

# Color

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May 8, 2017

“Colors are perhaps the visual property that people most often misuse in visualization without being aware of it”

Robert Kosara

What function does color serve?

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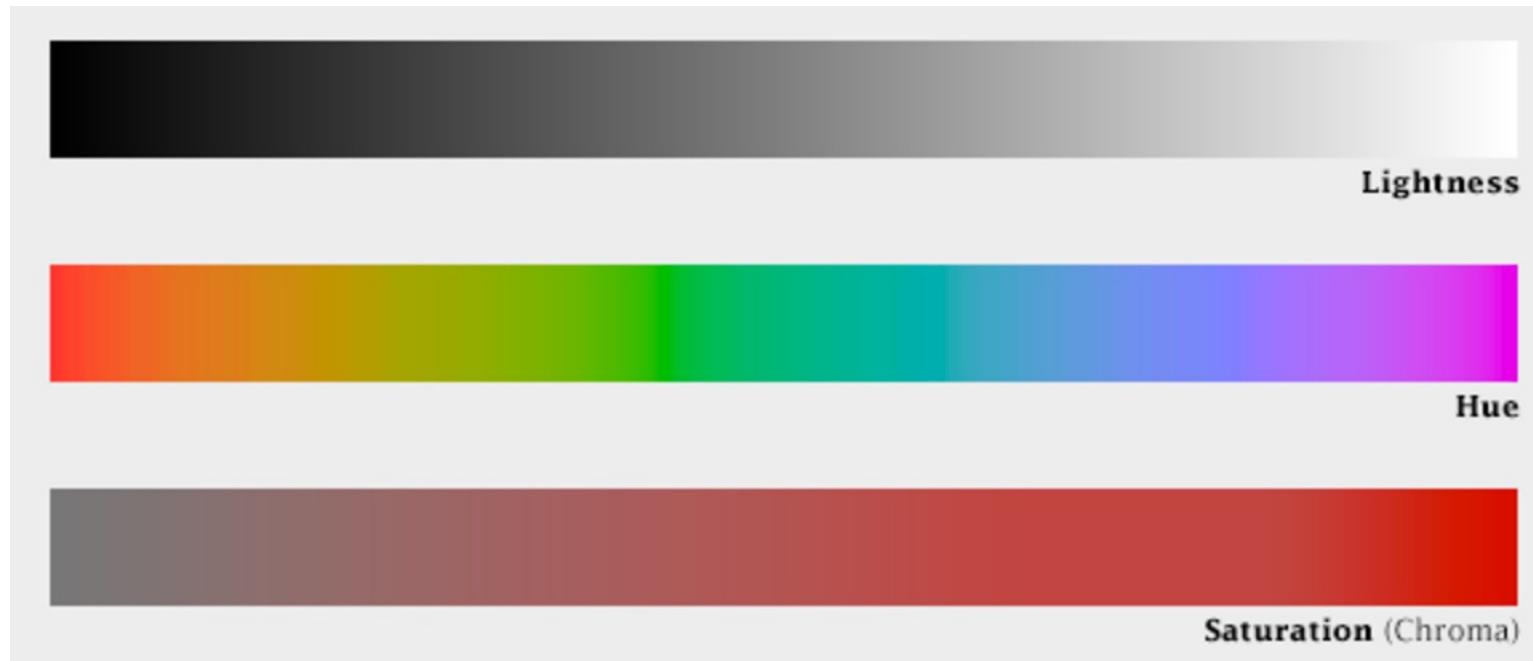
To label and classify

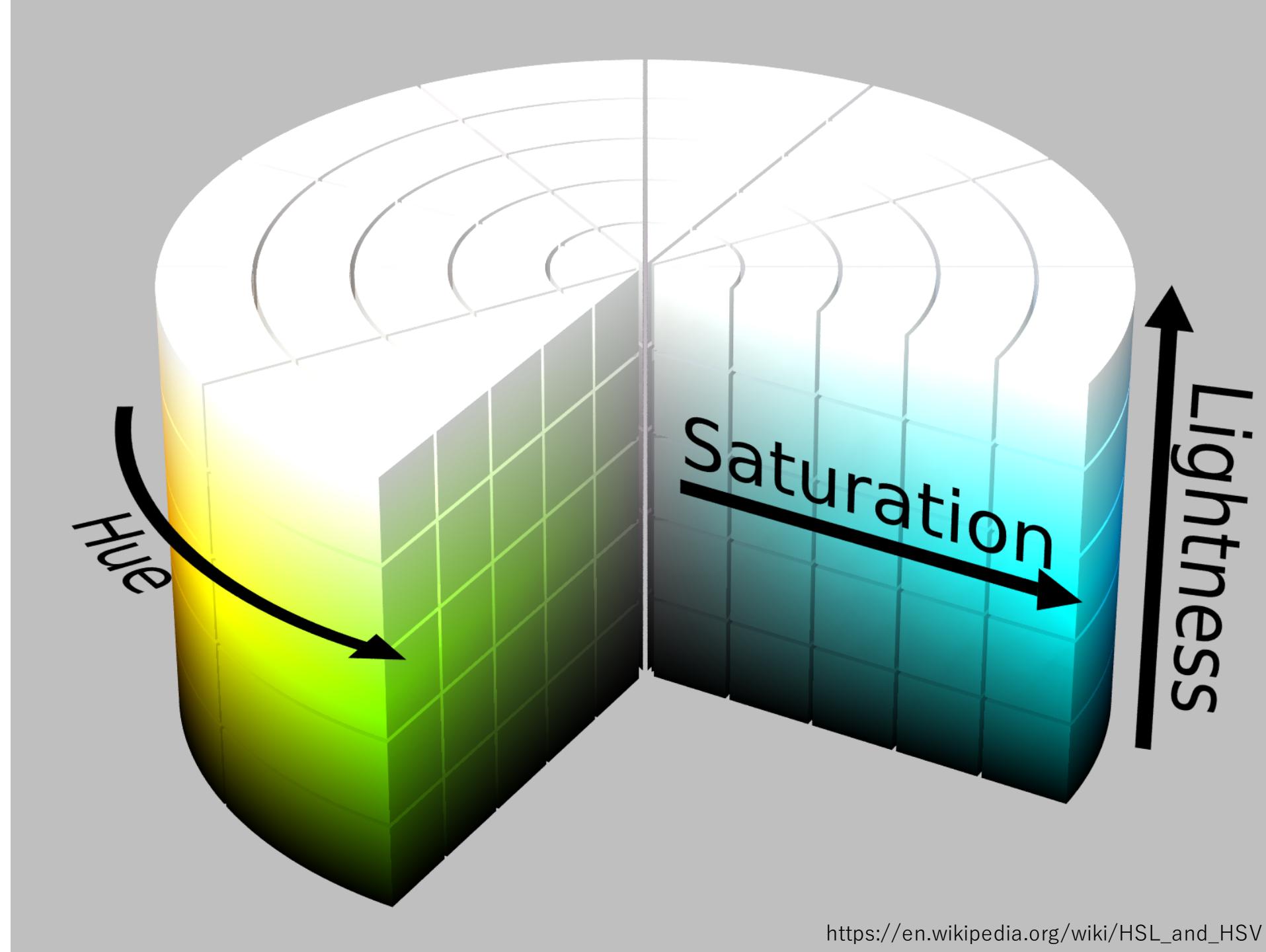
To measure

To represent reality

To decorate or enliven

# COMPONENTS OF COLOR

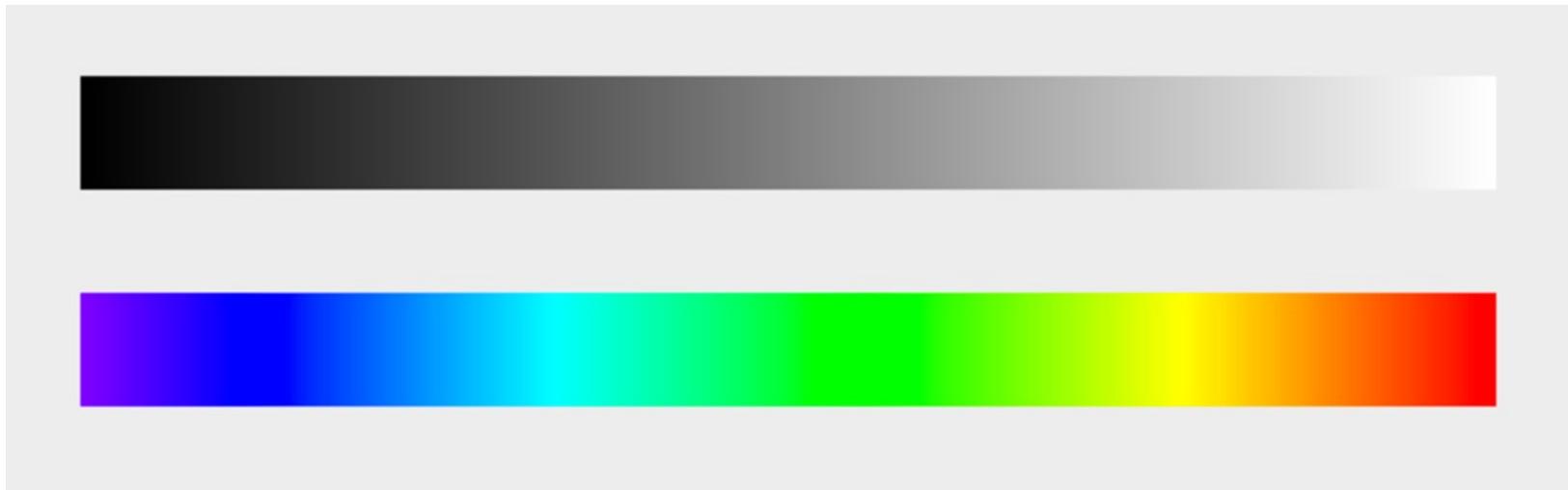




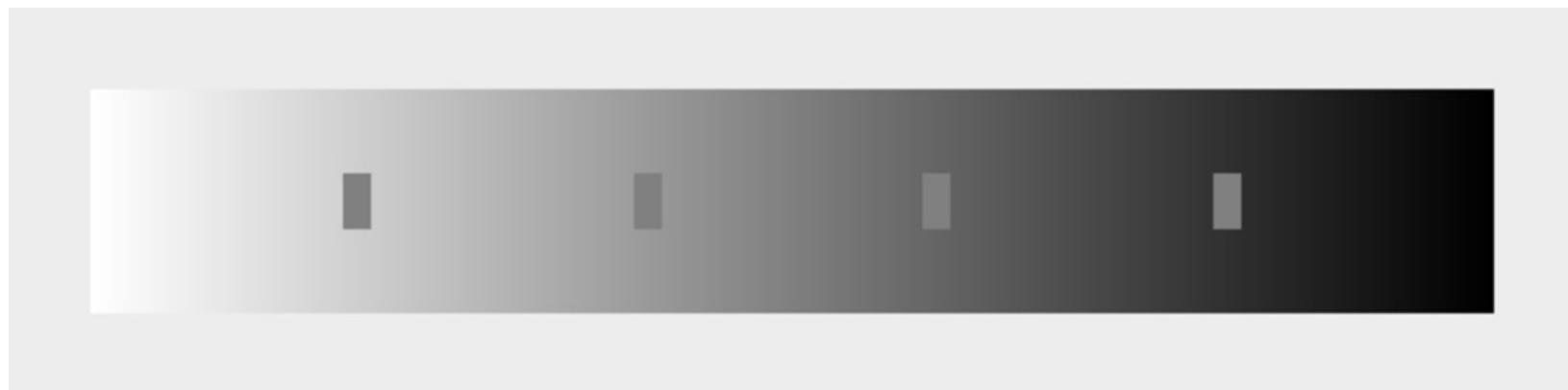
Computers think in RGB, but humans do not



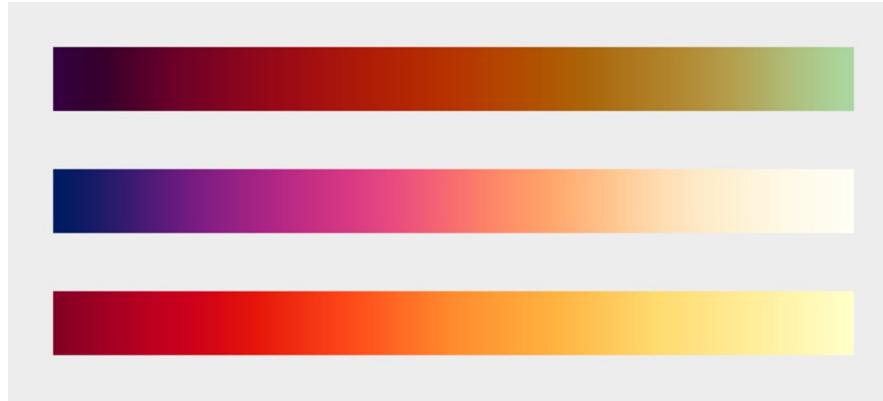
## Uniform versus non-uniform steps in color



## Simultaneous contrast



Combined continuous increase in lightness  
and shift in hue



A good color palette should

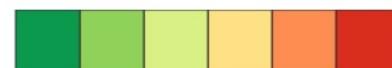
bring unity, identity, consistency, and  
hierarchy to a visualization

## TYPES OF COLOR SCHEMES

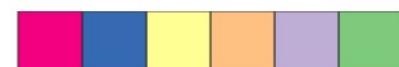
Sequential



Diverging



Qualitative



Beware default color palettes!

Software isn't always designed with the best  
understanding of proper color use in mind

It is up to you as user to choose appropriate  
color schemes

A good color palette should

have colors that are easy to distinguish



Using a total of 4 – 6 different colors is ideal

Beyond 12 colors, a palette becomes  
difficult to discern ([why?](#))

If necessary, transform your data to reduce  
the number of data classes

Select and use color palettes that are  
inspired by art and nature



Color use is just as important as color choice

Bright, strong colors are overwhelming in large quantities but effective in drawing attention in small quantities

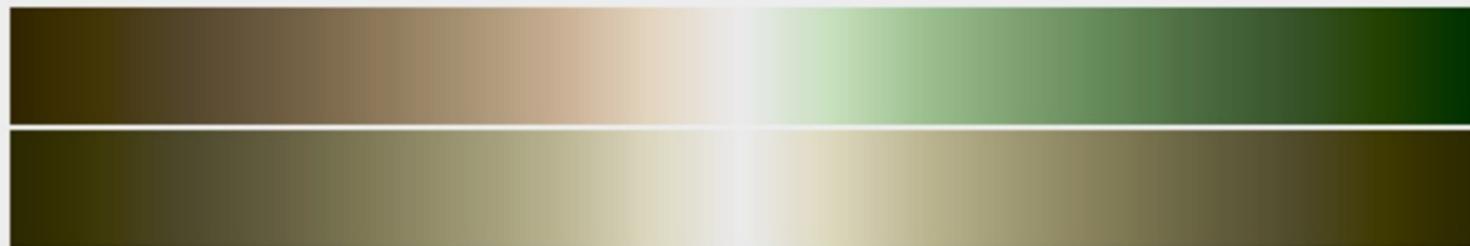
## Color chroma produces perceptual effects

The smaller the mark, the harder it is to distinguish differences between colors

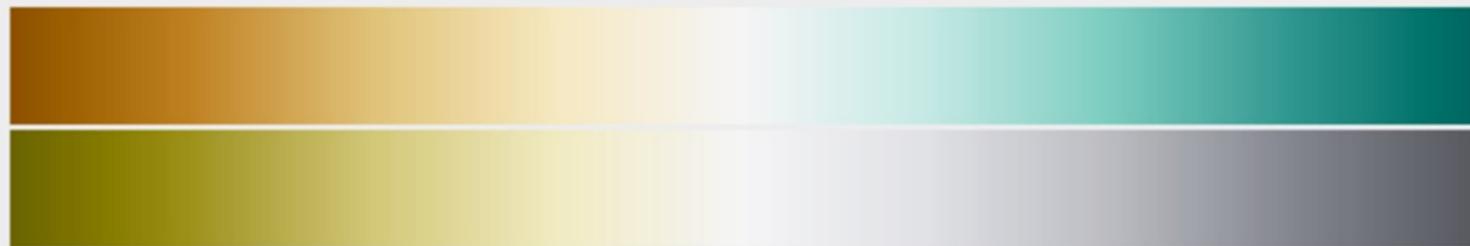
A good color palette should  
be accessible



Flat UI Colors in full colors, protanopia mode, and grayscale.



**original palette**



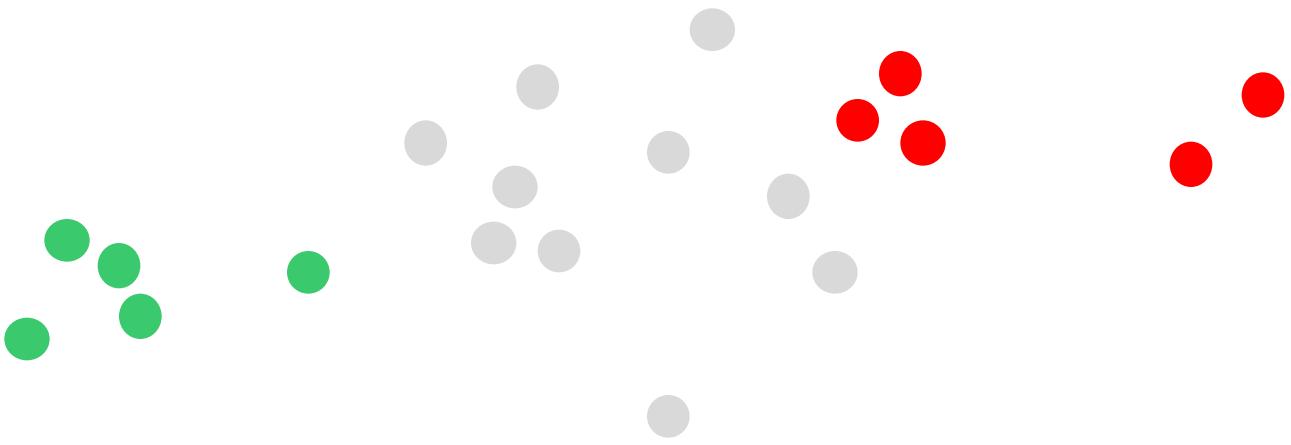
**red-green colorblind safe palette**

When accessibility is a concern, color can be used to redundantly encode data in a visualization

Color provides [contrast](#), which helps guide  
the attention of the viewer

The use of gray helps bring depth and  
contrast to a visualization that uses color to  
encode values

Use semantically relevant colors that are consistent with the tone and content of the data your visualization represents



# Colours In Culture

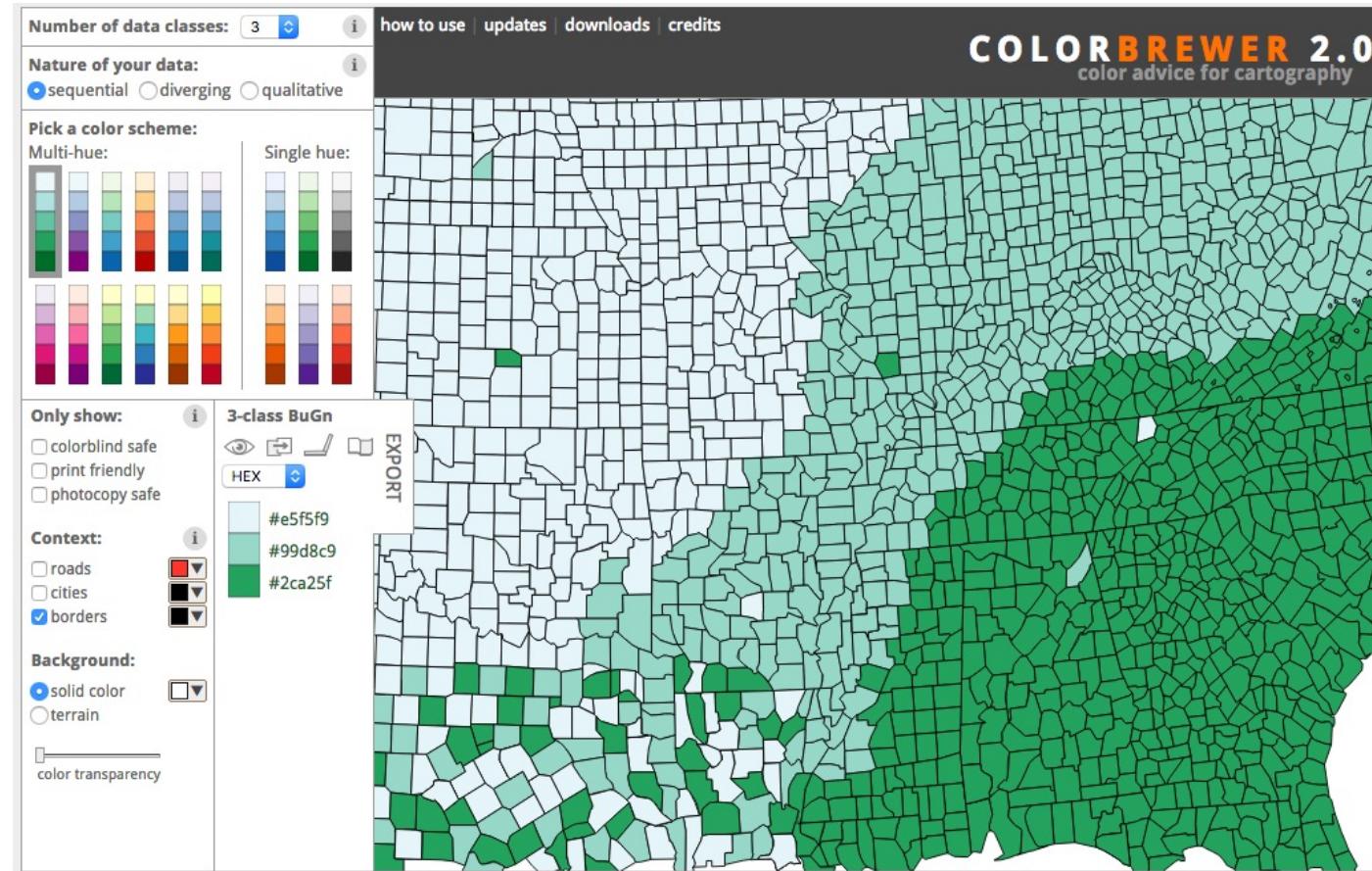


A Western / American	1 Anger	19 Desire
B Japanese	2 Art / Creativity	20 Earthy
C Hindu	3 Authority	21 Energy
D Native American	4 Bad Luck	22 Erotic
E Chinese	5 Balance	23 Eternity
F Asian	6 Beauty	24 Evil
G Eastern European	7 Calm	25 Excitement
H Muslim	8 Celebration	26 Family
I African	9 Children	27 Femininity
J South American	10 Cold	28 Fertility
	11 Compassion	29 Flamboyance
	12 Courage	30 Freedom
	13 Cowardice	31 Friendly
	14 Cruelty	32 Fun
	15 Danger	33 God
	16 Death	34 Gods
	17 Decadence	35 Good Luck
	18 Deceit	36 Gratitude

37 Growth	55 Luxury	73 Royalty
38 Happiness	56 Marriage	74 Self-cultivation
39 Healing	57 Modesty	75 Strength
40 Healthy	58 Money	76 Style
41 Heat	59 Mourning	77 Success
42 Heaven	60 Mystery	78 Trouble
43 Holiness	61 Nature	79 Truce
44 Illness	62 Passion	80 Trust
45 Insight	63 Peace	81 Unhappiness
46 Intelligence	64 Penance	82 Virtue
47 Intuition	65 Power	83 Warmth
48 Religion	66 Personal power	84 Wisdom
49 Jealousy	67 Purity	
50 Joy	68 Radicalism	
51 Learning	69 Rational	
52 Life	70 Reliable	
53 Love	71 Repels Evil	
54 Loyalty	72 Respect	

█ Yellow  
 █ Grey  
█ Gold  
 █ Silver

Color perception is highly **relative** and  
**subjective** across different observers

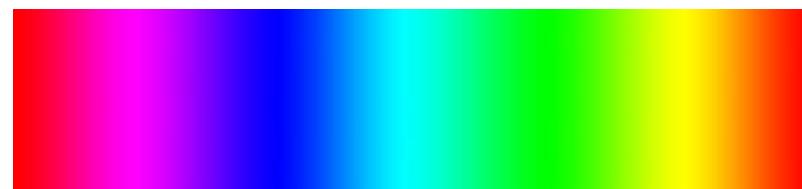


[www.colorbrewer2.org](http://www.colorbrewer2.org)

What's wrong with a rainbow color scheme?



## Color perception insensitivities



Red-green color blindness



Sanford, W. E., and Selnick, D. L. (2013). Estimation of Evapotranspiration Across the Conterminous United States Using a Regression with Climate and Land-Cover Data. *JAWRA* 49(1): 217-230.

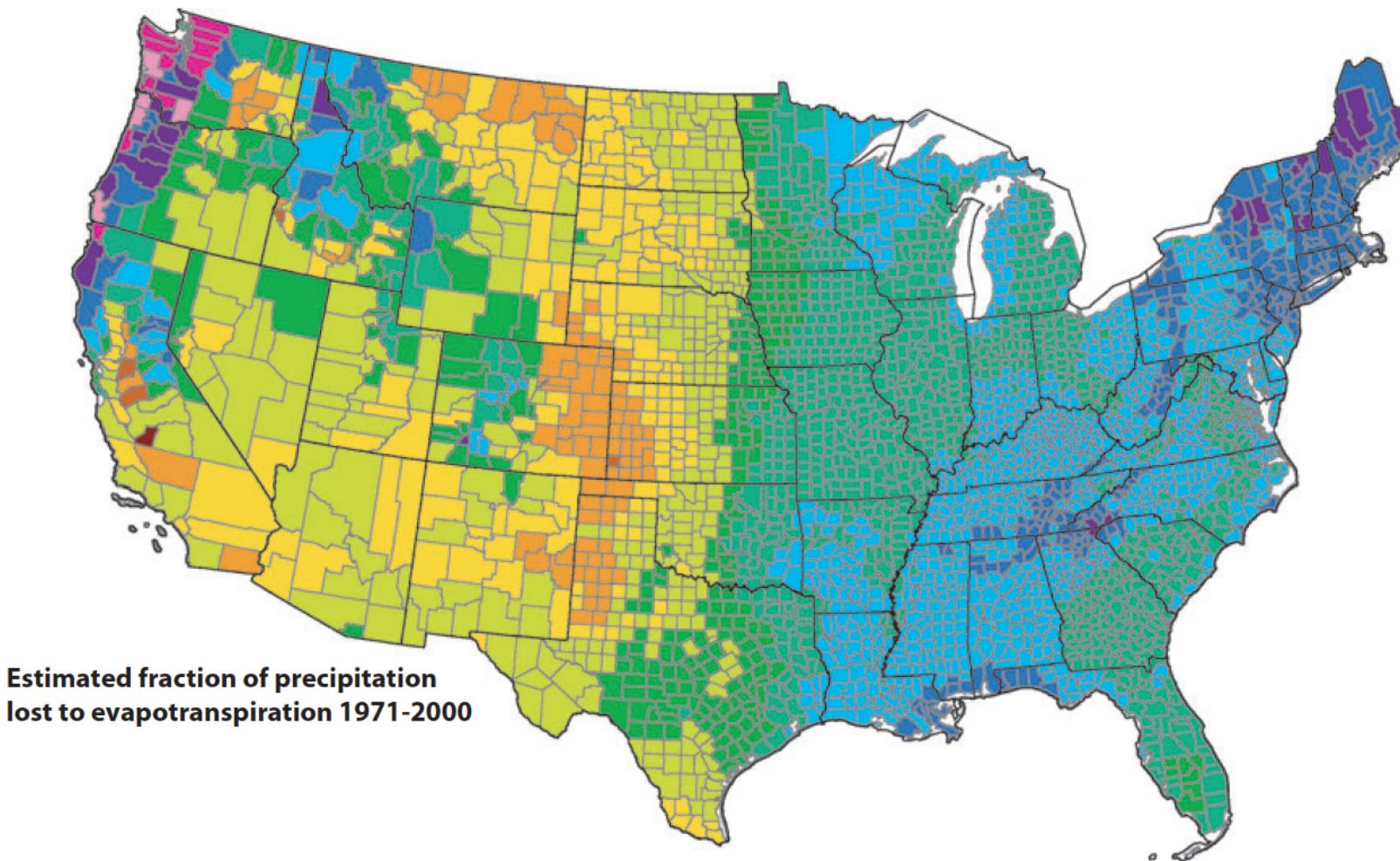


FIGURE 13. Estimated Mean Annual Ratio of Actual Evapotranspiration (ET) to Precipitation ( $P$ ) for the Conterminous U.S. for the Period 1971-2000. Estimates are based on the regression equation in Table 1 that includes land cover. Calculations of  $ET/P$  were made first at the 800-m resolution of the PRISM climate data. The mean values for the counties (shown) were then calculated by averaging the 800-m values within each county. Areas with fractions  $>1$  are agricultural counties that either import surface water or mine deep groundwater.

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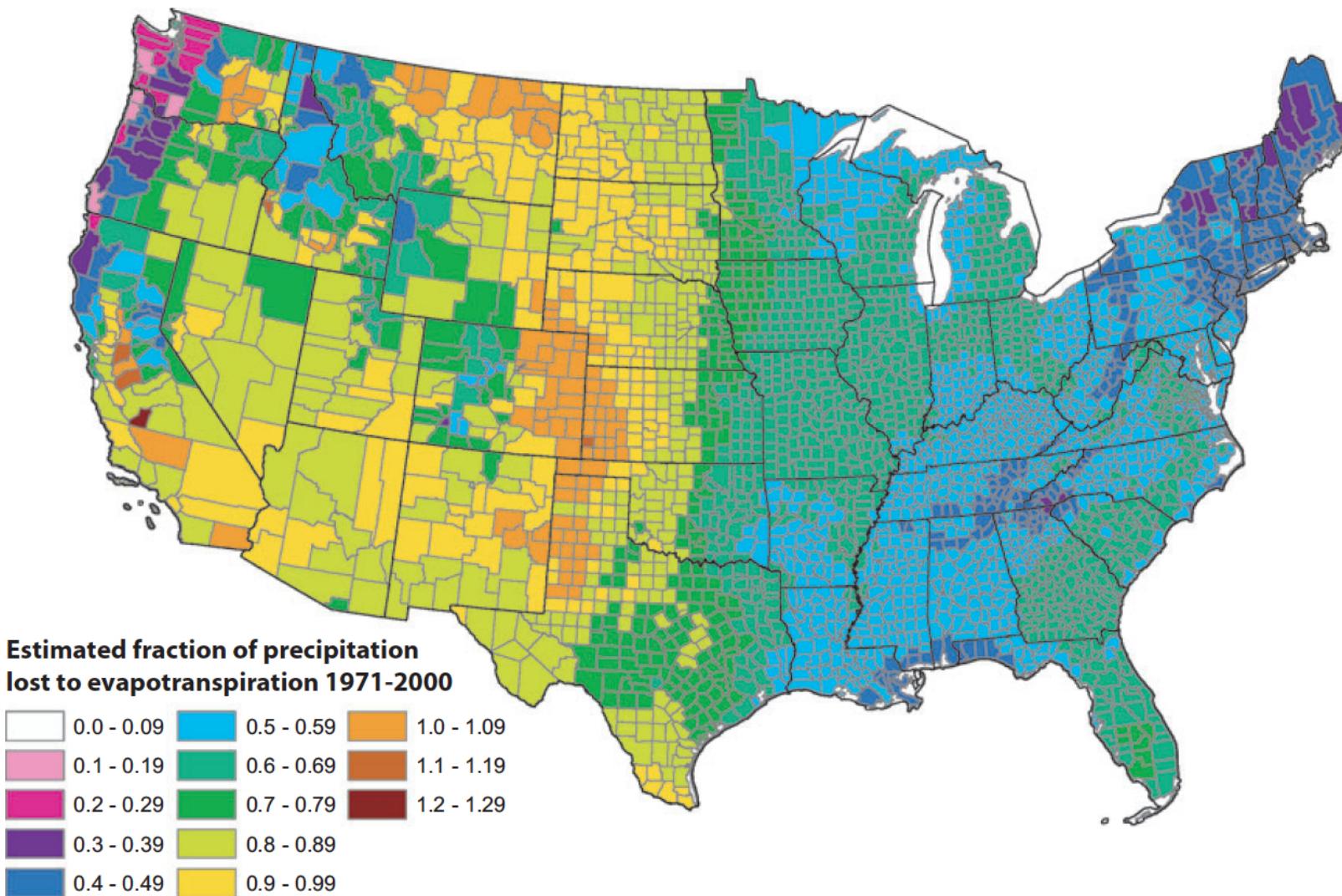
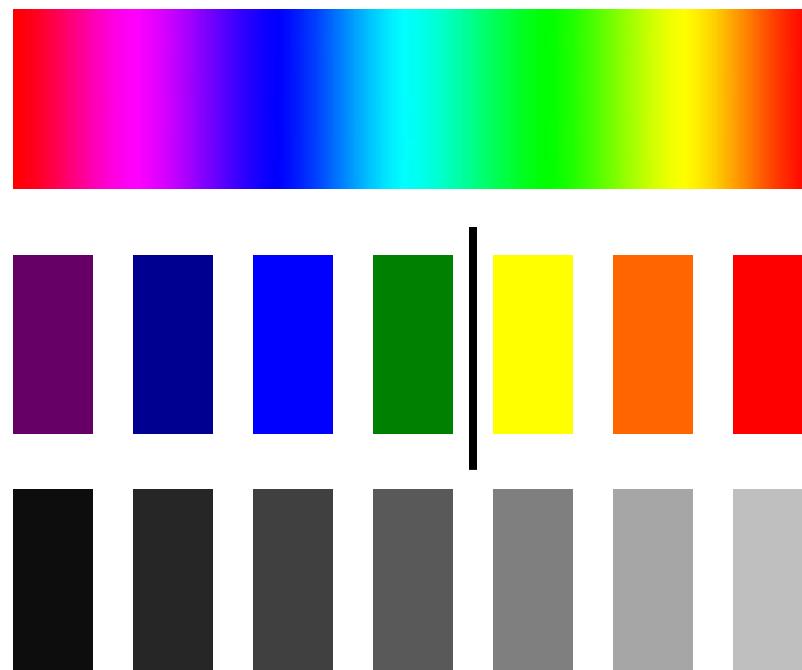


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## Color perception insensitivities



## Use of contrast



# Interactions of Color

**Josef Albers** Interaction of Color  
*50th Anniversary Edition*



## SIMULTANEOUS CONTRAST



## SIMULTANEOUS CONTRAST



## CONTRAST OF HUE



For color-blind users, variations in brightness are more accessible than variations in hue

Combinations of widely-varying hue AND brightness are universally ideal

# Avoiding the Use of Color

In the absence of color (e.g., black and white print), what kinds of alternative encodings can you use?

## VISUAL ENCODINGS

Color		Sequence		Length	
Value/Gradation		Size + Scale		Area	
Texture		Orientation		Proportion	
Symbol		Proximity/Density		Count	

# Mapping Quantitative Data to Color

## **TYPES OF QUANTITATIVE SCALES**

### **Interval**

Actual distances between points can be compared

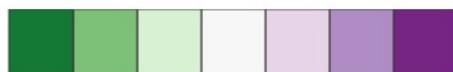
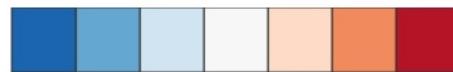
### **Ratio**

Provides an absolute zero point of reference

With quantitative data, color palettes  
should demonstrate  
[a natural ordering of magnitudes](#)

thresholds and binning should be natural  
and reflect genuine behaviors in the  
underlying data

Color palette choices should demonstrate parity in comparisons between both relative and absolute magnitudes



# Mapping Qualitative Data to Color

## **TYPES OF QUALITATIVE SCALES**

### **Nominal**

Distinct classes with no hierarchical relationships

### **Ordinal**

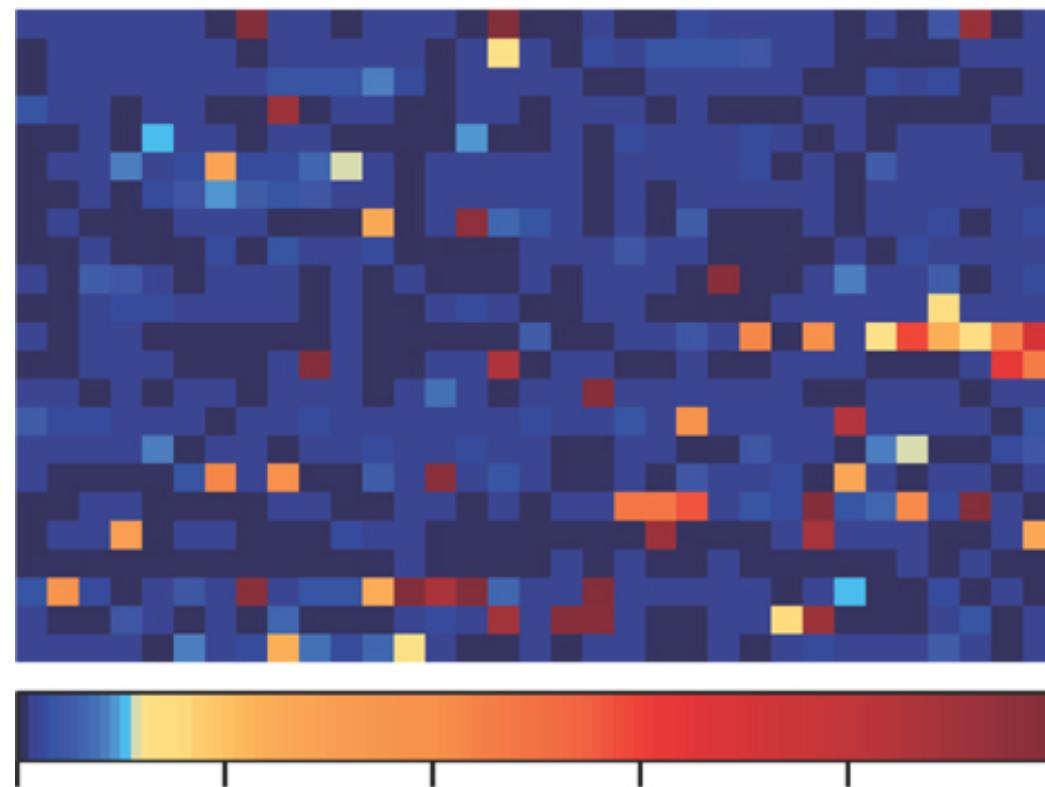
Distinct classes with natural hierarchy

Qualitative color schemes should only show  
**contrast** between classes  
and not **order of magnitude**

Use variations in hue,  
not variations in lightness,  
except when working with ordinal scales

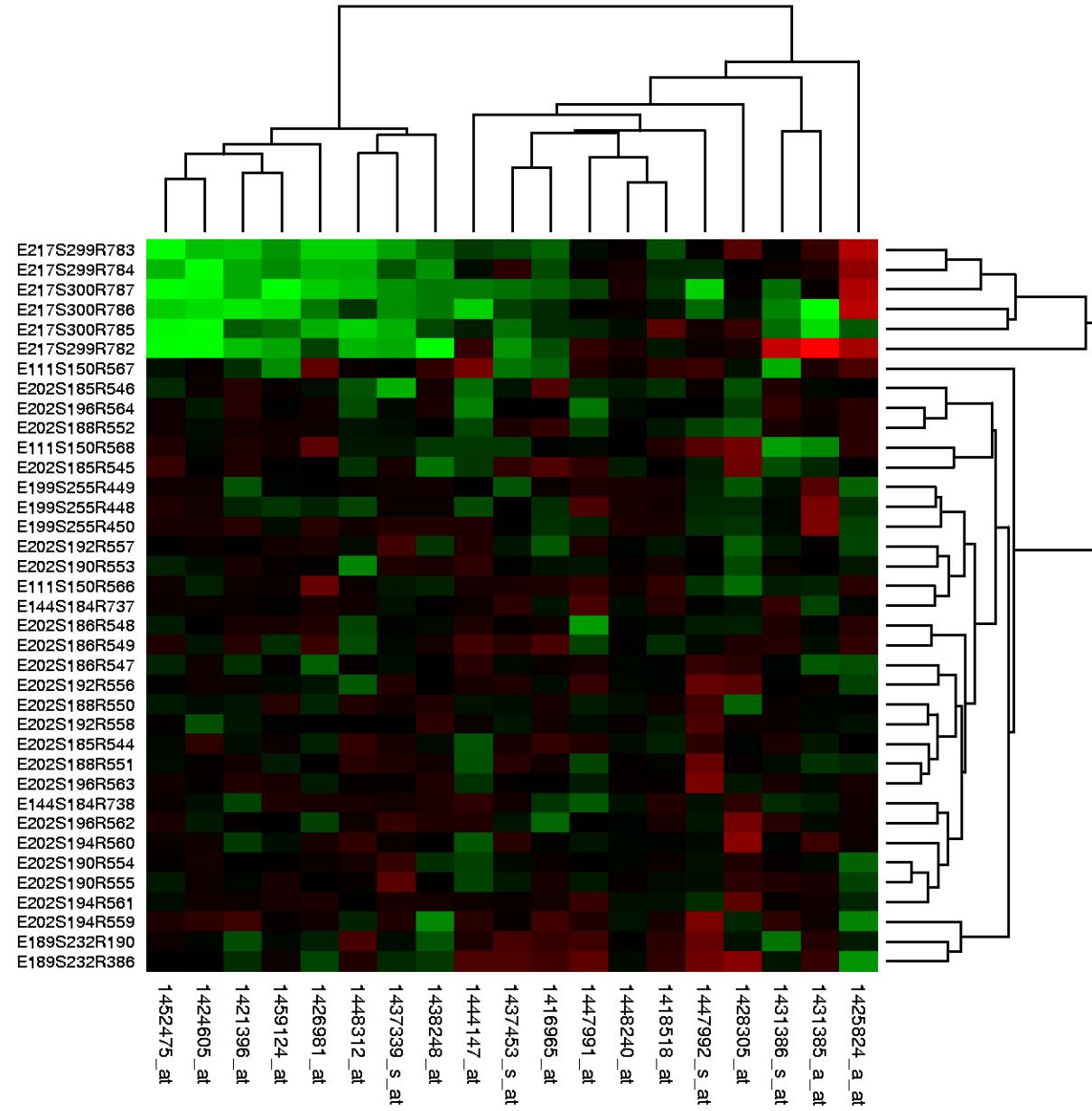
# Color in Heat Maps

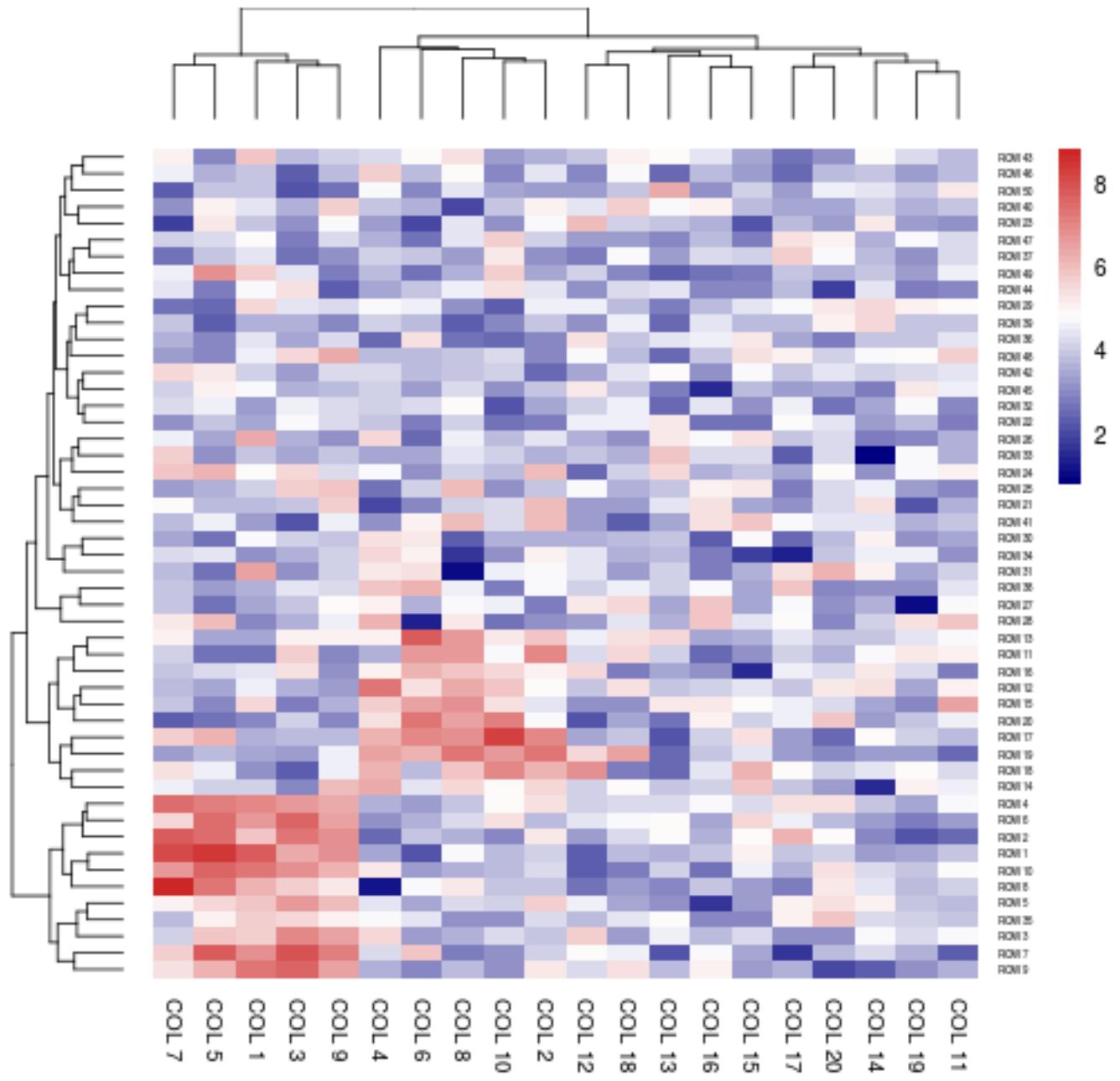
**a**



Low

High







Bang Wong, *Nature Methods* 7, 573 (2010)