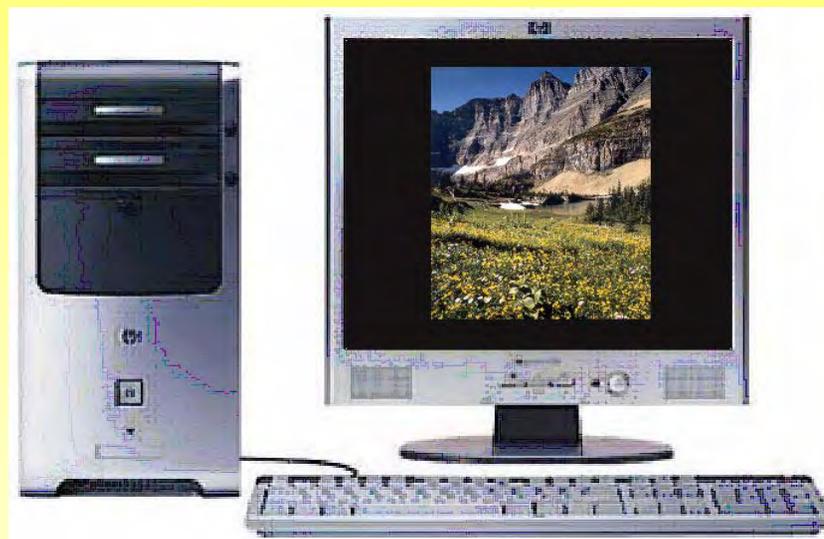
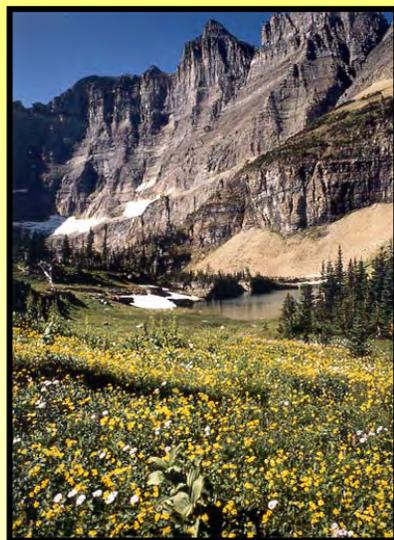


# Understanding Digital Image Characteristics and Viewing

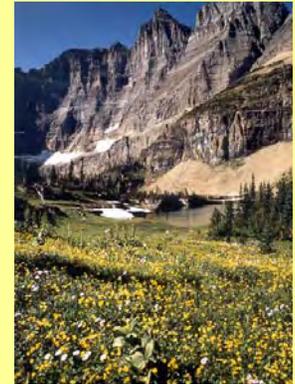
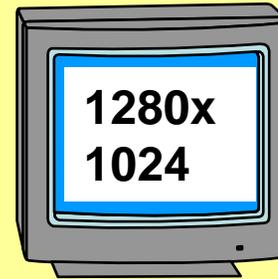


Michael J. Glagola  
[mglagola@cox.net](mailto:mglagola@cox.net)  
703-830-6860

**OR**  
**How To View Digital Images**  
**So That You Understand**  
**How To See What Is**  
**REALLY There**  
**&**  
**So That What You See IS**  
**What You Get**

# Short Quiz

## Question 1



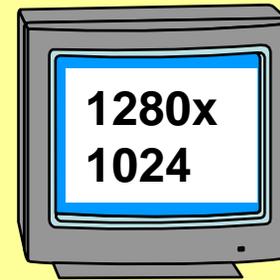
1000x1400

- You have an image that is 1000x1400 and a monitor that is 1280x1024. How should you view the image to evaluate it?
- A – Fit the image to the screen; that is, fill the screen with the image
- B – Show the image at 100% and let the image be larger than the screen
- C – It doesn't matter



# Short Quiz

## Question 2



375x525

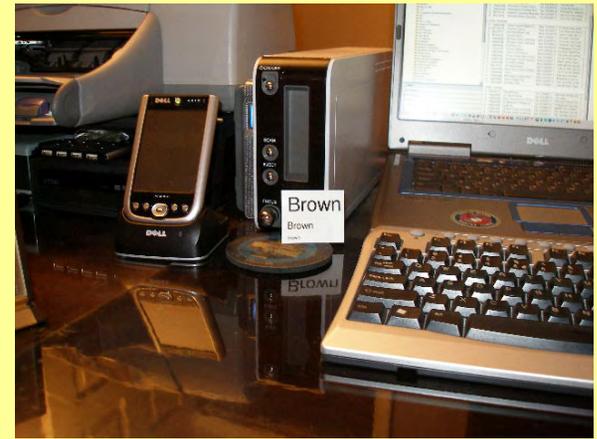
- You have an image that is 375x525 and a monitor that is 1280x1024. How should you view the image to evaluate it?
- A – Fit the image to the screen; that is, fill the screen with the image
- B – Show the image at 100% and let the image be smaller than the screen
- C – It doesn't matter

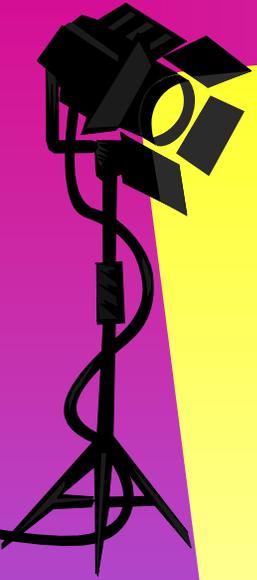


# Short Quiz

## Question 3

- You take a picture with a digital camera set to 3264x2448 pixels for the image dimensions. What is the X or Y Resolution of the image?
- A – What the Image Metadata says it is when the metadata file is opened
- B – 72 Pixels per Inch
- C - Unknown



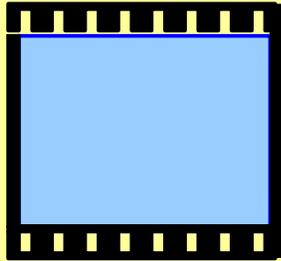


# Session Goals

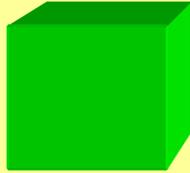
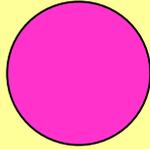
To provide an understanding of:

- What is a digital image file and what is stored in the file
- What occurs when one views a digital image
- Considerations one must take into account when viewing and manipulating digital images
- How to view and evaluate the quality of a image

# Viewing Film Images

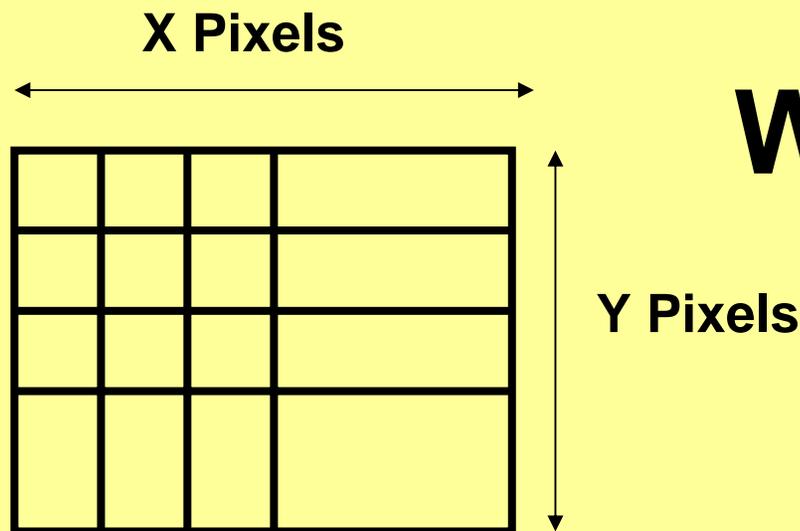


- Typically film images are viewed under controlled lighting with a 4X/8X loupe to evaluate the image
- The digital equivalent is a digital image viewed on a video or liquid crystal display



# Basic Definitions

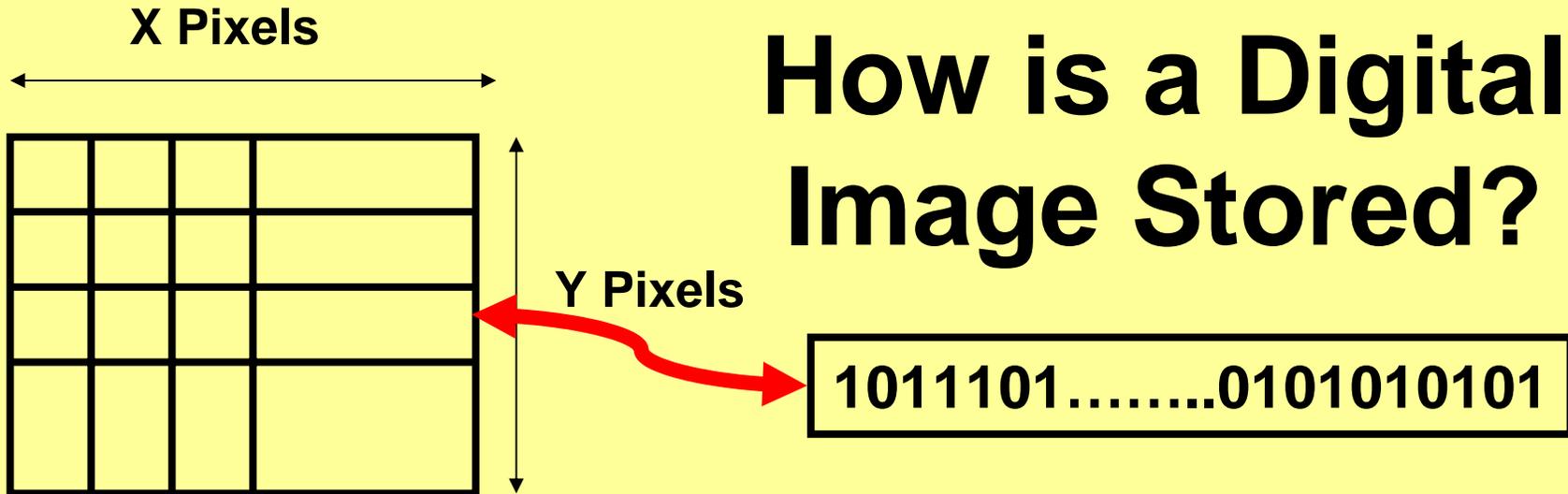
- Pixel - An abbreviation of the term 'picture element.' A pixel is the smallest picture element of a digital image. A monochrome pixel can have two values, black or white/0 or 1. Color and gray scale require more bits; true color, displaying approximately 16.7 million colors, 24 bits for each pixel. A pixel may have more data than the eye can perceive at one time.
- Dot – The smallest “unit” that a printer can print.
- Voxel – An abbreviation of the term ‘volume element.’ The smallest distinguishable box-shaped part of a three-dimensional space. A particular voxel will be identified by the x, y and z coordinates of one of its eight corners, or perhaps its centre. The term is used in three dimensional modeling. Voxels need not have uniform dimensions in all three coordinate planes.



# What is a Digital Image?

- Collection of pixels laid out in a specific order with width (x) and height (y) in pixels
- Each pixel has a numerical value which correspond to a colour or gray scale value
- A Pixel has no absolute size; pixels ***MAY (sometimes NOT always)*** have a spatial value (Spatial data is data associated with the pixels that provides information about the size of the objects in the image).

# How is a Digital Image Stored?



- File format which defines the components of the digital image (x & y values, values of the pixels, colour/gray scale, compression, manner in which the pixels are laid out, etc.) and provides for the storage and redisplay of the digital image
- Standard file formats provide for the easy exchange of digital image information
- Many file formats exist
- May be lossless or lossy
- Digital camera files have associated image metadata

# Examples of Digital Image Formats

- RAW – raw uncompressed data provided by source device; normally proprietary; note RAW usually data “as is/unfiltered/unchanged” from data source
- TIFF – desk-top publishing/document standard with over 50 different distinct subtypes
- JPEG – compressed raster image standard; based on DCT
- JPEG 2000 – new compressed raster image standard; based on wavelet compression
- GIF – vector graphics standard; supports only 256 colours
- BMP – Windows uncompressed image standard
- Proprietary – image standard unique to one company; often used as intermediate image standard for preservation of image data during editing (.psp, .psd, .pdd, ...)

# A Raw Image Format Example

## 12/16 Bit Image File Format

### Header

X-Resolution (2 Bytes)	Y-Resolution (2 Bytes)	Minimum Pixel Value (8 Bytes)	Maximum Pixel Value (8 Bytes)
------------------------	------------------------	-------------------------------	-------------------------------

### Image Data

First Row of Image Data (2 x X-Resolution Bytes)

Second Row of Image Data (2 x X-Resolution Bytes)

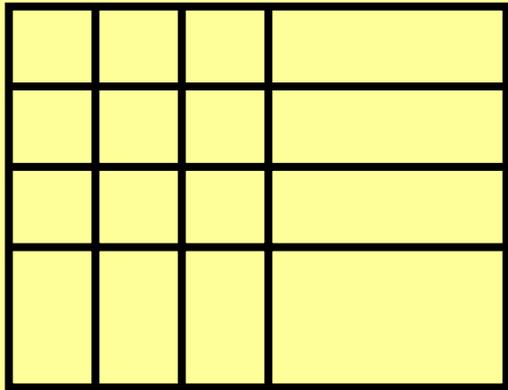
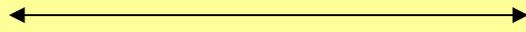


Last Row of Image Data (2 x X-Resolution Bytes)

$$\text{File Size} = [2 \times (\text{X-Resolution} \times \text{Y-Resolution}) + 20] \text{ (Bytes)}$$

- Above is a RAW format for a B&W Medical X-Ray image
- There is NO STANDARD “RAW” Format; each manufacturer’s RAW Format is UNIQUE

X Pixels



Y Pixels



# What is Metadata?

101...01010...10101

- Data in the image file that is about image data
- Examples of image metadata:
  - Type of camera, f-stop, shutter speed, colour bias, date image taken, ...
  - Scanner type, spi, date image taken, ...
  - Software that modified the image, date of modification, who modified image, ...
  - Digital watermark
- Exif 2.2 is the standard metadata format for digital camera image files

# Example of Image Metadata



**Image taken by Sony A-100 and  
accompanying Image Metadata**

- Original date/time: 2006:12:24 12:32:51
- Exposure time: 1/200
- F-stop: 8.0
- ISO speed: 200
- Focal length: 100.0000
- Focal length (35mm): 150
- Flash: Not fired
- Exposure mode: Auto
- White balance: Manual
- Orientation: Top-left
- Light source: Unknown
- Exposure bias: 0.0000
- Metering mode: Pattern
- Exposure program: Normal
- Brightness: 7.5000
- Digitized date/time: 2006:12:24 12:32:51
- Modified date/time: 2006:12:24 12:32:51
- Image description: SONY DSC
- Scene type: Photograph
- Custom rendered: Normal
- Scene capture type: Standard
- Gain control: None
- Digital zoom ratio: 0.0000
- Contrast: Normal
- Saturation: Normal
- Sharpness: Normal
- Camera make: SONY
- Camera model: DSLR-A100
- Resolution unit: Inches
- Camera version: DSLR-A100 v1.02
- Colorspace: sRGB
- File source: DSC

# Spatial Data

- Metadata associated with image that provides information about the size of the objects in the original image.
- Often called X/Y Resolution and expressed by # of pixels per resolution. Examples:
  - Scanner SPI
  - MRI Voxel size
  - Data based upon information implied-in and derived-from the image
- Digital Cameras do NOT capture Spatial Data! The default value in image metadata for X/Y resolution when UNKNOWN is 72!

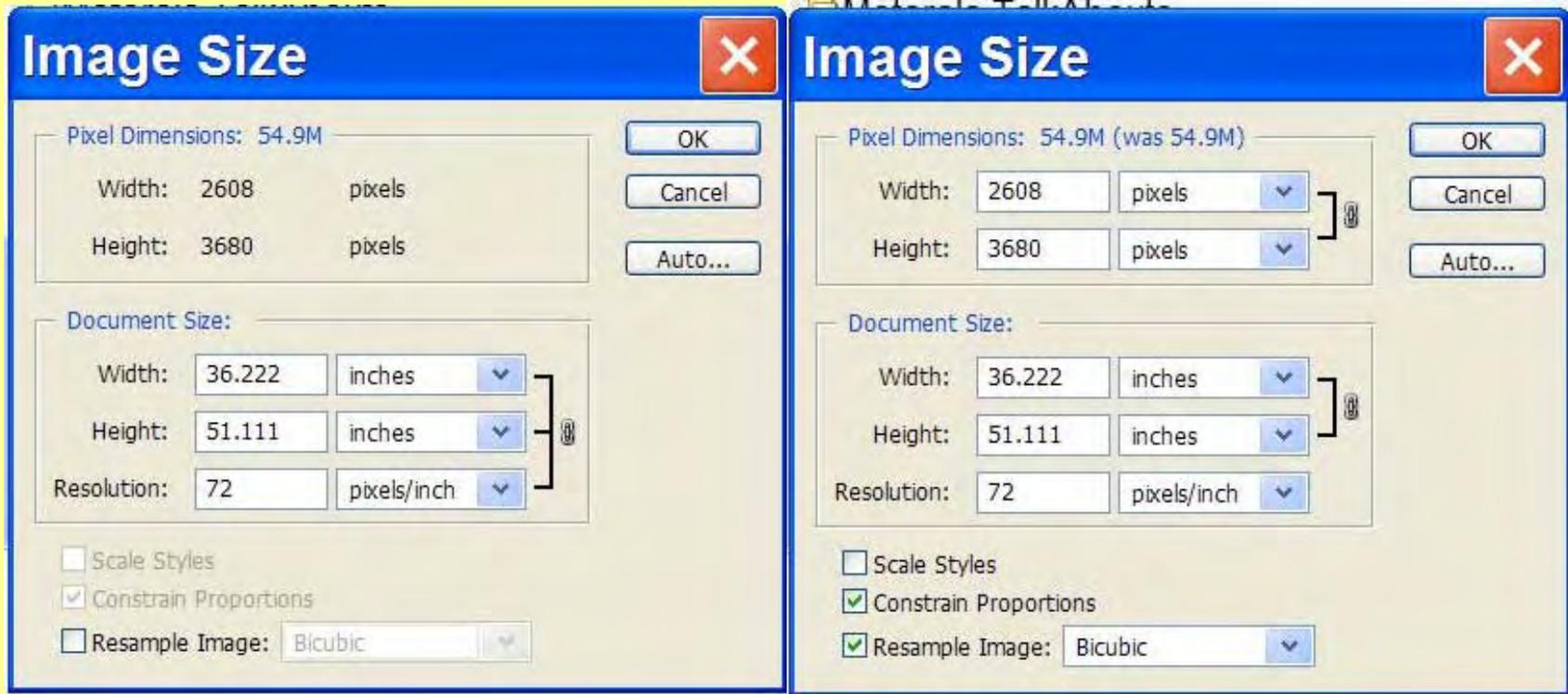


# Image Metadata Resolution

Metadata File data from an image:

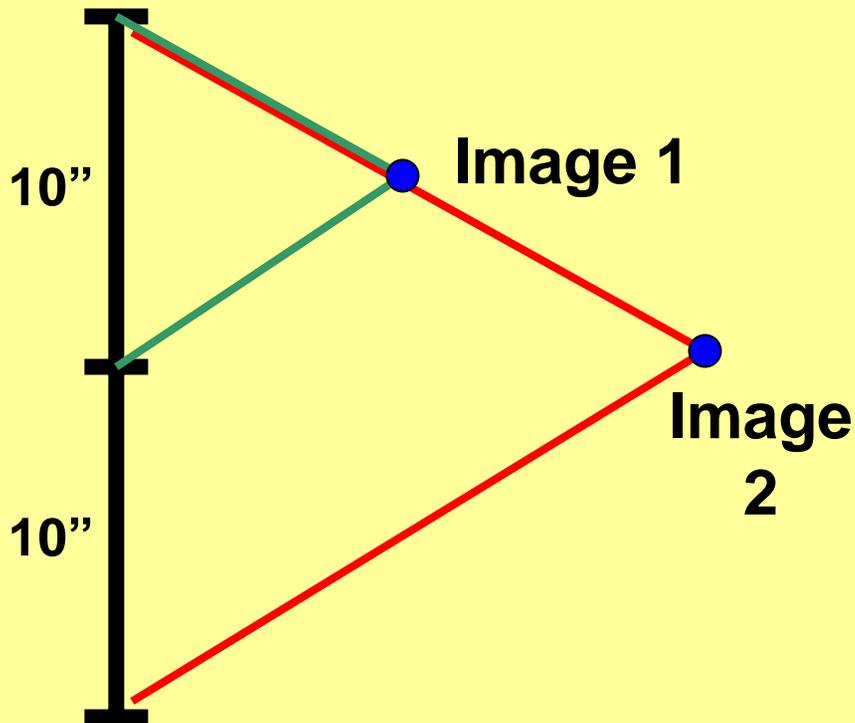
- Camera make: OLYMPUS IMAGING CORP.
  - Camera model: SP350
  - X resolution: 72.0000
  - Y resolution: 72.0000
  - Resolution unit: Inches
  - Camera version: Version 1.3
  - Colorspace: sRGB
  - File source: DSC
- 
- Exif 2.2 is the standard for embedded metadata in an image file. According to the standard, when the X or Y resolution is unknown, the default value is 72.

# Photoshop Image Size



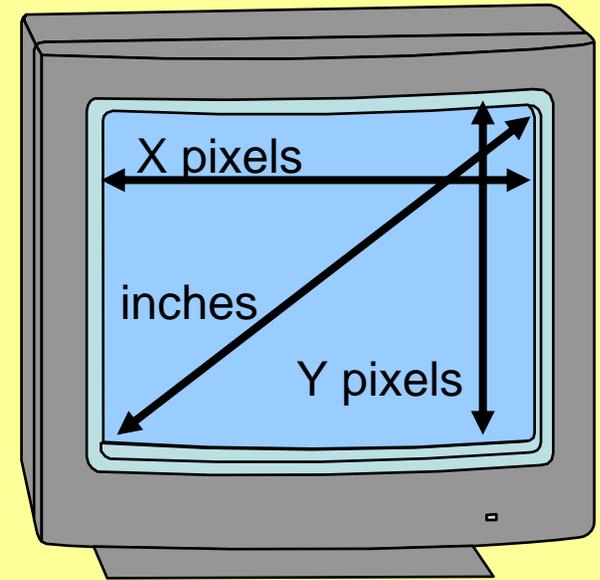
- Photoshop's Resolution in Pixels/Inch refers to the image when printed as A DOCUMENT. "The amount of detail in an image depends on its pixel dimensions, while the image resolution controls how much space the pixels are printed over." Photoshop CS Help

# Digital Cameras Do NOT Capture Spatial Data



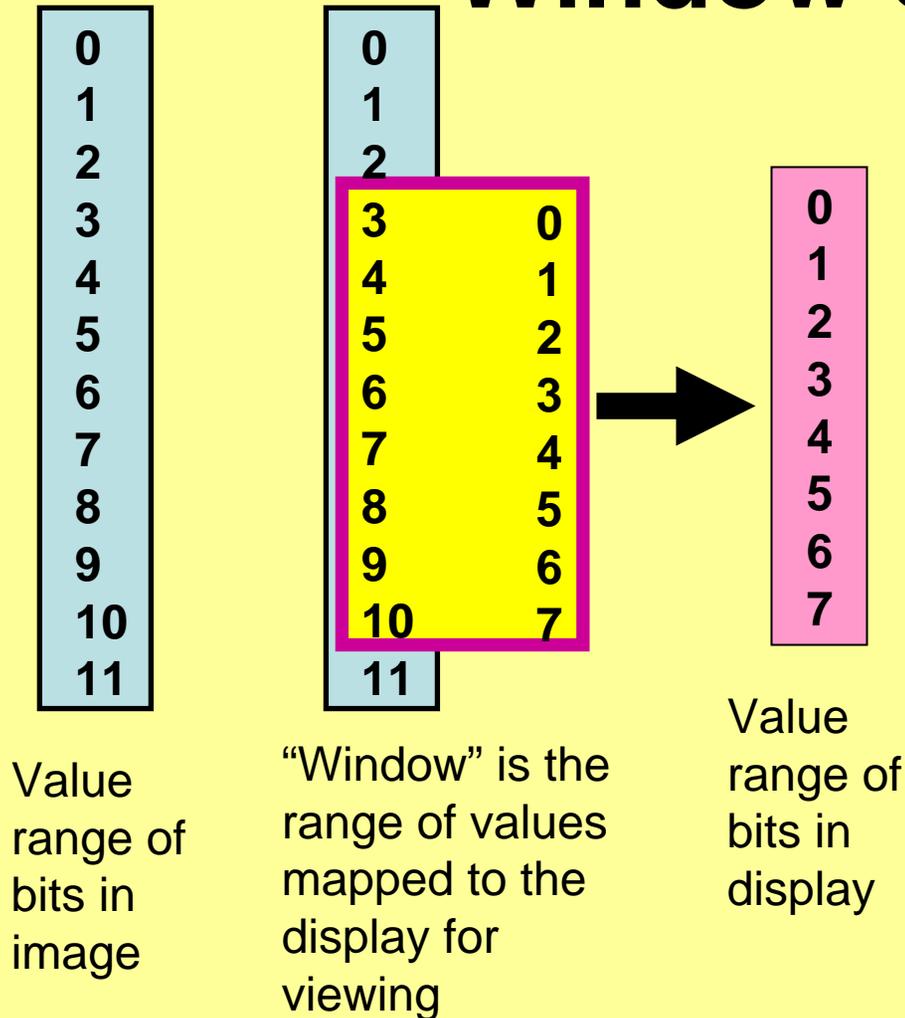
- Digital Camera set at 2000x1000
- Image 1 is of 10";  
 $2000/10'' = 200$  ppi
- Image 2 is of 20";  
 $2000/20'' = 100$  ppi
- Camera does NOT know difference between Images 1 & 2; enters 72 (default) into image metadata

# Digital Displays



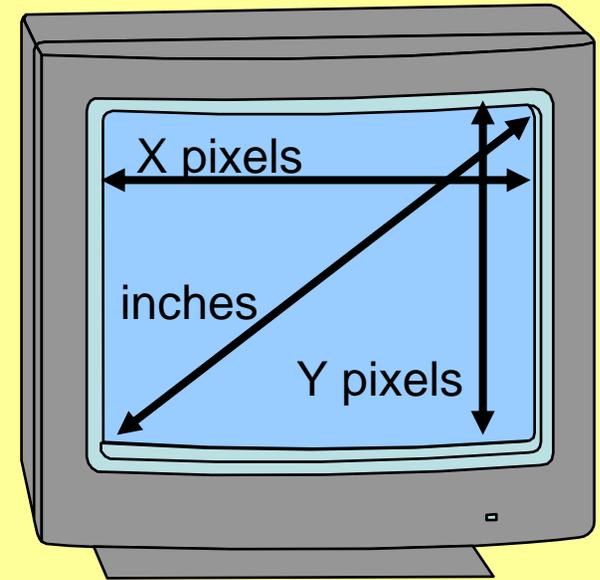
- B&W and Color
- Various Technologies: CRT, Plasma, LCD, ...
- Multiple adjustments: Tint, Brightness, ...
- Selectable Color Profiles allow displays to match color space of digital image

# Displaying Image Data – Window & Leveling



- The image may have more information than the monitor can display!
- **Window** – the range of bit values shown
- **Level** – the contrast “level” of the bits shown

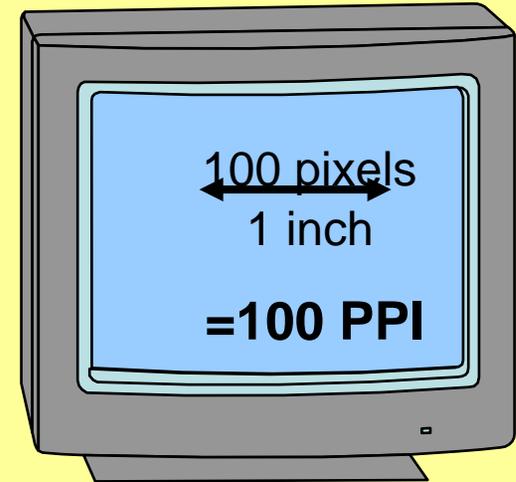
# Display Dimensions



- The “size” of the display is a combination of two sets of measurements
  - The X by Y pixel matrix dimensions (1280x1024, 1920x1200, ...) or display resolution
  - The diagonal measurement of the screen in inches (17”, 19”, ...)

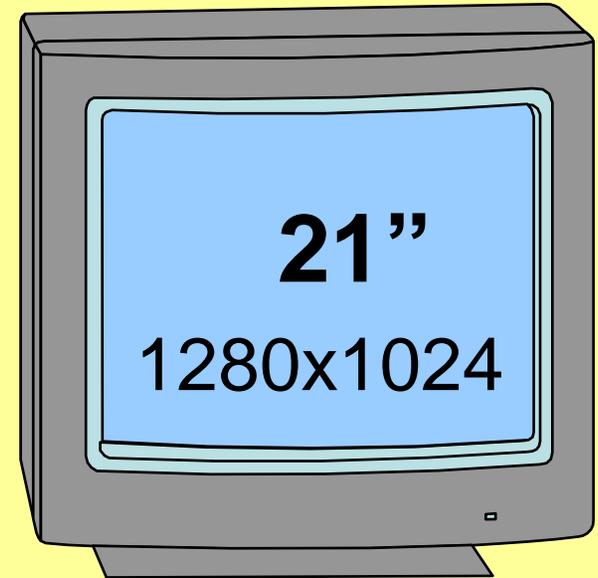
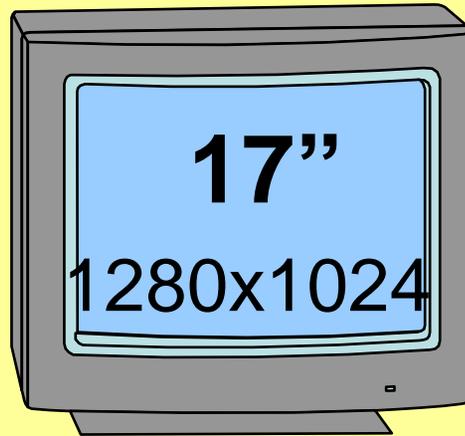
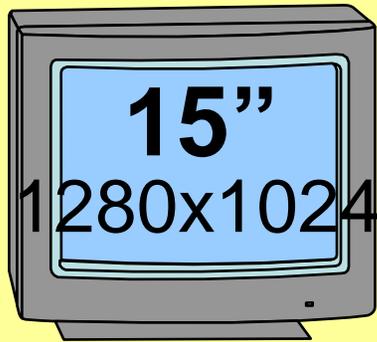
# PPI

## Pixels Per Inch



- “**PPI or pixels per inch:** a measure of the number of pixels displayed in an image. A digital image is composed of samples that your screen displays in pixels. **The PPI is the display resolution not the image resolution.** (Adobe Photoshop uses PPI and Corel Photo-Paint uses DPI for image resolution so it's no wonder everyone is confused.) Also known as: display resolution, screen resolution” Jacci Howard Bear, [Your Guide to Desktop Publishing](#)

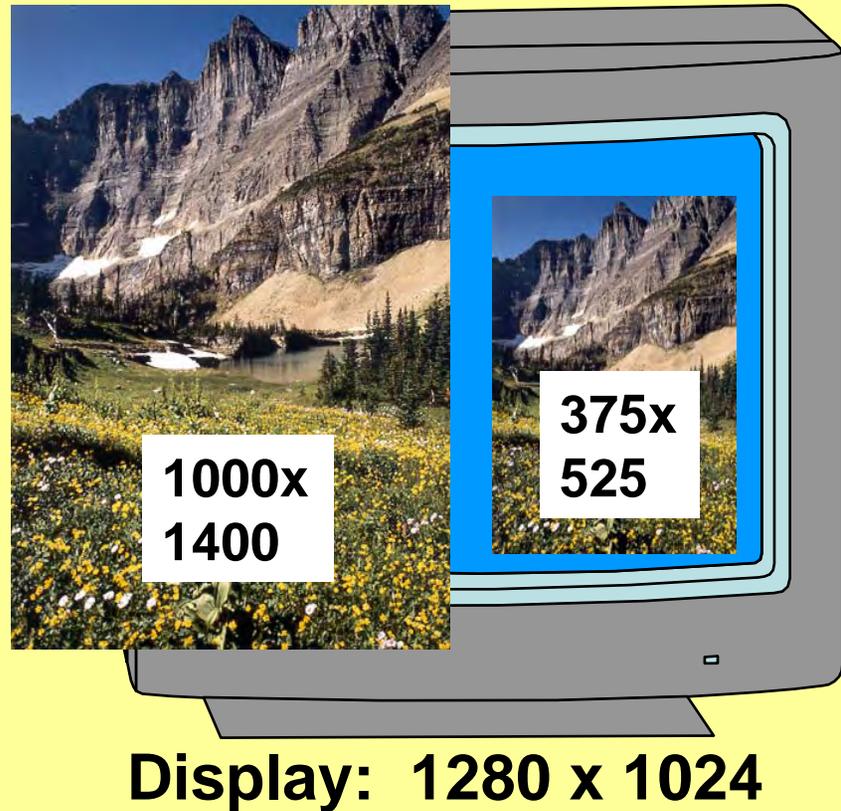
# Monitor Size & Image Viewing



- PPI of each monitor is different
- The same image (e.g. 1280x1024) shown on each of these monitors will fill the screen yet have a different size
- The view of the image on each monitor will be “the same” yet subjectively “different”

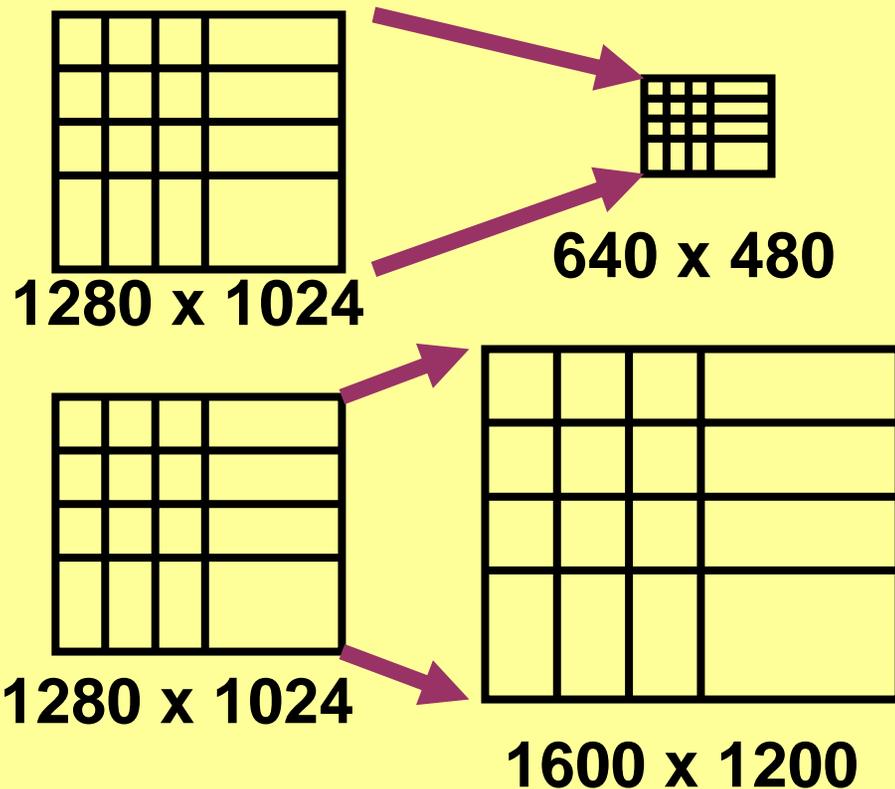
# Sizing Digital Images for Viewing

- What happens when the pixel matrix dimensions of the display do not match the image pixel matrix dimensions?



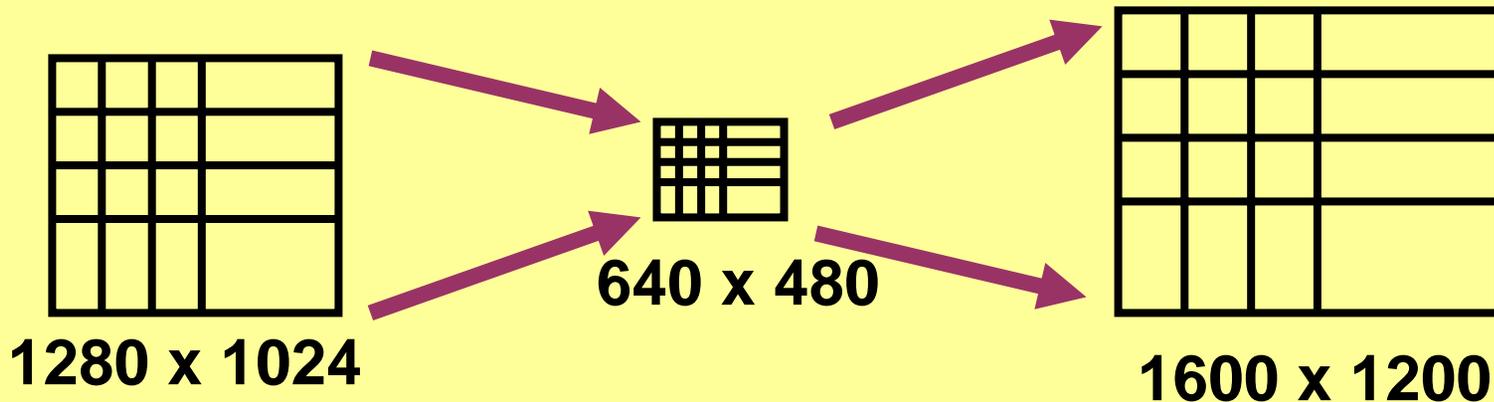
**Display: 1280 x 1024**

# The fundamental problem



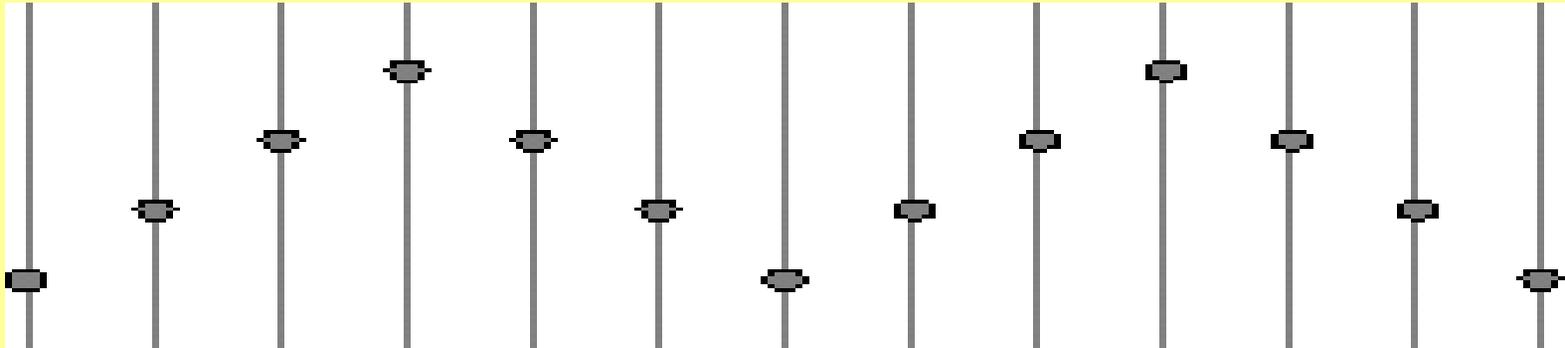
- If the display is smaller than the image what happens to the extra bits and which ones are not used?
- If the display is larger than the image how are extra bits added and where?

# Interpolation or Resampling

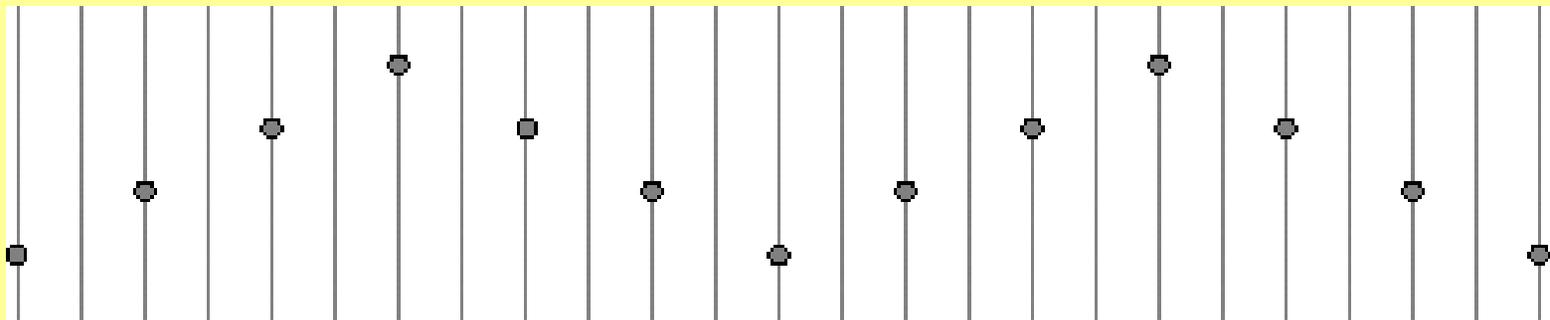


- Image Interpolation: algorithms that increase or decrease the number of pixel in an image. Interpolation changes the number of pixels in an image and can change the value of pixels in an image
- Examples: nearest neighbor, bilinear, bi-cubic, ...; Which algorithm used depends on the software used, the image type and results desired
- Interpolation occurs when an image is viewed at  $< 100\%$ ; this interpolation is only temporary
- Resampling an image or changing the pixel dimensions of an image makes permanent changes
- Sometimes the term resizing is used in lieu of resampling. This is confusing since sometimes resizing refers to changing the size of a pixel or a dot rather than changing the number of pixels.

# Interpolation Example - 1

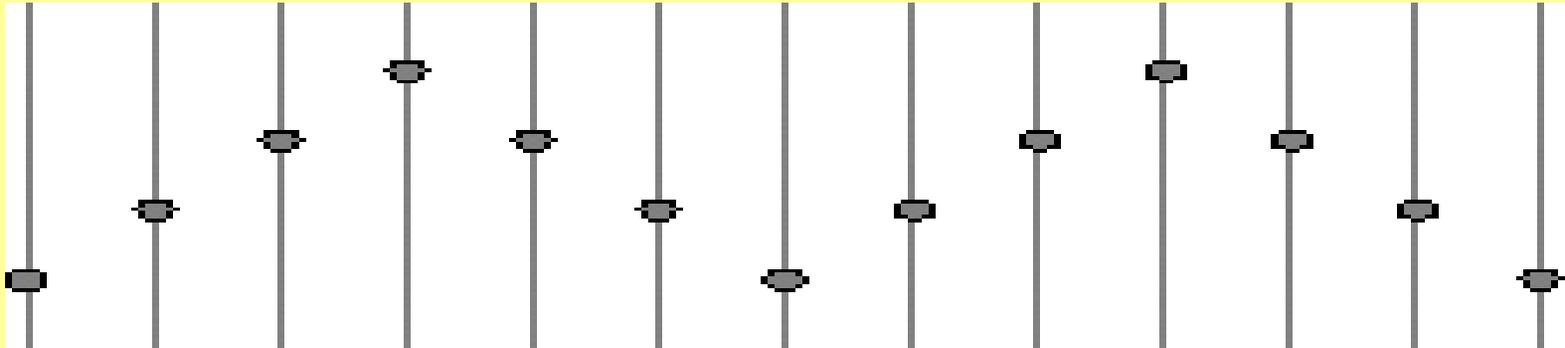


Original Sample

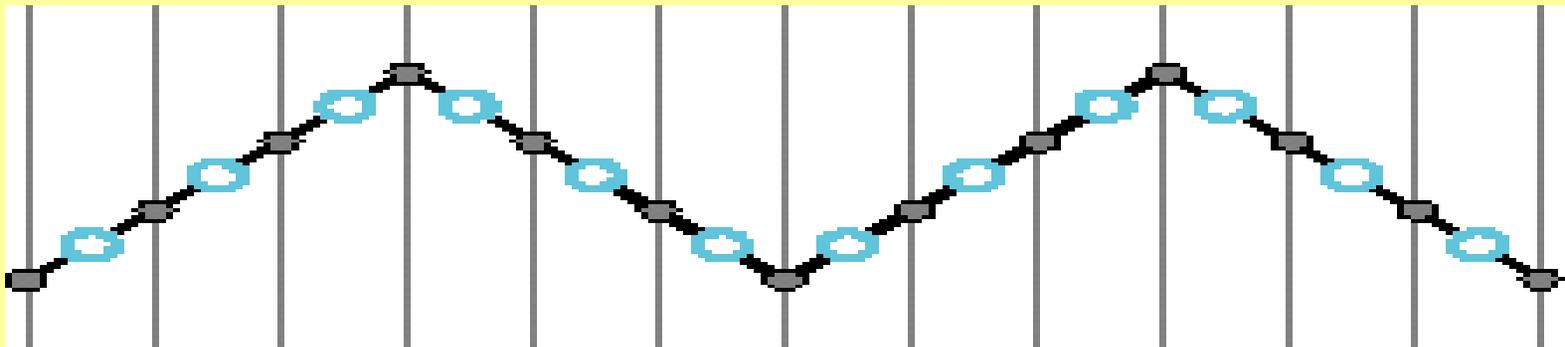


How does one increase the Resolution?

# Interpolation Example - 2

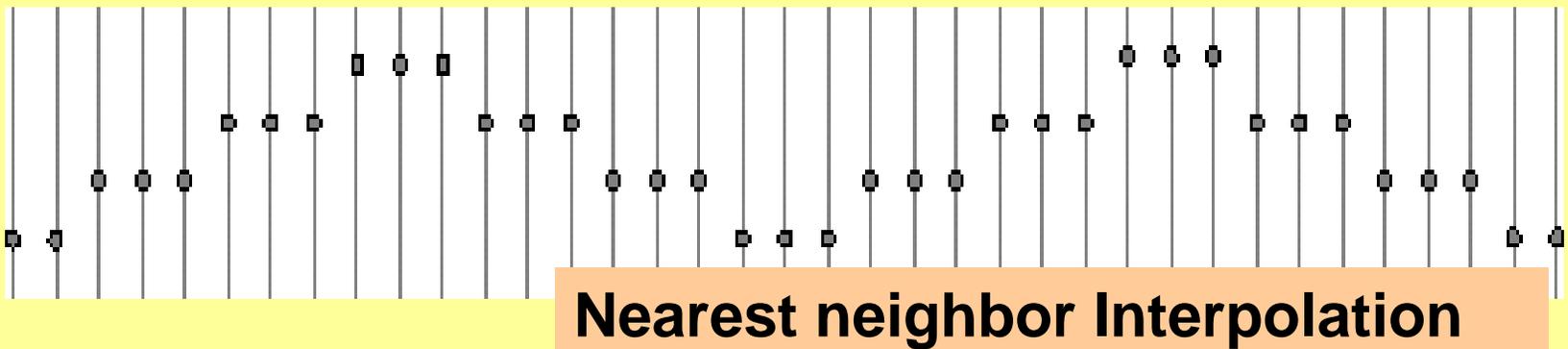
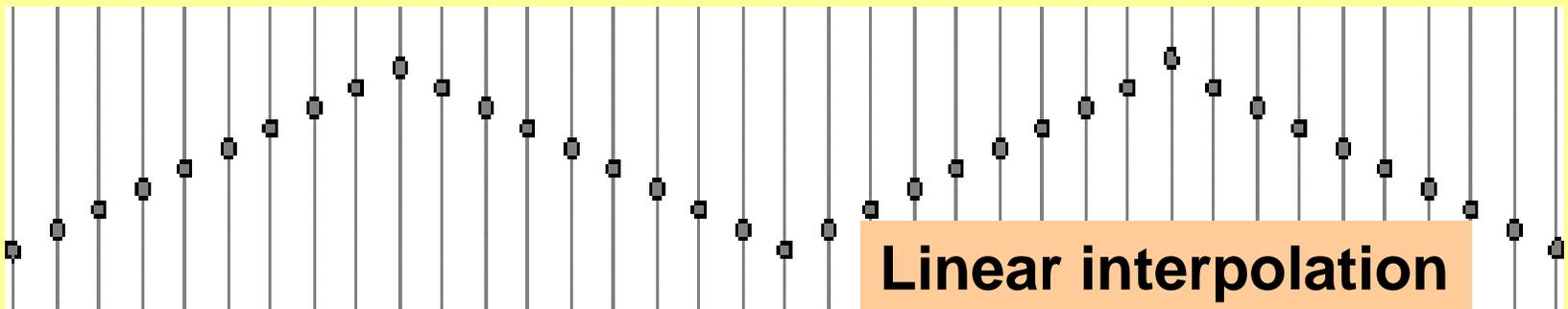
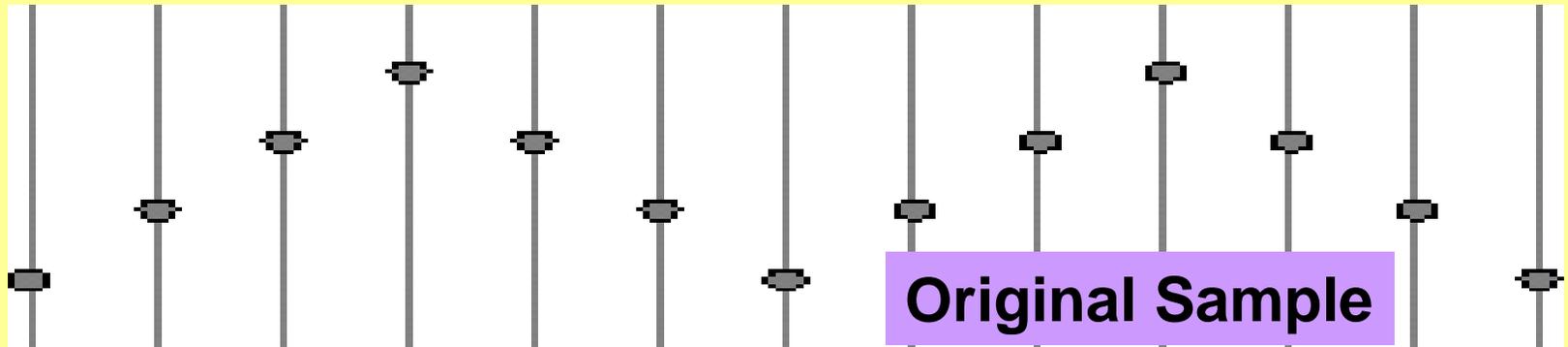


Original Sample

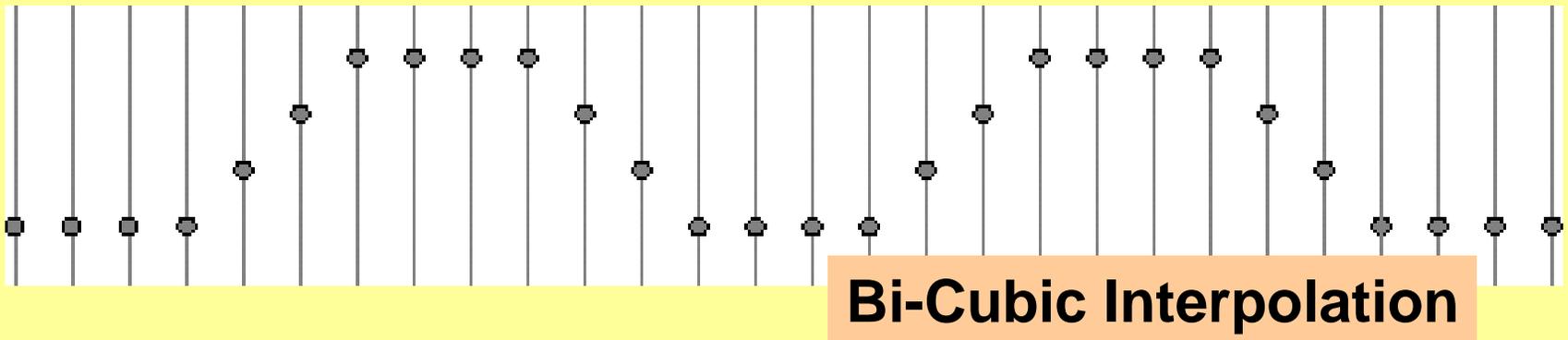
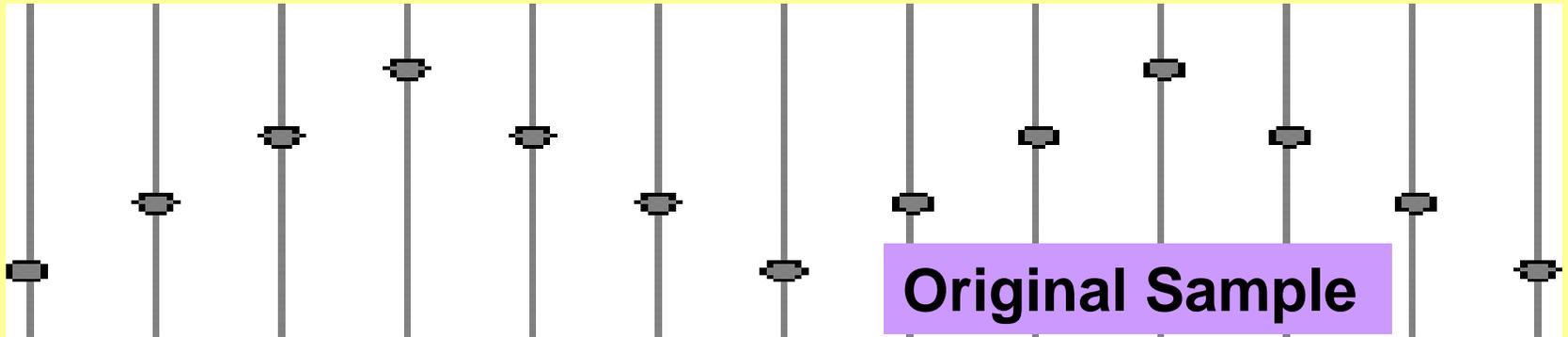


Interpolation answers how to fill in the “gaps”

# Interpolation Example - 3



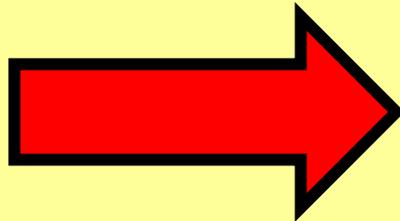
# Interpolation Example - 4



**Bi-cubic interpolation estimates how sharp an edge there should be by estimating the derivatives at each sample and then fitting a cubic curve between the samples**

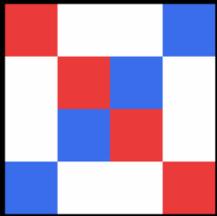
# Interpolation Example - 5

A	B
C	D

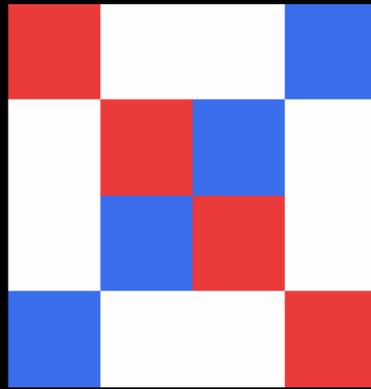


A	?	B	
?	?	?	
C	?	D	

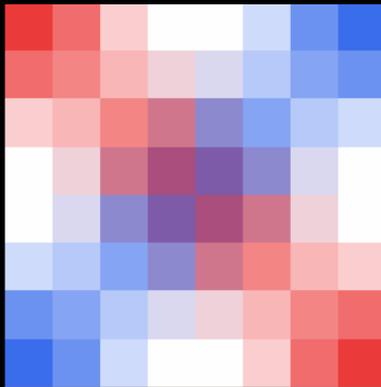
2 dimensional interpolation extends the interpolation simultaneously into two axis's



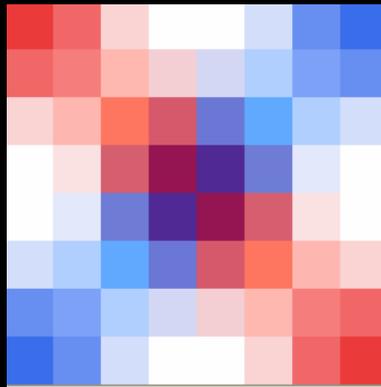
**Original**



**Nearest  
Neighbor**



**Bilinear**



**Bicubic**

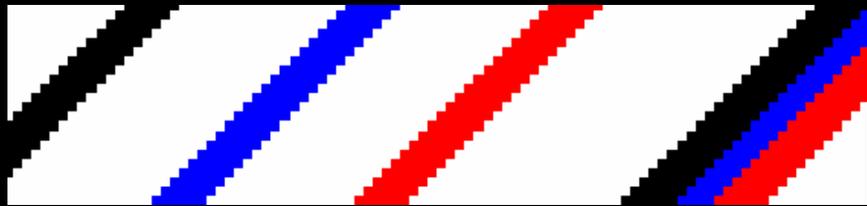
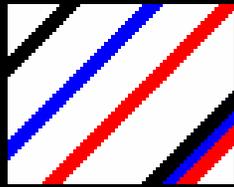
# Interpolation Example - 6

Interpolation  
4x4 to 8x8

Nearest Neighbor – no  
new colors

Bilinear – averages  
colors

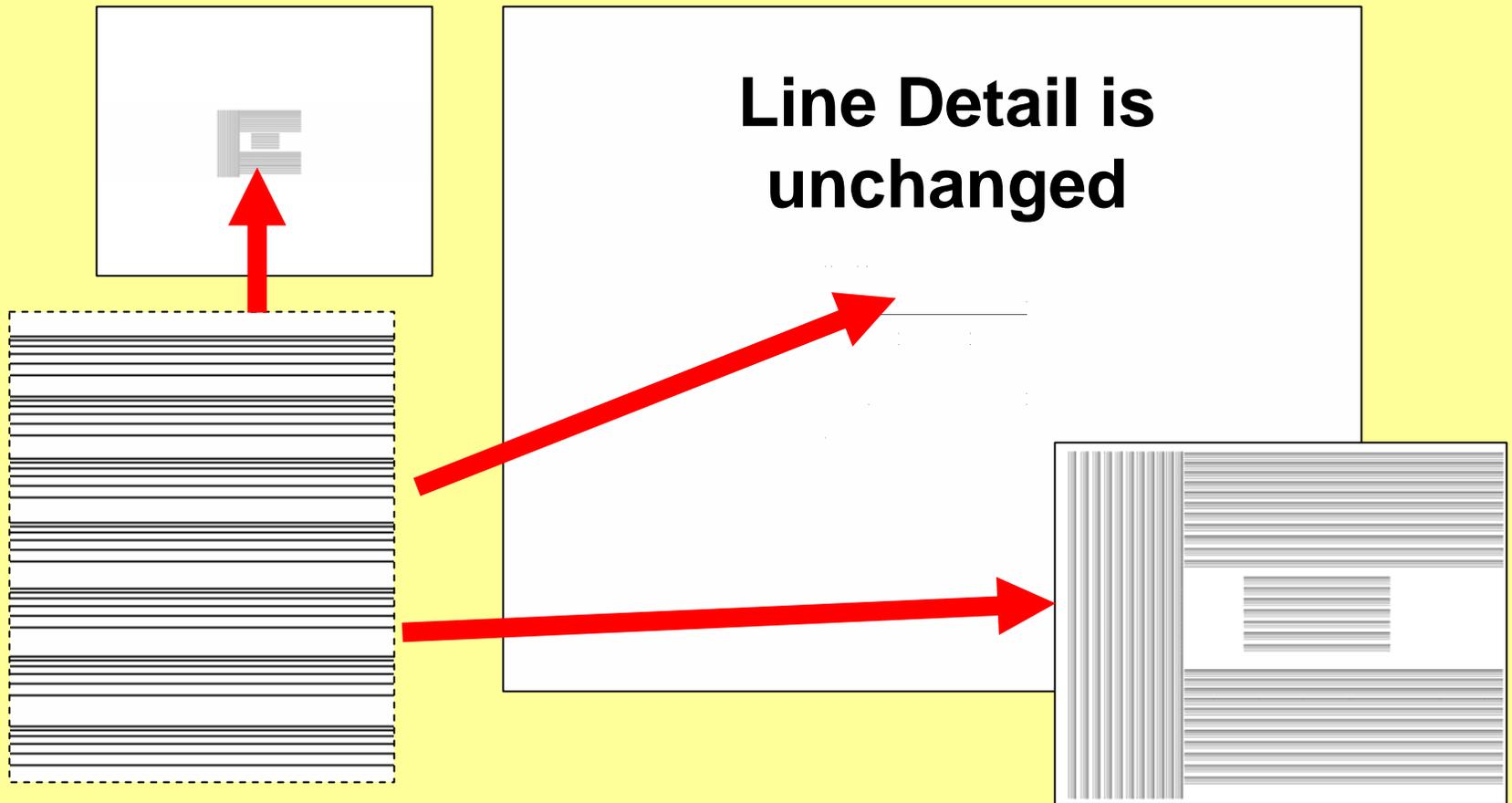
Bicubic – weighted  
averages colors



# Interpolation Example - 7

- Nearest Neighbor – no new colors; sharpest edges
- Bilinear – averages colors; smoother edges
- Bicubic – weighted averages colors; smoothest edges

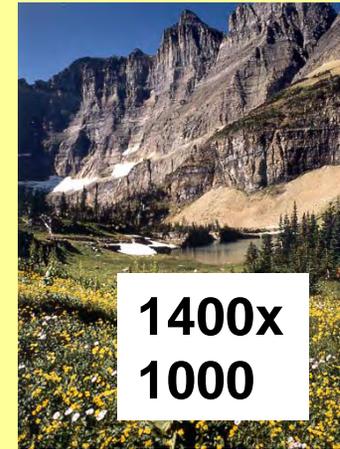
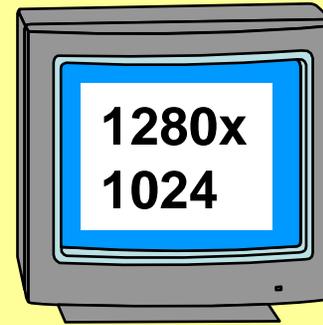
# Interpolation Example - 8



Large images details may appear dramatically different when not viewed at 100%

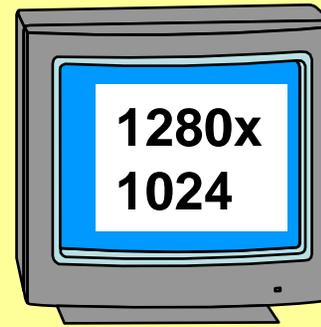
# Image Larger than the Display

- If the image is shown at a 1:1 pixel ratio (100%) then only a portion of the image can be viewed
- If the image is fit to the display then not all of the pixel detail can be viewed due to pixel resampling/interpolation



# Image Smaller than the Display

- If the image is shown at a 1:1 pixel ratio (100%) then the image does not fill the display
- If the image is fit to the display then the image is viewed at some level of magnification, pixels will be large and “blocky”, and data may be created due to pixel interpolation/resampling. If viewing at >100% ONLY multiples of 100% (200%, 300%, ...) will avoid interpolation.

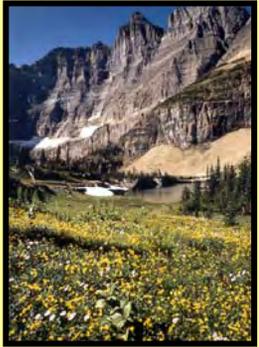


**525x375**



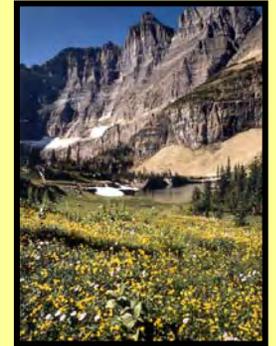
# Resampling/Resizing/Interpolation of Images

Original  
1600 x 2000

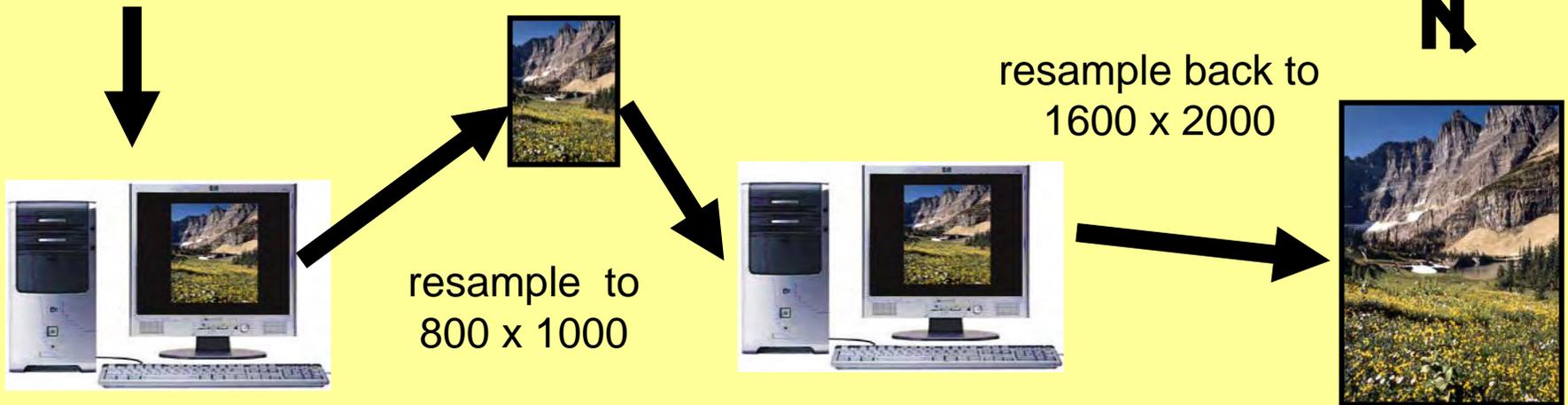


The final 1600 x 2000 image is **NOT** the same as the original; data has been lost and new data created due to interpolation! Do not resample/resize the original!

Original  
1600 x 2000



N



# Viewing Digital Images

- When viewing digital images the image must be viewed at 100% in order to see EXACTLY what the image contains
- If viewed at LESS THAN 100% some data is missing and modified from the image shown!
- If viewed at GREATER THAN 100% the image will be “blocky”, edges jagged, and data may be created! Only whole multiples of 100% will avoid interpolation
- Viewed at  $<$  or  $>$  100%, one may be unable to accurately evaluate the details of the image. Changes made to an image in such circumstances could well produce “incorrect” or “undesired” results. Be especially alert on images that are “fit to screen”.
- **AVOID THE LCD SCREEN OF THE CAMERA TO EDIT PHOTOS!!!**

# Digital Images

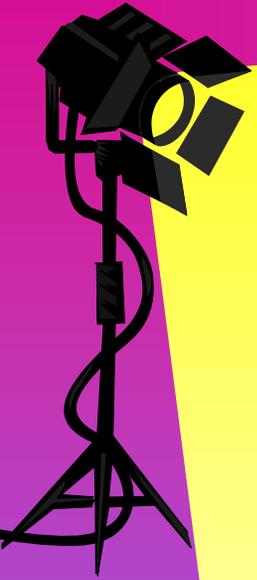
## How Many Pixels Do I Need?

- The higher the number of pixels in the image the better the details
- For viewing on a digital display and for purposes of the web, 1280x1024 is about as high as needed
- For printing, more pixels is better; this is especially true the larger the print

# Image Analysis

- **View the image and metadata for:**  
**(list is NOT inclusive)**
- **Exposure:** Shutter speed & aperture, Image dark or thin, color balance/color bias, contrast and brightness, shadows and highlights
- **Lens Selection:** Edge to edge uniformity, focal length/field of view
- **Focus and Sharpness:** Focus, camera shake/motion, details
- **Depth of Field**
- **Film Speed:** ISO\noise\grain
- **Color & Intensity**
- **Composition:** Subject location, subject pose, background, extraneous objects
- **Dust, Dirt, ... on lens**

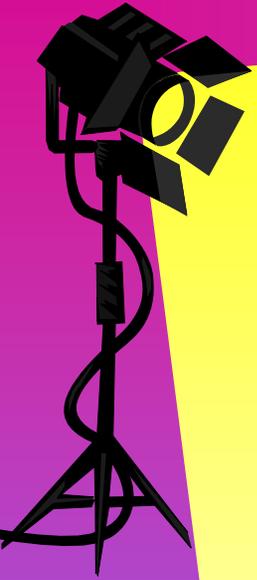




# Summary

Understanding digital image characteristics and viewing is essential in order to:

- See the image and all the image detail
- Critique the image and improve one's photographic techniques
- Edit the image and the results of the editing
- Print the image
- Obtain the optimum results from one's camera, display, tools, printer, and image
- Understand how others will view the image and how to best prepare the image for viewing by others

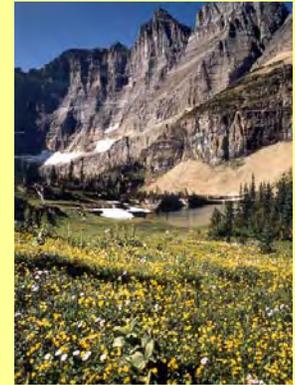
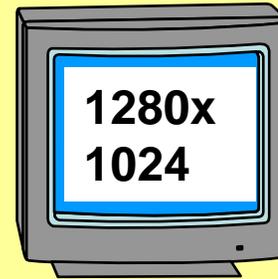


# Why Viewing Matter

- The goal of photography is to produce a picture; photography is painting with light
- Not understanding image viewing and not viewing the image in detail is similar to always using a camera on “Auto”; you can do it but you will not always get the best results and sometimes you will get very bad results when least expected
- If you do not view all the image details, you will not know if a “problem with a picture” is because of how you took the image or because of how you viewed the image.
- Just as with a camera on auto, the key is to know how to use image viewing technology to get the best results.

# Short Quiz

## Question 1

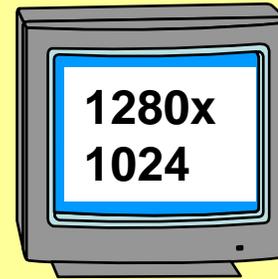


1000x1400

- You have an image that is 1000x1400 and a monitor that is 1280x1024. How should you view the image to evaluate it?
- A – Fit the image to the screen; that is, fill the screen with the image
- B – Show the image at 100% and let the image be larger than the screen
- C – It doesn't matter



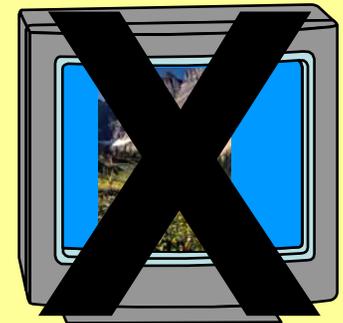
# Question 1 Answer



1000x1400

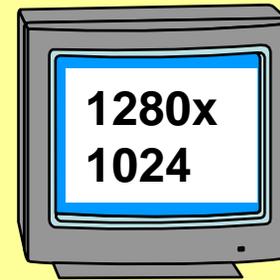
- You have an image that is 1000x1400 and a monitor that is 1280x1024. How should you view the image to evaluate it?

- ✓ **B – Show the image at 100% and let the image be larger than the screen. Viewing the image at <100% will result in some of the pixels in the image not being seen.**



# Short Quiz

## Question 2

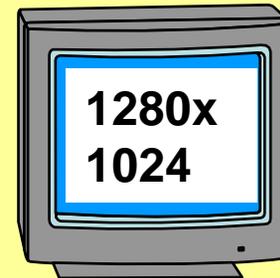


375x525

- You have an image that is 375x525 and a monitor that is 1280x1024. How should you view the image to evaluate it?
- A – Fit the image to the screen; that is, fill the screen with the image
- B – Show the image at 100% and let the image be smaller than the screen
- C – It doesn't matter



# Question 2 Answer



375x525

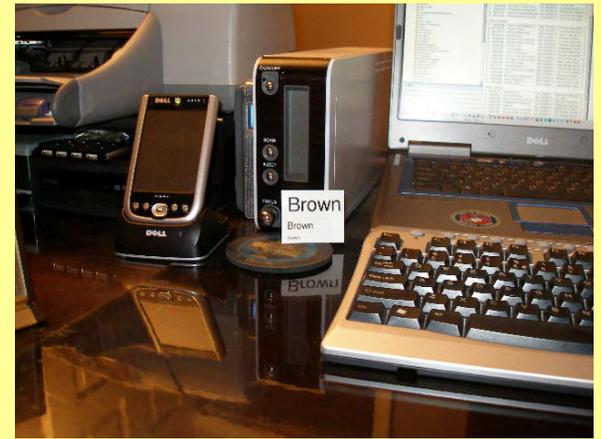
- You have an image that is 375x525 and a monitor that is 1280x1024. How should you view the image to evaluate it?
- ✓ **B – Show the image at 100% and let the image be smaller than the screen. The image can be viewed at whole number multiples of 100%. This will avoid interpolation and creation of data.**



# Short Quiz

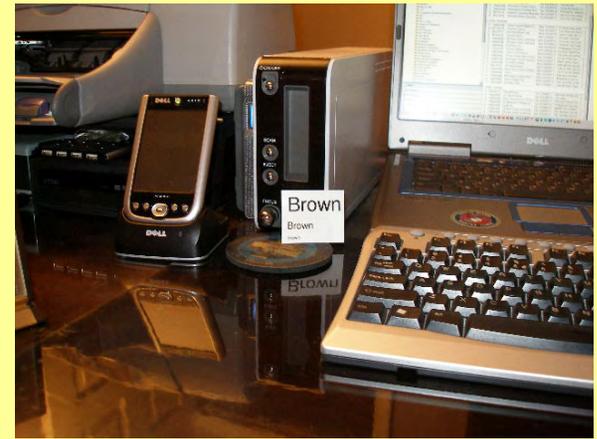
## Question 3

- You take a picture with a digital camera set to 3264x2448 pixels for the image dimensions. What is the X or Y Resolution of the image?
- A – What the Image Metadata says it is when the metadata file is opened
- B – 72
- C - Unknown



# Question 3 Answer

- You take a picture with a digital camera set to 3264x2448 pixels for the image dimensions. What is the X or Y Resolution of the image?
- ✓ **A, B, & C – ALL are correct. Technically it is unknown. X/Y resolution refers to spatial data which the digital camera does not know. The default metadata value when unknown is 72. Note this is NOT the Pixels Per Inch (PPI) in Photoshop which refers to the image as printed and is an arbitrary number selected by the user.**





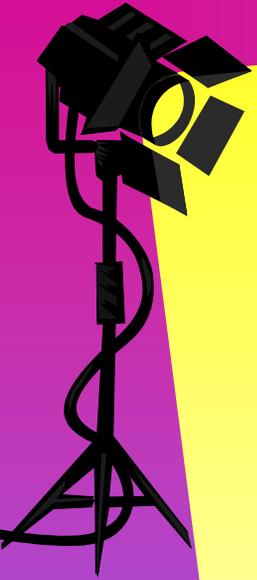
**Questions, Comments, or  
Suggestions?**

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**703-830-6860**



# Schedule

## (2nd Saturday of every Month)

Date	Description
3-10-07	Image Viewing Fundamentals
4-14-07	Image Color Spaces
5-12-07	* Vendor Presentation
6-09-07	Printing Fundamentals
7-14-07	Matching Image, Display and Printer Color
8-11-07	Digital Camera Picture Taking (how to get a good digital image)
9-08-07	* Vendor Presentation

**Additional Classes TBD**