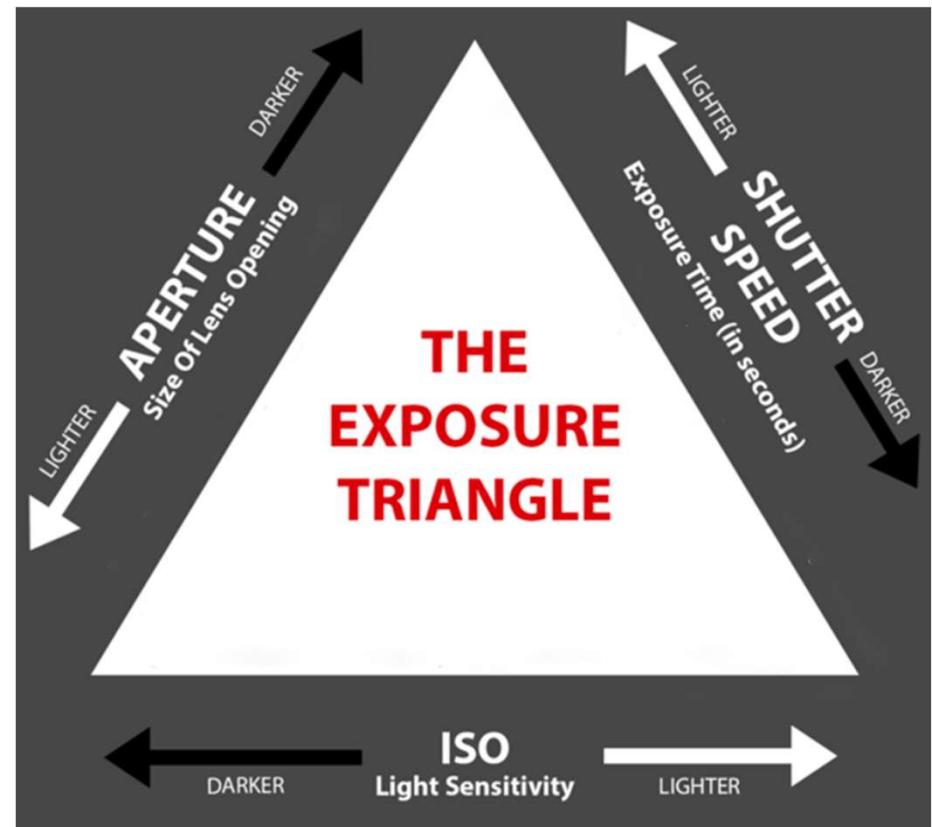




EXPOSURE

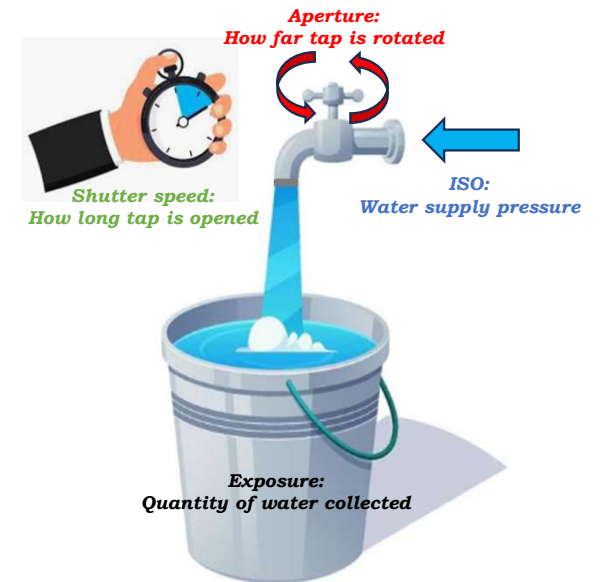
# What is the Exposure triangle?

- The exposure triangle refers to the three key camera settings that work together to determine image exposure
  1. *Shutter speed*
  2. *Aperture*
  3. *ISO*
- By adjusting one or more of these settings the exposure can be increased or decreased producing a lighter or darker image.



# Analogy to filling a bucket of water from a tap

- If we consider collecting light with our camera sensor as analogous to collecting water from a tap in a bucket:
  - Aperture is analogous to how far we open the tap valve – as we open wider more water flows into the bucket
  - Shutter speed is analogous to how long we open the tap for – the longer we open the tap the more water we collect in the bucket
  - ISO is analogous to the water supply pressure – increasing the pressure increases the flow rate



# Capturing the desired quantity of light on the camera sensor

Shutter speed refers to how long the sensor is exposed when the shutter button is pressed

- The longer the shutter remains open the more light is captured by the sensor resulting in a brighter image

Aperture refers to the size of the hole, or diaphragm, in the lens

- The wider the aperture, the more light hits the camera sensor, and the brighter the resulting image



ISO refers to the sensitivity of a digital camera's sensor to light (or the sensitivity of film in a film camera)

- The term ISO doesn't describe its function; it just refers to an acronym for the International Standardization Organization who originally set the ISO sensitivity numbering scale
- The higher the ISO sensitivity the brighter the resulting image

Shutter speed and aperture control how much light is collected by the sensor

The ISO setting determines how much amplification is applied to the electronic light information collected by the sensor (similar to the volume control on a radio, but amplifying light instead of sound)



- Before looking more closely at how these three variables interact with each other in the exposure triangle, it is also useful to define what is meant by a [stop of light](#) in photography
- A stop refers to doubling or halving of the amount of light that makes up an exposure. Each photo that we take requires a certain quantity of light to expose it correctly
  - Adding one stop of light doubles the exposure, brightening an underexposed image
  - Conversely, reducing an exposure by one stop (halving the amount of light) darkens an overexposed image

# Stop values for Shutter speed, Aperture and ISO

- **The numbering system for shutter speed** is seconds and fractions of a second

So for example starting with a 4 second exposure and decreasing one stop (half the exposure) at a time the shutter speeds would be:

4 sec, 2 sec, 1 sec,  $\frac{1}{2}$  sec,  $\frac{1}{4}$  sec,  $\frac{1}{8}$  sec,  $\frac{1}{15}$  sec,  $\frac{1}{30}$  sec,  $\frac{1}{60}$  sec etc.

- **The numbering system for aperture** is the f-stop which is a little less intuitive\*, but reasonably easy to work with by just remembering that the lower the number the wider the aperture (and the brighter the image)

Starting with a large aperture of f/1.4 and decreasing one stop (half the exposure) at a time the aperture values would be:

f/1.4, f/2, f/2.8, f/4, f/5.6, f/8, f/11, f/16, f/22 etc.

\* An f-stop is defined as the ratio of the focal length of a lens to its aperture diameter.

For example a 100mm lens with a 25mm diameter aperture equates to f/4

Halving the aperture implies halving the area of the aperture circle, equating to a factor of 1.414 between each f-stop:

e.g.  $f/2.8 \times 1.414 = f/4$ ,  $f/4 \times 1.414 = f/5.6$ ,  $f/5.6 \times 1.414 = f/8$  etc.

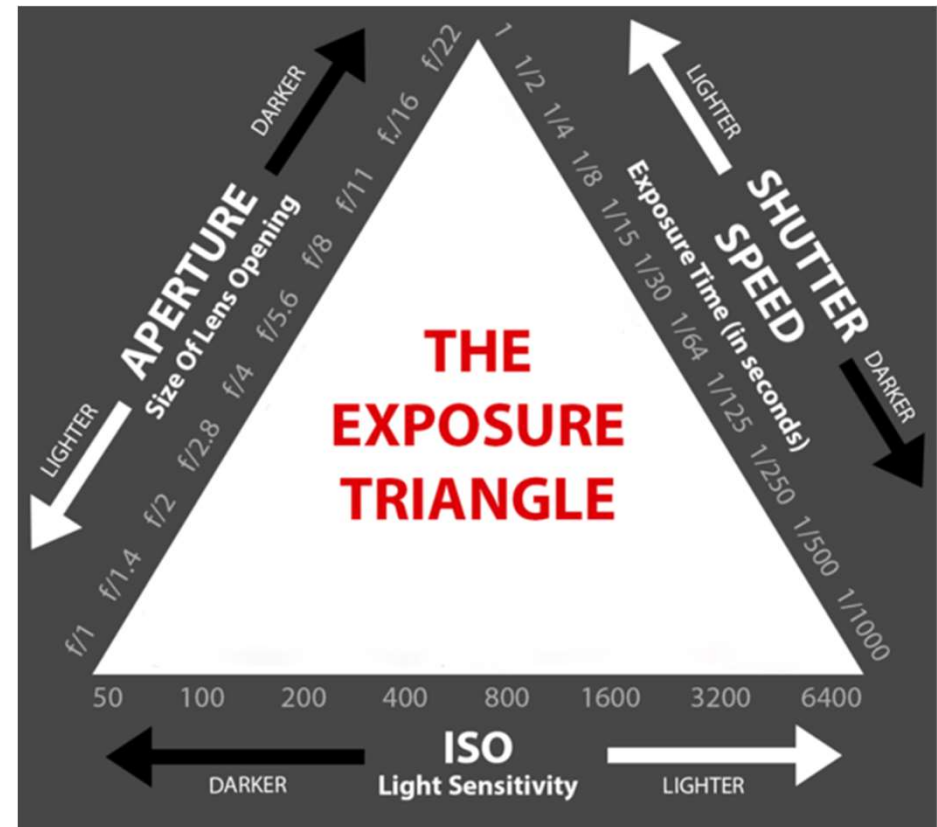
# Stop values for Shutter speed, Aperture and ISO

- **The numbering system for ISO** commonly starts with a camera 'native' ISO of 100 and doubles for each one stop (double the exposure) increase in sensitivity i.e. ISO 100, 200, 400, 800, 1600, 3200, 6400 etc.

**NOTE:** Cameras generally allow finer adjustments at  $\frac{1}{2}$  or  $\frac{1}{3}$  stop intervals so there are more intermediate values available between these listed for each of the 3 exposure variables

# What is the Exposure triangle? Part 2

- The exposure triangle refers to the three key camera settings that work together to determine image exposure
  1. *Shutter speed*
  2. *Aperture*
  3. *ISO*
- **By adjusting the values of one or more of these settings** the light captured by the camera image sensor can be increased or decreased to change the exposure producing a lighter or darker image



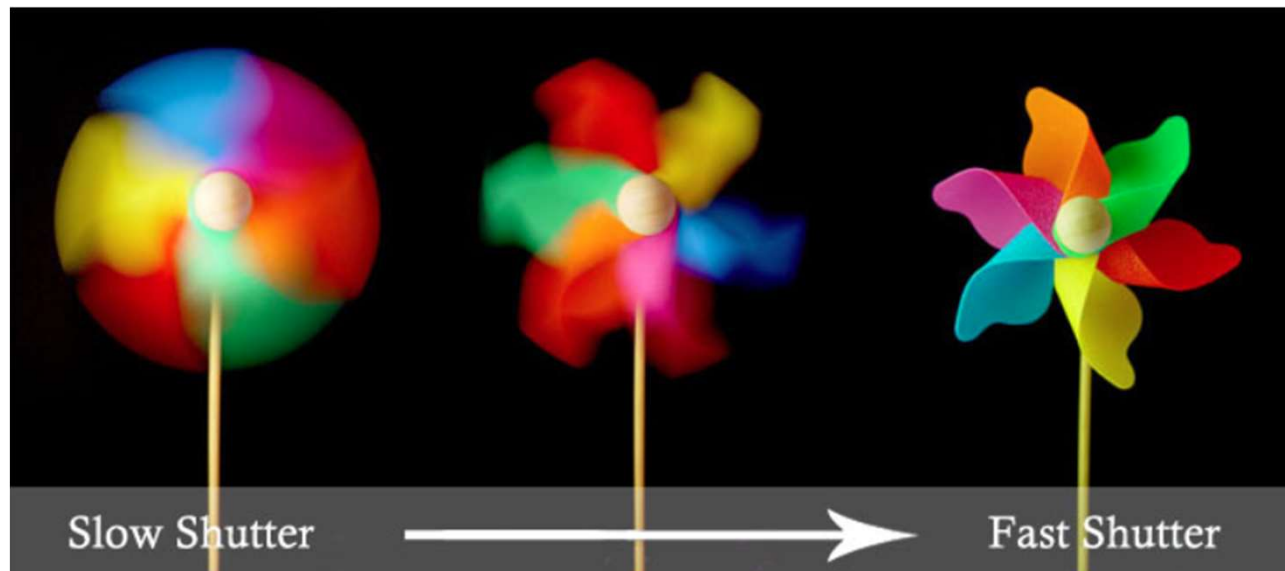


# Multiple combinations for any given exposure

- For any specific exposure (i.e. quantity of light on the sensor) there are many combinations of shutter speed, aperture and ISO (the exposure triangle) that will achieve the same exposure result:
  - For example if we reduce the shutter speed by 2 stops we could maintain the same exposure by increasing the aperture by 2 stops, or increasing the ISO by 2 stops, or increasing both aperture and shutter speed by 1 stop each
- Although these combinations all maintain the same exposure brightness, each of the 3 variables has other properties which affect how the final image looks: Creative photography relies on the skill of the photographer to consider these secondary properties and select an appropriate combination to best achieve their artistic vision

# Effects of shutter speed settings

- Shutter speed can be used creatively to freeze action (fast) or to show the effect of motion (slow), but a handheld shot at too slow a shutter speed risks unwanted blur (camera shake) ruining an image



# Effects of aperture settings

- Aperture can be used creatively to control how much of the scene in front of and behind the point of focus is acceptably sharp (the depth of field). A wide aperture results in a shallow depth of field and a narrow aperture results in front to back sharpness. Very small apertures can cause softness degradation due to diffraction effects



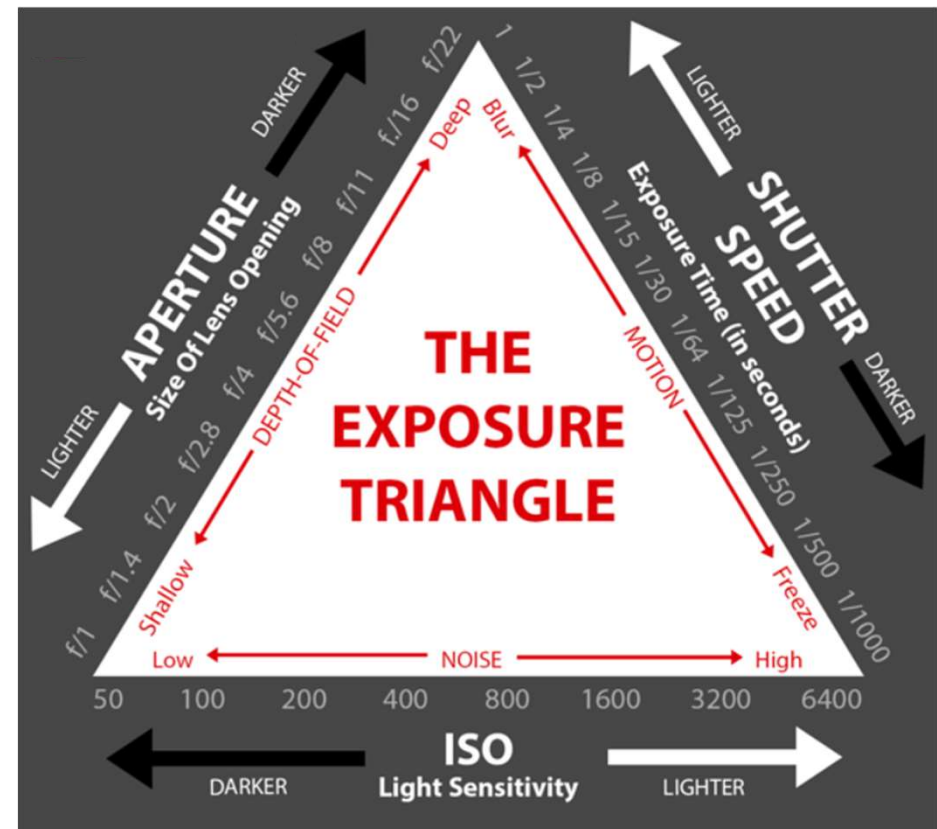
# Effects of ISO settings

- ISO is used to reduce or increase the sensor light sensitivity to allow the creative properties of various aperture and shutter speed combinations to be utilised over a broader range of lighting conditions. This helps to reduce or avoid side effects such as camera shake and diffraction, but using a higher ISO causes grain/noise degradation to the image



# What is the Exposure triangle? Part 3

- The exposure triangle refers to the three key camera settings that work together to determine image exposure
  1. Shutter speed
  2. Aperture
  3. ISO
- By adjusting the values of one or more of these settings the light captured by the camera image sensor can be increased or decreased to change the exposure producing a lighter or darker image
- **As well as controlling exposure the exposure triangle settings have other effects on the captured image (depth of field, motion blur, noise)**



# Concentrate on choosing settings to achieve your desired artistic effects - undesirable side effects can be minimised later in post if necessary

- The primary goal should be to capture a well exposed image without major flaws such as camera shake
- It is far better to have sharp shot that is a bit noisy because a high ISO has been used, than to have a blurry shot with camera shake from having to use too slow a shutter speed to keep a lower ISO value
- Settings are more important for some shots than others: If the scene is static, well lit and with no near objects to cause depth of field concerns then several combinations of shutter speed, aperture and ISO would all produce a near identical result i.e. the same exposure(quantity of light) with negligible side effect differences



- Camera sensors and post processing continue to improve. Today's digital camera sensors introduce less noise at high ISOs than their predecessors. Post processing functionality is also continually improving, such as the Topaz noise reduction software demonstrated at our last roll up session
- Even software generated blurred background/ shallow depth of field effects are now possible. These work better on some images than others but the algorithms and effectiveness will undoubtedly continue to improve in future

# No definitive right or wrong exposure

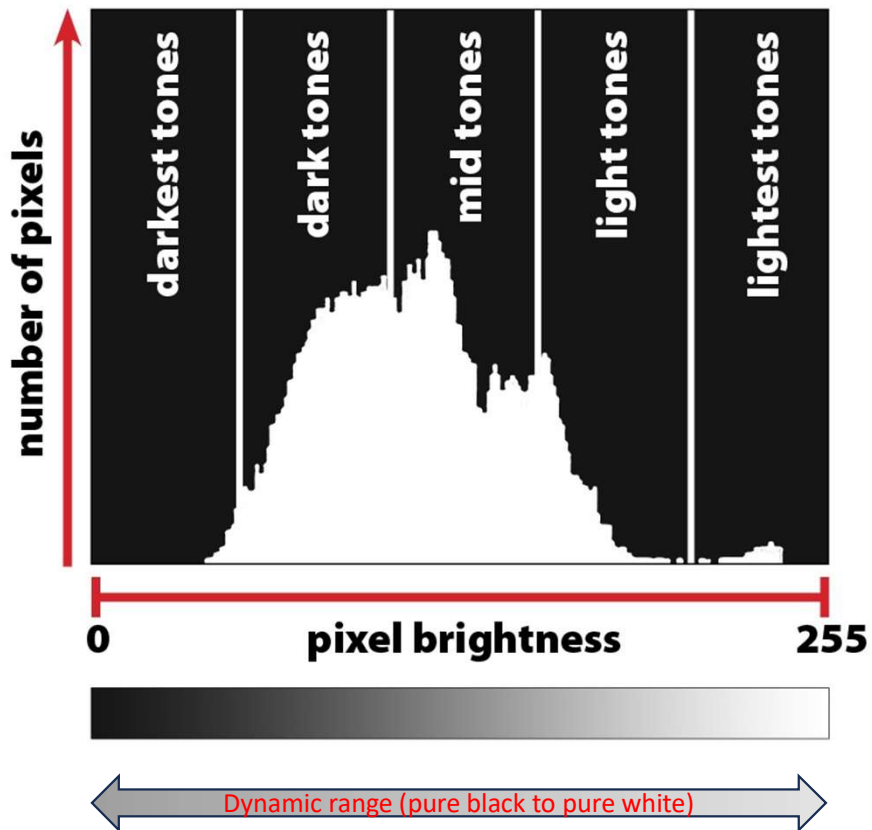
It is up to the photographer to adjust exposure values to the 'correct' settings to achieve their creative intent



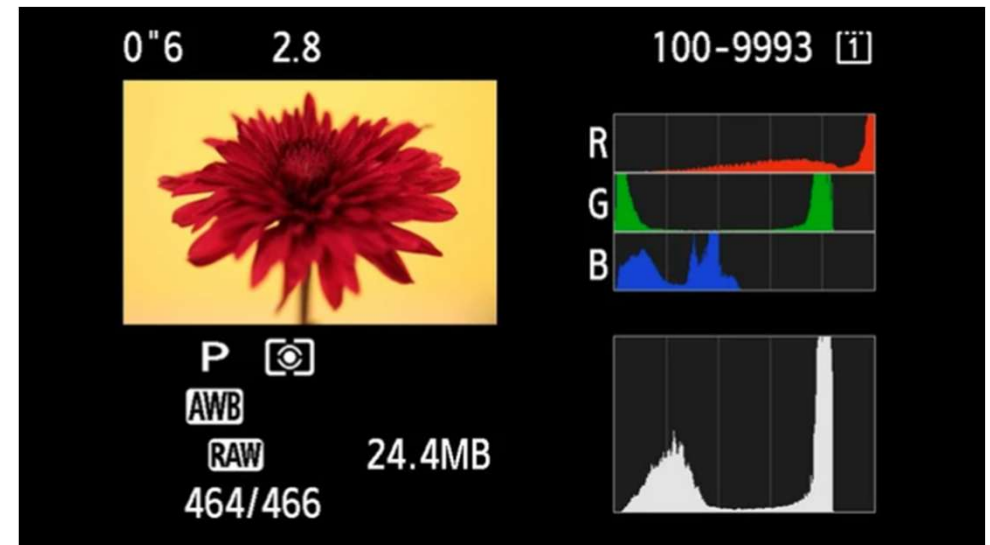
The camera exposure meter in the camera is dumb. For example, it doesn't know whether you're pointing your camera at a black cat in a coal cellar or a polar bear in the snow. It generally assumes you want your image to be an 'average' exposure brightness (mid grey) regardless of subject. It's up to you to decide whether to override the meter and adjust settings to achieve the exposure you want

# Graphical overview of exposure - Histograms

Luminosity (brightness) histogram



RGB channel & luminosity histograms

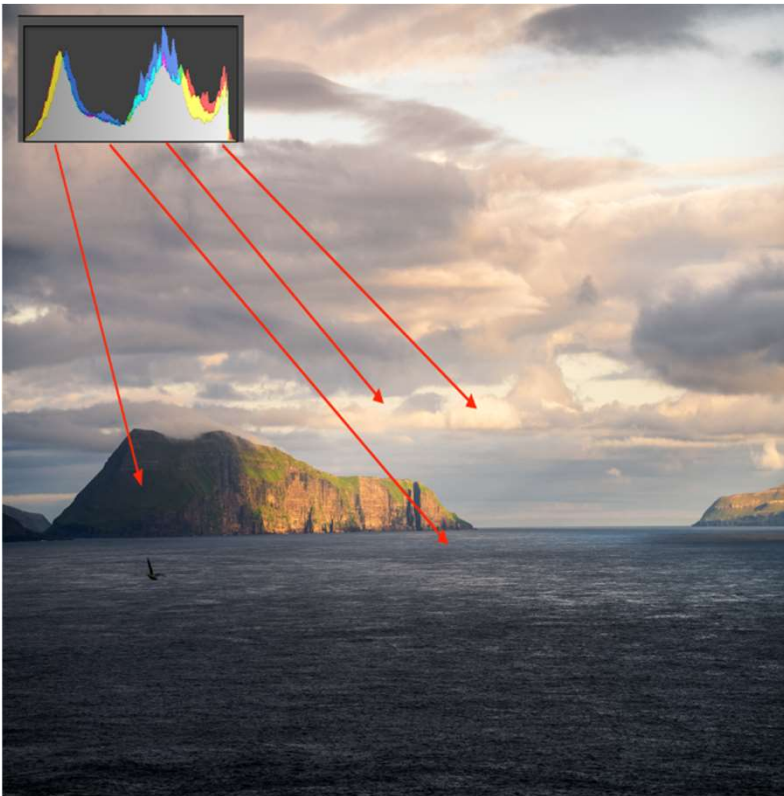


## Dynamic Range

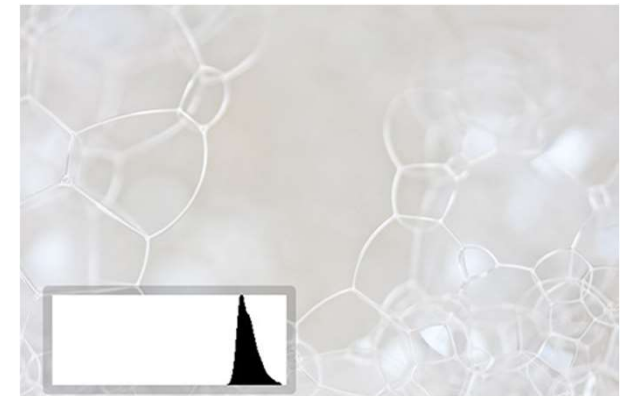
- Human eye about 21 stops
- Typical camera sensor about 15 stops



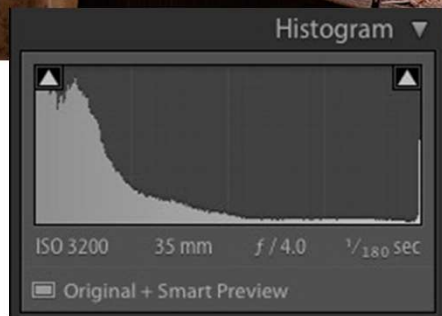
# Example histograms



In this example, where 2 or 3 RGB colours overlap histogram colour is mixed e.g. yellow, magenta or cyan



# Histograms - Clipping



- The histogram for this image shows clipping at both ends:
- Overexposed (pure white) highlights (light bulb & window) and underexposed (pure white) shadow areas
  - Ignore?
  - Change composition (point of view) to remove certain areas from the frame?
  - Graduated filter?
  - Bracket and combine multiple exposures (HDR)?
  - Flash?

# Camera exposure modes



- P (Program Auto mode)
  - Camera sets both aperture and shutter speed to achieve correct exposure\*. Different combinations achieving the same exposure (larger apertures numbers with shorter shutter speeds or vice versa) can be selected by the user
- A or Av (Aperture priority mode)
  - User selects aperture to control depth of field, and camera selects shutter speed to achieve correct exposure\*
- S or Tv (Shutter speed priority mode)
  - User selects shutter speed to freeze or blur motion, and camera selects aperture to achieve correct exposure\*
- M (Manual mode)
  - User selects both aperture and shutter speed

\* Correct exposure means the exposure determined by the camera's metering system

# Exposure compensation



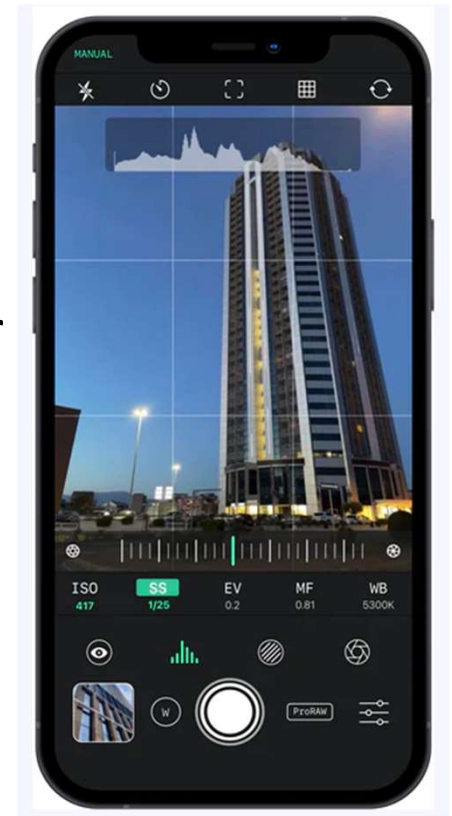
- By applying an exposure compensation setting the user can alter the exposure from the value suggested by the camera to over or under expose the image, usually in  $\frac{1}{3}$  or  $\frac{1}{2}$  stop increments

Note: The exposure suggested by the camera is also affected by the user choice of metering method e.g.

- Matrix (most natural result in most situations)
- Centre weighted (entire frame metered but higher weighting given to central region)
- Spot (small area metered usually centred on the selected focus point)

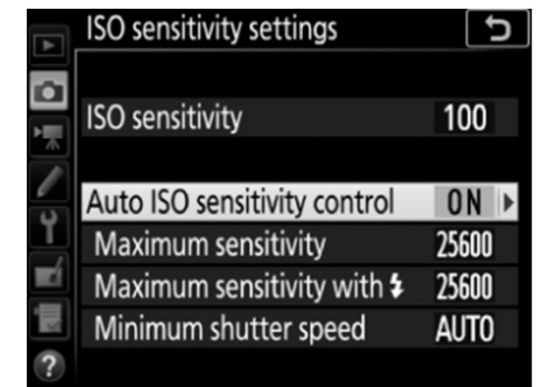
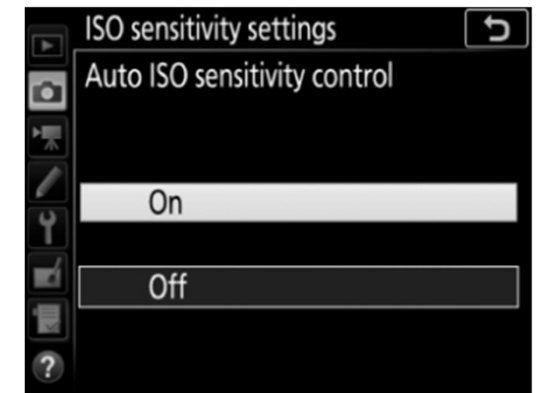
# User exposure control for mobile phone cameras

- The aperture is fixed in most mobile phone cameras
- The phone camera achieves correct exposure by automatically adjusting shutter speed and ISO
- Several software apps are available which allow the user to manually select shutter speed, ISO, exposure compensation etc. They also provide manual control of white balance, RAW or JPEG file format, focus peaking display aid etc.
- Example apps include Reeflex, ProCam8, Pro Camera



# Auto ISO sensitivity

- Some cameras provide an Auto ISO option which supplements the other PASM exposure mode options to automatically increase ISO to achieve optimal exposure, if this cannot be achieved at the selected shutter speed and aperture values.
- For example in Aperture priority mode the user can also enable Auto ISO to allow the camera to automatically increase ISO to achieve the correct exposure, without setting an unacceptably low shutter speed which would cause camera shake. The user can set a low shutter speed limit to be applied, and also a maximum ISO limit to prevent very noisy high settings.



# ISO invariance

- ISO invariance refers to the ability of some higher end cameras to produce the same image quality by staying at a low ISO and dramatically underexposing in camera then brightening it up in post processing (Photoshop, Lightroom, Affinity), compared to if a higher ISO was used to achieve the correct exposure in camera
- e.g. For an application such as astrophotography the use of very high ISOs such as 25000 can produce very grainy photos. Using a lower value to underexpose in camera, then increasing exposure in post processing might provide a better overall result

# Final thoughts

- Using the full auto or specific scene mode settings etc. can achieve some very well exposed pictures, but mastering exposure will help you take control, instead of just relying on the 'best guess' decisions made by your camera
- Although mastering exposure is beneficial, learning to find and compose interesting images is arguably an even more important skill: An incorrectly exposed image can likely be improved in post processing and be quite successful if it is well composed, but a badly composed image is rarely successful even if perfectly exposed