Color and Images

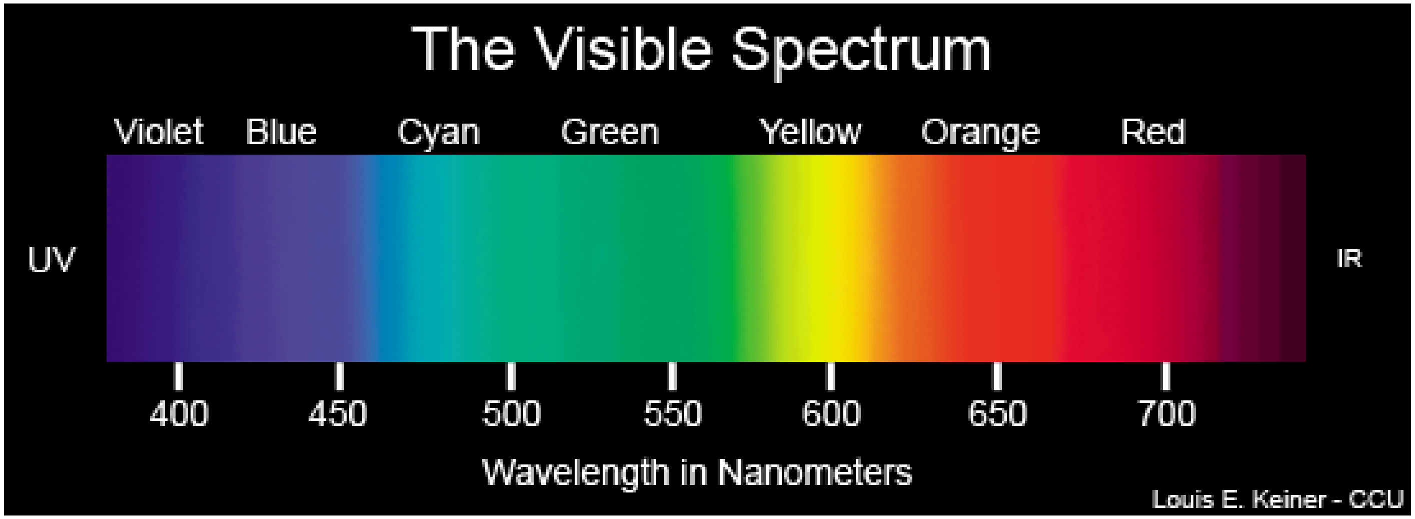
Lecture 20

Colors in CSS

- Use: fonts, borders, backgrounds
- Provides semantic signal:
  - **Green** – go, success, complete, solution
  - **Red** – stop, failure, incomplete, problem
  - **Yellow** – yield, warning, attention
- Helps to set mood/emotion/tone:
  - **Bright** – cheerful, playful, positive
  - **Dark** – somber, serious, negative
  - **Warm** – energetic, alert, active
  - **Cool** – calm, tranquil, peaceful

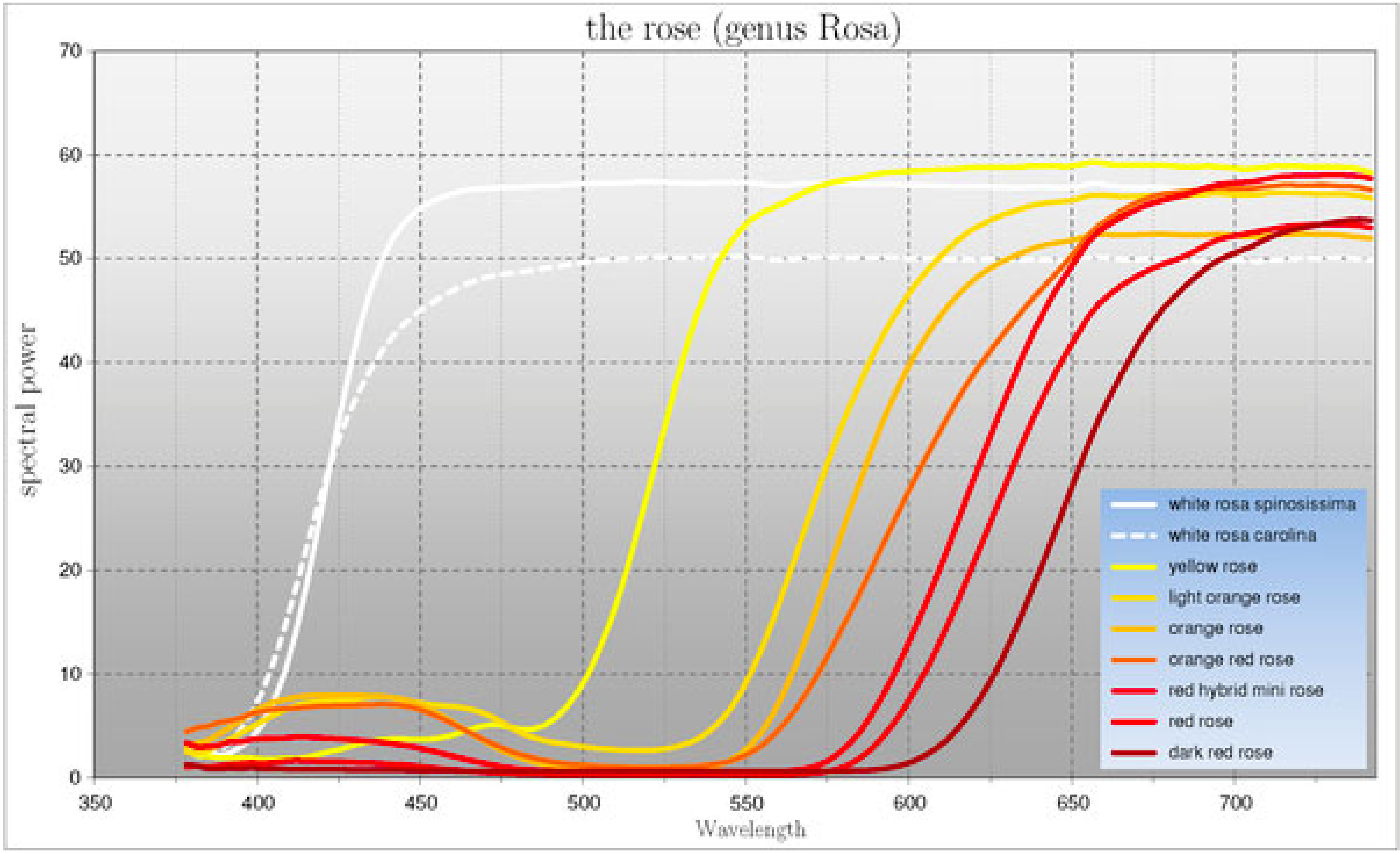
Elementary Color Theory

- Combination of
  - Physics: wavelengths in nm
  - Biology: perception of “red” vs “yellow” vs…
- Visible spectrum: 390-700nm
  - Spectral colors: rainbow, single wavelength
  - Nonspectral colors (pink, brown, white…) result from presence of *multiple* wavelengths



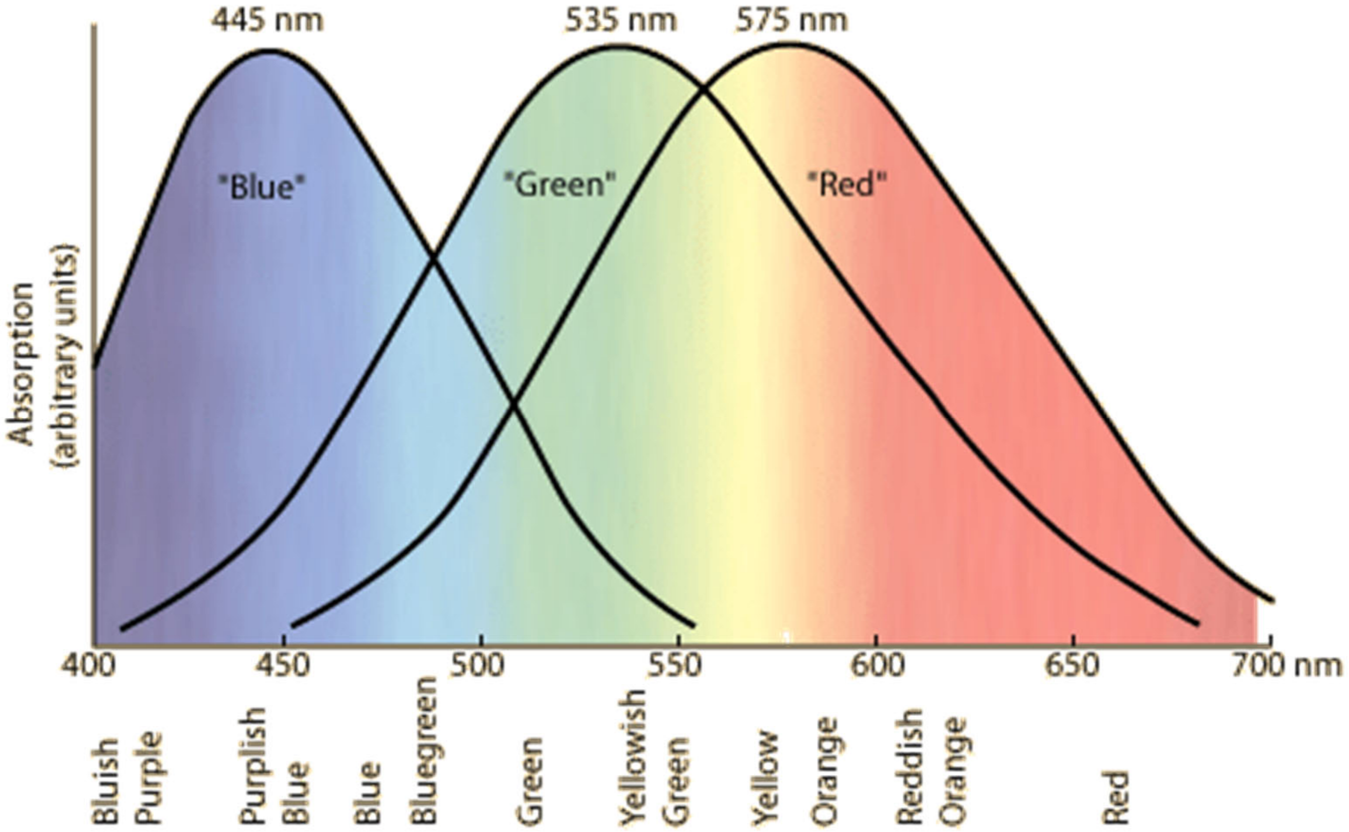
Louis E. Keiner - CCU

Power Spectrum = Color



Color Perception

- Human eyes have 3 types of cones
  - Respond to different wavelengths (LMS)
- Perceived color = eye's cone response

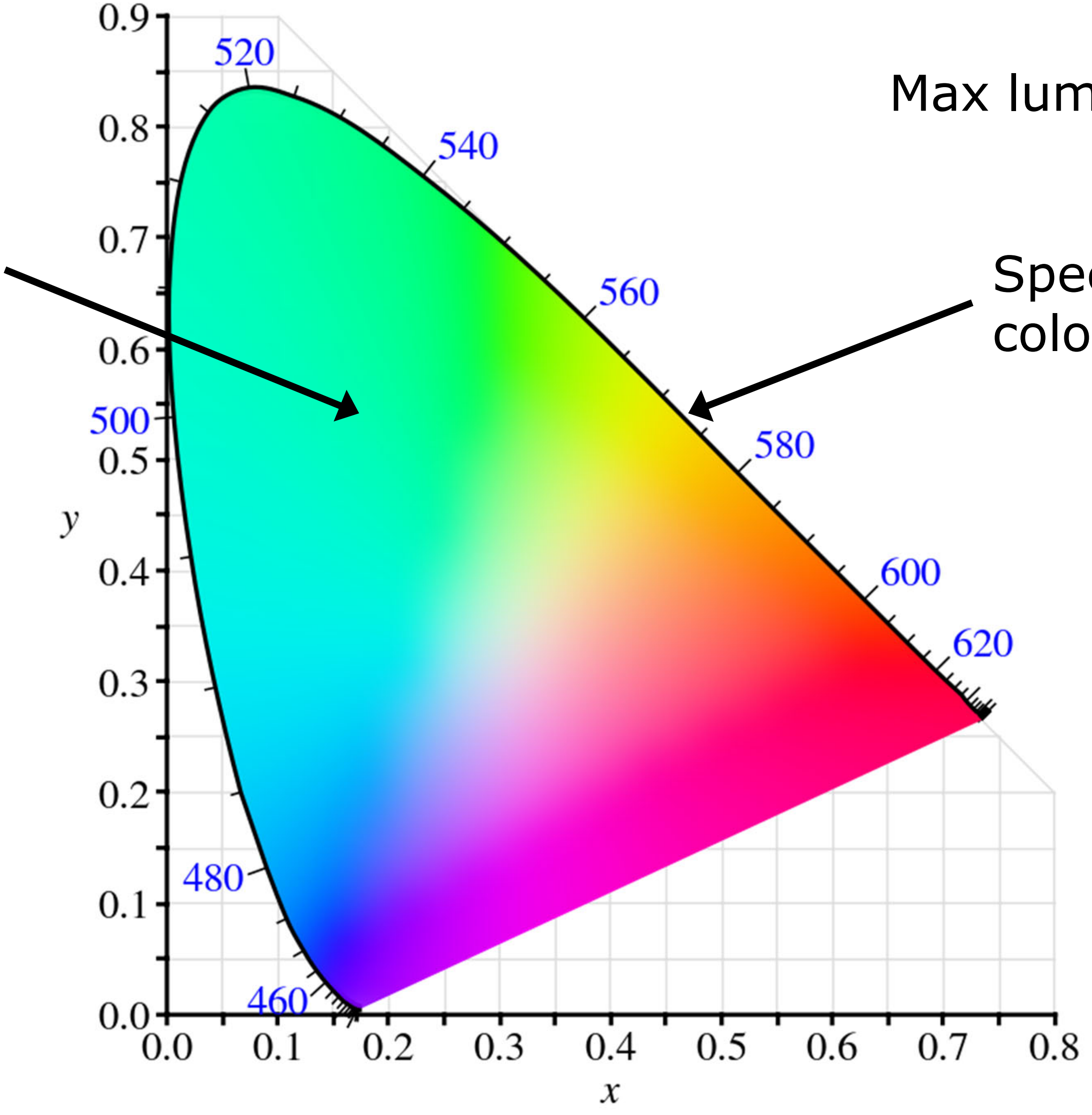


Metamerism

- Different (continuous) spectra that stimulate our eyes in identical ways
  - Consequence: Different spectra with indistinguishable (to humans) color
- Example: white
  - Spectrum 1: all wavelengths equally present
  - Spectrum 2: a few wavelengths present, stimulating LMS cones equally
- Consequence: Any continuous spectrum can be projected down to 3 components (as far as human eyes are concerned)
  - XYZ “tristimulus values”
  - Not truly independent (overlap of response), so any 2 give the 3rd; ie a 2D space (xy)…

CIE 1931 xy Chromaticity

Max luminance (100%)



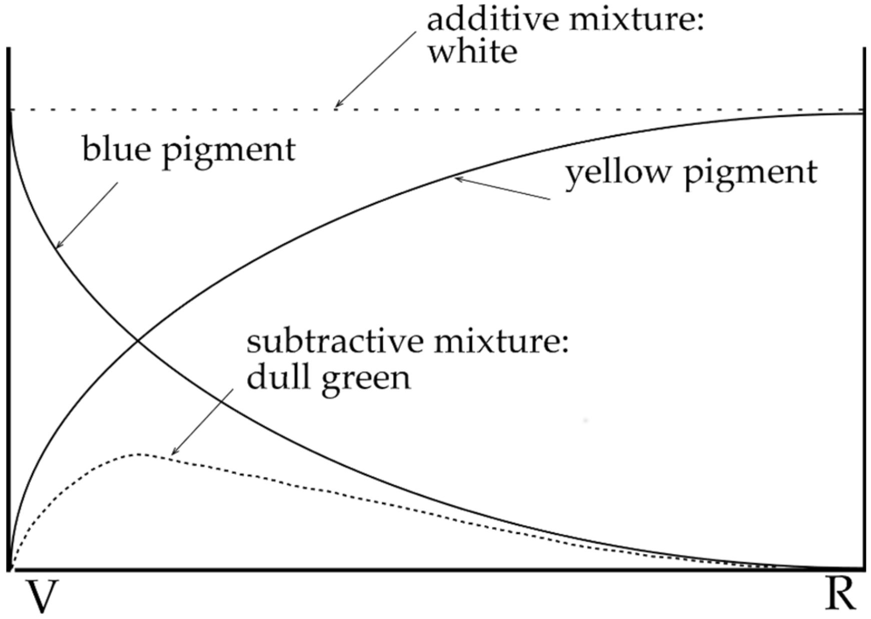
Perceivable colors

Spectral (pure) colors

Color Mixing

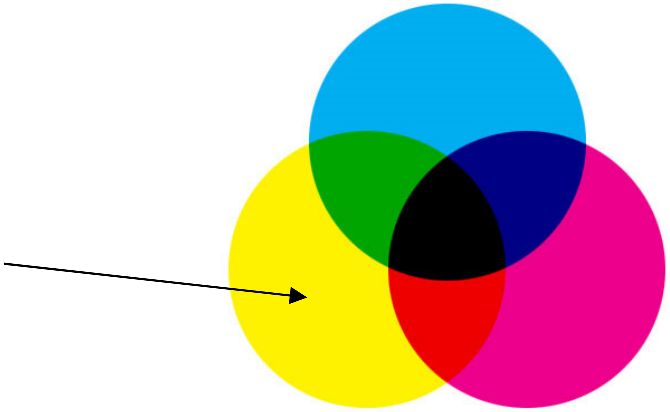
□ There are two ways to combine colors

1. Subtractive: Color is a *filter*
   - Mixing = filter out both
   - Used for printing (& dyes, paints, gels)
2. Additive: Color is a *light source*
   - Mixing = sum
   - Used for monitors



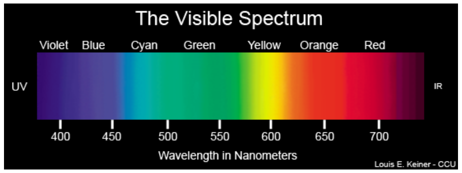
Subtractive Color Mixing: CMYK

- Filters transmit different *spectra*
  - Mixture transmits the *product* of both
  - Mix all three primaries = black
- Primary colors: cyan, magenta, yellow
  - Black (K) added for quality and cost
  - Traditional set (RYB) popular for painting

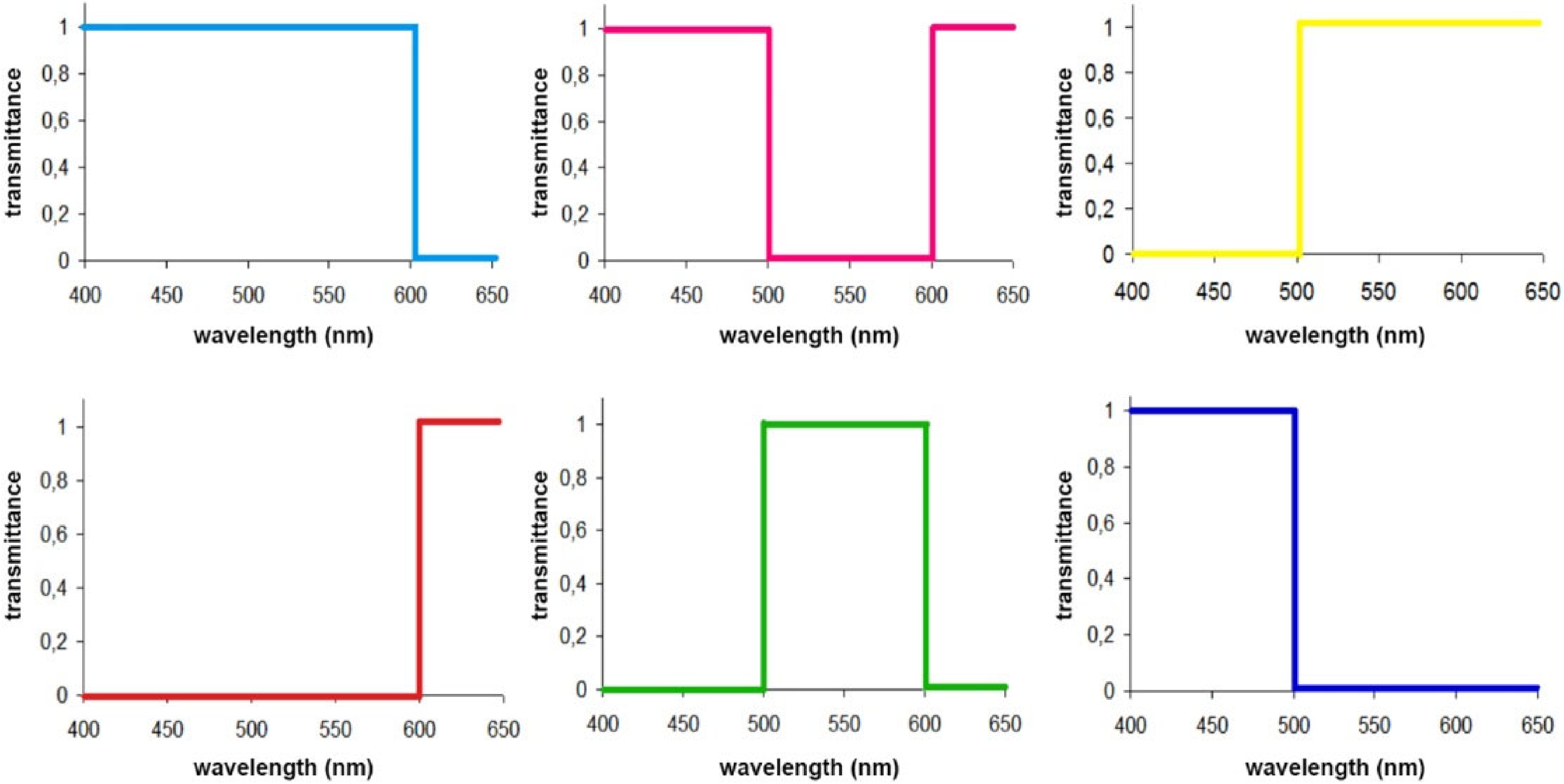


Primary yellow
(transmits R & G)
(absorb B)

Colors as Filters

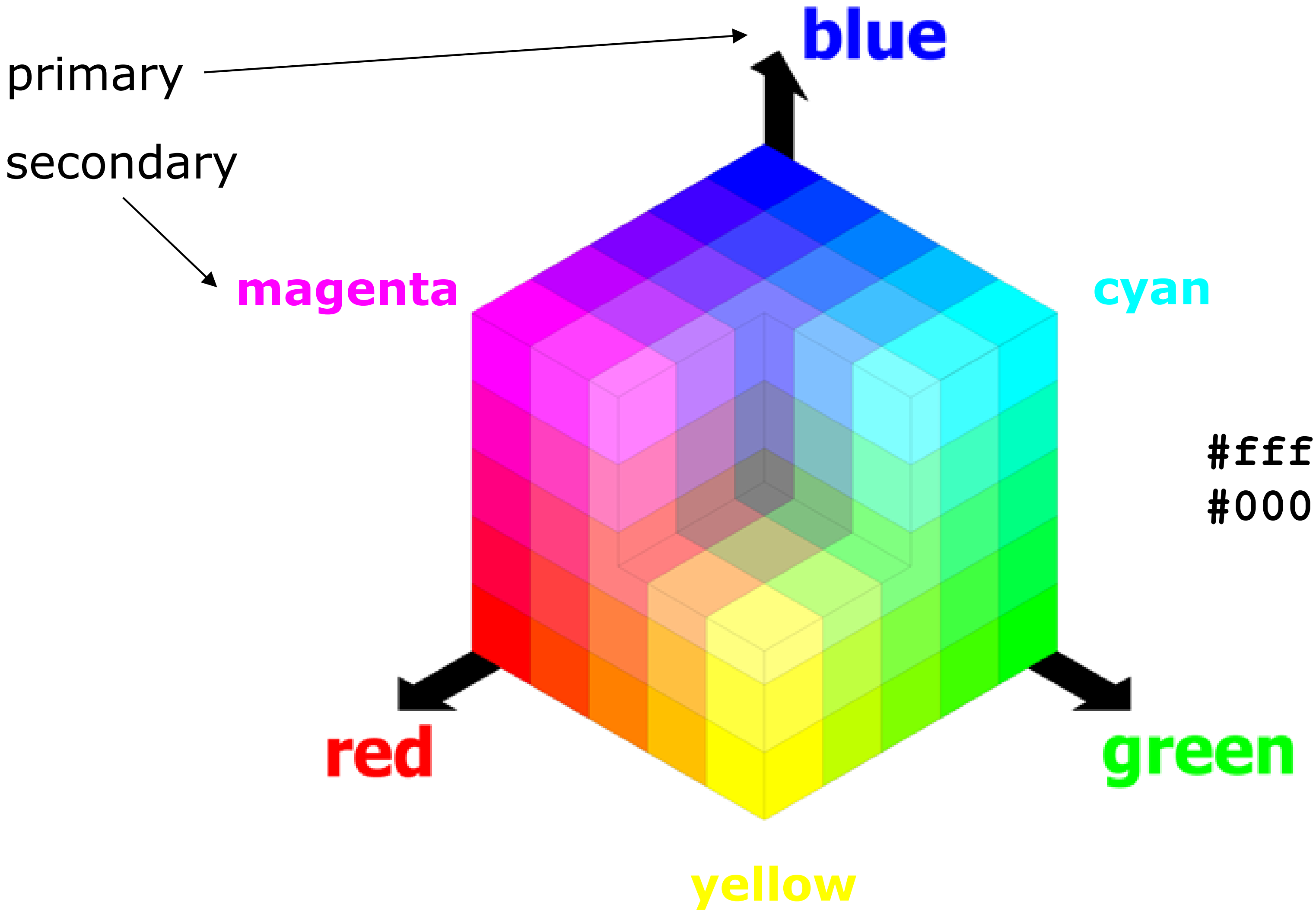


Yellow:
Filters out (only) blue



Rosi et al., Euro. J. of Physics, 37(6), 2016

Additive Color Mixing: RGB Cube



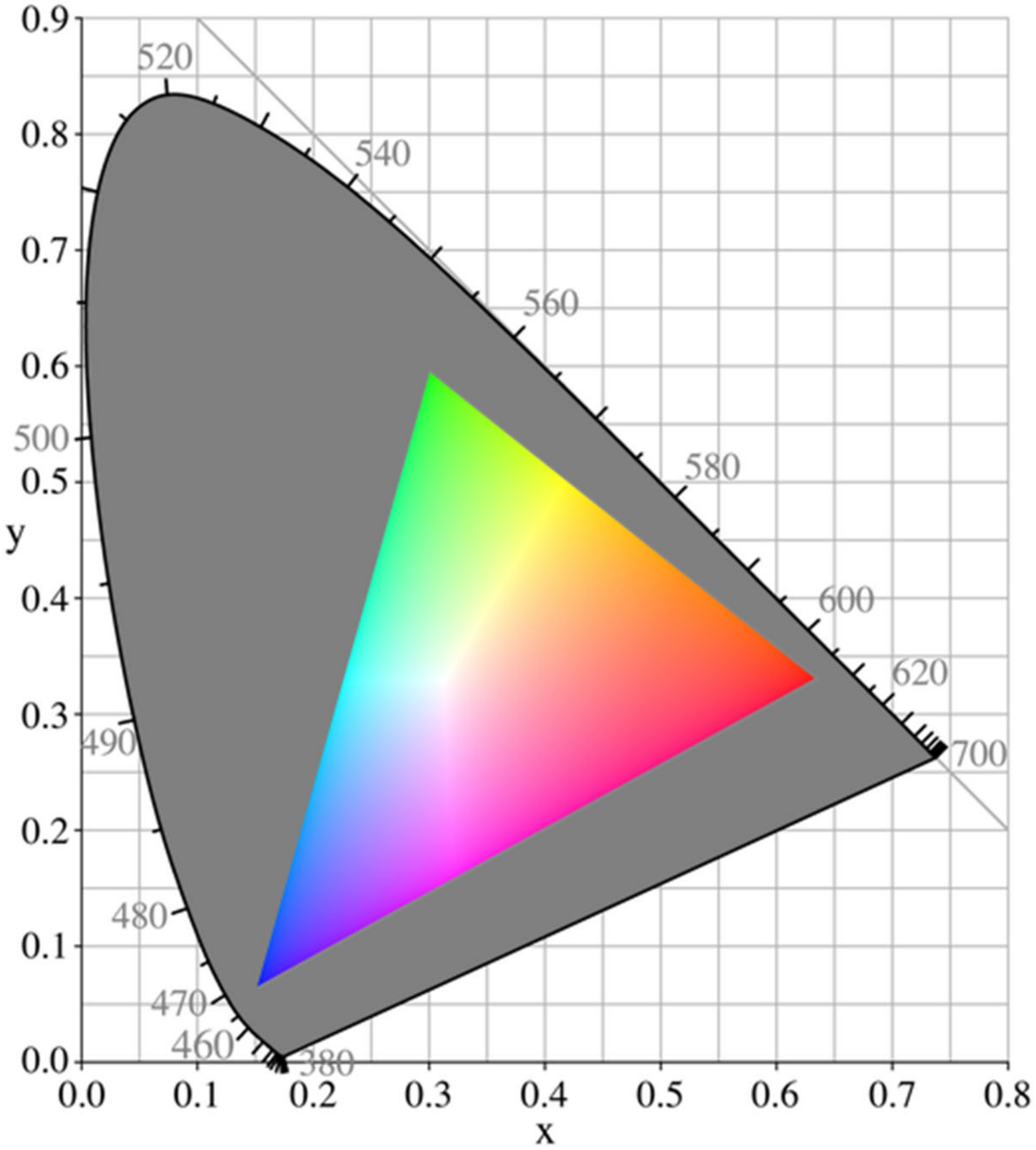
primary

secondary

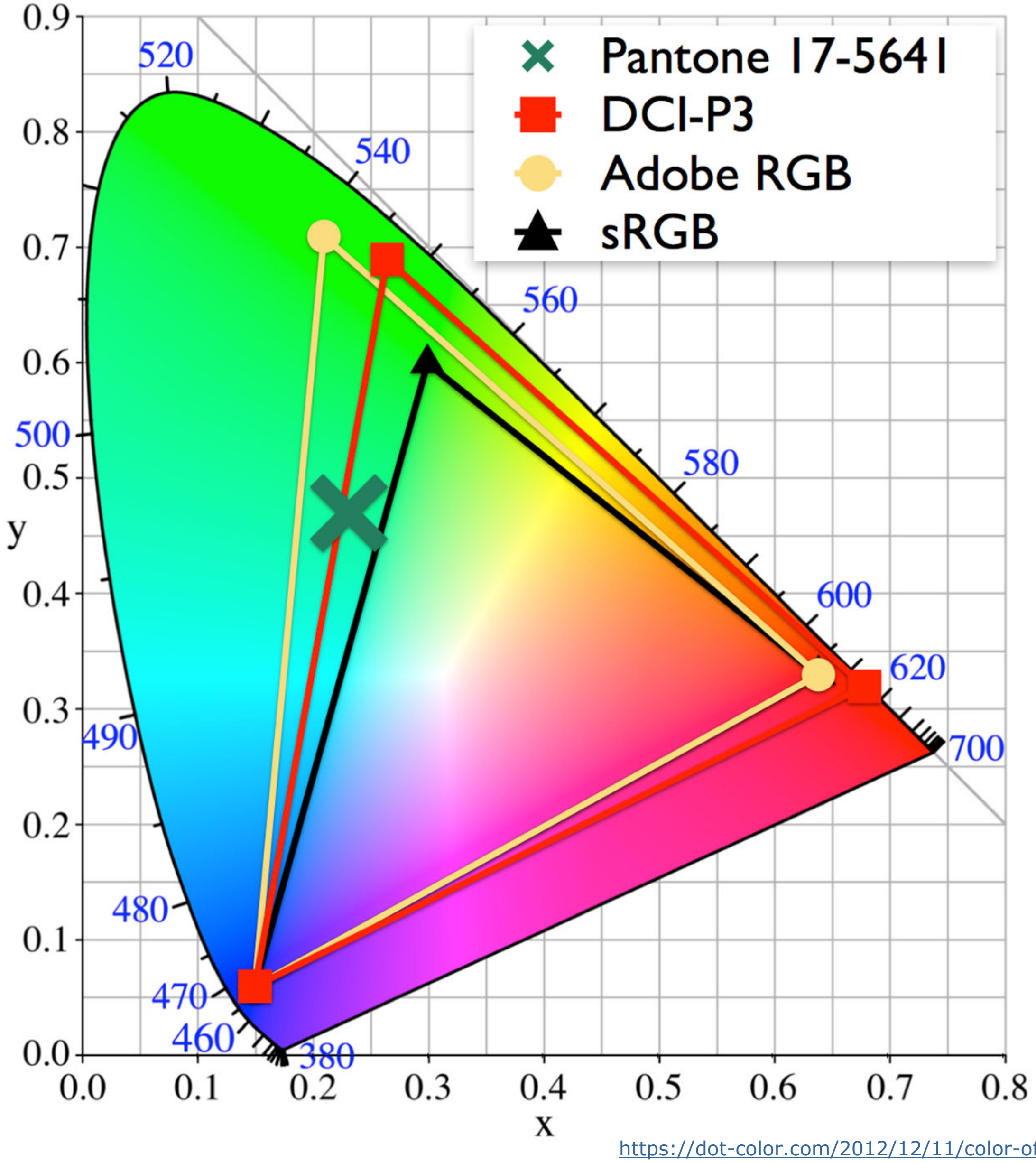
```
#fff /* white */
#000 /* black */
```

http://www.flickr.com/photos/ethanhein/3103830956/

Color Mixing: sRGB Gamut

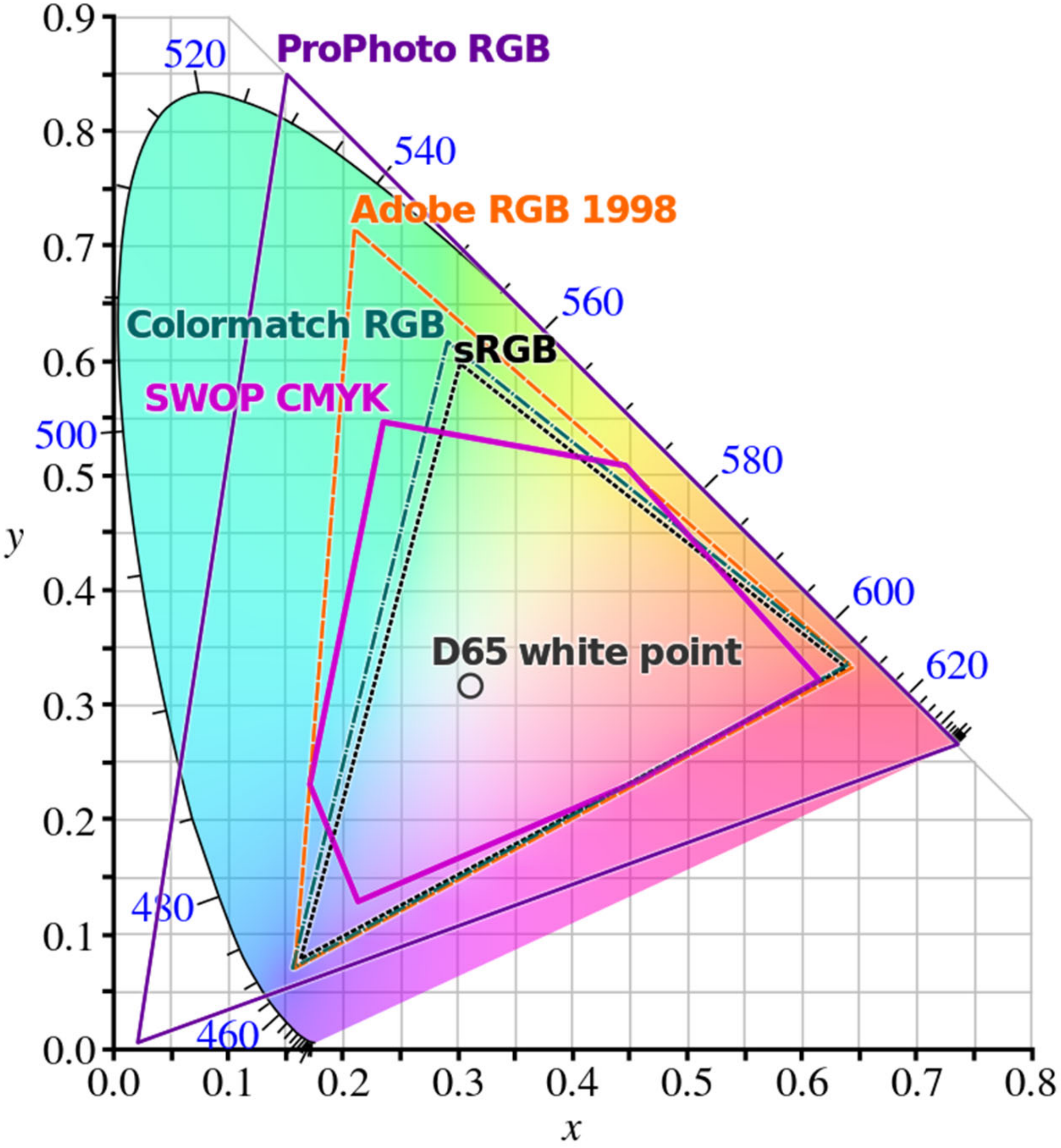


Gamuts for Monitors

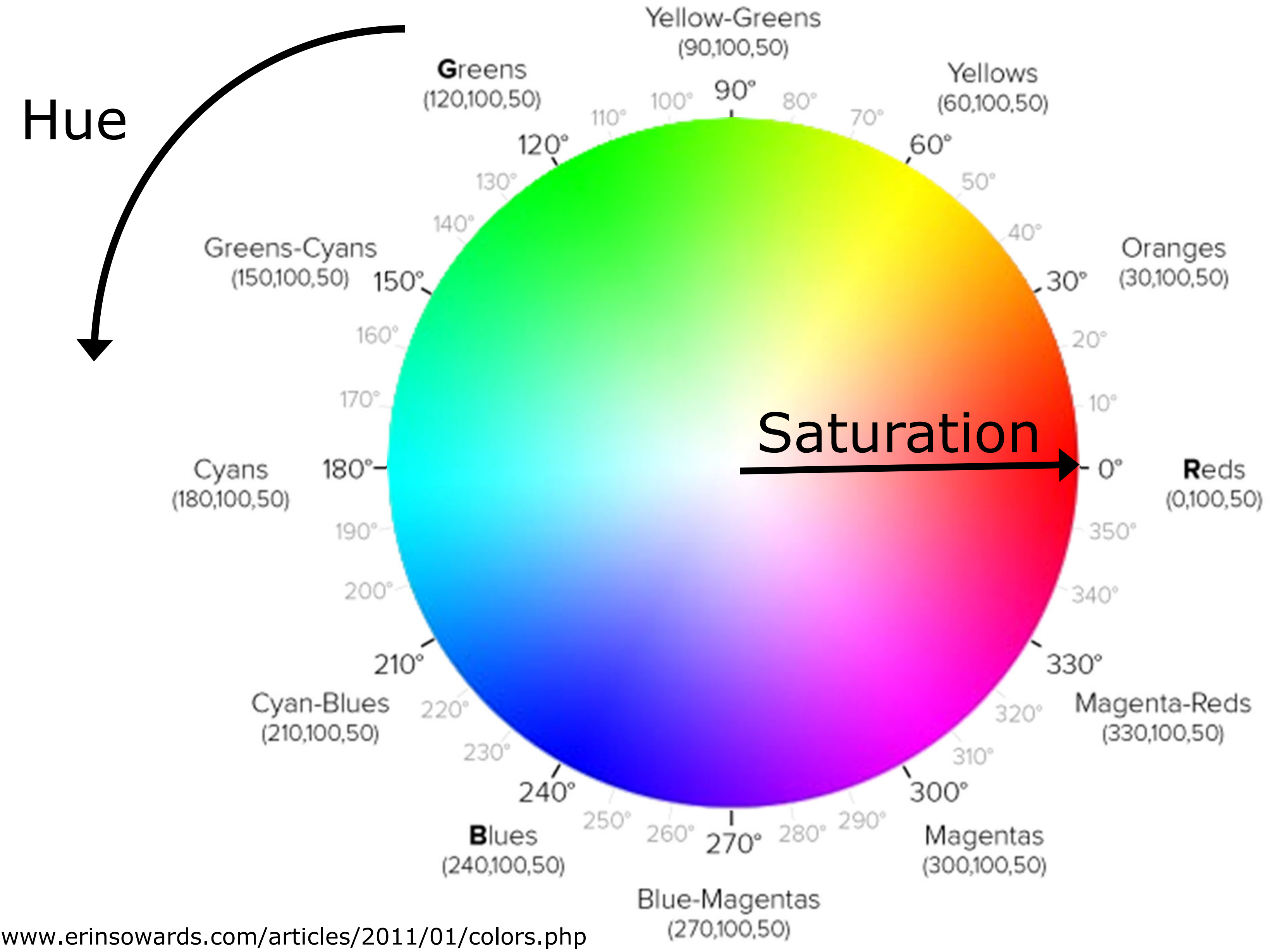


https://dot-color.com/2012/12/11/color-of-the-year-for-2013-falls-outside-srgb-gamut/

And Many More Gamuts…

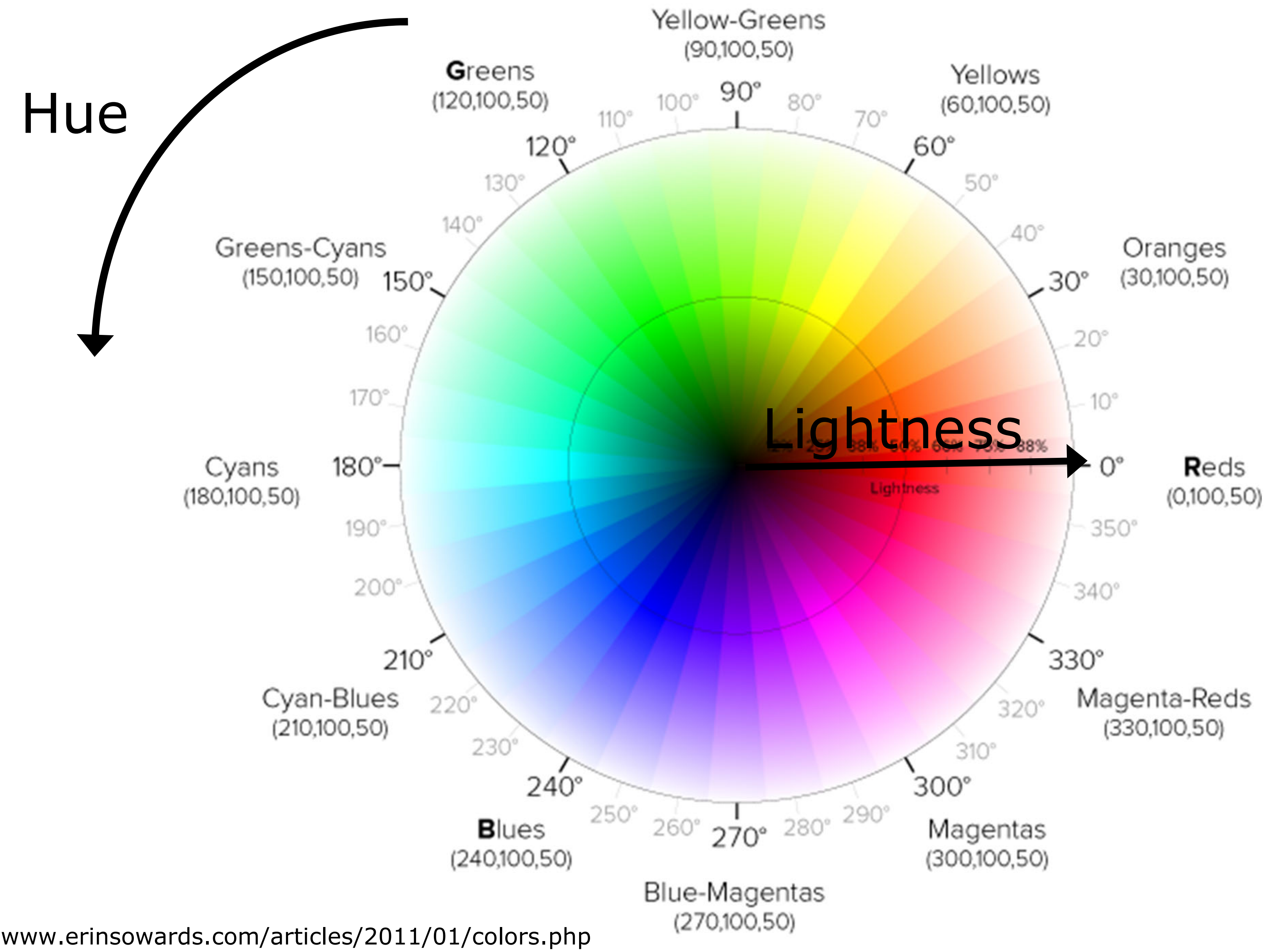


HSL Color Wheel (50% Lightns)



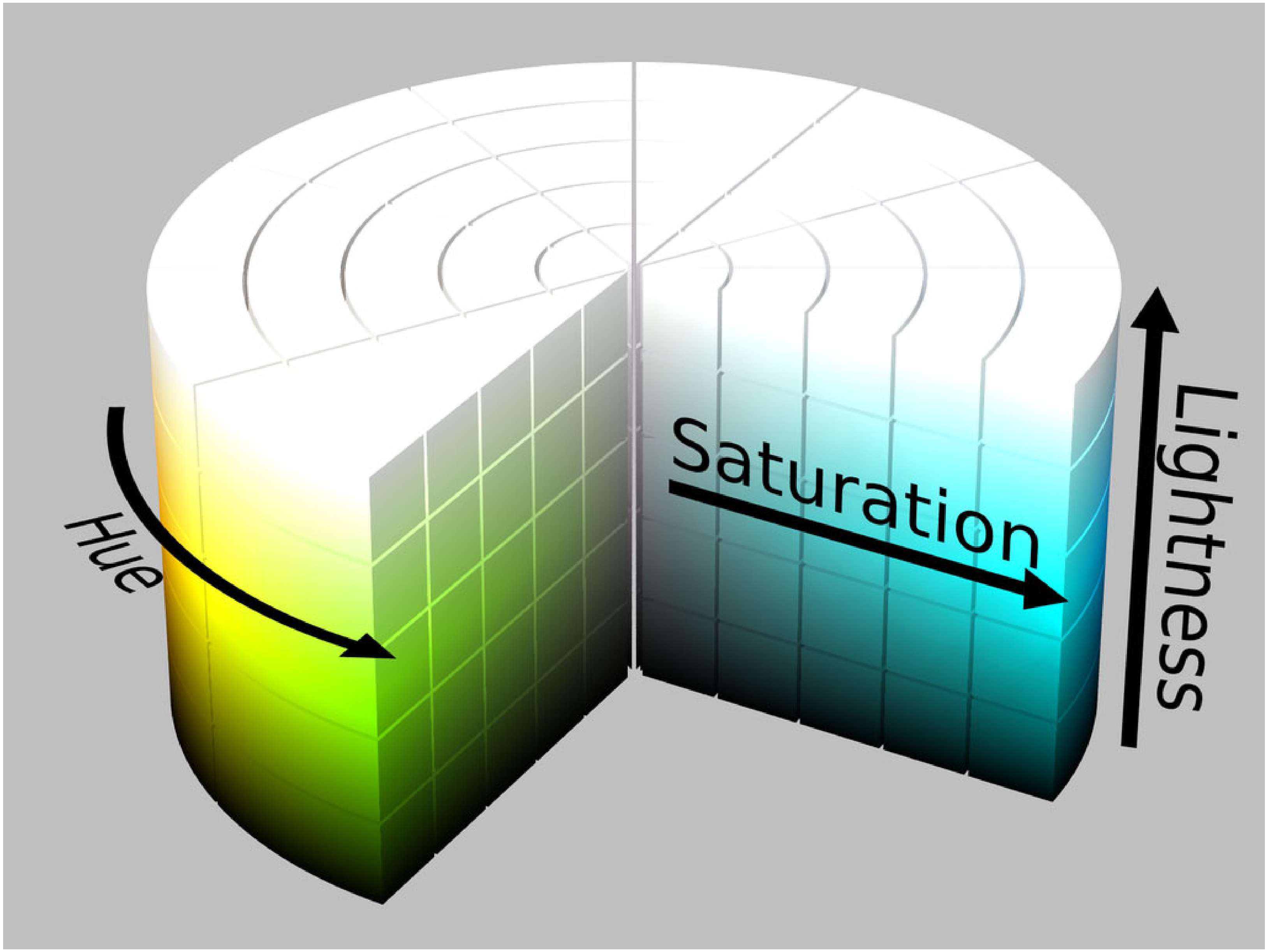
http://www.erinsowards.com/articles/2011/01/colors.php

HSL Color Wheel (100% Sat)

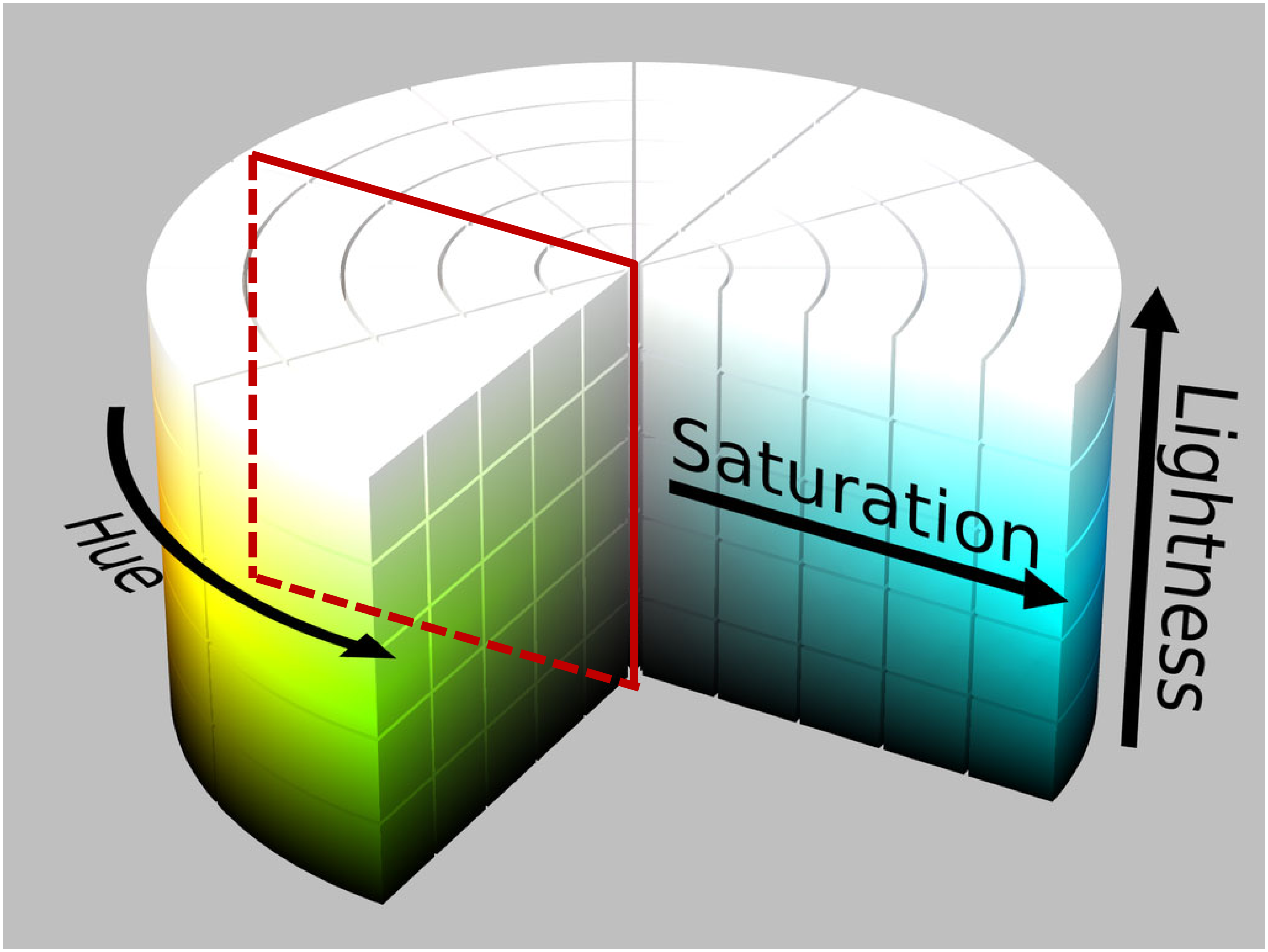


http://www.erinsowards.com/articles/2011/01/colors.php

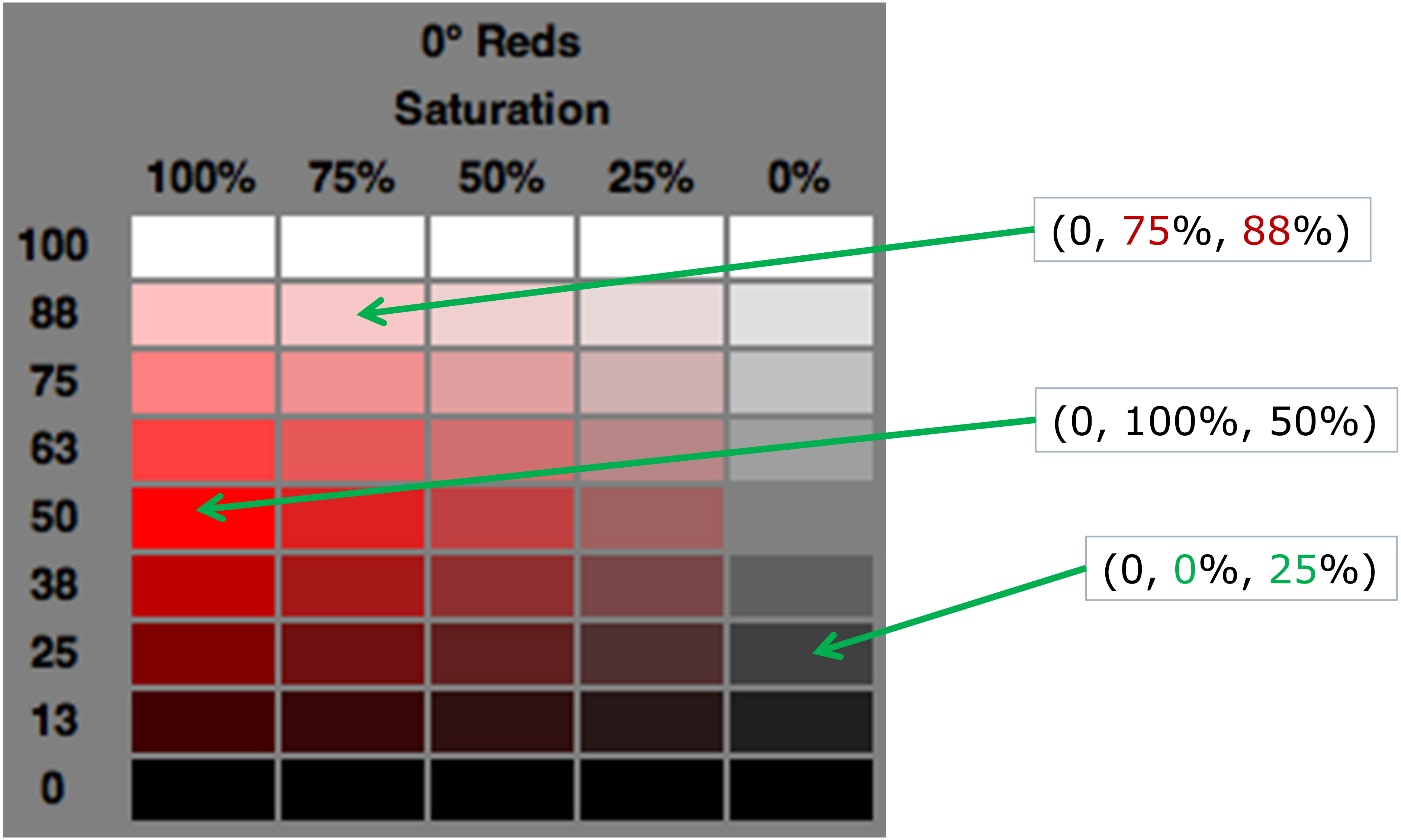
HSL Color Space: 3D Cylinder



HSL Color Space: 3D Cylinder



HSL Grid for Red (ie 0, S, L)



(0, 75%, 88%)

(0, 100%, 50%)

(0, 0%, 25%)

CSS Color Values

- Keywords: case-insensitive identifiers

```
red, navy, firebrick, chocolate
```

- RGB as decimal (0-255), percentage, or hex

```
rgb (255, 0, 0)  /* pure red */
rgb (100%, 0%, 0%)
#ff0000
#f00 /* expand by doubling each digit */
```

- HSL (Hue, Saturation, Light)
  - Hue (0-360) is angle on color wheel: 0 is red, 120 green, 240 blue
  - Saturation & light are both %'s

```
hsl (0, 100%, 50%) /* full bright red */
```

- Alpha channel (transparency): 1 is opaque!

```
rgba (255, 0, 0, 0.5)
hsla (0, 100%, 50%, 1)
```

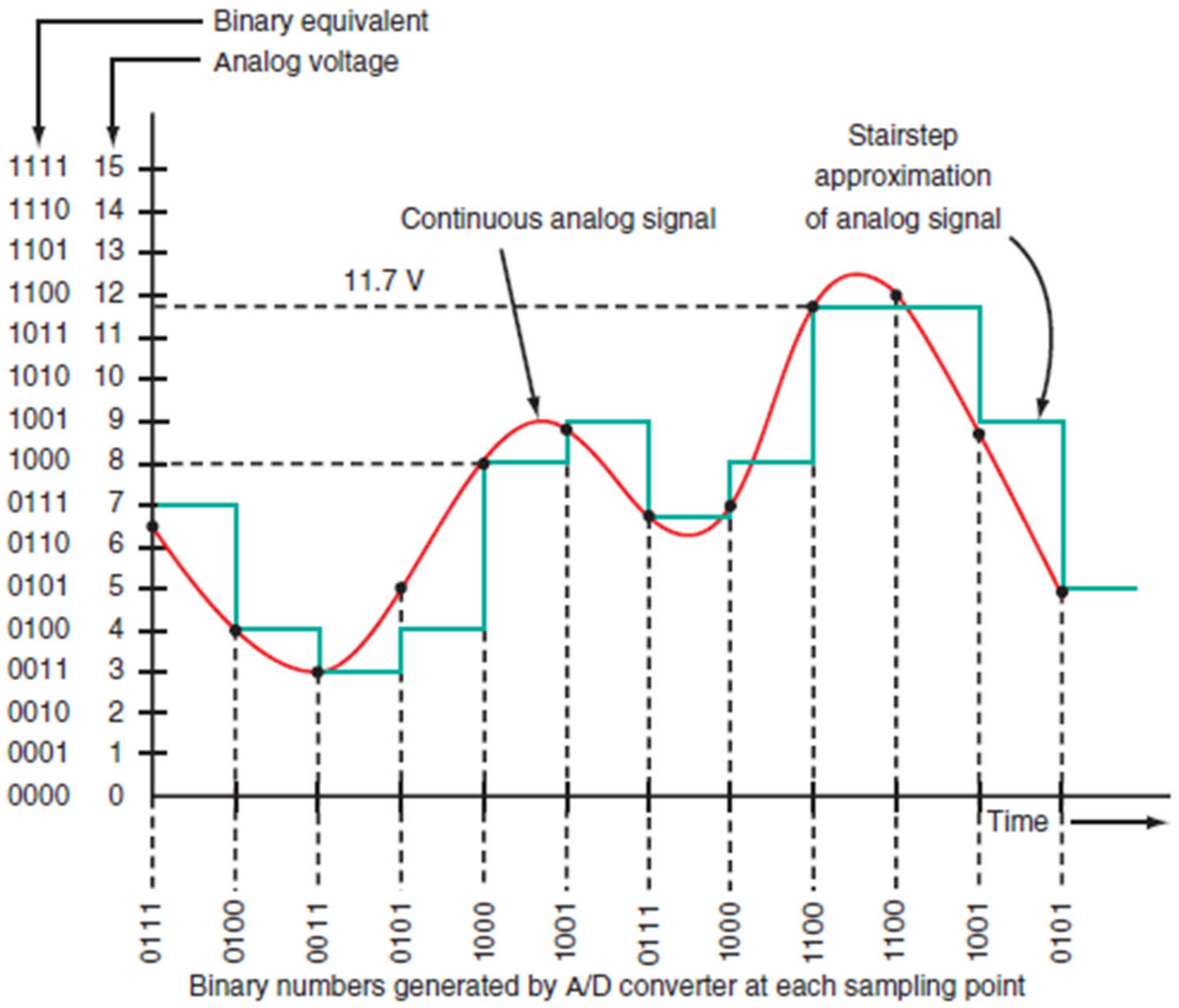
Color Keywords: 147 (141 dist.)

aliceblue	antiquewhite	aqua	aquamarine	azure	beige
bisque	⬛	blanchedalmond	blue	blueviolet	brown
burlywood	cadetblue	chartreuse	chocolate	coral	cornflowerblue
cornsilk	crimson	cyan	darkblue	darkcyan	darkgoldenrod
darkgray	darkgreen	darkkhaki	darkmagenta	darkolivegreen	darkorange
darkorchid	darkred	darksalmon	darkseagreen	darkslateblue	darkslategray
darkturquoise	darkviolet	deeppink	deepskyblue	dimgray	dodgerblue
firebrick	floralwhite	forestgreen	fuchsia	gainsboro	ghostwhite
gold	goldenrod	gray	green	greenyellow	honeydew
hotpink	indianred	indigo	ivory	khaki	lavender
lavenderblush	lawngreen	lemonchiffon	lightblue	lightcoral	lightcyan
lightgoldenrodyellow	lightgray	lightgreen	lightpink	lightsalmon	lightseagreen
lightskyblue	lightslategray	lightsteelblue	lightyellow	lime	limegreen
linen	magenta	maroon	mediumaquamarine	mediumblue	mediumorchid
mediumpurple	mediumseagreen	mediumslateblue	mediumspringgreen	mediumturquoise	mediumvioletred
midnightblue	mintcream	mistyrose	moccasin	navajowhite	navy
oldlace	olive	olivedrab	orange	orangered	orchid
palegoldenrod	palegreen	paleturquoise	palevioletred	papayawhip	peachpuff
peru	pink	plum	powderblue	purple	rebeccapurple
red	rosybrown	royalblue	saddlebrown	salmon	sandybrown
seagreen	seashell	sienna	silver	skyblue	slateblue
slategray	snow	springgreen	steelblue	tan	teal
thistle	tomato	turquoise	violet	wheat	white
	whitesmoke	yellow	yellowgreen		

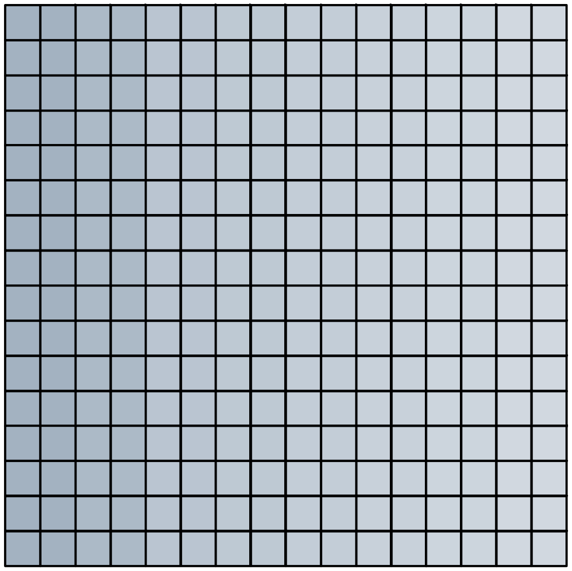
Color Depth

- "Depth" = # of bits in representation
  - 8 bits ➔ 256 different colors
  - 24 bits ➔ 16,777,216 different colors (eg 8 bits each for r, g, b)
- Alpha may be (incorrectly) included
  - rgba is a point in 4-dimensional space
- Problem: image color depth > display color depth
  - Quantization: each pixel gets closest available color (leads to banding)
  - Dithering: add noise, which looks better!

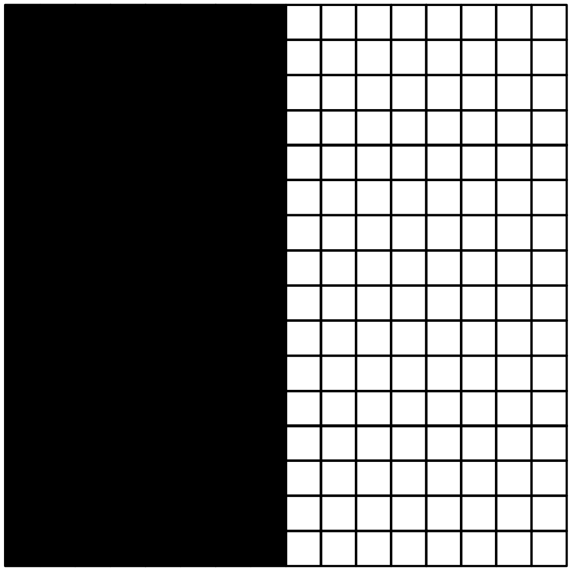
Quantization of Continuous Func



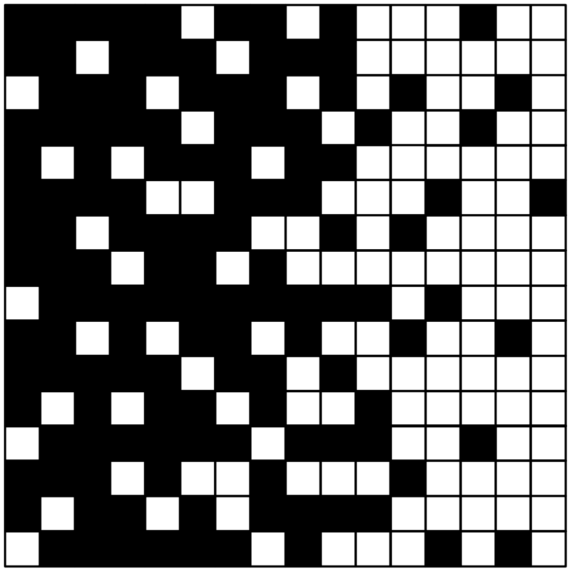
Quantization vs Dithering



original

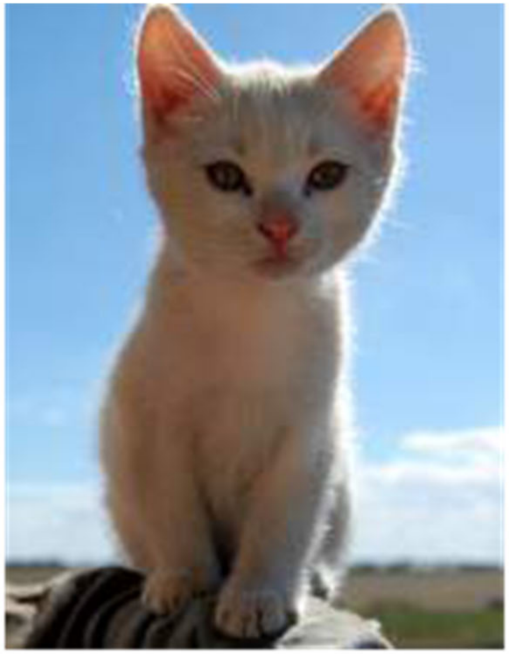


quantized

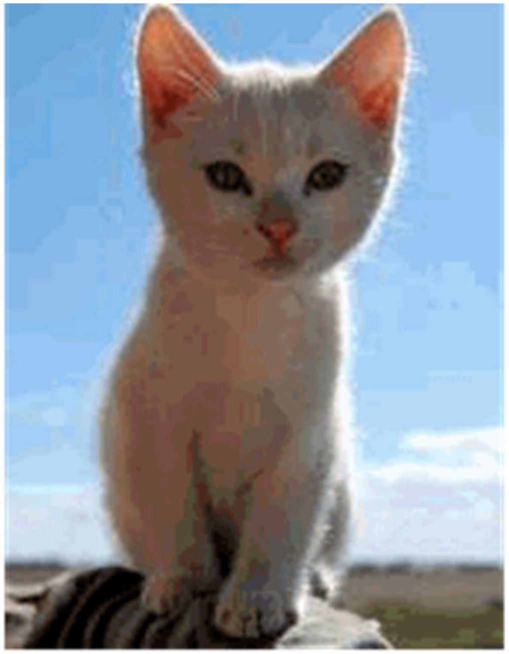


dithered

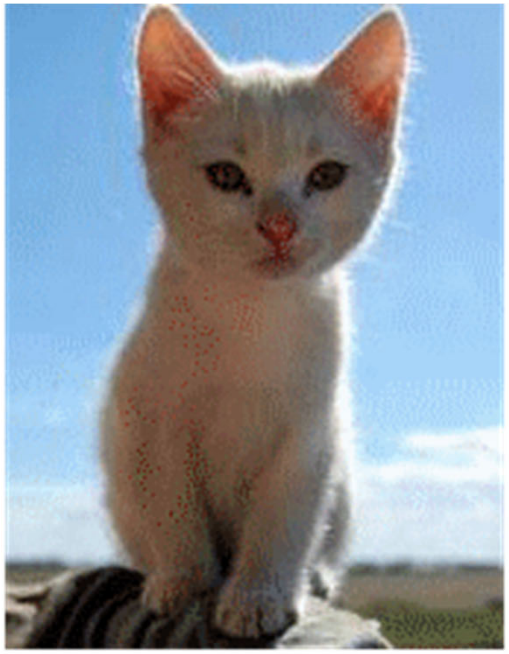
Quantization vs Dithering



Original Image



GIF without dithering



GIF with dithering

www.coffeecup.com/help/articles/dither-modes-in-animation-studio/

HTML **`<img>`** Tag Attributes

- **`src`**: location (URL) of image file
- **`width`**, **`height`**:
  - Area in *window* to reserve for image
  - Image is *scaled* to those dimensions
  - These attributes affect browser flow, regardless of when/if image is displayed
- **`alt`**: text to show if graphic can not be displayed or seen (ie alternative)
- **`title`**: text to *augment* displayed graphic (eg tooltip)

Image Representation

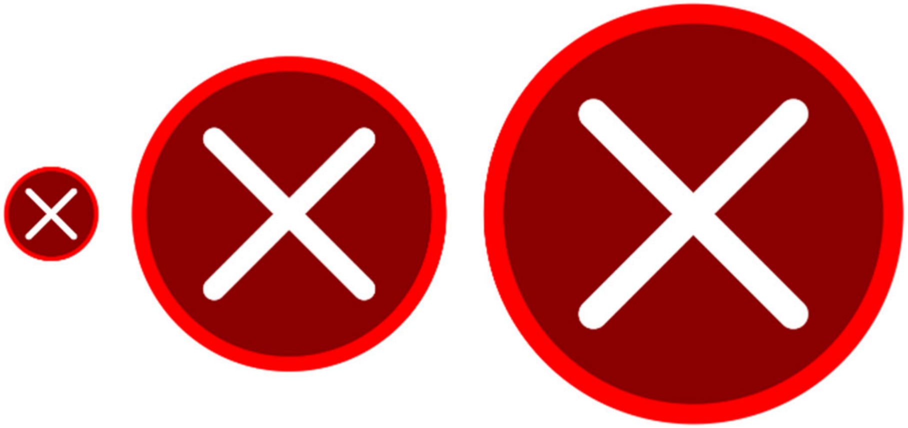
- Raster vs vector graphics
  - Raster: stored pixel-by-pixel
  - Vector: mathematical description
- Compression of raster images
  - Lossy: better compression, lower quality image
  - Lossless: largest file size, best quality

Major Formats

- GIF
  - Raster graphics, lossy compression (oldest)
  - 8 bit, basic transparency (on/off)
  - Frame-based animation (groan)
  - Good for small file size, crisp lines, logos
- JPEG
  - Raster, lossy compression
  - 24 bit, no transparency
  - Good for photos, gradual gradients
- PNG
  - Raster, lossless (but still often good) compression
  - Variable depth, full alpha transparency
  - Good replacement for GIF (but no animation)
- SVG
  - vector graphics
  - Good for crisp lines, simple logos, graphs

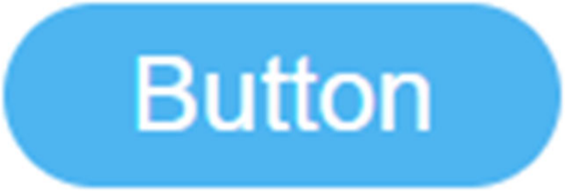
Scaling Images

- Vector graphics scale perfectly



- Raster images should be *pre-scaled*
  - Width (height) attributes of image tag should match actual width (height) of image
  - Why?
  - Cloud services can help (eg cloudinary.com)

Alternative: CSS



```
.button {
  display: inline-block;
  padding: 0.3em 1.2em;
  margin: 0 0.3em 0.3em 0;
  border-radius: 2em;
  box-sizing: border-box;
  text-decoration: none;
  font-weight: 300;
  color: #FFFFFF;
  background-color: #4eb5f1;
  text-align: center;
  transition: all 0.2s;
}
```

Summary

- Color theory
  - Perception, metamerism
  - Mixing: subtractive, additive
  - RGB, HSL, keywords
- Images
  - Quantization and dithering
  - Raster graphics vs vector graphics
  - Formats jpeg, png, gif, svg
  - Tradeoffs of size, quality, features