Digital image representation

- Different range
  - What can we see?
    - Human visible gamut
  - What can a sensor capture?
  - What can be displayed/printed?
    - sRGB – standardized color space for monitors, printers and the Internet.

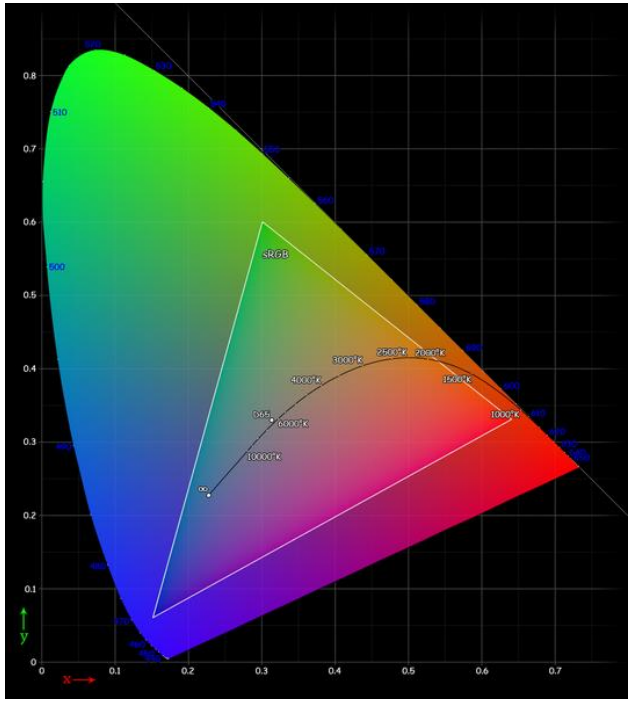
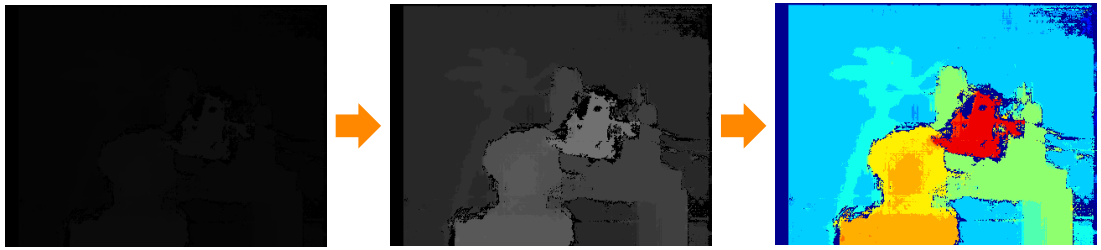


Image from Wikipedia

- Application?
  - Interpretation
    - Human vs computer
  - Display

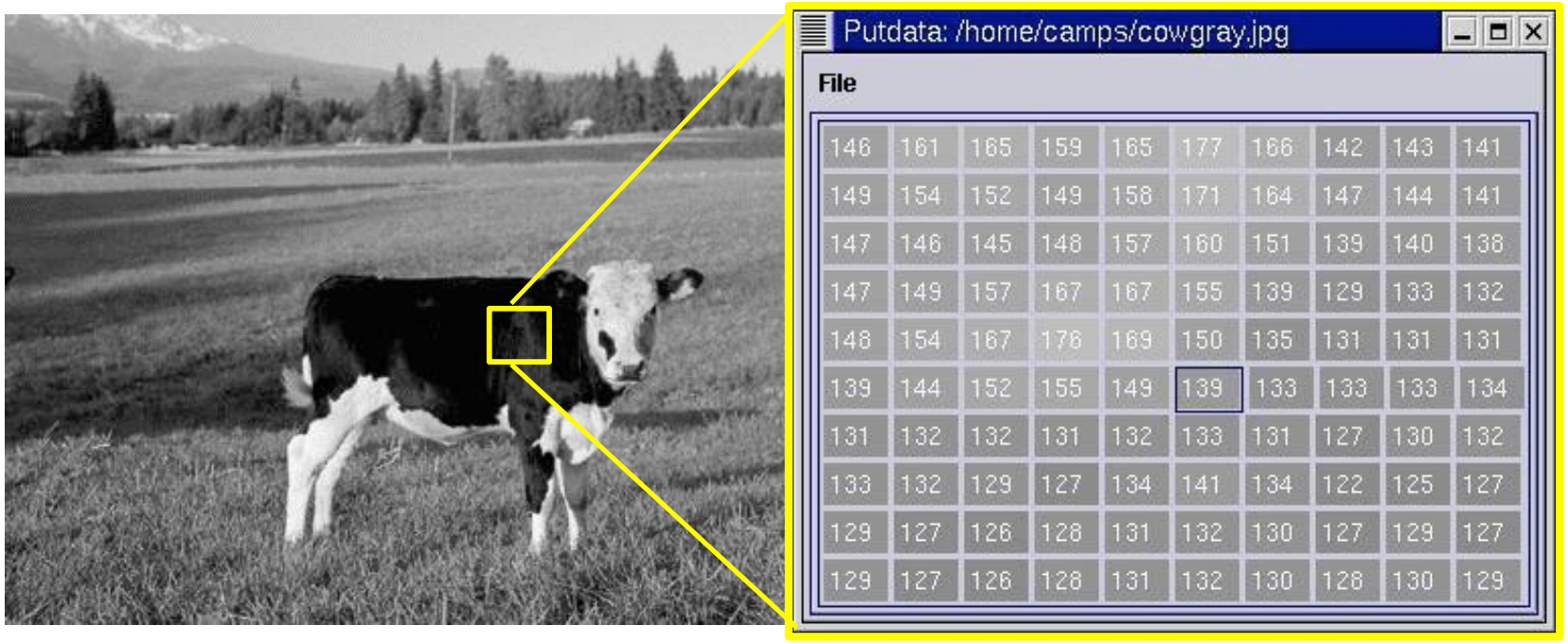


4-bit (0-15) 8-bit (0-255) 24-bit, 3 colors

Image representation – Gray scale

Intensity pattern

2d array of numbers



We “see it” at this level

Computer works at this level

What is the value of a white pixel? And black?

Image representation – RGB

- RGB color space
  - A triplet
  - 8-bit [0, 255]
  - Float [0.0, 1.0]
- RGB image
  - One plane per color
  - r*c*p, where p = 3

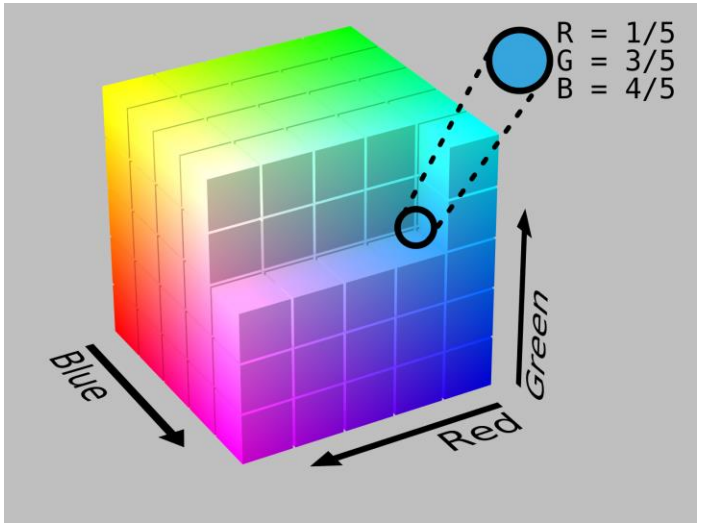
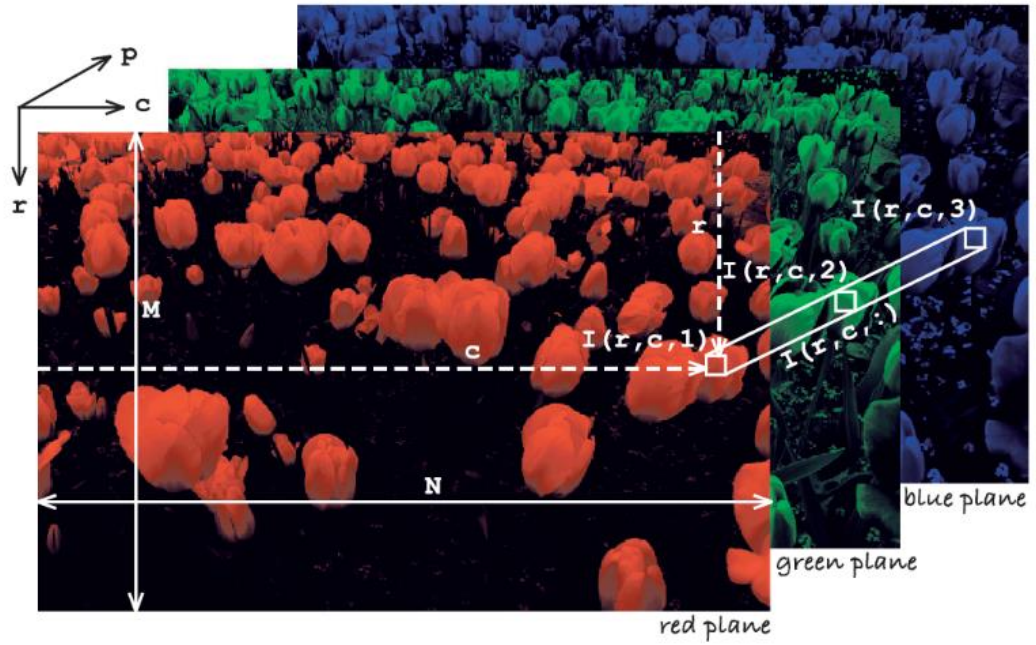


Image from Wikipedia



Assuming a color depth of 8-bits, what is the representation of red?
If we have floating point values, what is the represenation of white?

RGB to Intensity/Luma

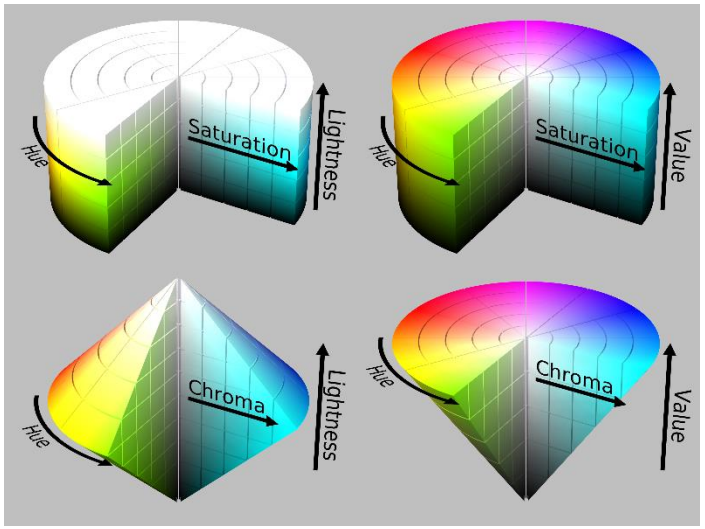
- Average?
  - I = (R+G+B)/3
- Yes, but the human eye is not equally sensitive to all colors. Matlab documentation:

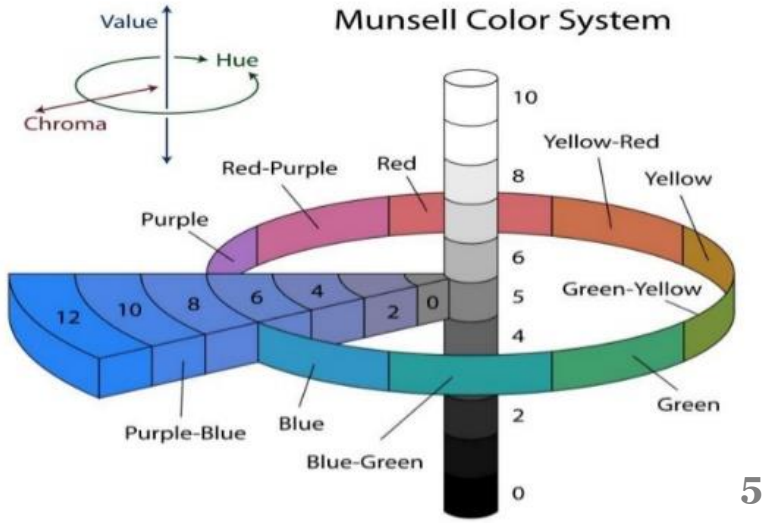
> rgb2gray converts RGB values to grayscale values by forming a weighted sum of the *R*, *G*, and *B* components:
> 0.2989 * R + 0.5870 * G + 0.1140 * B
> These are the same weights used by the rgb2ntsc function to compute the *Y* component.
> The coefficients used to calculate grayscale values in rgb2gray are identical to those used to calculate luminance (E'y) in Rec.ITU-R BT.601-7 after rounding to 3 decimal places.
> Rec.ITU-R BT.601-7 calculates E'y using the following formula:
> 0.299 * R + 0.587 * G + 0.114 * B

- I = 0.2989 * R + 0.5870 * G + 0.1140 * B ← **Luma**

Image representation
HSL & HSV (HCL & HCV)

- More human aligned color representation
- HSV – how colors of paint mix (Matlab)
- HSL – how colors are perceived (Munsell; coloring of TV)
- Hue – dominant color
- Saturation – color purity (relative to white)
- Chroma – color purity (relative to own brightness)
- V for value – L for Lightness





RGB to HSV

- Hue

Chroma

$$M = \max(R, G, B)$$
$$m = \min(R, G, B)$$
$$C = \text{range}(R, G, B) = M - m$$

$$H' = \begin{cases} \text{undefined}, & \text{if } C = 0 \\ \frac{G-B}{C} \bmod 6, & \text{if } M = R \\ \frac{B-R}{C} + 2, & \text{if } M = G \\ \frac{R-G}{C} + 4, & \text{if } M = B \end{cases}$$

$$H = 60^\circ \times H'$$

What is H for red, green and blue?

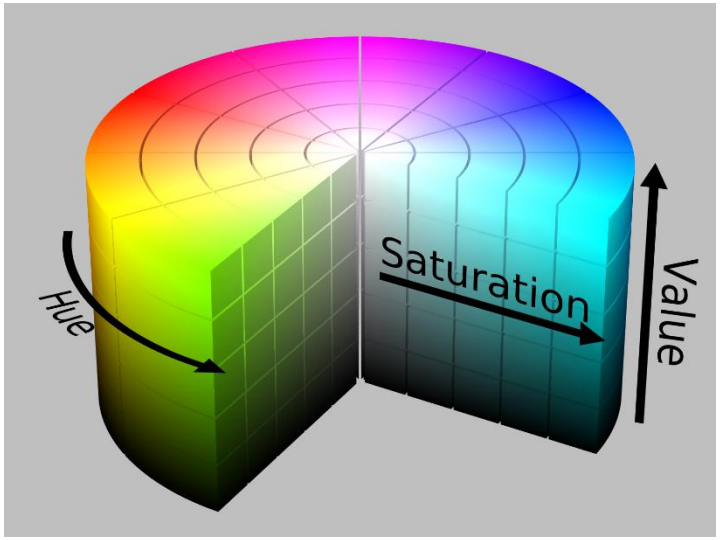
- Value

$$V = \max(R, G, B) = M$$

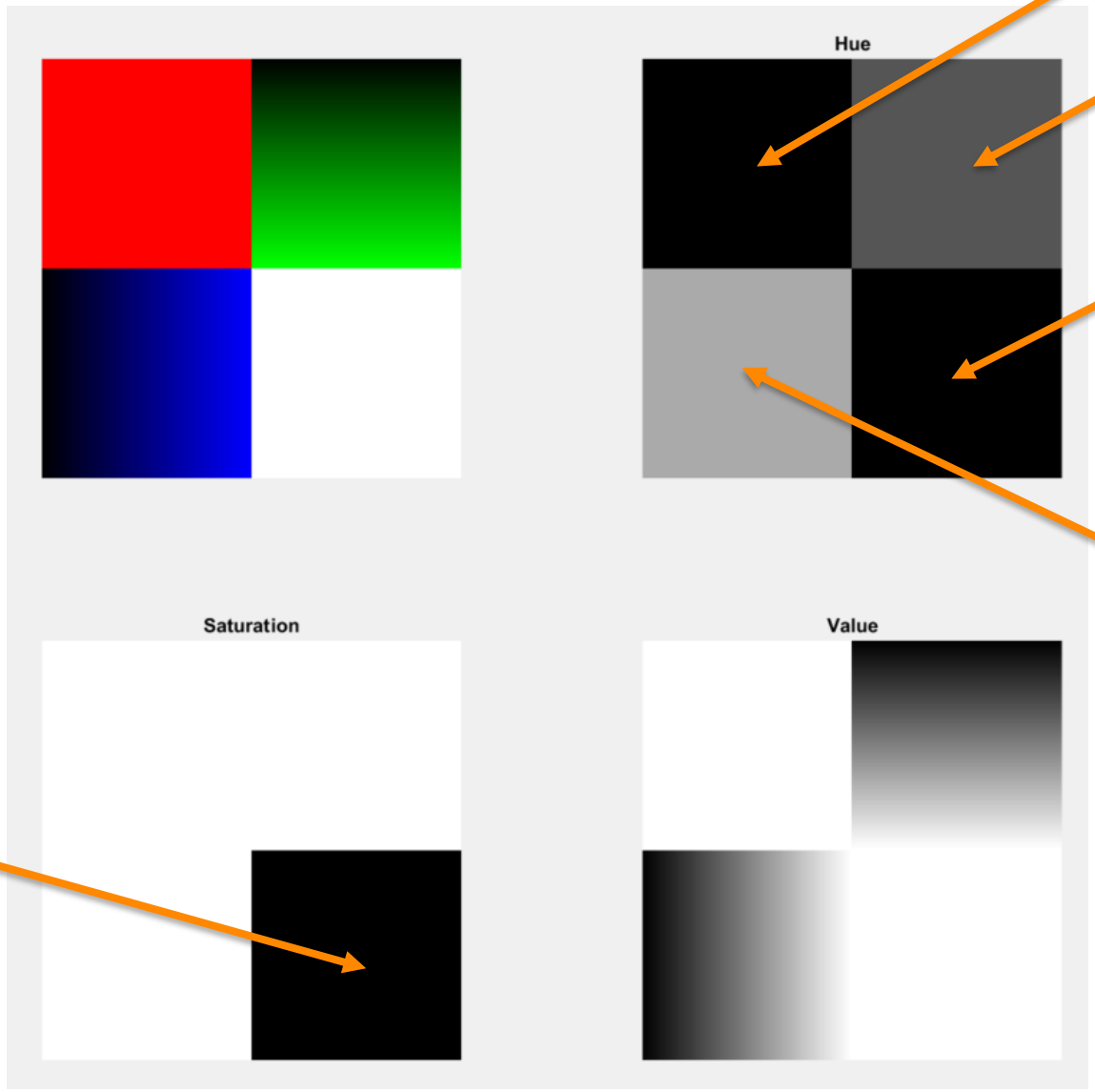
- Saturation

$$S_V = \begin{cases} 0, & \text{if } V = 0 \\ \frac{C}{V}, & \text{otherwise} \end{cases}$$

What is the range of S?



HSV (Matlab, rgb2hsv)



0

1/3 = 120 deg

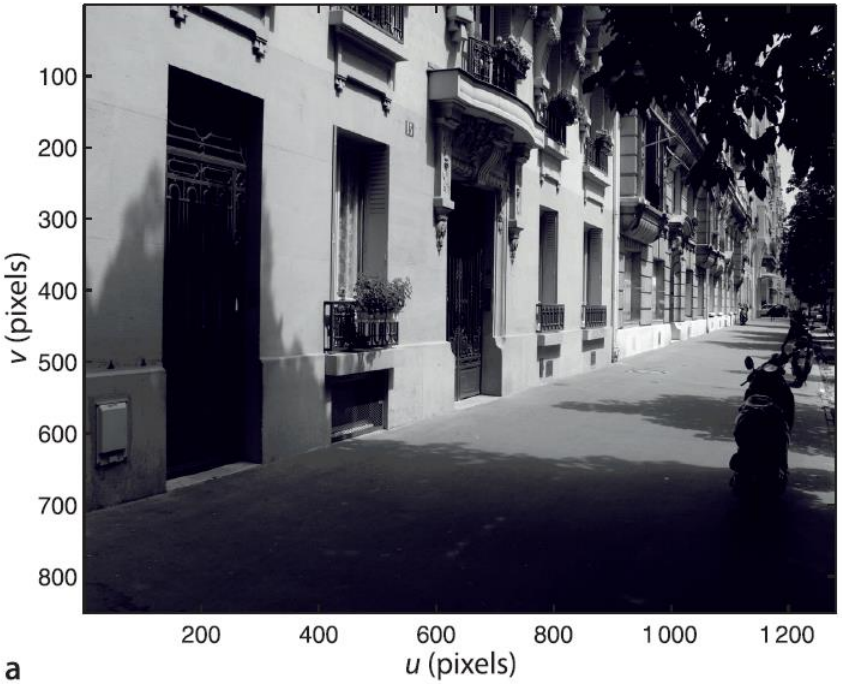
undefined

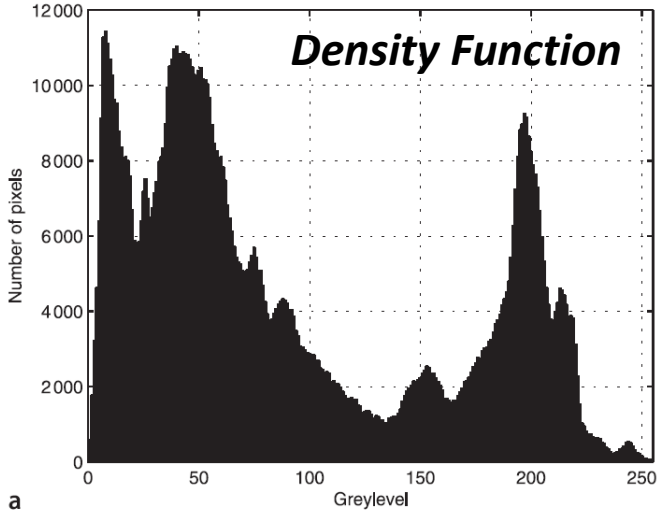
2/3 = 240 deg

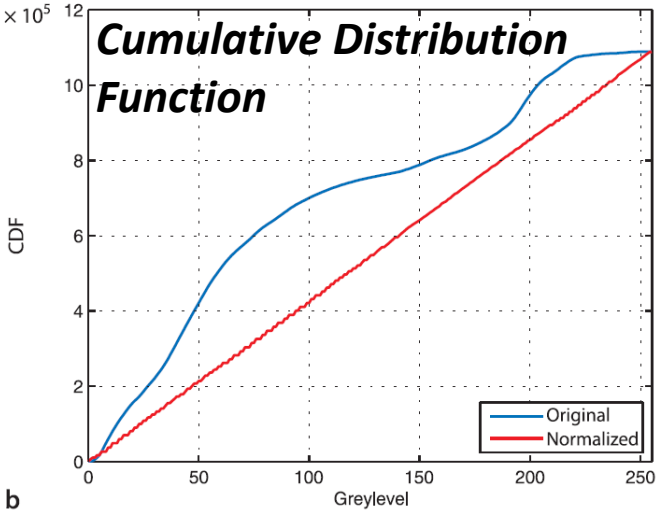
Center of cone

Histogram

- Channel distribution

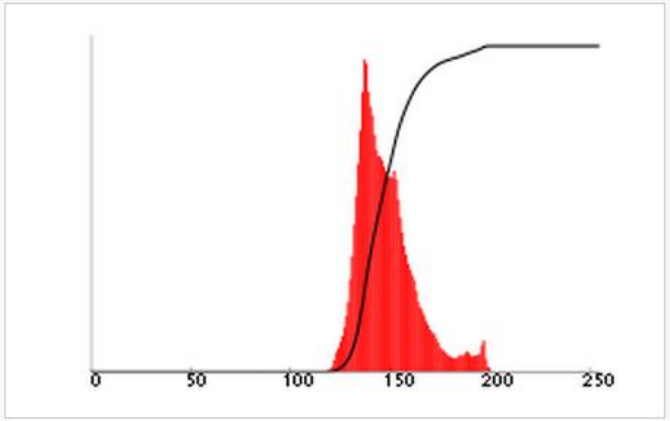






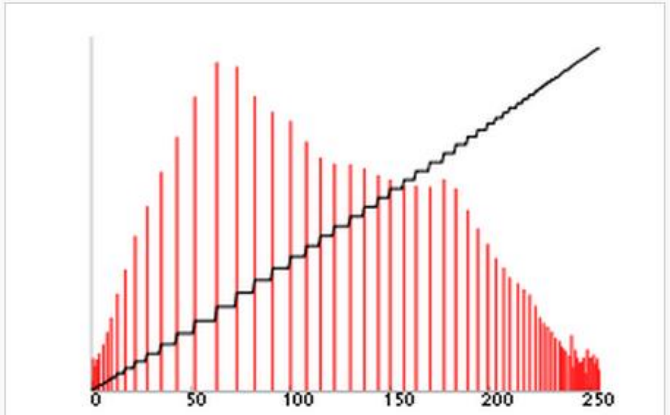
Histogram equalization

An unequalized image



Corresponding histogram (red) and cumulative histogram (black)

The same image after histogram equalization



Corresponding histogram (red) and cumulative histogram (black)