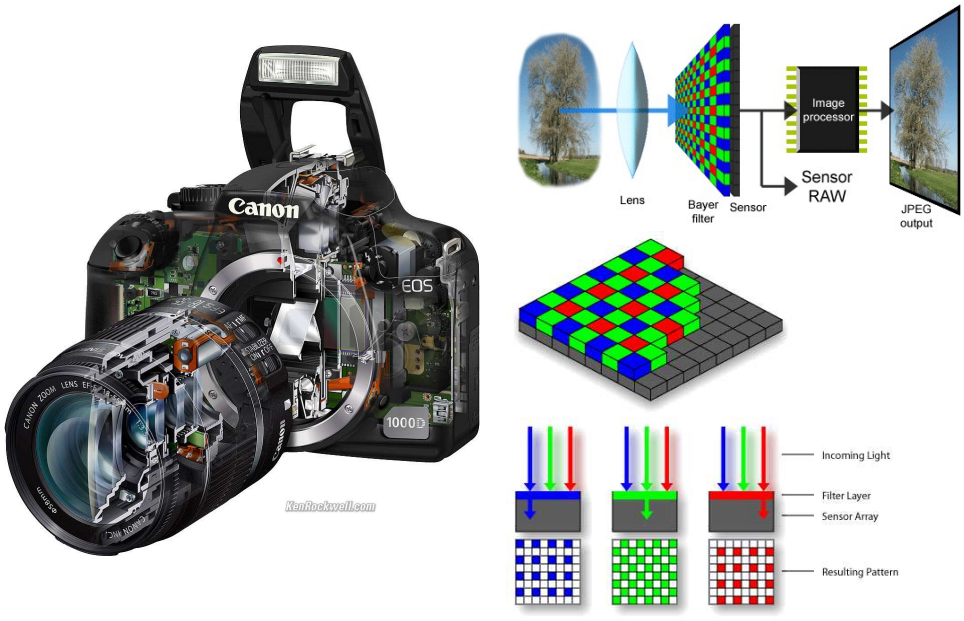
Part 6: Dynamic Range, Raw Image Format, High Dynamic Range (HDR) Photography

Steven Beard

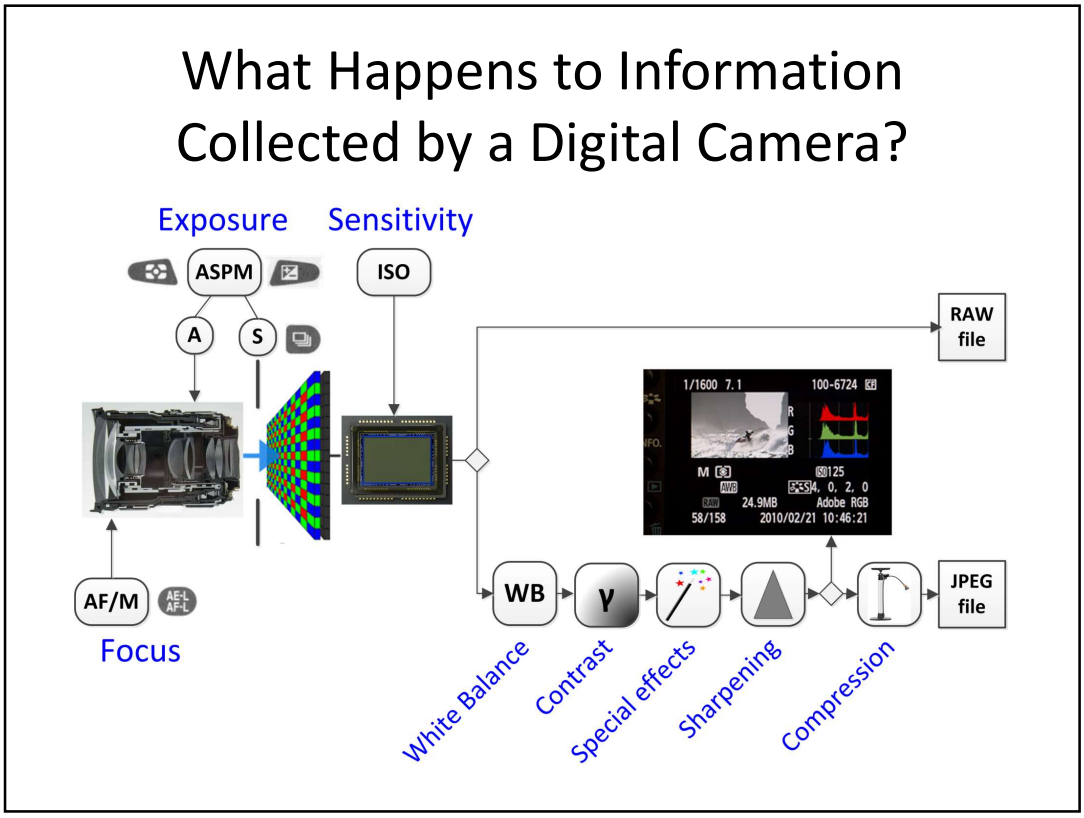
Musselburgh Camera Club

How Does a Digital Camera Work?



A digital camera contains a detector consisting of an array of light sensitive cells = photo-receptors (c.f. light buckets). Cells can be made sensitive to different wavelengths of light (e.g. visible or IR), but in a detector array all the cells are the same, so they react to colour in the same way. Colour information is recorded by adding a clever device know as a Bayer filter, which directs different coloured light to adjacent photo-receptors. When converted to information, each light sensitive area is known as a picture element, or pixel for short. The information for different colours is separated into channels.

You can image the camera's detector as an array of little buckets which collect rain as it falls from the sky. The camera electronics is like an army of people with rulers measuring the depth of the water in the buckets. Some of the water might splash and spill, creating noise. If a bucket overflows it can no longer collect information – your highlights are blown. Better cameras (such as digital SLRs) have larger buckets and are less affected by spills, which means less noise. Raising the ISO setting on a camera is like squeezing the buckets. They become narrower and easier to fill with water, but they become more sensitive to spills and therefore more noisy.

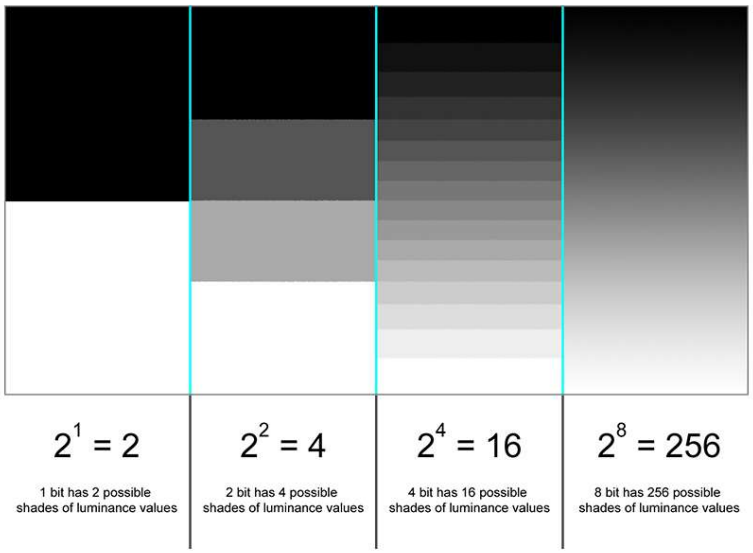


This is the flow of information through a camera. Some settings (the ones on the left) are vital because they cannot be changed once the image is captured. Some camera settings (from white balance onwards) are not as vital because they can be changed later (if you save in RAW). If you intend to process images with Photoshop, always save in RAW. Saving images to JPEG is an option if you don't use Photoshop or if high speed capture is important (sacrificing some image quality). JPEG compression can introduce ugly artefacts, so keep compression to a minimum. TIFF format is better than JPEG but not as good as RAW. Be aware that the histogram you see on the back of a camera is based on the converted JPEG, not the RAW image.

The Meaning of Bit Depth

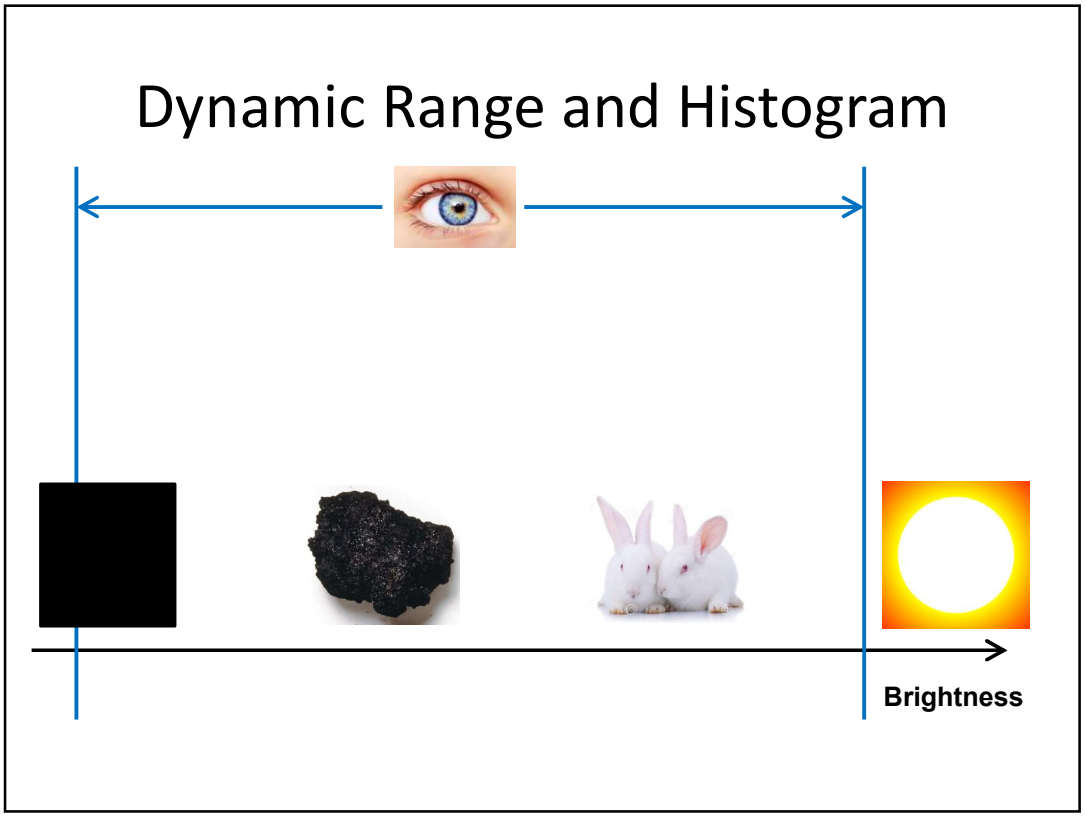
4 bits, 16 levels

0001 = 1
0010 = 2
0011 = 3
0100 = 4
0101 = 5
0110 = 6
0111 = 7
1000 = 8
1001 = 9
1010 = 10
1011 = 11
1100 = 12
1101 = 13
1110 = 14
1111 = 15

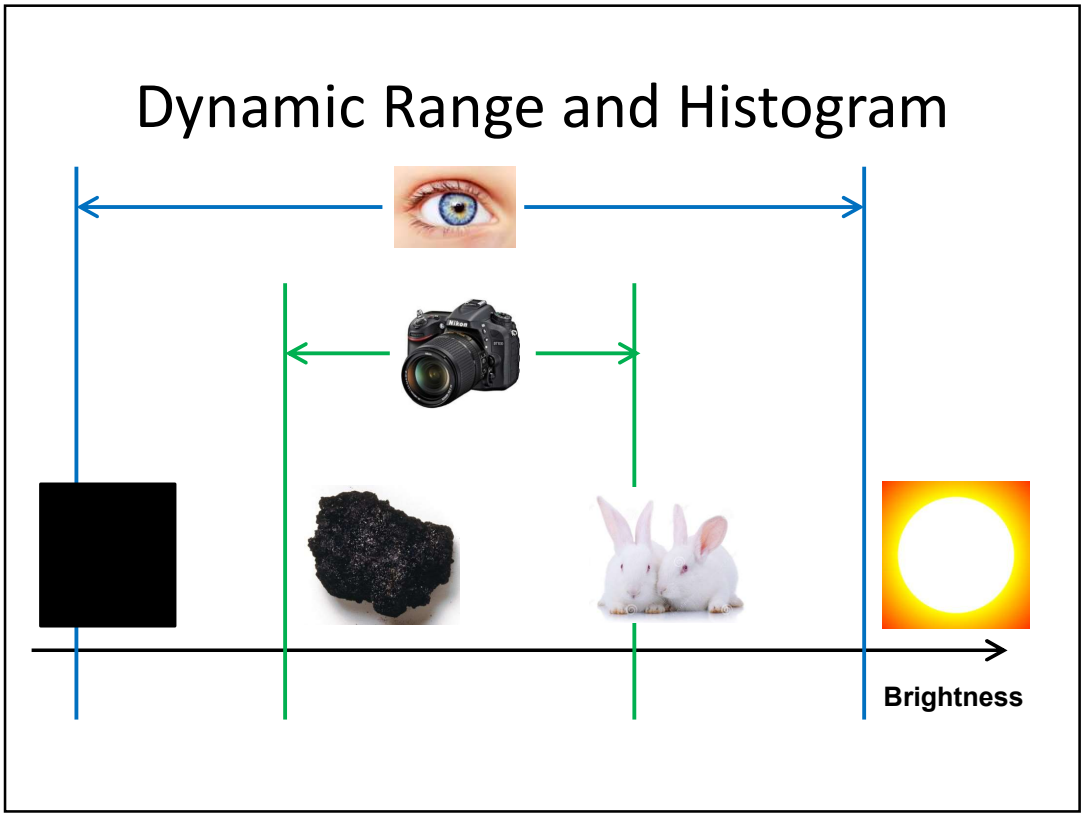


The camera electronics stores digital information as a collection of numbers. The range of light levels that can be stored depends on the number of bits allocated to each light level in the camera's memory. The more bits, the greater the range of levels. Here are some examples showing how the number of bits relates to the number of brightness levels. Binary numbers are base 2, which means they are presented only by 1s and 0s (compared with the 10 digits we use normally). Having more bits allows more numbers to be represented.

JPEG files are normally 8-bit, which allows light intensity to be described as 256 different levels. Some data formats, such as RAW and Photoshop store information as 16-bit numbers, which distinguishes 65536 different levels.



The human eye has a very large dynamic range, and can see a wider range of shadows and highlights than a digital sensor. A camera's sensor picks up a subset of that dynamic range. The exact subset can be controlled by varying the exposure. This is why photographs of high contrast scenes can turn out disappointing – your eye can detect the whole scene, but your camera can't.



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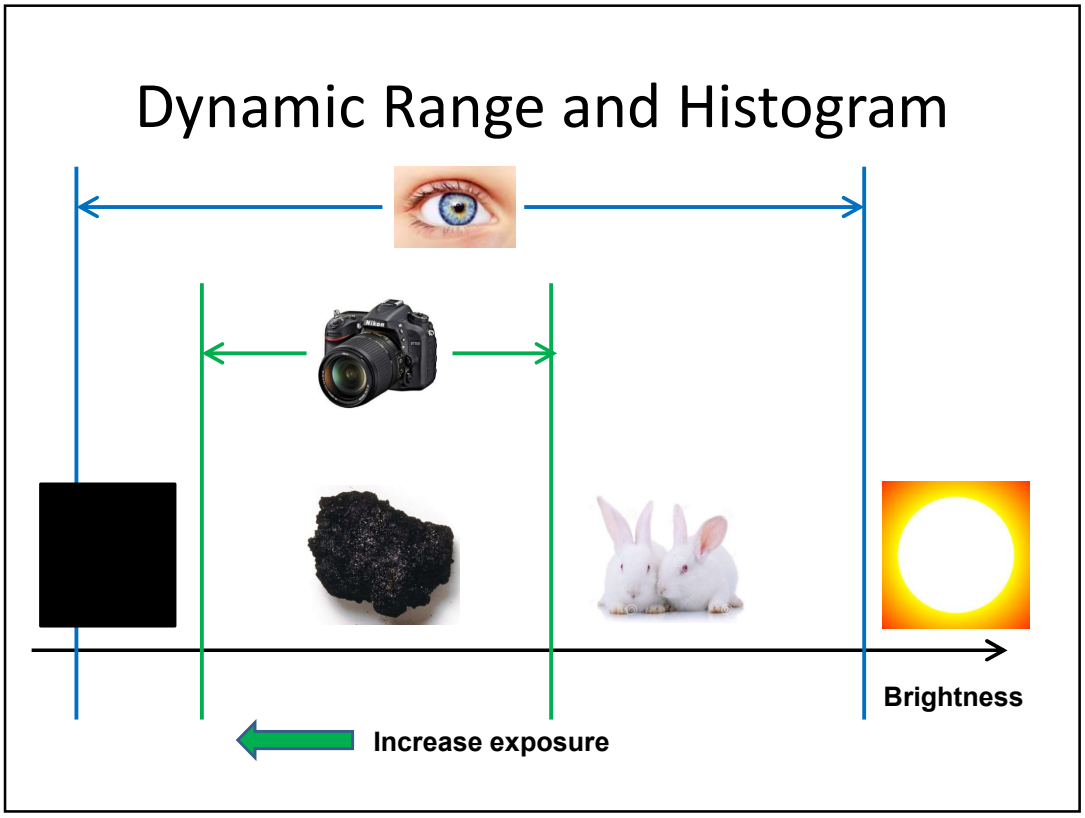
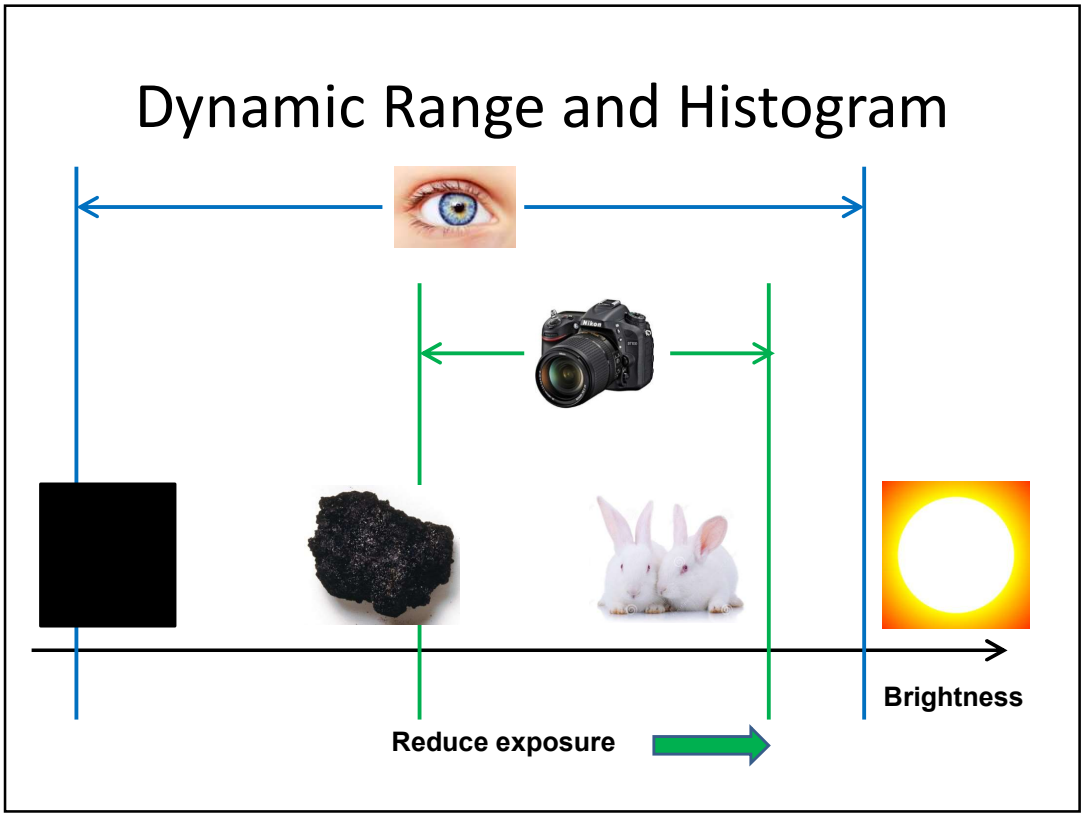


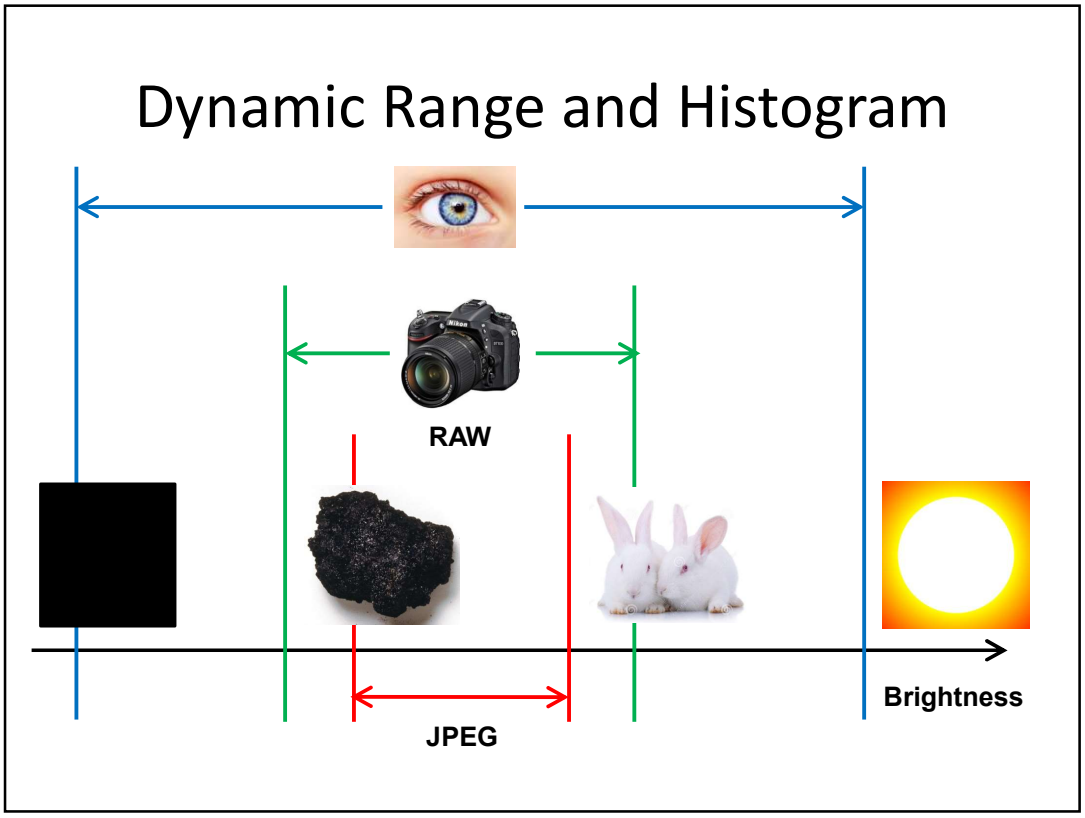
Increasing the exposure allows the camera to detect the darker parts of a scene, at the expense of the lighter parts.

A graduated filter helps the camera when one half of an image (sky) is much brighter than the other half (ground).

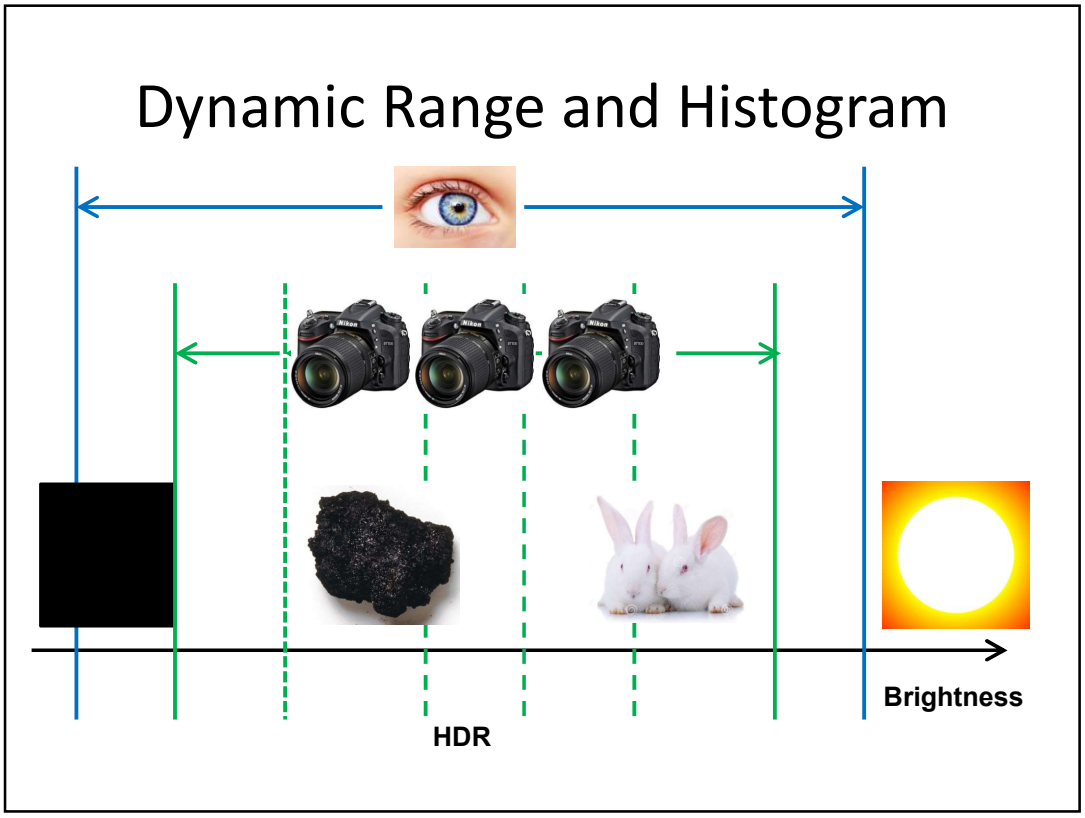


Reducing the exposure allows the camera to detect the lighter parts of a scene, at the expense of the darker parts.

A graduated filter helps the camera when one half of an image (sky) is much brighter than the other half (ground).



It is also important to realise that the dynamic range contained within a JPEG image may be less that the original range captured by the camera's sensor. Save in RAW to keep as much information as you can.



ASIDE: In High Dynamic Range (HDR) photography, the dynamic range can increased by combining more than one exposure at different settings.

Sometimes it is possible to improve a scene by combining just two images together: one exposed for the bright sky and another exposed for the shadows.