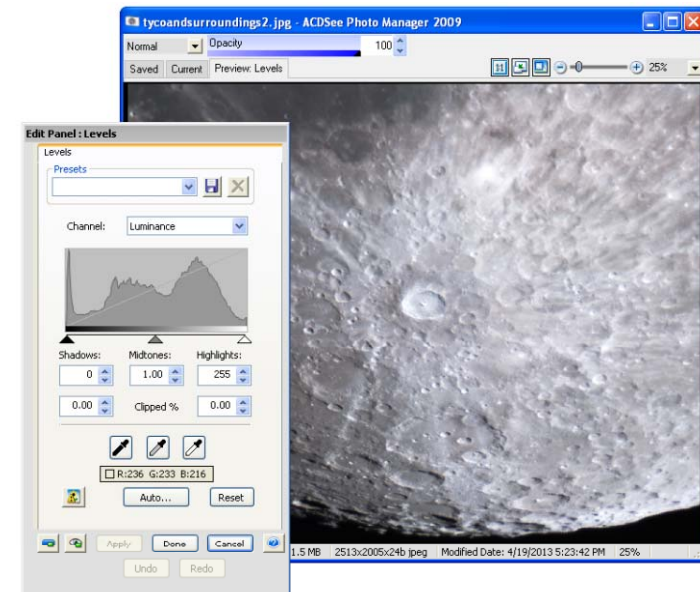


# What the Heck is a Histogram?

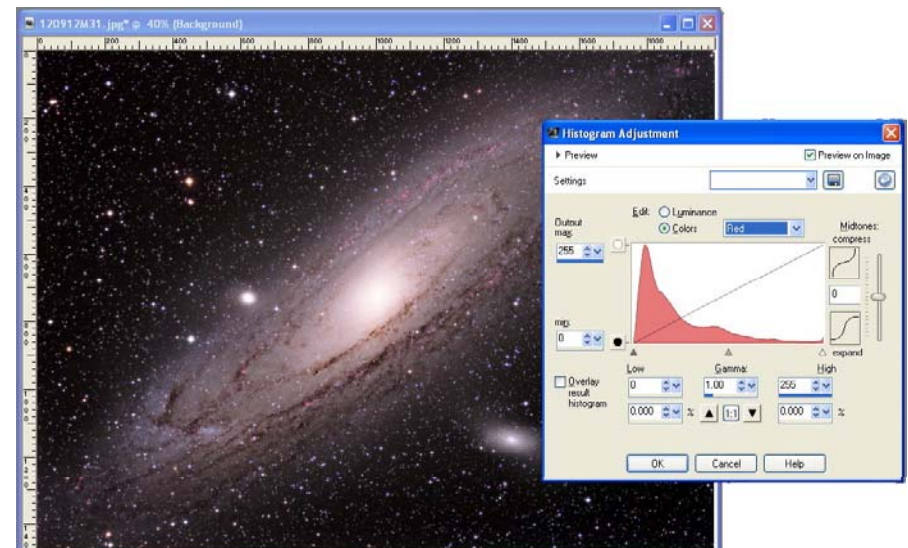
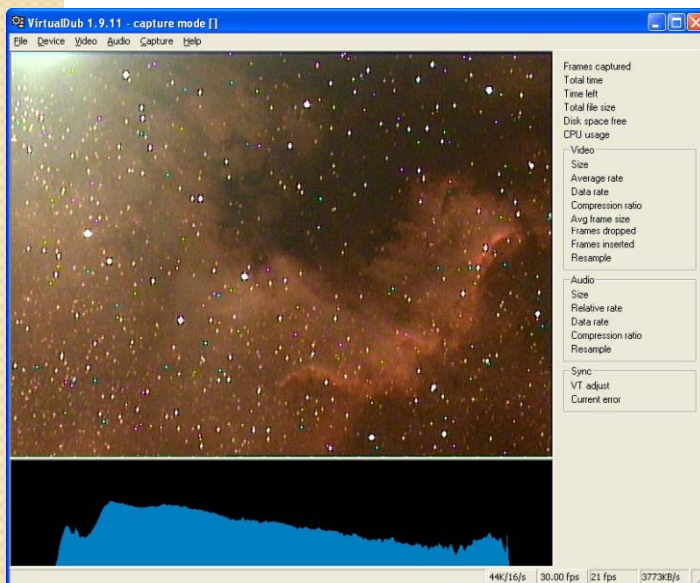
*(And how do I use it?)*

OAOG Workshop #5

Jim Thompson



M31 by Tony Peterson <http://gemmacaelestis.ca/astro.html>



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Something is wrong with  
these images!



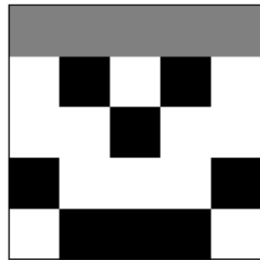
*Histogram to the rescue!...but first...*

# What is a histogram?

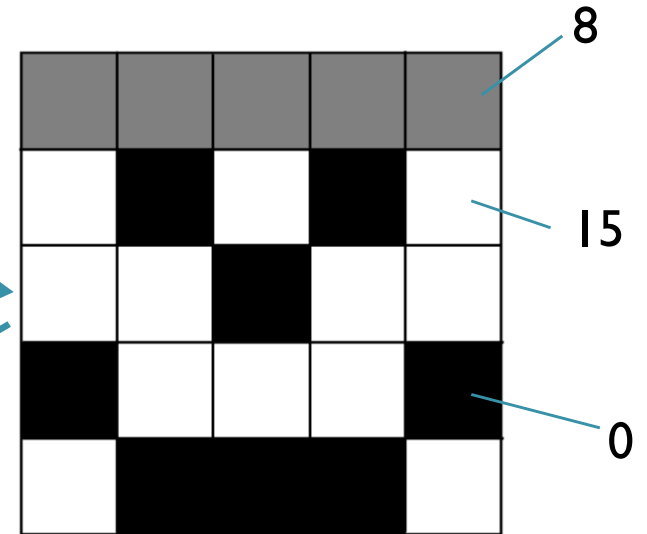
- “A graphical representation of the **frequency** distribution of a **variable** in a body of **data**”
- In our case:
  - Frequency = number of occurrences
  - Variable = pixel colour or intensity
  - Data = our image



# A Simple Histogram



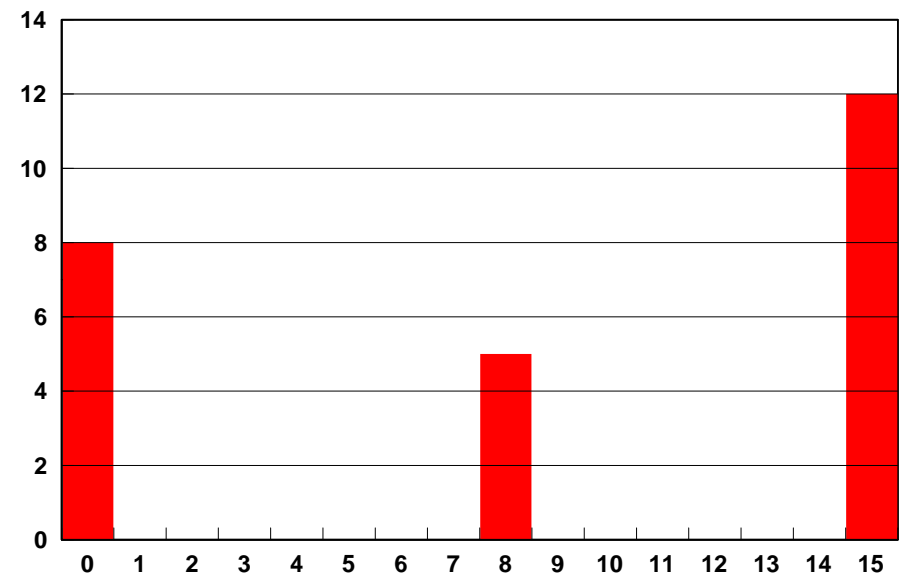
1. Consider this small simple 4-bit greyscale image.



2. Examine each pixel in the image individually, what colour/intensity is it?

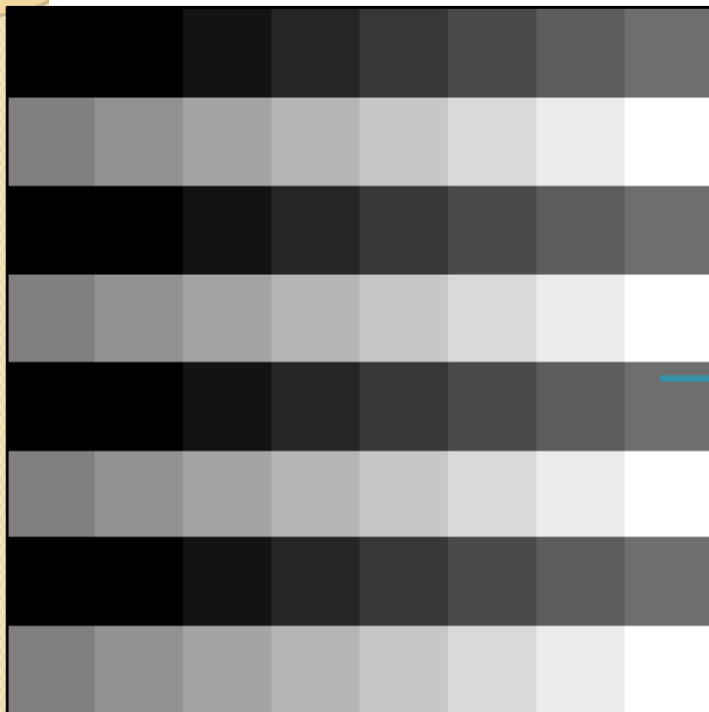
1	2	3	4	5
1	1	2	2	3
4	5	3	6	7
4	8	9	10	5
11	6	7	8	12

3. Count how many pixels of each colour/intensity there are.

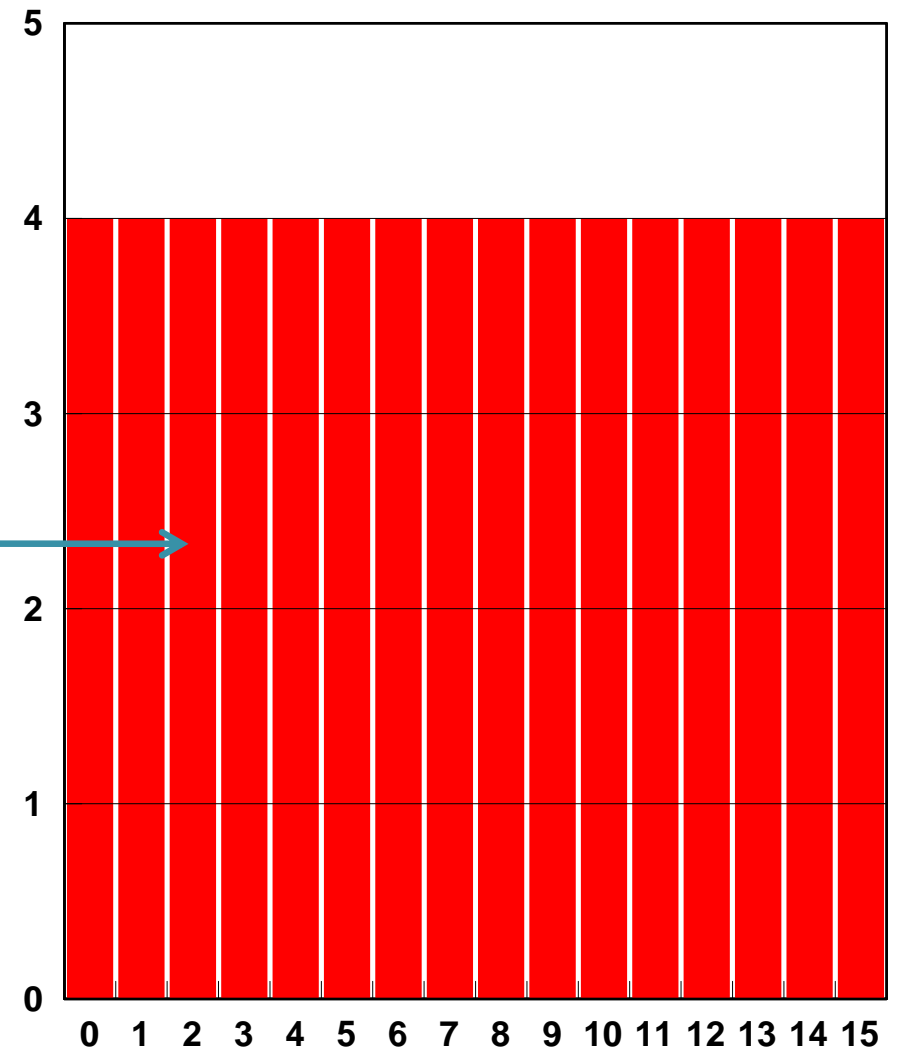


4. Plot results to get a histogram.

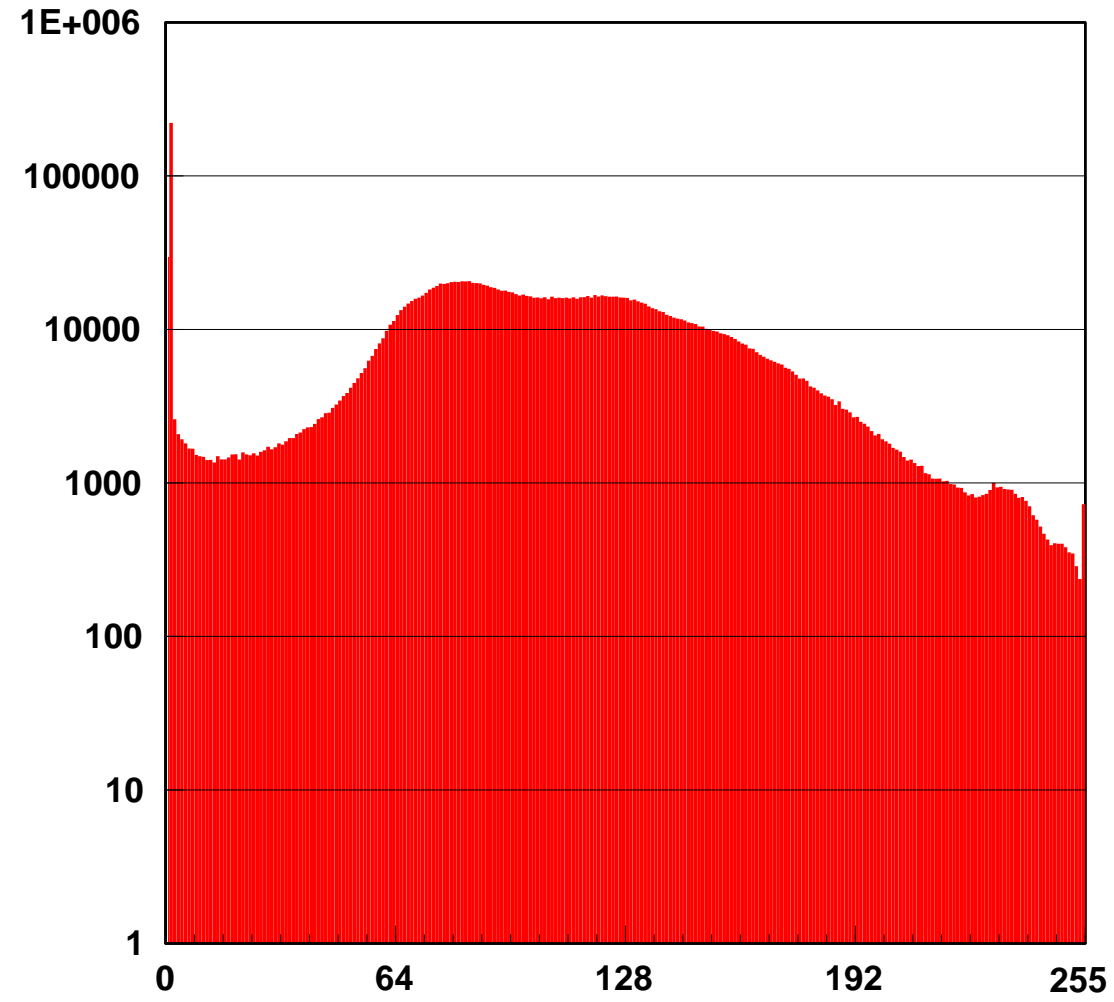
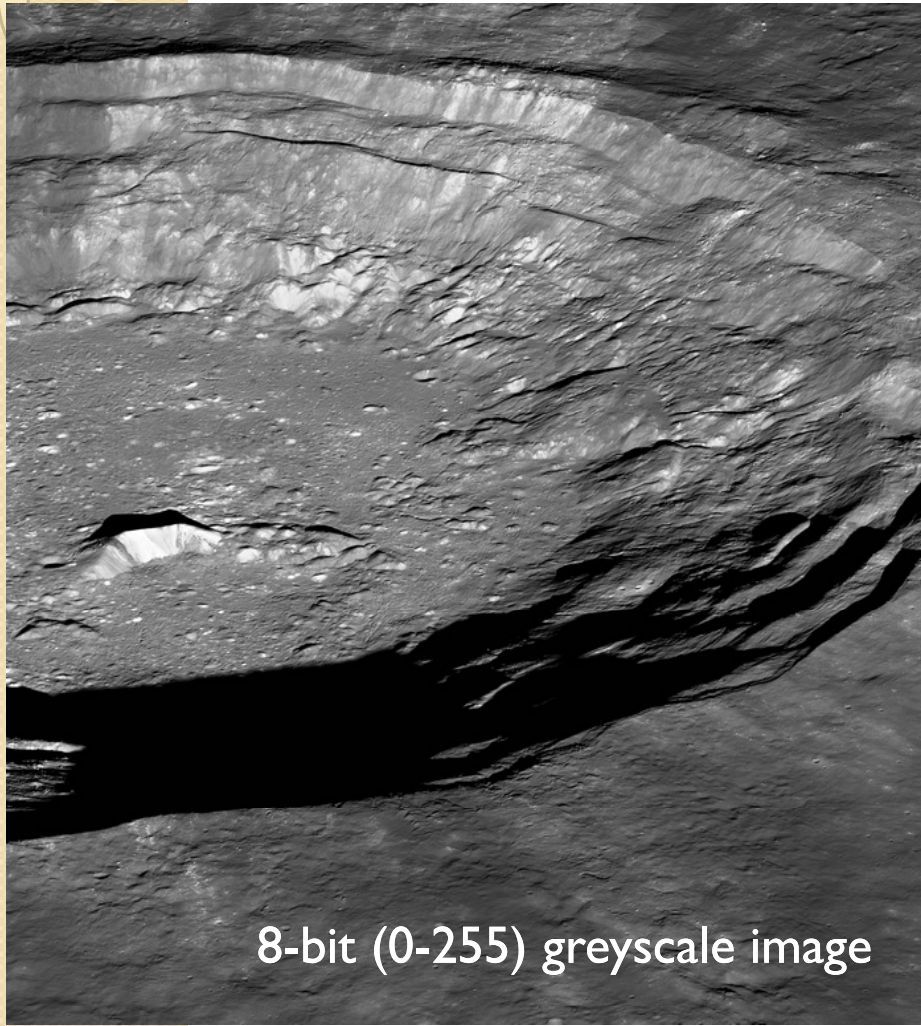
# Another Simple Histogram



4-bit (0-15) greyscale image

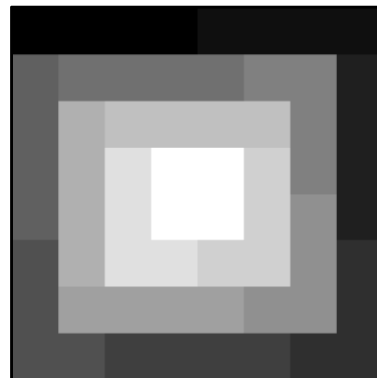
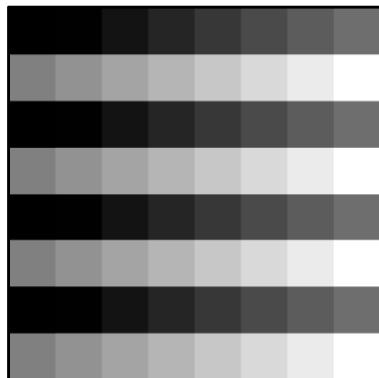


# A More Complex Histogram



# What can a histogram tell us?

- How your image is distributed amongst **light pixels**, **dark pixels**, and **mid-tone** pixels
  - Whether or not you are losing information due to clipping at the light or dark end of the image
  - Whether or not you are making the best use of the available image colour (bit) depth
  - How well colour balanced the image is
- A histogram does NOT tell you where in your image the different colours are located, only the number of occurrences



- These two images have identical histograms



# Clipping (Saturation)

Too dark

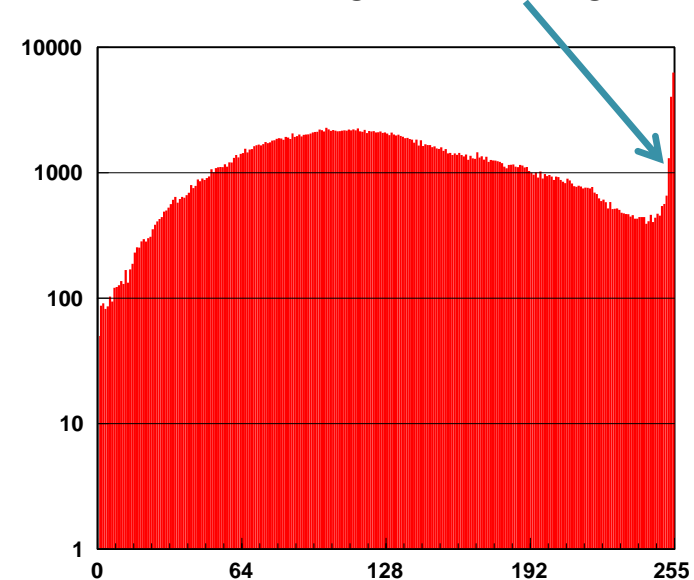
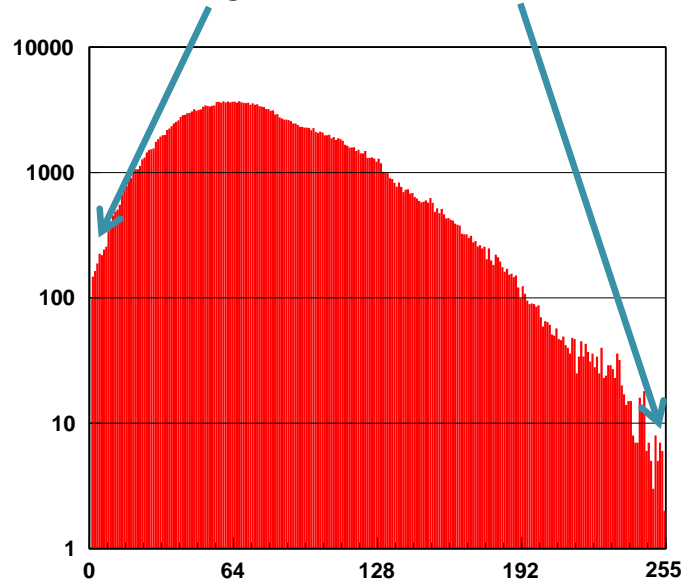
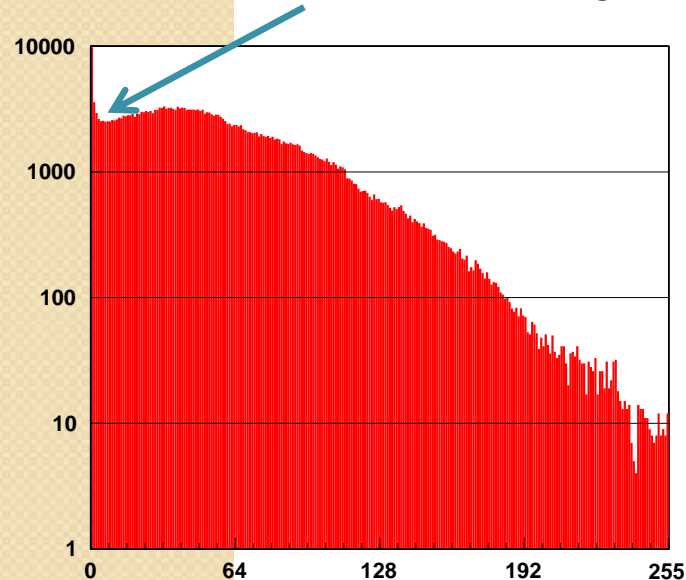
Just right

Too light

Roll up towards 0 = under-saturation,  
data lost on dark end of image

Nice roll off on both ends, all  
image data is contained

Roll up towards 255 = over-saturation,  
data lost on bright end of image





# Dynamic Range (Bit Depth)

Too narrow

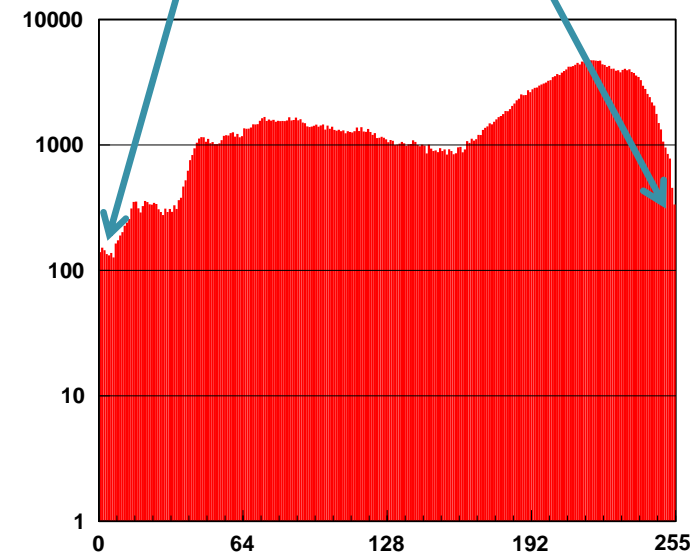
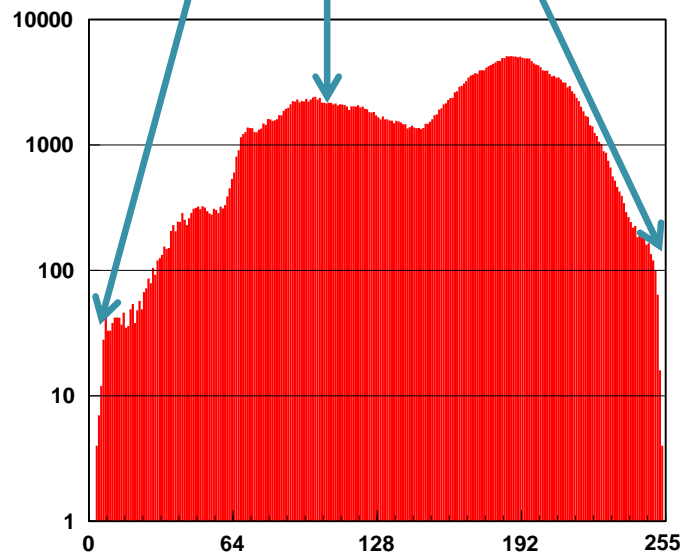
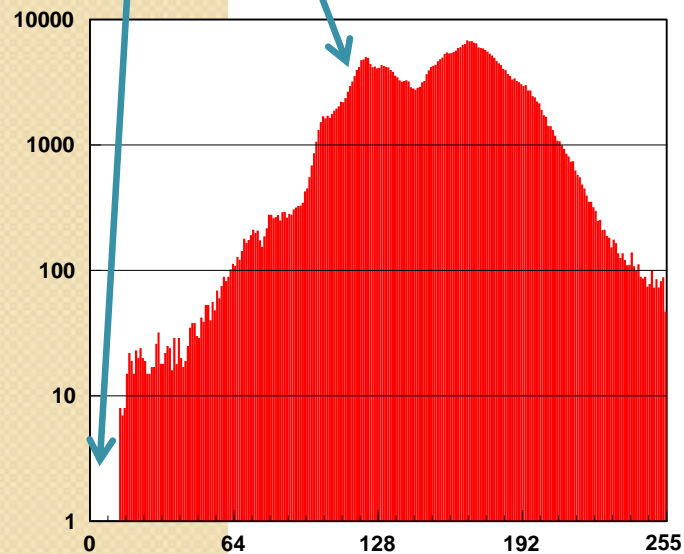
Just right

Too wide

Narrow peak, histogram does not go all the way to end, not making good use of image bit depth

Broad peak with nice roll off on both ends, all image data is contained

Data clipped\* at dark and light ends, does not all fit into image bit depth



*Moon image by J. Thompson*

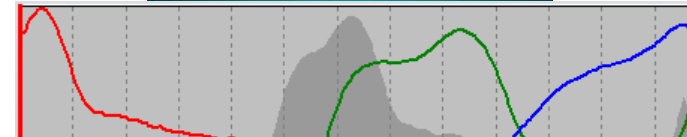
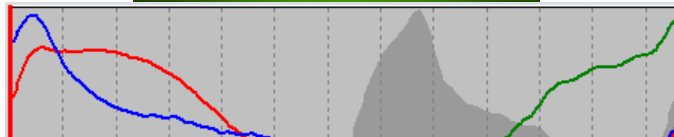
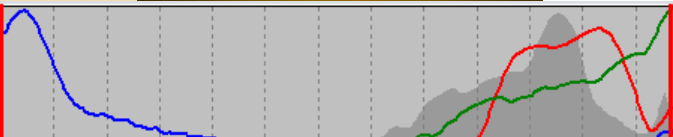
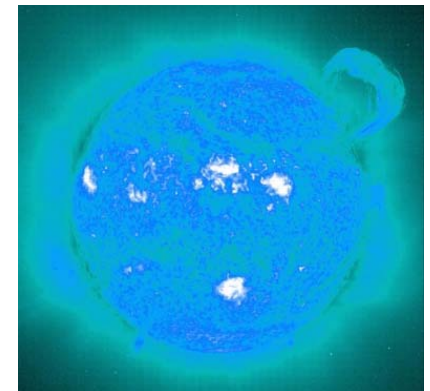
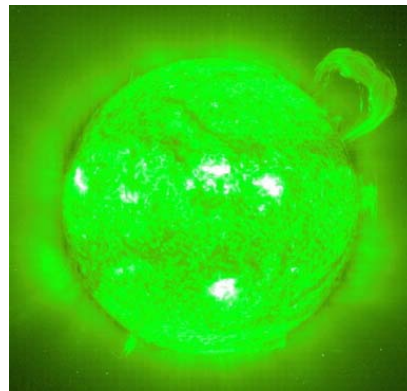
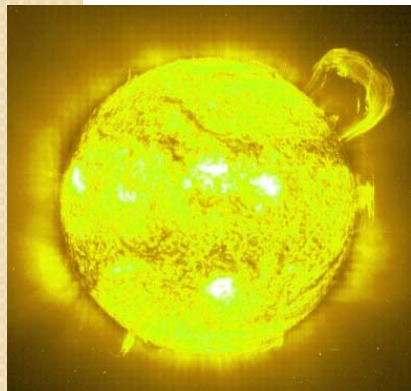
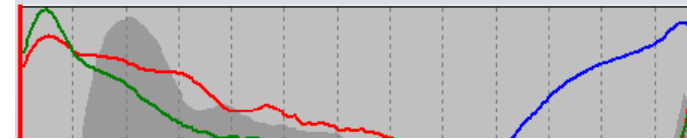
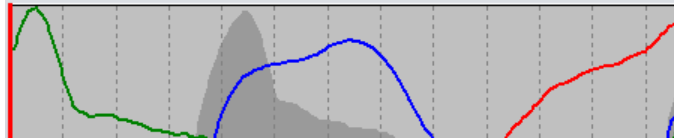
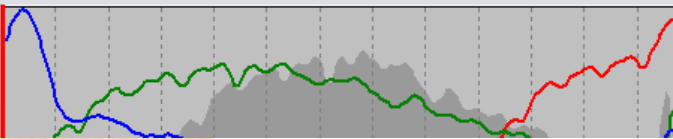
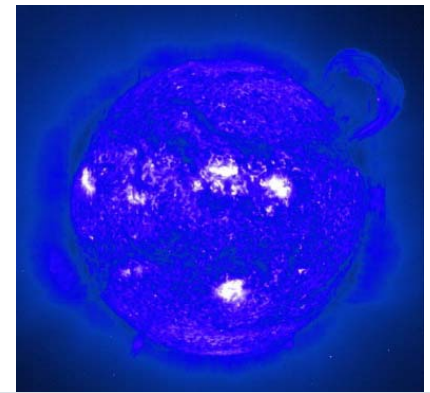
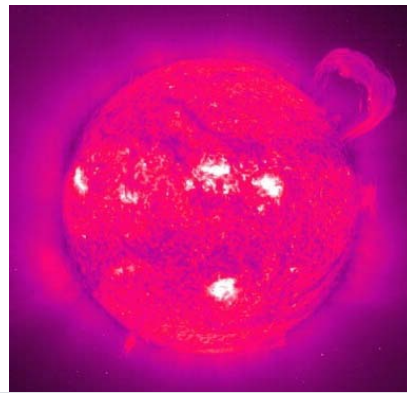
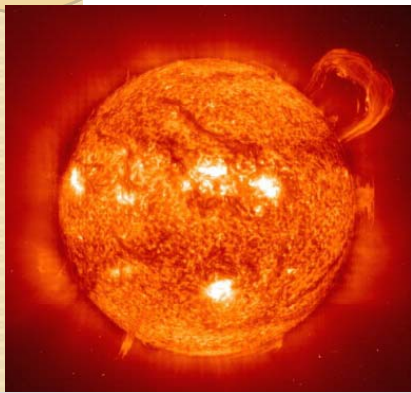
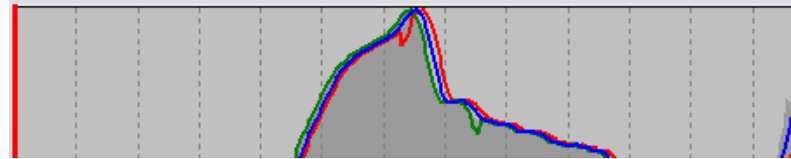
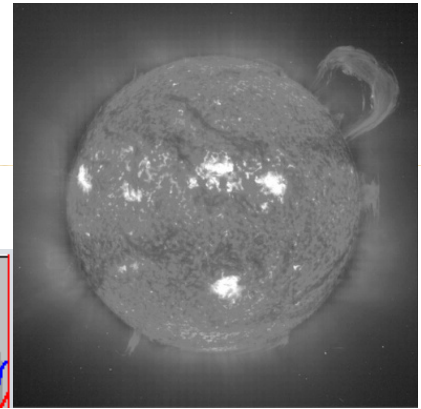
\* In this case no roll-up indicates clipping is moderate

# Notes on Colour Images

- A colour image represents colour using a combination of 3 or 4 base colour channels (RGB or CMYK or HSL)
- A colour image will have one histogram for each colour channel, which can be manipulated independently
- Overall image “brightness” can be manipulated using Luminance, a weighted average of the 3 (or 4) colour channels

# Colour Balance

*Sun image by NASA*



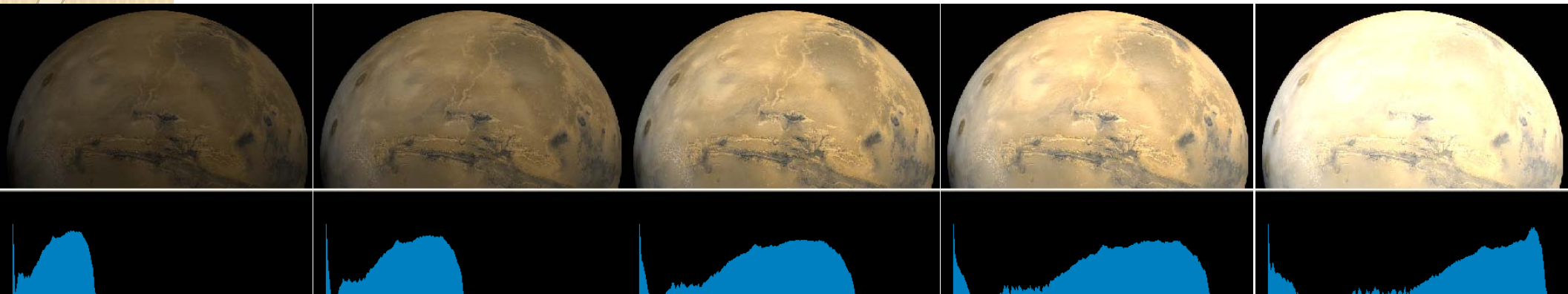


# Tools to change your histogram

- Most image capture or image editing software has tools to adjust your image's histogram
- Commonly used tools include:
  - Brightness & Contrast adjustment
  - Gamma adjustment
  - Tone balance / Tone mapping / Curves
  - Dark point / White point setting
  - Shadow / Midtone / Highlight adjustment
  - Direct Histogram adjustment

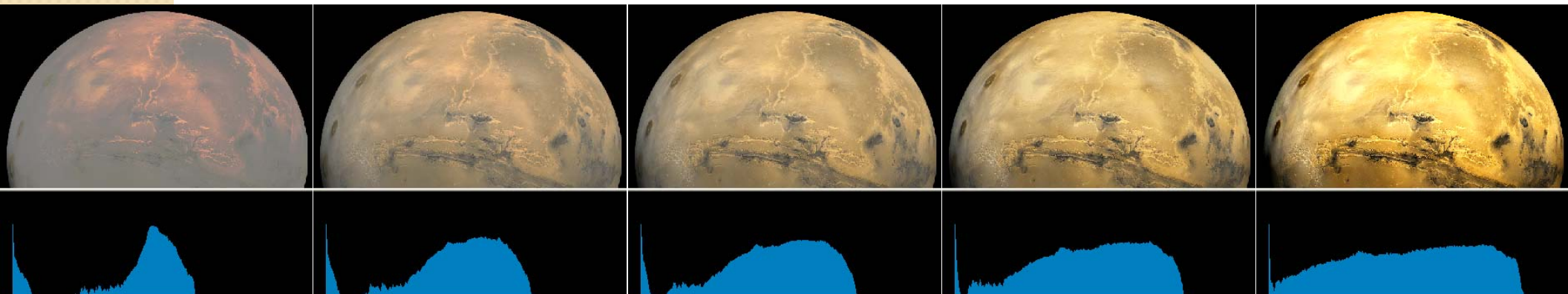
# Brightness & Contrast

## BRIGHTNESS



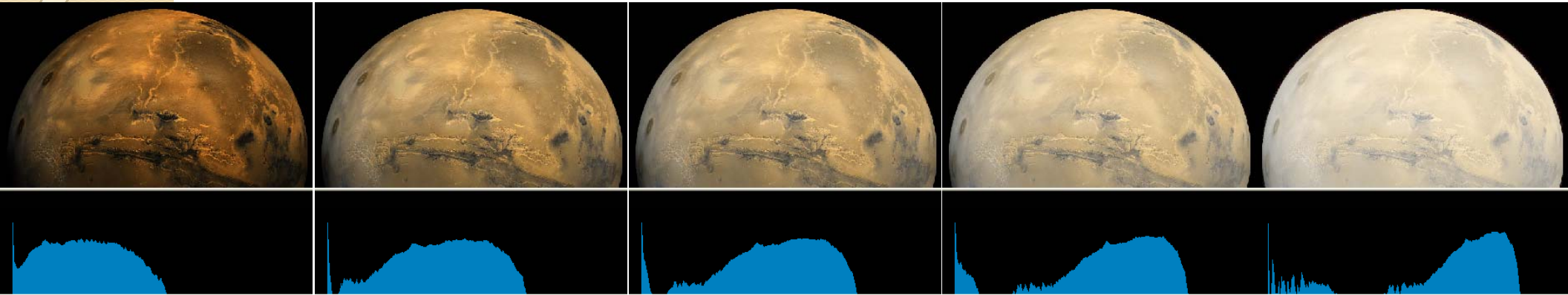
- Increase Brightness = Stretch histogram to the right (everything brighter)

## CONTRAST



- Increase Contrast = Stretch histogram both directions (darks darker, brights brighter)

# Gamma



- Increase Gamma = Mid-tones brighter, Black/White Points the same
- Like Increase Brightness but little or no clipping (saturation)



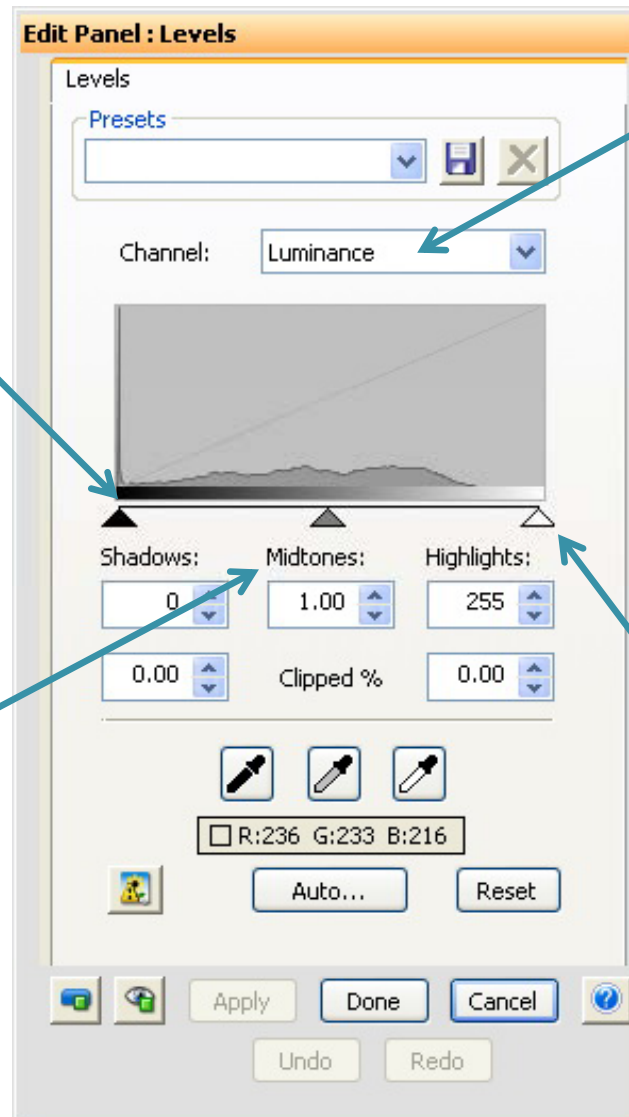
# Tone Balance

## Black Point:

- Set what pixel value in your image data you want to be shown as black
- Stretches histogram left (darker)
- Can clip data on dark end

## Mid-tones:

- Set how pixel values in the middle of your image data are to be shown
- Stretches middle of histogram right or left (brighter or darker)
- Does not clip data
- Mid-tone slider right = GAMMA down, Mid-tone slider left = GAMMA up



## Channel:

- Normally can apply to each colour channel separately OR to luminance channel (overall image brightness)

## White Point:

- Set what pixel value in your image data you want to be shown as white
- Stretches histogram right (brighter)
- Can clip data on light end
- Same as BRIGHTNESS increase

- Basically same as: Tone mapping, Dark / White Point, Shadow/Highlight/Midtone Adjust, Levels

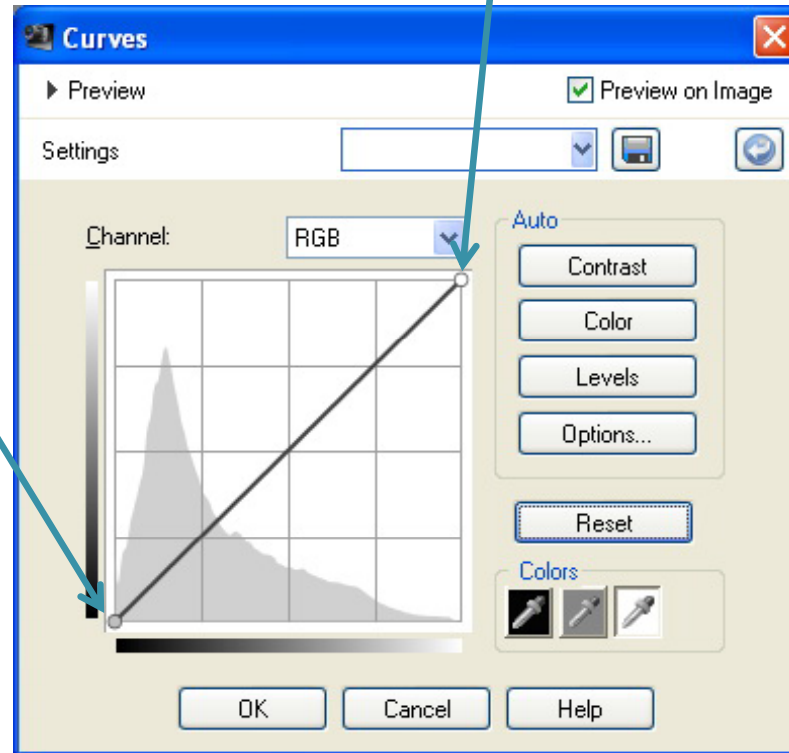
# Curves

White Point:

- Move down = CONTRAST down, whole image darker
- Move left = BRIGHTNESS up, clips data on light end

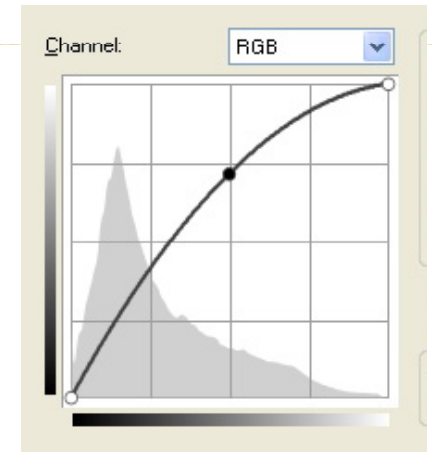
Black Point:

- Move up = CONTRAST down, whole image lighter
- Move right = BRIGHTNESS down, clips data on dark end



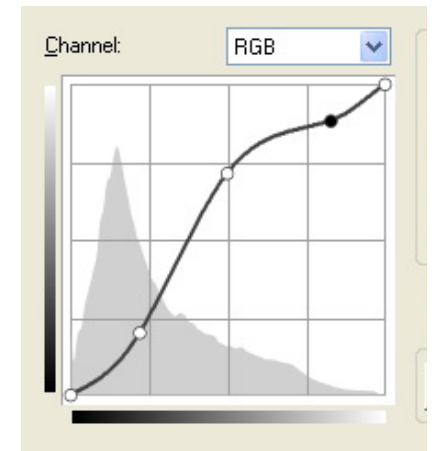
Add Mid Point:

- Just like mid-tone or gamma



Add Many Points:

- Total control...go wild!



- Ultimate control over how data is distributed between Dark & Light
- Can provide same functionality as BRT, CONT, & GAMMA

# Final Notes

- Histogram when recording image data is often different (darker) than if simply observing:
  - Want all the data in your recorded image, no clipping
  - Some clipping okay in live observed image in order to enhance details
- In a camera, increasing EXPOSURE has the same effect as increasing image BRIGHTNESS except that the signal-to-noise ratio of your target also goes up
- In a camera, increasing GAIN has the same effect as increasing image BRIGHTNESS
- The best way to learn how to use the histogram is to USE IT!