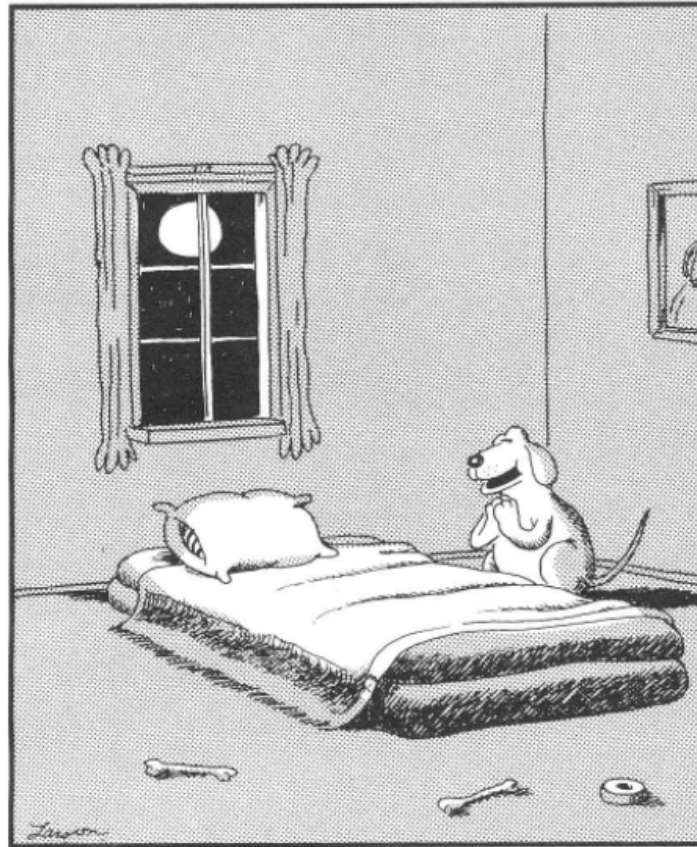


FUNDAMENTALS OF DATA VISUALIZATION

Color



“... and please let Mom, Dad, Rex, Ginger, Tucker,
me and all the rest of the family see color.”

The Far Side, Gary Larson

COLOR IS THE NEW BLACK

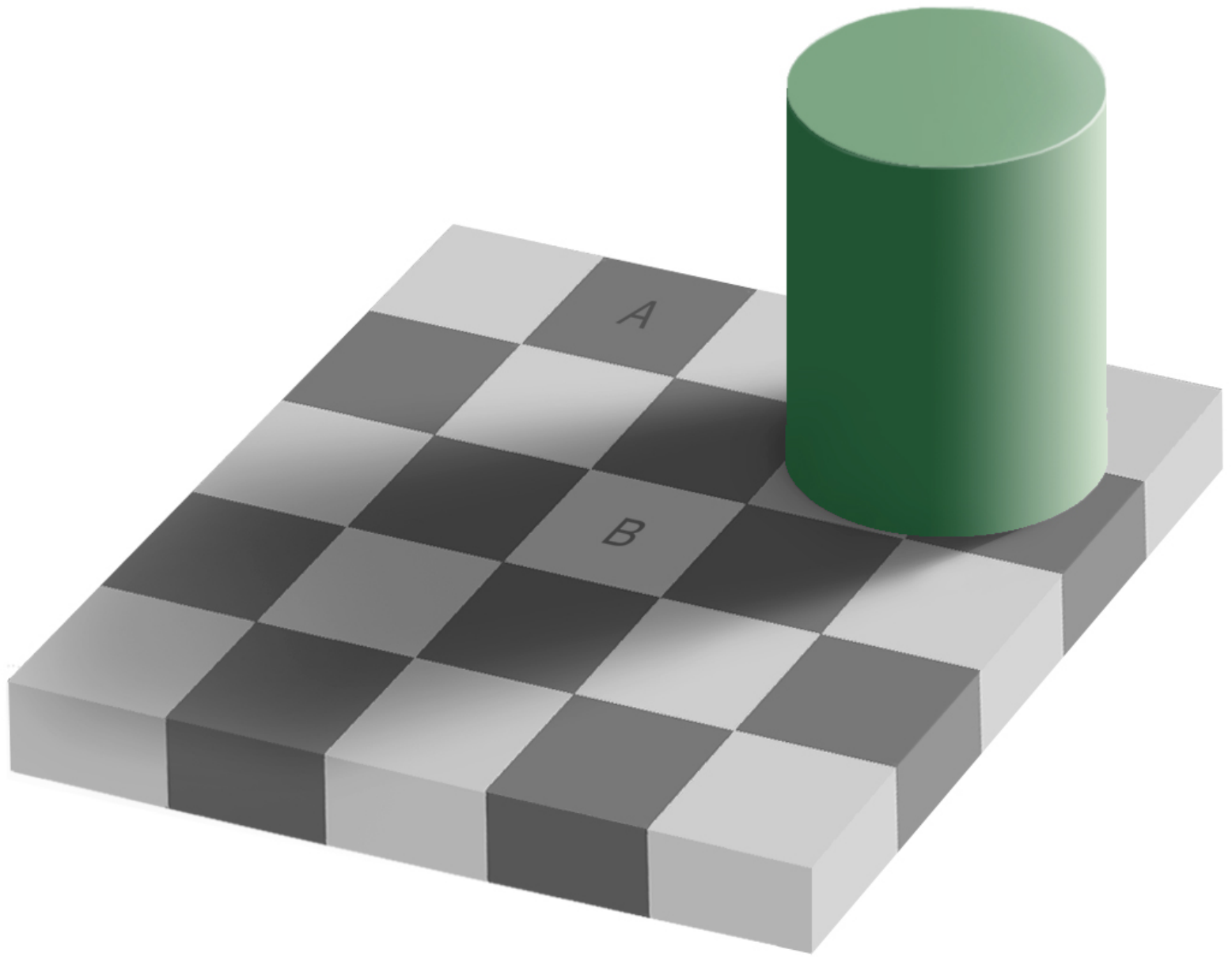
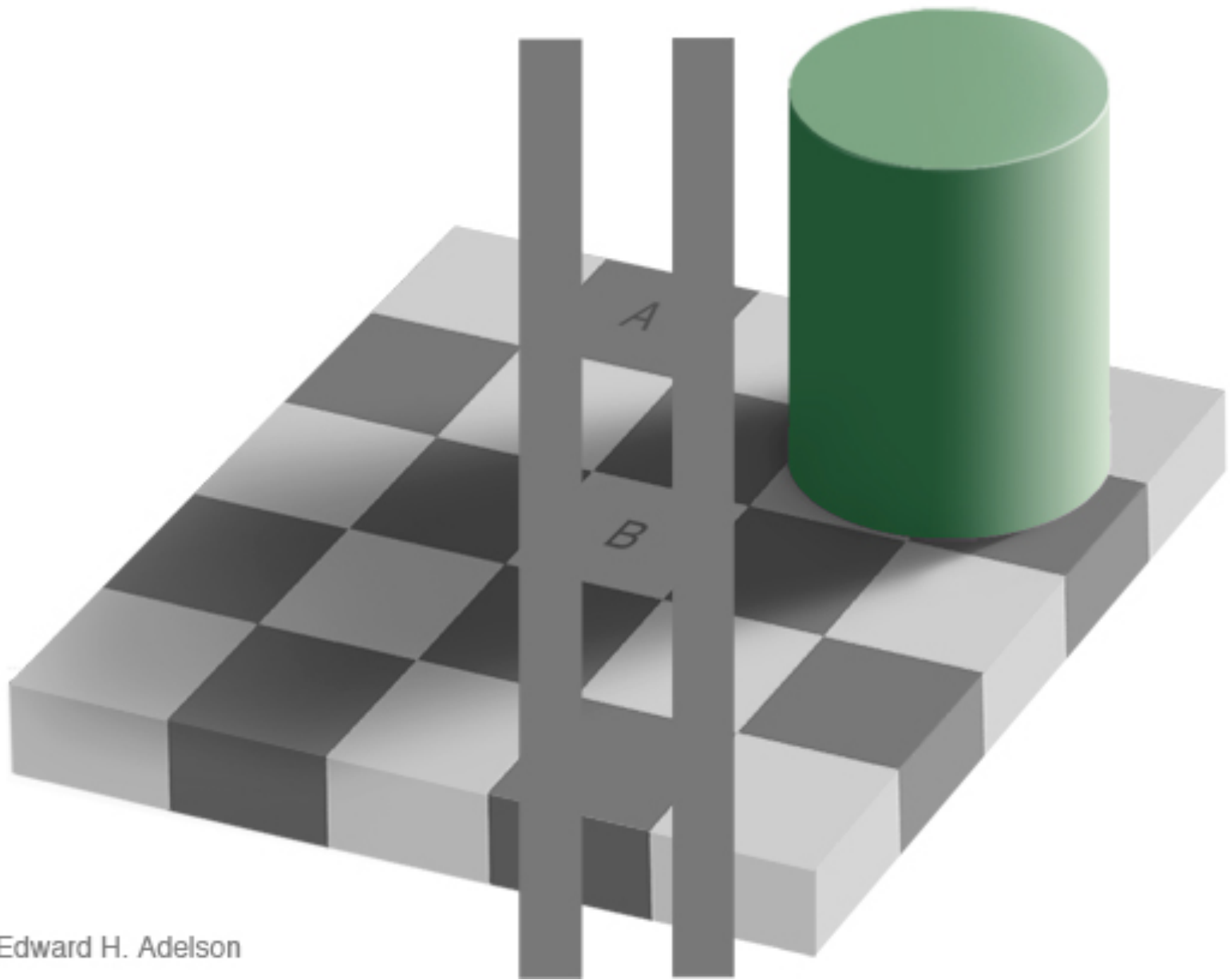


Image from Adelson, MIT

POP QUIZ, HOTSHOT

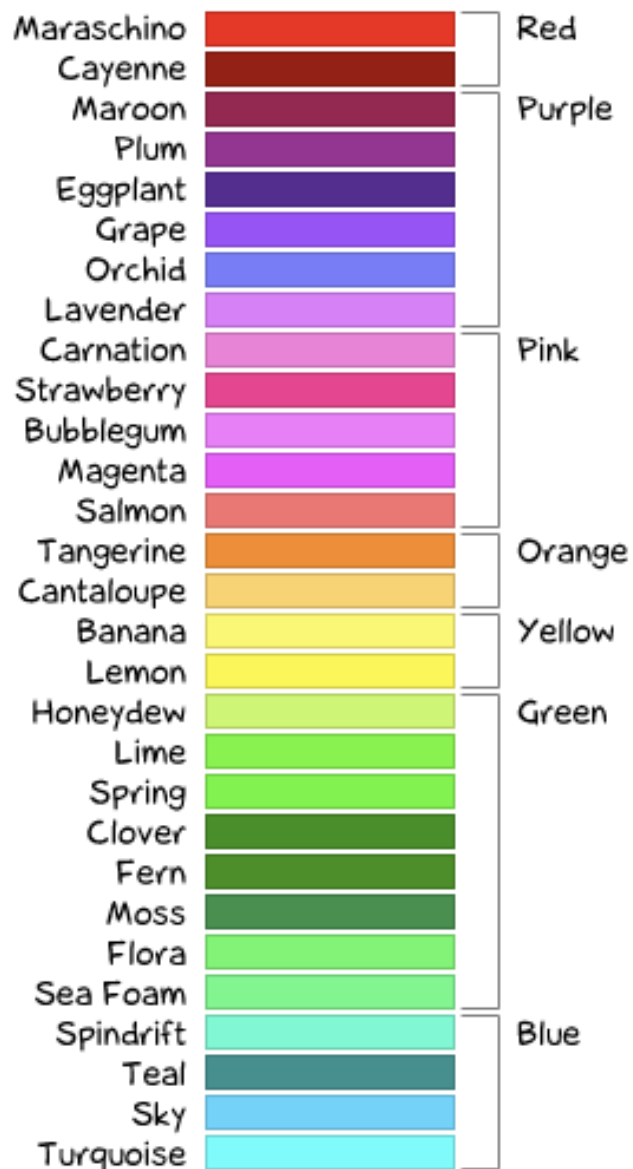
- 1) A IS LIGHTER THAN B
- 2) B IS LIGHTER THAN A
- 3) A AND B ARE THE SAME
- 4) JUST TELL ME, ALLRIGHT?



Edward H. Adelson

Image from Adelson, MIT

Color names if
you're a girl...



Color names if
you're a guy...

Doghouse Diaries
"We take no as an answer."

Actual color names
if you're a girl ...

Actual color names
if you're a guy ...



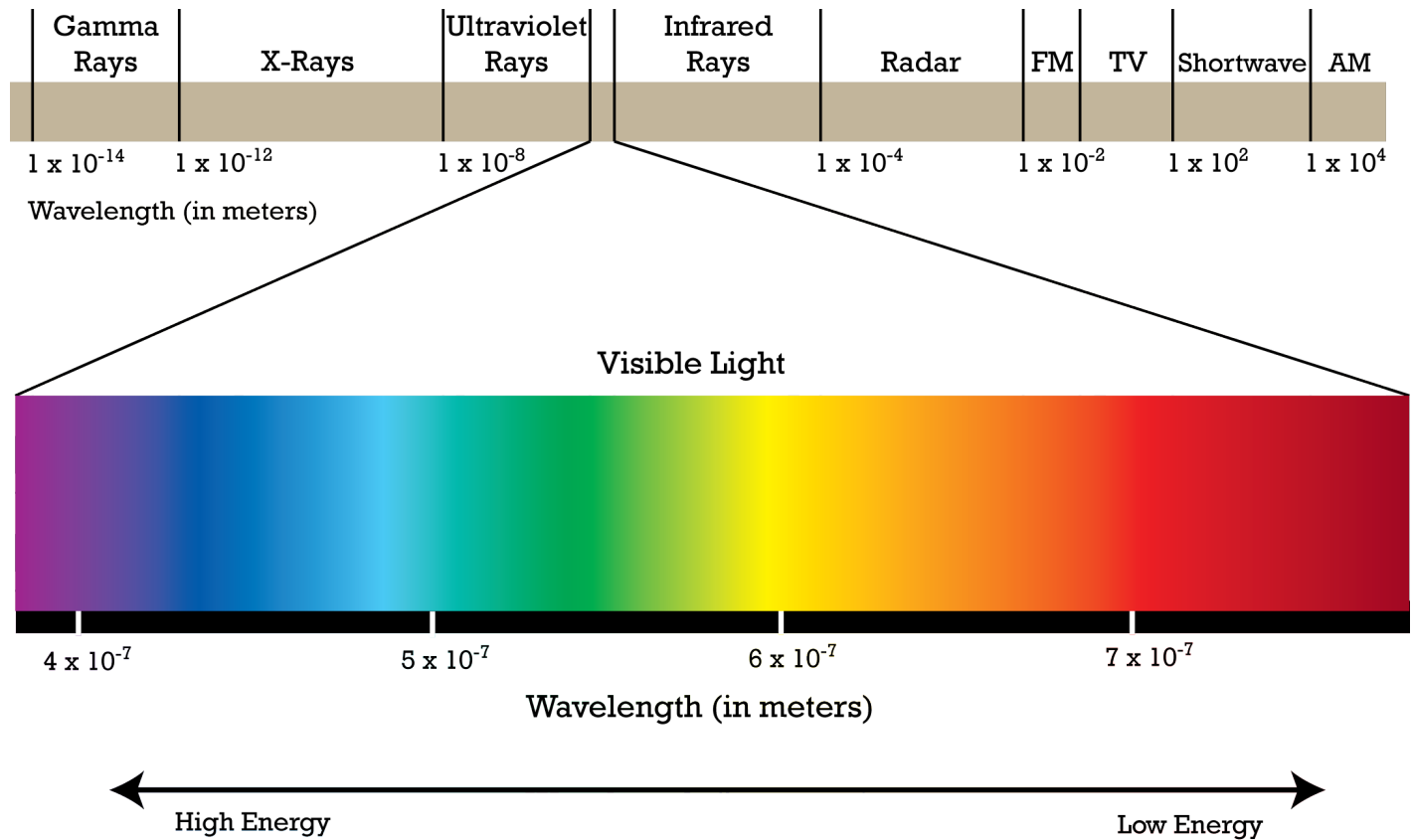
WHAT IS COLOR?

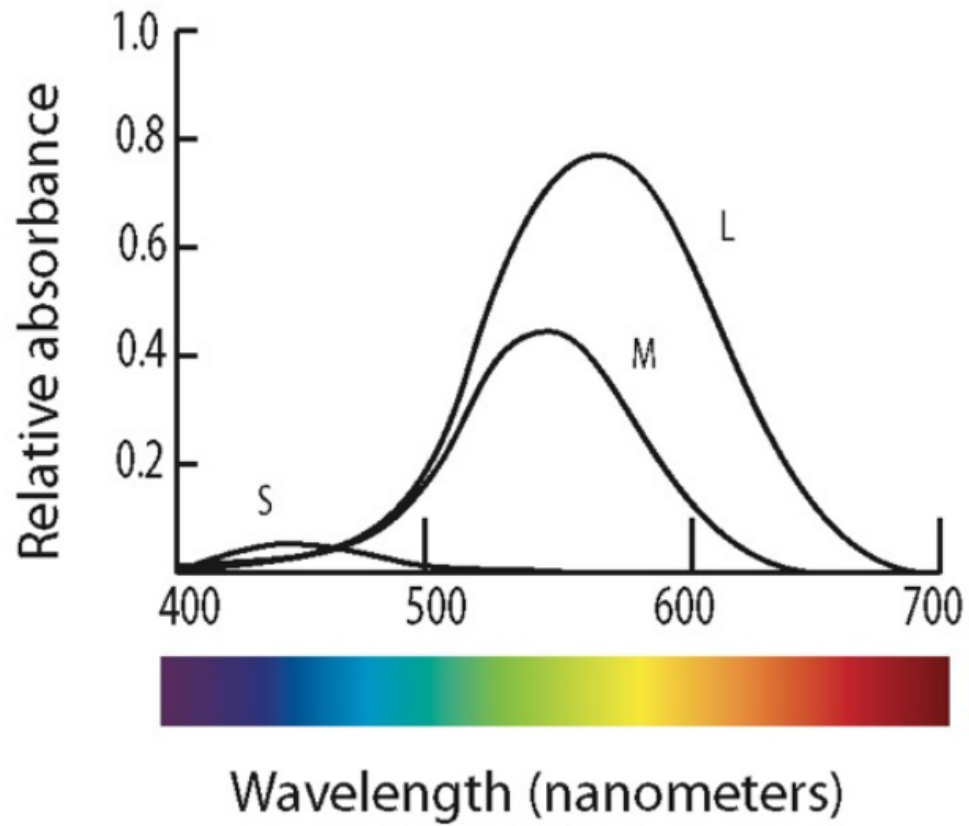
Physics	Biology	Visual System	Mental Models
Light Energy	Cone Response	Opponent Encoding	Perceptual Models
Wavelength	L, M, S	L, R-G, Y-B	Color perception

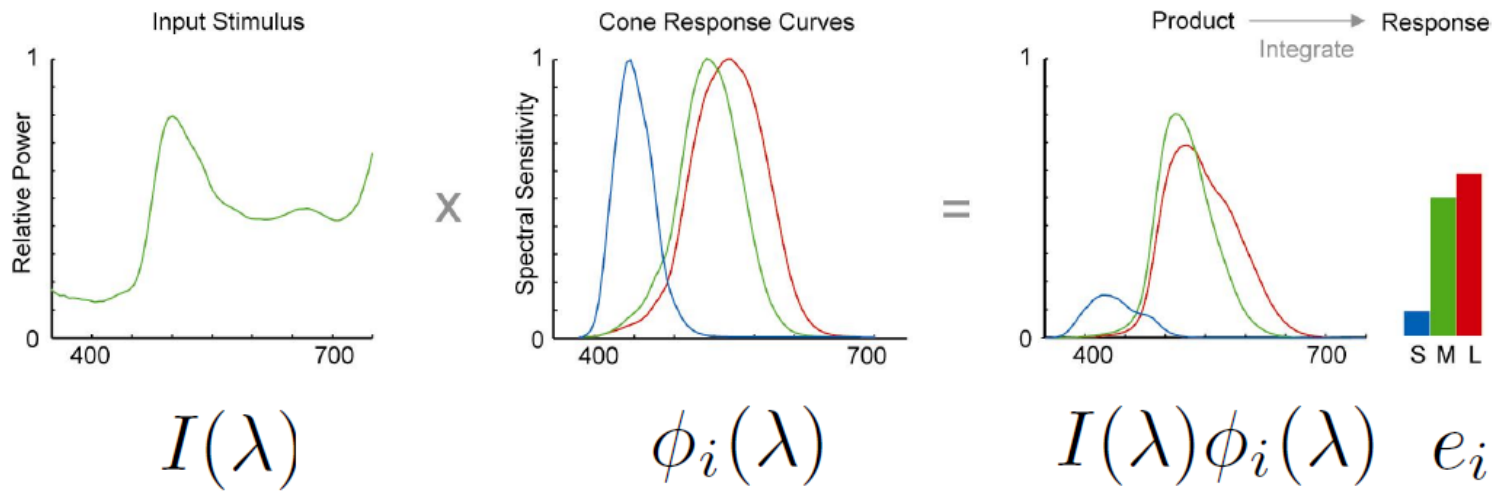
THE HUMAN EYE

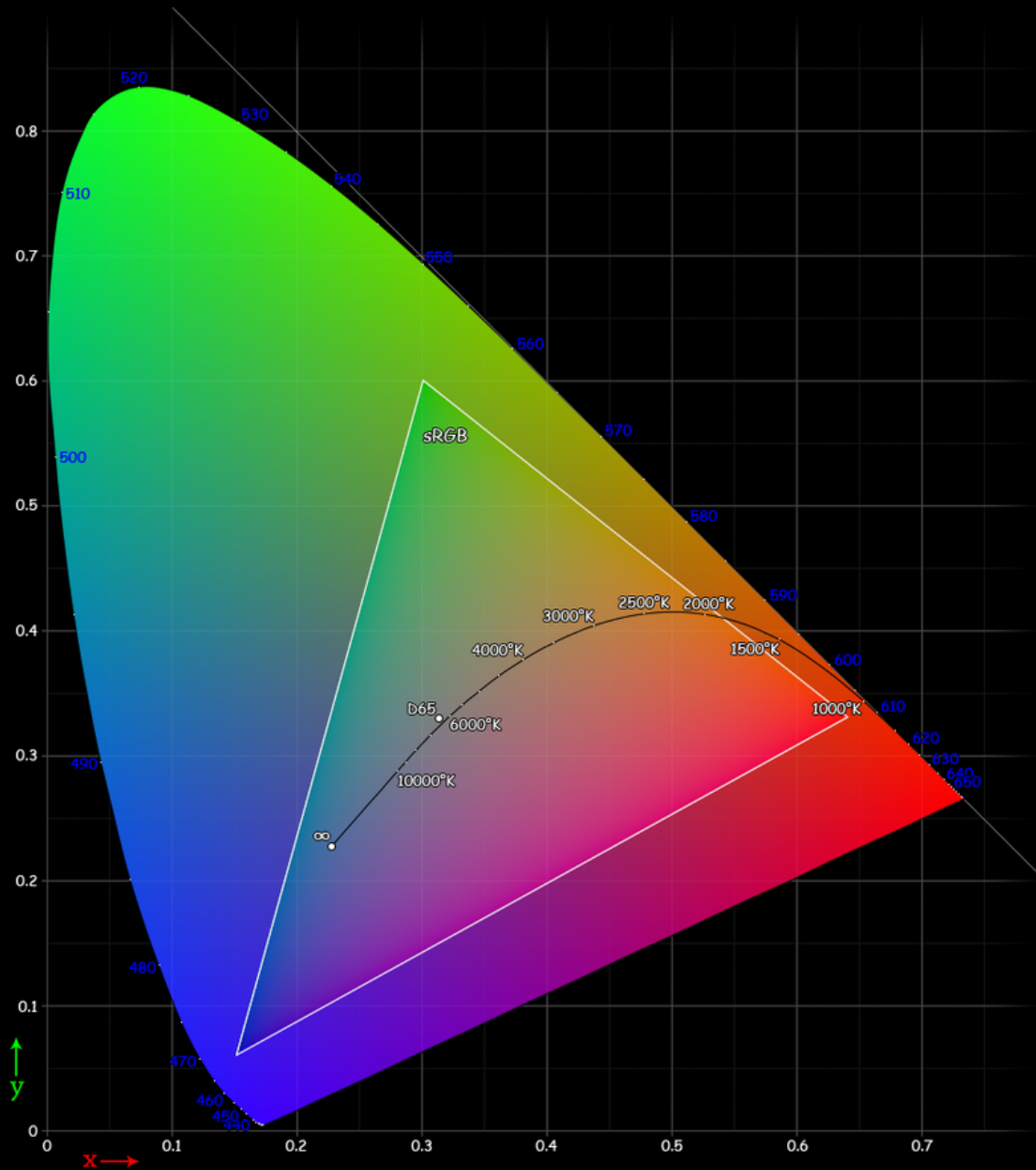
SMALL FREQUENCY RANGE

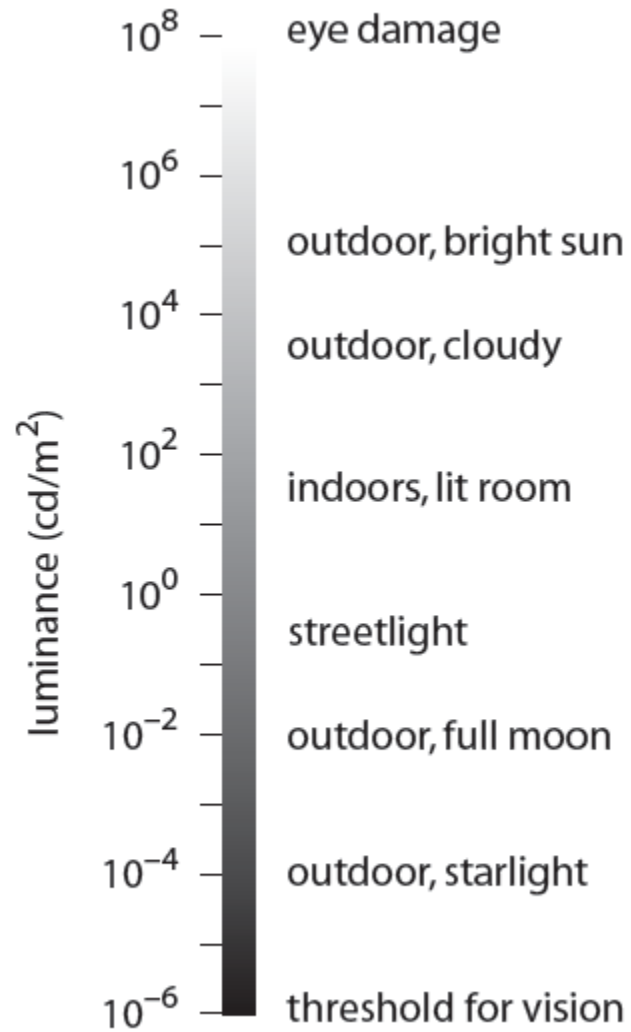
HUGE LUMINANCE RANGE

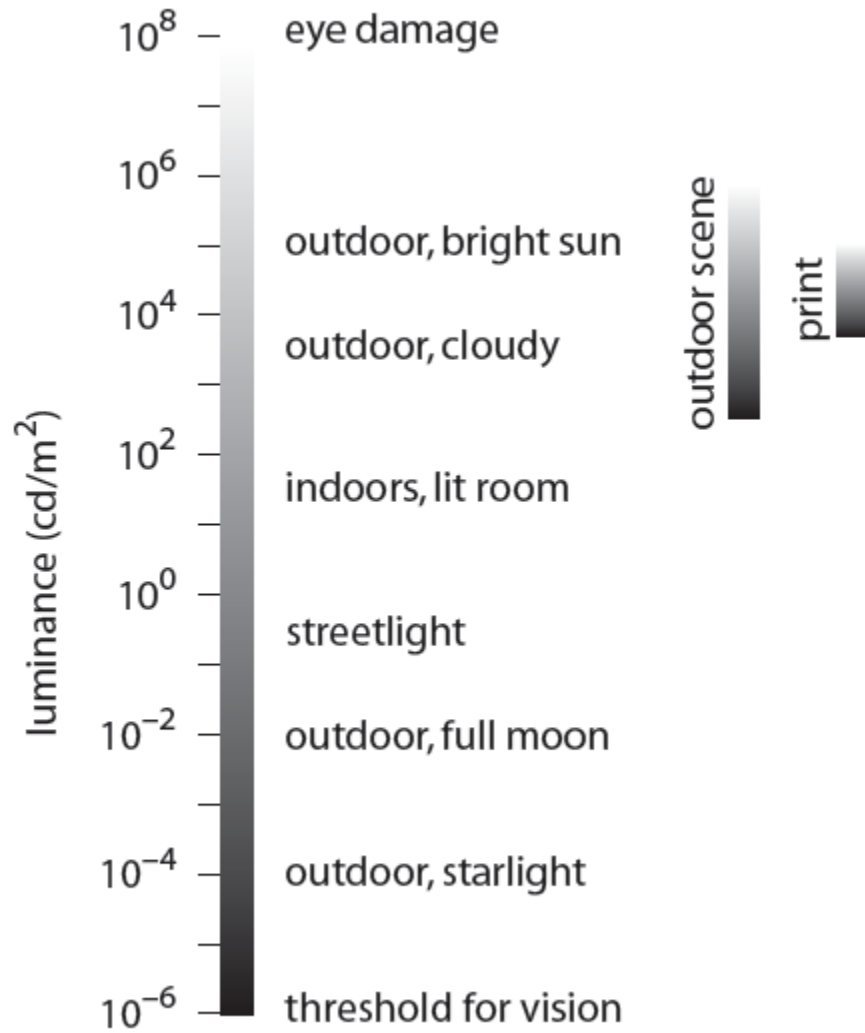












A

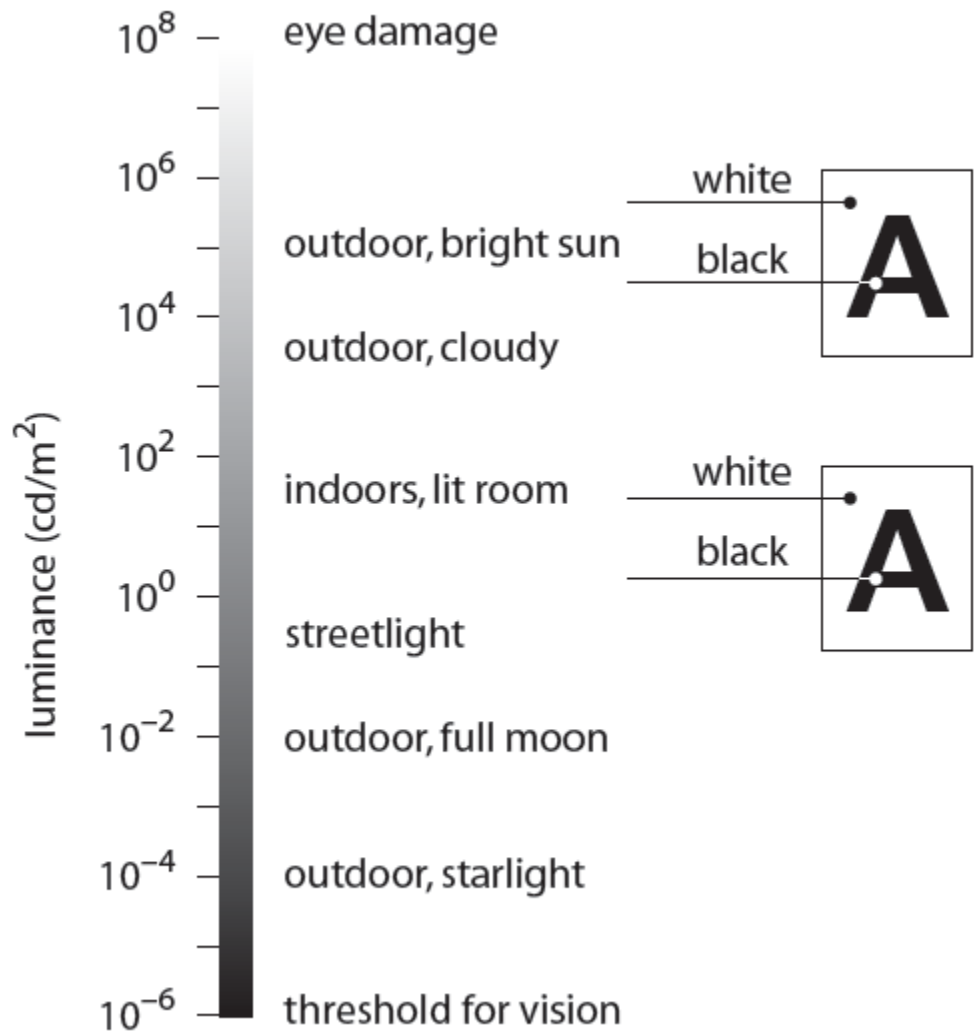
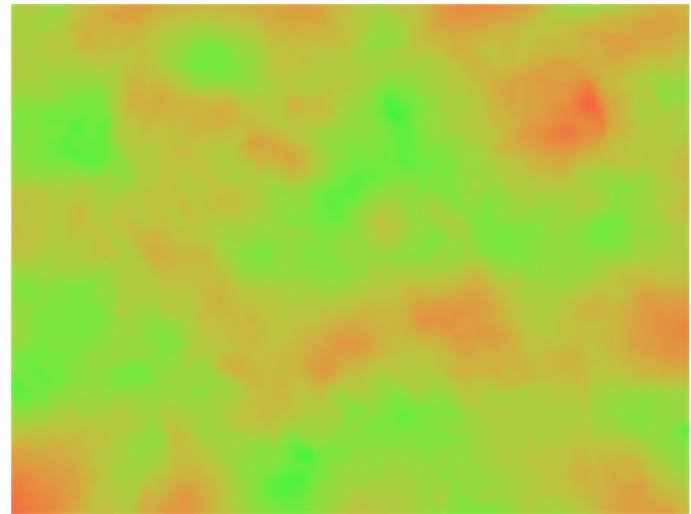
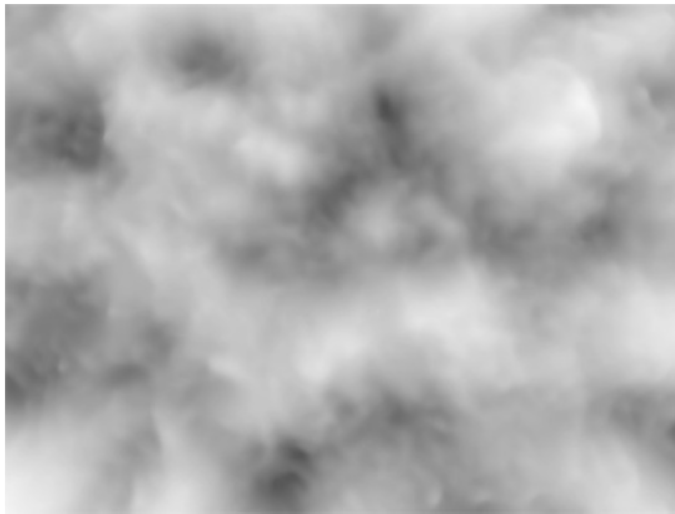
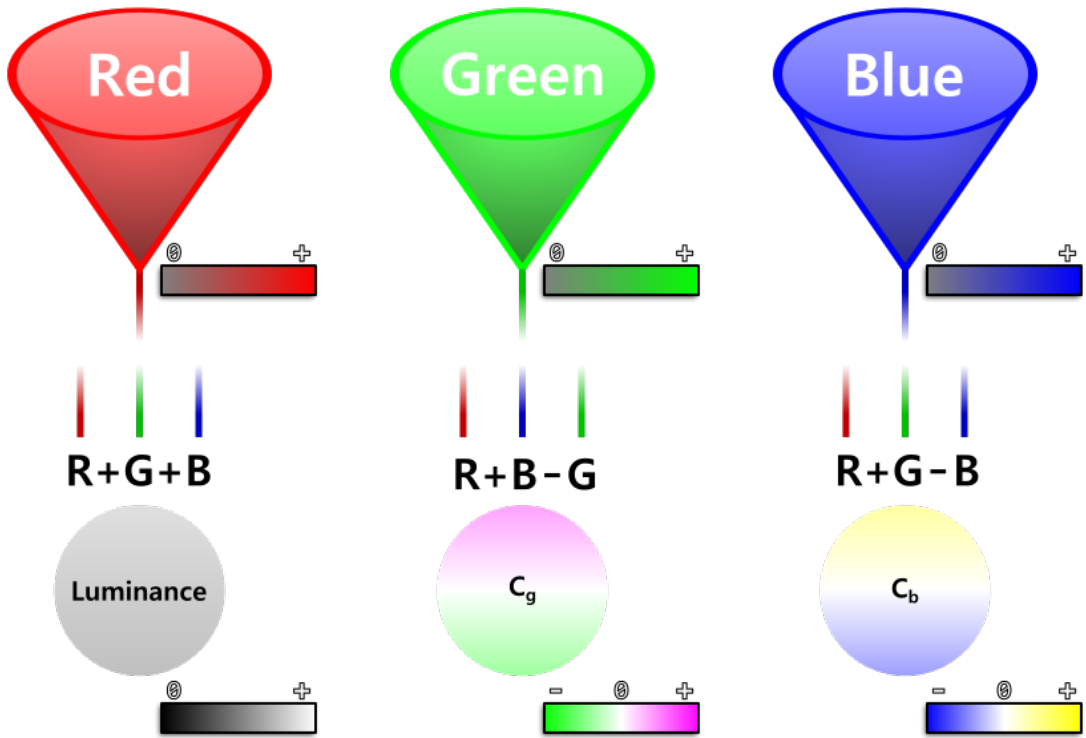




Image from <http://ideas.etublogs.usj.edu.lb/>





1. Trichromatic Stage

Trichromatic cone cells respond positively to one of three frequencies exhibited by photons arriving on their surface.

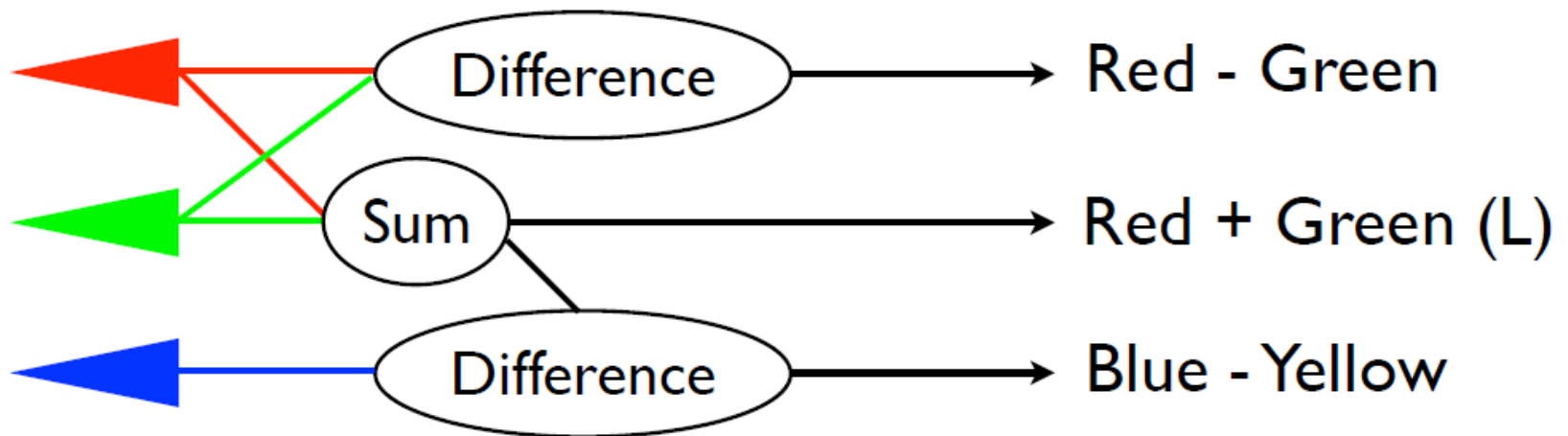
2. Opponent Process Stage

The three color channels are discovered by nearby opponent cells.

Opponent cells tuned to luminosity are excited by the red, green, and blue color signals.

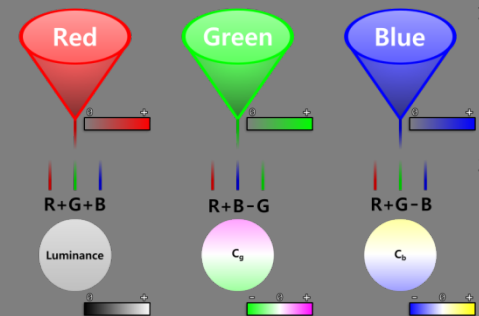
C_g cells are excited by red and blue and inhibited by green. C_b cells are excited by red and green and inhibited by blue.

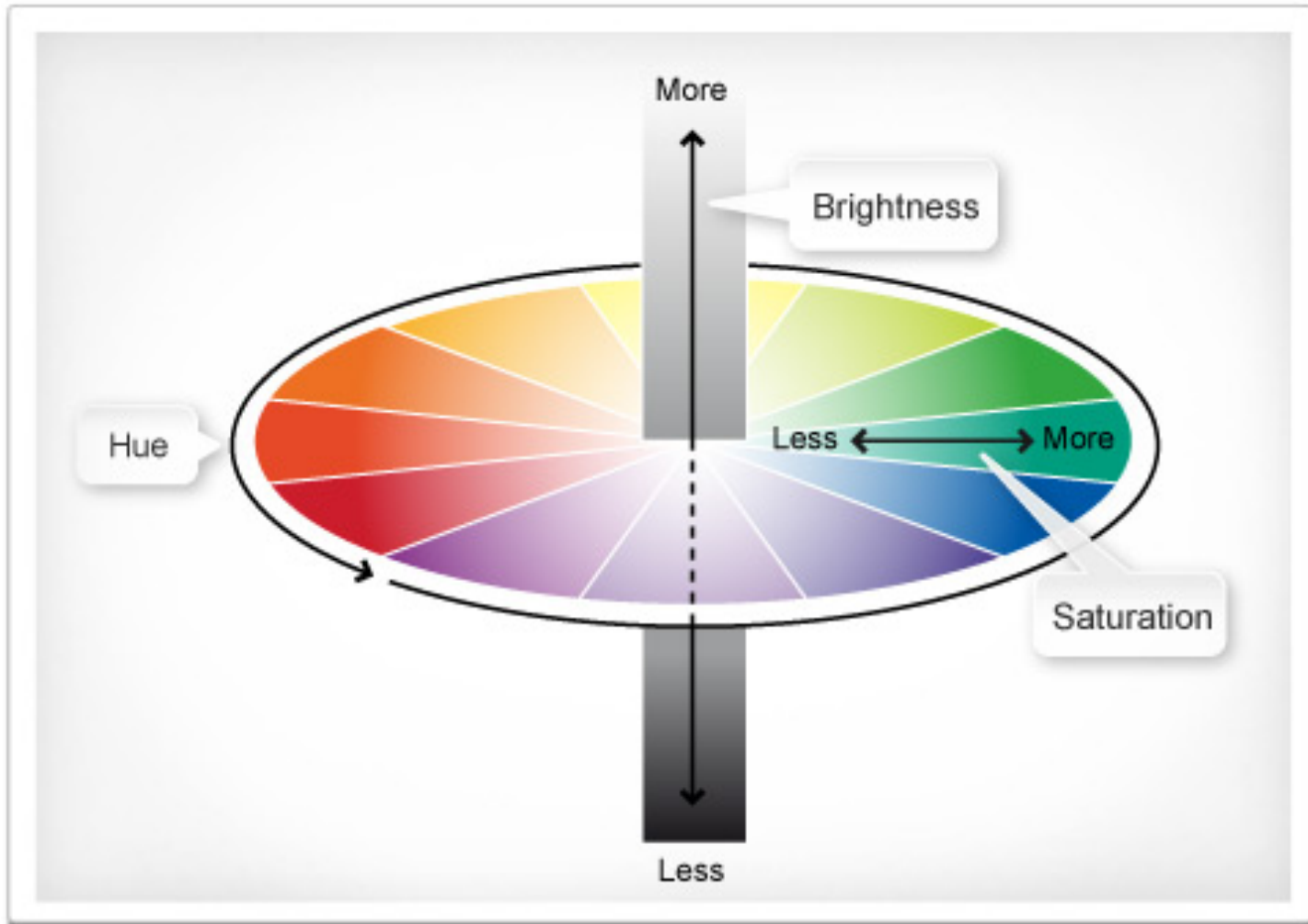
- Luminance (L): Sum of Red and Green
- Red - Green: Difference between Red and Green
- Yellow - Blue: Difference between L and Blue



THE RETINA & COLOR

- 1) SPATIAL COMPRESSION
- 2) ADJUST LUMINANCE RANGE TO NERVE S/N
- 3) EXTRACT REFLECTANCE (COLOR)





Who in the rainbow can draw the line where the violet tint ends and the orange tint begins? Distinctly we see the difference of the colors, but where exactly does the one first blendingly enter into the other? So with sanity and insanity.

—*Herman Melville, Billy Budd*

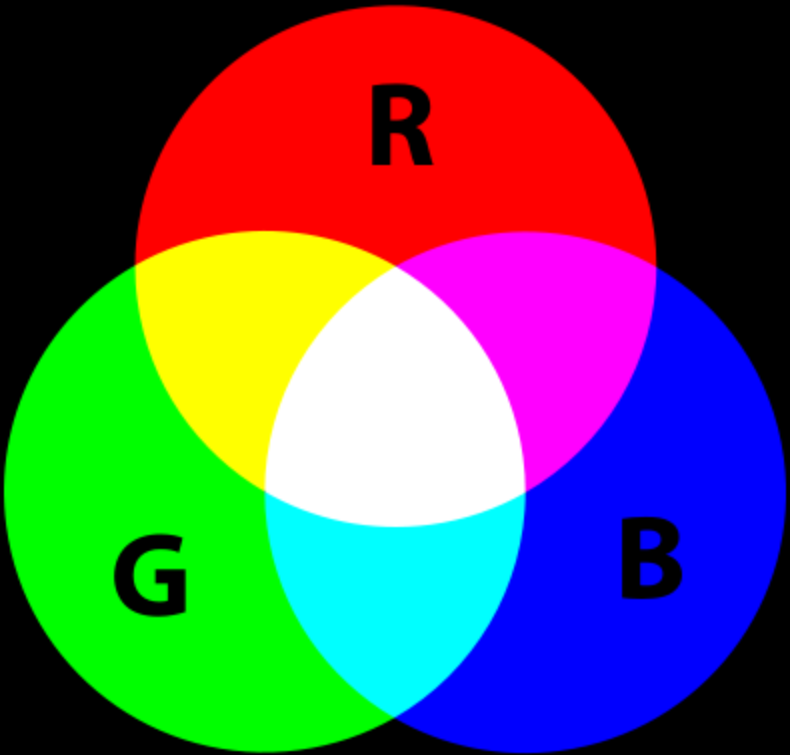


Image from Wikipedia

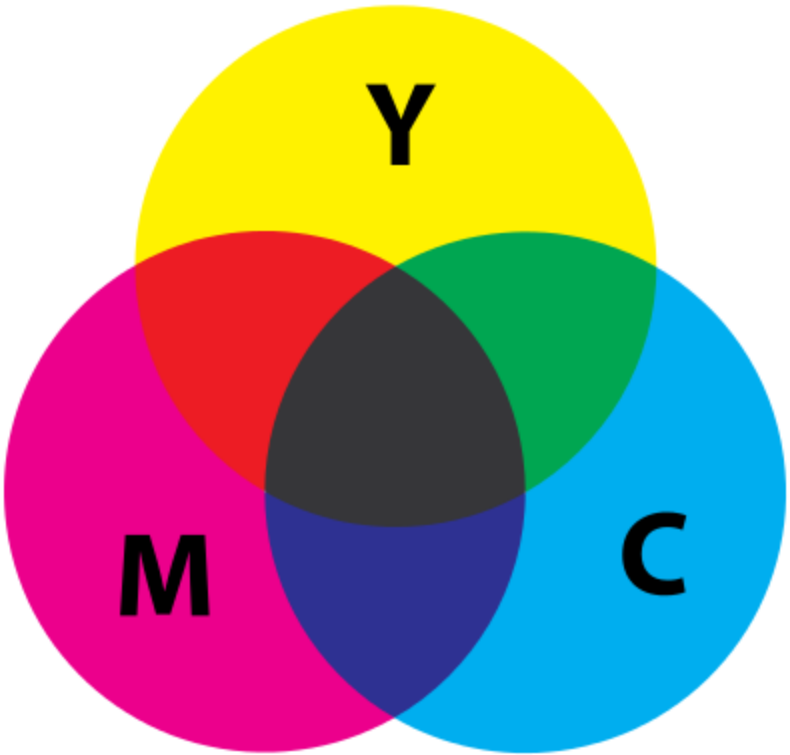
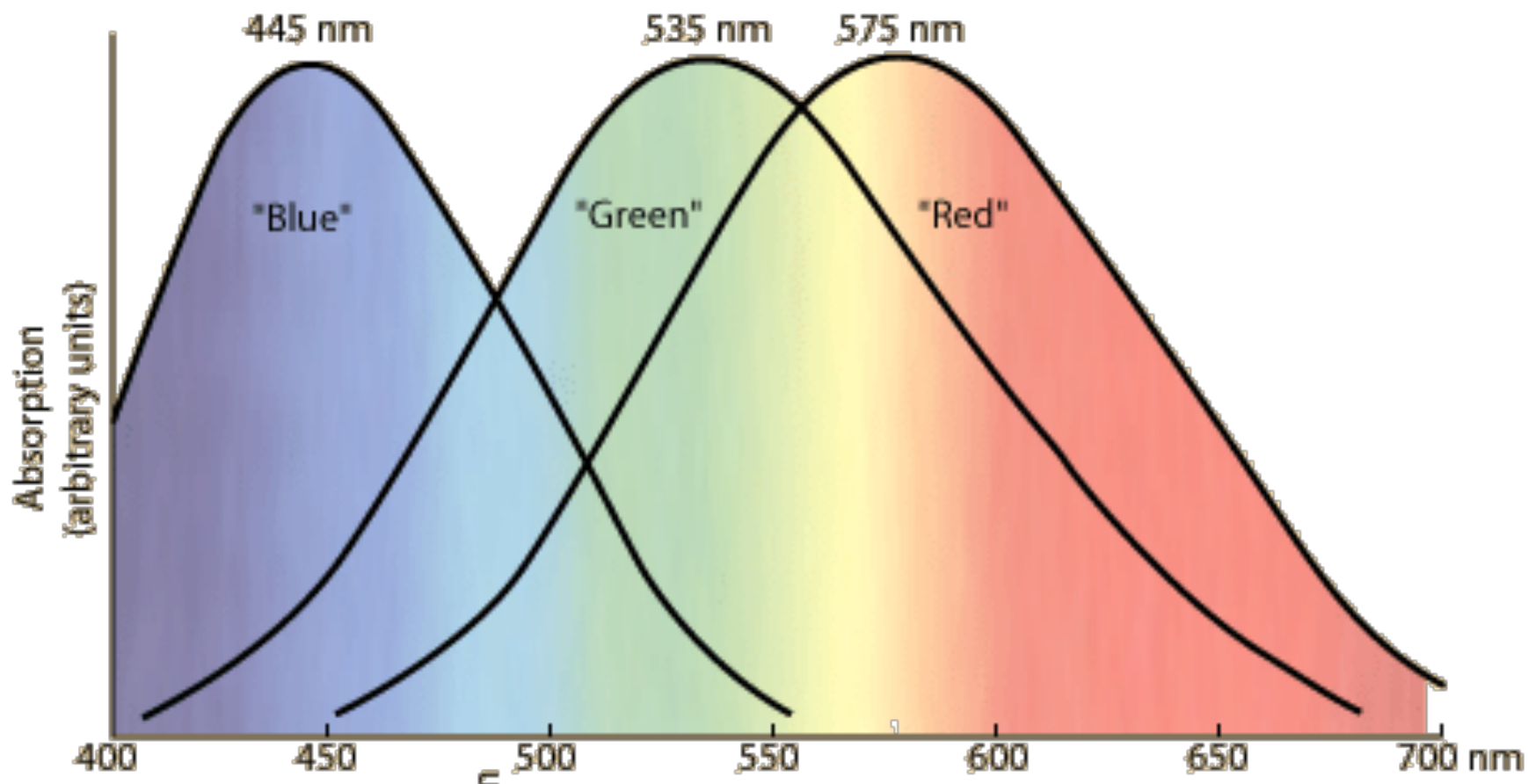
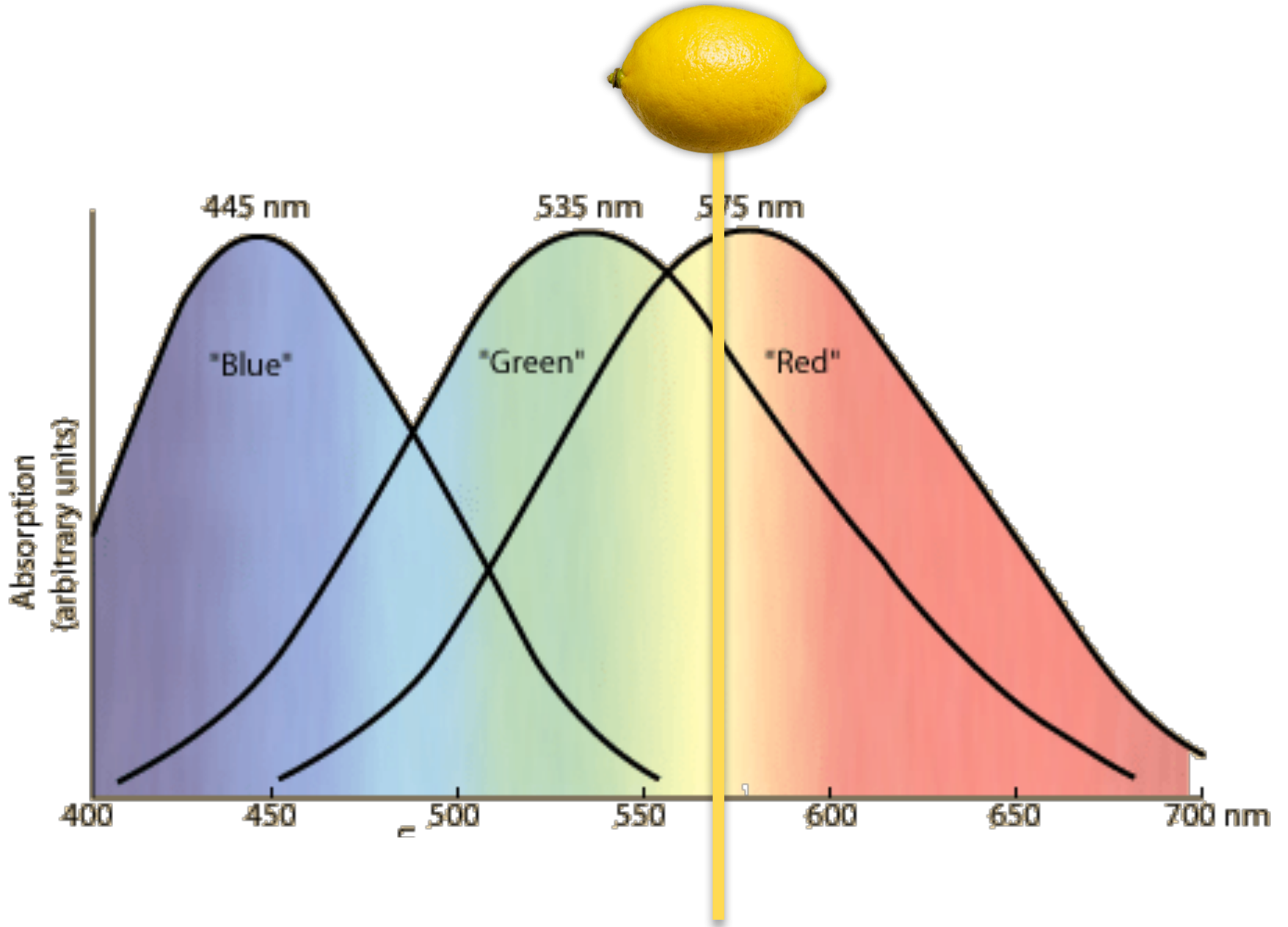


Image from Wikipedia

GOOGLE THIS IS NOT YELLOW





WHAT IS YELLOW?

REAL WORLD: 570 NM

SCREEN: ADDITIVE (R+G)

PRINT: SUBTRACTIVE





Tritanope

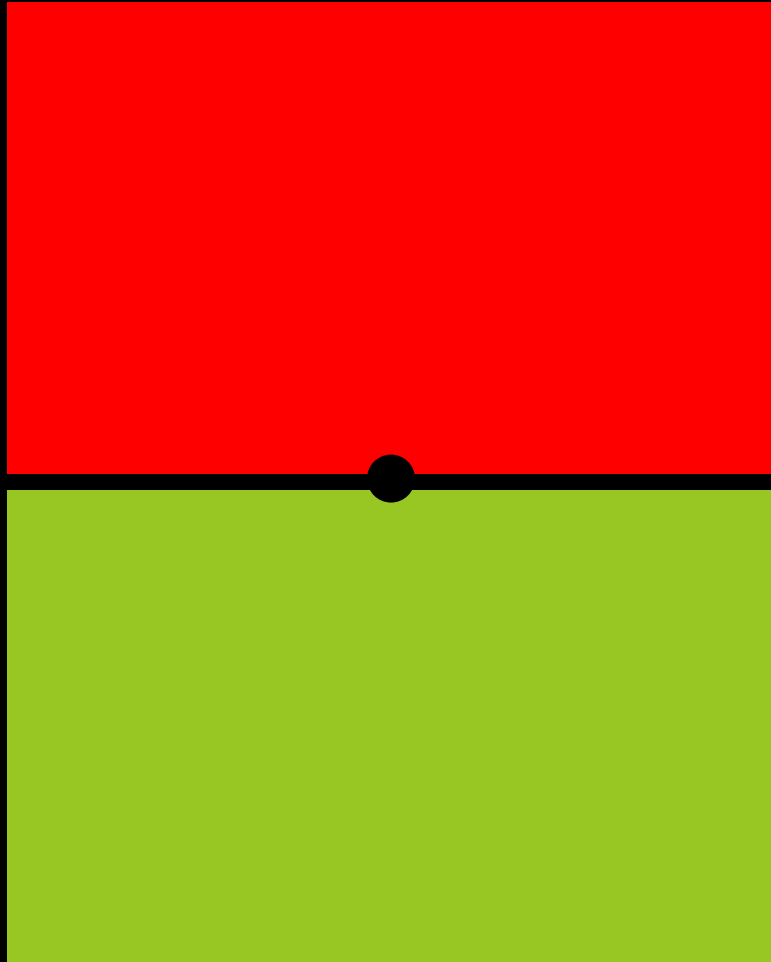


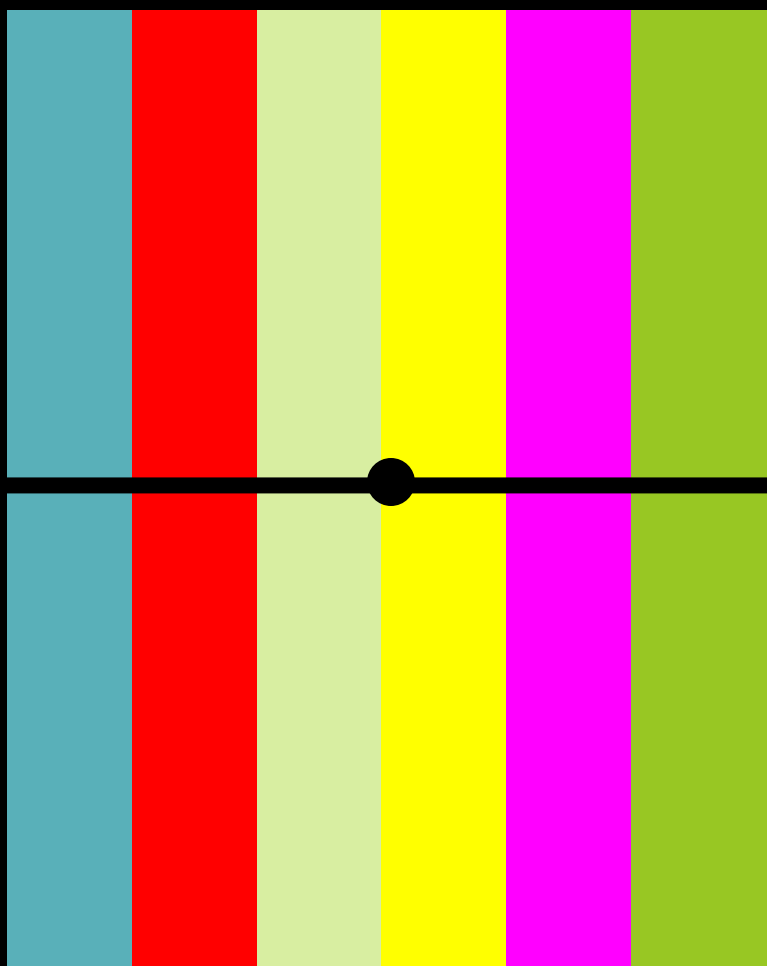
Normal



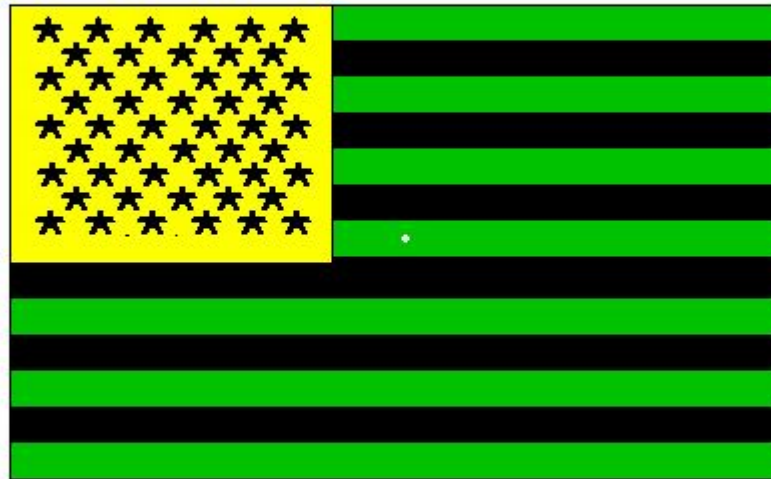
Deuteranope

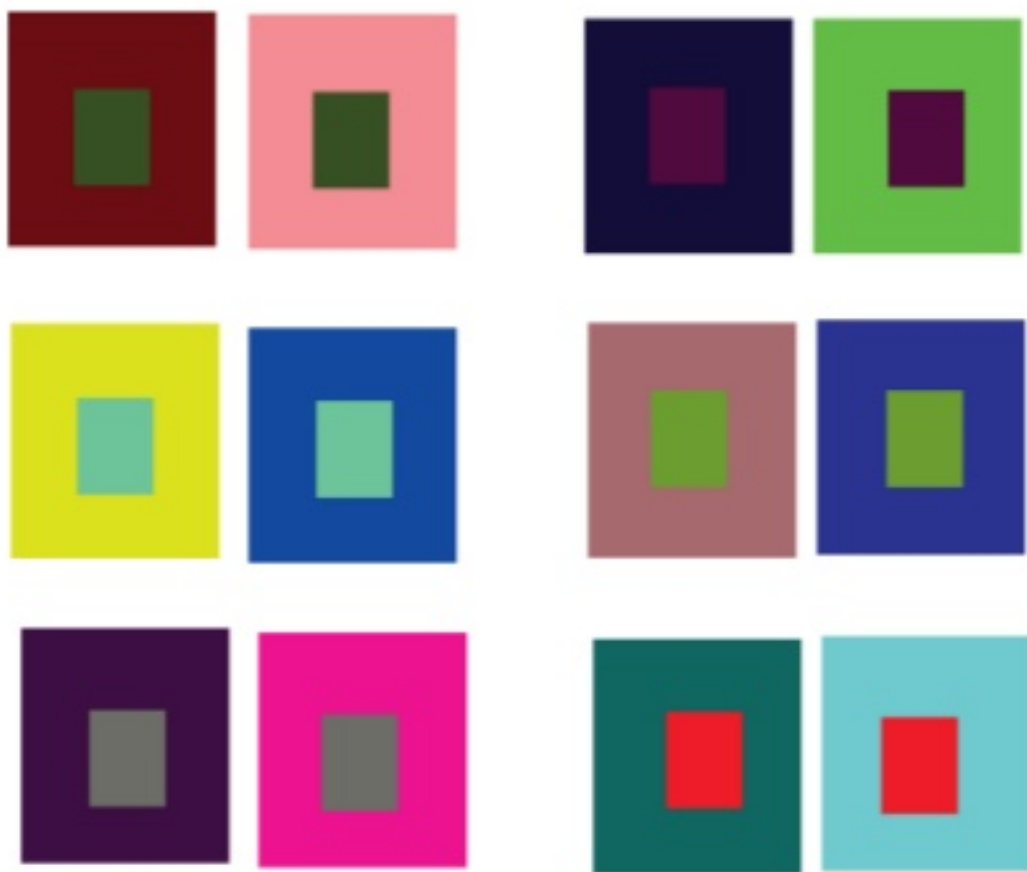
SOME COLOR ODDITIES

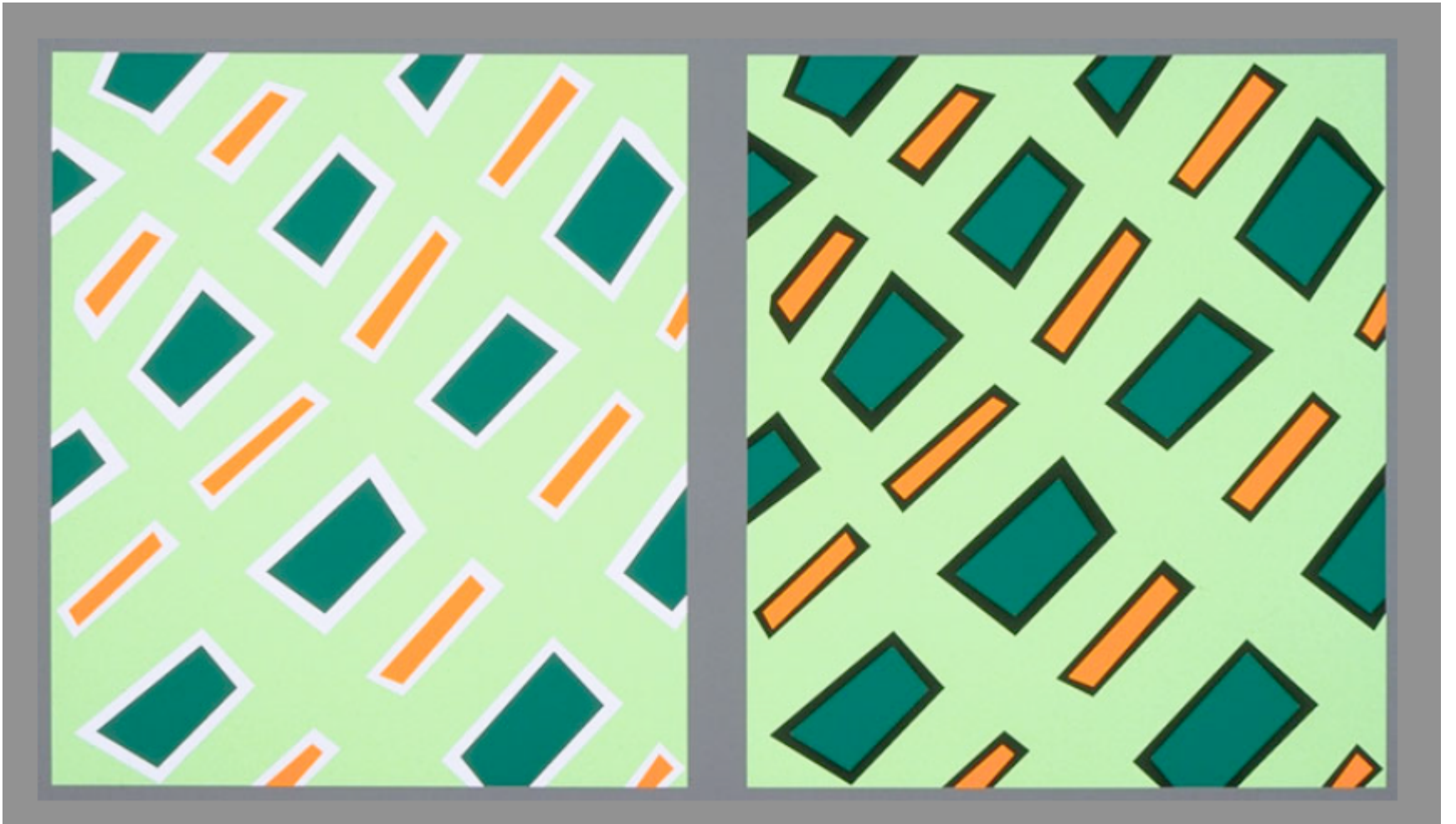












COLOR EMOTION GUIDE

<i>blue</i>	<i>red</i>	<i>black</i>	<i>green</i>
TRUST SMART CALM FAITH NATURAL STABLE POWER	LOVE IMMEDIACY ENERGY SALE PASSION ANGER HUNGER	BOLD RICH POWER MYSTERY ELEGANCE EVIL STRENGTH	SOOTHING ECO-FREINDLY NATURAL ENVY JEALOUSY BALANCE RESTFUL
<i>yellow</i>	<i>orange</i>	<i>pink</i>	<i>purple</i>
CHEER ATTENTION CHILDISH FRESH WARMTH ENERGY OPTIMISM	HEALTH ATTRACTION STAND OUT THIRST WEALTH YOUTHFUL HAPPINESS	TENDERNESS SENSITIVE CARING EMOTIONAL SYMPATHETIC LOVE SEXUALITY	ROYAL MYSTERIOUS ARROGANT LUXURY CHILDISH CREATIVE SADNESS

The collage features the following text and icons:

- OPTIMISM** (yellow)
- CLARITY** (yellow)
- WARMTH** (yellow)
- FRIENDLY** (orange)
- CHEERFUL** (orange)
- CONFIDENCE** (orange)
- EXCITEMENT** (red)
- YOUTHFUL** (red)
- BOLD** (red)
- CREATIVE** (purple)
- IMAGINATIVE** (purple)
- WISE** (purple)
- TRUST** (blue)
- DEPENDABLE** (blue)
- STRENGTH** (blue)
- PEACEFUL** (green)
- GROWTH** (green)
- HEALTH** (green)
- BALANCE** (grey)
- NEUTRAL** (grey)
- CALM** (grey)

Logos and icons include: Nikon, UPS, Google, NBC, Amazon, Sprint, IMDB, eBay, Microsoft, Subway, Shell, Best Buy, DHL, Target, Ace Hardware, Stutz, Harley-Davidson, Hertz, McDonald's, Avis, Gulf, TACO BELL, VIMEO, Oral-B, BP, Walmart, Canon, Acer, HP, Dell, JPMorgan, Lowe's, Barbie, Lynx, Oreo, Welch's, Facebook, IBM, Nike, Puma, Tropicana, Avianca, Whole Foods, A Planet, Spotify, and various symbols like a megaphone, yin-yang, peace sign, fist, lightbulb, lightning bolt, smiley face, and thumbs up.

RULE OF THUMB

**COLOR: FORM & FUNCTION
QUALITATIVE**

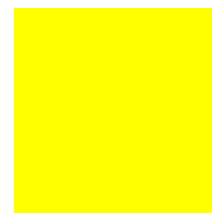
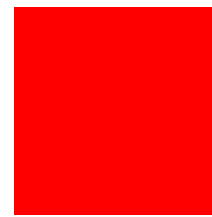
**LUMINESCENCE: DEPTH
SLIGHTLY QUANTITATIVE**

USING COLOR

NOMINAL



ORDINAL



ORDINAL / SEQUENTIAL



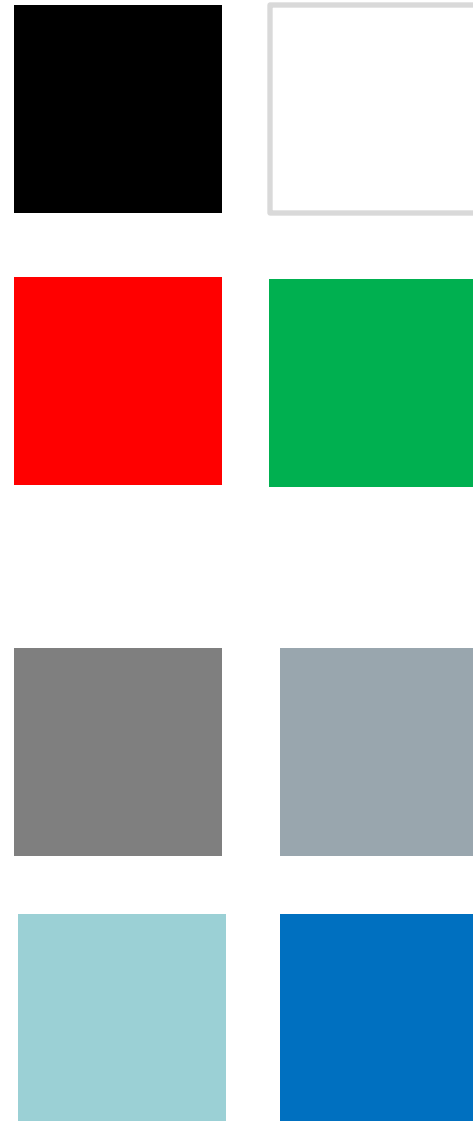
DIVERGENT

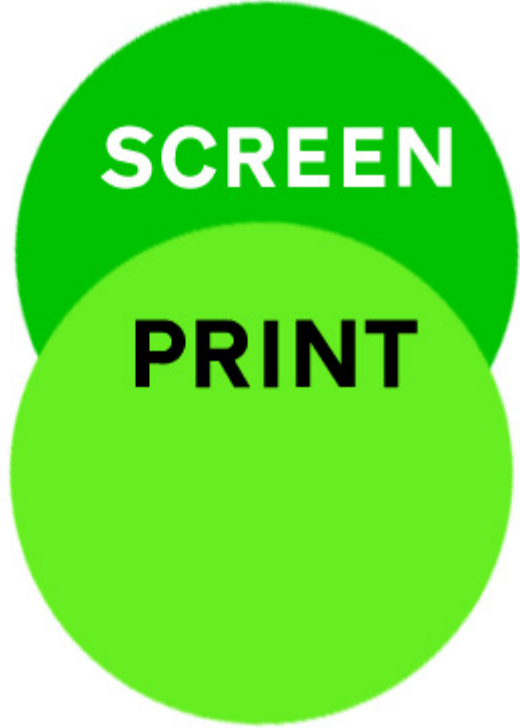
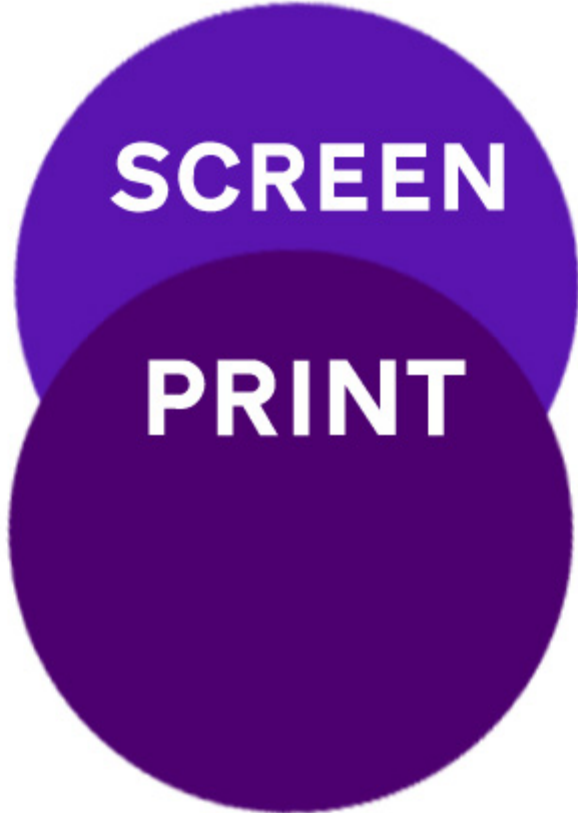
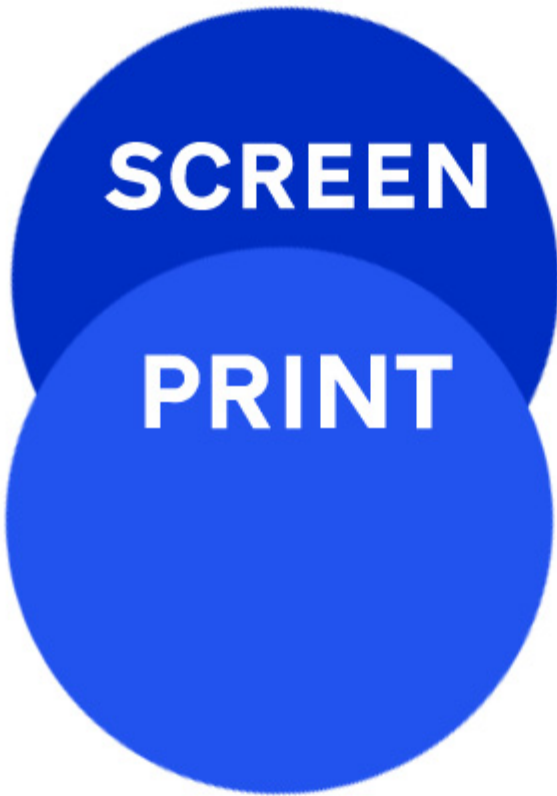


SEQUENTIAL



SEPARABLE INTEGRAL





DON'T DO THIS!

- Avoid loud, garish colors...dark text on light background or vice versa is best.
- Avoid text colors that fade into background, i.e. blue and black
- Avoid color-blind combinations:
 - Red and green
 - Blue and yellow

CHECK LUMINANCE & COLOR IN GRAYSCALE

“Get It Right in Black and White”

M. Stone



Hanspeter Pfister, quoting Stone

Number of data classes: 3



[how to use](#) | [updates](#) | [downloads](#) | [credits](#)

COLORBREWER 2.0

color advice for cartography

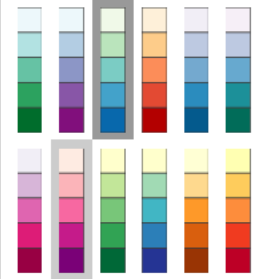
Nature of your data:



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

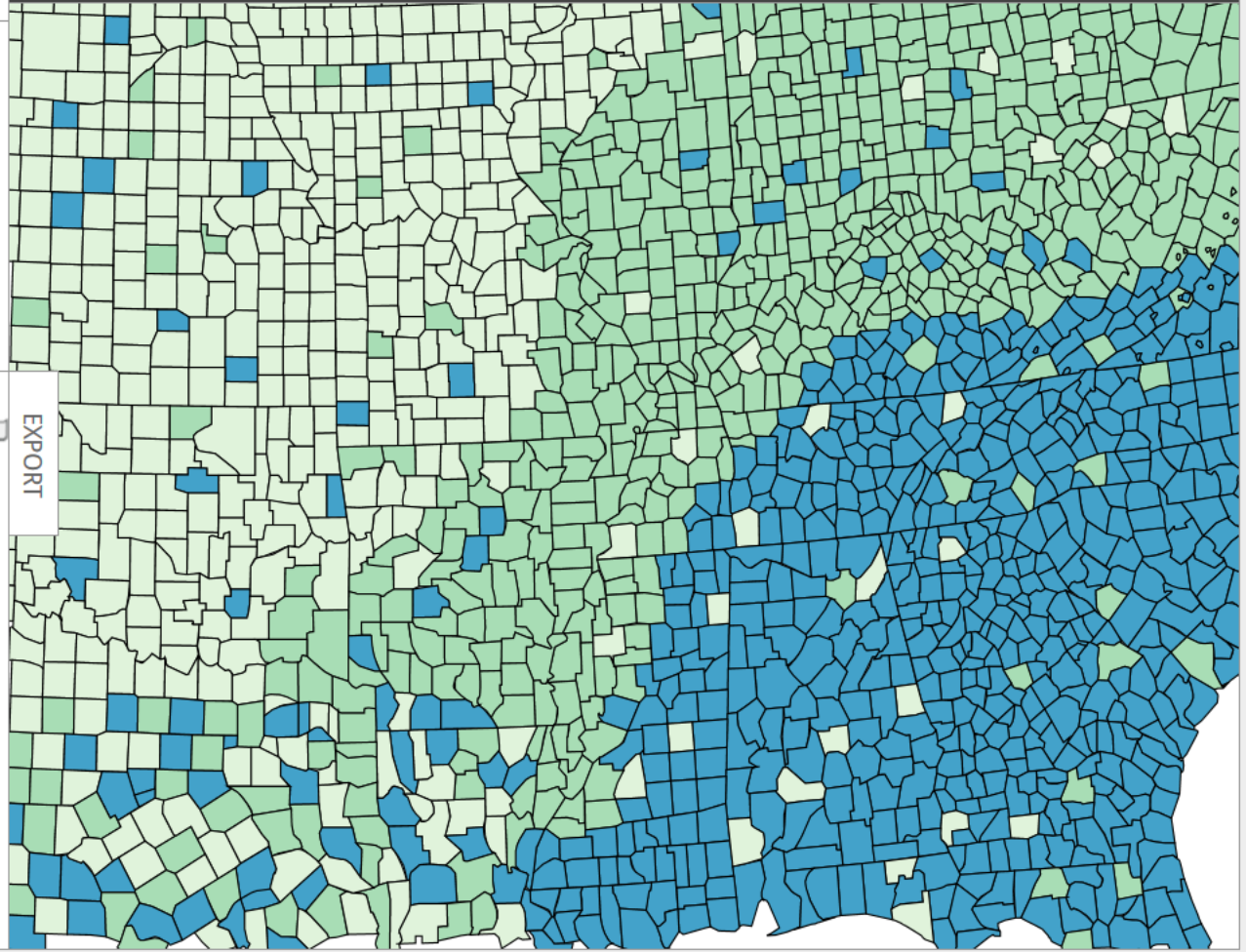
color transparency

3-class GnBu



HEX

- #e0f3db
- #a8ddb5
- #43a2ca



Adobe Color CC Create Explore My Themes SIGN IN Adobe

Save My Color Theme

Color Rule

Analogous

▶ RGB	255	83	13
HEX	FF530D		

RGB	232	44	12
HEX	E82C0C		

RGB	255	0	0
HEX	FF0000		

RGB	232	12	122
HEX	E80C7A		

RGB	255	13	255
HEX	FF0DFF		

View

- All Themes
- Most Popular Week Month All
- Most Used
- Random



sandy stone beach o... 9K+ 9K+ 326



Firenze 9K+ 7K+ 185



Neutral Blue 9K+ 6K+ 50



Cherry Cheesecake 9K+ 4K+ 105



1944mustang 8K+ 3K+ 44



Honey Pot 6K+ 3K+ 40



Watermelon 9K+ 3K+ 151



Sea Wolf 5K+ 3K+ 38



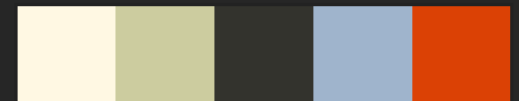
Phaedra 4K+ 3K+ 14



Aspirin C 6K+ 3K+ 27



Vitamin C 5K+ 3K+ 37



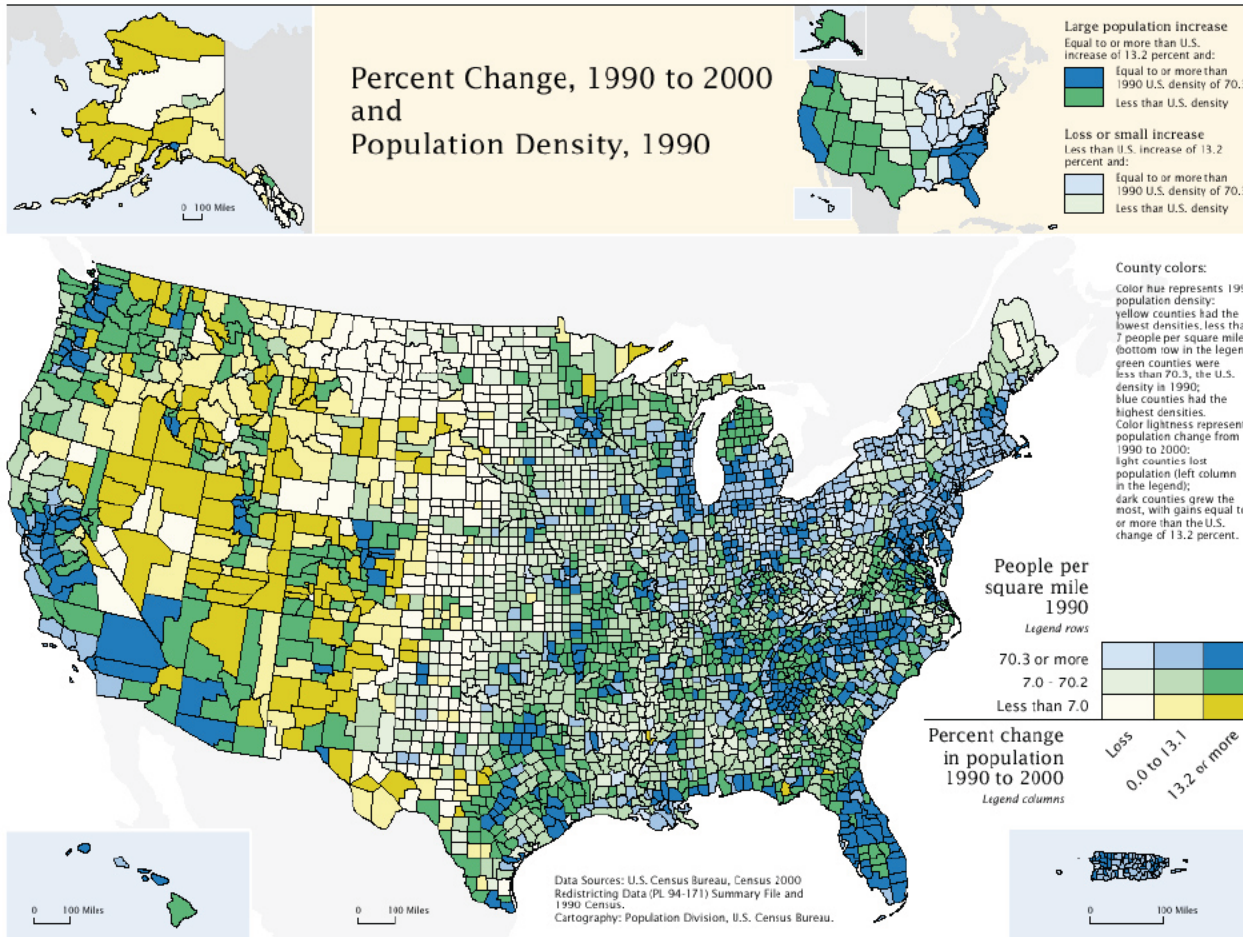
Orange on gray 8K+ 3K+ 46

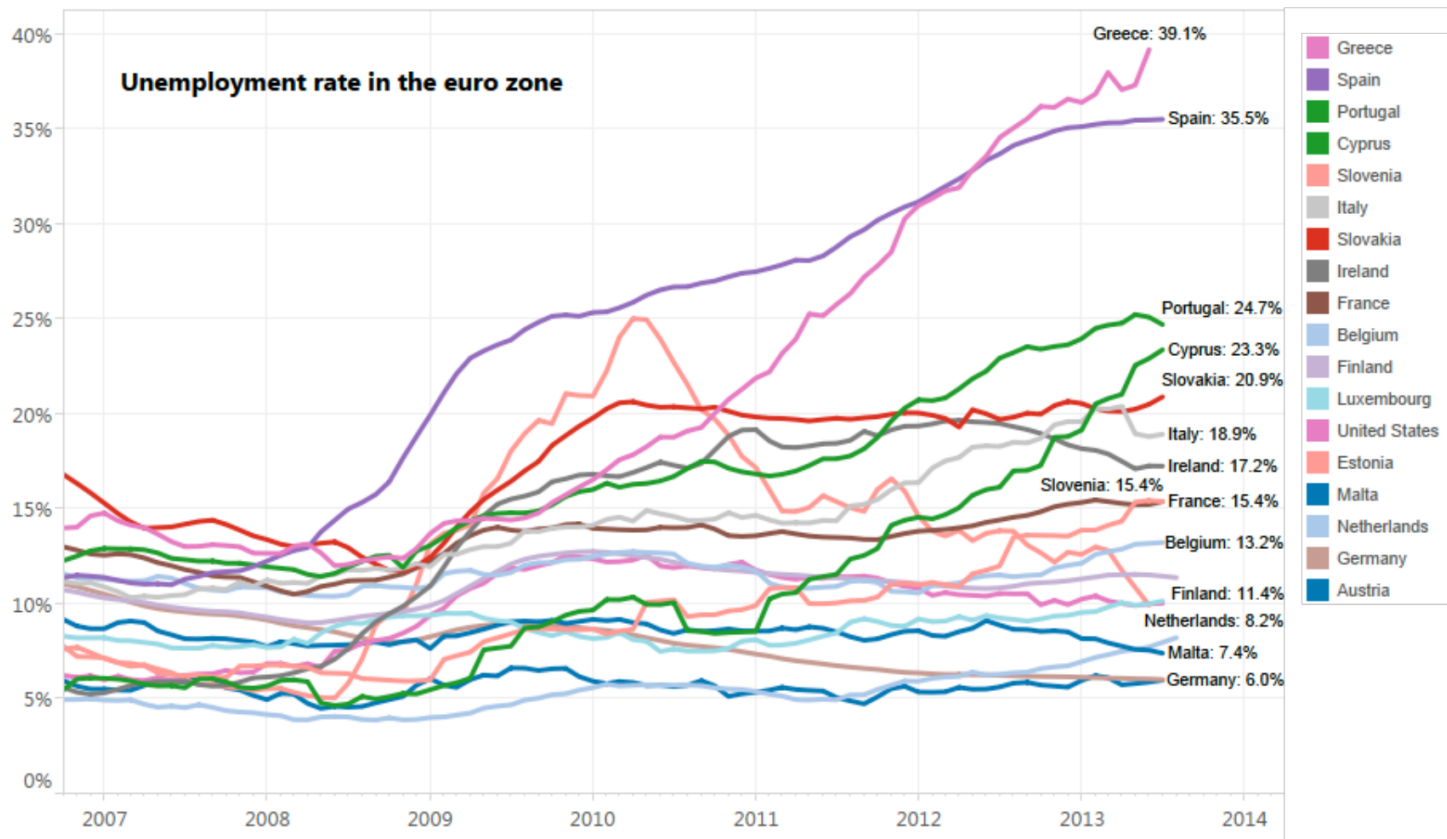
[HTTP://WWW.COLOR-BLINDNESS.COM](http://www.color-blindness.com)

[HTTP://WWW.VISCHECK.COM/](http://www.vischeck.com/)

[HTTP://COLOR.ADOBE.COM](http://color.adobe.com)

COLOR ABUSE



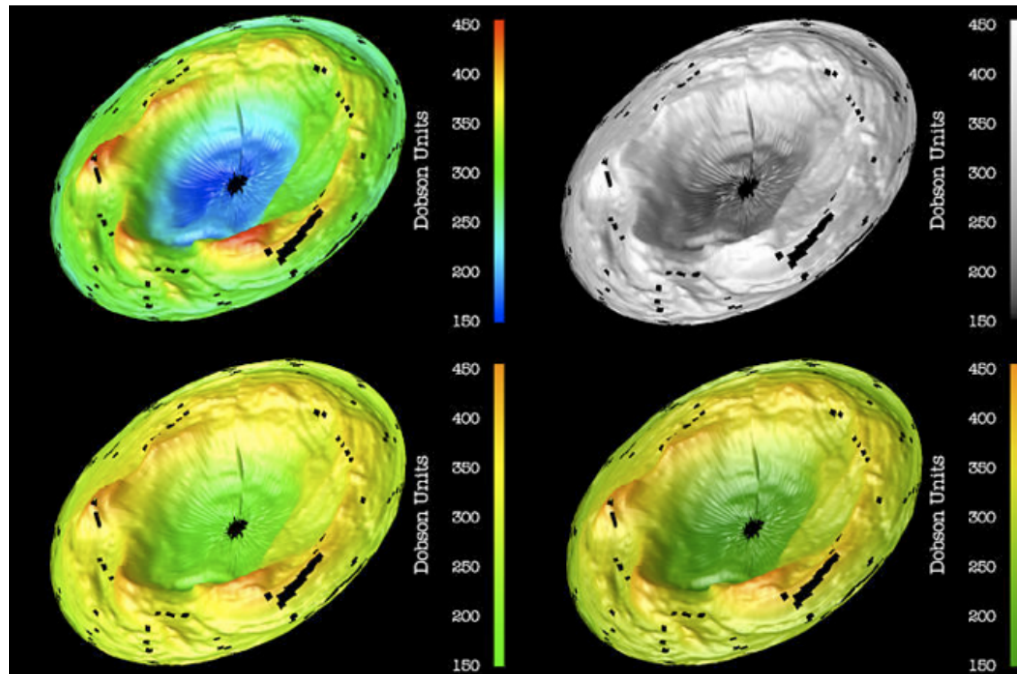


Jim Wahl, 2014

**COLOR USE:
QUASI QUANT**

**HUE:
SKITTLES**

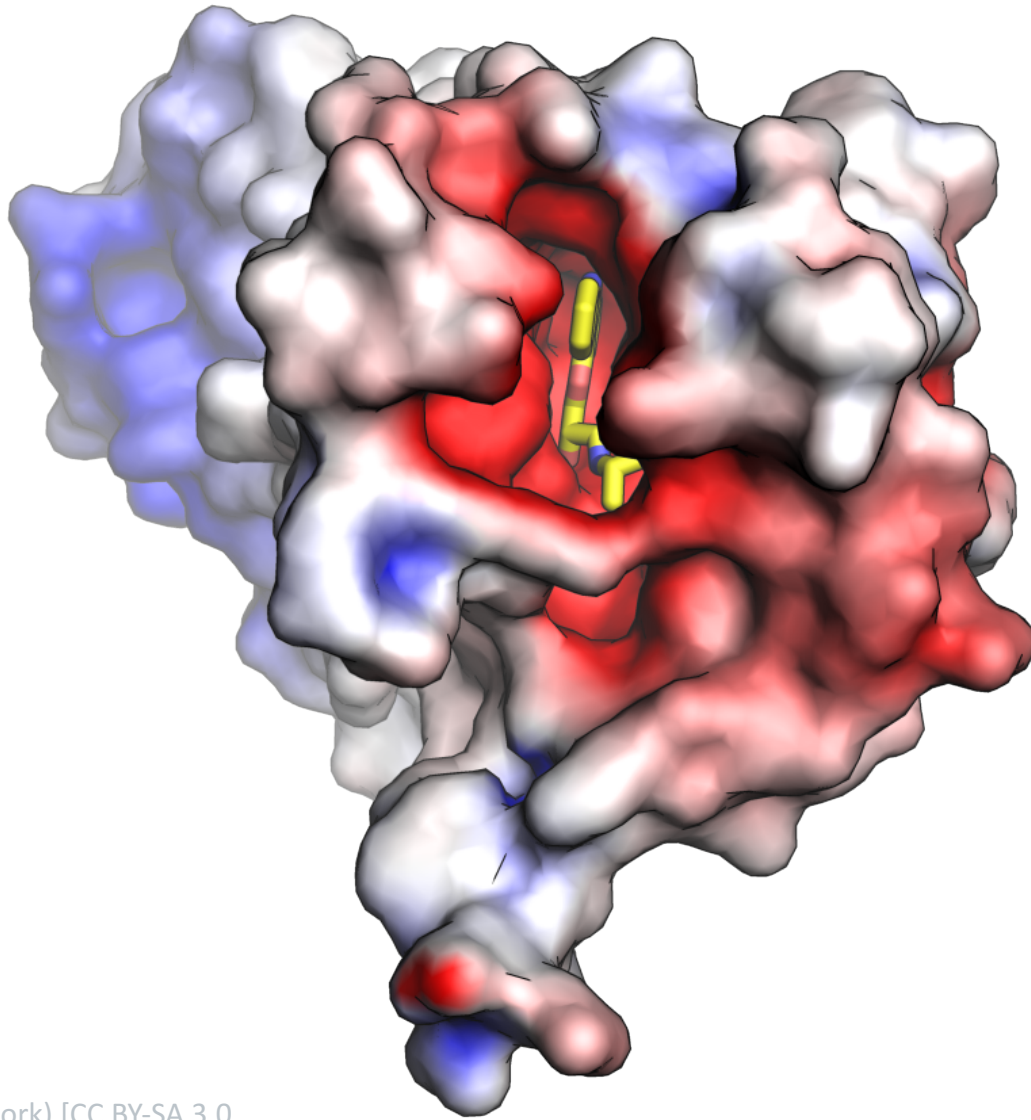
**HUE:
BIVARIANT**



LUMINESCENCE

**HUE +
LUMINESCENCE**

COLOR USE: FIELD NORMS



By Opabinia regalis (Own work) [CC BY-SA 3.0
(<http://creativecommons.org/licenses/by-sa/3.0>)
or GFDL (<http://www.gnu.org/copyleft/fdl.html>)],
via Wikimedia Commons

What's your field norm?

What's your field norm?

**“AVOIDING CATASTROPHE
BECOMES THE FIRST
PRINCIPLE IN BRINGING
COLOR TO INFORMATION:
ABOVE ALL, DO NO HARM.”**

Tufte, Envisioning Information