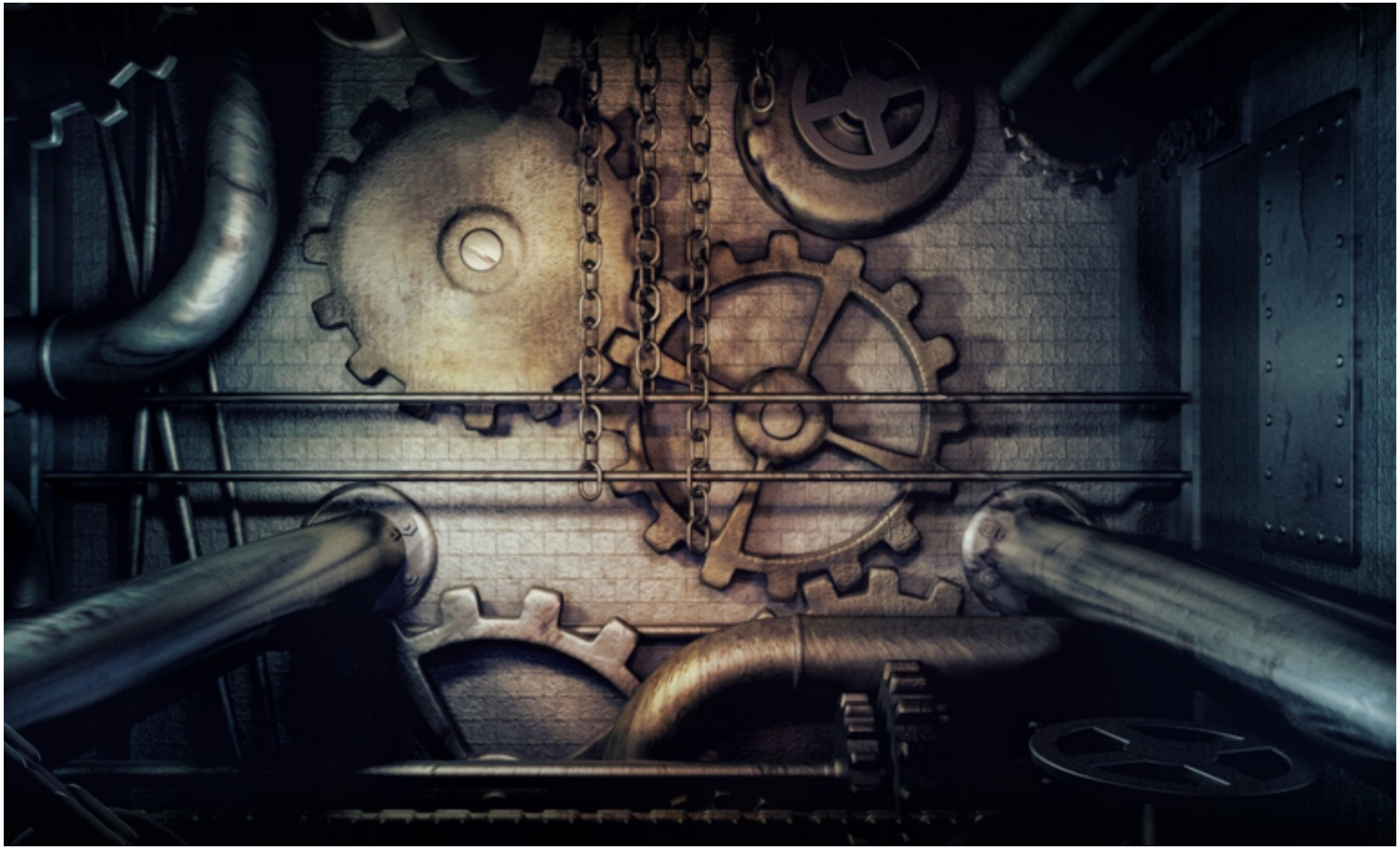
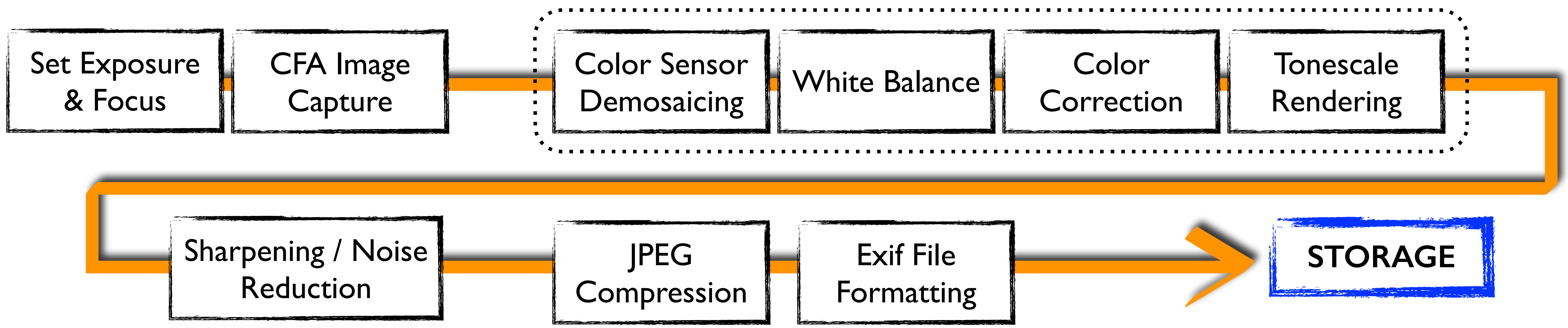


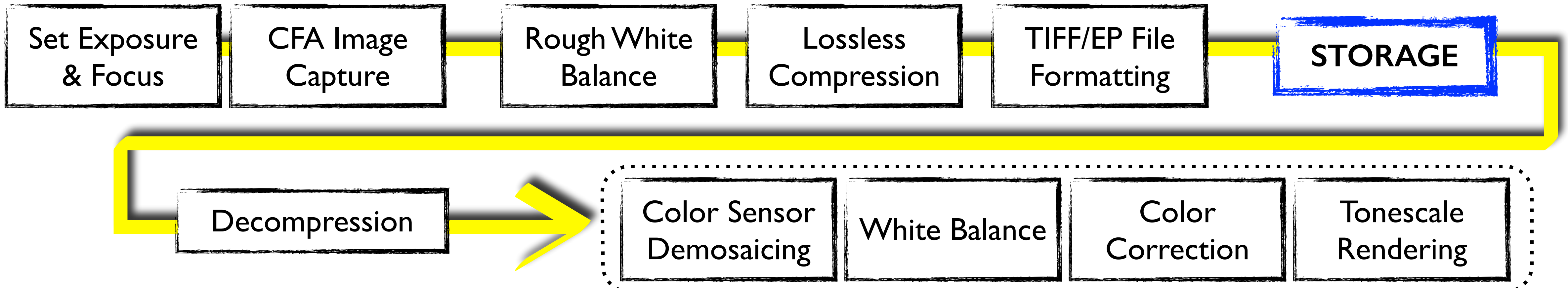
Digital Photography Processing Pipeline

Computational Photography 15-463

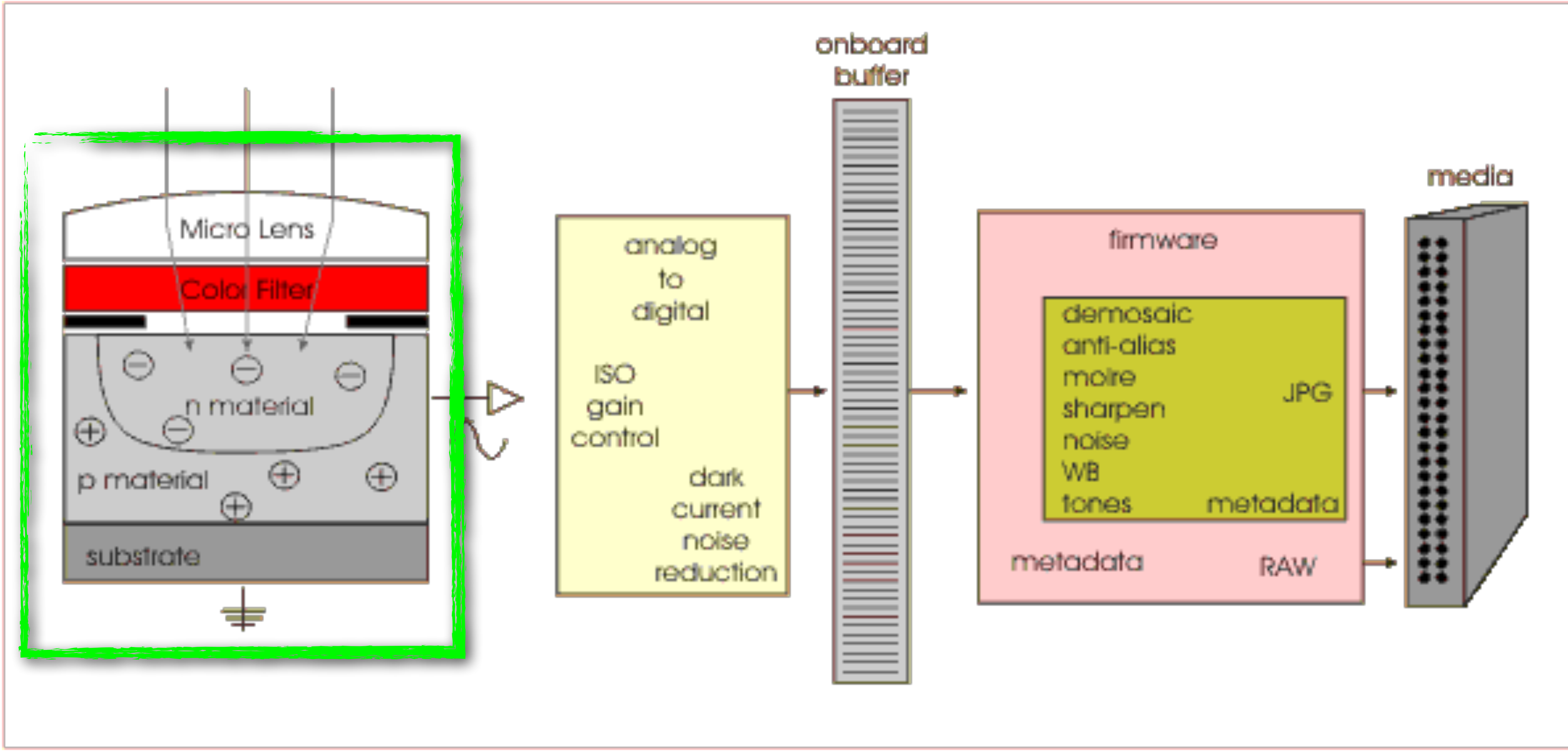
Consumer camera



Professional camera

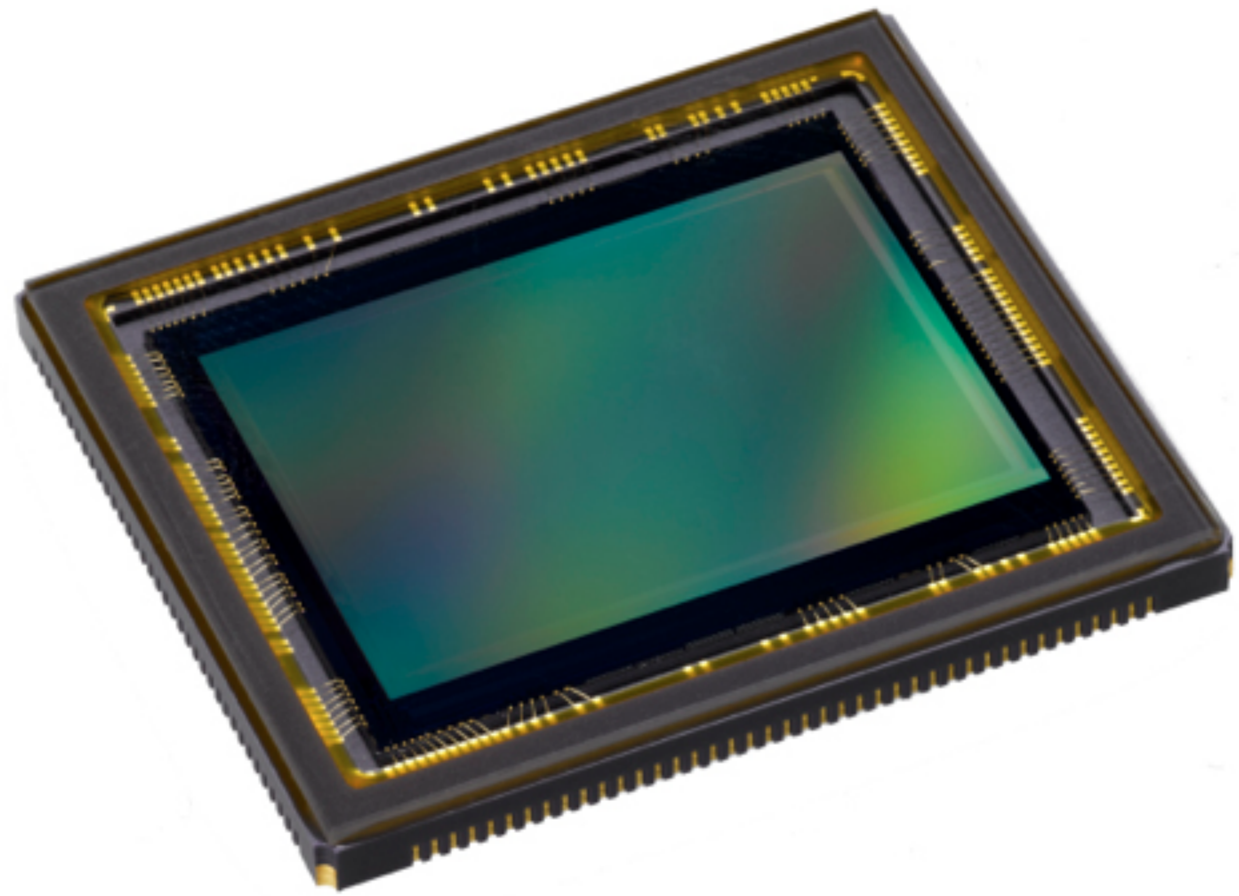


Credit: Parulski & Spaulding



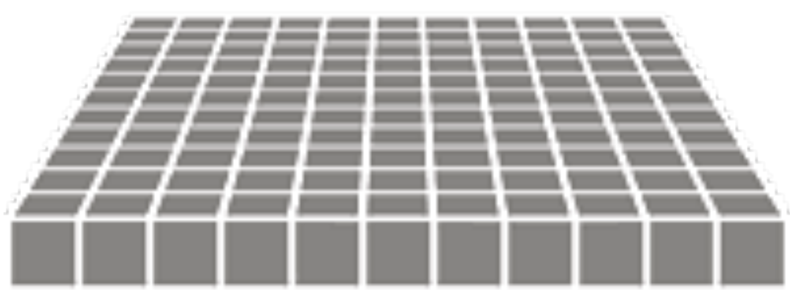
http://www.rags-int-inc.com/PhotoTechStuff/Pipeline/

The sensor

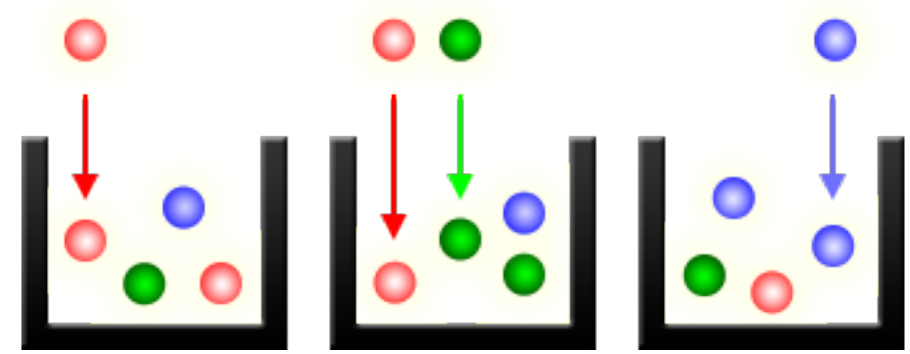


So what’s inside?

Open shutter, exposure begins ...



Array of light cavities



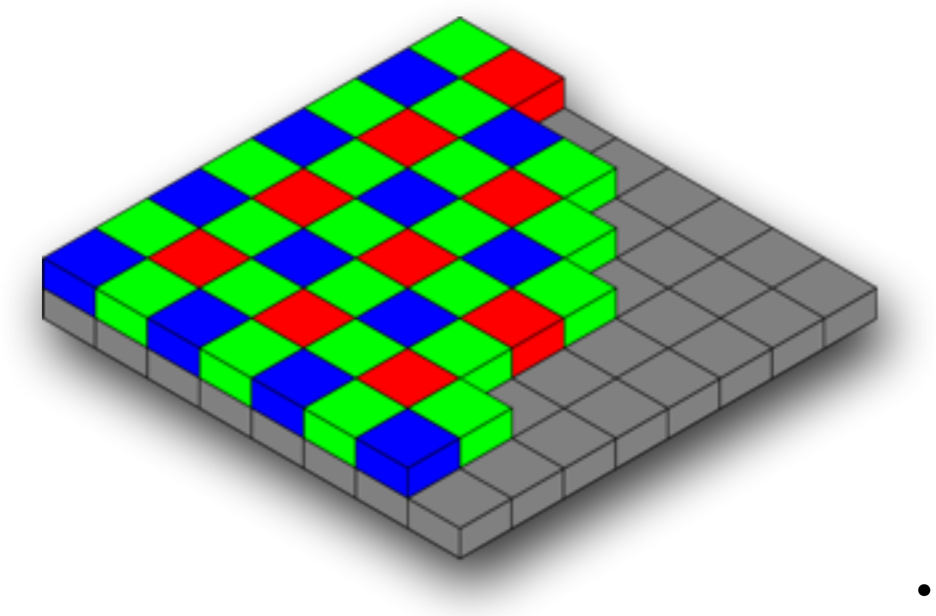
Light cavities

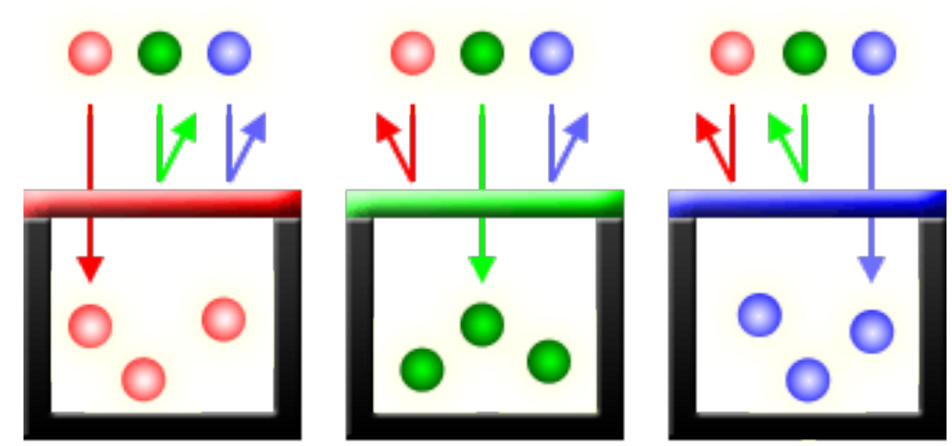
... photons are stored and converted to intensity readings.

Just grayscale. How do you get color?

http://www.cambridgeincolour.com/tutorials/camera-sensors.htm

For color images ...

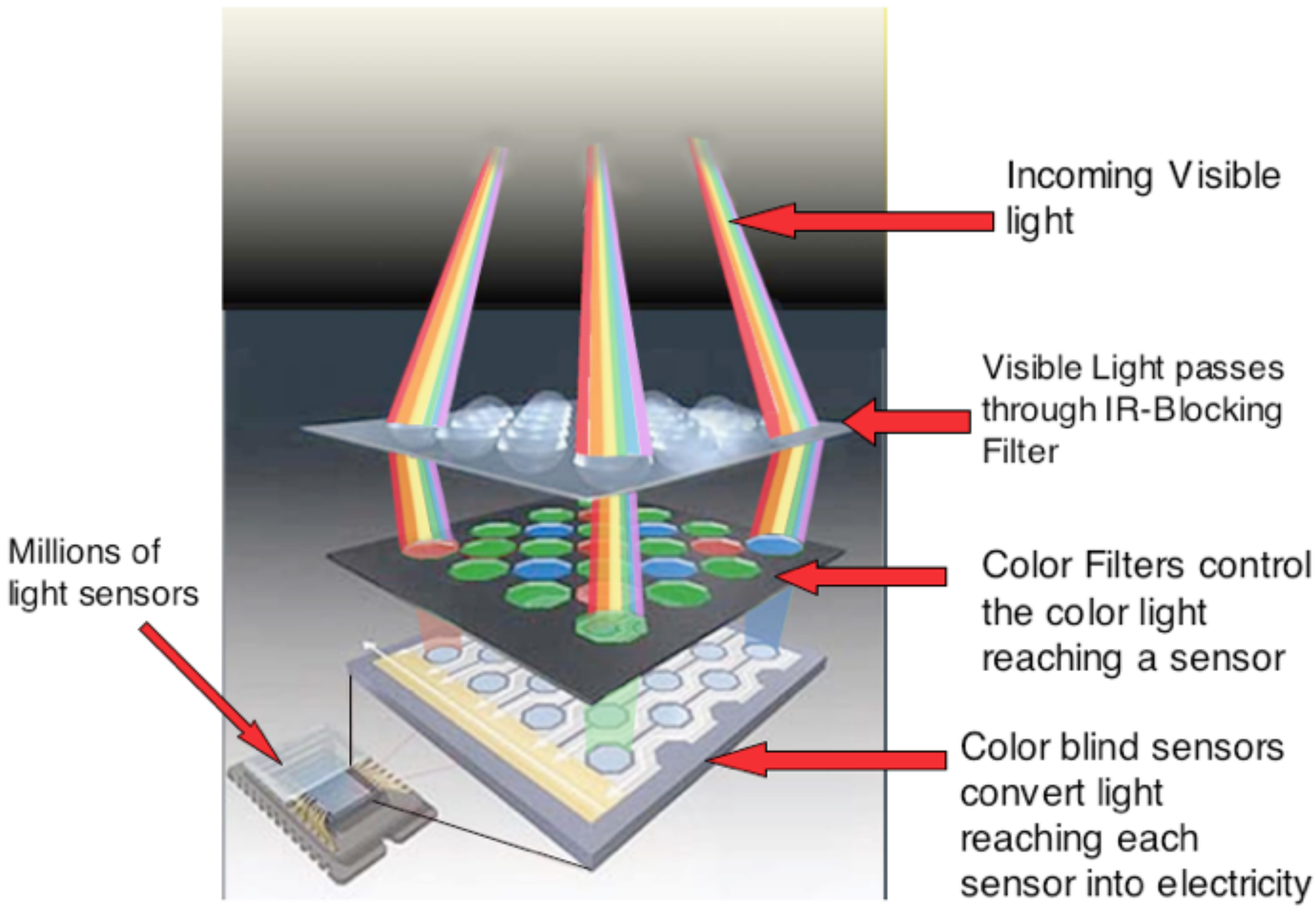




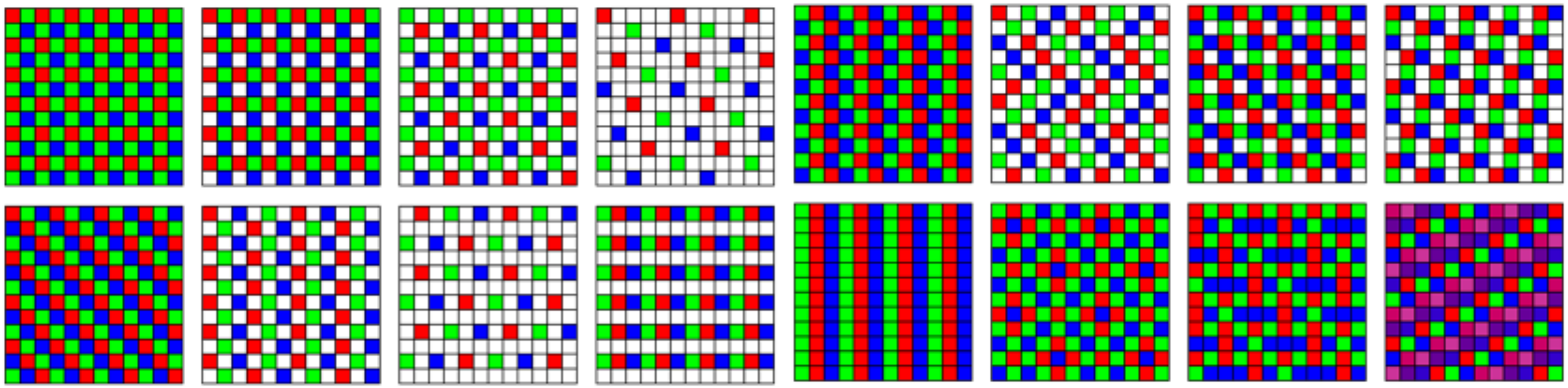
... filters are placed over each cavity.

What percentage of the light is discarded?

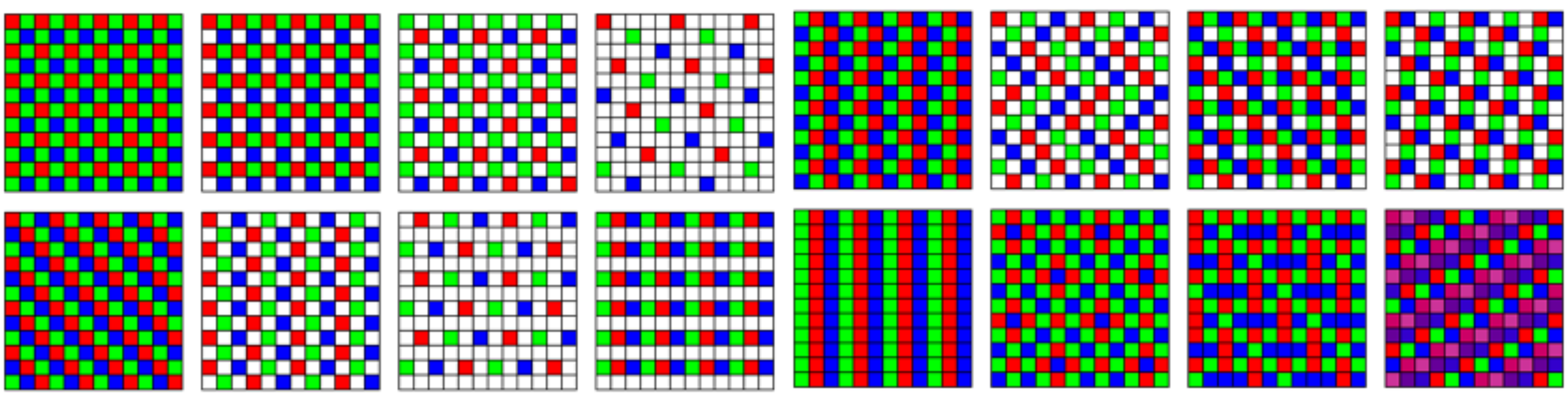
http://www.cambridgeincolour.com/tutorials/camera-sensors.htm



Credit: Photoaxe

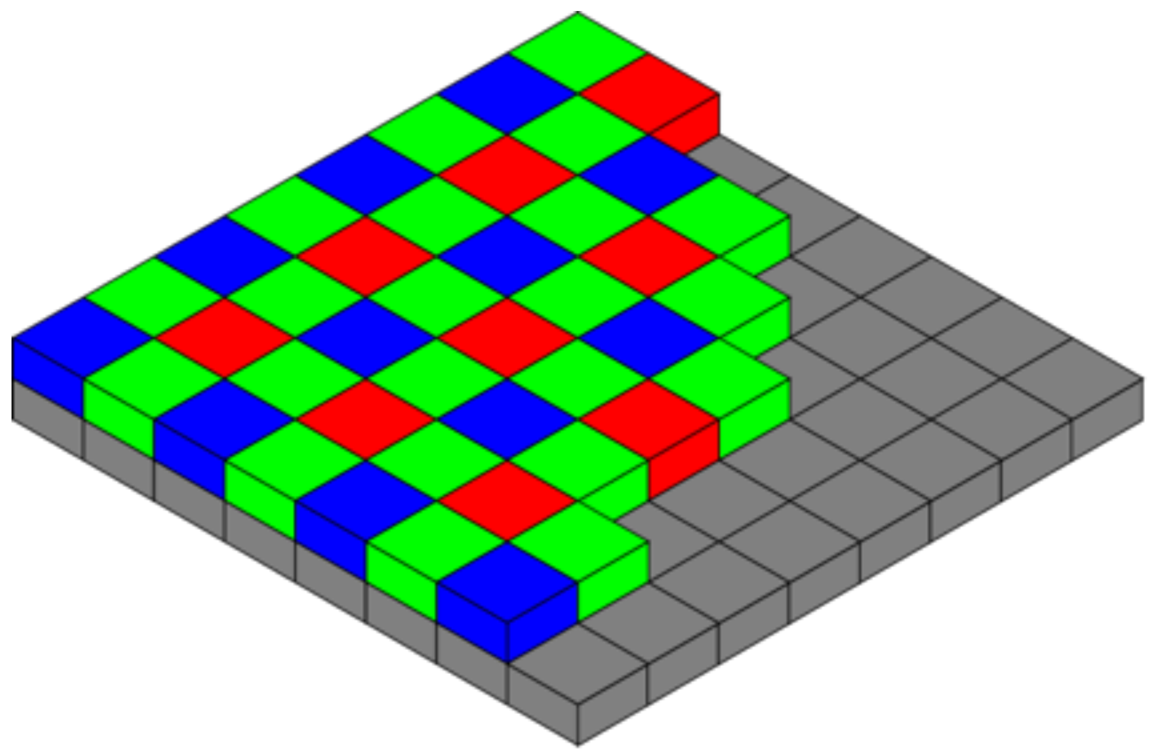


How would you arrange the color filters?



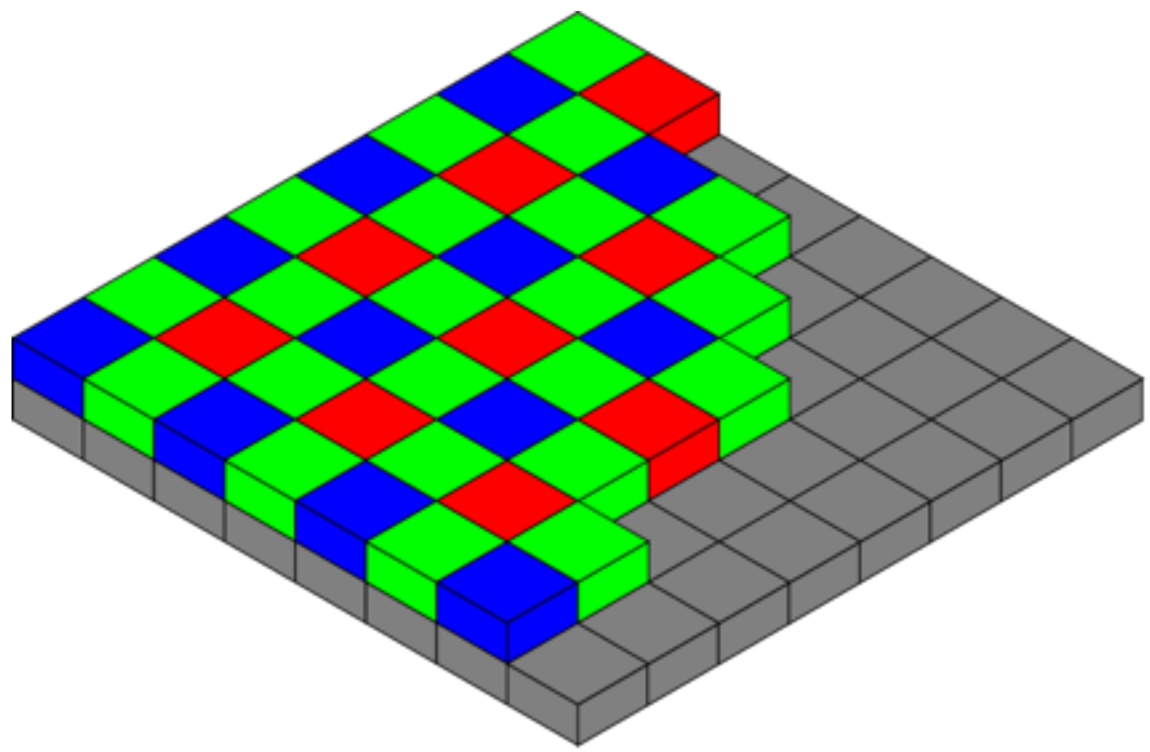
Mosaicing

Bayer Mosaic



Why more green?

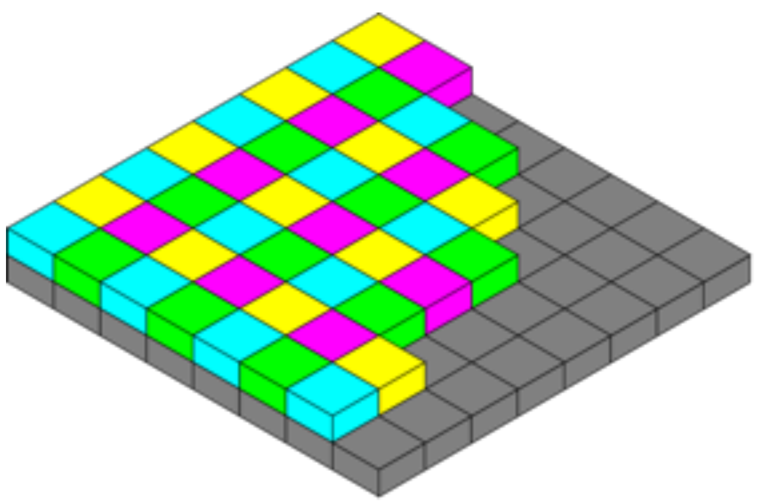
Bayer Mosaic



Why more green?

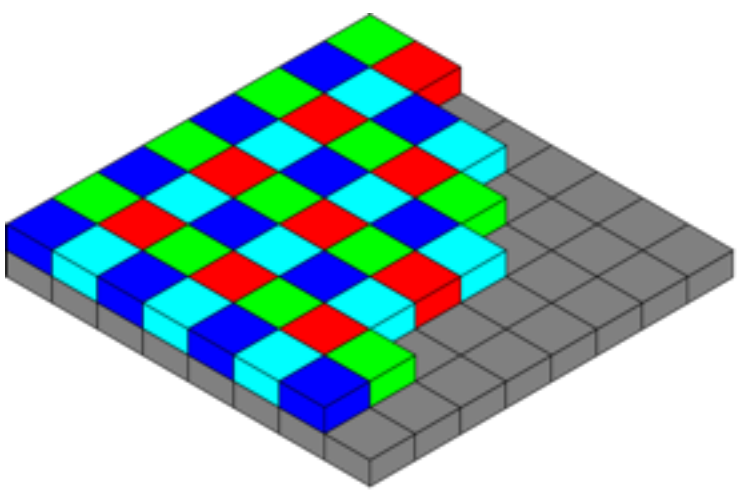
Since the human vision is sensitive to green, the redundancy gives the appearance of higher detail and less noise.

Color filter arrays (CFA)



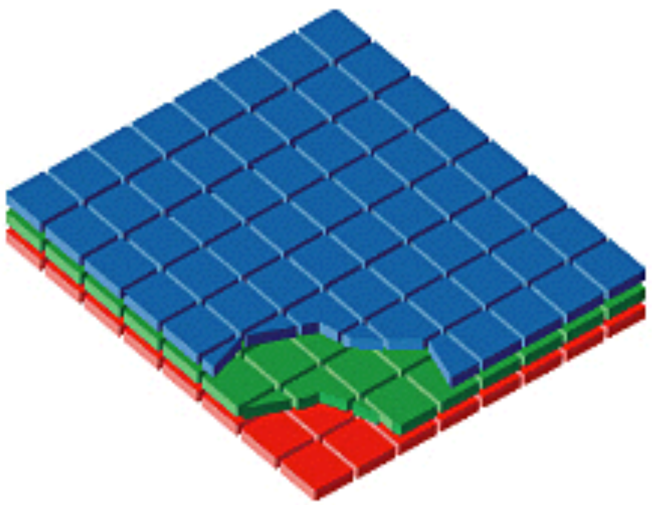
CYGM

Canon IXUS (2000), Powershot S10



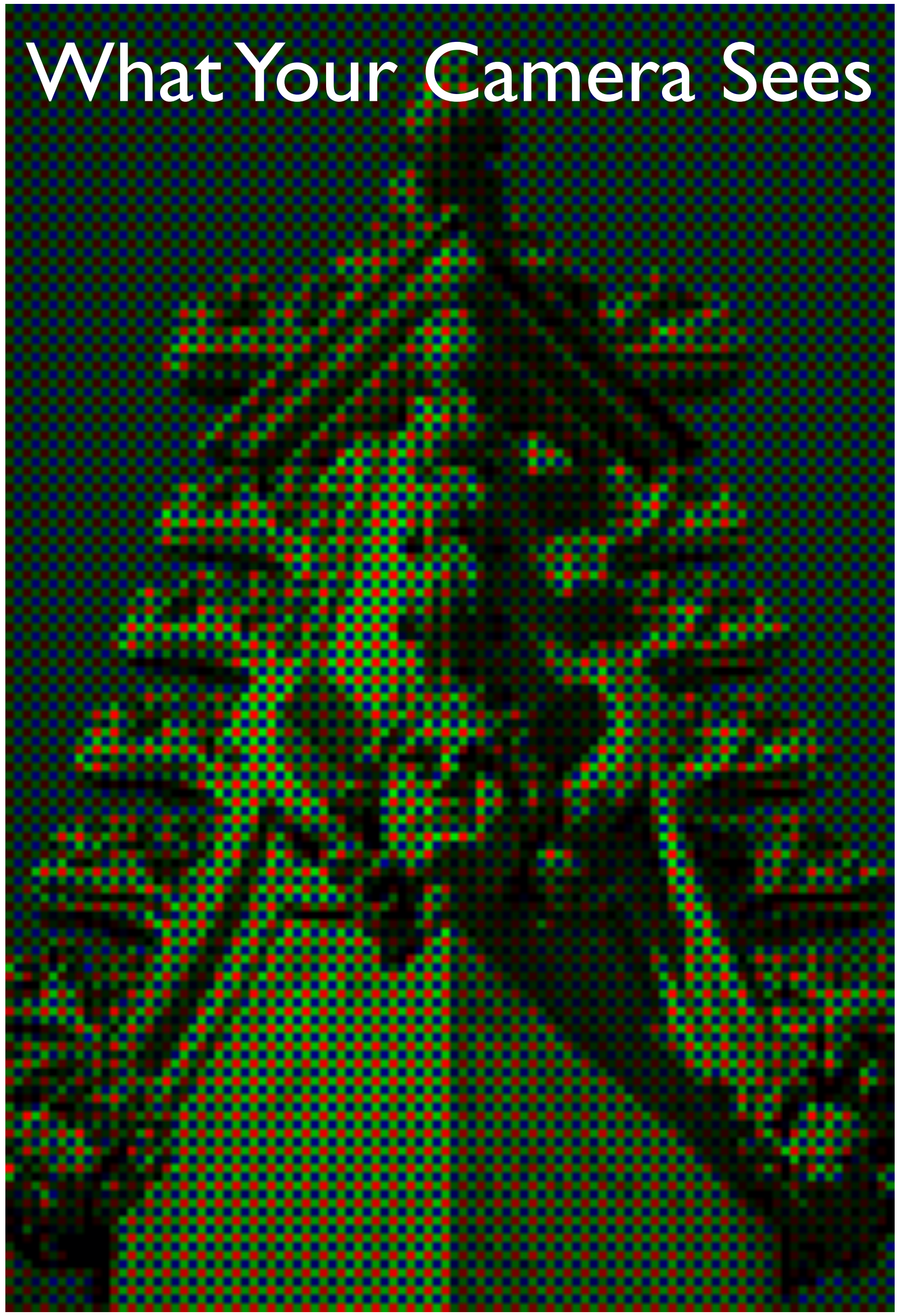
RGBE

Sony Cyber-shot DSC-F828



Foveon X3

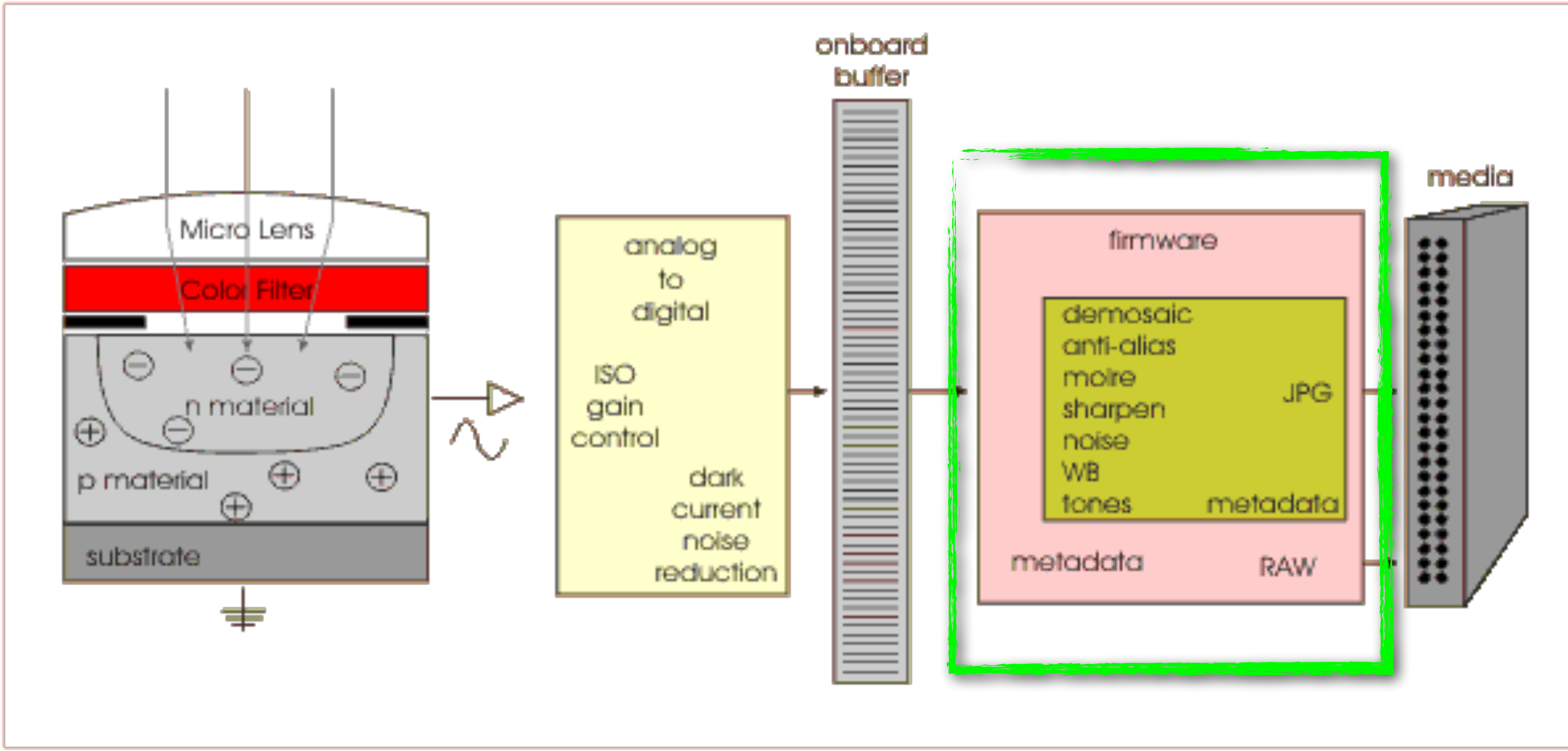
Sigma SD9



http://www.cambridgeincolour.com/tutorials/camera-sensors.htm

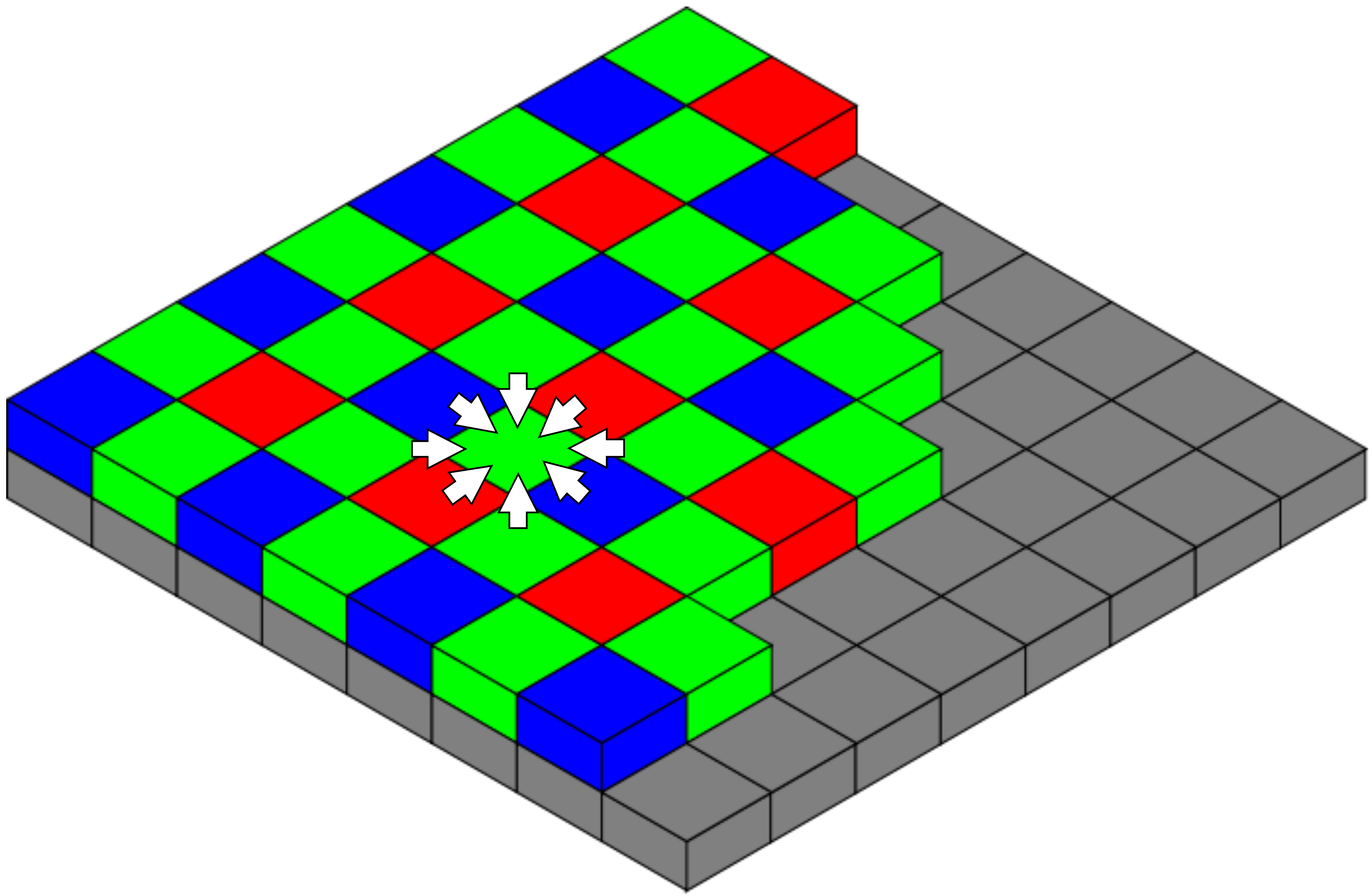
(There are many other ways for color acquisition)

http://www.bealecorner.org/best/test/raw-crop1.png



http://www.rags-int-inc.com/PhotoTechStuff/Pipeline/

Demosaicing



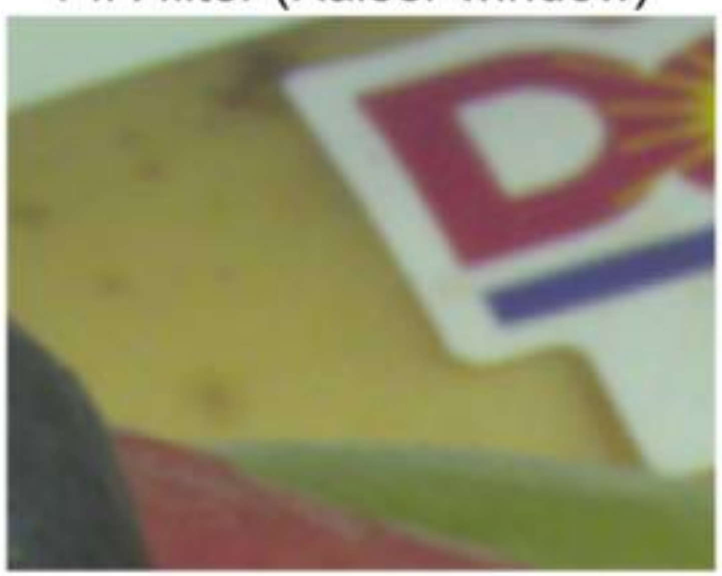
Credit: Wikipedia

TIFF

Nearest Neighbor

Bilinear

FIR filter (Kaiser window)



FIR filter w/ high cut-off freq.

Bilinear w/ LS-method C_C

http://scien.stanford.edu/pages/labsite/2003/psych221/projects/03/piquant/index.htm

White Balance

We can perceive white under different light sources, a camera cannot.

White balance - *the process of removing unrealistic color casts, so that objects which appear white in person are rendered white in your photo.*

Different lighting conditions
(color temperature)

Color Cast

Daylight White Balance

http://www.cambridgeincolour.com/tutorials/white-balance.htm

WB SETTINGS	COLOR TEMPERATURE	LIGHT SOURCES
	10000 - 15000 K	Clear Blue Sky
	6500 - 8000 K	Cloudy Sky / Shade
	6000 - 7000 K	Noon Sunlight
	5500 - 6500 K	Average Daylight
	5000 - 5500 K	Electronic Flash
	4000 - 5000 K	Fluorescent Light
	3000 - 4000 K	Early AM / Late PM
	2500 - 3000 K	Domestic Lightning
	1000 - 2000 K	Candle Flame

http://www.exposureguide.com/white-balance.htm

Manual

- Choose color-neutral object in the photos and normalize
- Use camera WB presets

Automatic (AWB)

Can you think of an automatic way of white balancing?

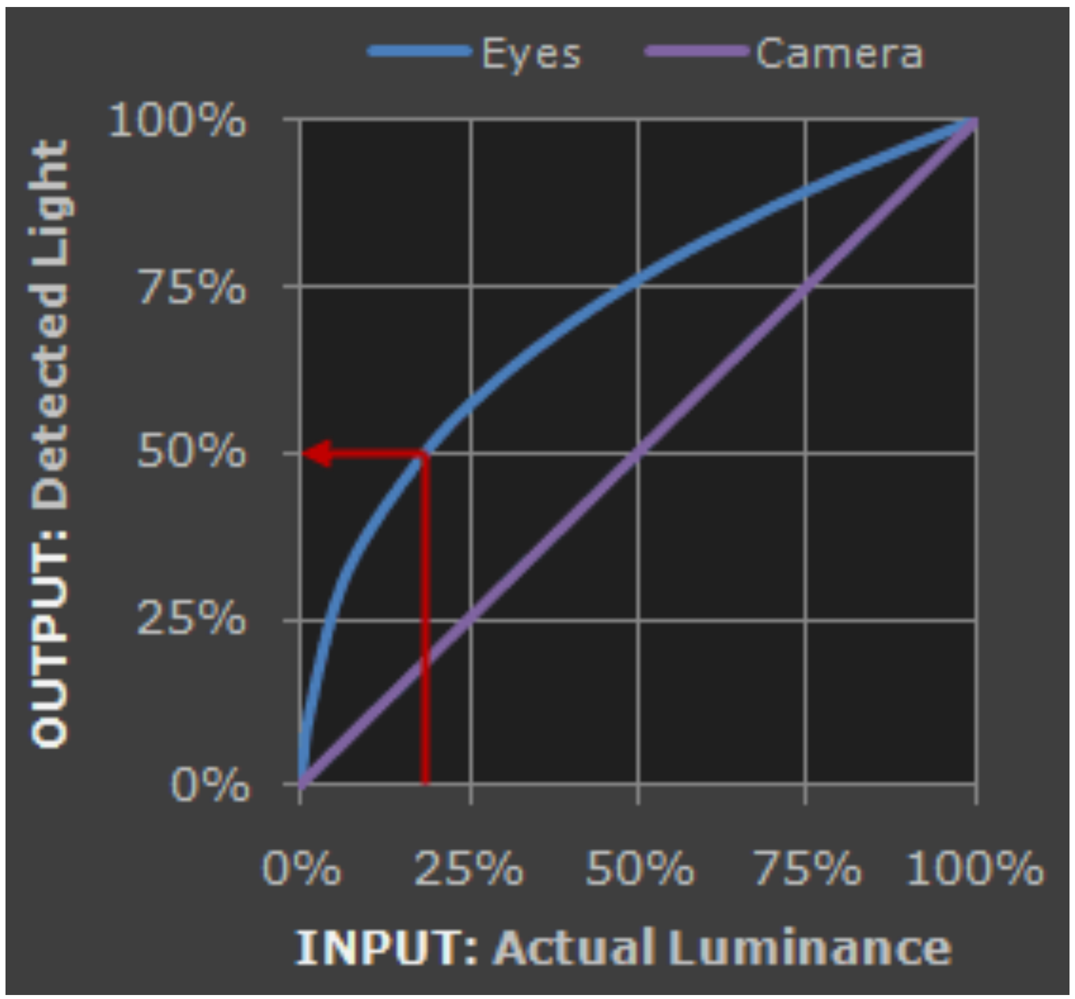
Manual

- Choose color-neutral object in the photos and normalize
- Use camera WB presets

Automatic (AWB)

- Grey World: force average color of scene to grey
- White World: force brightest object to white

Tone mapping / Contrast correction



Human eyes

- More sensitive to dark tones
- Approximately a Gamma function
- Non-linear relation

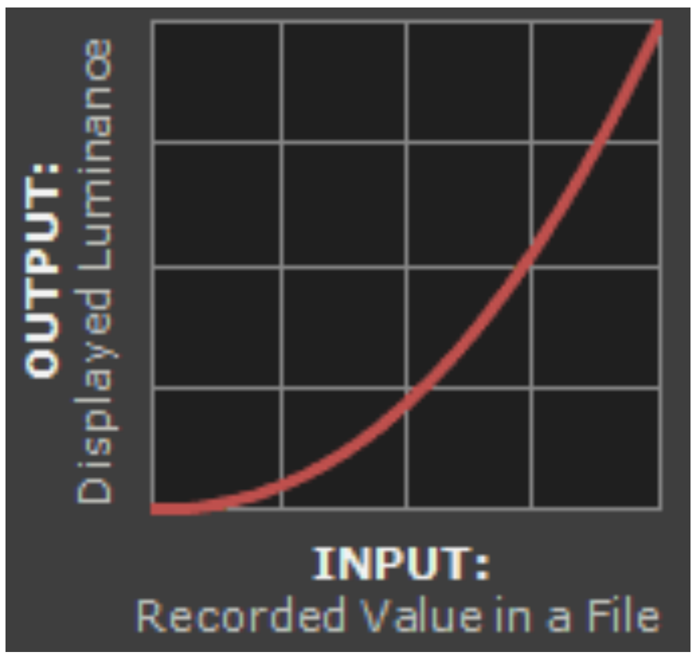
Camera

- Limited bias to difference in tone
- Approximately linear

http://www.cambridgeincolour.com/tutorials/gamma-correction.htm

Typical display gamma

Image on the display (projector) without gamma correction

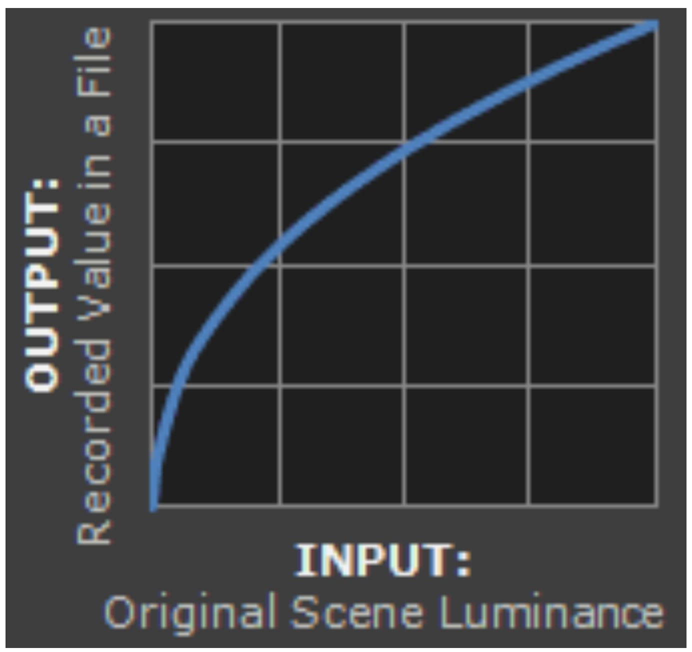


Dark areas look even darker when shown on a screen

How do we fix this?

http://www.cambridgeincolour.com/tutorials/gamma-correction.htm

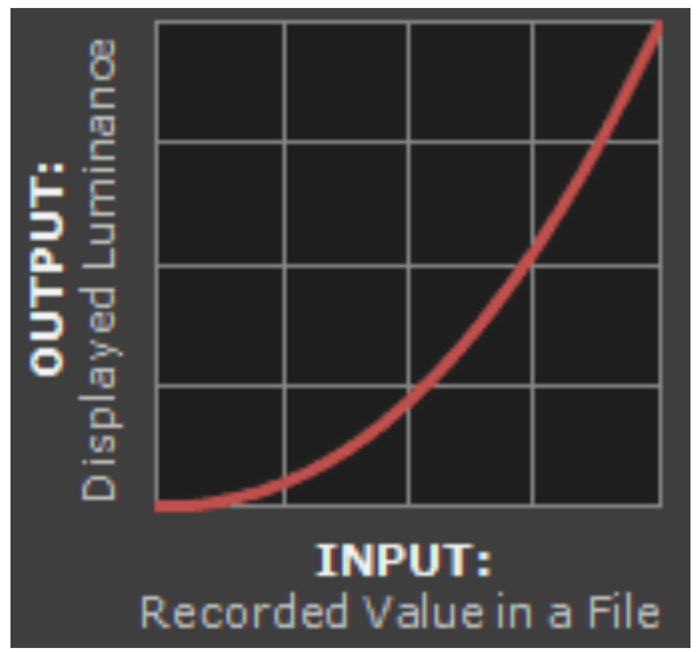
Image gamma



RAW image save as JPEG

+

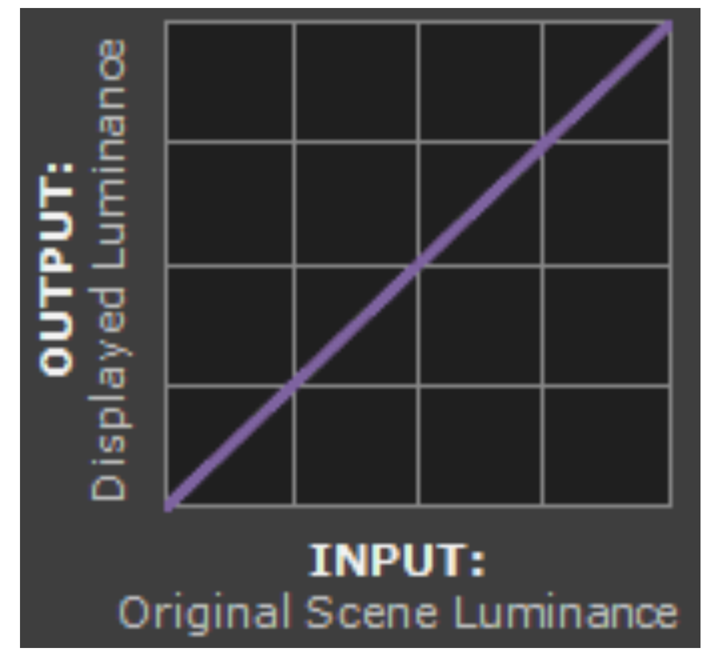
Display gamma



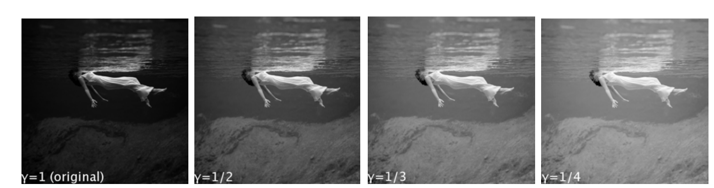
JPEG viewed on monitor

=

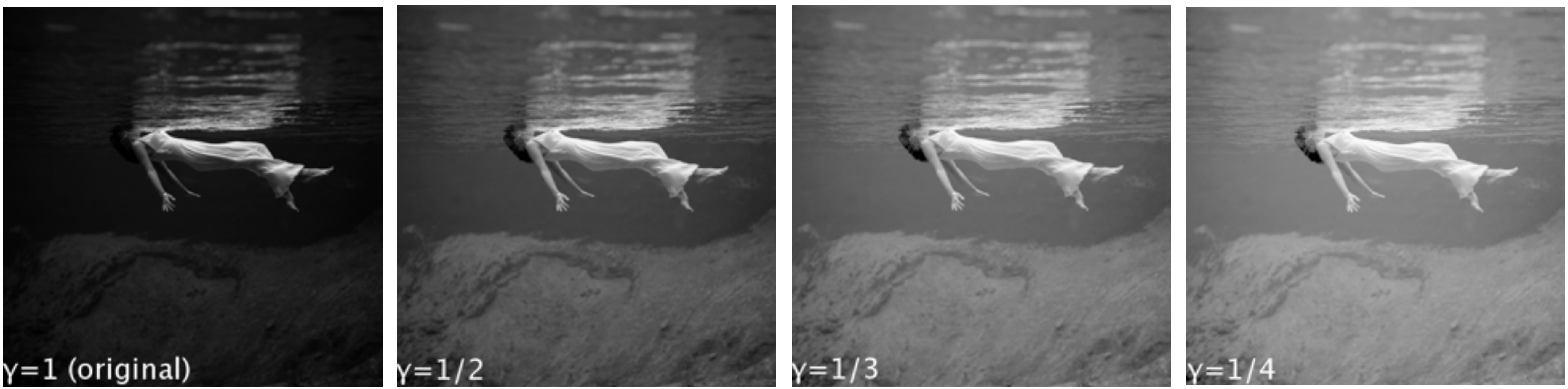
System gamma



Net effect



http://www.cambridgeincolour.com/tutorials/gamma-correction.htm



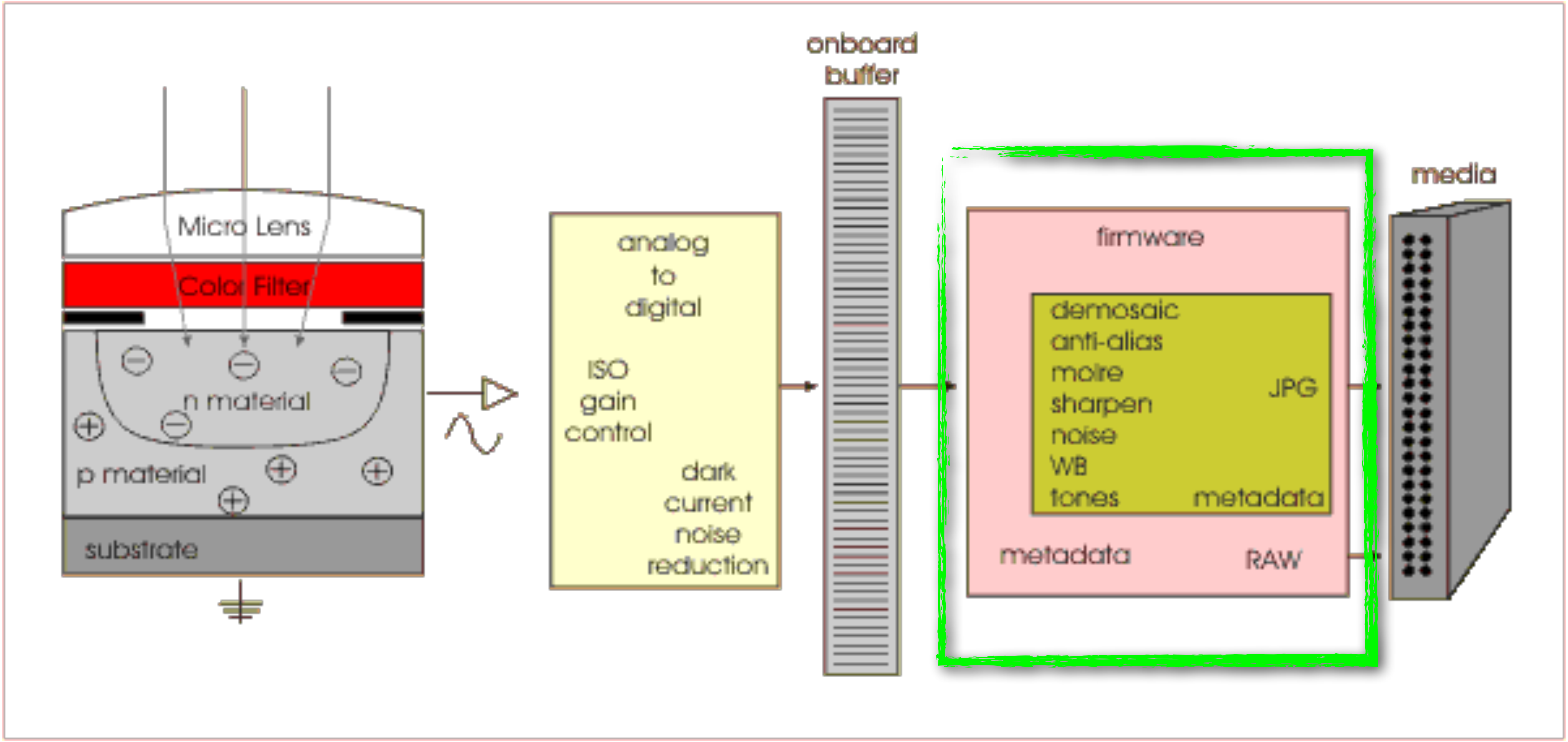
Gamma correction allows us to see an image the way see would see it

(There are many other ways for contrast correction)

http://en.wikipedia.org/wiki/Gamma_correction

Denoising & Sharpening

(Next lecture on image filtering)



http://www.rags-int-inc.com/PhotoTechStuff/Pipeline/