**Making a Good Exposure**

Making a good exposure in the camera is the all important first step in documenting your research. To produce publication quality images it is crucial to have a good starting exposure to work with. I don’t know how many times I’ve heard something like this from an excited researcher: ”...the experiment that we did last summer turned out to be really important and we want to publish a plate of images....we took pictures with the labs digital camera and they’re pretty dark and sorta fuzzy but can you fix them up and make one ready for a possible cover shot….it’ll take too long to redo the experiment just for photography so this is all we’ve got to work with...”. After much hemming and hawing and the old “_rap in, _rap out” speech, I do what I can but usually the results are not good and almost never cover quality.

**What is Exposure?**

Exposure is the amount of light that contacts the imaging sensor of your camera. There are two components of exposure: brightness and duration. In the camera, brightness is controlled with the lens diaphragm and duration is controlled with the shutter. Equivalent exposures can be made with many different combinations of diaphragm openings (also called aperture, f-number, or f/stop) and shutter speeds. Although the exposure can be equivalent using different combinations of aperture and shutter speed, the visual effects of these different settings will vary greatly. For this reason, it is good to have some understanding of how changes in f/stop and shutter speed will affect the final image.

**Aperture and Depth of Field**

The amount of light that passes through a camera lens is regulated by an iris diaphragm. The opening size, or aperture, of this diaphragm is referred to as its f/stop. The f/stop is derived by dividing the focal length of the lens by the aperture diameter. This leads to the counter-intuitive situation where a small number f/stop actually represents a large aperture, and a large number f/stop denotes a small aperture. More light will pass through a lens set to f/2.8 than one set to f/22.

Depth of field, which is the distance in front and behind the plane of focus that can be considered to also be in focus, is dependent on the f/stop. At a low f/stop (large aperture, say f/2.8) there is very little depth of field, while a high f/stop (small aperture, say f/22) exhibits much more depth of field. This can be visualized easily by photographing a ruler, tilted to a 45 degree angle, at these 2 f/stops (below). For this test a 60mm lens was focused on the number 6. At f/2.8, the depth of field extends from approximately 5.5 to 6.75 on the ruler. At f/22 the depth of field is greatly enlarged as the picture shows.
In real world terms this means that you can control the amount of your subject that will be in focus by choosing different f/stop settings. When photographing flat objects, the aperture setting is not critical, for if you have the camera back parallel to the subject it will all be in focus. When you photograph a 3D object though, you must decide which plane of the object you wish to be in focus and how you want to use depth of field. You can decide to use a shallow depth of field (low f/stop, 2.8) to highlight one plane of the subject while blurring the rest. Conversely, you may decide to have as much of the subject as possible in focus by using a high f/stop like f/22. Remember though that if you have less light entering the camera, the exposure time must be longer in order to get a proper exposure on the image sensor.

### Shutter Speed and Movement

The shutter on your camera controls the length of time that light exposes the image sensor. The numbers on a shutter speed dial refer to fractions of a second, thus the numbers 8, 15, 30, 60 really mean 1/8, 1/15, 1/30, and 1/60 of a second. It is not a good idea to hand hold a camera at exposure times longer than 1/60 second (unless blurs are what you’re after). For these longer times it is advisable to mount the camera on a tripod. If a tripod is unavailable, try bracing yourself against a wall or tree for added stability. Slight camera movement during exposure will result in poor quality pictures. If you notice directional streaks when viewing images at high magnification you should use a higher shutter speed or tripod.
When photographing botanical specimens it is also important to keep the subject from moving. This might require turning off fans, closing off drafty rooms, or blocking wind with sheets of cardboard.

**ISO**

The ISO setting refers to the sensitivity of a digital sensor to light. The ISO setting of most digital cameras is variable and can be changed to fit the lighting conditions. On some cameras this is done through a menu system and on others it can be changed on a dial. It is best to set your digital camera to the lowest ISO that allows you to expose the subject with the settings (f/stop and shutter speed) you want. At higher ISO settings a digital image will get increasingly “noisy” and degrade the quality of the image.

**Color Temperature and White Balance**

Different sources give off light with different relative intensities of blue to red wavelengths. Candles and tungsten lights emit a redder light than the sun at noon on a clear day. In photographic terminology this difference in the relative intensity of blue to red is called color temperature. Tungsten lights have a color temperature around 3000 Kelvin (K-the units used to measure color temperature) while sunlight at noon on a clear day is about 5500K. Our brains filter out these differences in color and make the dominant light source always appear to be white. A digital sensor does not do this though.

On a digital camera the adjustment for color temperature is called white balance (WB). Most digital cameras have WB settings which allow you to match the chips sensitivity to a particular light source. Some cameras have the WB options in their menu systems others on a dial. For most situations it is OK to leave the WB on AUTO and let the camera determine the proper setting. In certain situations it is advisable to manually set the WB to tungsten or daylight or one of the fluorescent light settings to obtain accurate color fidelity.

**Light Meters**

All new digital cameras have built in light meters. These meters, especially on professional cameras, can be very complicated and offer numerous features. They all do essentially the same thing though, they tell you how to produce a gray image. A long time ago in a land far far away (probably Rochester, NY) photographic researchers designing
light meters calculated the average brightness of numerous average scenes (landscapes, portraits, etc.) and came up with an average gray tone. This gray tone, known as 18% reflectance gray, is what all photographic light meters are calibrated to. Light meters measure the light reflecting off a subject, average the tonalities, and tell you what combination f/stop and shutter speed (at the set ISO) to use to make that scene 18% gray.

This is all fine and well if the subject is “average” but what if it’s not. What would happen if your subject is a fine, feathery plant on a black velvet background? The light meter in the camera will see all that black and give you settings to make the background 18% gray. This results in overexposure and washed out color and detail from the subject. Conversely, the same plant on a white background would result in underexposure (the meter would try to make the white background render as gray). In both these common situations a camera set to Automatic Metering would produce poor quality images. To get the proper exposure you need to override the meter and adjust the exposure manually. Most consumer digital cameras have methods of easily adding or subtracting exposure so get to know your camera and learn how to use this feature.

All digital SLR and many non-SLR cameras have multiple metering systems. It is important to understand these different systems to properly use your cameras light meter.

**Average** – This metering system determines the exposure by averaging the tonalities of everything in the field of view. Not terribly accurate unless the scene is average.

**Center-weighted** – This system determines the exposure by measuring light from the whole field of view but gives more weight to a small central area. Center-weighting provides more accurate readings most of the time because important objects tend to be framed in the middle of a picture. This is the default setting for most digital cameras.

**Spot** – In this system light is only measured from a very small area of the viewfinder. Spot metering is very accurate for almost every situation if used properly. By placing the spot directly on the subject, the meter is not affected by bright or dark backgrounds but makes it’s reading from the subject only. Some cameras have movable spots for readings anywhere in the viewfinder, other cameras have set spots at the center of the viewfinder.

**Matrix** – This is a new metering option found on many professional cameras. In this system, the viewfinder is divided into numerous segments, each with their own weighting.

Now to make things even more confusing, most cameras offer several Exposure Modes. These modes range from fully manual to fully automatic functioning, with several partially automatic modes in between.

**Manual (M)** – In manual mode, the photographer can set the camera to any combination f/stop and shutter speed. Most cameras allow the photographer to view the exposure suggestions from the meter (set to whichever metering system one prefers) and then
decide which settings to use. Give me manual control any day! It’s not the fastest and you have to think a little, but it provides total control over the exposure. Unfortunately, many non-SLR digital cameras do not make manual mode easy to use. Manufacturers think that most users want everything to be automatic so they bury the manual features in the menu system of the camera and make it difficult and clumsy to access.

**Aperture-Priority Automatic (AP)** – In this mode, the photographer sets the aperture (f/stop) and the camera decides what shutter speed to use automatically. This allows you to control depth of field but you have to be careful that the shutter speed does not get automatically set longer than 1/60 sec if you are hand holding the camera.

**Shutter-Priority Automatic (SP)** – Similar to AP, but here the photographer picks the shutter speed. Used often when photographing fast moving objects.

**Program (P)** – This is a totally automatic mode. The camera decides what f/stop and shutter speed to use. This mode should seldom be used when doing scientific photography, as you have no control over depth of field or camera motion.

**Gray Cards**

18% reflectance gray cards are available at most camera stores and are very valuable for determining proper exposures and obtaining correct color balance. The information booklet that comes with the Kodak Gray Card is very informative about determining exposure, lighting ratios, color balance, and density. I highly recommend that anyone doing scientific photography pick one up and keep it in their camera bag.

To use a gray card to determine exposure, do the following:

1. Set up specimen and camera.
2. Set camera to M exposure mode. If this is not possible, check with camera manual to find out how to use the exposure lock function.
3. Hold the gray card in front of camera so the same lighting that strikes the subject is also illuminating the card with no shadows or glaring reflections.
4. Take a meter reading from the gray card (on most cameras accomplished by holding the shutter release button half way down). If in M mode, set the camera to this setting. If using the exposure lock function, lock the automatic exposure to this setting.
5. Remove the gray card and make an exposure.

By using the gray card, you have set the cameras exposure to middle gray for the lighting conditions and now the other tones should fall into place. White objects will photograph white and black objects black. Some tweaking may have to be done depending on the
subject, background, and lighting conditions but this will get you very close to the correct exposure.

If at all possible, it is also a good idea to include a small piece of the gray card in the picture. This will prove to be very useful later when you are adjusting the color balance on the computer. Because the gray card has no color tint, it can be used to judge an overall color imbalance (incorrect WB setting for example).

Focus

Most non-SLR digital cameras are autofocus. This allows for sharp focus under most conditions but sometimes the focusing mechanism can be fooled so it is a good idea to know how your camera determines focus. Most cameras have a center spot in the viewfinder that focuses on whatever it is pointed at. When you push the exposure button half-way down the autofocus mechanism measures the distance from camera to subject and adjusts the lens to this distance. If the subject in this center spot has very little contrast (imagine photographing a petri dish with fungal colonies at four corners, but only clear agar in the center) the camera will not focus properly. On some cameras the shutter will lock if the autofocus mechanism can’t set a focus. In this situation you need to find the focus lock setting on the camera (check the manual), point the camera at an object in the same plane of focus that is contrasty (one of the fungal colonies), lock the focus on that object, then reframe the picture and make an exposure. Some of the professional and advanced cameras have multiple focusing spots. You can choose which spot you want to use to set focus.

Histogram

Most digital cameras have a histogram feature which is very useful in determining a proper exposure. A histogram is a graphical representation of the tonality of the pixels in an image. Each camera has a different method of accessing the histogram feature so check your cameras manual for instructions. The histogram will be displayed on the cameras LCD screen and will look something like this:
When the graph shows an even distribution of pixels between the shadow and highlight regions, this is a good exposure. A graph that is skewed toward either the shadows (underexposure) or highlights (overexposure) denotes a poor exposure and should probably be reshot (see below).

<table>
<thead>
<tr>
<th>Even distribution</th>
<th>Sloping up to the right</th>
<th>Sloping up to the left</th>
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<tbody>
<tr>
<td>Correct exposure</td>
<td>Overexposed</td>
<td>Underexposed</td>
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There are certain situations where the histogram will look skewed but you do have a correct exposure. When a specimen is transilluminated, the background should go white, so there will be many pixels in the highlight end of the graph. When a subject is photographed against a black background there will be many pixels in the shadow end. In general, with digital photography, it is better to slightly underexpose than to overexpose an image. If overexposed, the pixels in the highlight end are “clipped” and no detail can be obtained from them. If slightly underexposed, the image will start out dark but detail in the shadow areas can be extracted by manipulation in Photoshop.

### Putting It All Together

Now it’s time to put all these considerations into play and make a great exposure. Previsualize the final picture then set things up to make this vision happen.

1. Prepare the specimen – In the studio decide what background will work best with the specimen. Decide what type of lighting accentuates the subject. In the field decide which camera angle shows the specimen best and determine if natural lighting is sufficient or if extra lighting with reflectors or flash is necessary.

2. Set cameras ISO to the lowest number that is appropriate for the situation (usually between 100 and 400).

3. Set the White Balance to auto. If you review the image after exposure and the color balance is not right, set the WB manually for the lighting conditions.

4. Check the camera resolution and make sure it is set to the maximum possible. Decide if you want a compressed Jpeg file that is a small file size or a larger uncompressed Tiff or RAW file. Try to use RAW format if the picture is important and this option is available.

5. Decide how much depth of field is appropriate. To highlight a specific plane of focus or to focus on a subject while throwing its background out of focus use a large aperture (small f-number, f/2.8). To achieve maximum depth of field use a small aperture (large f-number, f/22). For in between effects, use in between settings. If control over the depth of
field is an important criteria for the image, make sure the light meter is set to Aperture Priority Mode. If the shutter speed that the camera chooses is less than 1/60 sec, brace yourself for handholding or set the camera on a tripod. You can also increase the ISO setting but be aware that this may add noise and blotchiness to the final image.

6. If choice of shutter speed is more important than depth of field (fast moving objects) set camera to Shutter Priority Mode and select the appropriate shutter speed.

7. Determine which metering system to use. Usually center weighted or spot will work best. Obtain meter reading from the subject of photograph and make exposure compensations if subject is lighter or darker than middle gray. Alternatively, make meter reading from gray card and lock exposure setting. Include a small piece of the gray card in the image if possible.

8. Focus on subject. If autofocus won’t work, focus on nearby object that is in the same plane as subject and lock the focus.

9. Make an exposure!

10. Review the exposure and histogram, make appropriate changes to camera settings, and reshoot if necessary.

I know that this seems like a lot of effort for one photograph but consider how important that one photograph might be. With experience you will find that all these decisions become second nature and your photographs become consistently better.