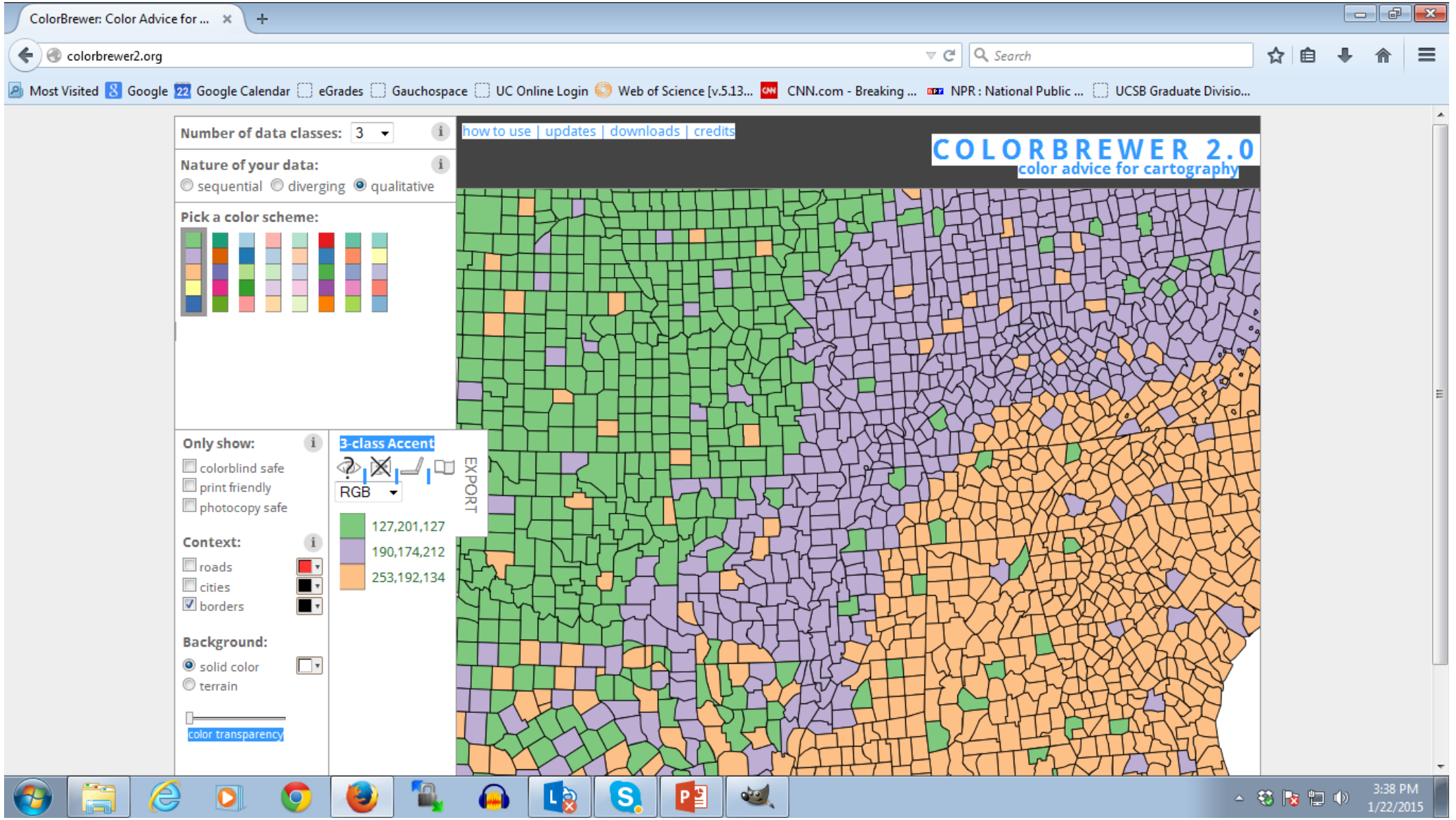
Qualitative



Summary

- Color is complex and powerful
- Light behaves as both a wave and particles
- Light interacts with all aspects of map viewing
- Colors can be additive or subtractive
- Color models allow color specification and control
- Covered RGB, CMYK, HSV, Munsell and CIE
- Colorbrewer recommends color sequences for sequential, diverging and qualitative color sets
- Don’t forget: Hue suggests class, saturation and intensity suggest value