Photography is all about light - intensity, color & balance

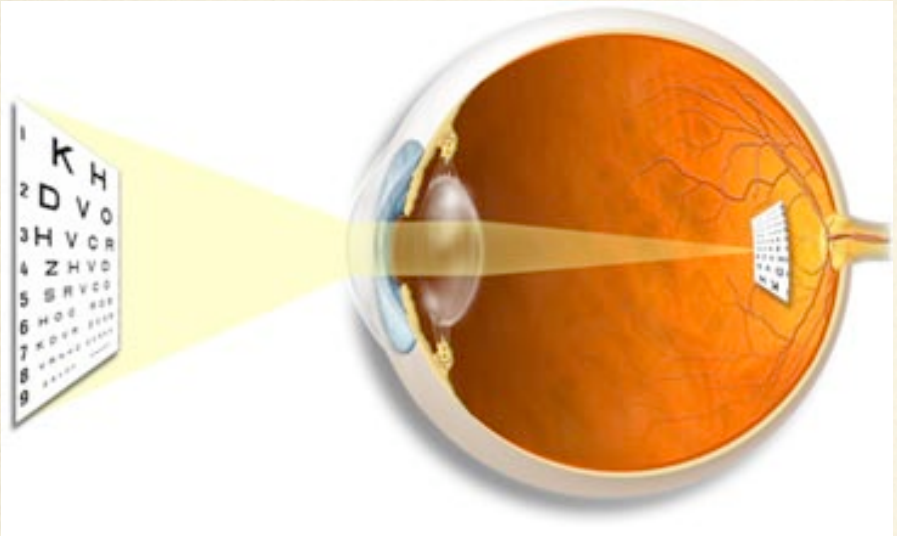
So, how do I get the results I am after using a digital camera?

By Jerry Work

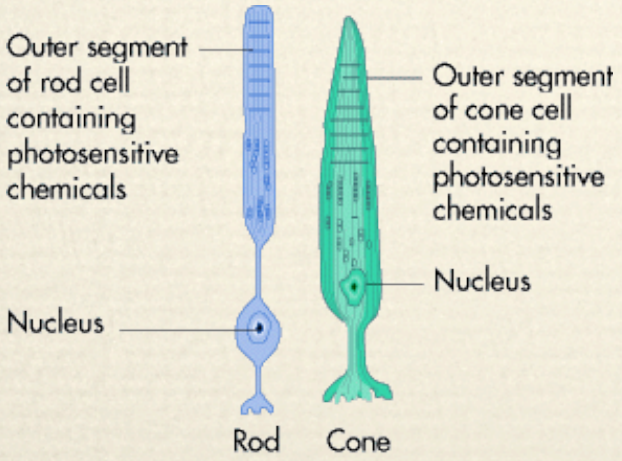
Five parts to the answer

- How does the eye “see”?
- How do cameras record and store images?
- How do computers allow you to adjust an image once captured?
- How do I get my printer to match the image on my computer screen?
- Which digital camera should I buy/use?

How the eye "sees"

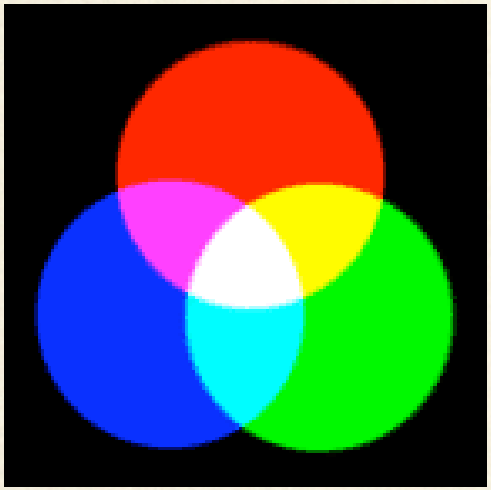


The brain continuously receives intensity and color signals from the eye, processes them into "images" and then selectively discards some and stores some for later recall



- Lens to focus on curved surface
- Diaphragm to control light
- 6 mil cones capture color
- 12 mil rods capture intensity
- Image continuously recorded
- Twice as many green as red or blue cones

How reflected light and color work

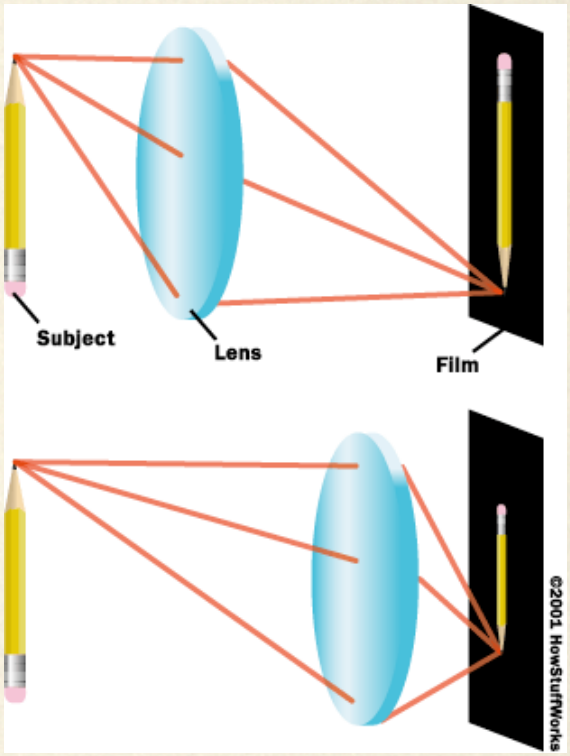


RED, GREEN, and BLUE (RGB) are the basic components of visible light such as the light "seen" by the eye, by film and by the photo sensor in a digital camera. By adding different amounts of each of these three, all other colors are formed.

Add the maximum amount of each of these three and the color white is formed. Take away all three and the color black is formed. This is called an additive color scheme.

How film cameras work

- Lens to focus on a plane
- Silver halide crystals deposited on a plate or flexible surface to record image
- Diaphragm to control intensity of light
- Shutter to control duration of light



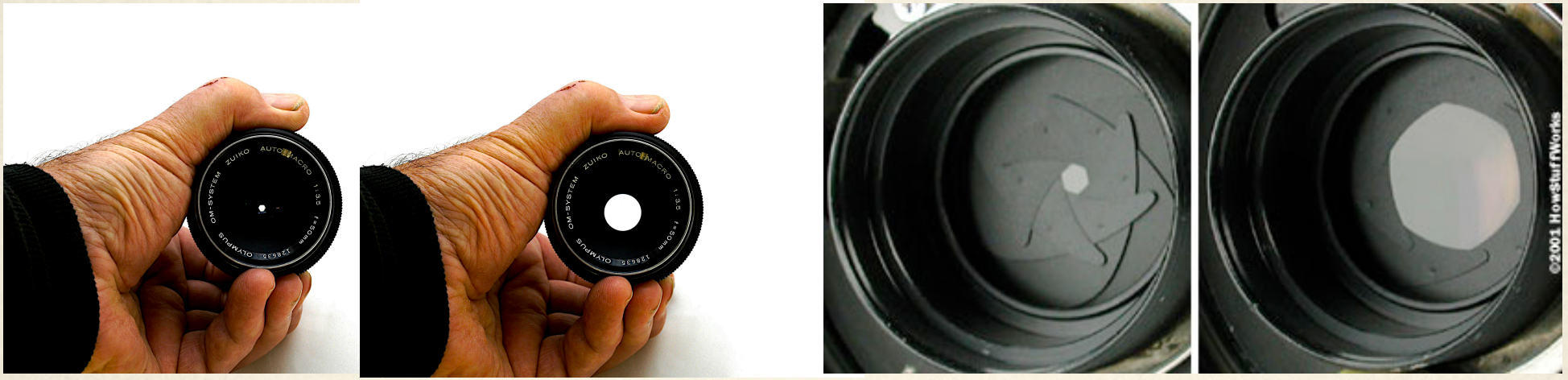
How film works

- Silver halide crystals change state chemically when exposed to light
- When subsequently contacted with another chemical (“developer”) the crystals become more or less opaque
- The less the light, the more transparent
- The more the light, the more opaque
- The result is called a negative and is the recording media for film cameras

How does color film work?

- Three layers of silver halide are used
- Each layer only allows one color (red, green or blue) to be recorded
- The mix of the amount of red, green and blue at each point on the film determines the overall color present at that point in the image

Diaphragm & “F stop”

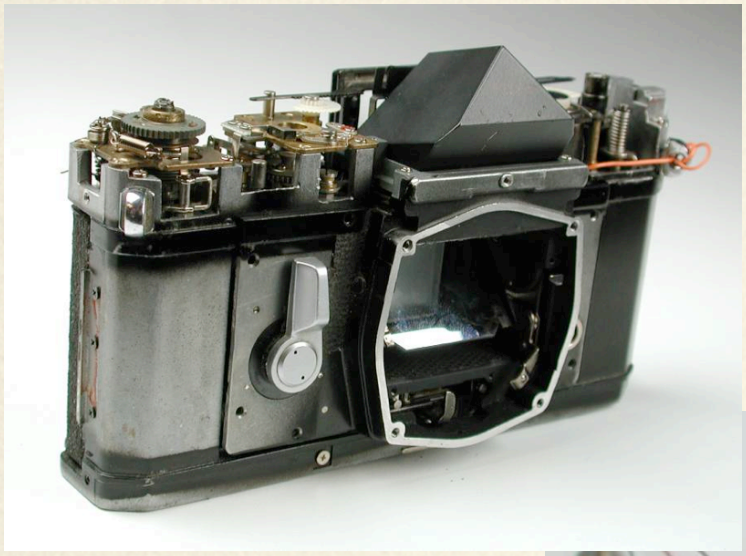


- Inside lens is a diaphragm to allow more or less light to pass through in a given period of time.
- Ratio of open area to focal length of lens is called an “F stop” (2, 2.8, 4, 5.6, 8, 11, 16, 22, 32 ....
- Each F stop lets in half as much light as the preceding F stop

Shutter

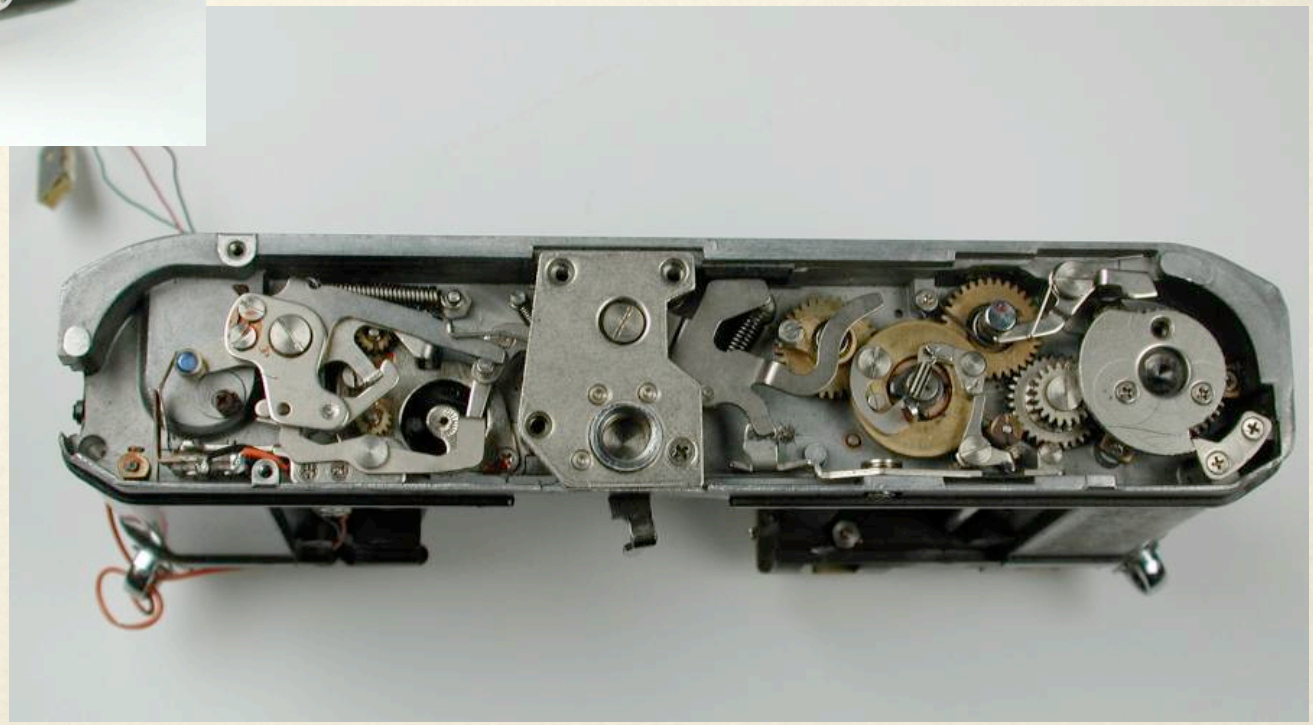
- Also inside the camera is a shutter to control how long the light is allowed to pass through the diaphragm and onto the film plane
- Like the diaphragm, shutter speeds are in a series each letting in half as much light
- Series is fractions of a second - 1, 1/2, 1/4, 1/8, 1/16, 1/30, 1/60, 1/125, 1/250, 1/500, 1/1000

Mechanical shutters are complex



Film cameras usually employ gears and levers to move a slit in a curtain across the film plane for the time indicated

Most digital cameras use a much simpler electronic shutter



Measuring light sensitivity of film

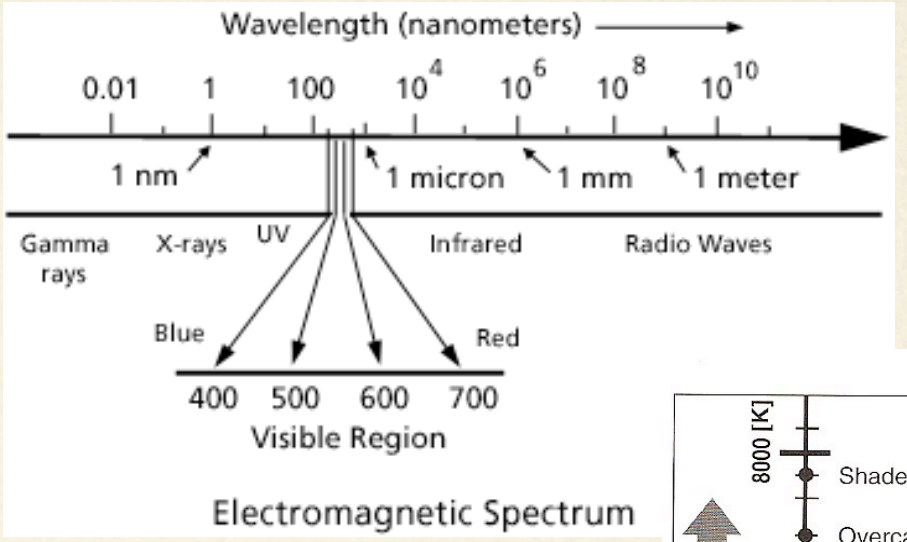
- Larger silver halide crystals are more sensitive to light, smaller crystals are less sensitive
- Since the film plane is fixed in physical size (24mm x 36mm for 35mm film) it is possible to deposit more smaller crystals than larger.
- A negative made up of smaller crystals looks sharper but requires more quantity of light to expose properly
- A negative made up of larger crystals looks grainer but takes less light to expose properly

Measuring light sensitivity of film

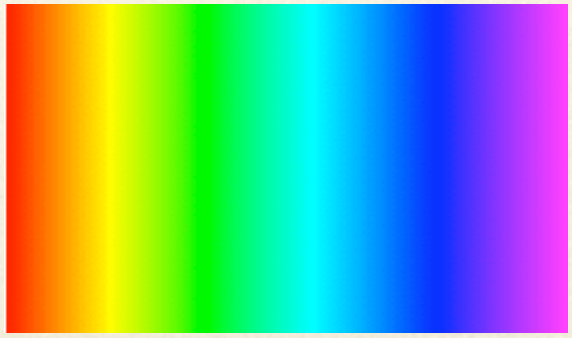
- Industry formed organizations to standardize the measurement of light sensitivity of film
- Called International Standards Organization in Europe (ISO) is now the standard worldwide
- Called American Standards Association in U.S. (ASA) seldom used any more
- Scales are different, but in both cases the scales are a series where twice the number means twice the light sensitivity (ISO 25, 50, 100, 200, 400....)

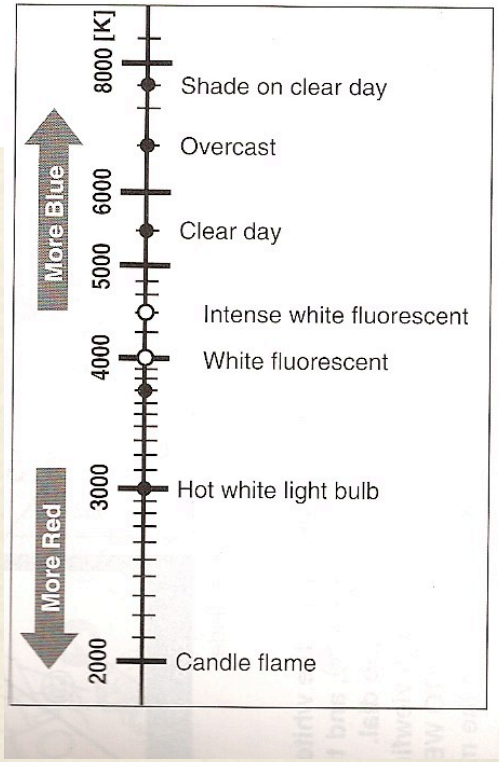
Measuring color

- Color the eye can see is a narrow band in the electro-magnetic spectrum
- Visible light is measured on Kelvin Color Temperature scale



Electromagnetic Spectrum





What is “white balance”

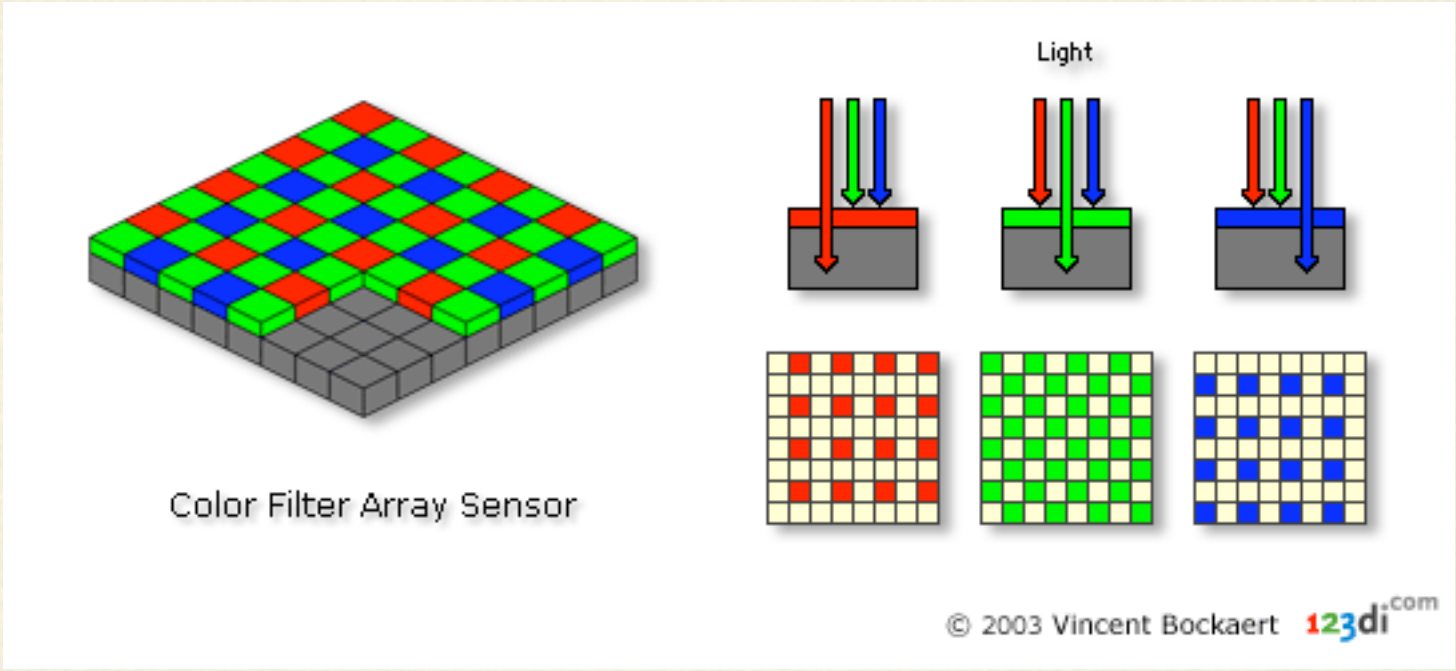
- Different colors of light reflected off of a white object will appear to be colored to our eye
- White balance is matching the film or image sensor to the color temperature of light used to illuminate the white object so our eye will see it as white
- In film the white balance is fixed at the time of manufacture (ie: daylight film, indoor film)
- In digital the white balance can be set on the camera for each exposure if desired

How does a digital camera work?

- Lens to focus light onto a photo sensor
- Diaphragm and shutter to control amount of light
- Computer to receive signals from photo sensor, process and store them on a non-volatile memory card
- Resulting “image” is series of numbers from zero to 255 representing intensity of red, green and blue light at each point on the sensor

How does the sensor work?

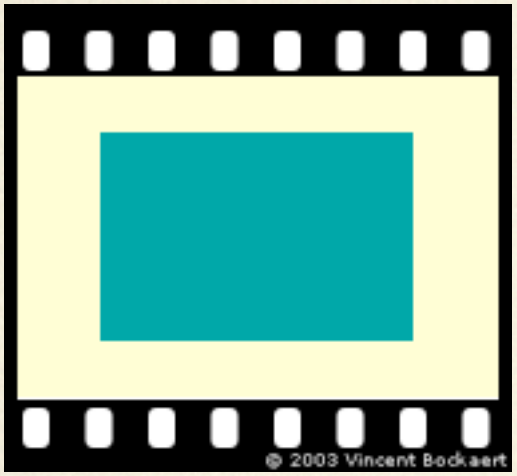
Twice as many green as red or blue sensors, just like the eye

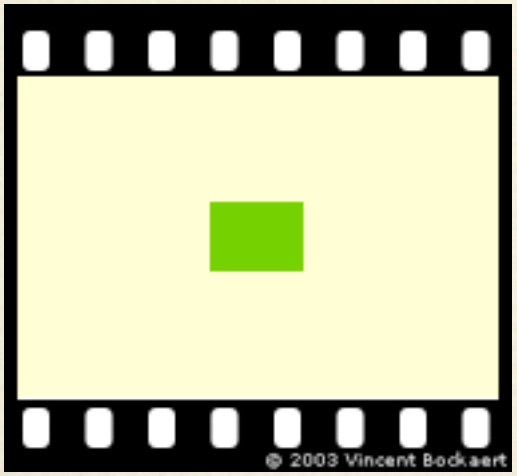


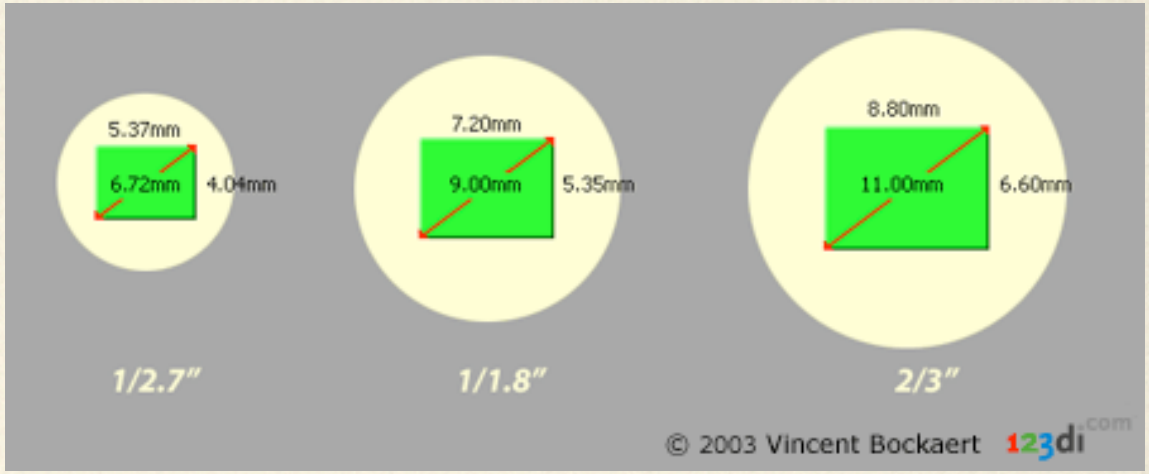
Three layers each allowing only red, green or blue light to hit that part of the sensor.

Light intensity measured on scale from zero to 255 at each point, mixing the red, green and blue values represents color at that point

Different sizes and numbers of pixels, different construction



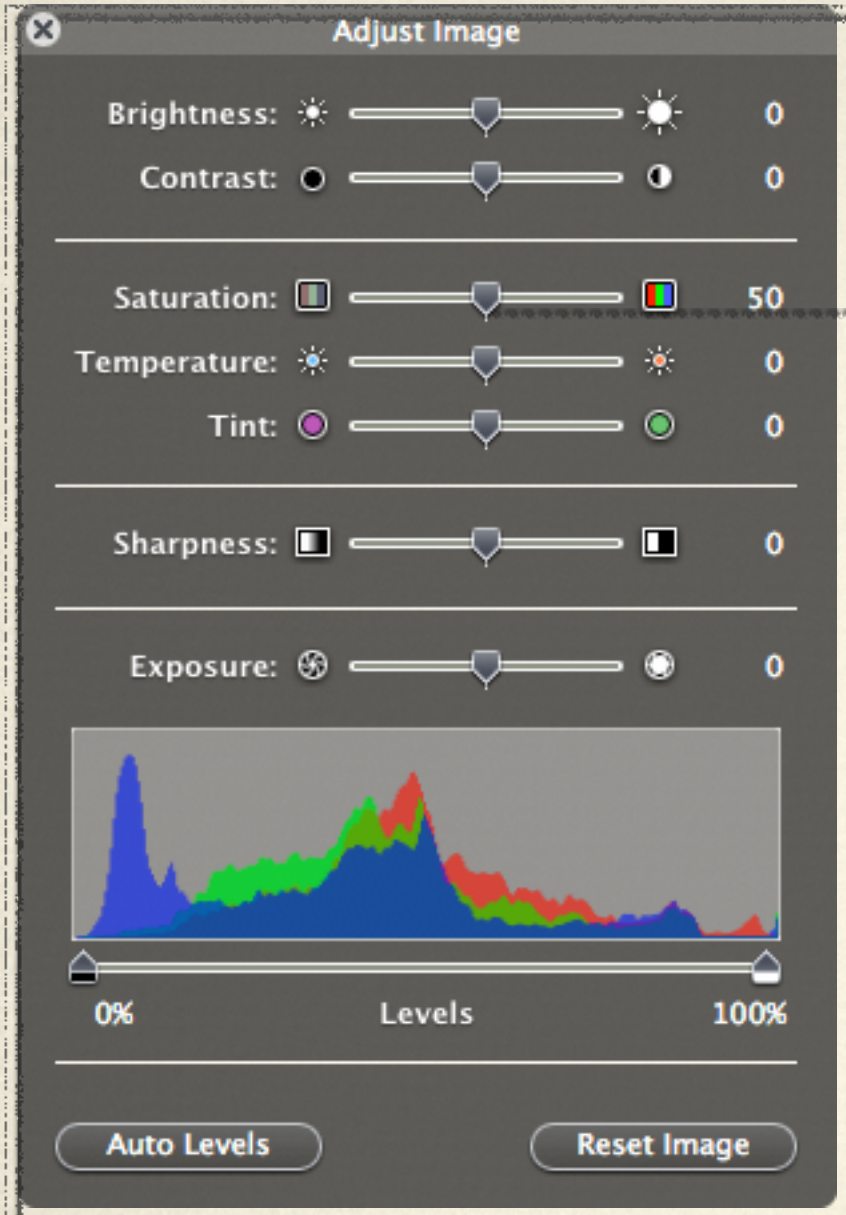




Number of pixels not nearly as important as quality measured by signal-to-noise ratio

Cramming more pixels onto sensor of given physical size usually results in less quality

Histogram



The frequency with which each light intensity value from 0 to 255 occurs in the image is called a histogram & is what is stored as the digital image

Digital cameras can store image data in several formats

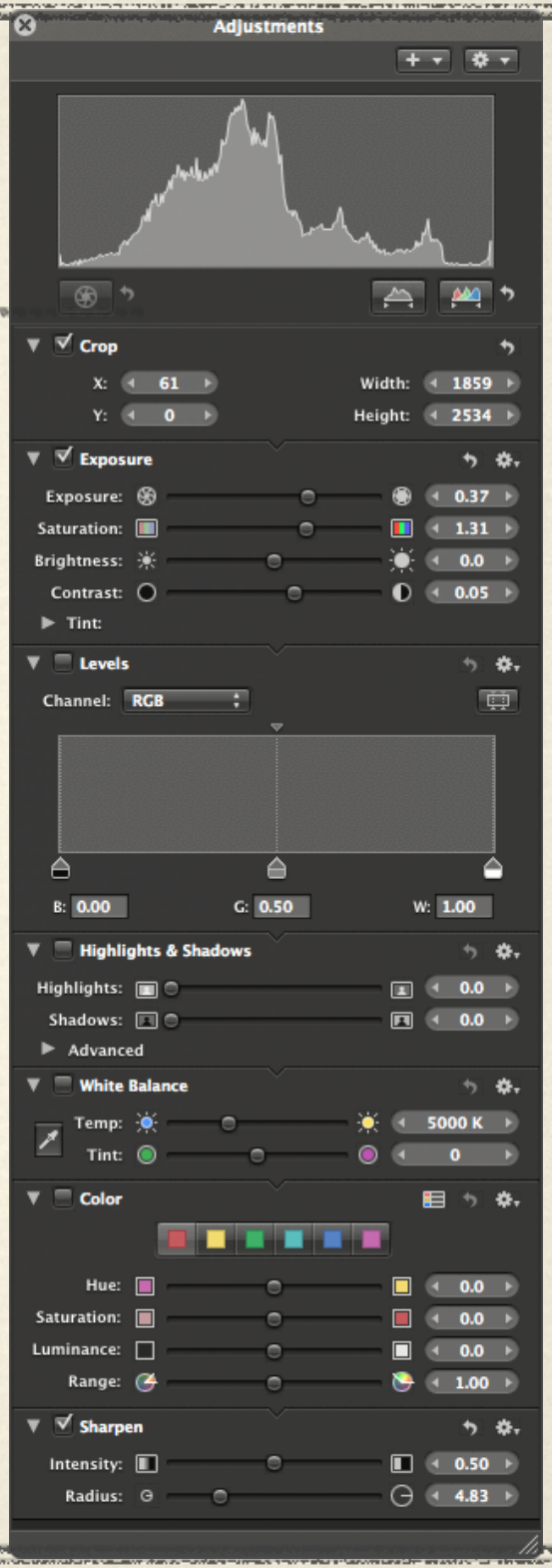
- The computer inside the digital camera captures the image data from the sensor, optionally adjusts it and stores it in a image file on a memory card
- The Joint Photographic Experts Group developed a popular means of compressing the size of a digital image file with little loss in quality (JPEG)
- Many newer cameras allow storage of the RAW sensor image data without much in-camera processing. These files are large & very useful.

Many kinds of memory cards

- Memory cards come in many form factors
- The most common are called “secure digital” and “compact flash”
- Both are available in storage capacities up to 16gb and in different record speeds
- Neither is “better” than the other

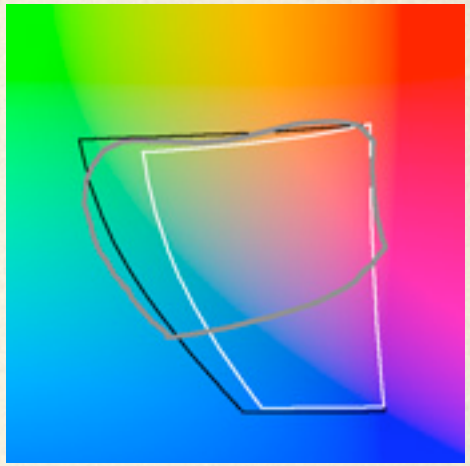
Image files can be down loaded to a computer

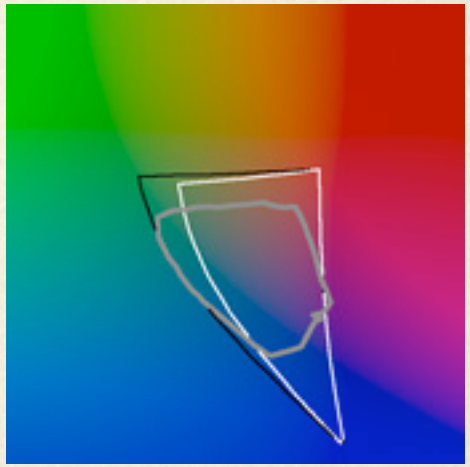
- Once there, the image can be adjusted or manipulated in a bewildering number of ways
- All adjustments "simply" manipulate the histogram of image data
- The newest and best programs are Apple Aperture and Adobe Lightroom - they do "non-destructive" editing, preserving your original digital negative



Calibrating screen & printer

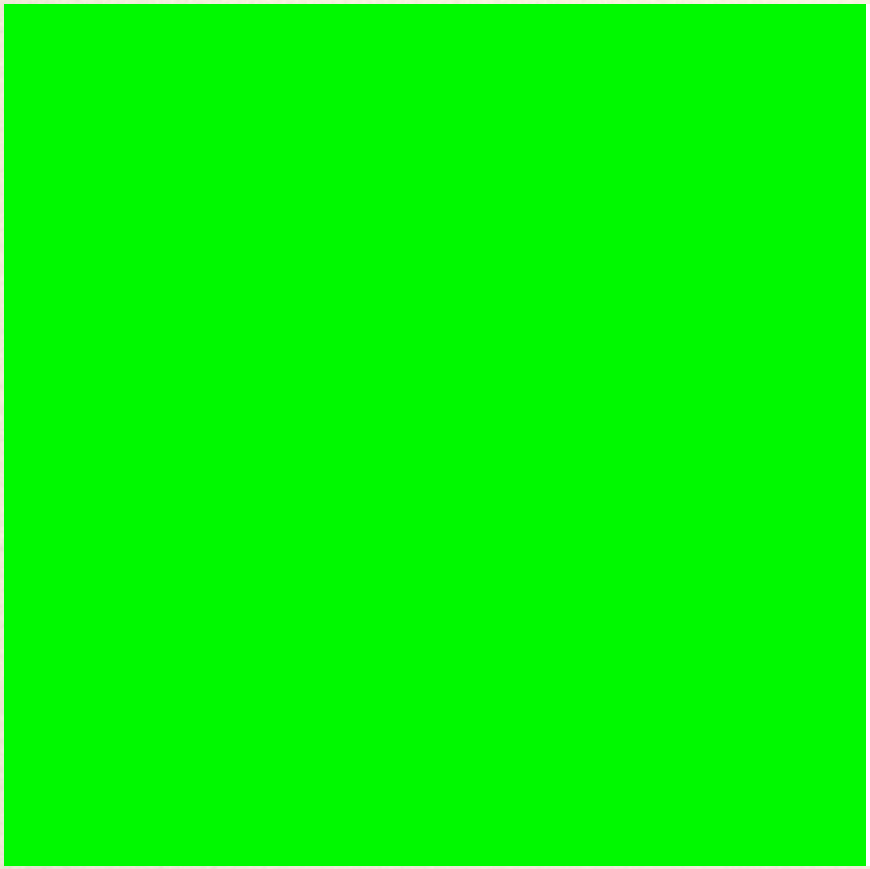
- No two humans “see” color in the same way
- No two computer devices do either so a standard had to be developed to make them work together
- International Color Consortia color profiles provide for commonality
- Color space - dynamic range - Adobe 1998 far better than sRGB





Color space really matters

88, 249, 17 in Adobe RGB



Same value in sRGB

Image quality, what's important

- **The quality of the lens makes more difference than everything else. Watch out for "kit" lenses**
- **The sensor signal-to-noise ratio is far more important than the number of "mega pixels"**
- **The computer and software inside the camera**
- **Manually set white balance and ISO to match your scene - auto mode only works sometimes**
- **Use aperture preferred mode to control depth of field and shutter preferred mode to control camera shake.**
- **Scene modes useful. Use full auto mode only for snap shots**

So, what camera should I buy?

- **Brand doesn't matter much - Nikon and Canon have 70% market share so show up more often but are not "better"**
- **Buy the best lens you can afford - Stay away from "kit" lenses on DSLRs other than Leica. For all the rest buy a body only plus a quality lens from their line. Avoid the off brand lenses and lens add-ons.**
- **Useful optical zoom range is from 35mm equivalent of 28mm up to at least 105mm. Good names are Leica, Schneider, Zeiss, Nikon, Canon, Olympus, Sony(Minolta).**
- **Best value is fixed lens cameras with large zoom range, easiest are compact point shoot, most versatile are DSLR**
- **You want an easy way to quickly set ISO, WB, exposure and flash compensation plus easy menu navigation**

Example fixed lens camera

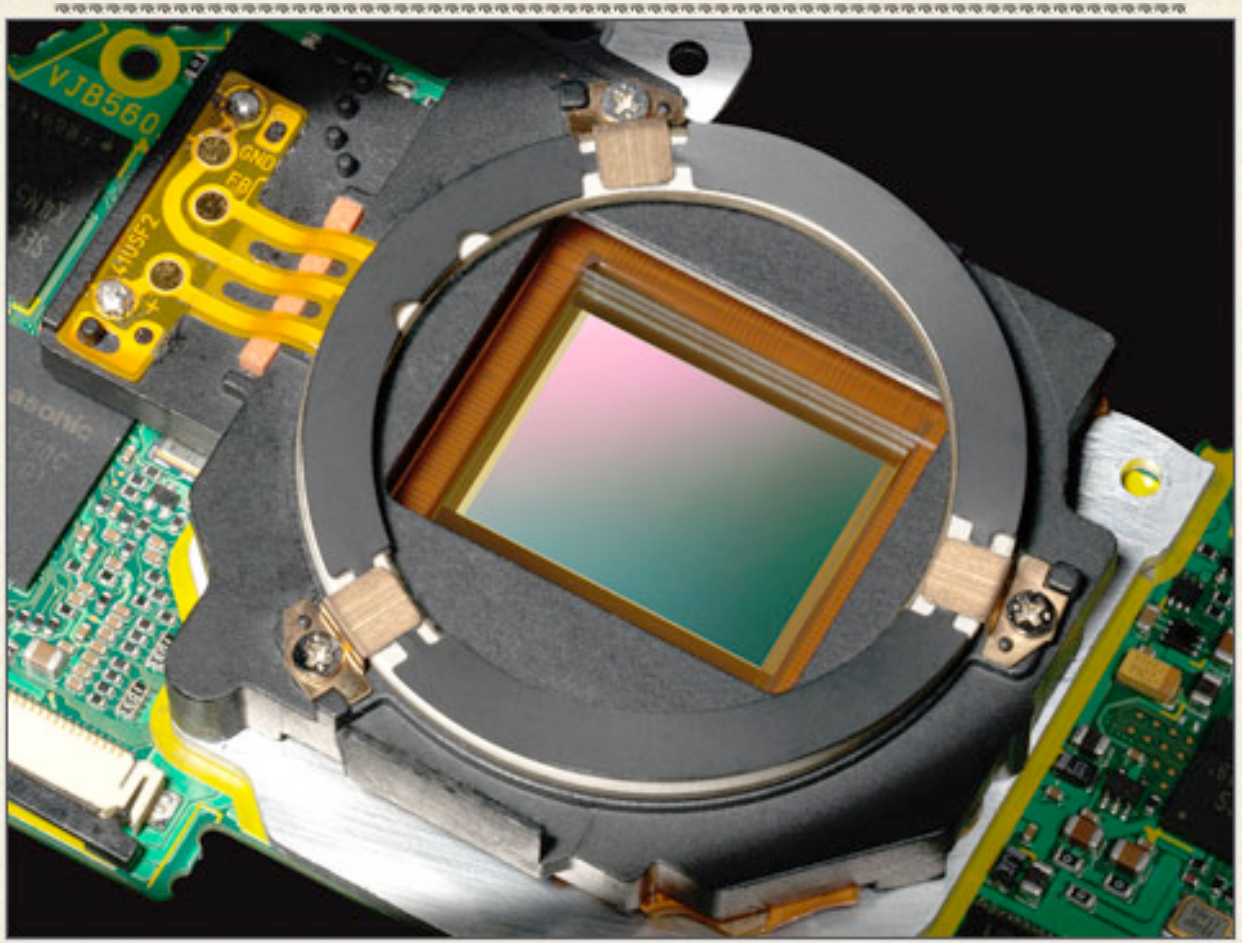
Most have electronic view finder & menu/live preview window

Example Point-and-Shoot Camera

Example Popular DSLR

Example Professional DSLR

What camera should I buy?



- For DSLR make sure there is good auto cleaning of sensor built in - sensor dust can be a problem

What camera should I buy?

- Optical or sensor image stabilization is very good but avoid those that just increase ISO speed
- “Scene” modes are useful when you first start out
- Insist on either Secure Digital or Compact Flash memory card storage

One final note.....

- The “best” camera is the one you will use so be sure you like the feel, the view finder, the controls and the menu system
- Use the camera often, learn the various settings and experiment with adjusting images on your computer
- Learn to share images with family and friends via email, print, CDs and your own web page
- Enjoy!

Optimal Print Viewing Resolution (ppi)

Here is a table of the minimum resolutions for common print sizes. These are the subjective **minimum acceptable base resolutions** to produce a quality viewing experience rivaling film. Higher resolutions are always better. The maximum ppi you'll ever need is 360.

4 x 5"	5 x 7"	8 x 10"	11 x 14"	16 x 20"	20 x 24" and up
360 ppi	300ppi	240 ppi	200 ppi	180 ppi	140 ppi

Optimal Printing Resolution (dpi)

To print those images to rival film, the number of dpi is determined by the viewing distance. Most current ink jet printers are capable of printing at least 1440 x 720 dpi.

3 ft. and closer	6 ft. and closer	Farther than 6 ft.
1440 or 2880	720 dpi	360 dpi

These are by no means set in stone, but it gives you an idea of what to shoot for. 2880 dpi is overrated and unnecessary unless you have "precious" (to you at least) shadow details, or customers toting loupes. And, note that it takes twice as long to print at 2880 as 1440 dpi and requires more ink.