

High Dynamic Range Photography

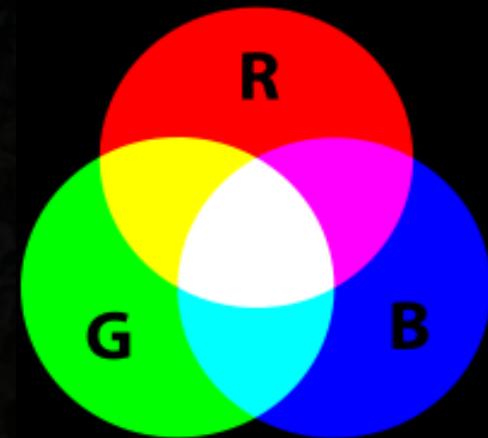
Extending the Capabilities of your Digital Camera

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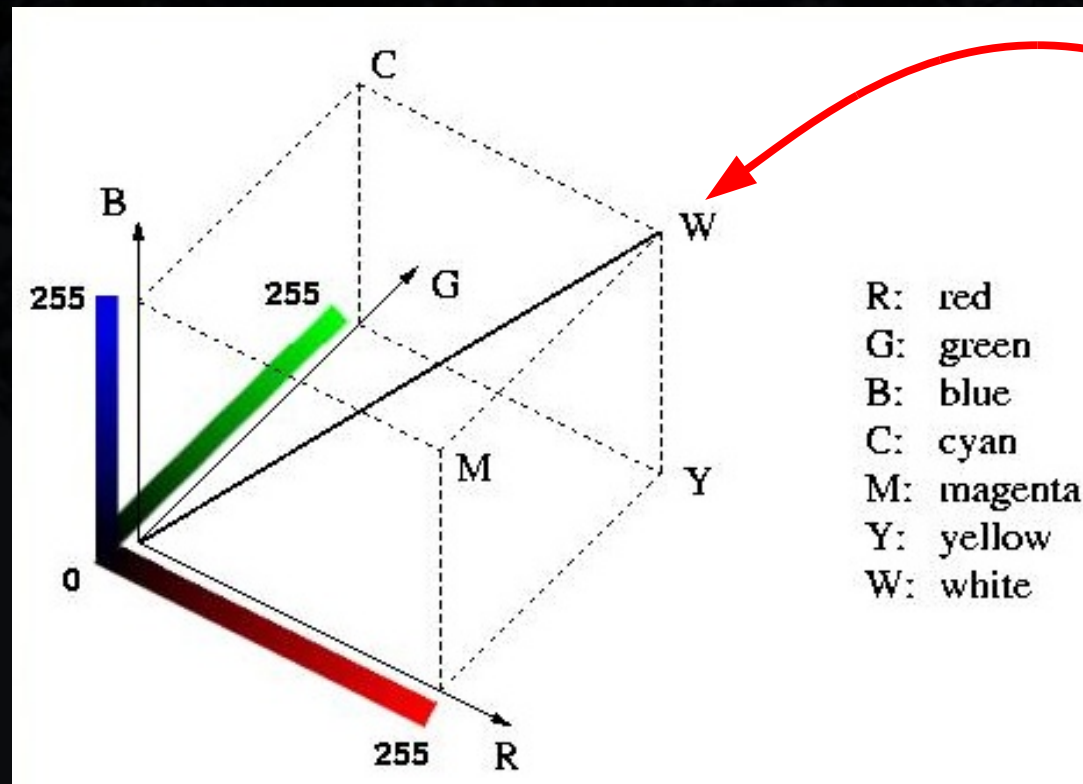
First, Some Digital Photo Basics

- What's in a typical (JPEG) digital photo?
 - Rectangular array (e.g., 3MP = 2048x1536) of individual colored dots, called pixels, which together make up the image
 - Each pixel is encoded as a blended combination of three colors: Red, Green, and Blue
 - Each of the 3 colors can have one of 256 levels of brightness, from very dark to very light
 - Any possible pixel color in a digital photo can be represented by some combination of those colors and shades

1 pixel = 3 colors * 8 bits/color = 24 bits
16 million color possibilities per pixel

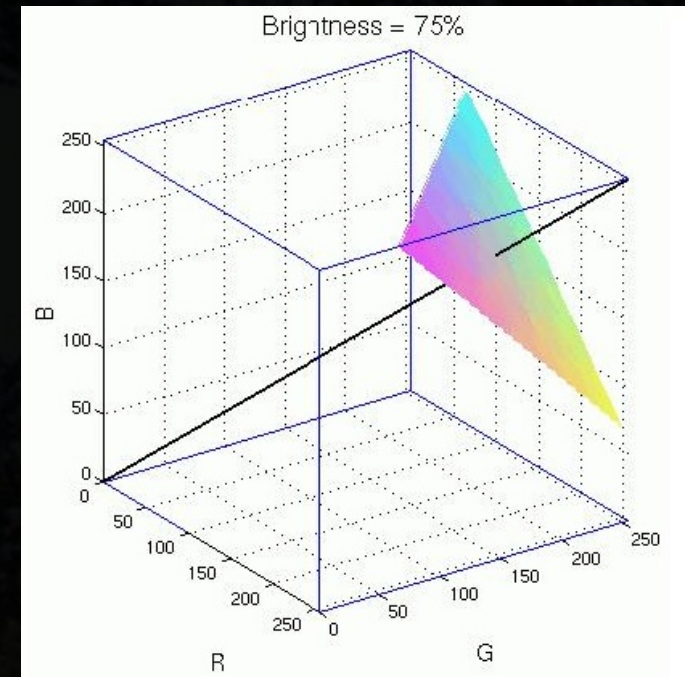
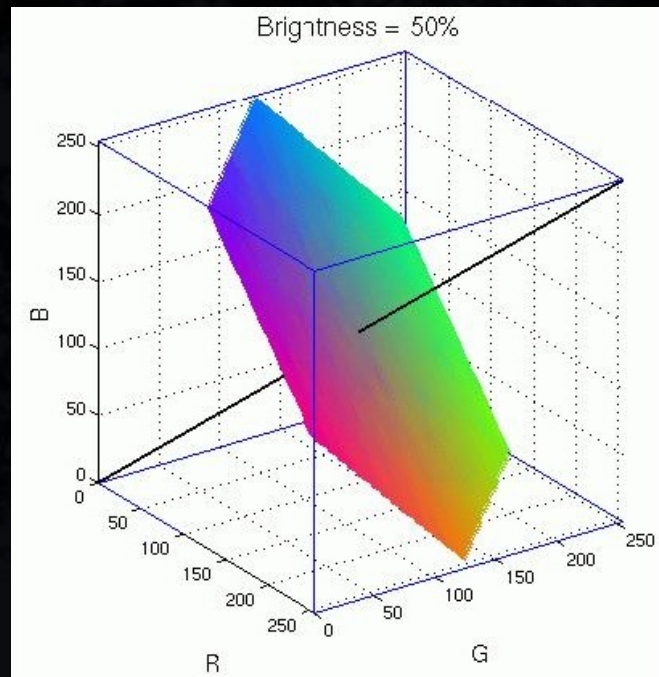
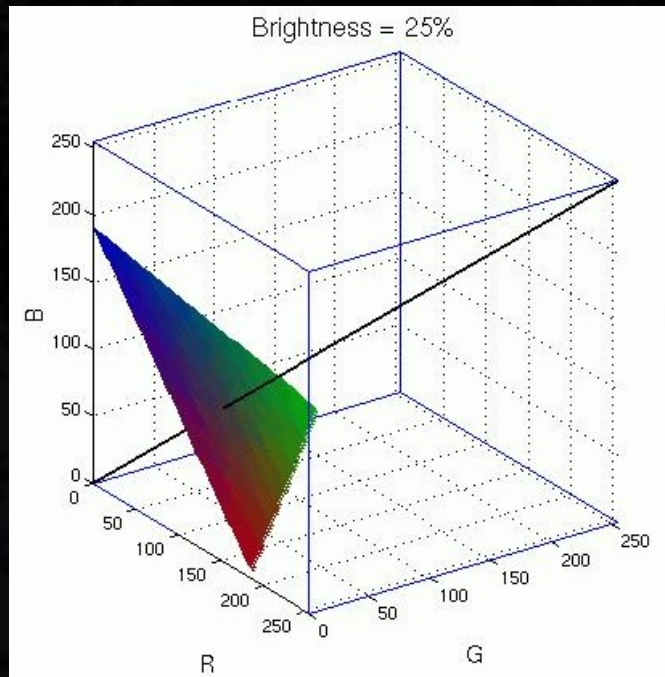


The RGB “Color Cube”

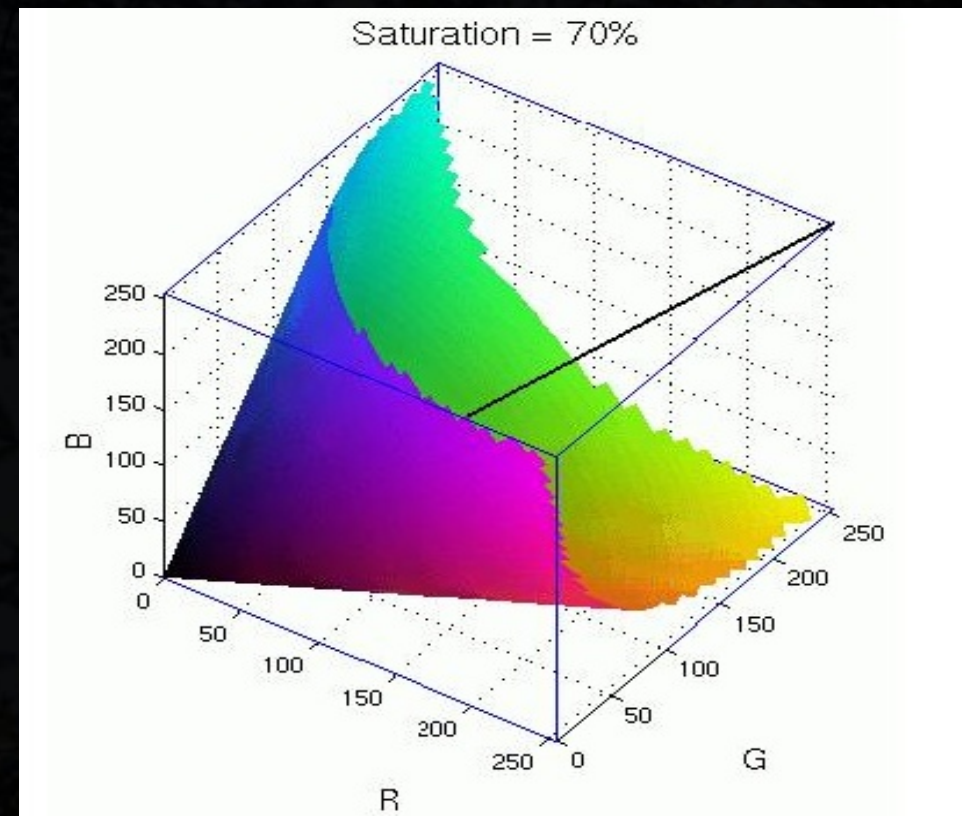
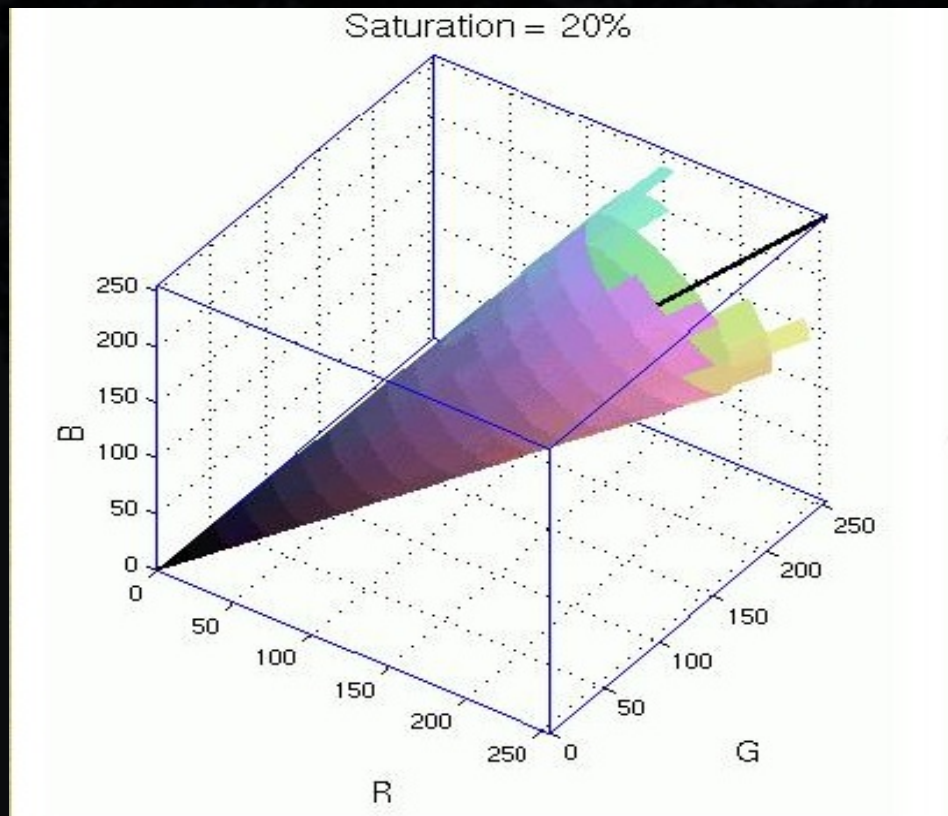


The line from 0 to W represents color values in which the R, G, and B numbers are all equal. This is essentially the grey scale which goes from black to white.

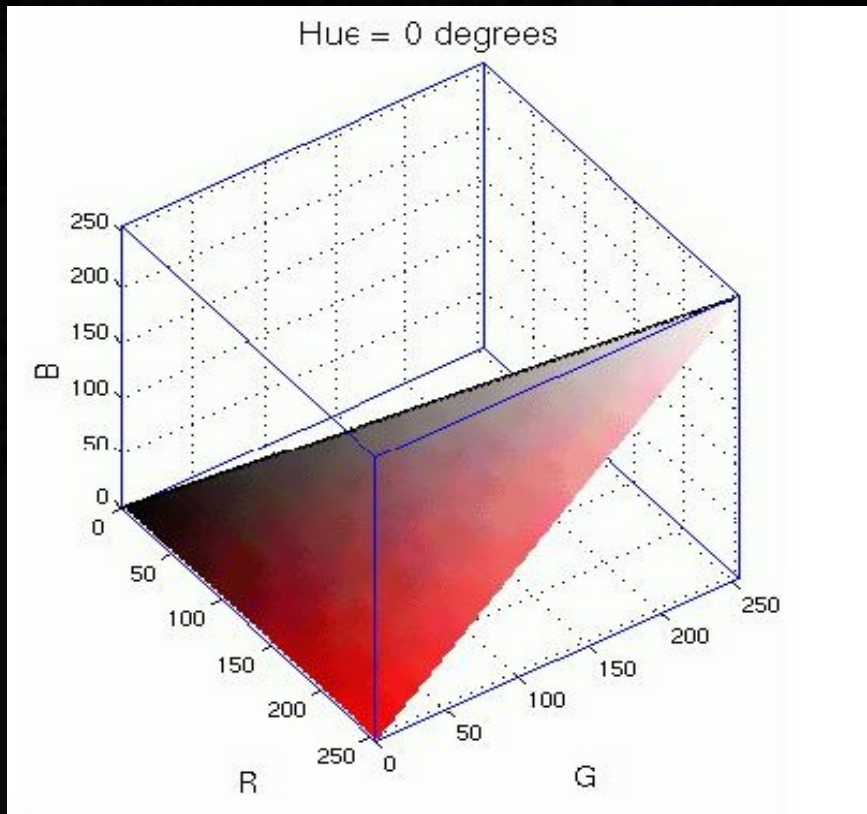
RGB - Colors versus Brightness



RGB – Saturation versus Brightness



RGB – Hue (Color)



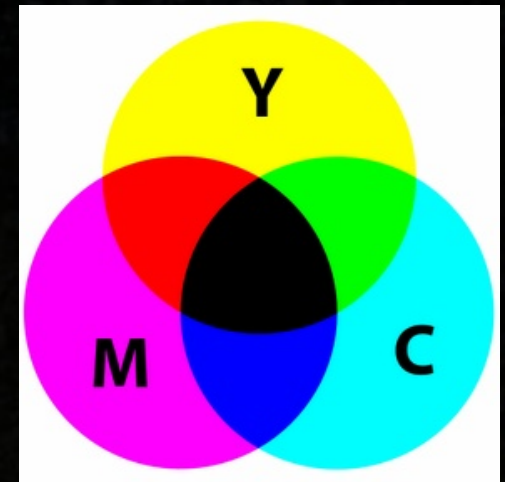
All points on the same triangle, where one side is the grey scale line and the other two sides connect to some point on the surface of the cube, are considered to be the same Hue, or Color.

RGB Digital Photo Limitations

- Limited dynamic range of luminance (256 levels)
 - Contrast ratio of film prints is approximately 128:1
 - Contrast ratio of a typical LCD display is about 700:1
 - “Real world” luminance range is more like 10,000,000:1
- Relationship between luminance, hue, and saturation
 - Luminance is the amount of light, or “brightness”
 - Hue is the specific color (resulting from the RGB blending)
 - Saturation is the purity (strength or depth) of color
 - Change any of these attributes (e.g., in a photo editor) alters the RGB values, and therefore can affect the other attributes

RGB Digital Photo Limitations

- RGB is not a good representation for printing
 - RGB model is based on projected light, where the RGB colors are “added” together to create other colors
 - Printing is based on reflected light, so it requires a model where colors are “subtracted” to create other colors
 - That's why you'll see references to the “CMYK” (Cyan, Magenta, Yellow, Black) color model for printing (and why inks come in those colors)
 - JPEG files must be converted to the CMYK color model when printed, but software does that automatically for you (color space conversion)



What About RAW Formats?

- RAW = unprocessed RGB data from a camera sensor
 - Advantages
 - No data loss due to compression (lossless compression used)
 - No data loss due to camera processing
 - Most modern cameras have 12 bits / color channel
 - Can provide more dynamic range for building HDR photos
 - Disadvantages
 - Non-standardized – different between different manufacturers
 - Very large files (usually >10MB per picture)
 - Not pre-processed for white balance, sharpness, exposure
 - Sensor response is linear, Exposure values are exponential
 - You need a sensor range of 4x to capture twice as much light

“Enhancing” JPEGs with a Photo Editor

Photo Editor Function Categories	Examples
Change the number and/or location of pixels (without modifying individual pixel content)	Crop, Rotate, Flip, Resize
Change the basic content/type of pixels	Color->Greyscale, Transparency (Alpha channel)
Overlay/blend pixels	Fill, Paint, Erase, Add Text/Shapes, Layers, Cloning
Perform “global” transformation, affecting all pixels similarly (“pushing pixels” around the color cube)	Brightness, Contrast, Hue, Saturation
Perform locally-sensitive transformations, affecting only specific pixels in specific ways	Sharpen, Blur, Noise Reduction, Red-eye

Important Note: Although these functions can certainly make a photo more esthetically pleasing, or enhance certain detail, most cause some loss of information from the original digital photo content!!

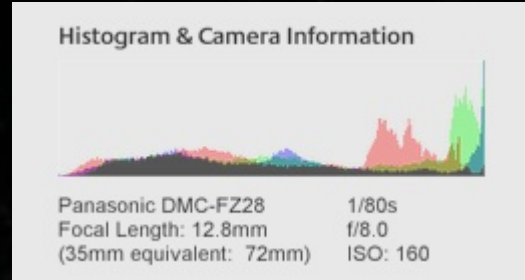
High Dynamic Range (HDR) Photos

- Enhance photos by capturing more information
 - Use exposure settings on your camera to capture the same picture at more than one exposure setting
 - Blend the resulting multiple exposures together into an HDR digital image format with a greater dynamic range than RGB
 - Use a technique called “tone mapping” to process the HDR image into an RGB-based “view” which approximates the HDR's appearance, so that it can be viewed on a standard computer monitor
 - Results can range from realistic to “artistic” – to bizarre

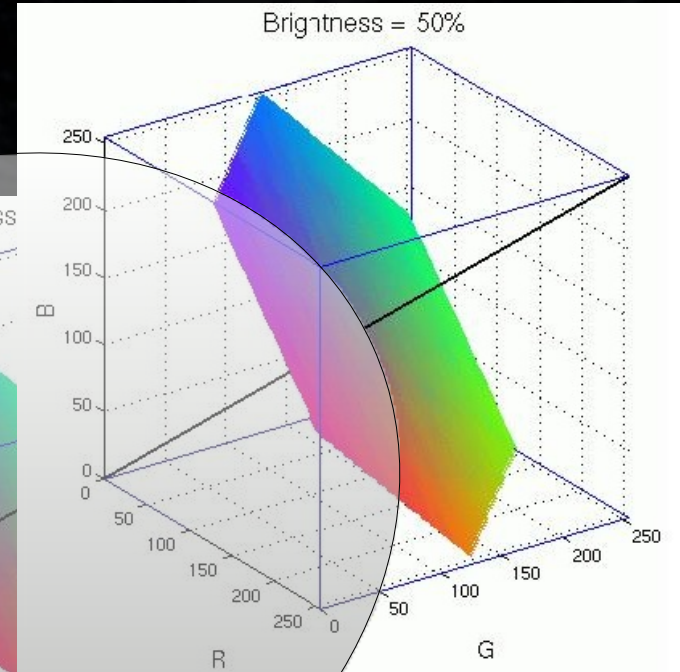
High Dynamic Range (HDR) Photos

- Step 1 - Taking the picture
 - Take the same picture with multiple, different exposures
 - Typically at least 3 exposures – normal, under, over
 - Variations of +/- 2Ev seem to work best
 - If your camera has an auto-bracketing mode (takes 3 photos with different exposures), this makes it much easier, although many cameras only do brackets of +/- 1Ev
 - Best to use the Aperture priority setting on your camera (if it has one), and let the camera adjust the exposure time
 - Best to use a tripod, so the exposures align precisely
 - Use a remote shutter release, or the timer, to minimize shake
 - Choose subjects with very little movement between exposures
 - Movement results in “ghosting” when exposures are blended

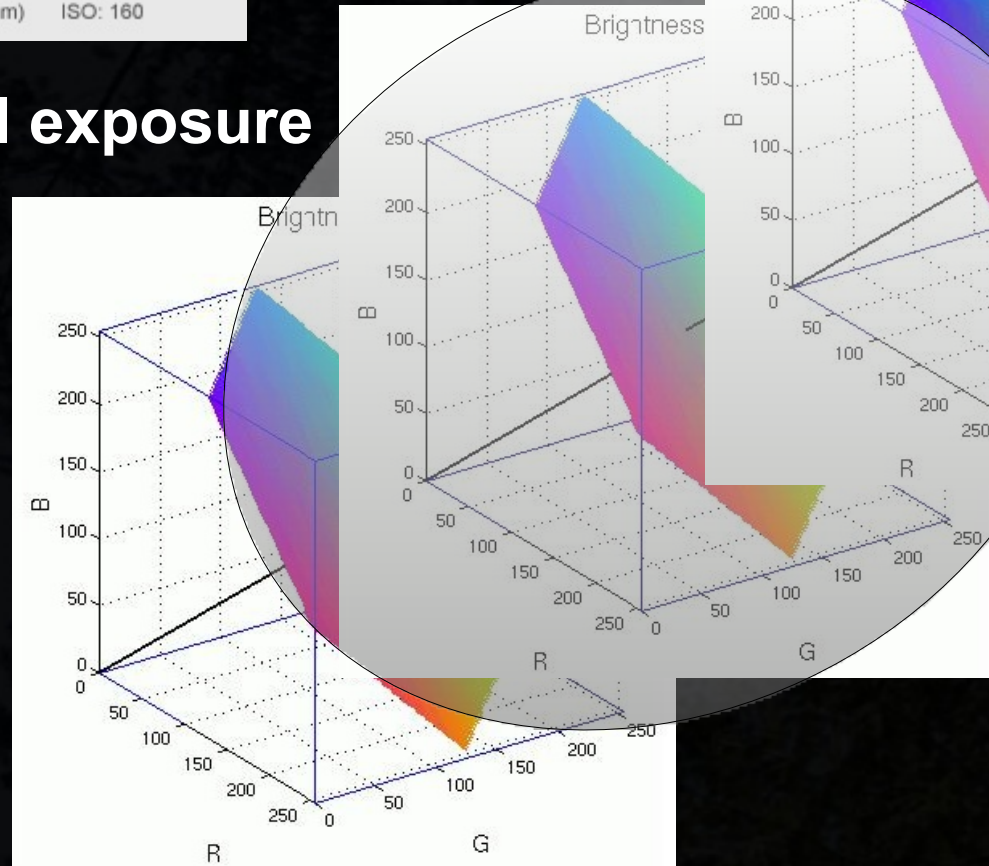
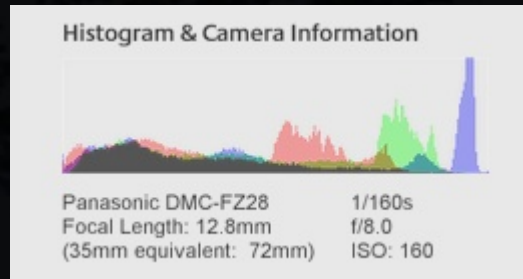
Photo Bracketing for HDR



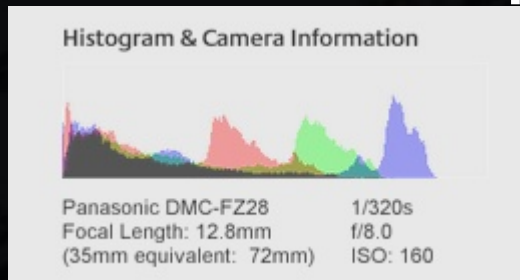
Overexposed



Normal exposure



Underexposed



High Dynamic Range (HDR) Photos

- Step 2 – Merging Step 1 photos into an HDR image
 - Using HDR software, select the 3 (or more) photos to merge
 - Ensure the photo images are aligned precisely
 - Let the software do its stuff
 - Save the generated HDR image (if desired)

HDR Imaging Software

- Photoshop CS4
 - Basic HDR creation tools, but not much workflow assistance
- Photomatix (\$99, www.hdrsoft.com)
 - Leading commercial HDR imaging product
 - Available as standalone program or Photoshop plugin
- Qtpfsgui (Free, qtpfsgui.sourceforge.net)
 - Capable HDR workflow tool, some experimentation required
- A few others (less interesting, so far)
 - Picturenaut, FDRTools, Essential HDR

Popular HDR Photo File Formats

- Radiance HDR (.HDR)
 - Also known as RGENE, 8-bit floating point with shared exponent
- OpenEXR (.EXR)
 - Open file format for HDR images, with lossless compression
 - 16- or 32-bit floating point, or 32-bit integer per color channel
- TIFF (.TIF)
 - Originally a simple B/W scanner format, now up to 8- or 16-bit integer per color channel, lossless compression
- Portable Floatmap Stream (.PFS)
 - Flexible file format used for early HDR tools

High Dynamic Range (HDR) Photos

- Step 3 – Tone mapping the HDR image from Step 2
 - Using HDR software, open the HDR image
 - Select Tone Mapping algorithms to apply to the HDR image
 - Selection depends on what effect you are trying to achieve
 - Mostly based on experimentation and personal preference
 - Save the RGB outputs of the tone mapping process (JPEG/TIFF)
 - In some cases, blend one or more tone-mapped output files
 - Open one JPEG in regular photo editor that supports layers
 - Open a second JPEG as a new layer
 - Set blend mode to Overlay, and adjust the opacity
 - Example – open Drago output, open Fattal as new layer, set blend mode to Overlay, set opacity to ~70%

Useful HDR Web References

- **General Digital Photography**
 - <http://www.cambridgeincolour.com/>
 - <http://www.dpreview.com/learn/?/Glossary/>
 - <http://osp.wikidot.com/>
- **HDR Photography**
 - <http://osp.wikidot.com/parameters-for-photographers>
 - <http://osp.wikidot.com/qtpfsgui-manual>
 - http://www.vanilladays.com/hdr_tutorial/
- **Tone-Mapped HDR Examples**
 - <http://www.flickr.com/groups/hdr/>