Digital Photography Primer

Contents

Primer Introduction

This digital photography primer is intended to provide a basic overview of issues and considerations related to digital photography equipment and shooting for documentation purposes. We cover the basics since a wealth of information is available online at sites including Wikipedia (en.wikipedia.org), Digital Photography Review (www.dpreview.com), among many others. We recommend you also investigate digital imaging for forensic documentation, covering a broad range of issues including digital image storage, processing, and legal considerations, check out Practical Forensic Digital Imaging ISBN-13: 978-1420060126.

Camera Selection

The choice of an appropriate camera will do a lot toward making your medical photography a smooth process. Major factors include price/budget, quality, convenience, and flexibility.

Cameras tend to fall into several price ranges:

- Under $80 – toy/disposable cameras, usually unsuitable to this type of use.
- $80-300 – consumer point-and-shoot cameras. There are many choices in this range with different characteristics. Depending on your needs for quality and flexibility, you may find several cameras in this price range that will satisfy your needs.
- $300-1000 – advanced amateur and low-end professional cameras. These tend to break down into four divisions:
    - Quality point-and-shoot cameras – small size, convenient packaging.
    - High-quality lens cameras – with a (sometimes seemingly unusually) permanently attached large lens of high quality.
    - Advanced pocket-sized cameras – with interchangeable lenses often larger than the camera, and high-quality sensor elements.
    - Low-end digital SLRs – much larger sized, intended to provide amateurs a professional-style interchangeable lens digital SLR.
- These choices all have advantages and disadvantages, discussed in detail below. However, you will find a considerable increase in quality, on average.
- $1000-3000 – professional digital SLR cameras. These provide the best in quality available with today's technology in many ways. Our optional Nikon Photography Package includes a Nikon D90 DSLR.

Let's talk about the factors which separate these different cameras.

Understanding Image Sensors in Digital Cameras – A Tutorial

One of the main factors which separate different cameras at different prices is that of image sensors. Digital cameras have a chip built in, on which the lens focuses the image. This chip is a grid like a chessboard, where every square can individually *capture* the light falling on it, converting that light eventually into a number (the digital in digital cameras). Each of these is called a picture element, or *pixel* for short. The number of these pixels on the chip (rows x columns), divided by a million, is the number of *megapixels* on the chip.

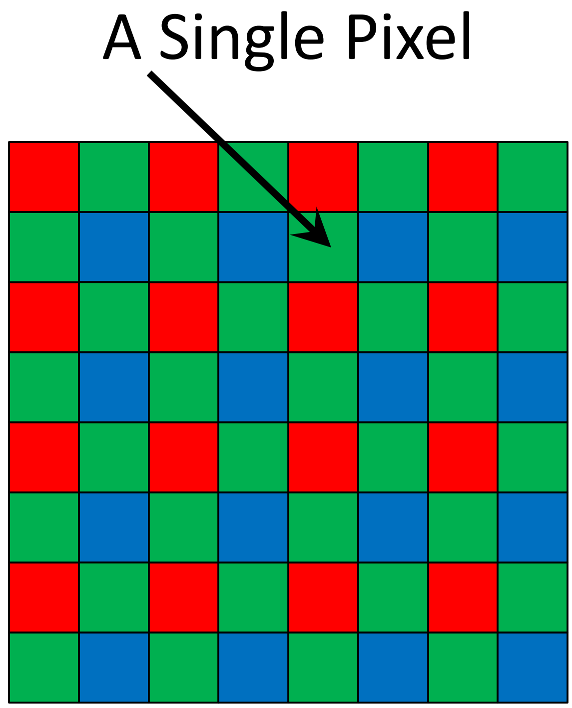

Figure – Sensor Pixels

In most digital cameras, the each pixel in the sensor detects one of three colors: red, green, or blue. For each pixel, in order to create the final digital picture, a value for red, green, and blue must be determined. A full pixel is usually referred to as an RGB value or "red green and blue" value. So for each pixel, the camera will take the detected value, for example the red level, and use the values of green and blue from the surrounding pixels to determine a full RGB for that pixel.

Each pixel is "turned on" for a brief period of time (all at the same time) to "capture" light. For instance, it might be for 1/60th of a second. During that time, the amount of light striking each pixel is "added up" by that pixel.

It works very much like a bucket in the rain:

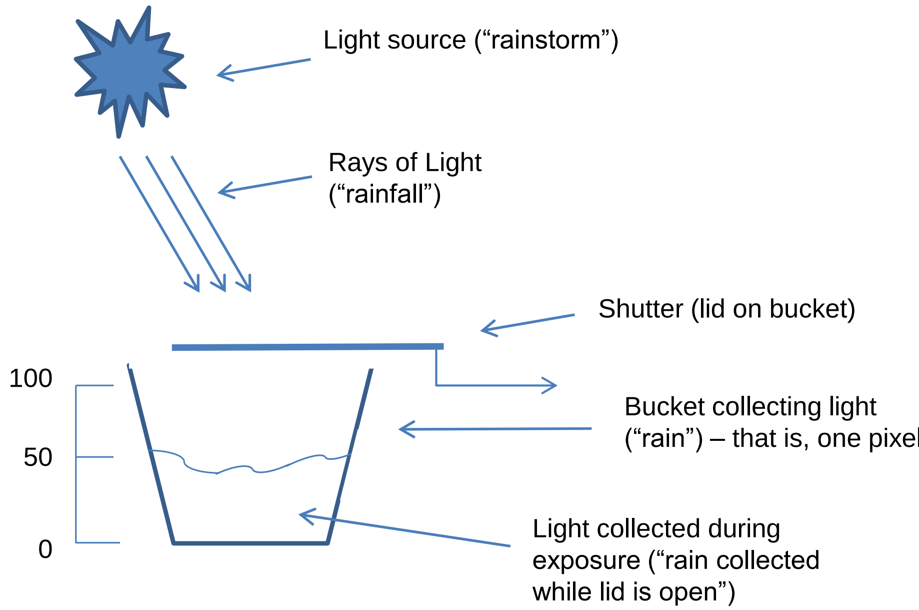

Figure - Sensor Operation

Let's talk about it as if we had a bucket in the yard during a summer shower. We would say, "We opened the lid for a short period of time. Then, the rain fell into the bucket. We closed the lid, and saw how deep the water was in the bucket, reading the level from the scale on the side of the bucket."

Now, let's repeat that for the image sensor: "The shutter opened for a small period of time. The pixel accumulated all the light that struck it during that time. The total amount of light was converted into a number representing how light or dark was that part of the image."

The key concept here is that the two are exactly the same process. This is, fundamentally, how digital cameras work. You dump the bucket out, and then are ready for the next exposure.

However, when you empty a bucket, there's always a little bit of slop left in the bottom. When the rainfall is light, or the exposure time is very brief, then the amount of rain (light) that falls in the bucket isn't much more than that small leftover in the bottom. Thus, the leftover amount – slightly different for every pixel – messes up the reading. This is called *noise*. (For larger exposures – more stuff in the bucket – that slop is insignificantly small.)

How much can the bucket hold? A deeper bucket can hold more light – and thus, the difference between the lightest and darkest areas (bucket very full vs. very empty) is larger – meaning, the pixel can record accurately larger differences in tone.

There are two common types of sensors:

- CCD – the best quality available, with the most useable dynamic range.

- CMOS – a lower quality sensor, with lower dynamic range, but you can sometimes make up for this by throwing more megapixels at it. However, there is typically more noise.
- Better cameras have CCD sensors, which give better results.

Both CMOS and CCD sensor capture separate pixel values for RGB. Very high end cameras may actually use 3 separate sensors (CCD or CMOS) to capture the actually RGB values for each pixel. These designs are more complicated and more expensive, but can give a much higher level of color accuracy. Additionally, there are proprietary sensors such as the Foveon used by Sigma cameras that capture all three RGB values for each pixel using a single sensor. Color accuracy in using the Foveon sensor is outstanding and more cost effective than 3 sensor designs.

Image Sensor Area

Image sensors are also rated in terms of their size, as in "How big a circle of light must the lens make at the image sensor end to *completely cover* the sensor itself? For instance, 1/3 inch or 35mm are among the many sizes used.

In order to make cameras smaller, the sensor must be made smaller. (In addition, this allows the lens to be smaller – and cheaper.) But, this causes a problem.

Image sensors are made up of pixels. Just like rain buckets, the bigger the pixel is, the more light it can capture and measure. However, what happens when you have a smaller sensor (say, 1/3" diameter, rather than a larger 4/3" size)?

Smaller size means less light-gathering ability. This means that the bucket is smaller, and that the total amount of light it can gather at certain exposure time and scene brightness is less. And that means, in turn, that the amount of noise is more significant, the difference between lightest and darkest reading (dynamic range) is less, and the quality is therefore not as good.

All other things equal, a larger image sensor size, with each pixel having a larger area, means better-looking pictures.

Megapixels

Someone always asks, "How many megapixels do I need?" -- and assume that more is better. In reality, a very well exposed image reproduced full-size on an 8x10 sheet of paper, with a quality lens and sensor, can result in a great looking photo – with only 5 megapixels (5MP) behind it!

Unfortunately, perfection does not always exist. When dealing with real-world situations, more megapixels can mean better photos. Do you always need 14MP? The answer is probably not.

Since so many people think more megapixels is the key sign of quality, the manufacturers have made sure all their high-end cameras have over 10MP. Essentially, you can't find a good quality camera with less anymore.

One monkey wrench in all this: with the exception of the Sigma camera, the image sensors cannot recognize all colors at each pixel. In fact, it takes three adjacent pixels in the sensor to create one full-colored pixel – and one or two of those three are also used in creating *adjacent* full-colored pixels. This creates a color fringing effect that might be classified as a *chromatic aberration* (a problem once limited to describing poorer lenses when photographing wide-open). More megapixels reduce the size of this type of error, thus making it less visible, or unnoticeable, in most normal uses.

Many quality cameras today have in the range of 10-15 megapixels. This is why we generally recommend 12MP-class cameras. However, the exact number can and will vary from model to model, with little impact on your results.

An example:

	Nikon 14MP S3100	**Nikon 12MP D90**
Sensor Type	1/2.3" (= .43")	1.8"
Sensor Width in mm	5.76	23.70
Sensor Height in mm	4.29	15.70
Pixels / mm^2	566433.57	32820.62

Notice that the S3100 has more pixels than the D90, and yet the image sensor on the S3100 is actually *smaller* than the D90. This means that the area of each individual pixel on the S3100 is much smaller than a pixel on the D90 – and so, a smaller amount of light is falling on it. Less light means more noise. The result is the D90 has better picture quality, even though it has fewer megapixels.

The Imponderable: Matrix Calculation

Experts say that the totality of all the characteristics of the camera and lens together, combine to define the quality (or lack thereof) in the camera unit as a whole. One of the most difficult parts of this equation is the mathematical computations the camera makes, inside of it, to convert the raw output into a JPEG or TIFF image. There is no printed specification for this. However, you can pretty much figure that the major brand names and the better cameras in their lines take a great deal of effort to perfect this.

In summary: if money is no object, but quality is, go for the largest-format CCD you can afford. You can read more at

`http://www.digitalversus.com/guide-sensor-size-digital-cameras-article-796.html.`

You can also view excellent tutorials at:

http://www.cambridgeincolour.com/tutorials.htm.

Manual Mode Shooting and ISO Rating

ISO rating is the modern term for what film photographers called A.S.A., and then ANSI, ratings. (ISO stands for International Standards Organization.) This indicates how sensitive the camera's sensor is to light striking it. Higher ISO means less light is necessary; lower ISO means more light is needed – to get the same results.

Some better cameras give the option of setting the ISO rating. Often, ISO 100 is the "normal" rating; each doubling (or halving) of this number indicates twice (or half) the sensitivity.

When you are actually photographing, better cameras also have a setting for E.V. (exposure value). This starts at zero and can be set to +1, +2, +3, and to -1, -2, -3 (and so forth). Each numerical step of E.V. is exactly the same as doubling, or halving, the ISO setting. (Some cameras have both ISO and E.V. settings.)

Photographers typically set ISO once, but change E.V. possibly for every picture. For instance, if it is a very bright area you are photographing, but the subject itself is small and too dark, you might want to set the E.V. to +1 to "brighten" the image, overriding the automatic exposure setting.

Some cameras, including pro-quality models, do not *really* have different sensitivities to light. Setting the ISO to 50 or to 200 is just a way to force the camera to make all photos brighter, or darker. In fact, setting an extremely low ISO sometimes has the result of greatly reducing the dynamic range – the difference in brightness and darkness – removing the really dark darks completely. Setting an extremely high ISO sometimes causes the same effect, with much more noise (which appears as a grainy pattern in the image). This is because not enough light is striking the pixels to come anywhere close to "filling up the buckets."

However, the ability to manually control the camera settings is a hallmark of a better camera. It allows you to overcome situations that would cause defects in the image. Some manual settings include:

- E.V. and ISO – lets you force photos to be much brighter, or much darker, than the automatic exposure feature would select.
- Shutter speed – a shorter shutter speed eliminates camera shake and blurs, and removes problems from moving subjects. A longer shutter speed lets you compensate for not enough light.

- Aperture – a smaller f/stop number (meaning a larger lens opening) compensates for lower light conditions, while a larger f/stop number (meaning a smaller lens opening) gives you more depth-of-field, meaning that more is in focus at one time.
- White balance and color temperature – permits you to compensate for the color of the light in the room so that the subject photographs looking more natural.

For the best image quality, you should choose the best camera. This is almost always the Single-Lens Reflex.

However, your needs may not be completely demanding. This opens up a wider selection. Here are the significant differences to choose between.

Viewfinder

- Through-the-lens – what you see is what you get. However, what most people don’t realize is that by holding the camera to your face and looking through the viewfinder, you steady the camera considerably, resulting in better images with less shake and therefore less blurring.
- Viewfinder – the same benefits *but* what you see is shifted slightly from what the lens sees, and shifted a *lot* for close-in photography. Going out of style.
- Viewfinder with mini-display – the same benefits with accurate framing, *but* sometimes showing the subject at a much lower resolution than the end photograph, sometimes making it more difficult to see a detail you especially need to document.
- Large LCD viewing panel on the rear – although this gives you the absolutely best view of what the camera is seeing, it is absolutely the worst for camera shake and blur, compared to other cameras with the same effective shutter speed setting. Most people just cannot hold the camera at comfortable viewing distance and not shake – a lot. If you use this type of camera, you *must* either use a lot of lighting, or use a wide-angle zoom setting.

Lens availability

- Single-lens-reflex (SLR) cameras inevitably have interchangeable lenses, allowing the most appropriate lens to be selected – and even changed from time-to-time.
- All other cameras have a fixed lens. If this lens is of a lower quality – so goes all your photo images. Certain premium brands, such as Lumix™ from Panasonic or Exilim™ from Casio, have quality lenses on some (but not necessarily all) models.

- Most cameras with a fixed lens have a variable zoom lens. Key to know if you can go from macro (tulip mode) to wide angle to take body shots. Don't need zoom.

You can often tell by the size of the lens or by a premium brand name (such as *Carl Zeiss™*), that they are of a better quality. See the Lens Selection section for more details.

In Summary

We have selected the Nikon D90 SLR camera for our Nikon Digital Photography option. Major brand names – Nikon, Minolta, Sony, Canon, Olympus, Pentax, Fujifilm, and the like – all have very fine digital SLRs. You can't go wrong with any of these brands.

If you can afford a digital SLR, then we suggest going for a quality premium fixed-lens camera such as a Sony, Lumix, or some of the above brands. Other brands to consider are Exilim and Samsung. There are many ratings available online for more exploration.

Here are some options chosen from the current Nikon product line:

- Under $500
    - Nikon D3000 Digital SLR ($500)
    - Nikon Coolpix P7000 point-and-shoot ($400)
- Under $1000
    - Nikon D5000 DSLR with 18-35mm Lens ($600)
    - Nikon D3100 DSLR with 18-35mm Lens ($700)
    - Nikon D5100 DSLR with 18-35mm lens ($900)
- Under $1500
    - Nikon D90 with lens (about $1200) – comes with our optional 4D Imaging Nikon Photography Package

If in doubt: find a reliable full-service professional photo dealer, and ask them to help.

Lens Selection

When you buy a digital camera, one of the key characteristics you are paying for is the quality of the lens. And, the quality of the lens will directly reflect in the quality of your photographs. As superficial as it sounds, you can tell a lot by just observing the size of the lens on the camera. Here are the key differences between lenses:

- Permanent vs. interchangeable
- Macro vs. standard (or close focusing)
- Fixed-focus vs. auto focus (and in addition, some have manual focus capabilities)
- Fixed-focal-length vs. variable focal length (zoomable)
- Zoom ratio range (usually measured in ratios, such as 3:1)
- Digital vs. Optical Zoom
- F/stop maximum size (note that *smaller numbers* are *larger lens openings*)

Permanent vs. Interchangeable

Less expensive digital cameras have fixed lenses. In these cameras, there is no option to improving the quality of the lens by changing it out. However, certain brands – such as Sony or the Panasonic Lumix – use better-quality fixed lenses – and proudly identify their design origin, such as *Carl Zeiss Lens*. These better lenses usually have larger maximum f/stops (smaller numbers), larger zoom ratio, and have macro focusing capabilities. (One indicator is the size of the lens – bigger lenses gather more light and are usually better.)

Often, cameras with interchangeable lenses supply better-quality lenses as a matter of course – with you having the option of selecting from a range of alternatives.

Macro vs. Close Focusing

Let's talk about the term *macro*. (Nikon uses the interchangeable term *micro*.) This word has certain implications in professional usage. A macro lens has the following characteristics:

- Can focus on an object close enough so that the full frame photographs no more than twice the focal plane. What this means in English is that if the camera has an image sensor ½ inch across, then you can focus full-frame on a subject one inch across or smaller.

- Has a flat field of view. In other words, if you aimed the camera straight at a postage stamp that completely fills the frame, then all four corners of the image are in focus at the same time as the center of the image. This will be critical for taking the most accurate measurements from photo images.

A lens that allows you to focus on a small object at a short distance, but does not meet the above criteria, is technically referred to as *close-focusing*. In particular, imagine cutting a basketball in half, then photographing the inside, so that you focus on the farthest point in the center of the curve. Oddly, the corners of the picture, curved closer toward you, will also be in focus. If the subject were instead a flat image (like that stamp), the corners would be out-of-focus. A true macro lens also tends to keep straight lines straight – poorer lenses will show the outer sides bulging out, or bent in, by a slight amount (called barrel and pincushion distortion).

A true macro lens is advantageous in photographing a human subject. When you try to photograph an object resulting in much magnification, then the *depth-of-field* problem arises.

How many times have you seen a cheap old movie photographing a model train close-up, pretending it is real, and it's so obvious to you: so much is out-of-focus, which you can tell that something is wrong. In fact, depth-of-field – that is, from near to far, how much of the image is simultaneously in focus – is a problem when photographing close-up.

When photographing human subjects close-up, in many cases, as you progress from the center of the image to the edges, the subject curves away from you – for instance, if you focus on the arm, the edges curve away, not toward, the camera.

With a close-focusing lens, this gives the worst possible case for focus. You would need intense lighting and set a very small lens aperture (a large f/stop number) to have any hope of having it all in focus. But, with a macro lens, the sweet spot at the corners is a lot closer to the body parts, thus requiring not so intense lighting or so small a lens opening – and giving you a better quality photo.

Fixed-Focus vs. Autofocus

Extremely inexpensive lenses have fixed focus. They depend on bright light and a small lens aperture to generate enough depth-of-field to give acceptable focus in many cases. We suggest you avoid these.

Better lenses have auto-focus. The lowest cost models just have a few "zones" – say, far, middle, and close. But, most auto-focus lenses can truly focus on the subject in the middle of the field of view. Problem is – what if you have to focus a little bit farther away from that (so that depth-of-field will include the entire curved arm)?

This is why the best lenses allow you to manually focus if you wish. For demanding purposes, and especially if you have thru-the-lens preview of the actual shot – manual focus allows you to very quickly get the best looking picture.

[With auto focus camera that do not have manual focus alternatives, you can often “fake it out” by doing the following. Let’s say you want to photograph an arm very close up, and you wish to focus slight farther away from you than the closest point (that is, you want to focus half-way between the closest and farthest part of the subject to get best depth-of-field). You do this by shifting the camera sideways so the focus point in the viewfinder is pointing at a place that is halfway between near and far. Then you press the exposure button down half way, forcing the camera to focus. Without taking your finger off the button, shift the camera back so the near point is in the center of the view. Then, press the button down the rest of the way to actually take the picture.]

Fixed Focal Length vs. Zoom and Zoom Ratio

Only the most inexpensive cameras feature fixed-focal-length lenses. Most cameras today have zoom lenses included. Zoom means you can zoom in (magnifying the image larger) or zoom out (so you are photographing a larger area) without moving the camera. It also means that focus is maintained throughout the zoom. (Lenses that do not retain their focus when adjusted are called *varifocal* lenses, and are thankfully relatively uncommon today.)

The focal length is measured in millimeters, and the number represents the distance from the front of the lens to the surface of the image sensor itself. A big number means you are magnifying the image (“moving closer”) while a smaller number means a wider field of view. Since so many pros learned the effects of zoom based on 35mm cameras, and the sensors in many cameras are smaller than 35mm film, then different cameras will have different zoom values representing the same field of view. Some camera makers actually label their lens focal lengths in 35mm-equivalent numbers (“as if this were a 35mm camera”). Most don’t.

The important factor is: what is the difference between the most-zoomed-in number, and the most-zoomed-out number. For instance, zooming “closest” might be 50mm, while zooming “farthest” (or “widest”) might be 12.5mm. You see here that 50 is four times 12.5, so the lens has a 4:1 (“four-to-one”) zoom ratio.

A larger zoom ratio means you can be farther away and still have the same-sized subject fill the camera view. Generally but not always, larger zoom ratios require higher quality lens designs, and thus take better pictures. (Very large zoom ratios, however, sometimes are achieved by reducing lens quality.) Incidentally, a large zoom ratio sometimes also means you can get a wider field of view, thus photographing larger objects (such as an entire body shot) in a limited space, without having to back up a long distance.

Beware: using a high amount of zoom also means the camera will be extremely shaky, and the shake that is natural (because of pulse and other factors in the photographer) will be amplified. By using a tripod or camera mount of some kind, you remove this problem.

For 35mm lens-equivalent focal lengths, a general rule-of-thumb is that for hand-held shots, the focal length cannot be larger than twice the shutter speed. This means that if you set the shutter speed to 1/60th of a second, then you can hand-held up to 120mm. (55mm is about what your eyes perceive unaided.) While on better digital cameras you can set the shutter speed, remember also: faster shutter speeds mean less light, and thus the lens has to be opened up to a wider aperture (smaller number), thus losing depth-of-field. It's a balancing act.

With a 35mm-type camera lens (which means the lens is covering a circle of about 1¾" at the image sensor), photographers are used to different focal lengths for different uses:

20mm	Extreme wide-angle, used when you are close to the subject and need to include a lot (this width will generally and unavoidably cause distortions near the edges)
35mm	General wide-angle photography, often used for photographing groups, or when close
52mm	Similar to natural eyesight's view from the same distance
105mm	Mild telephoto, often enhances appearance of people by slightly flattening features
250mm	Telephoto, used when some distance away from the subject, flattens features

In some digital cameras, you will see these numbers used – even though they are inaccurate – because "all photographers know what the focal lengths do on 35mm cameras."

Here is a table that gives the approximate equivalent focal length in mm for several image sensor sizes:

35mm camera	DSLR (4/3")	1/3"sensor	2/3" sensor	APS-C sensor
20	10	3	5	14
35	17.5	4.5	8.5	24
52	26	7	13	36
105	53	14	26	73
250	125	33	61	175

You will most likely want a zoom lens that has a wider field of view – say, 24mm to 80mm (in 35mm-camera-equivalent sizes), since this will allow you to photograph wider fields of view without backing up a long distance. However, when doing true macrophotography (where the subject is a relatively small feature), a macro lens in the 50mm to 150mm range is helpful; the slight telephoto characteristic keeps you from having to literally hold the lens 2” from the subject while photographing it, giving you a more easy working range of, for instance, a foot.

F/Stop - Aperture

F/stops are the ratio of the focal length to the width of the lens opening – thus big numbers represent small openings, and small numbers are large openings. The largest opening (smallest numbers) results in the most light passing through the lens (for darker situations), while the smallest opening (largest numbers) reduces light the most for bright situations – and also increases the depth-of-field.

Better lenses are visibly larger because they provide more light-gathering capability – and often (but not always) are designed better than cheaper lenses. Lenses with smaller apertures available can allow better depth-of-field – with enough lighting – to take close-up or macro images with more, or all, of the subject in focus simultaneously.

In many cases, when lenses are set to the largest apertures, the quality or *resolving power* is reduced. As a rule-of-thumb, you will ideally want to use a lens where the aperture is usually being set somewhere in the middle of its range to get the best quality. While some lenses improve in quality the smaller the lens opening, in a few cases, extremely small openings can reduce a bit of the quality.

Again, F stop is key for medical photography. You want to drive to higher f stops to increase the focus. F8 – F16 for shooting macro. This only works if you have a large sensor or you have specialized lighting.

Conclusions

All that said, usually lenses made by major manufacturers, such as Nikon, Canon, Olympus, KonikaMinolta, Zeiss, Leica, and others often are of uniformly high quality. Lenses from off-brand manufacturers are often more variable in quality. That notwithstanding, occasionally lenses from the oddest of brands turn out to be gems. Photography magazines spend a lot of effort testing lenses to determine their quality at different settings – but you will often be happy by sticking with a major name brand.

Lighting Considerations

White balance

Nearly all digital cameras benefit from a feature called *white balance*. In general, this means that you point the camera at a white sheet of paper filling the viewfinder, and placed at a position similar to where you will photograph the patient, and under the same lighting. If you would benefit from relatively accurate colors, you should calibrate the camera according to its instructions to set the white balance. (Better cameras may permit you to save settings for each of several exam rooms, and thus be able to switch to the correct settings for any room without recalibrating.)

Important characteristics

There are four characteristics of light that affect medical photography:

- Brightness
- Directionality/quality
- Color temperature
- Accuracy

Brightness

Brightness is important in photography, since more light = better-quality photos for these reasons:

- You can “stop the lens down” (use a higher-numbered f/stop setting) to improve depth-of-field (what’s in focus) for close-up photography, and also get the lens to its “sweet spot” where it exhibits more resolving power.
- You can set a higher shutter speed (shorter exposure time), removing any blurring from camera movements when hand-held (an inescapable natural process).
- There will be enough light to allow a full tonal representation – meaning, you can see slight variations in dark areas and light areas alike.

If brightness is within the range that can be handled by your camera, and you have proper light quality, you can use “existing light” to take your images. If this is not possible due to facilities limitations, you may need to use an electronic flash (also called a strobe).

A larger sensor like in the D90 gives you more flexibility to work in lower light conditions since you can increase the ISO setting

Quality

Light quality affects how the image will look. Focused (direct, point-source) light, say from a single incandescent bulb or from a medical light source can be quite effective to illuminate an object. However, when viewed (or photographed) from off-axis, there can easily be harsh shadows making it difficult to see features. (However, the elimination of all shadows can make it difficult to see subtle surface height variations – in this case off-camera-axis lighting can be quite effective.)

If you are limited in the lighting situation and thus need to use an electronic flash, most units naturally produced this type of light, which is slightly off-axis. ("Remote" flashes and adapters exist so that you can intentionally move the flash *very* off-axis, if needed.) To get a perfect on-axis light, and get a bit of diffusion, you will want to instead use a "ring flash," called so because it fits on the end of the lens and forms a ring around it.

Diffuse lighting – where the light is coming from many directions and is "soft" – controls specular reflections and high-reflectivity features, greatly reducing shadows and increasing the tonality – again, allowing you to photograph and see subtle variations in very dark or very light areas (or both, in the same picture).

If required to use electronic flash, there are many techniques to diffuse the light, from pointing it away from the camera at a silvered "umbrella", to pointing it at a wall or ceiling to "bounce" it, to placing various diffuser gadgets over the flash itself. Some enterprising photographers take a translucent plastic cup and place it over the flash head to somewhat achieve this effect.

Light fixtures and ceiling/wall qualities affect diffusion. The most diffuse fixtures usually reflect the light off the ceiling. The most directed fluorescent light is created using "mirrored cube" diffusers (use one-inch square size to maximize the directionality). Different diffuser panels covering fluorescent lights can create intermediate steps.

If you are trying to photograph a subject at close hand (for instance, in macrophotography), lighting is always a problem. First, the camera and lens blocks a good part of the light that would naturally fall on the subject. Second, you often need more light to allow better depth of field (a smaller aperture), which is often a challenge.

A good option for these circumstances is the previously mentioned gadget called a ring light. This is an electronic flash that fits over the end of the lens barrel, forming a complete ring around it. Since light is coming from all directions, a natural diffusion occurs, along with intense bright light perfect for close-up or macro photography. One example of a recent model with good ratings is the Sigma EM-140DG, which fits over Canon, Nikon, and Pentax standard lenses and works with all those digital SLRs (among others).

Color Temperature

Color temperature refers to the theoretical "center" of all colors in the spectrum, and is specified in degrees Kelvin (^{o}K). Daylight is 5400 to 6500 ^{o}K, on the blue side, while incandescent lighting (sometimes also called tungsten or halogen) is generally 2750 to 3300 ^{o}K, on the orange side. (Generally, if you are in a room illuminated by all one or all the other, you will perceive white as white; only when compared side-by-side do you see the difference clearly.)

Cameras generally have a setting for light source that, essentially, sets the camera to a fixed color temperature. If you set the color temperature to one of these, like the "little light bulb" or the "little sun" you will be approximately correct.

However, cameras also have a much more precise way of making white look white. The white balance calibration feature will take color temperature into account, in a more accurate way. If your camera is set to the incorrect color temperature, you will know it right away. In most (better) cameras, you focus on a sheet of white paper (like the back of the Slate sheet) and press the White Balance button – and the camera will calibrate itself for the quality of light at the location where that white sheet was located.

Fluorescent bulbs can cause problems if you don't set the white balance. They are not full-spectrum light sources. When you aim a camera at a subject illuminated by fluorescent lighting, strange color casts can result.

Accuracy

Color accuracy can have a profound (and sometimes surprising) effect, depending on the nature of the lighting source and of the camera settings. Incandescent lighting, and daylight, provides continuous, full spectrum lighting. Most fluorescent lighting has a discontinuous spectrum, occasionally leading to highly inaccurate colors in images.

Fluorescent bulbs are rated as to their Color Rendering Index (CRI), which is a percent, with 100 being perfect color rendering, and low numbers representing increasingly incorrect color casts. The best CRI ratings, over 90, give accurate colors over most of the spectrum. Cheap bulbs often have CRI near 50 or 60, and can cause strange color shifts in observed and photographed objects. If using fluorescent and you care about observing colors as they really appear, then you should select high CRI bulbs. (These are usually printed on the carton, and can be researched on the Web by using the code numbers on the bulb, such as "F40/32N.")

High CRI fluorescent bulbs can be more expensive. We recently priced them at $2.50 each at Home Depot in boxes of 10.

We suggest that you use similar color temperature products throughout your office to prevent any jarring “that looks so blue” appearances when two radically different color temperatures are nearby. Note that if you have daylight streaming through the window, you should choose high color temperatures; if you have incandescent or halogen light fixtures, you should choose low color temperatures.

Tips and tricks

Positioning Considerations

Most of the time, you will want to be at right angles to the surface you are photographing. However, sometimes you will want to take some photographs aimed along the surface. This shows variations in height.

Light can help, too: if the light is diffuse, or if it is coming from the camera (say, a ring light), you will accurately record the overall appearance. However, a directed light source, aimed along the surface rather than from the camera's direction, can often create shadows that better show variations in the surface texture and features.

Camera Settings for Best Quality

Generally, you are going to want to set the camera in auto exposure mode, so it chooses the correct shutter speed and lens openings for the best photos. If you provide enough light on the subject, you will get the best quality.

The best lens opening is usually somewhere in the middle of its range; the best shutter speed is "fast enough to remove the shake". For instance, f/8 at 1/250 of a second is a good place to be. If your camera chooses a slower shutter speed (1/30, 1/15) and/or a wider opening – near the widest, most open setting the lens is capable of – then you need brighter lighting in the room, or need an electronic flash or ring light.

Remember, you can cure the slower shutter speed/camera-shake problem to some degree by using a camera tripod or mounting arm to hold the camera still while taking the photo. (Our Nikon Photography Option comes with exactly this kind of mounting arm.)

If you have a zoom lens, all things being equal, again, the middle setting – or a bit on the wide side – is often better. Wide-angle views give you better depth of field and less sensitivity to camera shake. Telephoto (zoomed in) is just the opposite. Of course, you have to get close enough to fill the viewfinder with the subject area you are documenting.

"Caucasian" skin tones have a tendency to reflect more light. If you are taking a close-up picture that fills the frame with this type of light-colored skin, you should adjust the exposure value compensation setting to -1EV (that is, tell the camera to compute the exposure and then half it, because the skin is too light).

On the other hand, if the skin tone that is filling the screen is very dark, you will likewise want to set the EV dial to +1. Fortunately, you can see the exposure on the screen on the rear of the camera.

Did you white balance for this room's lighting? (*Is the date set correctly?*) Then, you are ready to shoot.

Taking the Photograph

Aim the camera at the patient. Compose the shot, adjusting your distance and the zoom on the lens (if it has it). Slowly press the exposure button ("shutter release") down. When it reaches the stop about half-way down, the camera will set the exposure and the lens will set the focus. Continue to squeeze all the way down until you hear the click sound. Look at the image on the display to see if it looks OK – adjust the exposure value (EV) control to lighten or darken the image – and then proceed to take several exposures. Electrons are cheap – getting the patient back into the office is costly.

Using the Marker for Measurements

Enhancer Edition

We have provided you with a sheet of *ruler markers*, which are used to permit automatic accurate measurement of features. (A copy of a Microsoft Word document to print more is installed in your **`photostation photo images`** folder.) To measure features in a single photo image, you must include the marker in the image. It should be positioned so it is on the same plane of the feature being measured – your ability to position it according to this rule will determine how accurate your measurements are.

There is no requirement to be physically adjacent to the feature as long as it is on the same plane as the feature. We do recommend, however, that your camera angle not be more than at a 15^{o} from that plane (and, of course, the marker and the feature you wish to measure). Ideally for the most accurate measurements, you will be directly perpendicular to the feature object of interest for measurement.