
Dynamic Range
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# Dynamic Range

- What is dynamic range?
- What is low or limited dynamic range (LDR)?
- What is high dynamic range (HDR)?
- What's the difference?
- Since we normally work in LDR
  - Why it is advantageous, in most cases, to increase the dynamic range of your image.
  - How you can obtain the highest dynamic range possible within LDR.

# Dynamic Range

Dynamic range in photography defines the ratio between the maximum and minimum measurable light intensity (white and black, respectively).

# Dynamic Range

- White (lightest) is easiest to measure (white of paper). Small differences are easily visible.

- Black (darkest) is harder to measure as it may be unclear where differences are no longer discernable.

# Dynamic Range

Dynamic range in photography is measured in terms of f-stops.

Each increase of an f-stop represents a doubling of the amount of light.

# Dynamic Range of various devices

- Slide Film – about 4 f-stops
- Negative Film – about 6 f-stops
- Digital Camera – about 6 f-stops
- Human eye – 10-12 f-stops.
- If we include the ability of iris to open and close – 24 f-stops

# Digital images

- All of the devices we use are Low (or limited) dynamic range and set limits on the range available.
  - camera - sensor elements (like a cup)
  - monitor - pixel brightness
  - printer - ink and printer drops
- Highest value in file = Brightest tone that can be measured or displayed.

# Computer Representation of Color is limited

8 or 24 bit color

- 3 colors (Red, Green, Blue)
- Each color is represented by “8 bits” of information
- Red – 256 levels
  Green – 256 levels
  Blue – 256 levels
- Total 16,777,216 levels of color which is more than the eye can discern.
- But range still limited by device (camera, printer)

# Computer Representation of Color is limited

## 16 or 48 bit color

- 3 colors (Red, Green, Blue)
- Each color is represented by “16 bits” of information
- Red – 65,536 levels
  Green – 65,536 levels
  Blue – 65,536 levels
- Total 281,474,976,710,656 levels of color which is more than the eye can discern.
  - More gradations (shades) available with 16 bit than 8 bit
  - But the dynamic range is still the same, limited by device (camera, printer)

# Low (limited) Dynamic Range

- The Dynamic Range is limited by our devices (camera, monitor, printer).
- We will look at techniques and methods to maximize the dynamic range within the system
- Discuss the newer concept of High Dynamic Range and how it works.

# Dynamic Range

- One problem in photography has always been the rendering of scenes with bright lights and dark shadows. It was true with film and is still true with digital photography.

# Limited Dynamic Range in Photography

1/20 sec  f11

3.2 sec  f11

6 f-stops

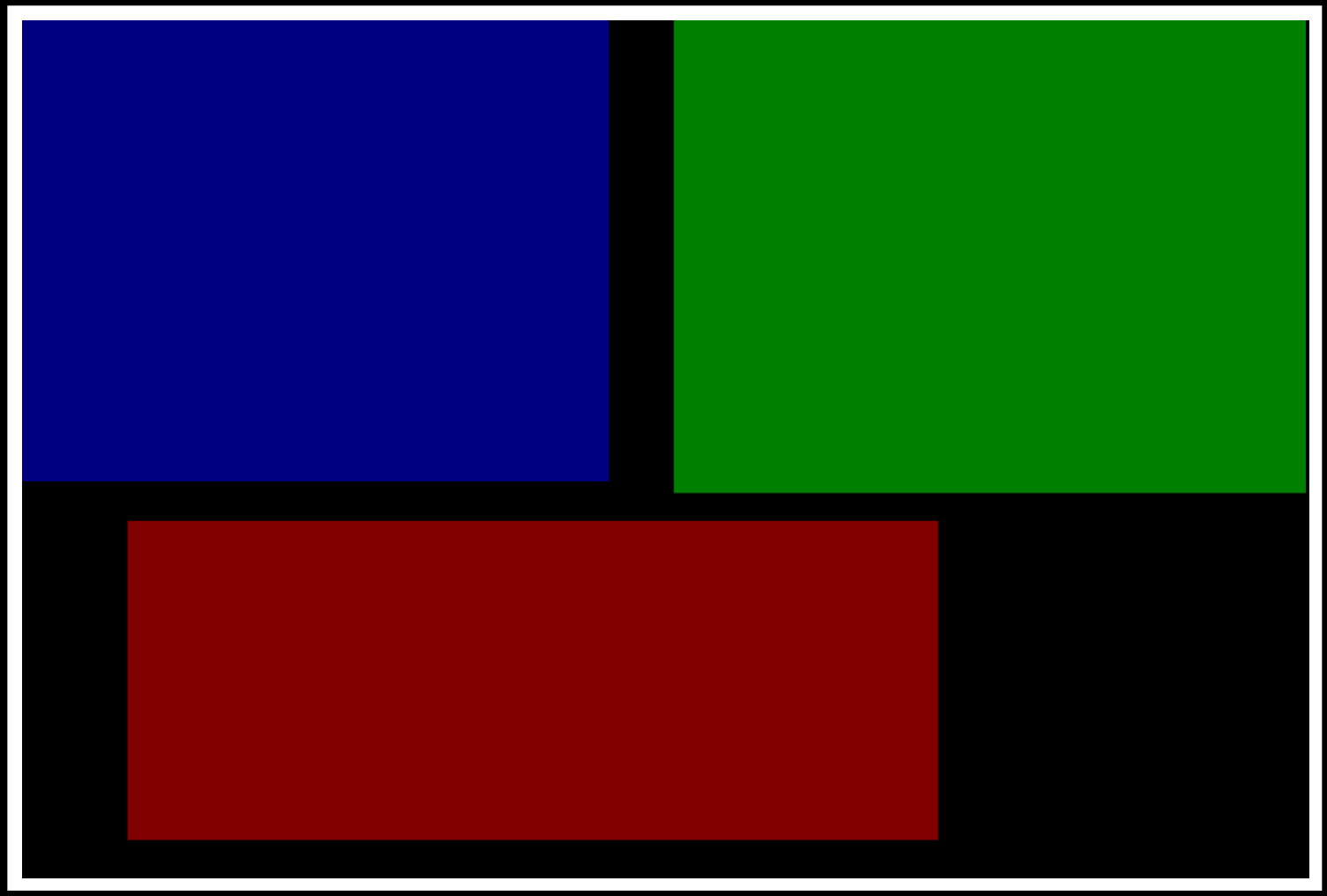
# Limited Dynamic Range in Photography

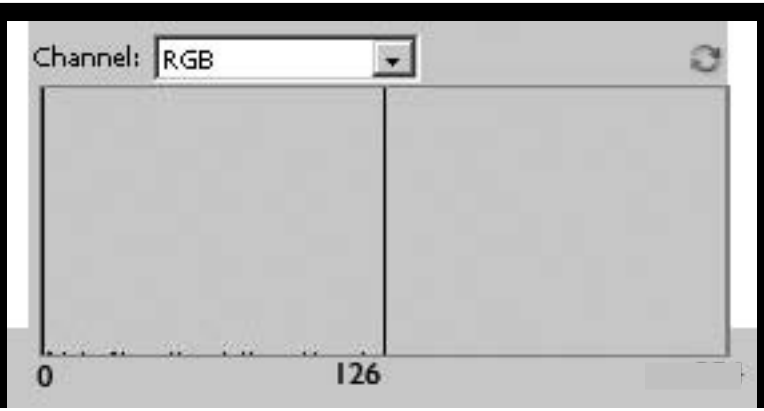
- The eye can see a much greater dynamic range than is possible in a camera.

- How can we produce photographs that get around the limited range?

# Histogram

- The ability to view and utilize a histogram is a great advantage of digital over film.
- Represents tone (brightness) at any point in the dynamic range – It is brightness and not color.
- Values can be between 0 and 255.
  - Limited by
    - Input devices (camera, scanner)
    - Viewers – screen
    - Output – printer, projector

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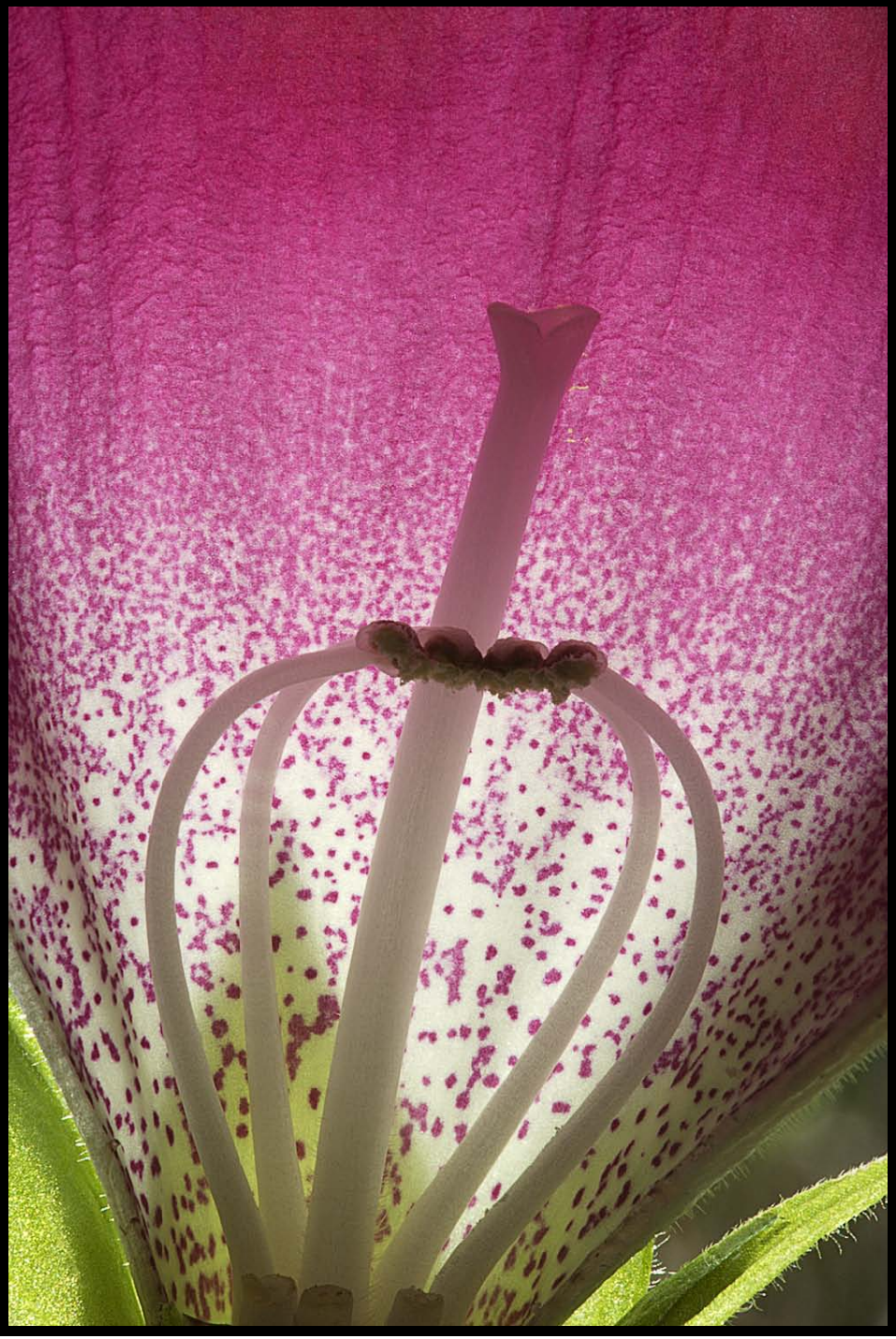
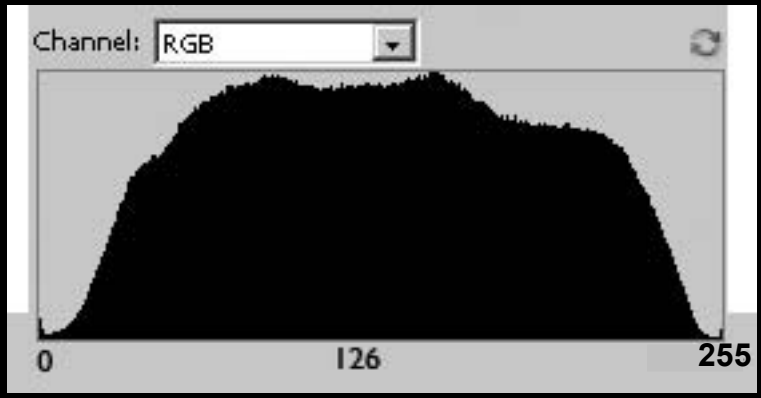
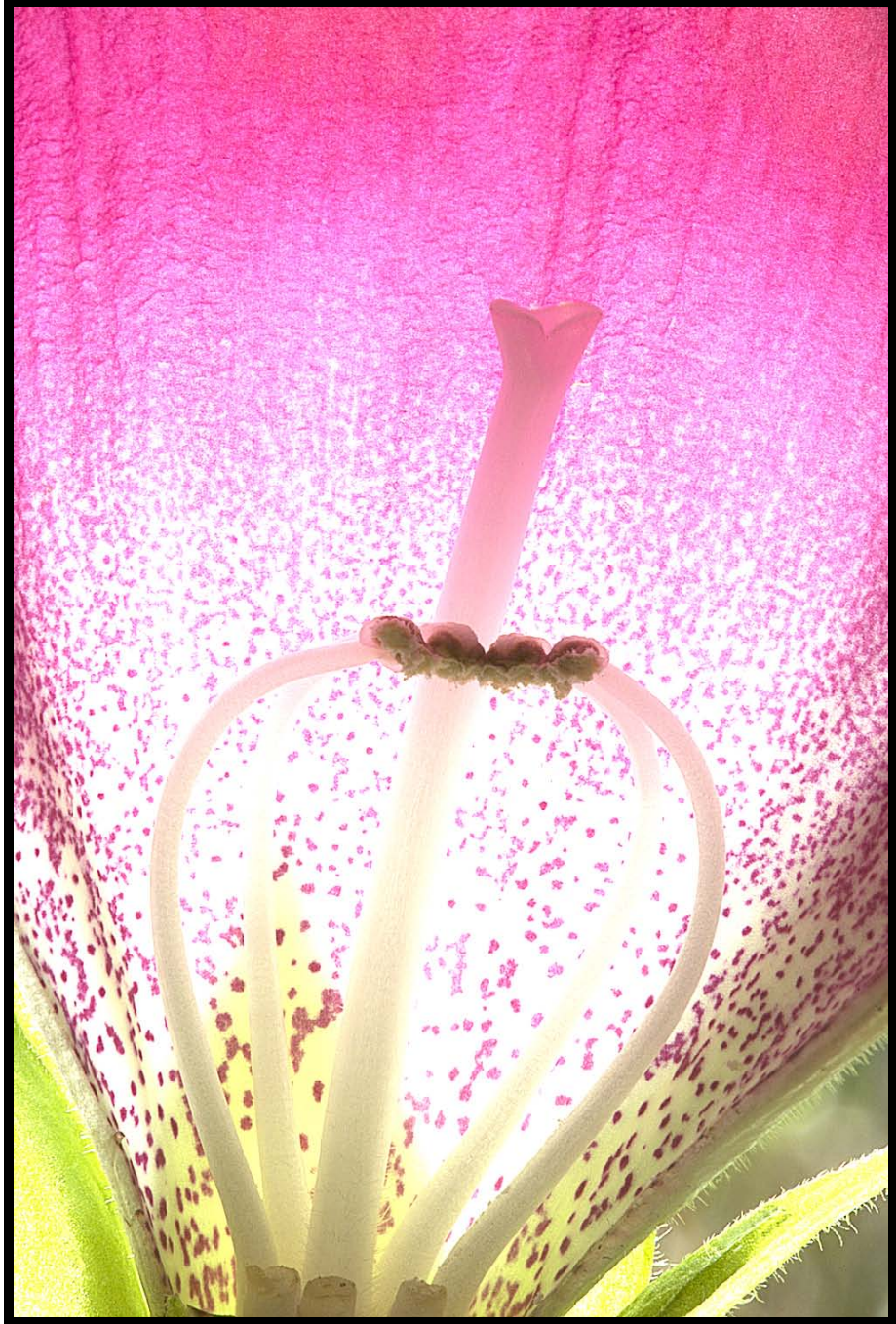





Histogram represents the number of pixels at each tonal value or brightness
Between:
0 = Pure Black
255 = Pure White

“Good” histogram:
No or minimal pixels at either end
No breaks in curve
Uses entire tonal range




Histogram represents the number of pixels at each tonal value or brightness
Between:
0 = Pure Black
255 = Pure White

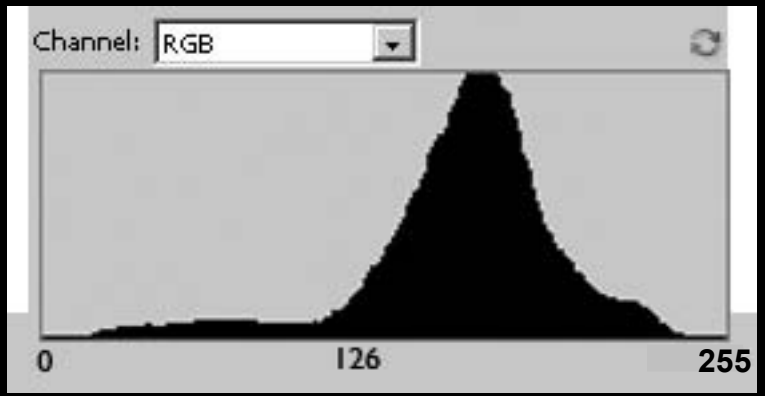
“Bad” histogram:
Pixels at right (white) = blown out
Breaks in curve = posterization (not continuous color)


Histogram represents the number of pixels at each tonal value or brightness
Between:
0 = Pure Black
255 = Pure White

“Bad” histogram:
Pixels at left (black) = no details in shadows.

Breaks in curve = posterization

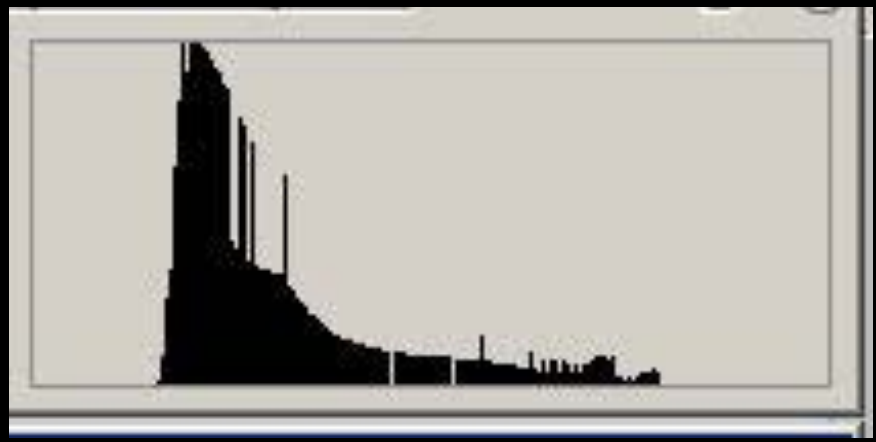
Histogram represents the number of pixels at each tonal value or brightness
Between:
0 = Pure Black
255 = Pure White

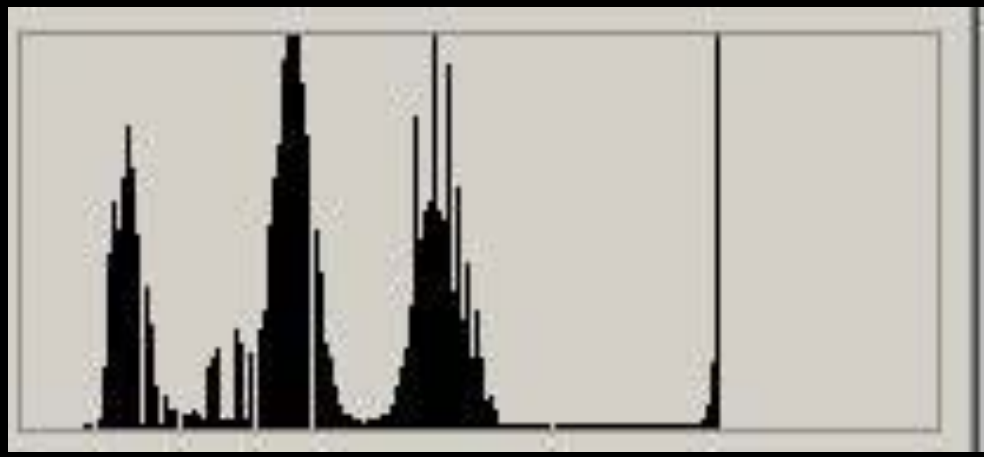



“Good” histogram:
No or minimal pixels at either end
No breaks in curve
Uses entire tonal range

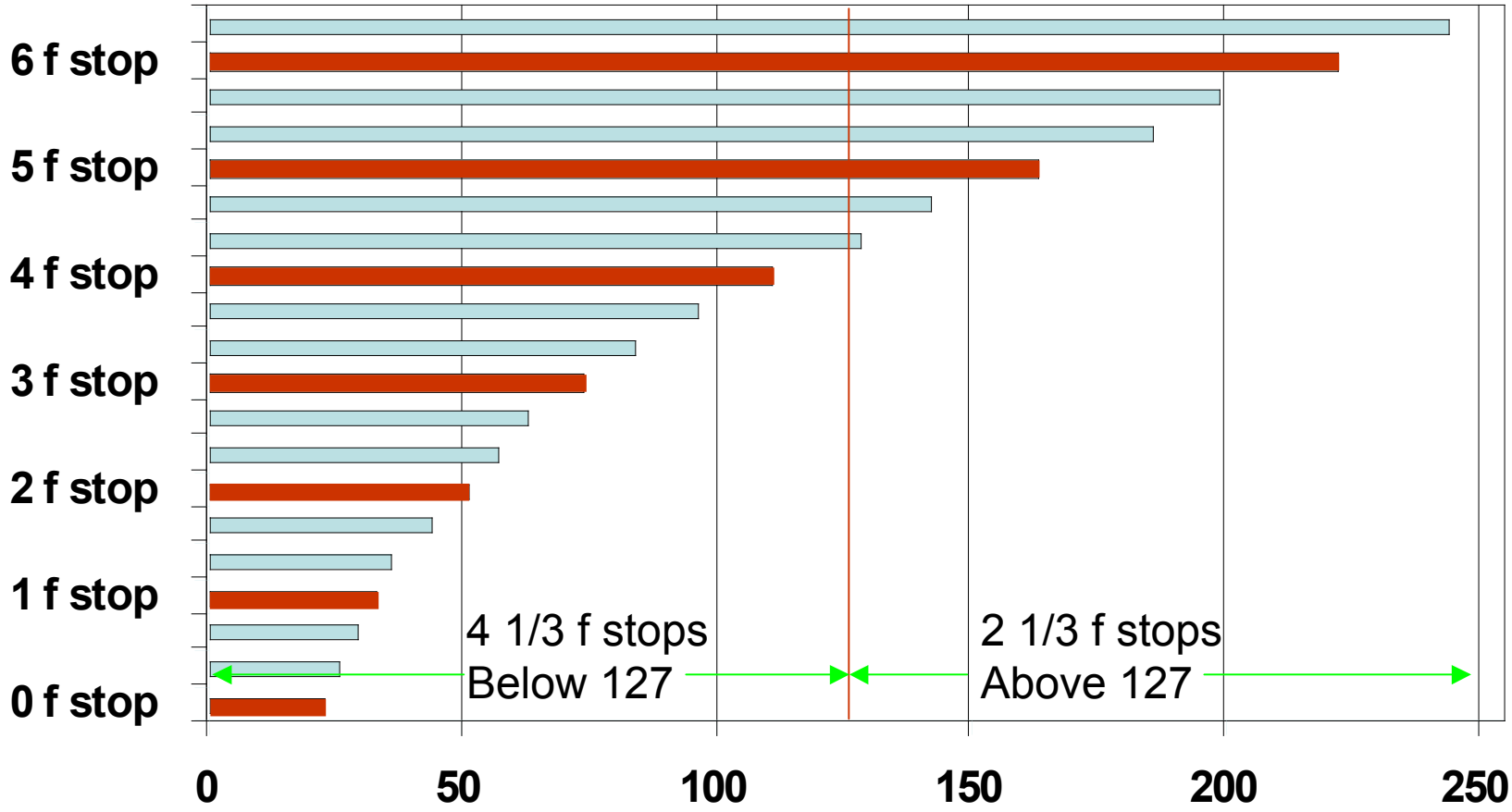
# Should one always *Optimize the Histogram* ?

- Some images look best with a Limited Dynamic Range.
  - Photograph in the fog.
  - Effect of low contrast.
  - Silhouettes
  - You may like the effect of dark shadows or very light highlights.





# Dynamic Range of Digital Camera
# f 5.6, Iso 100



# Dynamic Range

- How can you assure that you are getting the highest dynamic range possible?
  - When taking photograph
  - When processing photograph

# Methods of increasing dynamic range of image

While taking photograph:

- Take photo with graduated neutral density filter.
- Use Fill Flash
- Shoot to right of histogram (expose for brightest) – most important with JPG
- Take photo in RAW &16 bit rather than JPG & 8 bit.
- Keep file as RAW (do not convert to JPG).

# Use Fill Flash

1/20 sec  f11

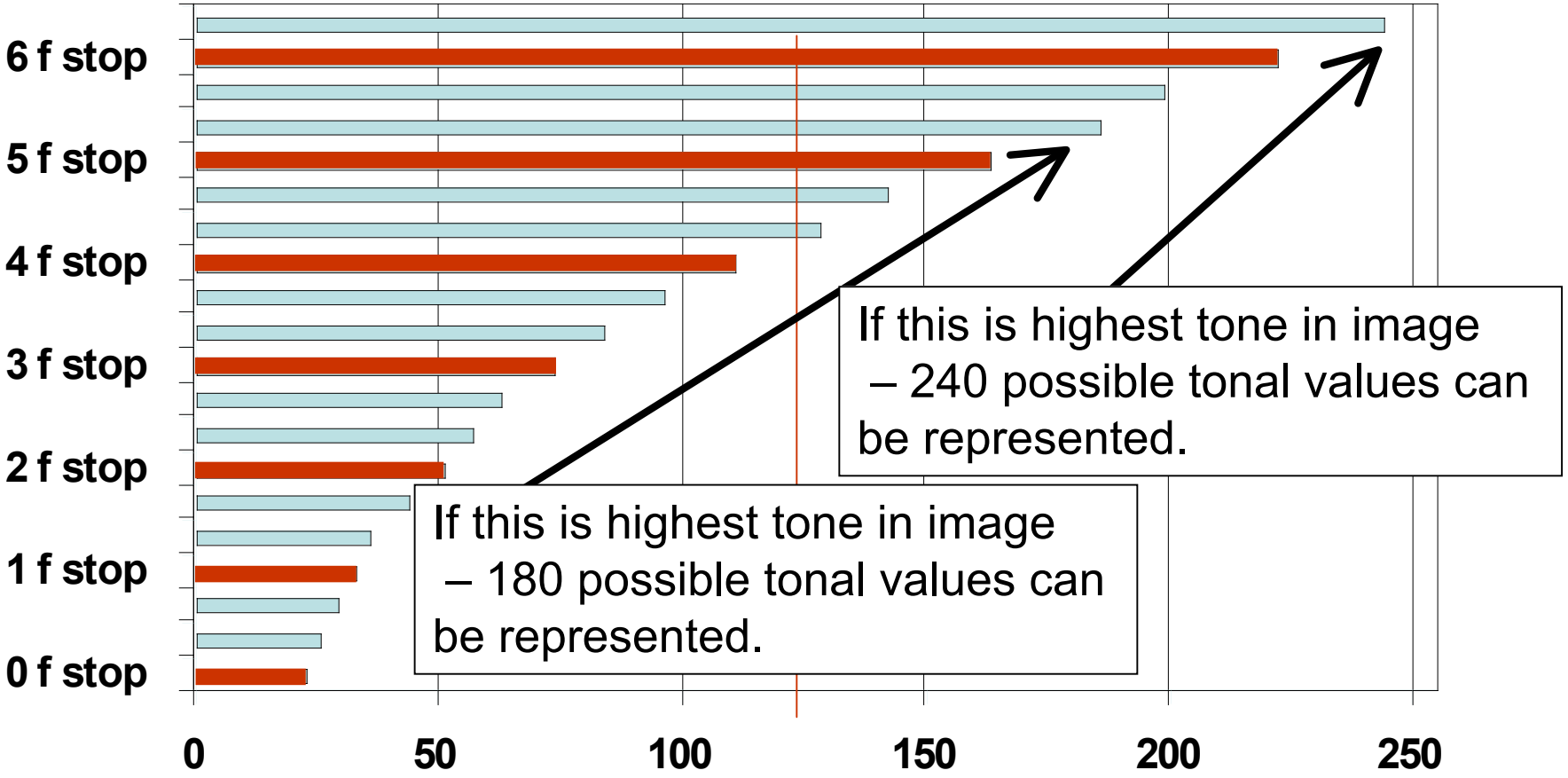
3.2 sec  f11

1/20 sec f11
With fill flash

# Methods of increasing dynamic range of image

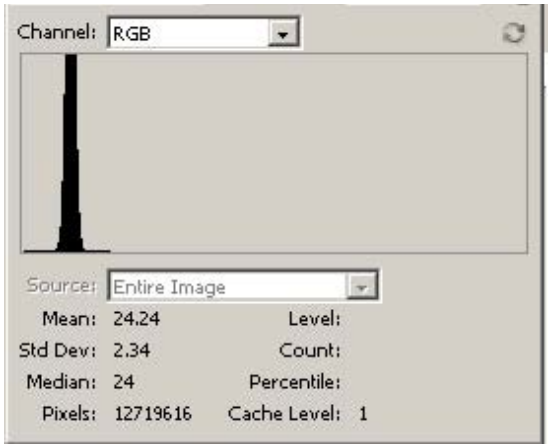
- "Shoot to right"
  - In theory, since 50% of range is in the brightest f-stop you will get more information by letting curve almost reach the right side of histogram.

# Increasing f-stop by 1 increases dynamic range by 60 or 30%

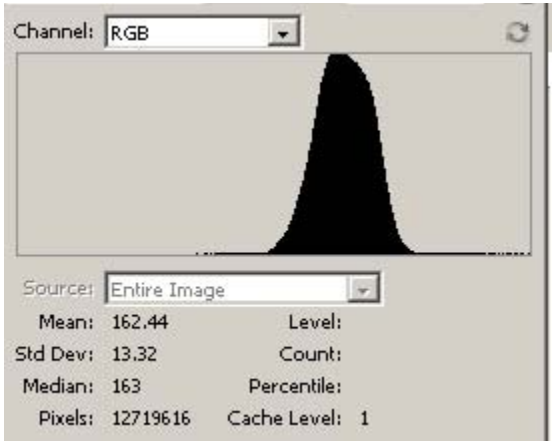


# Greater range of tones with exposure to right (5 f-stops difference)

0.8 sec
at f 5.6



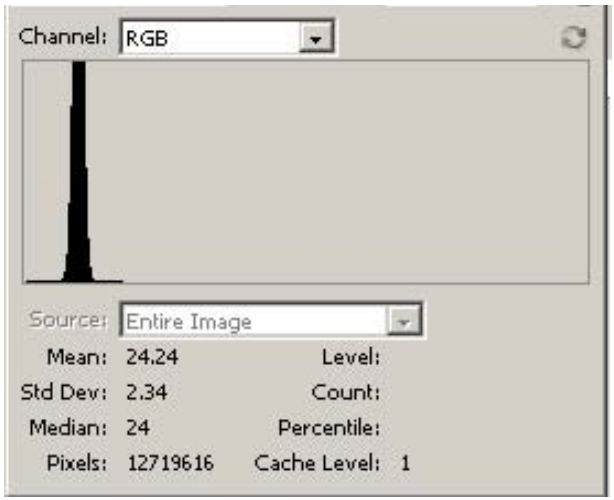

1/40 (.025) sec
at f 5.6

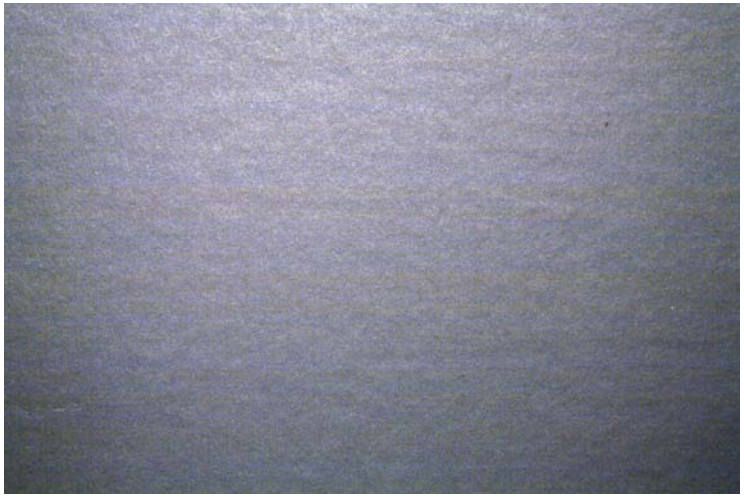


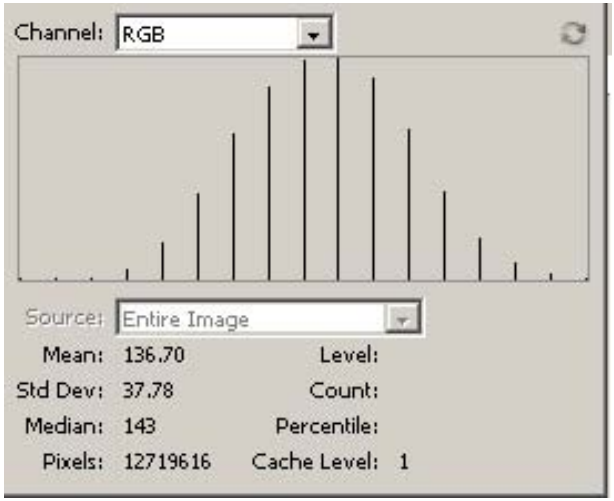
# Methods of increasing dynamic range of image

- Leave file as 16 bit rather than 8 bit until you are finished manipulating it in photoshop.
  - RAW, PSD, TIF can be 8 or 16 bit.
  - JPG can only be 8 bit

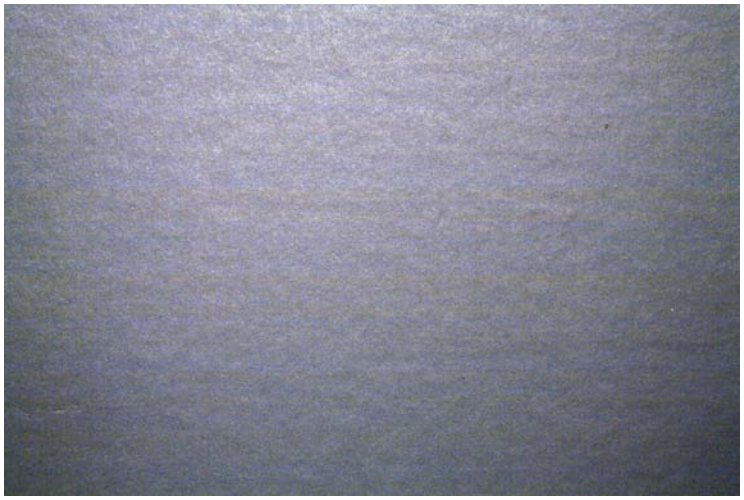
# Consider 8 bit image at dark end of tonal spectrum
# Spread out to increase dynamic range



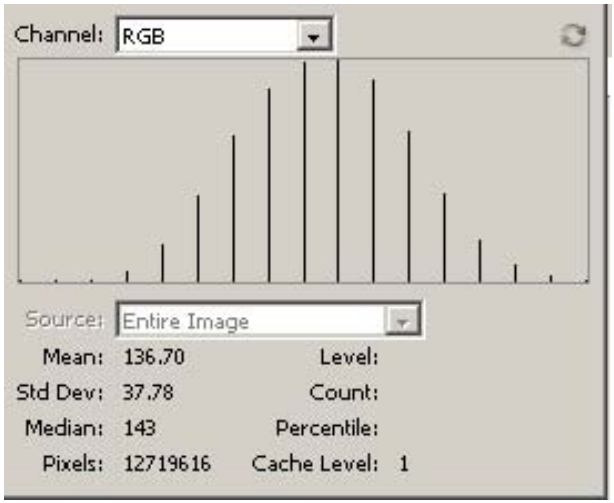



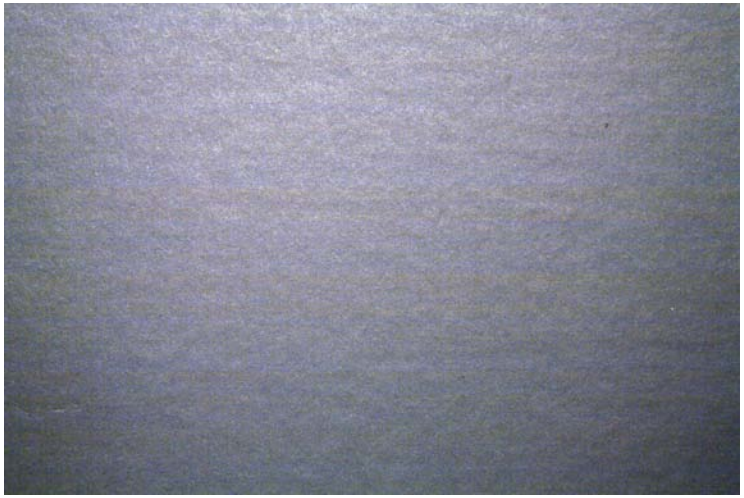


# Consider 16 bit image at dark end of tonal spectrum
# Spread out to increase dynamic range

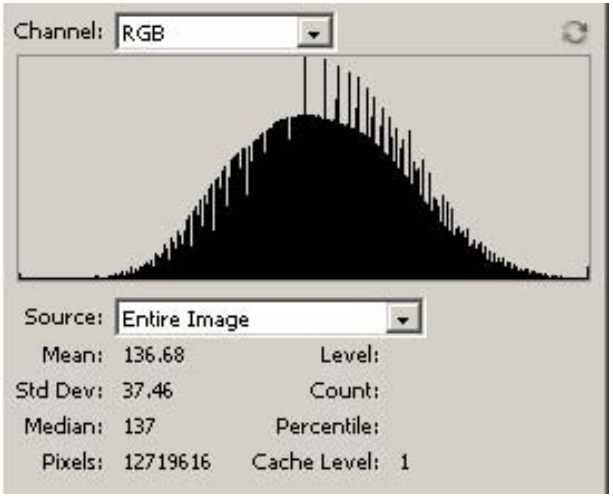


8 bit

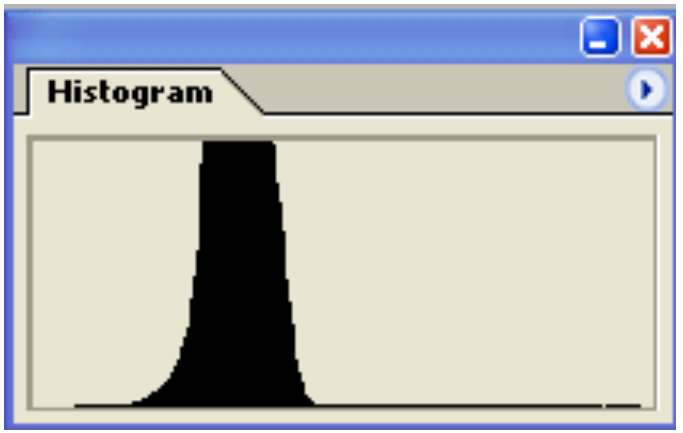


16 bit



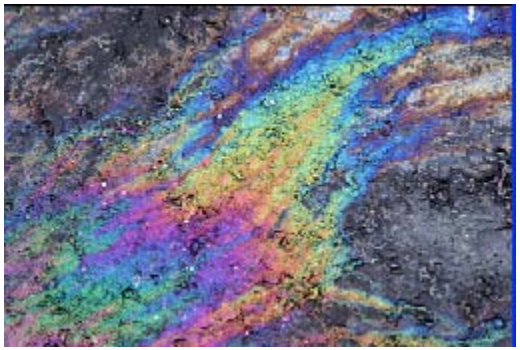
# Original Image

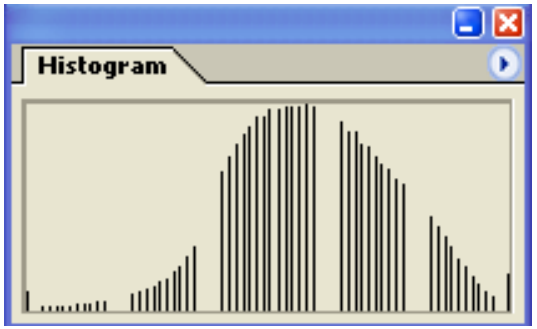


# Use Levels to Increase Dynamic Range

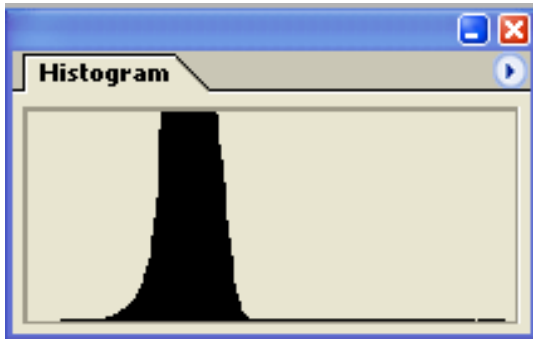
**Original**

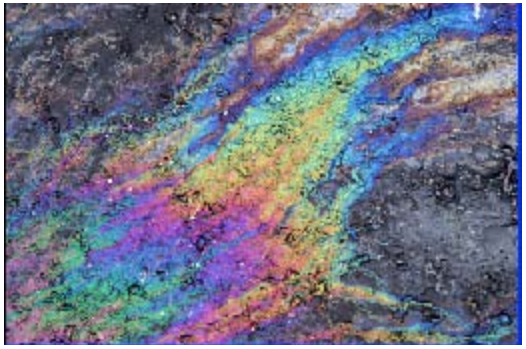
**8 bit**

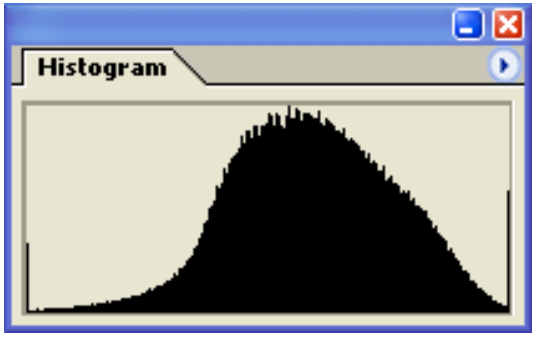





**16 bit**






# When converting RAW to JPG the camera must:

- Decrease 16 bits to 8 bits.
- De-mosaicize each pixel.
- Apply White Balance.
- Enhance with (sharpness, brightness, contrast, saturation) as per camera or you.
- Apply gamma (curve correction).
- Compress data.

# Advantages of RAW over JPG

- Keeping 16 bits avoids posterization especially if you will be increasing the tonal range of the image.
- Allows more details in opening up the shadows.

# Advantages of RAW over JPG

- De-mosaicizing each pixel is very computer processor intensive.
- Better algorithm in computer than in camera.

# Advantages of RAW over JPG

- JPG makes white balance changes.
- RAW retains flexibility to correct white balance or to use any white balance you choose after taking the photograph.

# Advantages of RAW over JPG

- JPG makes changes in contrast, brightness, saturation and sharpness that either the camera manufacturer or you have pre-determined.
- This might not be correct for your specific photo (need different adjustments for portraits, fog photos, landscapes, flowers etc.)
- Any change destroys data.

# Advantages of RAW over JPG

- JPG applies a “gamma” curve.
- RAW lets you do this to your own specifications (contrast enhancement).

# Advantages of RAW over JPG

- JPG looses data when it compresses image.
- RAW has no compression so you are making improvements on all available data.

# Advantage of RAW over JPG
# Exposed for no blow-out


# Advantage of RAW over JPG

Exposed for no blow-out
opening shadows with shadow/highlight adjustment

RAW

JPG

Better opening of shadows and less noise with RAW

# Image Saved as .tif vs .jpg

Saved as .tif file

Saved as medium .jpg
opened once

# Disadvantages of RAW vs JPG

- RAW files are larger than JPG therefore get fewer shots on a card and takes longer for camera to copy to card.
- RAW files are proprietary and therefore information is at the whim of company. (?DNG).
- RAW requires extra steps when you process them which may be time consuming if you took 1000 photos of an wedding.

# Disadvantages of RAW vs JPG

- RAW files have not been altered by camera (contrast, brightness, saturation, sharpness) and are therefore darker, lack contrast, less saturated than jpg

Unless you modify in Photoshop.

Most images look best when the dynamic range is *optimized*

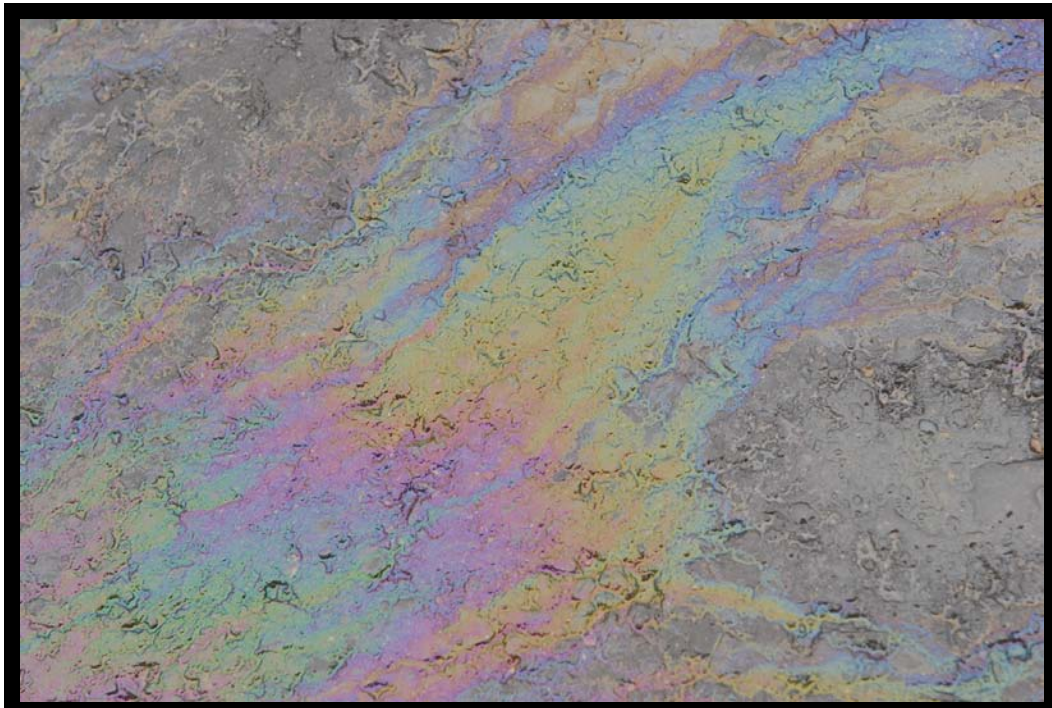
Therefore it is usually advantageous to use Photoshop to *optimize* the image.

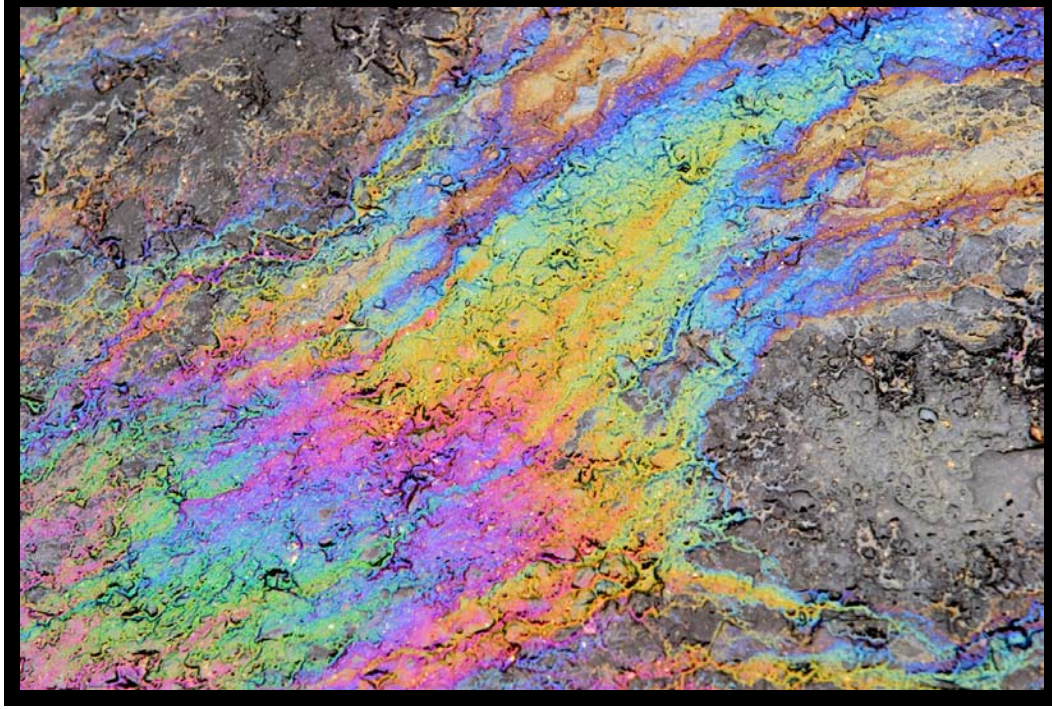
# Methods of increasing dynamic range of image after you have taken photograph

- Single photo –
  - Set white and black points in levels or curves
  - Modify with Shadow/Highlight Adjustment
  - Modify with curves or levels and masks
  - Modify in Camera RAW using “fill light”

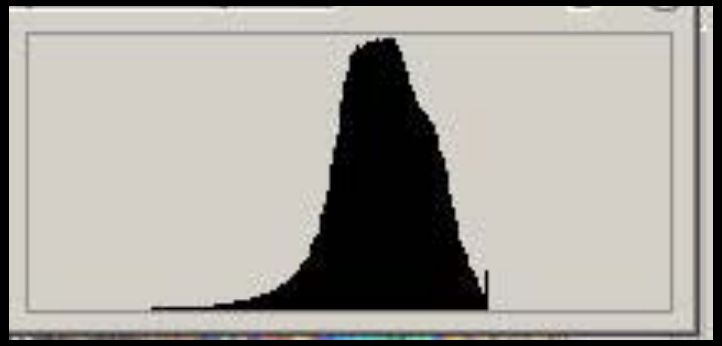
- Combine 2 photos (Expose for highlights/shadows)
  - Blend 2 images (Exposure Blending)
  - Blend CS4 Auto Align/Smart Object>stack mode>mean
- Combine 3 or more photos
  - Blend with HDR
  - Blend CS4 Auto Align/Smart Object>stack mode>mean

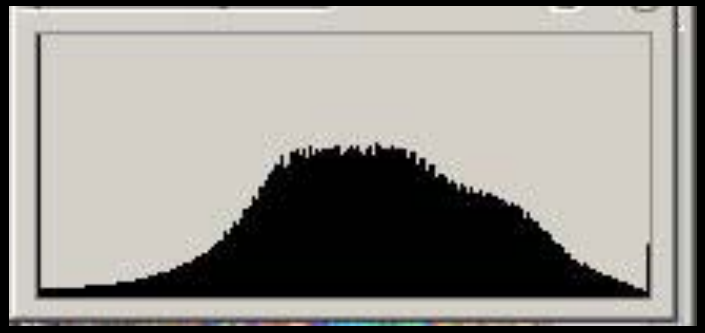
# Increasing Dynamic Range in One Image





## Setting black and white points





# Problem with expanding histogram

- Limited range of tones may lead to posterization
- Noise in shadows may become more visible.
- Can be minimized by manipulating as 16 bit rather than 8 bit.

# Image as seen by Eye and Camera

Eye

Camera
(using meter)

# Enhancing Dynamic Range of Single Image in computer

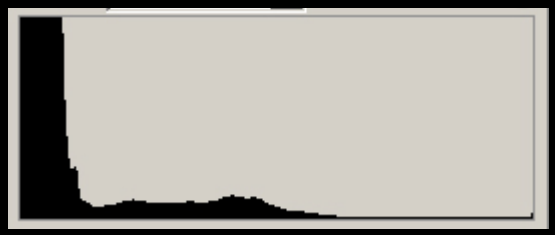
Photograph using metered exposure

# Attempt to improve single image with Shadow/Highlight Tool

Original

Shadow/Highlight
Adjustment in Photoshop

# Photograph
# Using -3 f-stops (no blow out)



# Photograph
# Using -3 f-stops (no blow out)
# Shadow/Highlight Tool

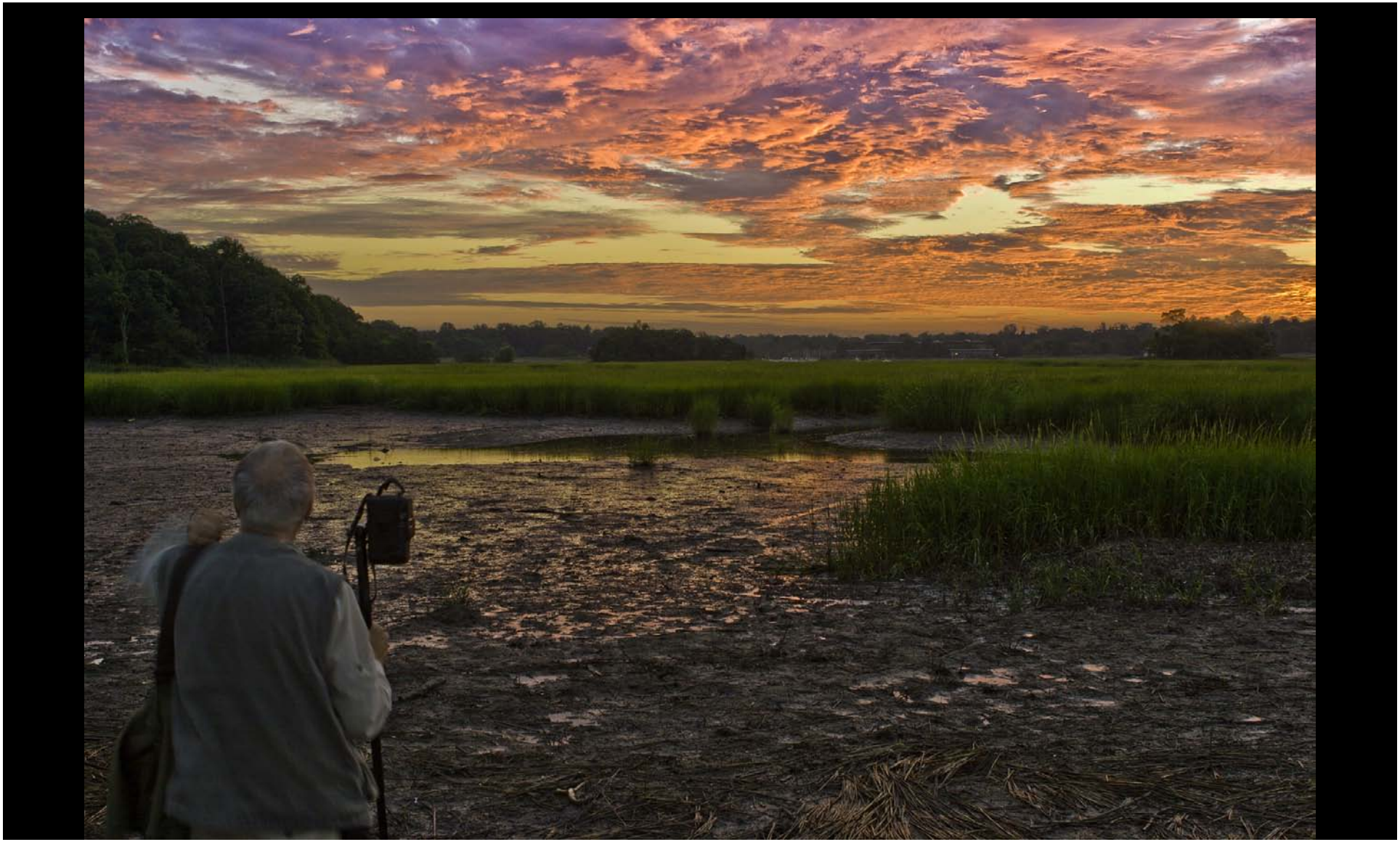
# Unmodified Digital Photograph

(taken with no blow-out)

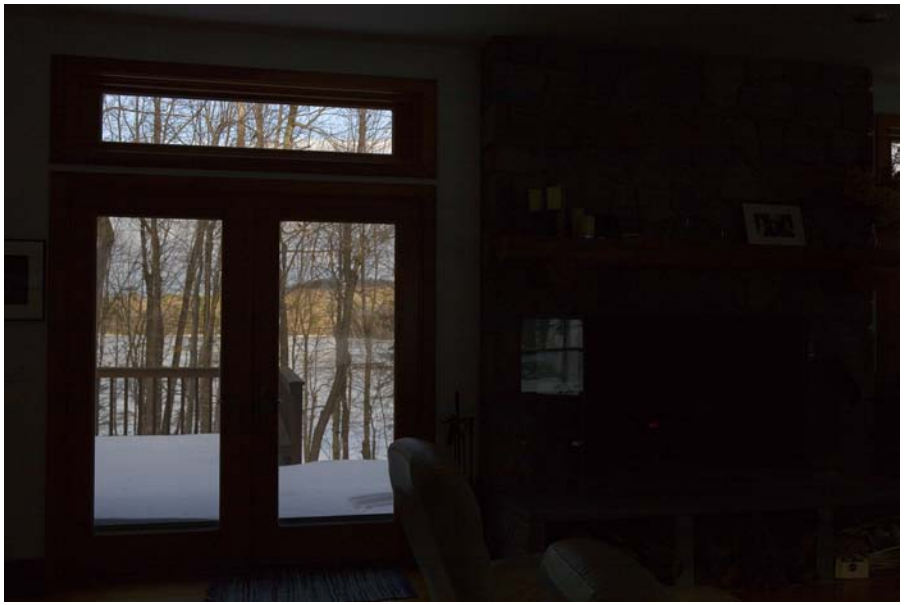
# Digital Photograph

## Brightness increased in Photoshop

# Digital Photograph
## Modified in Adobe RAW



# Combining 2 exposures

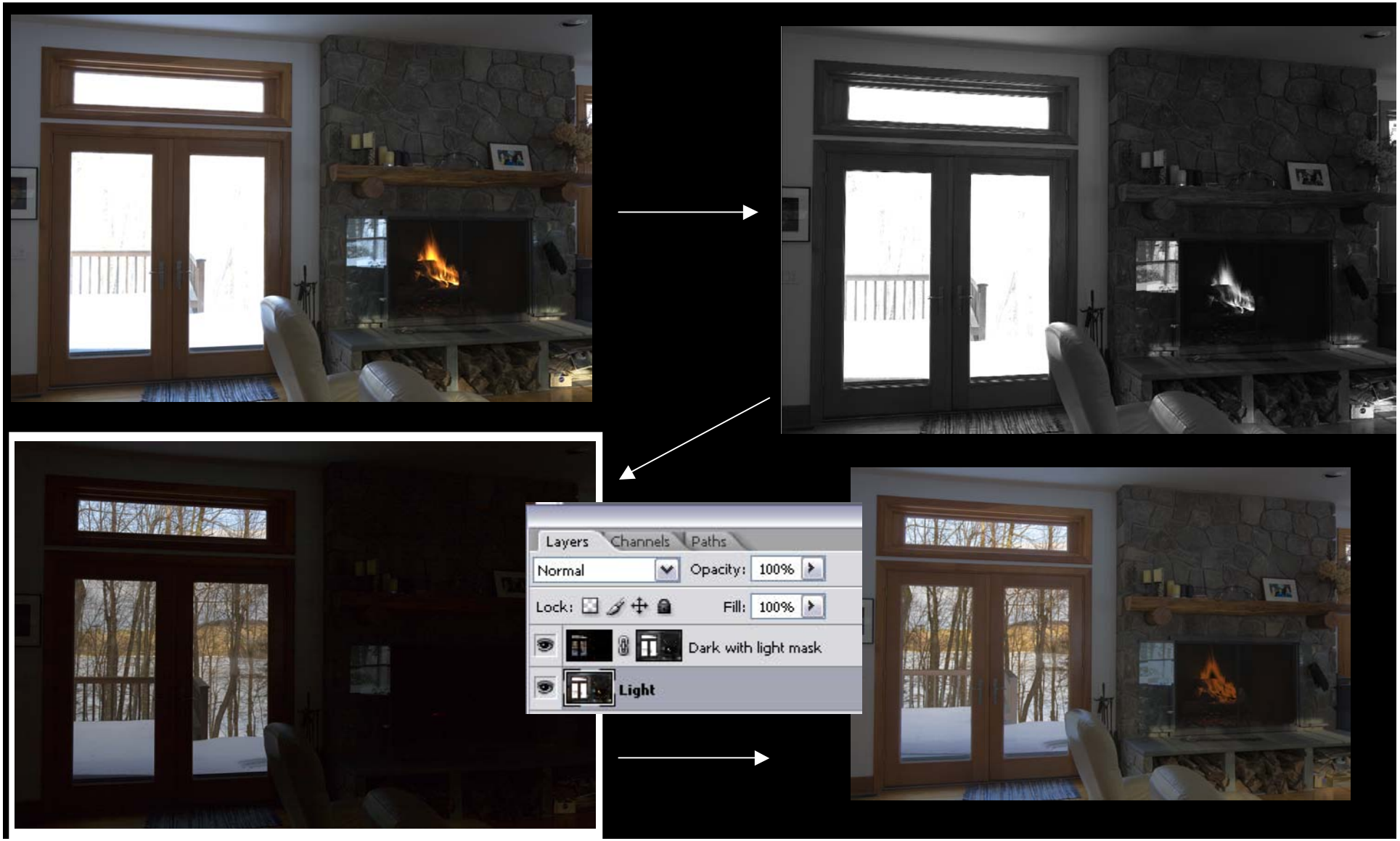


- 4 f-stops

+ 2 f-stops

# Combining 2 exposures

## Make mask from lighter exposure to mask darker exposure

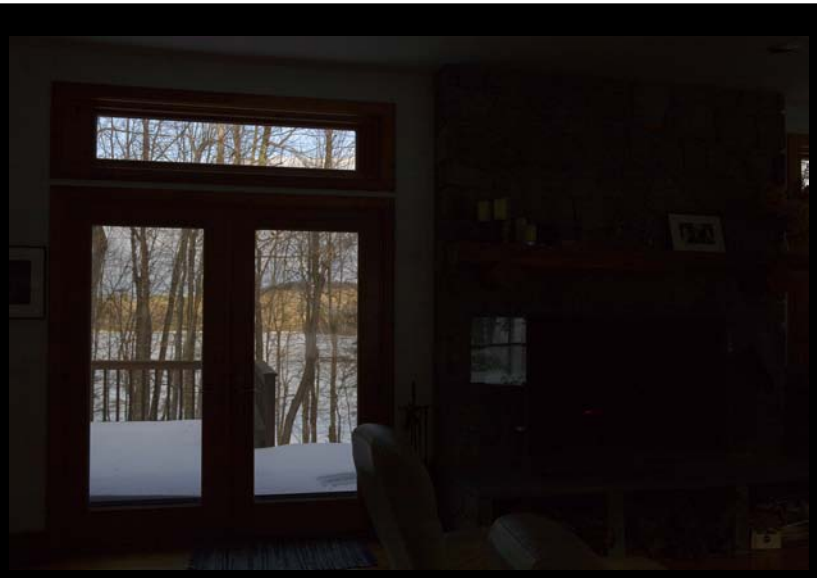


# Combining images in CS4

- Take 2 or more images
- In Adobe RAW Converter go to
  - Tools>Photoshop>Load Files into Photoshop Layers
  - Select all layers
- In Photoshop:
  - Edit>Auto-align layers
  - With all layers selected: Layers> Smart Object>Convert to Smart Object
  - Layer>Smart Object>Stack Mode>Mean

# Combining 2 exposures

## Utilize CS4 Auto Align/Smart Object>stack mode>mean



# HDR

- High Dynamic Range (HDR) is a new method of recording light in the computer.
- Use 32 bits (not 8 or 16) but in a different way.
- Enables the computer to record light across an infinite dynamic range.

# Shooting an HDR image

- Use Tripod
- Set camera to manual exposure setting with appropriate f-stop and lowest ISO.
- Take exposure using appropriate shutter speed.
- Slow down shutter speed (more light) by 1 to 2 f-stops and look at histogram. Do this until well away from left end and details are seen in shadows which are noise free.
- When satisfactory go back to original shutter speed and do the same thing by speeding up shutter speed and right end of histogram so no blown highlights.
- Can have any number of exposures (usually 3 or more)
- May be able to use Auto-exposure bracketing if it allows +/- 2 f stops and range sufficient.
- Combine images with HDR tool in Photoshop or use Add-in (Photomatrix etc.)

# How does the computer do it?

- The computer records the amount of light at the pixel.
- It also knows how many f-stops +/- it was exposed with.
- Therefore a pixel with a value of 127 taken -2 f/stops will be lighter than another pixel with a value of 127 taken +2 f/stops.

# Viewing an HDR image

- The monitor is LDR and therefore cannot represent the entire range of tonalities present in an HDR file.
- Neither can the printer.
- To represent the HDR image on the monitor or printer, must compress the tonal range resulting in an image with little contrast.

# Methods to view HDR on a monitor

- Exposure Blending:
  - Merges different sections of differently exposed photographs into an image with details in all areas. This is essentially what you do with two images and masks.

- Tonal mapping:
  - Compresses tonal data to display on monitor.

# Tonal mapping

- Global operators:
  - Each pixel is mapped to a visible range according to it's intensity in the HDR file.
  - Results in a flat image with little contrast.
- Local operators:
  - Pixel location is taken into account so a pixel will be mapped differently depending whether it is in a dark or light area.
  - Preserves local contrast.

# Tonal mapping in CS4

- **Exposure and Gamma**
  - Lets you adjust the exposure and gamma = brightness and contrast.
- **Highlight Compression**
  - Compresses highlights, may lose shadow details. No user adjustments.
- **Equalize Histogram**
  - This method attempts to redistribute the extremes in the HDR histogram into the contrast range of a normal 16 or 8-bit image. No user adjustments.
- **Local Adaptation**
  - Changes how much it brightens or darkens regions on a per-pixel basis (similar to local contrast enhancement). This has the effect of tricking the eye into thinking that the image has more contrast. Allows the most flexibility.

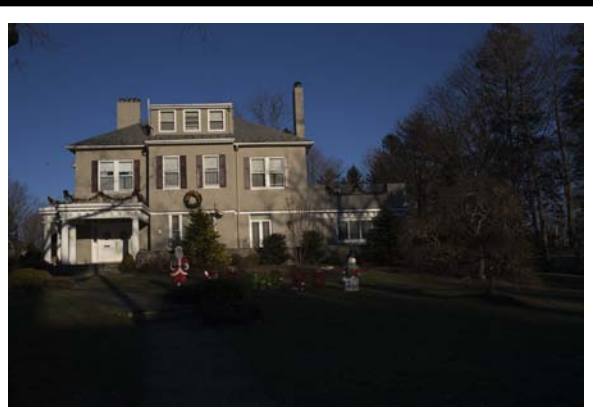
# Image as seen by Eye and Camera


Eye


Camera
(metered exposure)

# Here is a *Solution*

# -2 f-stops, Metered, +3 f-stops



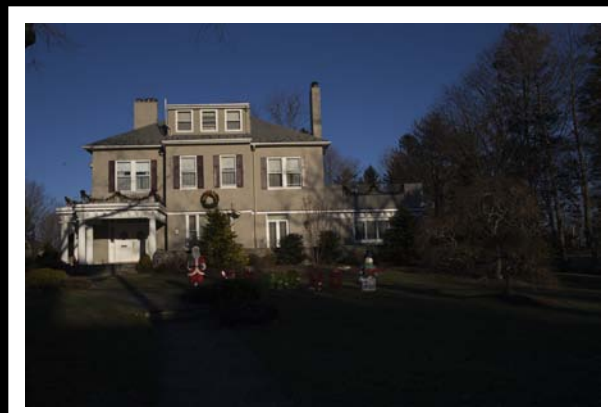
1/200 sec at f 11
- 2 f-stops

1/50 sec at f 11

1/6 sec at f 11
+ 3 f-stops

# -2 f-stops, Metered, +3 f-stops

Combining with stacks/smart object/mean



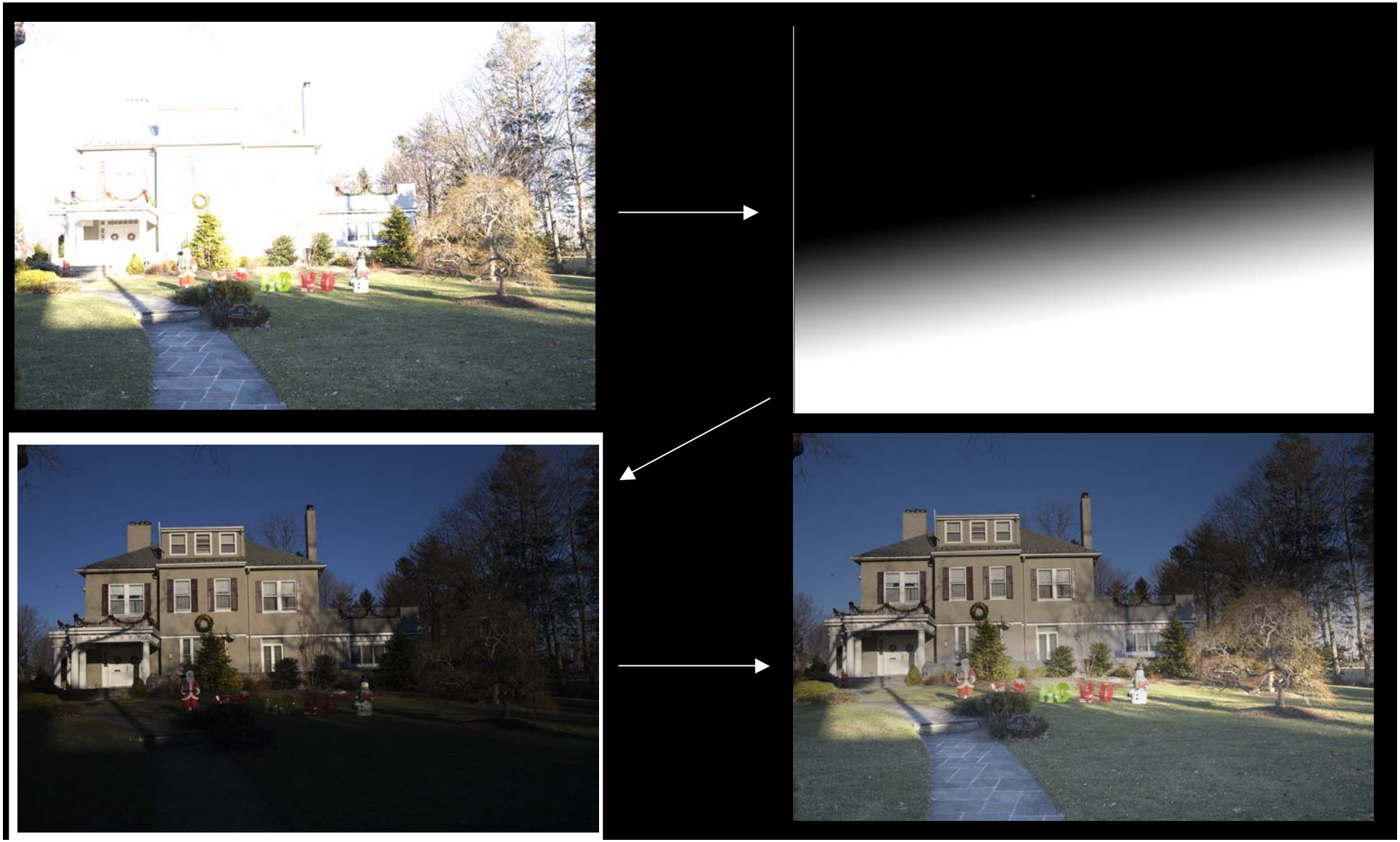
# Improvement with Shadows/Highlights Adjustment

1/200 sec at f 11
- 2 f-stops

Use of
Shadow/Highlights

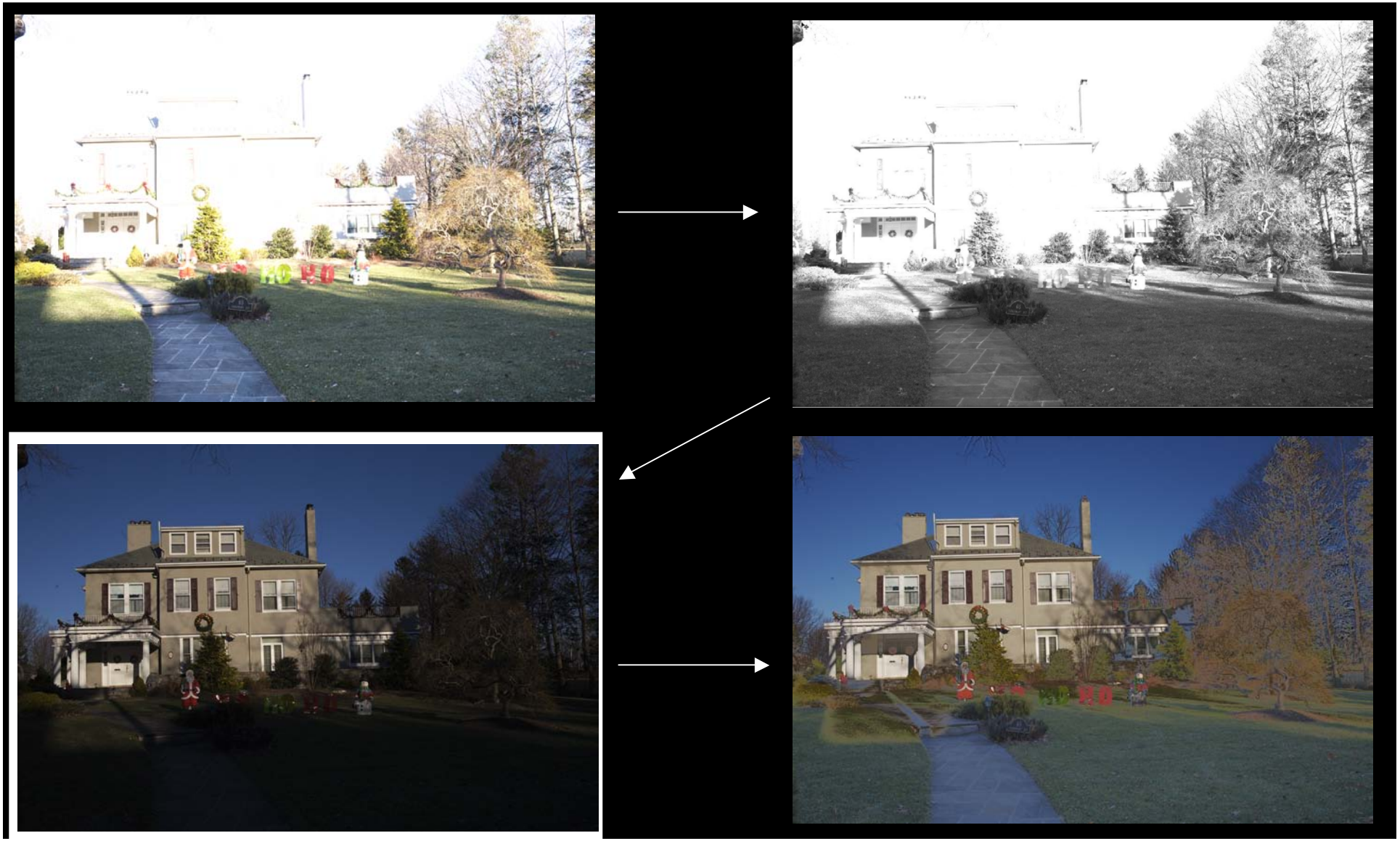
# Combining 2 exposures

## Gradient Mask (mimic Neutral Density Filter)



# Combining 2 exposures

## Make mask from lighter to mask darker



# HDR (4 methods)

Exposure & Gamma

Highlight Compression

Equalize Histogram

Local Adoptation

# -2, +4f-stops

# HDR (4 methods)

Exposure & Gamma

Highlight Compression

Equalize Histogram

Local Adaptation

# Dynamic Range Summary

- Dynamic range in photography defines the ratio between the maximum and minimum measurable light intensities (white and black, respectively).
- While our eye can see a dynamic range of 12 f-stops, the camera can only visualize about 6 f-stops

# Dynamic Range Summary

- In most cases maximizing the dynamic range increases details, enhances color minimizes noise, especially in the shadows and makes for a more pleasing photograph.
- There are many different ways to increase dynamic range. Which one you use depends on the circumstance and your familiarity with a technique.

# Dynamic Range Summary

- As with most photography, the best method is to “capture the picture correctly in the camera.”
- You can increase your chances of maximizing dynamic range by shooting RAW, 16 bit, and “shooting to the right”.
- You can also use a graduated neutral density filter or fill-flash in some cases.

# Dynamic Range Summary

- If there are no blown highlights, and the shadows are not too compressed, dynamic range may be increased with adjustments (especially shadow/highlights) in Photoshop.

# Dynamic Range Summary

- If the dynamic range is too great to capture in one exposure, use two exposures and combine using masks or other methods.

# Dynamic Range Summary

- If the usable dynamic range is greater than can be captured in two photographs - may require HDR.
- HDR is a relatively new method of greatly expanding the dynamic range over a wider range.
- HDR allows one to compress a very large range into an image.
- The tools to accomplish this are still in their infancy and may be difficult to use. Over time they will become easier to use and more sophisticated.

# Dynamic Range Summary

- There is a basic HDR function in Photoshop CS4
- Photomatrix Pro is a standalone program for Windows or Mac.
- Others available - including some open source.
- Now available in camera with Pentax K-7, K-x (3 exposures) and Sony DSLR A550 (2 exposures).