COLOR THEORY

For map design and better understanding of remote sensing

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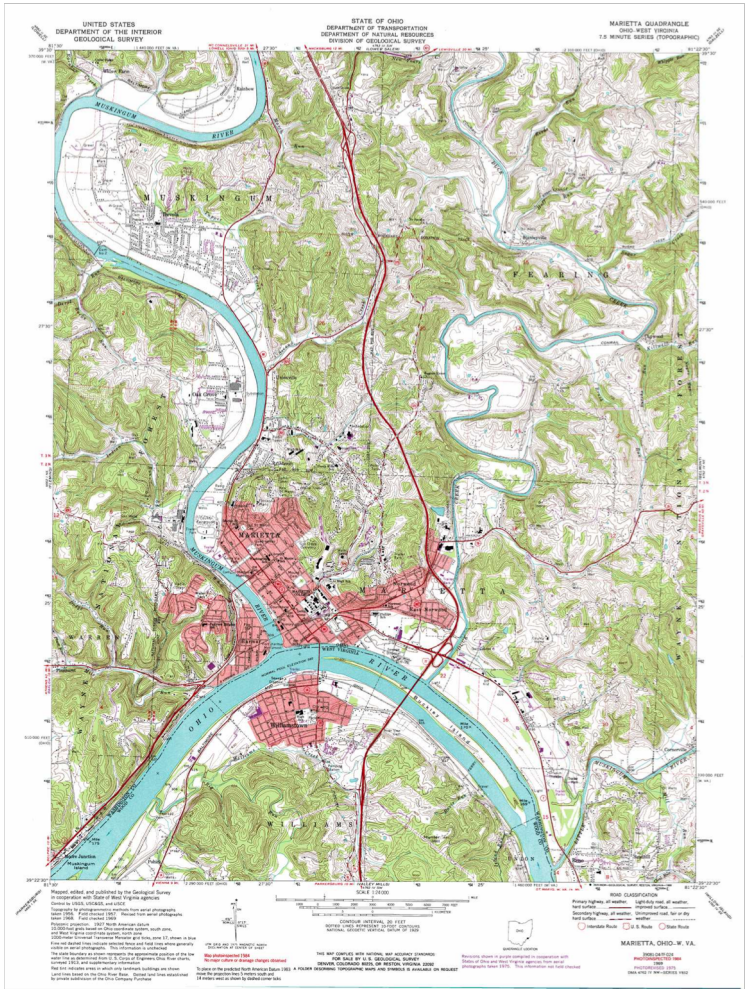
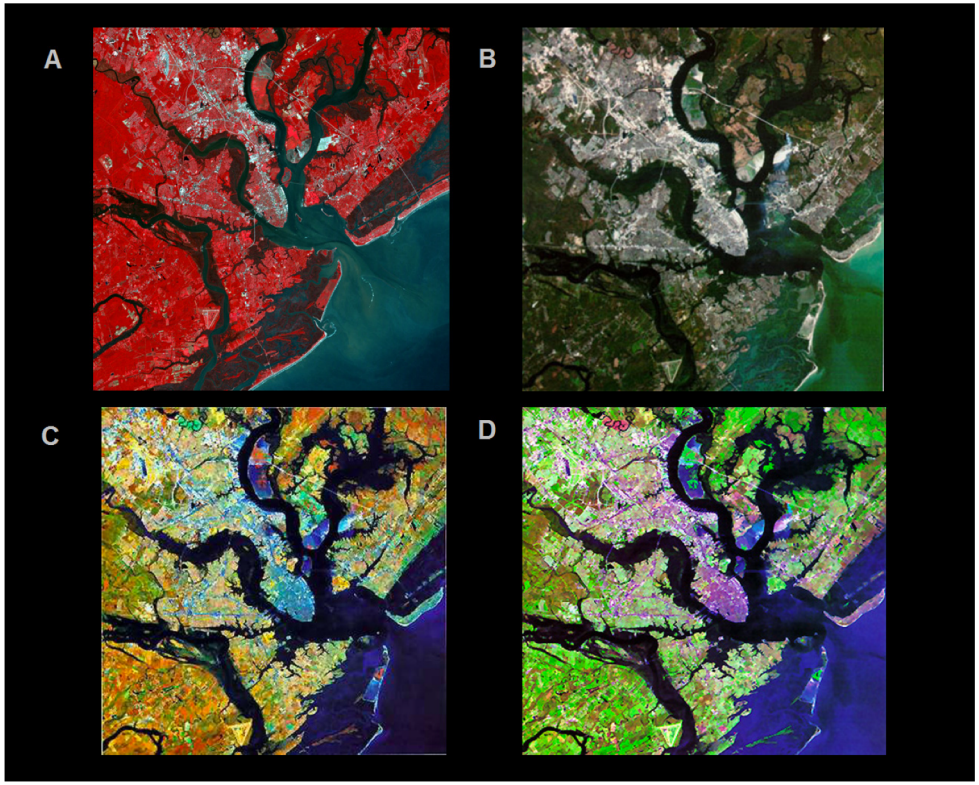
Why is color important in cartography and remote sensing?

Why is color important in cartography and remote sensing?

- Making certain information more obvious





What is color?

What is color?

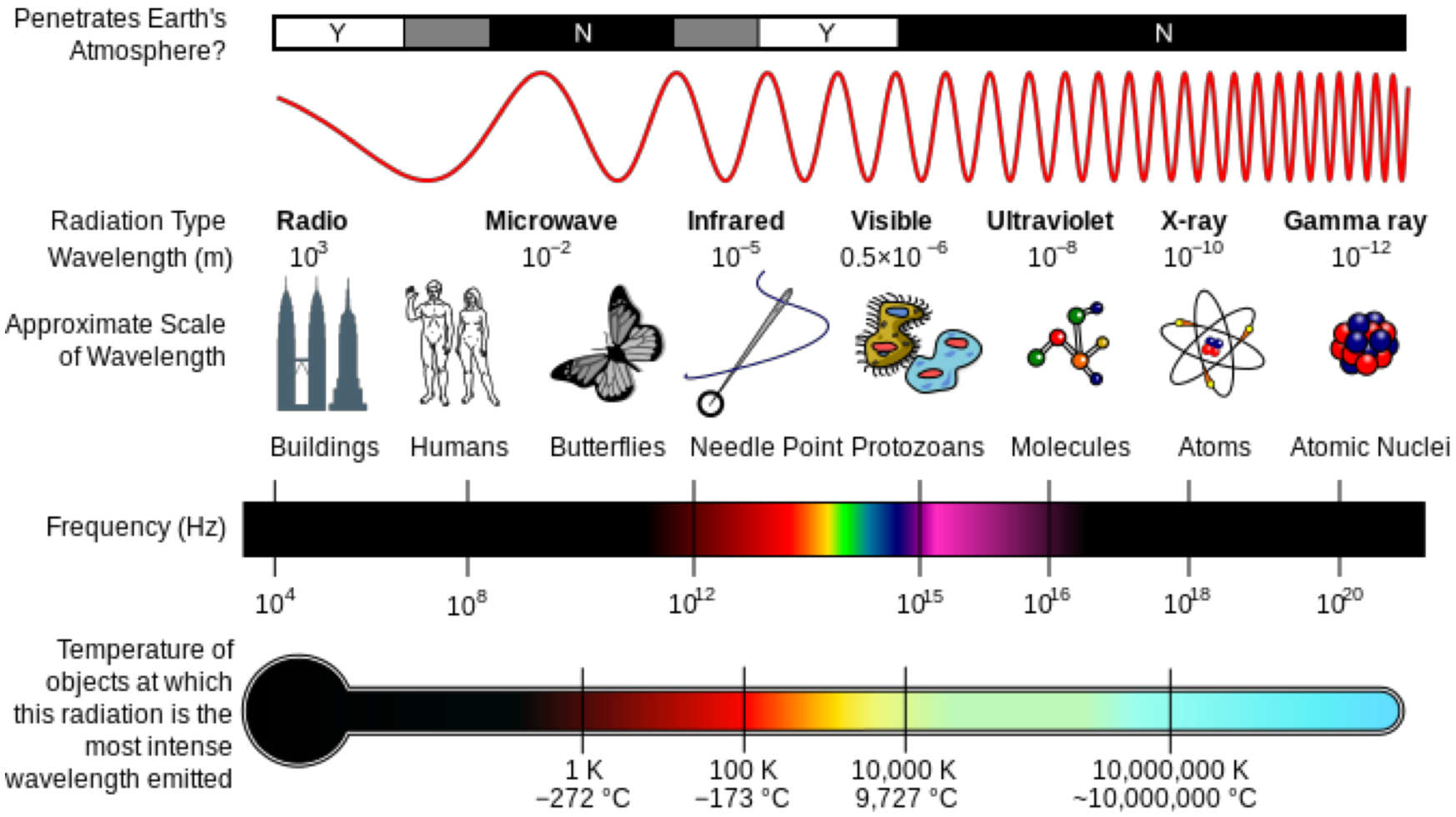
- Human perception, usually stimulated by the interaction of visible light with photoreceptors.

Color: human perception

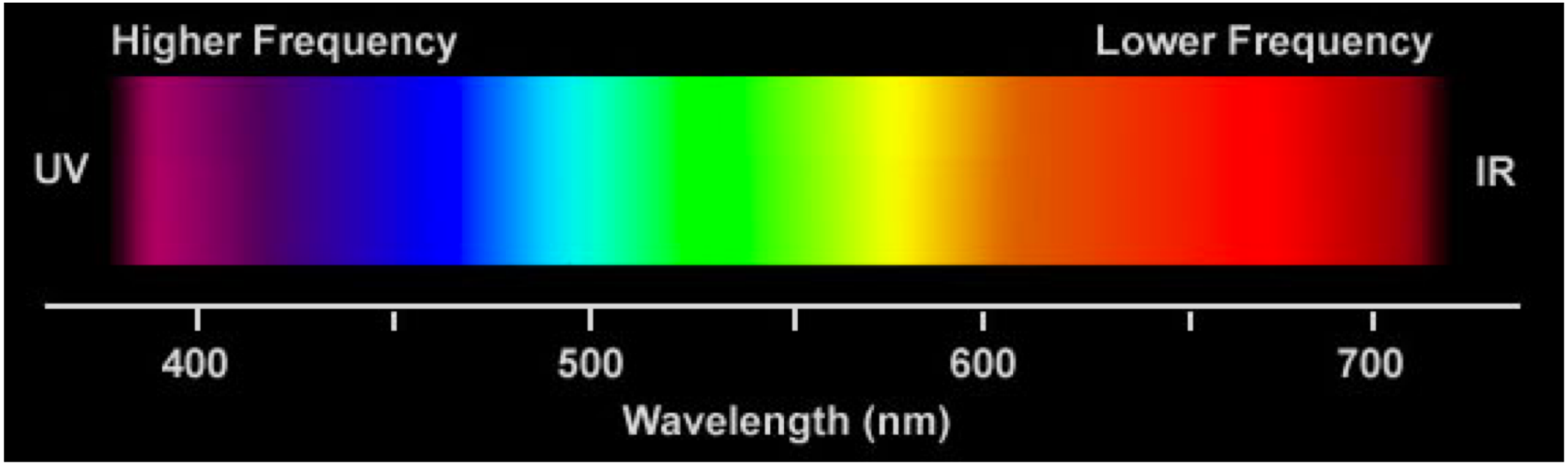
- Color is an ambiguous entity
- Color is an individual experience affected by
  - Biology (genetics, age, sex, environment)
  - Culture (meaning of colors)
  - Personal experiences (experiences with colors)

Electromagnetic waves

Color is often described as a **measurable wavelength**, but it is more than that.

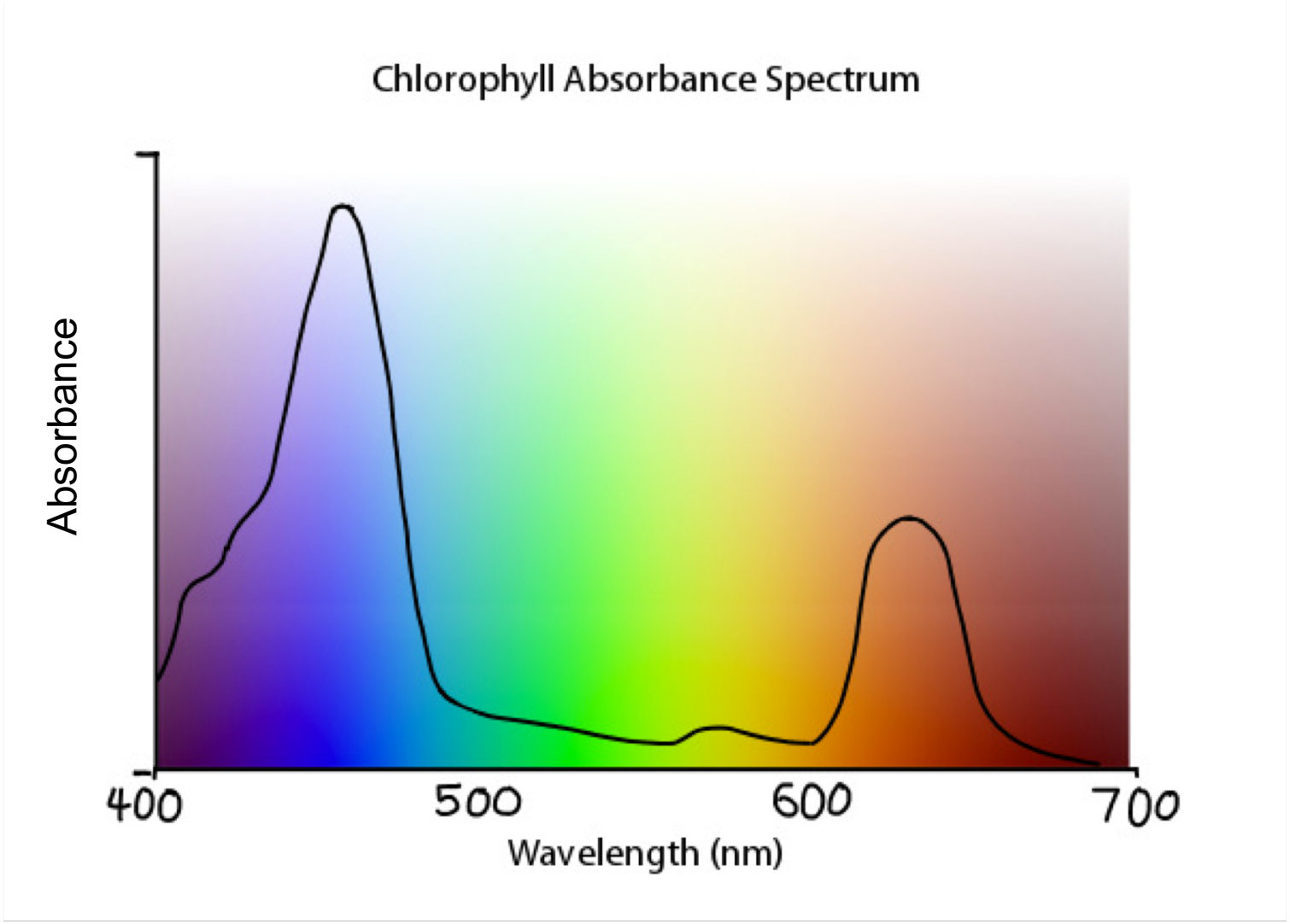


Visible spectrum



Visible spectrum: from about 390 to 700 nanometers

Why do we perceive a leaf as green?



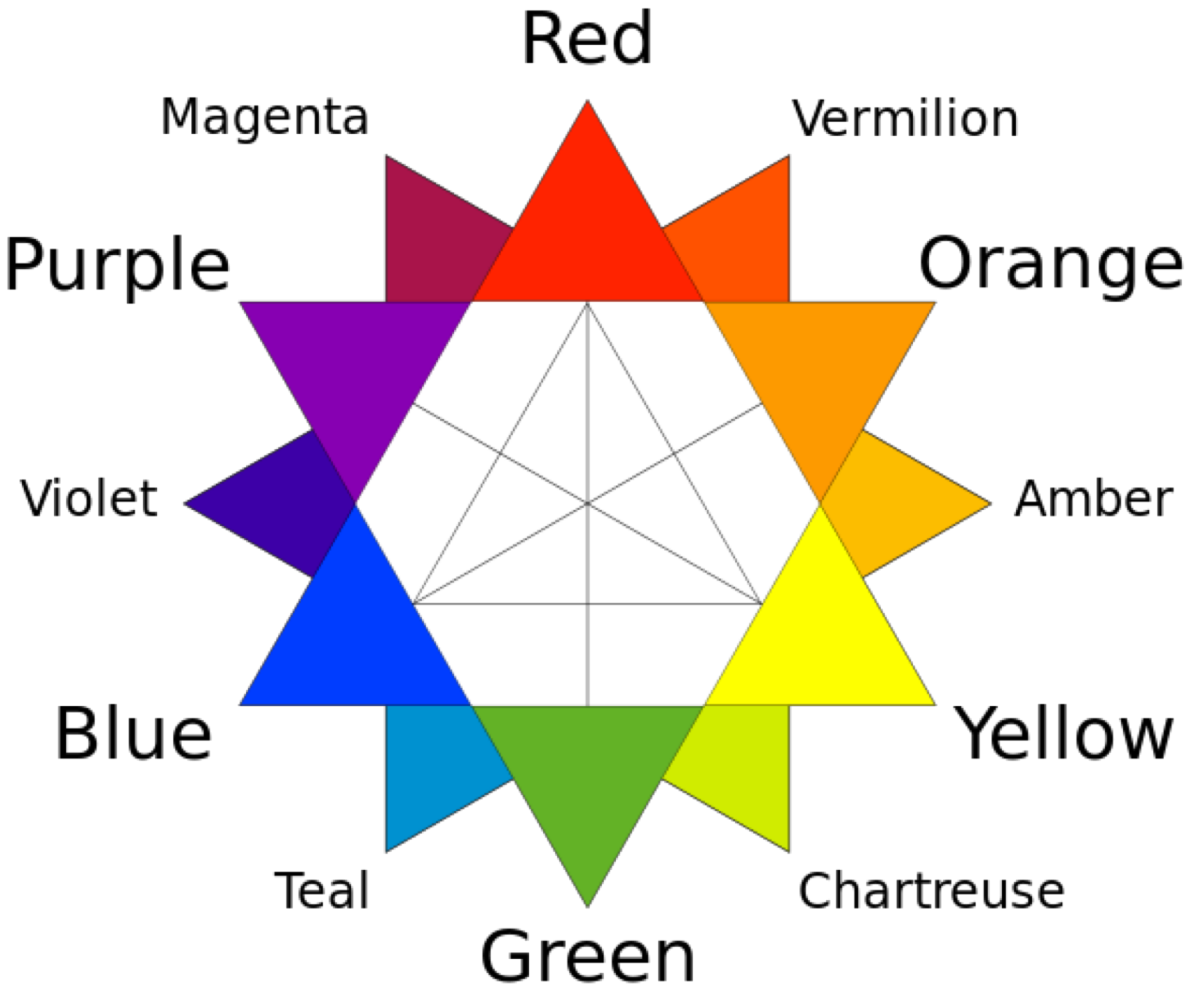
Which are the primary colors?

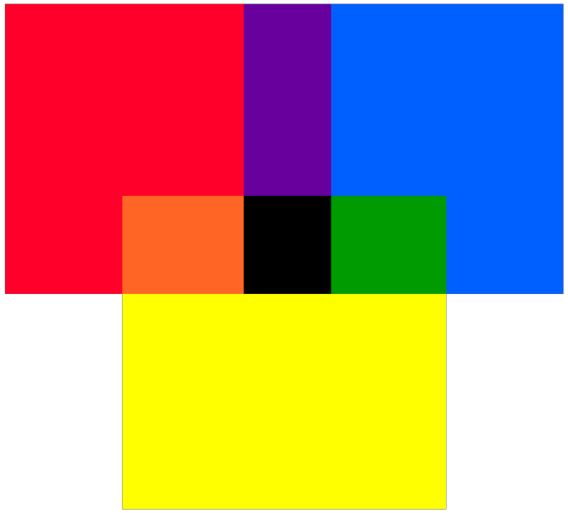
Primary colors are **arbitrary**

- Primary colors are an arbitrary set of pigments, lights, electromagnetic wavelengths or filters that can be combined according to some model to produce multiple colors.

RYB (pigment) color model

elementary school color theory





Subtractive color mixing

- Mixing of color is done by **absorbing** some wavelength.
- Hence we start with white and end with black
- RYB, CMY, & CMYK are considered subtractive color mixing models

CMY & CMYK model

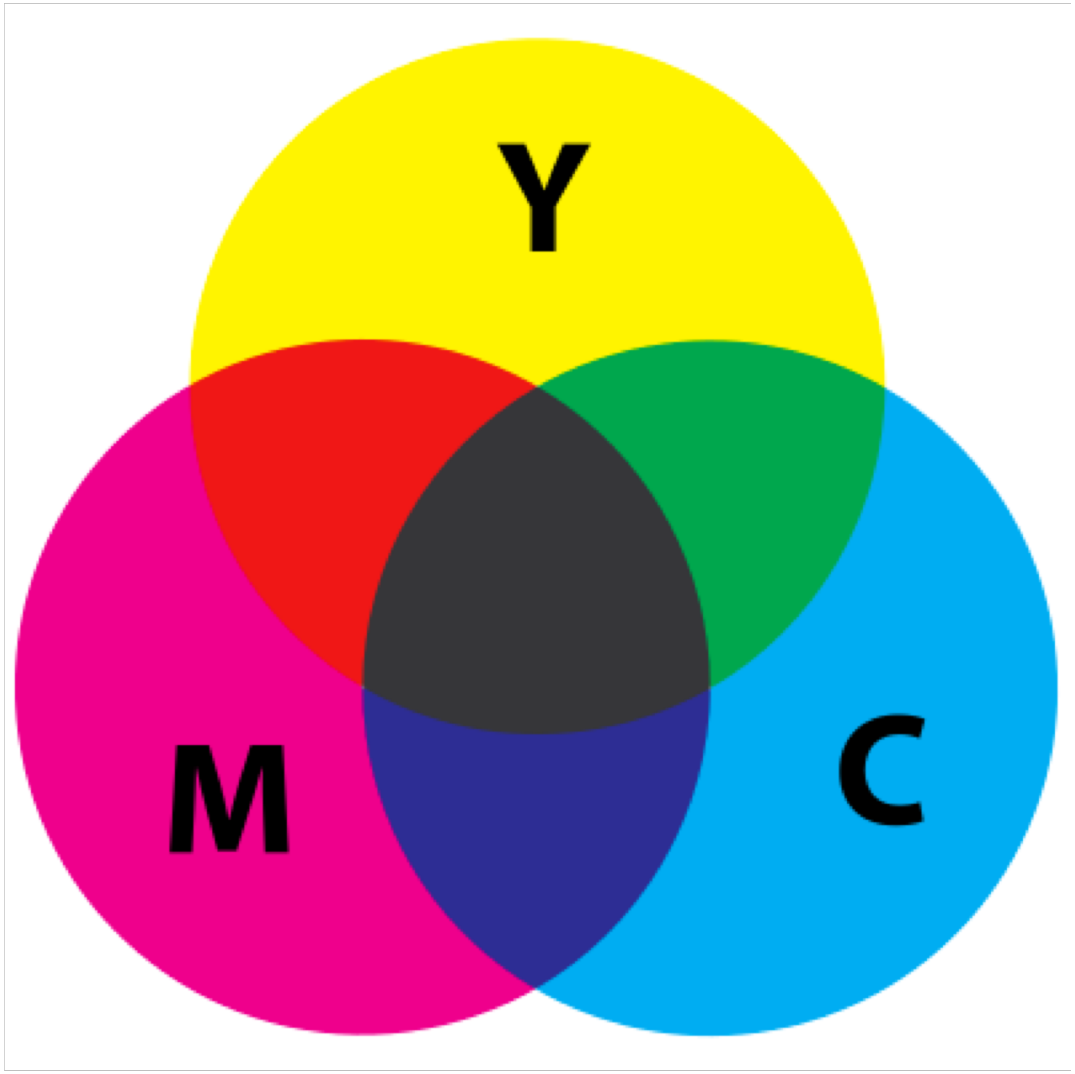
C = Cyan

M = Magenta

Y = Yellow

K = key (black)

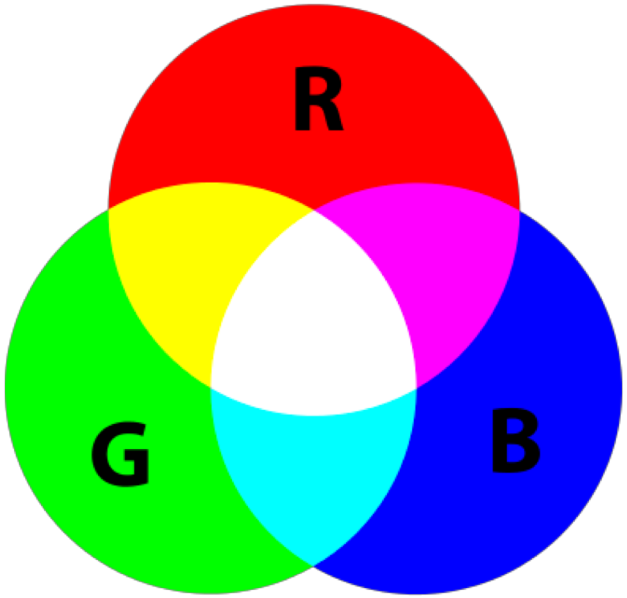
Inkjet printers contain these sets of colors, since they have been found to be better for color mixing.



Additive color mixing

- Mixing of color is done by **adding** some wavelength.
- Hence we start with black (no light) and end with white (all wavelengths)
- RGB is the best known additive color mixing model

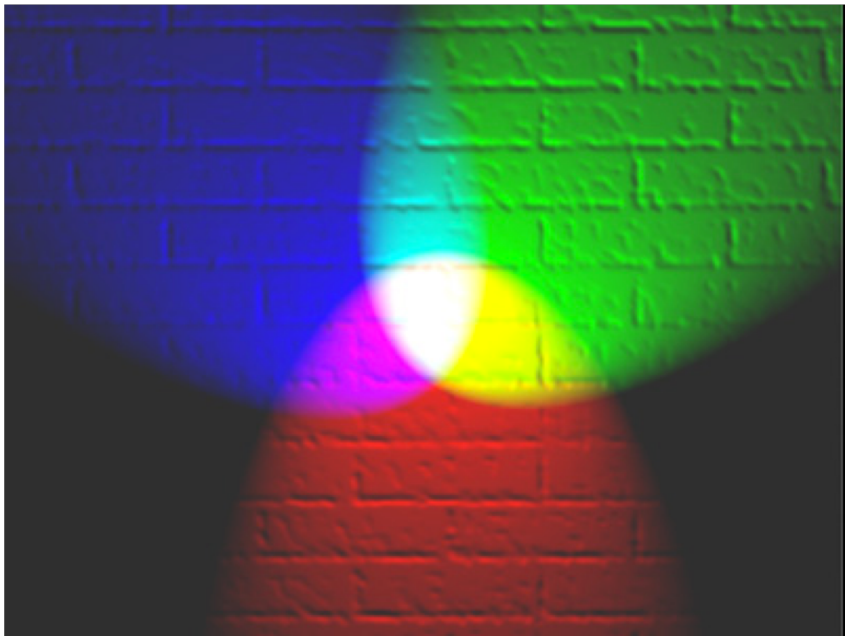
RGB color model



R = Red

G = Green

B = Blue



Digital remote sensing uses this model.

RGB

Organized as triplet of values related to the amount of red, green and blue.

If all values are 0 the outcome is black

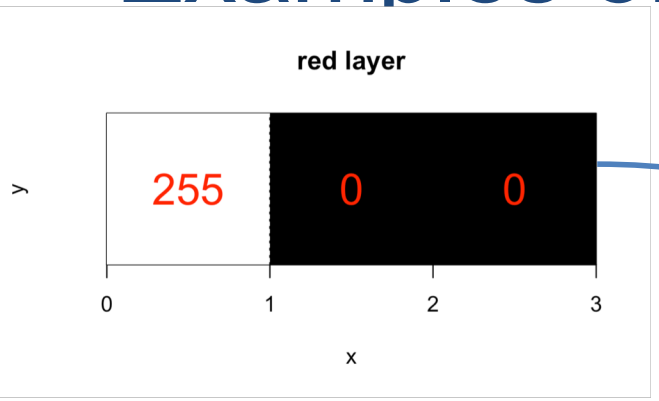
If all values have the highest possible number the outcome is white.

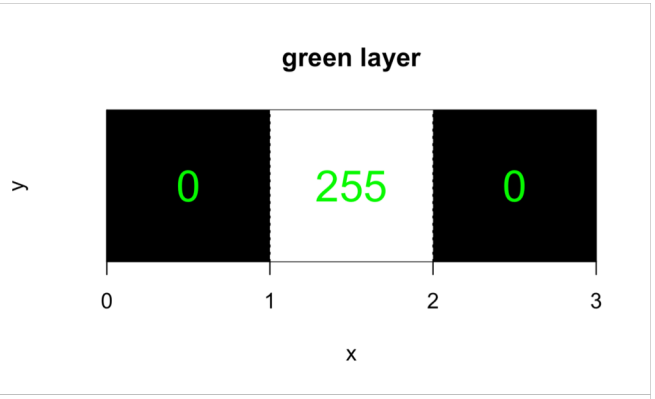
In the case of an 8bit display the values go from 0 to 255

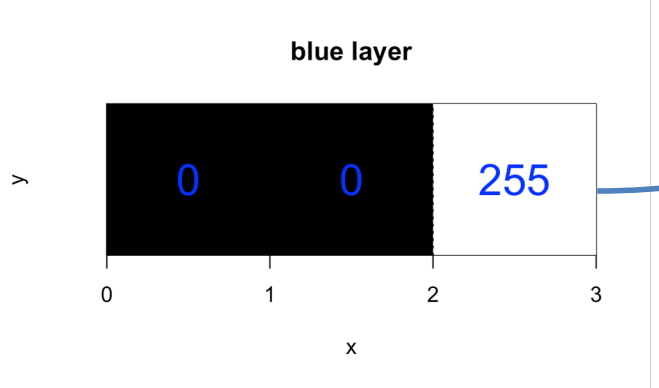
In remote sensing and GIS a RGB image is interpreted as 3 layers of pixels:

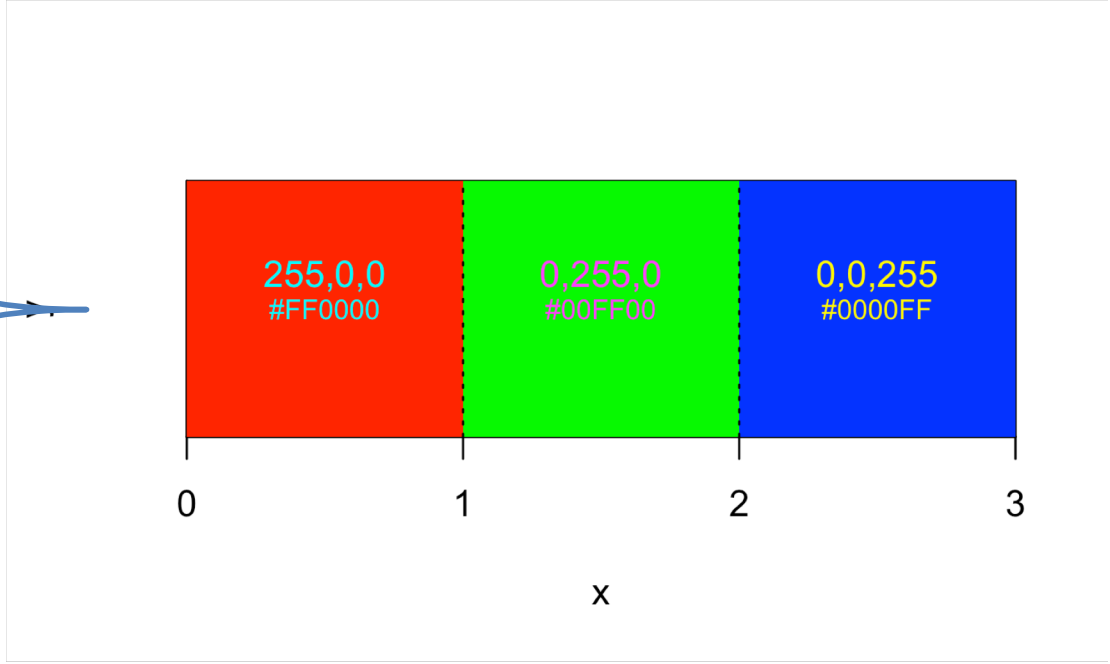
- One gray scale pixel representing the intensity of red
- One gray scale pixel representing the intensity of green
- One gray scale pixel representing the intensity of blue

Examples of RGB

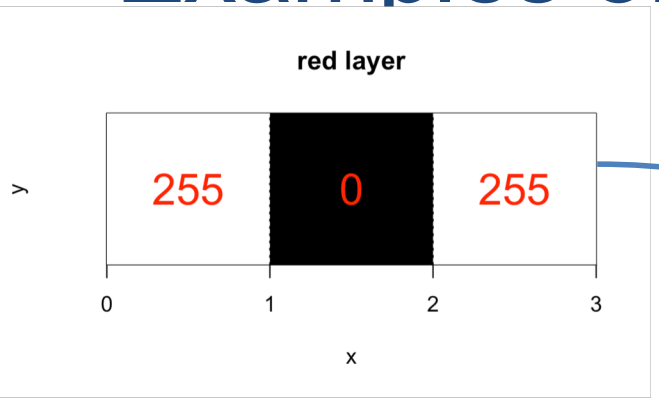


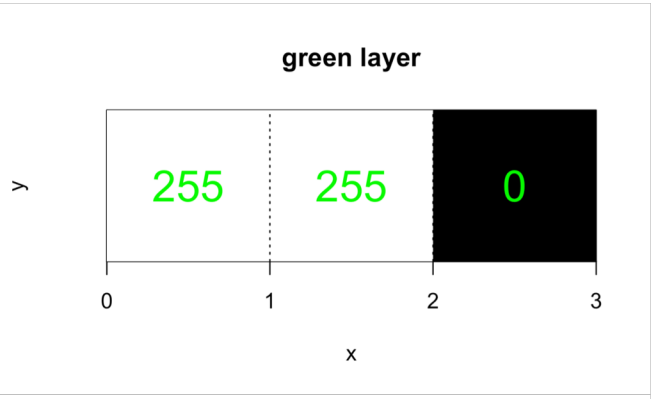


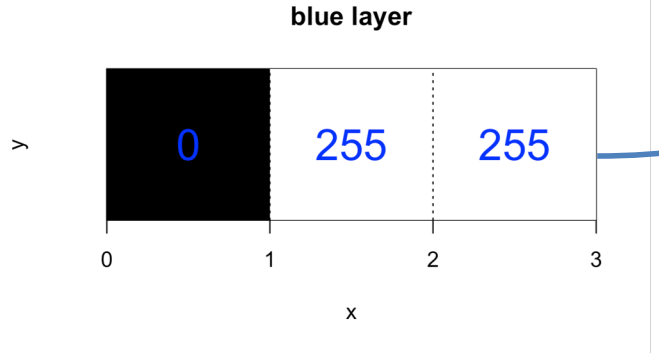


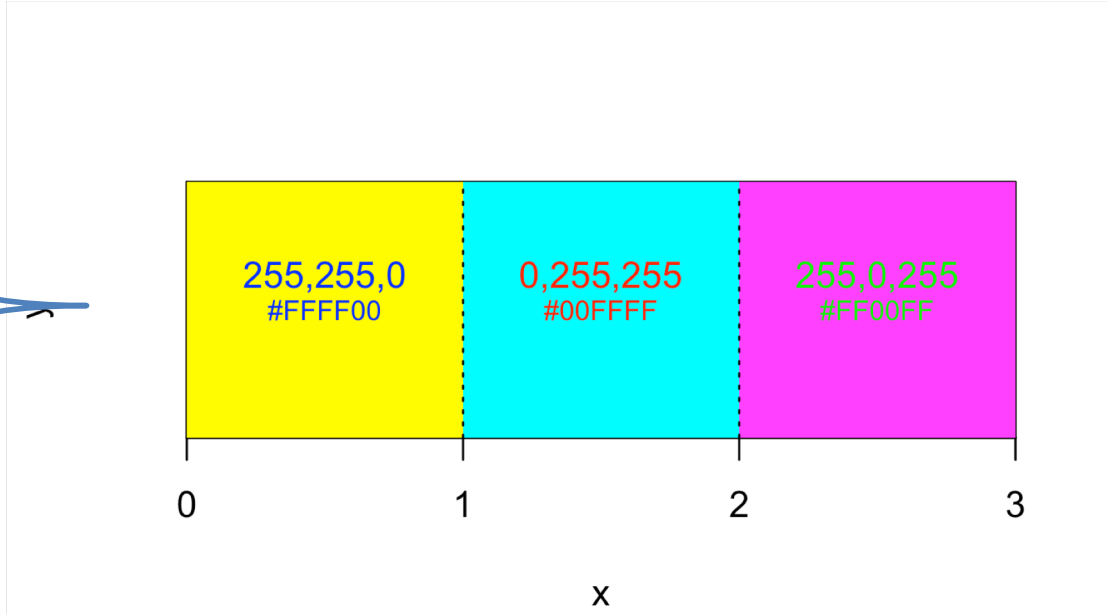


Examples of RGB

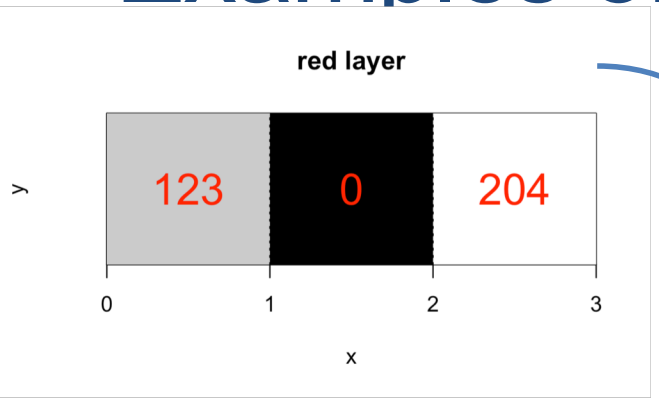


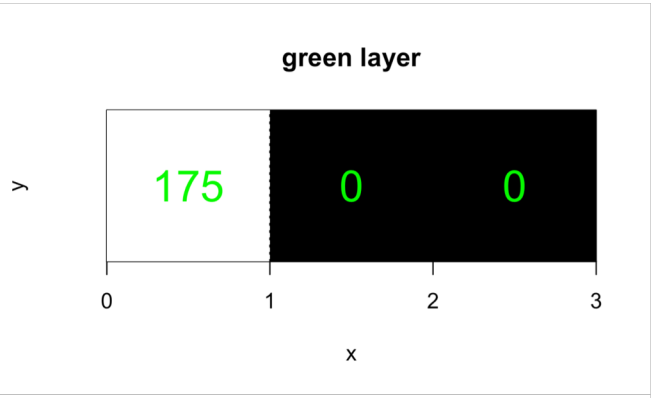


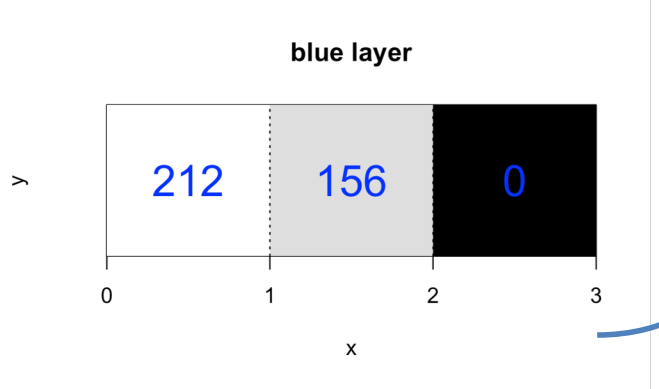


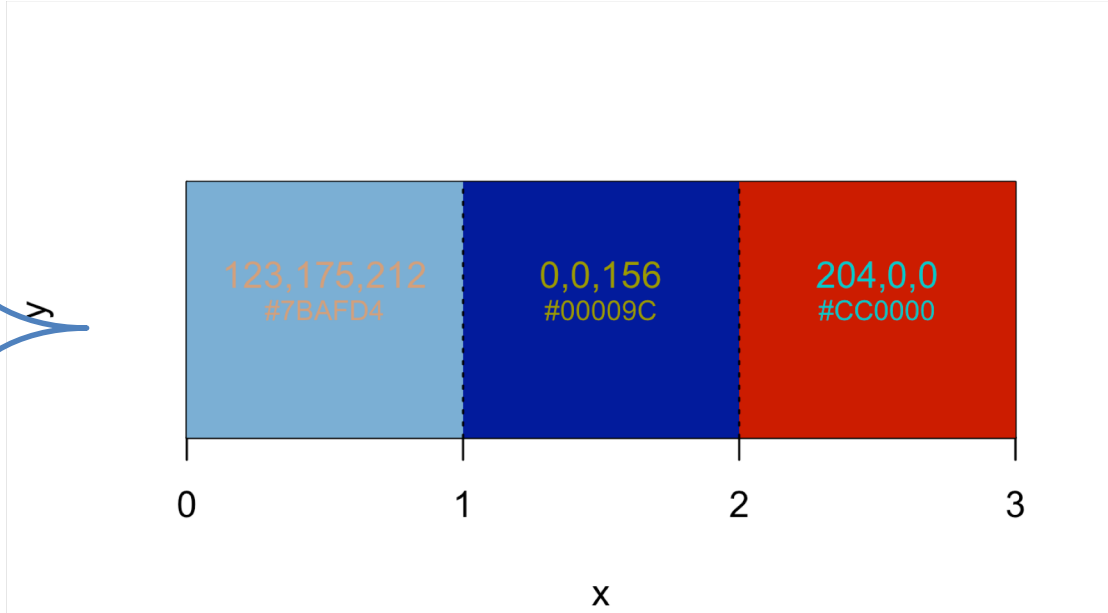


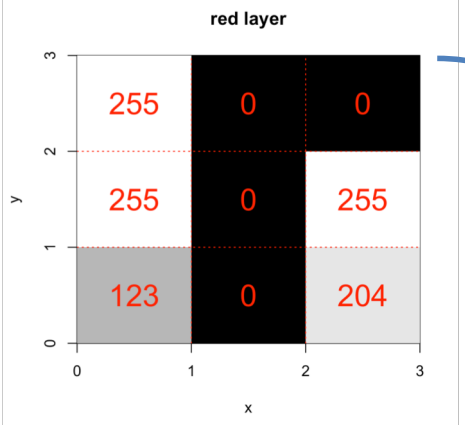
Examples of RGB







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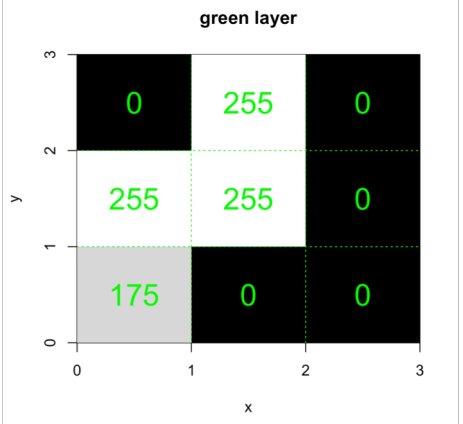
x
y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0
x
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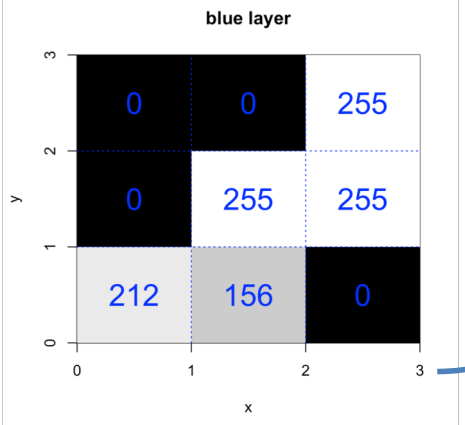
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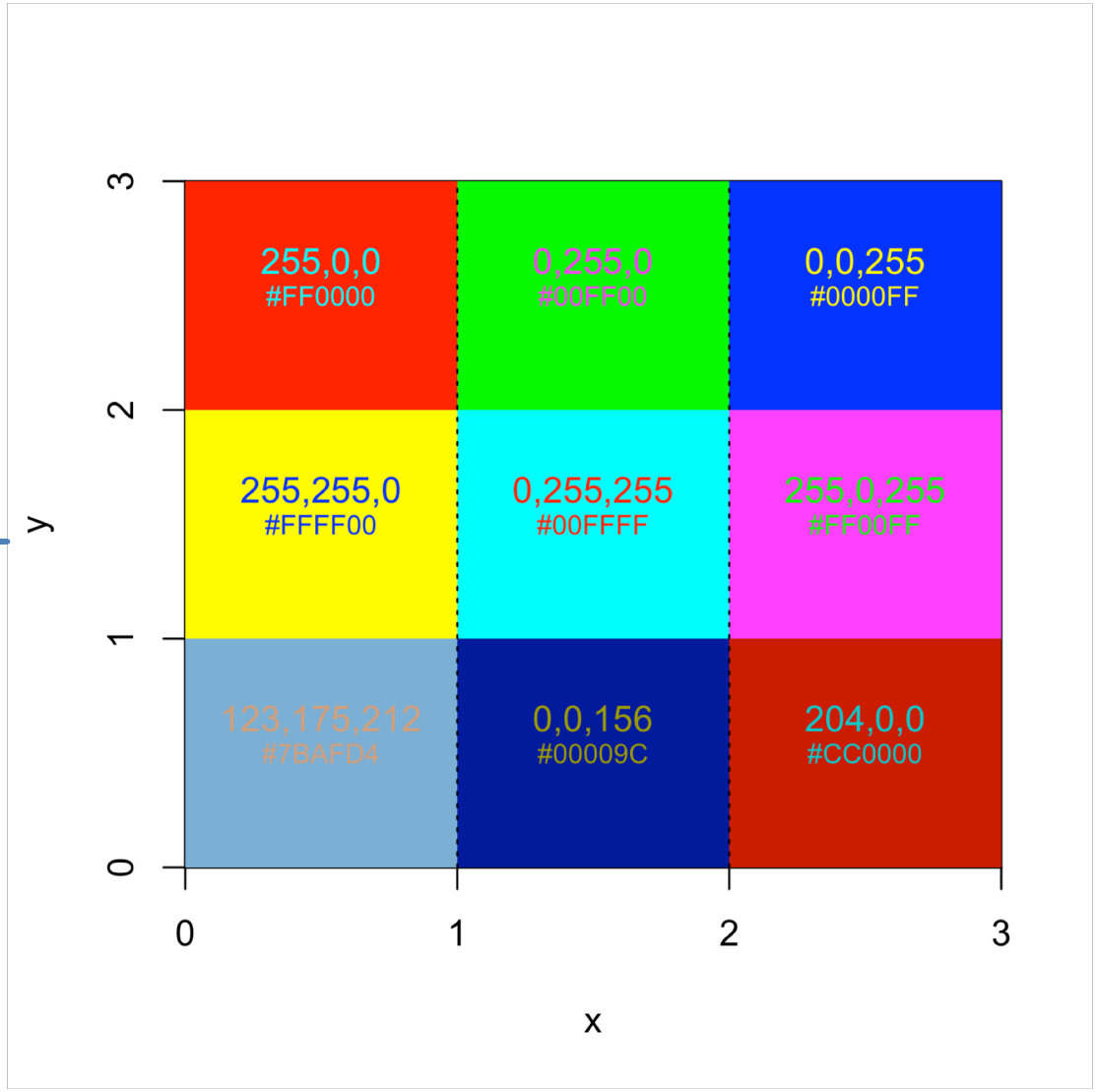
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QGIS Example

Our eyes and photoreceptors

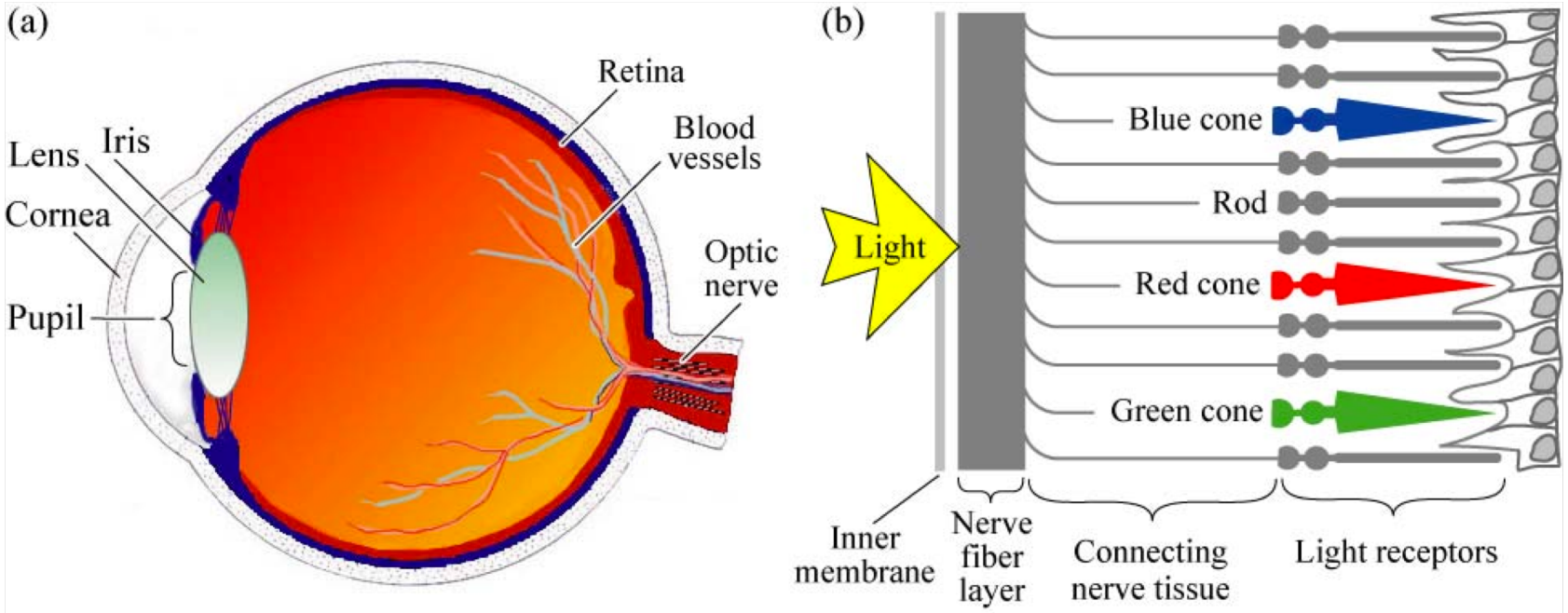


Fig. 16.1. (a) Cross section through a human eye. (b) Schematic view of the retina including rod and cone light receptors (adapted from Encyclopedia Britannica, 1994).

Photoreceptor light curve

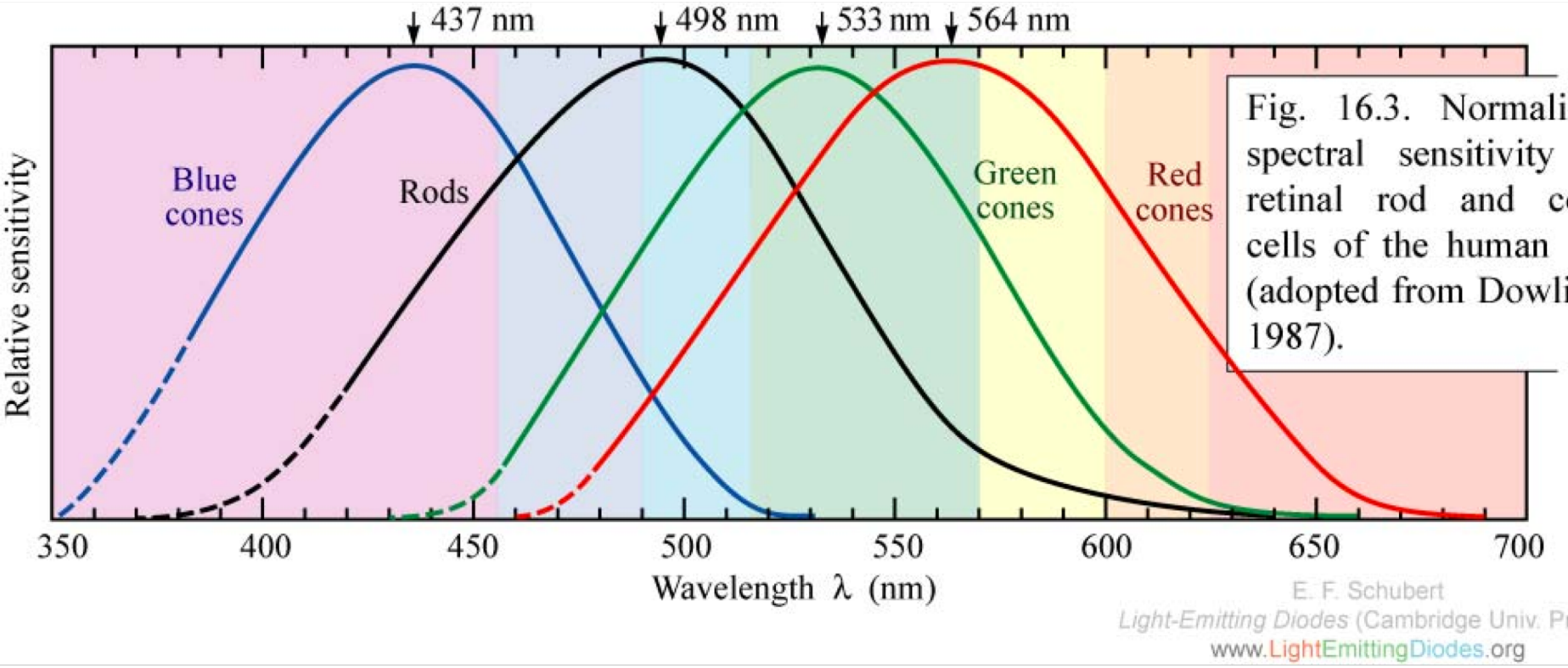
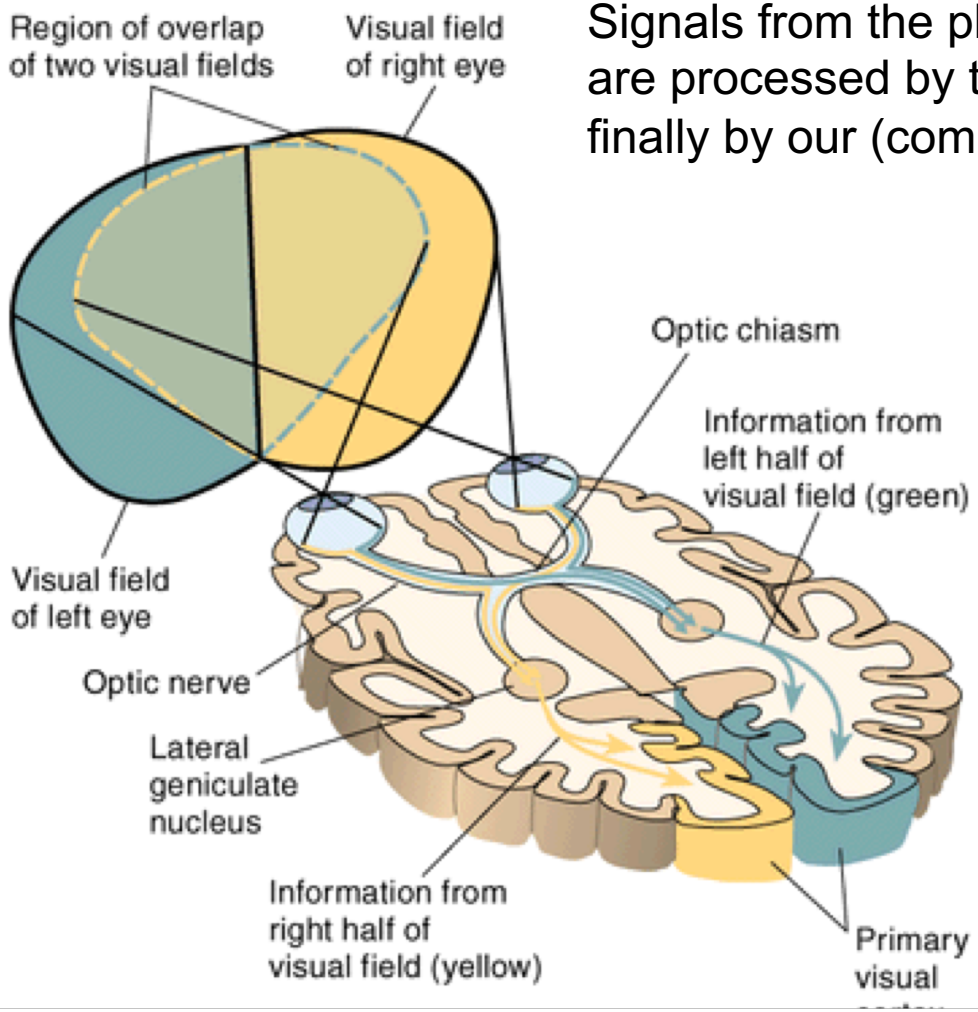


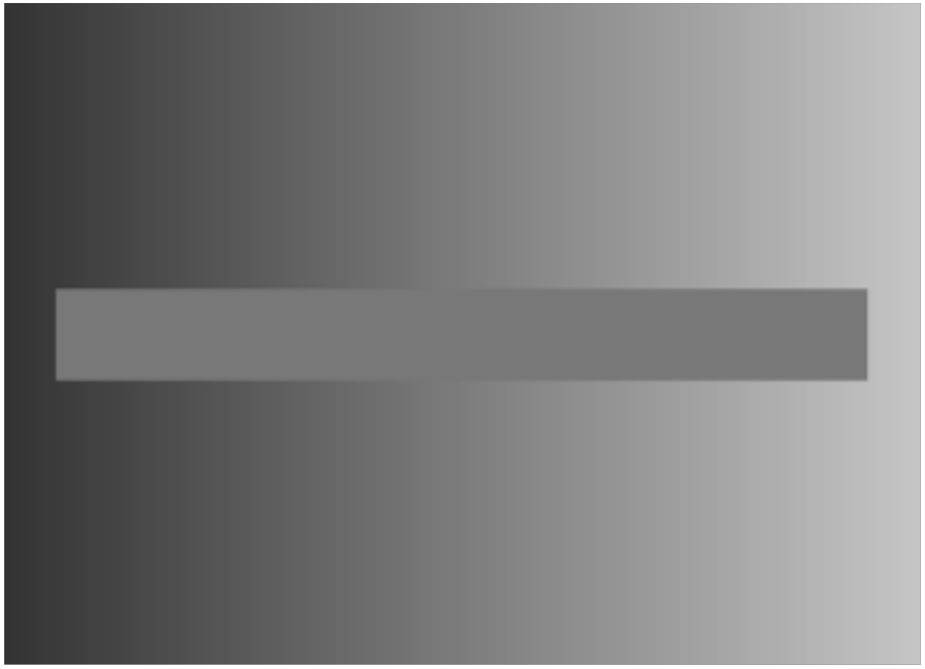
Fig. 16.3. Normalized spectral sensitivity of retinal rod and cone cells of the human eye (adopted from Dowling, 1987).

Visual signal processing

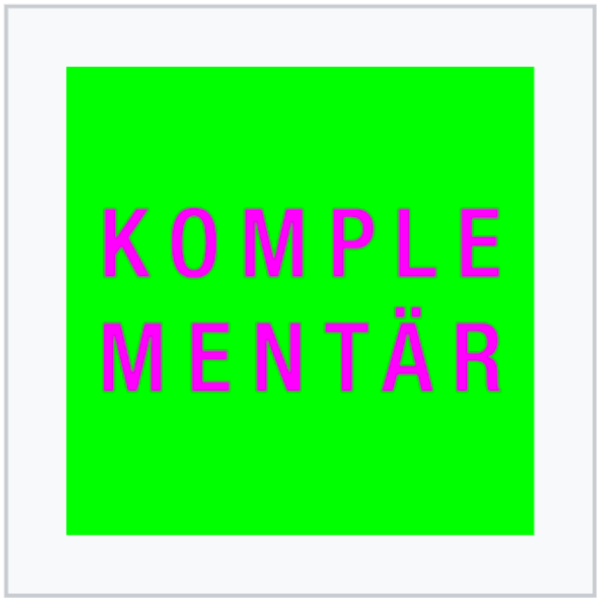


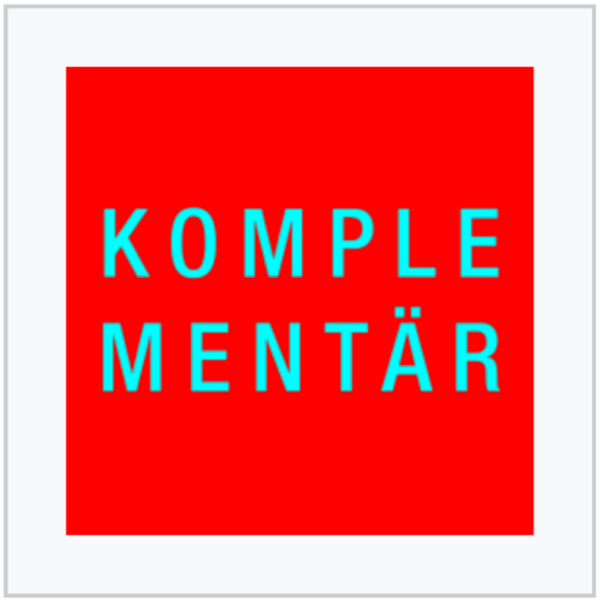
Signals from the photoreceptors are processed by the **neurons** and finally by our (complex!) **brain**

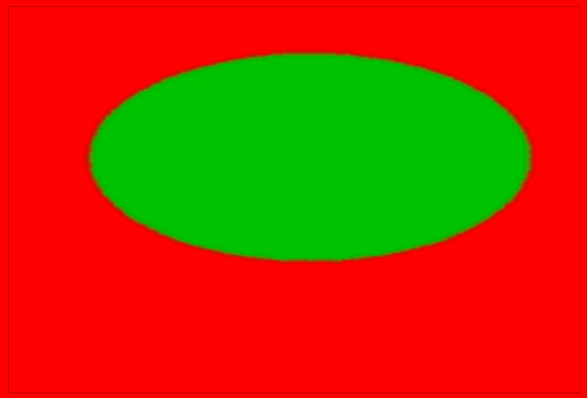
Vision and the brain

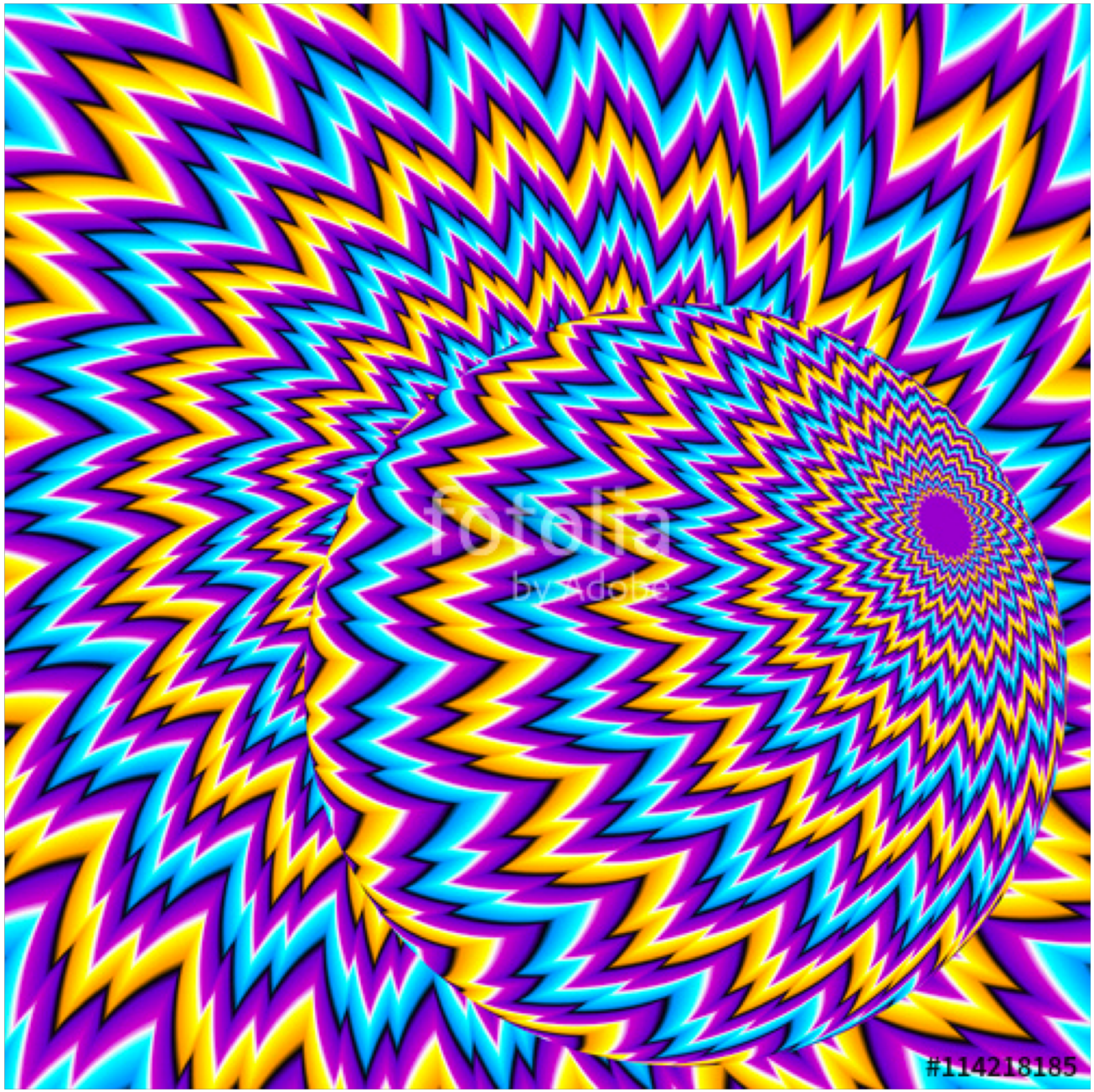


Opposing (complementary) colors





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by Adobe
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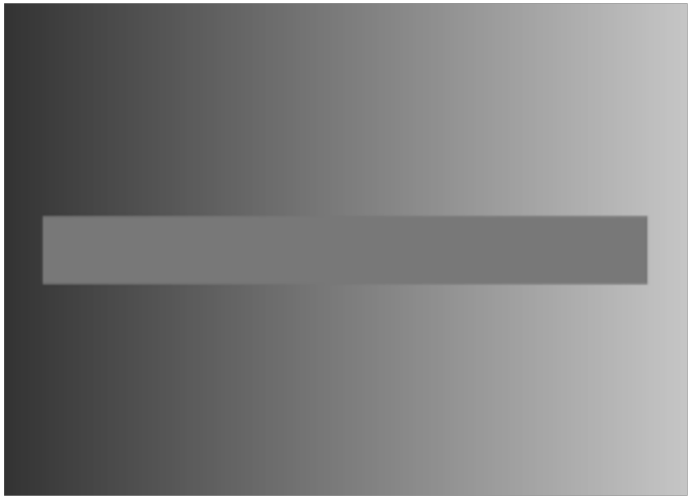
Applications to GIS and Remote Sensing

Why is all of this useful to know for GIS/remote sensing?

- The selection of colors has an effect on meaning and visual interpretation
  - colors have socially determined meanings
  - a color will have an effect on how a nearby color is perceived
  - colors and patterns allow us to understand physical and social processes

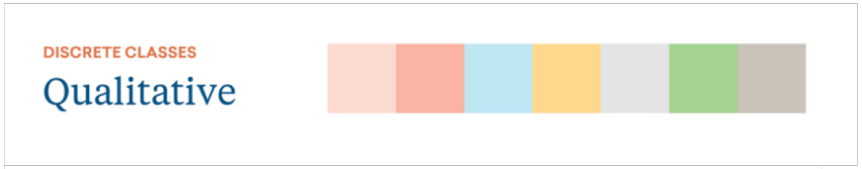
Selecting colors

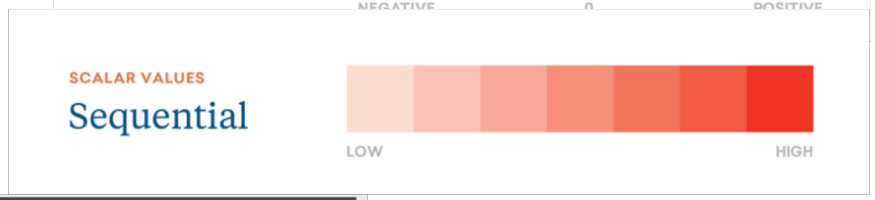
- While humans can distinguish millions of colors, it is difficult for a person to remember a legend describing what so many colors signify.
- Colors will affect the perception of neighboring colors, so the number of distinguishable color combinations is reduced.

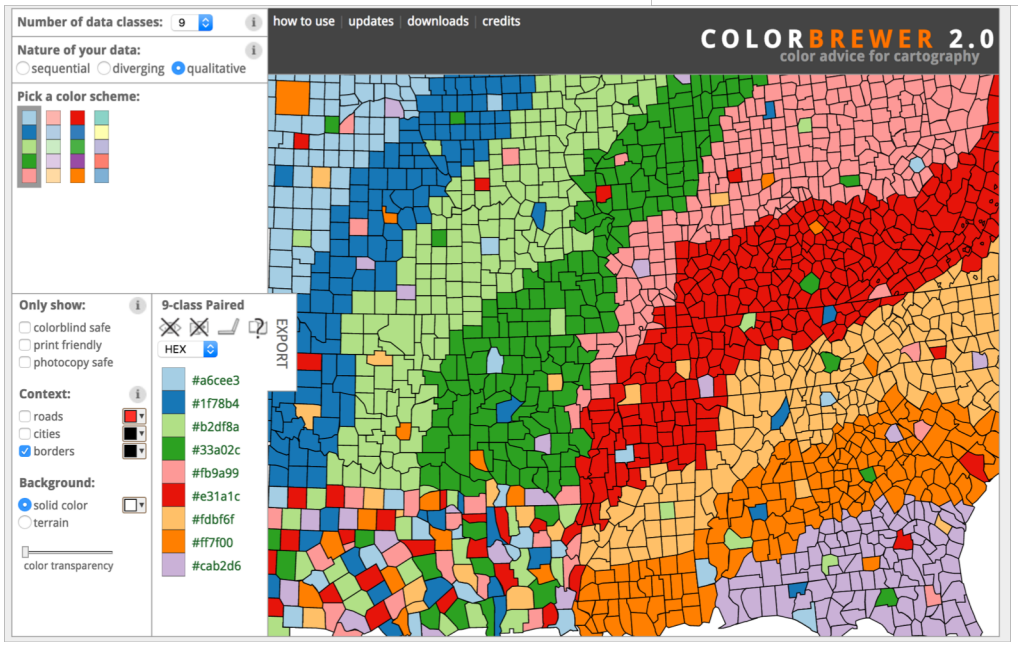


Color brewer

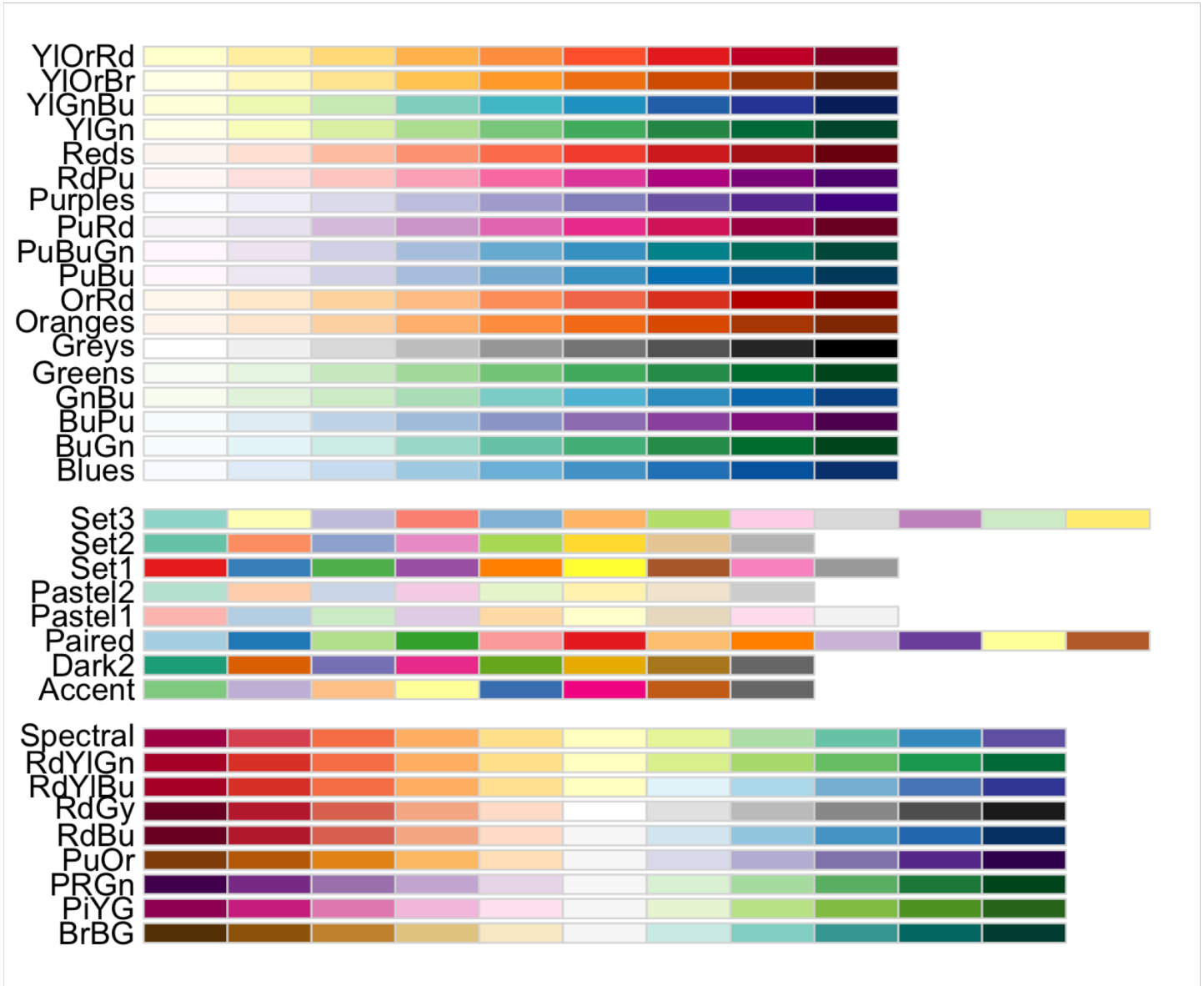
- How many colors? (rules of thumb)
  - “Qualitative?” no more than **12**
  - “Diverging?” no more than **11**
  - “Sequential?” no more than **9**



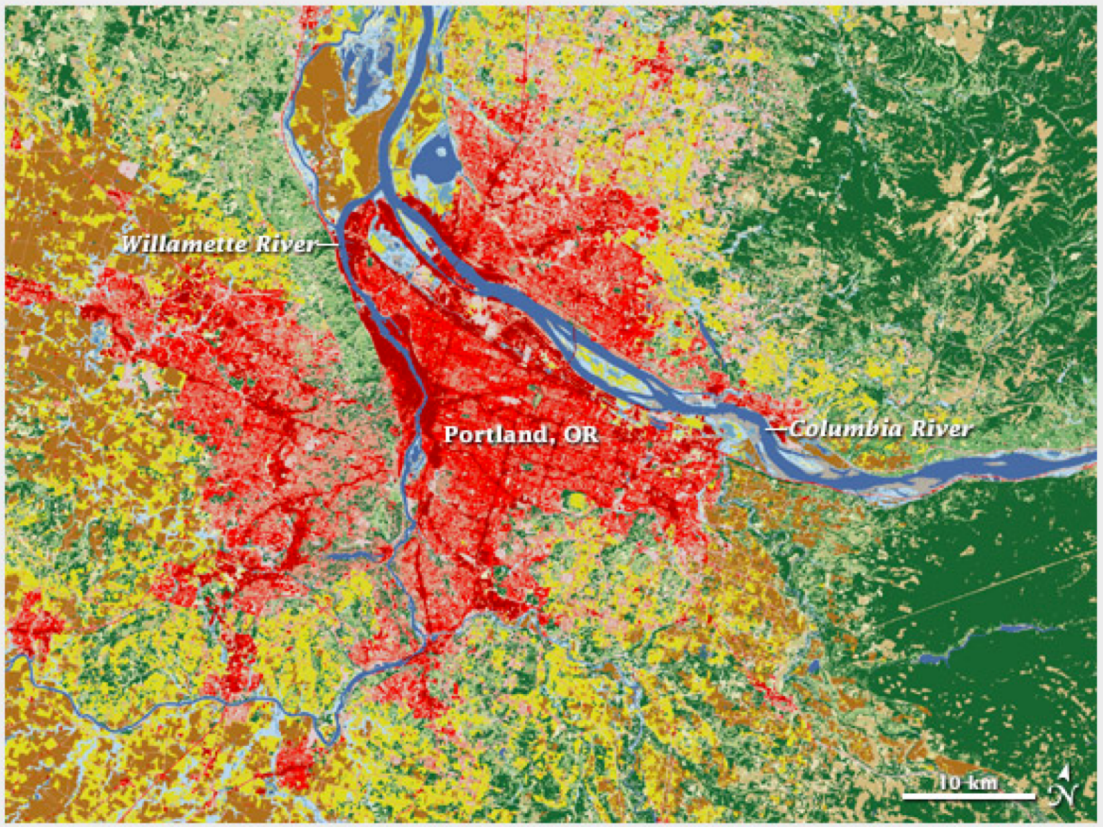




Color brewer

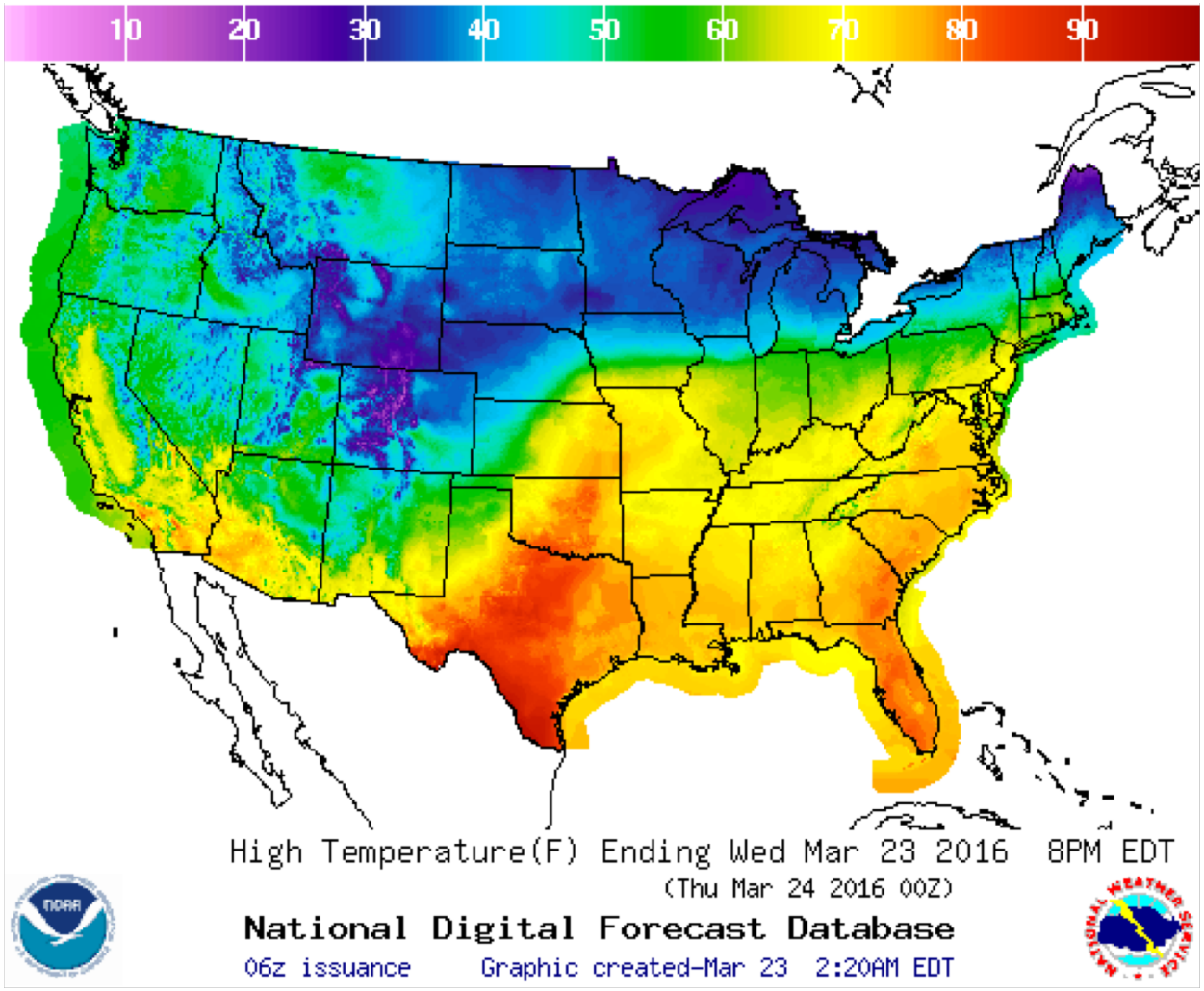


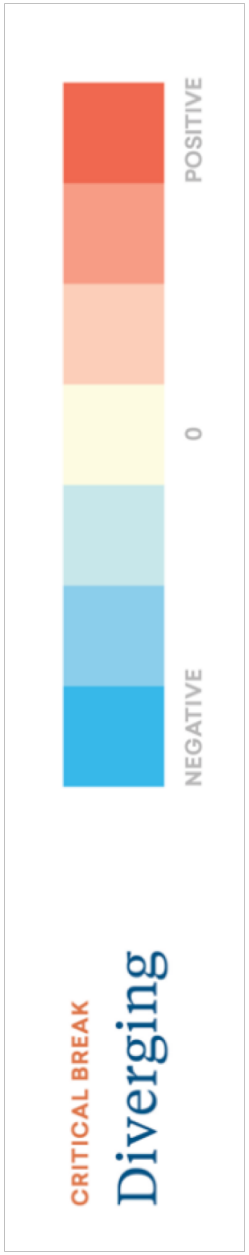
Qualitative color map example



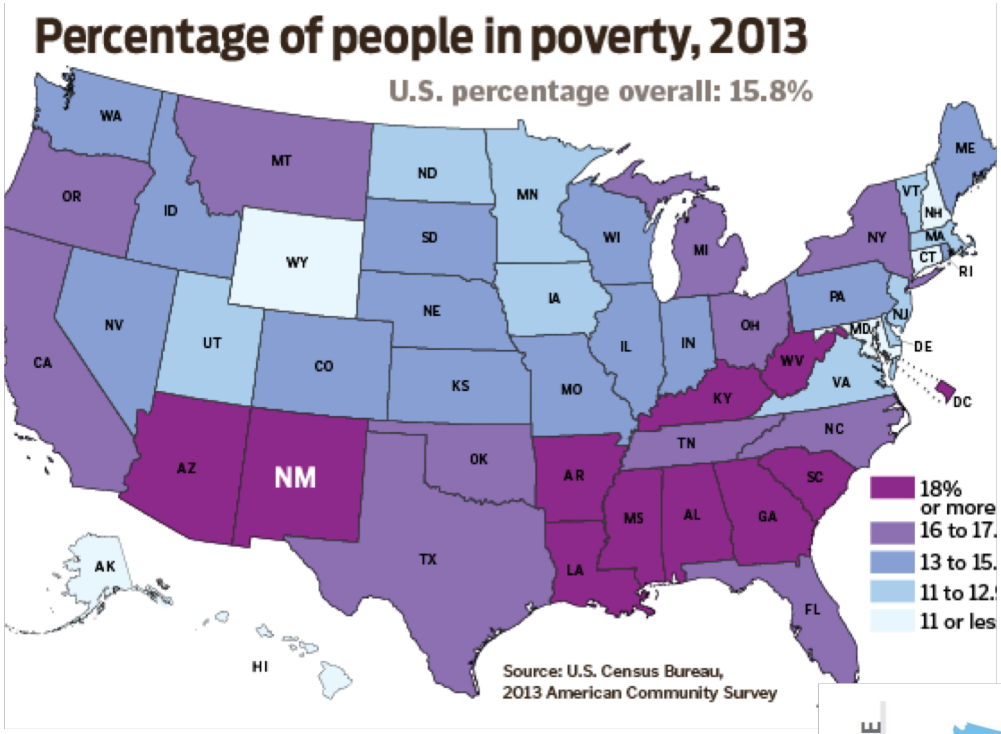
DISCRETE CLASSES
Qualitative

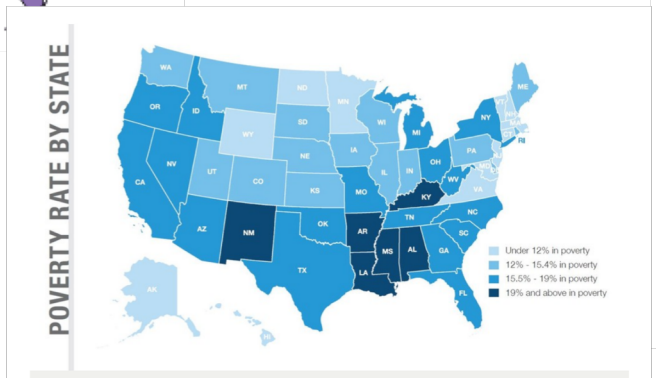
Diverging color map example



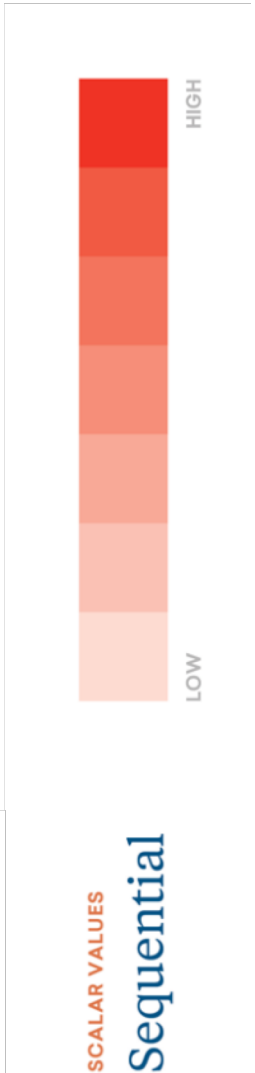


Sequential color map example





(Map courtesy of Alabama Possible)



Color in remote sensing

- Important for classification as well as visual appreciation of the image
- Information obtained through remote sensing is presented as images with a combination of RGB and (in some instances) Alpha (the transparency)
- What we select for presentation as Red, Green, Blue and Alpha will have an effect on how we appreciate/interpret the map.

Color in remote sensing