

# Insight into Digital Image Resolution and Quality

There appears to be a lot of confusion on how best to save and work with digital images while still maintaining optimum quality. This document is an attempt to clarify the situation.

Let's begin by saying that Resolution and Quality are not the same thing, but combined with Aspect Ratio and File Format they determine the end result.

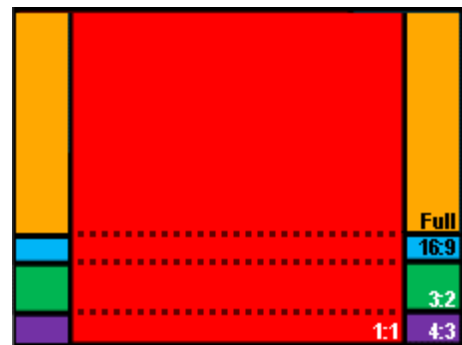
To ensure that we are all talking about the same things:

- Define Aspect Ratios
- Define Resolution
- Define Quality
- Define File Formats
- Discuss how these can be changed, intentionally or otherwise, and their effect on your images.

## 1. Image Aspect Ratio

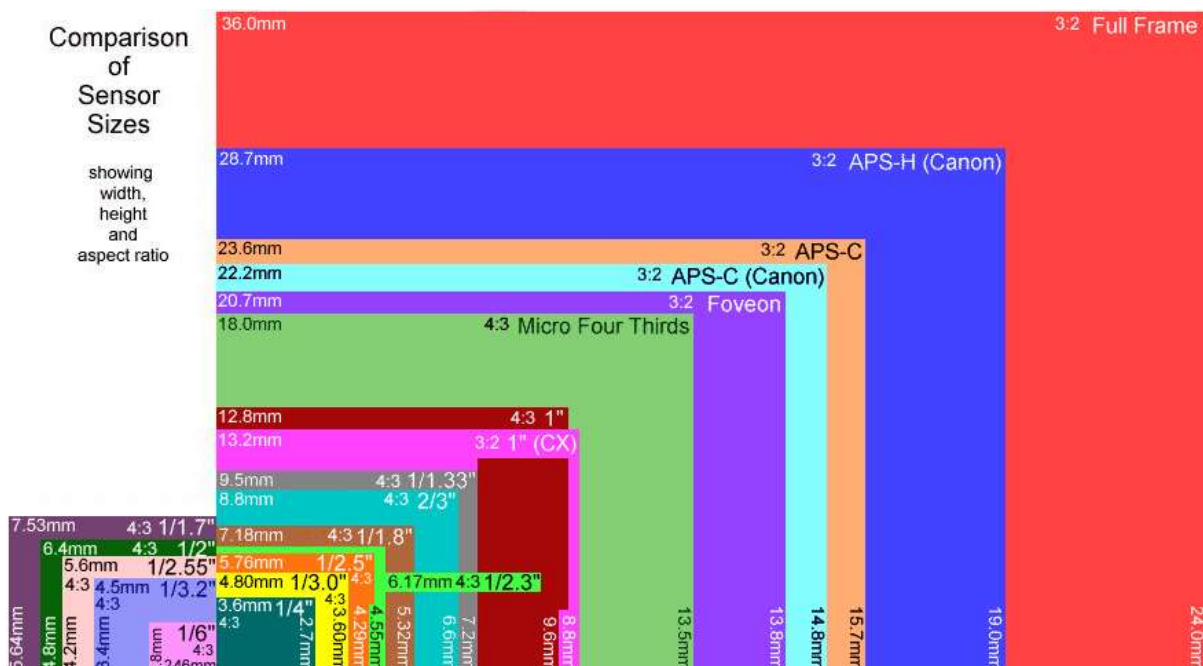
Most cameras and smartphones let you set the aspect ratio.

- **1:1** Square aspect ratio.
- **3:2** This is the same aspect ratio as 35mm film - is used for 5 x 7 inch or postcard size prints.
- **4:3** Native aspect ratio of the camera screen - is used for display on standard definition televisions or similar display devices and 3.5 x 5 inch or A-series prints.
- **16:9** - Used for display on widescreen HDTVs or similar display devices.
- **Full** - Used for full widescreen applications.



## 2. Camera Sensor Aspect Ratio

While you can set the aspect ratio, it is important to remember that the camera's image sensor also has an aspect ratio. Most of the larger image sensors have an aspect ratio of 3:2. All of the smaller image sensors are 4:3, although the 1" labelled variations have both ratios.

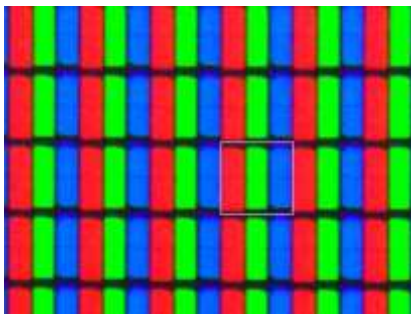
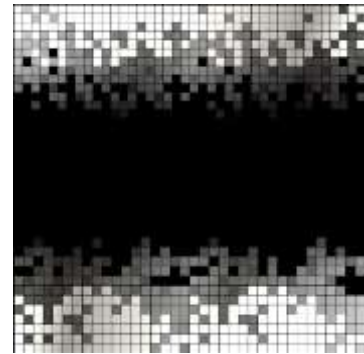


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## 3. Maximum Resolution

When you are told that a device has a maximum resolution, what does it really mean?

The maximum resolution is determined by the image sensor in your camera, phone or tablet. It is measured in pixels, and in its simplest form, a pixel is essentially an electronic dot that can have up to 256 levels of brightness. Because there can be a lot of them, resolution is normally expressed in Megapixels - i.e. the total number of pixels divided by 1,048,576 (1024 x 1024). So if your camera has around 20,971,520 pixels it will be designated as 20 Megapixels or 20 MP.



Colour images use 3 rectangular dots - 1 for each primary colour: Red, Green and Blue (RGB).

This means that it has lower definition due to the 9 times larger pixels, where each triad (group of 3) is a square. Each of the 3 primary colours has 256 levels of brightness, so 3 x 8 bits gives 24 bit colour delivering 16,777,216 colours.

Exactly how pixels are derived from triads depends on the type of image sensor in your camera and a lot of complex technical characteristics briefly mentioned later in this document. That is because the reality is much different from most people's expectations, and each camera manufacturer has multiple ways of trying to provide better images with new techniques being introduced on a regular basis.

## 4. Image Resolution

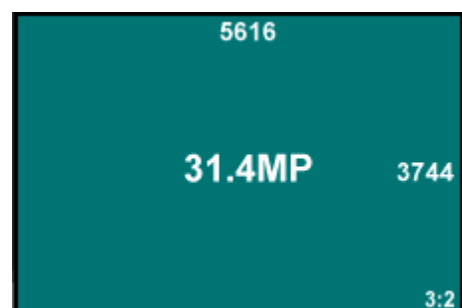
Most cameras and smartphones let you set the aspect ratio and the corresponding image resolution.

Resolution refers to the number of pixels defined horizontally and vertically. Here are some commonly found examples:

Smaller image sensors have a physical aspect ratio of 4:3, so if the image sensor has 20 Megapixels, we know that this will equate to approximately 5200 x 3900 pixels. If you change the aspect ratio to 1:1 (Square) the resolution will be 3900 x 3900 pixels, or if you change it to 16:9 (HD) the resolution will be 5200 x 2925 pixels.



Larger sensors may have a physical aspect ratio of 3:2, so if the image sensor has 31.4 Megapixels, we know that this will equate to approximately 5616 x 3744 pixels. If you change the aspect ratio to 1:1 (Square) the resolution will be 3744 x 3744 pixels, or if you change it to 16:9 (HD) the resolution will be 5616 x 3159 pixels.



Note that this simply defines the resolution of the image sensor and does not relate to its physical size.

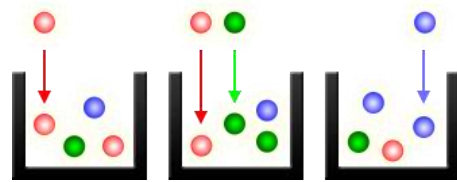
## 5. Resolving the Image

If the digital image measures 1920 x 1080 pixels, the resolution would be 2,073,600 or 2MB. That is the resolution of most computer screens and TV sets, and often referred to as High Definition (HD). A 4K or 2160p Ultra High Definition (UHD) screen on the other hand, displays 3840 x 2160 pixels, and it doesn't matter whether it is 36" or 98" in size, it still has the same number of effective pixels. You have to go to costly 8K or 16K screens to get more pixels. So if your image has more pixels than the device you display it on, onboard software will reduce the effective resolution to suit the device. This logic also applies to computer screens and applications that use images.

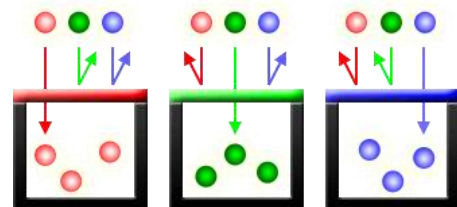
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## 6. Image Quality

Let's change focus to Image Quality, and discuss how images are resolved by the camera. For now, let's just say that pixels in a digital camera are derived from light sensitive cells called "photosites" that collect and store photons as an electrical signal on the image sensor. It is important to understand that photosites are colour-blind so cannot sense colour, and have to be filtered to ensure they only get to see light of a certain colour.

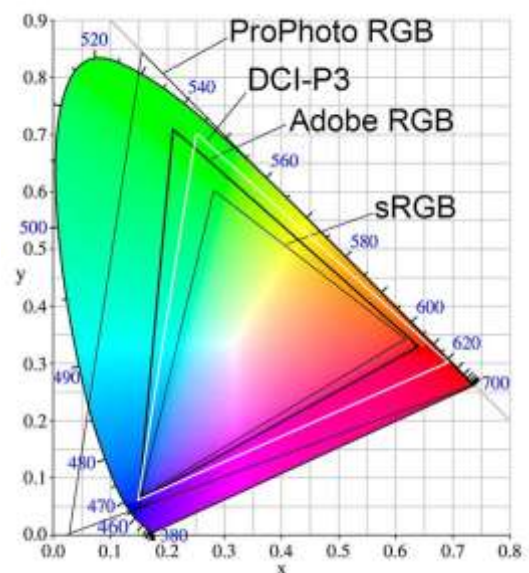


That is where it really gets complicated, so let's just say that they use a simple set of Red, Green and Blue (RGB) filters. There are many different types of filters and methods, and to discuss them all is outside of the scope here, but at least 3 photosites are needed per pixel - often many more.



When we think of pixels, we often think about them as dots hence we only associate them with a single bit of data, but we can see from this discussion that it is not the case.

You will often find references to the CIE 1931 Colour Space Map. This map, developed in 1931 by Commission Internationale de l'Éclairage (International Commission on Illumination) shows the defined quantitative links between distributions of wavelengths in the electromagnetic visible spectrum, i.e. the colour spectrum visible to the human eye.

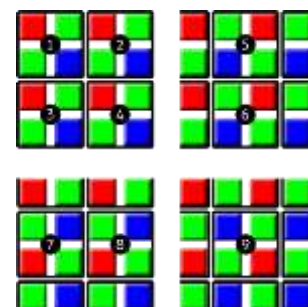


It is basically a graph where the x axis is chromaticity, the y axis is luminance, and the numbers show the wavelength in nanometres. The colours shown are indicative only because it is not possible to show all of the colours correctly using computer technology.

- sRGB is what most cameras can see and what computers can display.
- Adobe RGB 1998 may be available on higher-end cameras (35% more).
- DCI-P3 is a cinematic variant that is used on some of the latest iPhones and iPads.
- ProPhoto RGB is available on some of the professional cameras.

All of these standards are limited to 16,777,216 colours, but there are others with more colours. Where the image is converted from one space map to another may result in colour changes.

What you actually get is a mash-up of pixels from various photosites as determined by the logic inside your camera. This varies considerably between brands and even models within a brand, as new aggregation techniques are developed.



The Bayer 9-way filter demosaicing shown here is just one method – note that it uses more green photosites to compensate for the green weakness of the sRGB model, as shown in the previous diagram.

Quality is the range and accuracy of colour in your image. The aspect ratio, resolution and quality of the image will be whatever you have set it to in your camera and the colour method used.

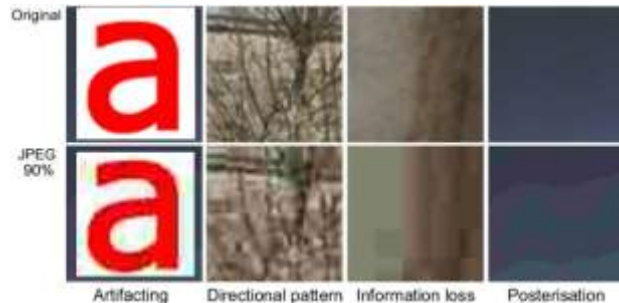
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## 7. File Format

Unless you are using a camera offering RAW or HEIC format, the resulting image will most likely be saved as a JPEG (.JPG) file, and this ultimately determines the quality of the image.

JPEG is a “lossy” format, because the information is compressed, and during that process some information is lost. How much is lost depends on the compression ratio used. The higher the compression ratio, the more information is lost, resulting in a lower quality image.

The image degradation causes strange effects that result from the JPEG compression algorithms. This is most noticeable in graphic images where artifacting will appear around characters, directional patterns will become distorted, solid blocks of colour will become blotchy and colour gradients may become posterised.



Each camera brand uses its own method to denote the various settings for both resolution and quality, so it is important to understand the settings on your particular camera.

Smartphone cameras generally have fewer options and each camera/lens combination may have different options, with different settings.

Scanning or photographing a document to JPEG can also have its issues, and is best done with minimum compression.

## 8. Clarifying what we know

Armed with this knowledge, let's clarify what we now know.

- The JPEG image format is a major limitation.
- Avoid multiple saving of JPEGs unless you compensate by using a lower compression ratio.
- The lower the compression ratio, the larger the saved file will be, but the resolution does not change – only the quality.
- Once you lose resolution or quality you cannot retrieve them back, although there are apps available that claim to do so using advanced interpolation techniques and artificial intelligence. One example of this is Google's new “Fly INTO Photos”, an AI designed to create 3D images from 2D images and effectively “fly” through the original image, which can in some ways be thought of as a development of Google Street View images offering 360° views, but it can also create image details even where there doesn't appear to be any.

## 9. Questions Arising

**Q1.** *When you use the telephoto setting on a zoom lens, does this affect the quality of the image?*

**A1.** It may do, but not that you would notice – in most instances it is the result of depth of field changes and lighting.

**Q2.** *When you use pinch to zoom on a smartphone, does this affect the quality of the image?*

**A2.** Yes – the resolution will not change but the quality will reduce because the image will be interpolated to fit the resolution.

**Q3.** *When you copy a digital image on your device, does this affect the quality of the image?*

**A3.** No – the content of the copied file will be unaltered.

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**Q4.** *When you copy a digital image to a USB Flash Drive, does this affect the quality of the image?*

**A4.** No – the content of the copied file will be unaltered.

**Q5.** *When you send a digital image as an attachment by email, does this affect the quality of the image?*

**A5.** No – the content of the attached file will be unaltered.

**Q6.** *Sometimes, it is convenient to group several digital images into a “zipped” folder for sending as an attachment by email, so does this affect the quality of the images?*

**A6.** No – the content of the zipped files should be unaltered, and in most instances compression of JPEG images within the zipped folder will be minimal, so no size saving. Most email providers have a limit on the size of attachments, so creating a zipped folder containing original JPEG images has no benefit – you typically have to send multiple emails.

**Q7.** *When you transfer a digital image to your computer and view it there, does this affect the quality of the image?*

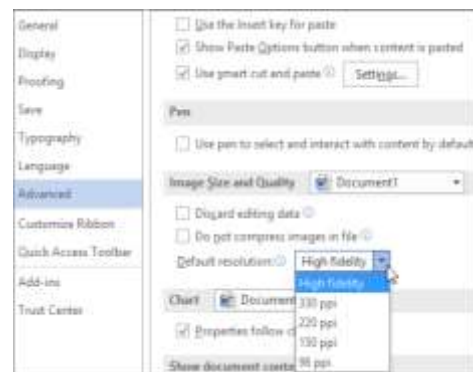
**A7.** The content of the transferred file will be not be altered simply by viewing it, but typically what you see is not the quality of the image taken by the camera. In most instances, your camera will have a higher resolution than your computer screen, so to view the full image on your computer the image quality must be reduced for display.

**Q8.** *When you insert a digital image into a MS Word document, does this affect the quality of the image?*

**A8.** The default image resolution in MS Office is 200 pixels per inch (ppi). This means that the size of the picture in Word may be compressed and quality lost, even if you specify 100%. However, you can change the default picture resolution or turn off picture compression completely, although if you resize it to less than 100%, compression will obviously occur.

If changing the default is something you want to do, from within MS Word, or any other MS Office program, click **File > Options > Advanced**. Under **Image Size and Quality**, select **High Fidelity** in the **Default resolution** list to turn compression OFF or one of the other values to suit your requirements.

On the other hand if you are using MS Word on macOS, click the app-name menu for **Word > Preferences**, then under **Authoring and Proofing Tools**, select **Edit**. Under **Image Size and Quality** in the **Default resolution** list select **High Fidelity**.



Older versions of MS Word may use a “**Do not compress images in file**” checkbox instead. It may also be worth noting that using High Fidelity or the checkbox will typically result in larger file sizes for the saved Word document.

**Q9.** *When you edit a digital image using Apple Photos or another image editing app, does this affect the quality of the image?*

**A9.** Apple Photos initially displays images using “Fit to window” logic, and at the top of the screen you will see the “Zoom” size that has been used. You can manipulate the zoom value - or +. If you edit the image, obviously you must save it, but you may want to add an extra step in doing so. Also be aware of the “Revert to Original” option in Edit mode. With the Photos app for Apple macOS, if you select ‘Photo kind’ as JPEG, there is a little drop down arrow next to it – if you click that you get to select JPEG quality which gives you

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Low, Medium, High and Maximum. You can also select the Colour Profile and Size (aka scaling).

**Q10.** *When you display a digital image using Microsoft Photos, does this affect the quality of the image that you see?*

**A10.** Simply put, “yes” if the resolution of the image is larger than the viewable screen area. In this situation it will use “Zoom to fit” logic and dynamically reduce the resolution of the image for display. You will see borders above and below the image containing other information, reducing the resolution even more unless  $\swarrow$  or F11 (Full screen) is used.

**Q11.** *When you display a digital image using Windows Photo Viewer, does this affect the quality of the image that you see?*

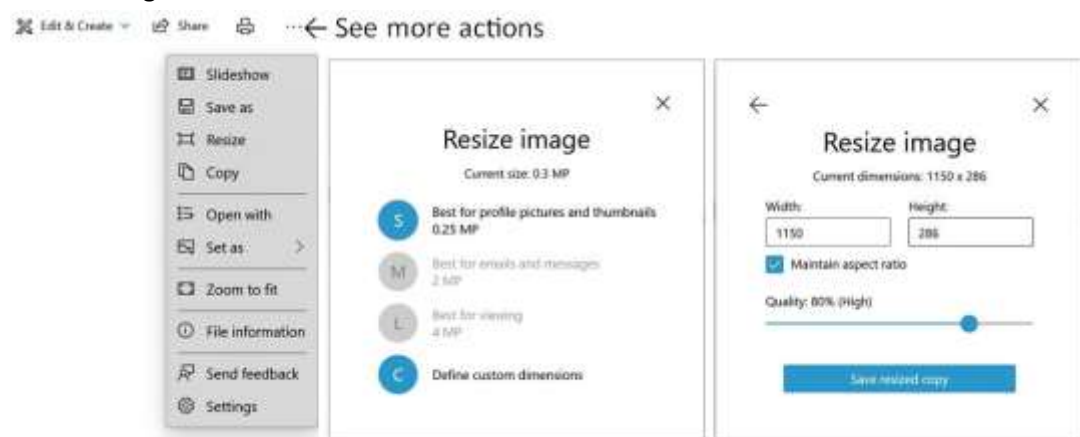
**A11.** The display logic used by the Windows Photo Viewer (if you have it) is the same as MS Photos – it even has the same software bugs, so no benefit there.

In either case, the Zoom controls can be used to enlarge the image for better quality until 100% is reached. Going above that will introduce new issues.

**Q12.** *When you edit a digital image using Microsoft Photos or another image editing app, does this affect the quality of the image?*

**A12.** When you select “edit” mode, Microsoft Photos displays the image even smaller and surrounds it with a lasso that can be used for cropping, by dragging the corners. If you save the image, even if you don’t edit it, the content of the saved file will be altered using default values. The image quality may change and the metadata may be lost. If you edit an image with MS Photos using Crop & Rotate, Filter, or Adjustments, you’ll need to save your changes. The only options you have are **Save Copy** or **Save**. Unless you want to overwrite your original image, use the Save Copy option. This will save your edited image using a default value for MS Photos which appears to be around 90%. If this is not what you want, you have no choice. This seems strange given that the **Resize** facility does have options:

- Click the '**See more actions**' option - 3 dots on the toolbar.
- Choose **Resize** from the dropdown menu.
- You will then see 4 options that affect compression only – S for Small, M for Medium, L for Large or C for Custom where you can specify the **image quality** rather than the compression ratio, i.e. 10-39=Low, 40-79=Med, 80-100=High.



The photo and video tools supplied with Microsoft Windows 11 were not very different from Windows 10. The Photos app for the initial release of Windows 11 was redesigned but appeared to have the same JPEG options as Windows 10.

Windows 11 update 22H2 was released on 20 September and the Photos app has changed again but details are not yet available, while Video Editor has been dropped completely in favour of Clipchamp.

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Most third-party photo editing tools such as Corel Paintshop Pro, Fotor, Lightroom, Photoshop, PhotoWorks, The Gimp, etc have an option to specify the level of JPEG compression which can give you better control.

Alternatively, any of the above enable you to convert the file to a non-lossy format and edit that, only saving the final result back to JPEG when editing and manipulation are complete.

**Q13.** *What image editing options exist for smartphones and tablets?*

**A13.** Smartphones and Tablets, both Android and iOS, offer similar or even better image editing facilities, where the resulting JPEG images are saved using the camera's default values. However, third-party apps can be downloaded for both platforms that provide JPEG compression control as a separate operation for manipulating quality. These apps are intended to save space on your device so more images can be stored, and not necessarily quality.

**Q14.** *I heard there are better options on the iPhone – what and where are they?*

**A14.** While iOS images generally default to JPEG format, you can go to Settings/Camera – Formats and choose High Efficiency, to store them in HEIC format which is far superior to JPEG. HEIC is automatically displayed by MAC computers, but you will need to download the HEIF Image Extension app to view them on Windows computers, unless you convert the image to JPEG on your iPhone by copying and pasting the images to your Files app. However, iOS screenshots are always saved in PNG format.

**Q15.** *If the image quality may have changed due to editing, what about the image resolution?*

**A15.** If you crop, rotate or resize the image, the resolution will change; otherwise it should remain the same. Cropping an image does not change the effective resolution, just the total number of pixels as determined by the crop, i.e. if you remove 50 pixels from each side, the resolution will be what you started with minus 100 pixels.

**Q16.** *Why is it that digital images from your camera look different on someone else's computer or on this projector?*

**A16.** There can be many reasons for variations:

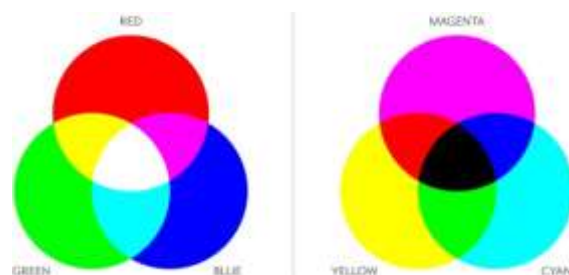
- The display device has a different resolution – for example, the projector used at the SeniorNet Eden-Roskill Learning Centre has a maximum resolution of 1280 x 800.
- The colour map on the display device is calibrated differently.
- Each application displaying the images uses different logic when reducing the image to fit on the screen.
- Sometimes a simple tweak of the brightness and contrast controls can make a big difference, including the environment.

### 10. Other Considerations

If you really want to show off your beautiful photos, the best option may be to print your photos onto paper. But this introduces another variable to the mix.

So far we have only discussed “Additive Colour” where colours are created by adding coloured light to Black using Red, Green and Blue.

When printing onto White paper “Subtractive Colour” is used where colours are created by completely or partially absorbing (or subtracting) some colours and reflecting others using Cyan, Yellow and Magenta. This is also known as CYM colour, but sometimes Black ink may also be used, in which case it becomes CYMK colour.



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The startling thing here is that using these 4 inks, colour printers can only manage around 16,000 colours – not 16 million. Colour variations will also occur due to the colour conversion process, and the pigment of the inks used, as well as the colour and reflectivity of the paper.

Many consumer colour printers are capable of printing up to 4800 x 1200 dots per inch, which is far higher than any computer screen or TV. Enlargements up to A4 size are also possible, especially if you use high quality photographic paper – paper prices vary according to size, quality and brand.

Small photo only printers are also available but these tend to be more costly to operate. Can be used wirelessly from a smartphone and can operate from batteries. Maximum print size is generally 4 x 6 inches, and the most economical way is to buy “Photo Paper and Ink Packs” which typically works out at around 50 cents per print.

Commercial photo printing services such as fotofinish, Kroma, Snapfish, etc are readily available and don't cost a fortune. They are often cheaper than doing it yourself using a consumer colour printer, plus they have other options. They will also prints A3 or A4 calendars, Folder cards, Photo books, Postcards, etc, and some even print onto canvas.

They may only print at 300 or 400 dpi: that is equivalent to 1200 x 1800 pixels (2.1MP) or 1600 x 2400 pixels (3.7MP) for 4” x 6” (100 x 150mm) prints. Beware - 4:3 aspect ratio images are typically cropped for 4” x 6” prints where A Series (3.5” x 5”) is not an option.

Email your images or take them on a USB stick and they can be printed in the size of your choice in optimum resolution within a short time, albeit with changes in colour rendition.

### 11. Conclusions

So what can we conclude from this discussion.

- What happens inside your camera is a compromise.
- The image quality is also compromised by the file format.
- What you display on a digital screen is compromised.
- What you print onto paper is compromised.
- You basically have to settle for a series of compromises.
- Determine what works for you to give the best results – it won't be the same for everyone, and may involve some image editing to adjust colour, brightness and/or contrast to obtain the result you want for the medium you want to use.

### 12. Additional Notes

If you find that you have questions later, please route those through Hetty Goodwin for future discussions.