Going Digital
256 Shades of Gray

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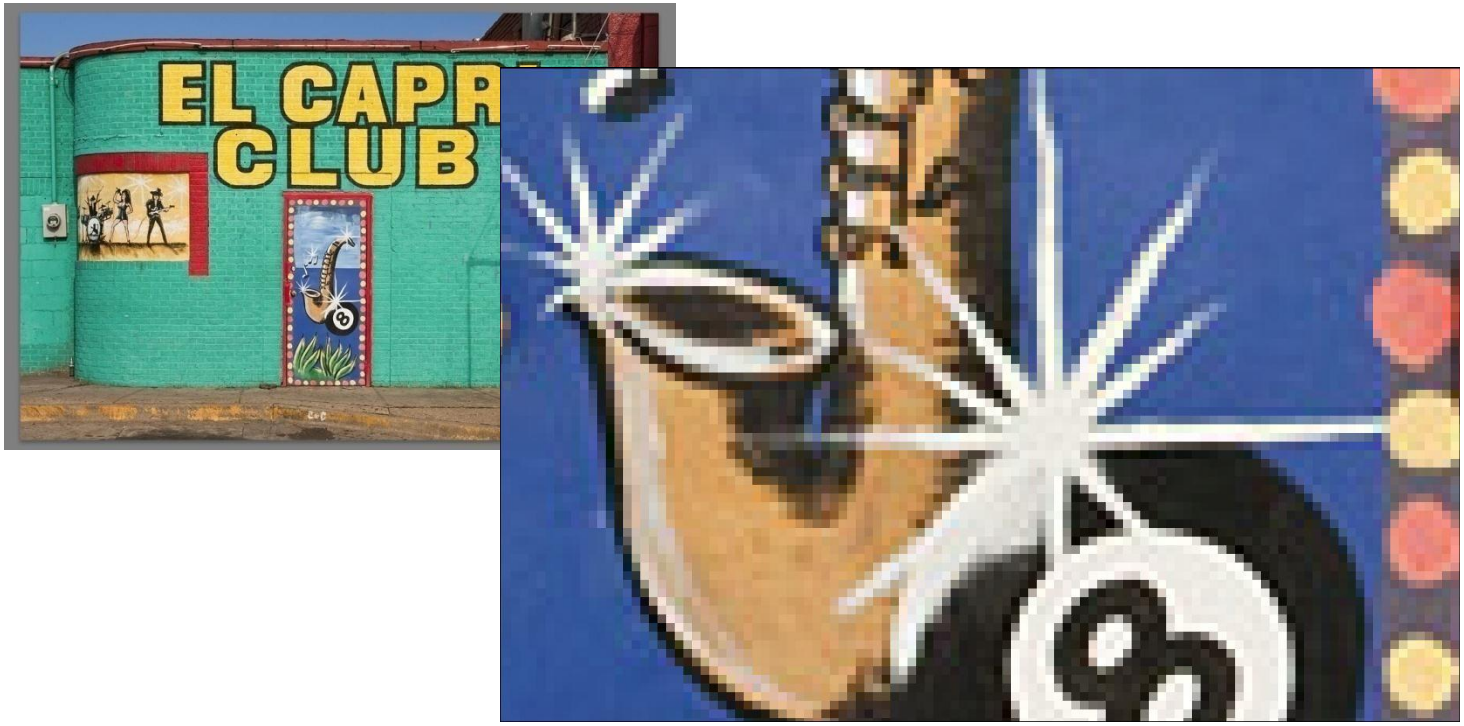
Education > Pre-Meeting Training Materials

Things Digital

- Number of pixels and resolution
  - Image size and detail
- Color space
  - Range of colors
- Dynamic range
  - Range of tonality
- Bit depth
  - Distribution of tones

Pixel Power



- **An image fundamentally communicates information.**
- **The more pixels the more total information available.**
- **The closer the pixels are together the more detailed the information within a specific area.**
- **These two attributes define the overall size and resolution of image .**

Definitions

(Often used interchangeably)

- **Pixel (picture element)** – smallest element on sensor or screen that can be assigned a color (1, 3 or 4 colors depending on the color space)

- **Dot** – Drops of ink used to represent a specific color in a printed image.
  - Came from Offset printing which uses colored dots of varying sizes to represent one or several pixels.
  - Inkjet printer puts down multiple droplets of colored ink for each pixel.

- **Size** – Overall dimensions of the sensor, monitor or print expressed in pixels or inches

- **Resolution** – The density, or fineness, of information content expressed in pixels or dots per inch
  - **ppi (pixels per inch)** – Resolution of displayed or printed image expressed as the number of pixels per inch
  - **dpi (dots per inch)** – Resolution of a printed image expressed as the number of dots printed per inch.

Image Capture

- Camera sensor size (dimensions) is expressed in megapixels (pixels)
  - Approximately equal to height (pixels) times width (pixels).
  - More pixels provide more information.

- How many megapixels are required to print an image of reasonable quality.

Print Size	Megapixels
8” X 10”	3 – 7
11” X 14”	6 – 14
16” X 20”	12 – 29
20” X 30”	24 – 54

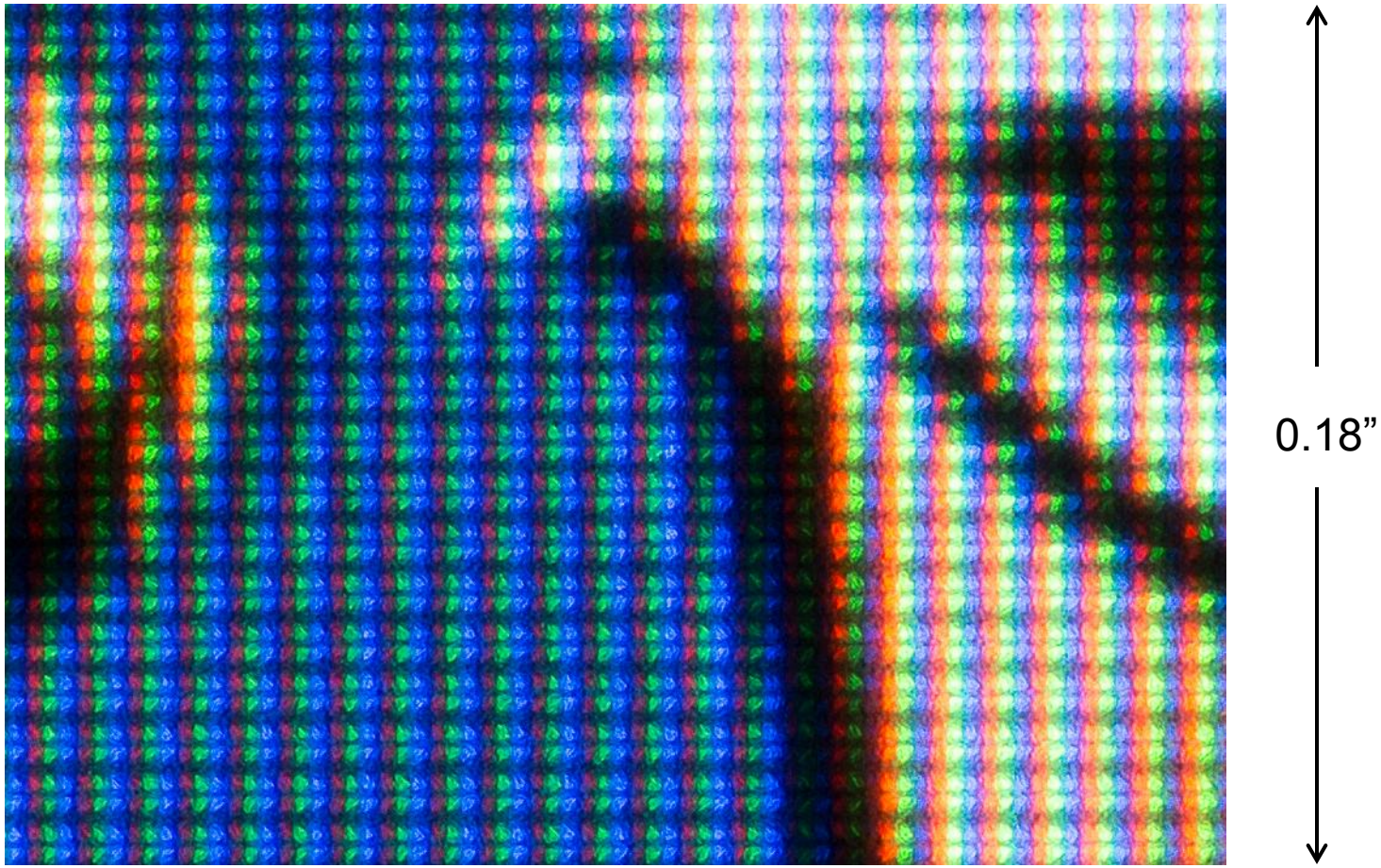
Assumes
200 – 300 ppi

- Shoot at maximum image size unless have good reason not to.

- Most cameras allow you to set resolution
  - Has no impact on capture.
  - Added to EXIF data for use in processing – if not changed during processing.

Monitor Displays Pixels

Pixels Contain Color Info



Each pixel on monitor contains RGB color information

Display on Monitor

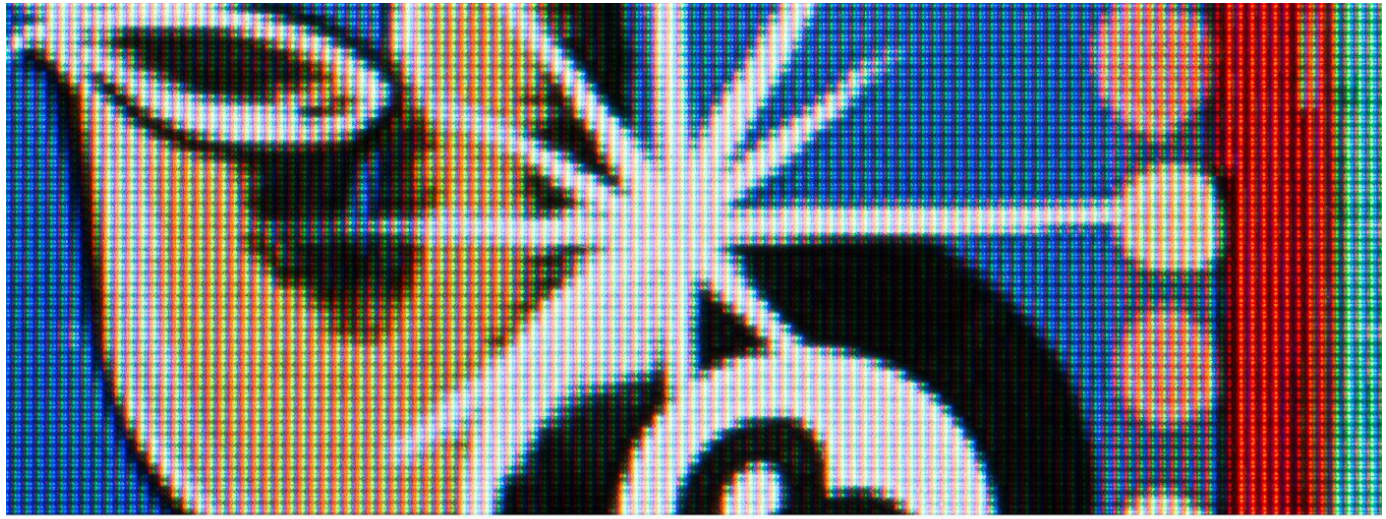
- A monitor has a fixed number of pixels which define the dimensions of image that can display.
- Image size on screen is determined by both the monitor’s and the image’s pixel dimensions.
- At 100%, one image pixel is represented by one pixel on the monitor.
- The image pixel dimensions are all that matter.
- Resolution setting has no impact on the displayed image. It is physical characteristic of the hardware only.

Zooming on Monitor

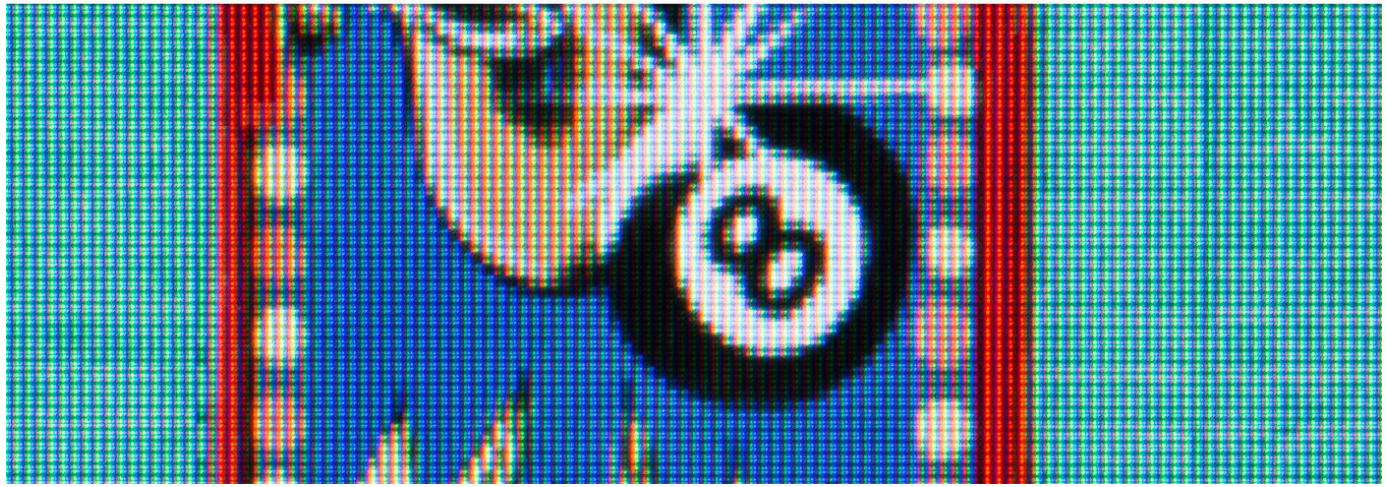
- Zooming is a software based resizing of the image that determines size of the image you see on the monitor.
  - Zooming out reduces the number of image pixels and reduces the size of the displayed image
  - Zooming in increases the number of pixels displayed and increases the size of the image. But not necessarily the image quality on the screen.
    - Neither PS or LR interpolate the displayed image when zooming in.

Zooming Out on Monitor

1:1
100% Zoom



1:2
50% Zoom

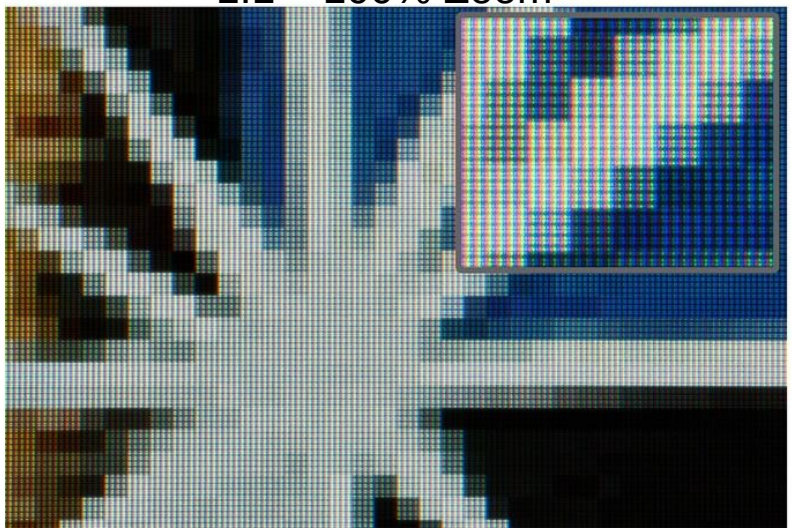


Zooming In on Monitor

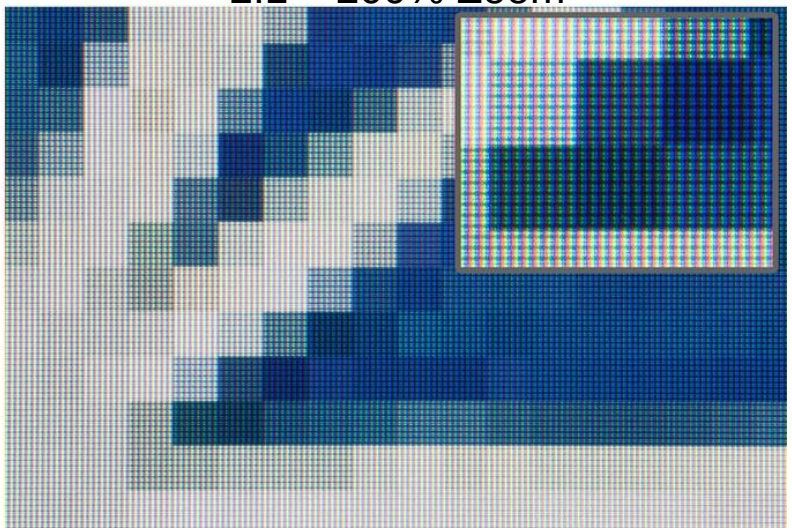
Each image is 1.5” X 1” on 94 ppi monitor

1:1 – 100% Zoom

2:1 – 200% Zoom



4:1 – 400% Zoom



8:1 – 800% Zoom

Display on Monitor

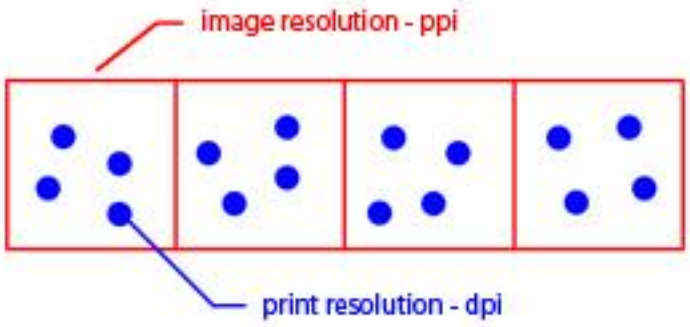
- Images as they would appear displayed on an XGA monitor (1024p X 768p) at 100% zoom (1:1).

- Left – image sized for projected image competition (1024p X 768p).
  - Display and image are the same size.
- Center – image sized for email (800p X 600p).
  - Image dimensions are less than the monitor.
- Right – uncropped image from 10 MP camera (3870p X 2582p).
  - Image size is larger than the display.

Inkjet Printing

- Inkjet printer input is pixels and the printer firmware algorithms translate the pixels into droplets of ink.

- Resolution is important when printing an image. Actually, two resolutions.
  - Image resolution - the number of pixels that you want to print per inch (ppi).
  - Printer resolution or quality setting - the number of droplets (dots) of ink that are used to represent each pixel expressed in dots per inch (dpi).

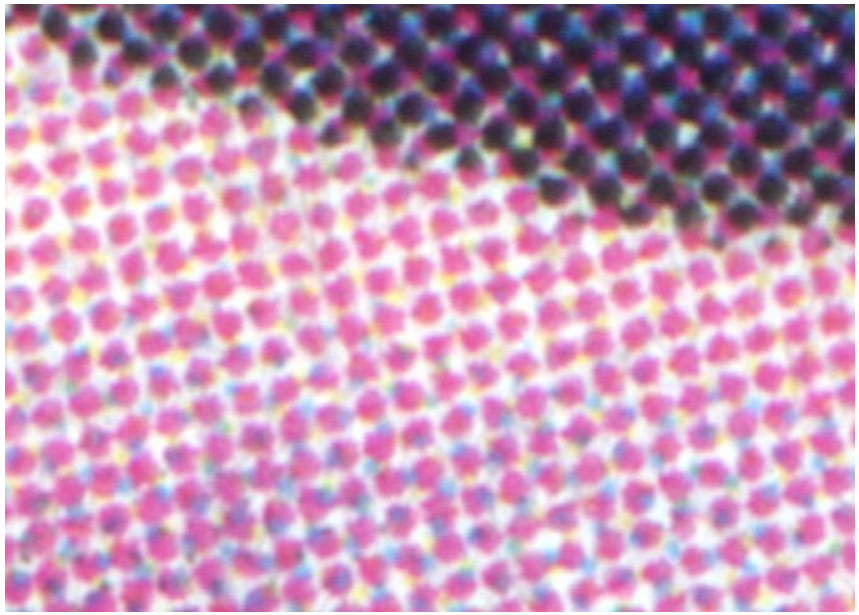


- When printing an image,
  - Image processing software sends pixels to the printer.
  - Printer takes care of putting ink down on paper.
  - Think in terms of image resolution (ppi) when sizing image.
  - Image quality choices determine the print resolution (dpi).

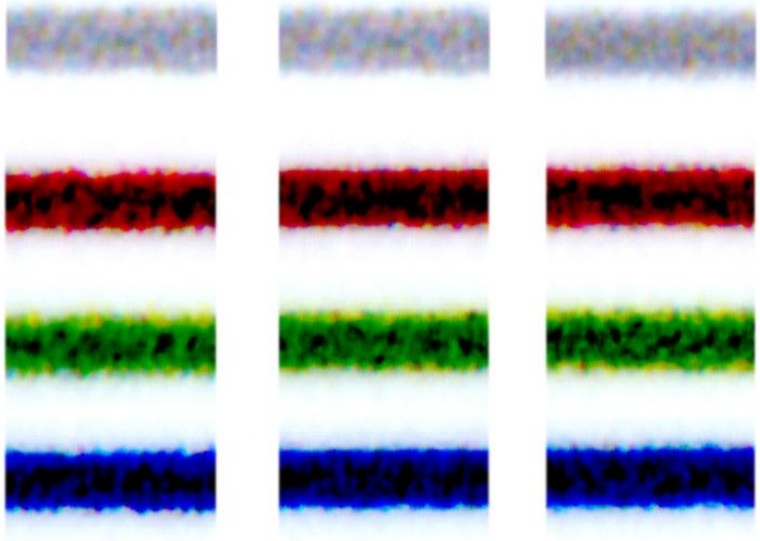
Inkjet and Halftone Prints

Moving from Image Resolution to Printer Resolution

(Both images are the same scale)



Lines 2 pixels wide (1/100”)
Image resolution 200 ppi



720 dpi 1440 dpi 2880 dpi
Printer resolution

Halftone images are screened in a regular pattern to produce different sized colored dots to represent several pixels. Dots per inch (dpi) originated with halftone printing.

Inkjet printers lay down many droplets in a random pattern to represent each pixel. The number of droplets per pixel is defined by the printer resolution (dpi).

Dealing with Resolution In Image Processing

- Image processing software (Photoshop, Lightroom, etc.) does not change the number of pixels unless the image is resized.

- Do not resize pixel dimensions during processing (other than creative cropping). Save a master without resizing.

- Processing is not effected by resolution setting until the image is prepared for *print* output.

- Resize, and/or set resolution, for final output based on intended use.

Digital Color

Color is just numbers in the computer
until they are interpreted.

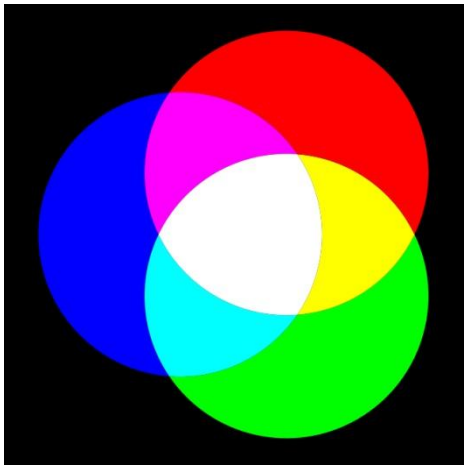
Interpreting these numbers to obtain a predictable color image
is what color management is all about.

What is color

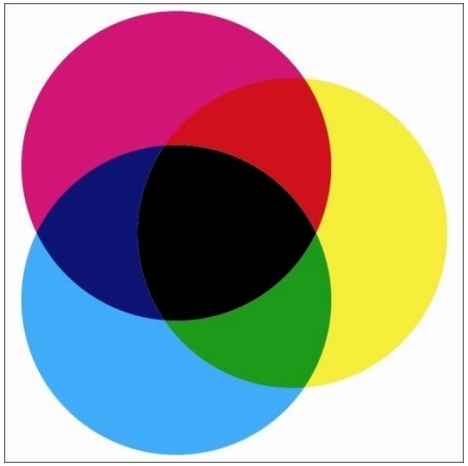
- Color Models
- Color and Computers
- Color Spaces and Gamut

Frank Richards
April 2011

Color Models

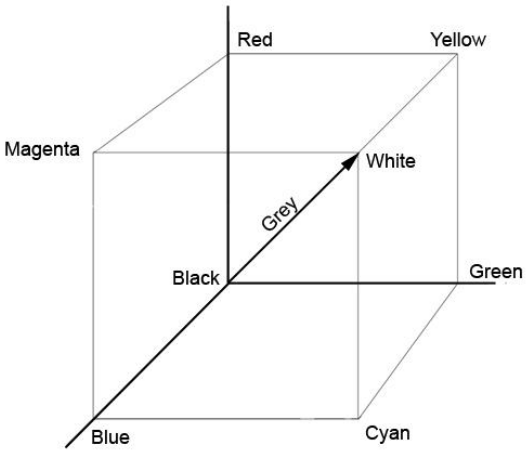


- **Red, Green, Blue (RGB)** is the color model used by computer monitors, TVs, scanners and digital cameras to combine light.
- Human eye responds to RGB
- All the colors added together provide white.
- The absence of light yields black.

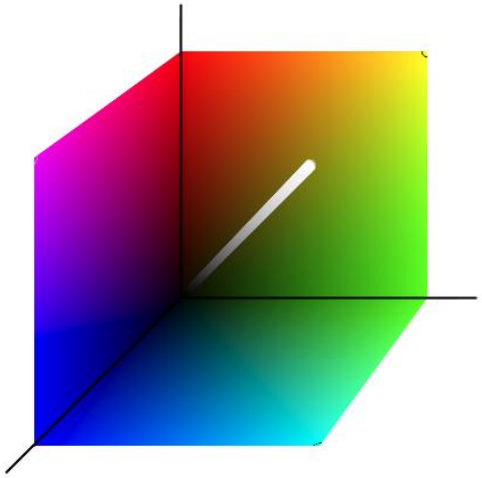


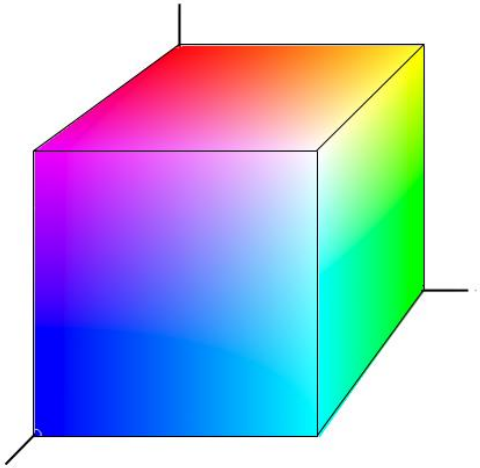
- **Cyan, Magenta, Yellow, Black (CMYK)** is the color model used by printers to combine ink.
- All the colors printed together provide black. Well, sort of:
  - CMY inks mix together to make a muddy brown-black. Black (K) is added to produce true blacks and grays.
- The absence of color yields white.

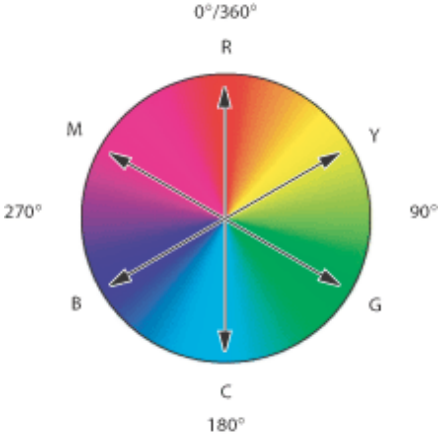
RGB Color Model



- The RGB color system can be represented as a cube. RGB, CMY, black and white are on the corners.
- The origin is Black (K). The diagonal is a gray gradient ending in white at the far corner.
- Different colors are represented by unique color values (numbers) within the cube.
- A color wheel is often used to represent the fully saturated colors.







Color Spaces

- **Color space** is a color model for which a specific set of values describe a specific color.

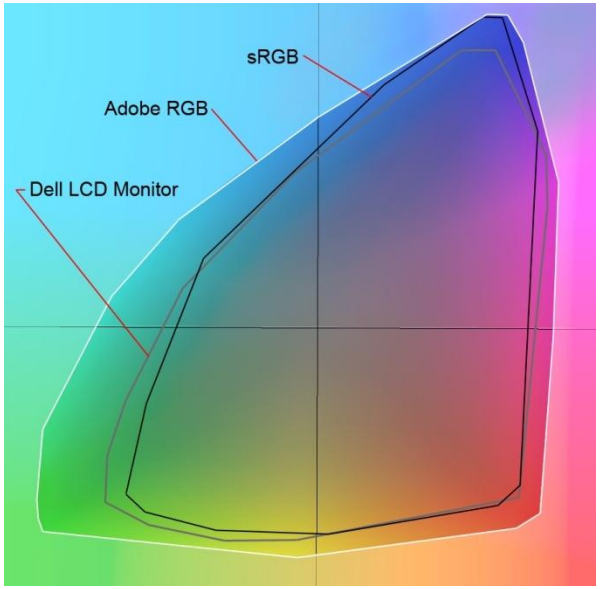
- Color spaces can be either device-independent (e.g. Adobe RGB) or device-dependent (e.g. Epson 1280 printer using Matte HW paper)

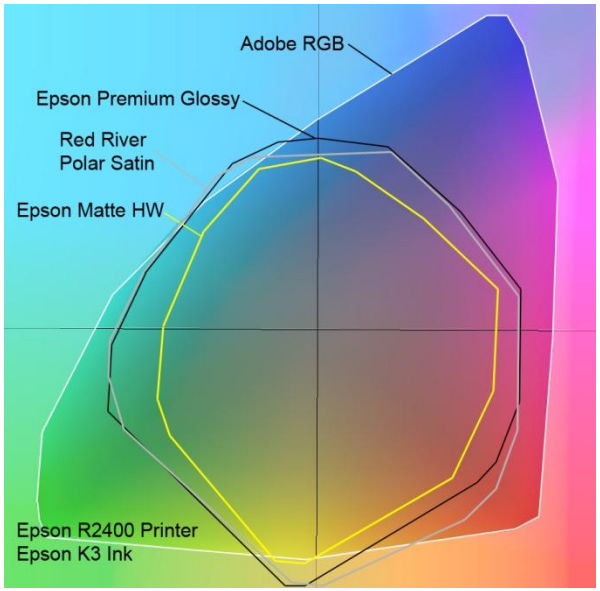
- Common device-independent RGB color spaces are:
  - sRGB IEC61966-2.1 - created by HP and Microsoft for images to be displayed on “typical” monitor. Used by many comercial labs.
  - Adobe RGB 1998 - developed by Adobe as an alternative to sRGB to provide a better match to printers. It is a good general-use color space for images that will be output on a verity of devices. It encompasses sRGB and roughly 50% of the visible colors of light.
  - ProPhoto RGB – developed by Kodak. Very large gamut designed for photo output. Includes all colors that are likely to occur in the real world and some that are not visible.

- Device-dependent color spaces describe the behavior of a specific device. They include color spaces for:
  - Cameras, scanners, monitors, printers/papers…
  - Commercial labs, offset presses…

Color Spaces and Gamut

- Gamut is the range of colors found within a color space.
- sRGB was developed to provide a color space that matches the typical monitor. Is default color space for the internet. Used by most drug stores and commercial labs.
- Adobe RGB was developed to better match printer capabilities. Is good general use working color space for images that will be output on a variety of devices. It is generally regarded as the best color space for photo inkjet printers.
- Most digital SLRs provide a choice of either color space for jpeg's. Suggest Adobe RGB capture unless images will only be processed in commercial labs or used on the internet.
- Inkjet printers have limited gamut and each color spaces is unique. A printer's color space depends on the type of printer and its settings, ink and paper.
- Adobe RGB contains most of the photo inkjet printer's gamut. sRGB does not.





Dynamic Range in Photography

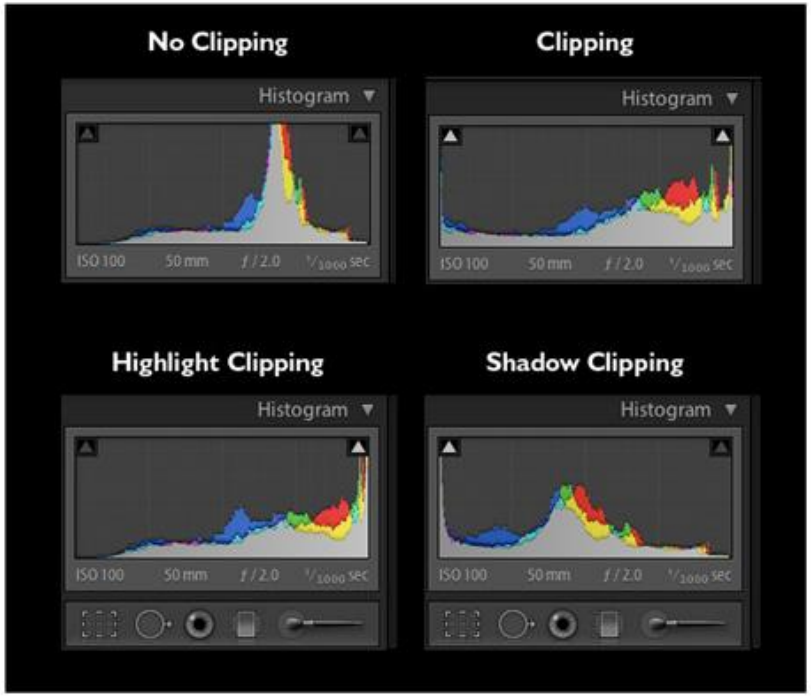
Dynamic range is the range of light intensities from the darkest shadows to the brightest highlights. It is measured in Exposure Value (EV) or “stops”.

The human eye can see a contrast range of over 20 stops of light intensities. A camera sensor can capture a contrast range from 5 stops to 10+ stops depending on the camera.

If the dynamic range of a scene is greater than what the camera sensor can capture, the shadows will be completely black or the highlights will be blown out or sometimes both.

Checking the histogram of an image will provide information for adjusting the exposure or the need to recompose.

Clipping



If the histogram spikes on the left or right of the scale that part of the image information is being lost--clipped. If the histogram is clipped on the left, the darkest shadows will be pure black with no detail. If the histogram is clipped on the right, the highlights are blown out with no detail.

Dynamic Range

- Dynamic range is ratio of lightest to darkest luminance (brightness) in scene.
- Photographers think in terms of f-stops (exposure values - EV).

Sunny Day	16-25 EV
Human Eye (long term adaptation)	20 EV
Human Eye (without adaptation)	14 EV
Negative Film	10-11 EV
Computer Monitor	9 EV
Glossy Print	6.6-7.6 EV
Digital Camera (16 bit RAW)	10-12EV
Digital Camera (8 bit)	6-8 EV
HDR (32 bit floating point)	30+ EV

High Dynamic Range

Clipping

HDR

Exposure Bracketing

- Exposure bracketing is taking multiple shots at different exposures
- Capture exposures without clipping in shadows and highlights.
- Combine these exposures so that resulting image has not clipping.
- This type of processing is referred to as HDR
- There are several ways to accomplish HDR processing

Exposure Bracketing

- Use camera meter and histogram to determine exposure range
- Bracket exposures to capture full tonal range of scene in 1 or 2 EV steps
  - Common AEB range of +/- 2 EV will cover many situations
  - Ghosting – frame to frame image motion (wind, water, boat, car, person…)
- Shooting HDR images – perspective, DOF, processing and color should not vary
  - Tripod - can handhold in a pinch
  - Use cable release and mirror lockup
  - Disable all in camera enhancements
  - Aperture priority mode
  - Manual focus
  - Fixed focal length
  - Set AWB or shoot RAW
  - Set ISO if shooting jpeg
  - Vary shutter speed (AEB or Manual)

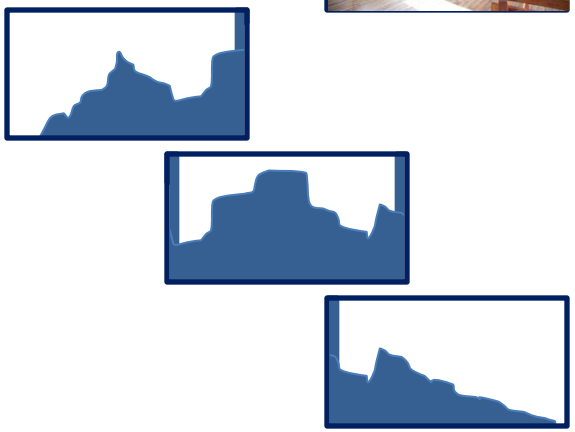
HDR Imaging

- HDR allows us to capture the full tonal range of an image that exceeds the dynamic range of the camera.
- The HDR image dynamic range can then be reduced to an LDR image that can be displayed or printed. The resulting LDR image is what we often refer to as an HDR image.

- Bracket exposures to cover full brightness range of the scene
- Combine images so that all brightness levels are represented (HDR)
- Reduce dynamic range so that image can be displayed or printed (LDR)

HDR Imaging Process

Bracket exposure to capture full tonal range scene



In camera histograms can be used to determine needed exposure range. Use 1 or 2 f-stop increments

Images are merged into single HDR image which contains complete tonal range recorded at the true luminance levels

Tone map HDR image to compress to LDR image that can be displayed and printed

How It Fits Together

- **Color space** defines the range of colors available
- **Dynamic range** determines brightest and darkest values available
- **Bit depth** determines the number of unique colors (tones) within the color space

Bit Depth

8 bit color channel

16 bit color channel

Bit depth determines the number of tonal values which will be recorded.
JPEG records at 8-bit and raw at 12- or 14-bit with the ability to open at 16-bit.

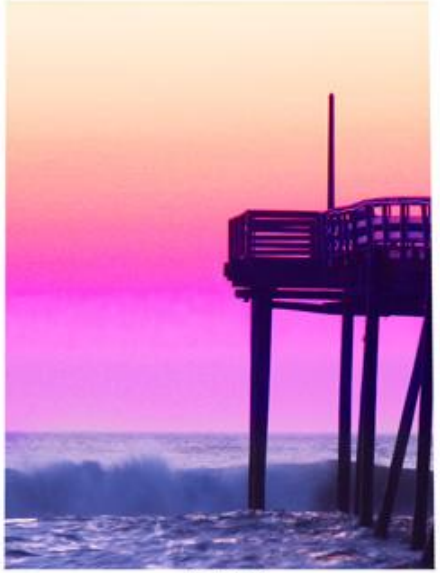
Bits	Number of Tonal Values
8	256
12	4,096
14	16,384
16	65,536

Editing 8 bit and 16 bit

Everytime an image is edited colors can be altered or discarded. In jpeg or 8-bit files editing should be minimized to avoid banding/posterization of tones. In 16-bit files there are more tonal values to allow for smooth color transitions allowing much more latitude when editing. Banding can occur in 16-bit files if pushed too far, but it will be later rather than sooner.

Banding

8-bit jpeg



16-bit tiff

Identical editing. Each was opened then saved the same number of times.

Bit Depth

- Bit depth determines the number of unique colors available in the color space
- 8 vs 16 bits per channel (color)
- 8 bits covers colors the eye can see
- 16 bits provides head room to process images
  - Reduces posterization (banding)
- Bit depth can be set at capture, during processing and output
- 8 bit – jpg, most output devices (the web, most displays and printers)
- 16 bit – raw, tiff, psd, most input devices (cameras and scanners)

More Than You Wanted to Know

- Image pixel size and resolution control output image size and detail
- Color space defines the range of colors available
- Dynamic range defines the darkest and brightest tones
- Bit depth determines how many colors (tones) are available within the color space