CLOSE-UP PHOTOGRAPHY LECTURE NOTES

By Andy Underwood

An adult cannot focus his naked eye closer than about ten inches (and in old age this gets worse!), though a child can do better by focusing down to about four. Because the actual size of an object in relation to its surrounding space is not the same as we normally get, close-up photographs always give us an exciting visual experience. The camera catches details that are normally missed.

How does one classify close-up and macro-photography? Normally it is in terms of the ratio between the imagine size focussed by the lens and the true size of the subject: 20:1 is the upper limit of a close-up. This is like using a 50mm lens at one metre, (for instance… filling the frame with a medium sized dog). The lower limit of macro-photography is about 1:10, i.e. ten times life-sized magnification, (for instance… filling the 35mm frame with a small ant). Further enlargement is in the field of photomicrography, since a multiple lenses system, like a microscope, is then needed. My microscope, for instance, goes from 16.5x to 1,350x; but usually 10x is the upper limit of the light microscope and the lower limit is 2,000x (this lowest point is due to the wavelength of light, an electron microscope is needed to go smaller). Where is the border between close-up and extreme close-up or macro-photography? This is taken as 1:1; i.e. when the image and the subject are the same height (life-size at **F**ilm **P**lane).

There are ten ways of producing close-ups

1) Using a teleconvertor with a long telephoto lens (This method only applies to a few special cases with professional gear and is not often viable.)
2) Enlarging detail by selective cropping, (This is done in camera, sometimes, by way of non-optical zooming). This requires a high pixel count.
3) Putting a supplementary converging lens in front of the prime lens. The best method of all, given reasonably good lenses.
4) Extending the focal length with tubes. (Drawbacks are low light, focussing and auto-control function problems).
5) Using bellows to extend the focal length even more. (But with similar drawbacks as extension tubes).
6) Using a special close-focusing prime lens called a macro. (Sometimes a fisheye or a super-wide lens also focusses close enough to make a good macro.) Also some macros offer Perspective Control and therefore better DoF.
7) Projecting a subject… (Often sandwiched between glass and sometimes living subjects!!!)
8) Using a lens reversing ring. (Needs an aperture control ring on the lens and usually causes focusing to require camera movement with a Focus-slide).
9) Putting a wide-angle lens in front of the prime lens with a double-male filter ring to make a compound lens system. This depends on which two lenses you choose, but it can be very useful.
10) Using special cameras and microscopes, for example dental and opticians' cameras, or even an electronic slide copier, mostly for photomicroscopy of very thin subjects on microscope slides. And there are experimental cameras being tested that may extend the DoF by computer control. These have an array of sixteen microlenses around the main lens these capture light angles so that a computer can reconstruct out of focus areas.

The Ten Methods explained:

1) Using a teleconvertor with a long telephoto lens

Those who are committed to photography to the point of owning a large aperture, long telephoto, like the f2.8 400mm Nikkor can now buy a teleconvertor of sufficient optical quality to take good close-ups. For example, I showed an image of a key that measured 65mm long, (about 2:1 magnification i.e. ½ life size at the film plane.) that I had taken from 2.6 metres away using an equivalent 800mm lens. A full size 800mm Nikkor lens would only focus down to 6.7 metres. A teleconvertor allows you to photograph close-ups that the focussing device on a normal telephoto lens cannot accommodate. An 800mm lens would need to travel 400mms internally to focus down to 2:1 and would then be about 1.2 metres long!

Normal cheaper teleconvertors are rather disappointing for close-ups because the closer they are focussed the softer they become. Teleconvertors need to be matched with suitable lenses.

2) Enlargement

One might think that close-ups are easily accomplished by simply increasing the enlarger to paper distance and blowing-up a small area of an ordinary negative using a fine grain film in traditional photography or, in the case of digital cameras, using a small portion of a high pixel count CCD and cropping off the unwanted detail around the edges. This has, in my experience, a limited application, as many shortcomings soon become apparent. You will need a fairly expensive camera lens capable of high resolving power (most zooms are definitely out!). Then it is best to allow at least twice as much depth of field as would be needed for a standard enlargement; therefore it is impossible to use much less than f/11 on the camera. (**NB** Focal length and Depth of Field are not related, please see my later remarks about DoF). The outcome of this is slow speed films (with low ISO numbers) or in digital, small apertures and so long exposures. Therefore you need to use a tripod or powerful flash. The calculation of flash at close range is very tricky and the automatic flash feature on most cameras is inaccurate at distances closer than about one metre. It all takes advanced planning and moving subjects are out; in addition, the small area of an image on the screen is incapable of showing good detail and tone separation; however small blemishes will show up wonderfully when over-enlarged!

In digital, **you should always work in RAW** and if you can work like that; (this will enable a greater amount of computer sharpening and contrast control etc.) then, if you have a ten mega pixel CCD on your camera (or more), you will probably be able to get away with using only about one tenth of the original area.

A sixteen megapixel camera can produce paper enlargements up to A2 size at 300 dots per inch (i.e. at very best quality). So for an A4 size print you could use one quarter of the image area (for perfection) and even one eight of the image area is still very acceptable. Club projection standard **1,620 x 1,080** is only 1.7496 megapixels and so only about one tenth of the pixels on a 16.2 megapixel camera like mine. There is little point in having more than 16 megapixels on a 35 mm full frame camera as this number gives near perfect focus with a typical 400 lines per millimetre of a modern high resolution lens. Any more pixels are simply wasted and can actually degrade the image through the introduction of false colour artefacts, such as chromatic aliases, zippering (abrupt unnatural changes of intensity over a number of neighbouring pixels) and purple fringing. (All of which then have to be removed by a computer algorithm.)

Sometimes this enlargement of detail is done “in camera” by non-optical zooming. Many cheap compact digital cameras only have a short range of optical zoom but can electronically extend the telephoto end of their zooming scale. However, whether they can focus close-enough to be true macro lenses is another matter entirely!

In general, the cropping-away method has little to recommend it unless you have an excellent image to start with. We now come to the four most commonly used methods of making close-ups.

3) Supplementary lenses

Converging lenses, which shorten the focal length of a prime lens and are added onto the front of the lens barrel like a filter, are very popular for close-ups. Although extension can sometimes be used with non-reflex cameras (that happen to have removable lenses) assuming careful measurement of camera to subject distances; supplementary lenses are usually the only method available to cameras with non-removable lenses.

Supplementary lenses do have some advantages in that they do not require additional exposure, are easy to carry around, simple in operation, and give perfectly good results when stopped well down. (This condition is fundamental to close-up photography; to achieve sufficient depth of field you are often confined to using smaller stops than f/11).

Low-power supplementaries naturally have a far wider range of focus than high-powered ones and are thus easier to use by measurement. It is advisable to use high dioptre lenses only with a DSLR, because of framing inaccuracy with range-finders unless Live-View is possible, or a field-frame is used.

This close-up method is restricted to low power close-ups as a 1:1 magnification would require a twenty dioptre supplementary lens on a 50mm! Extreme magnifications are impossible with these add-on lenses alone; nevertheless for increased magnification two or more supplementaries can be added together, with the most powerful nearest to the prime lens's front element, but optical quality is lost.

To some extent any lens can be used as a supplementary with a DSLR. For instance, I have obtained good results with an old enlarger's condenser lens that happens to be a perfect fit over my rubber lens hood. You can have fun with many curiously, distorted close-ups using the bottoms of glass tumblers, etc., in this manner.

Half-field Lenses are supplementary lenses that have been sawn in half. They enable both close focus and distant focus on the same frame. However the dividing line is a distracting diagonal blur. A similar effect is easier to obtain by using a fisheye or ultra-wide lens as a macro lens. (*see Macro Lenses, further down).

Tip… **Closing the right dioptre power for your lens.** If your camera lens focusses down to half a metre, you should choose a two dioptre supplementary lens. If it focusses to 33 cms choose three dioptres; 25 cms choose four dioptres; 20 cms choose five dioptres and so forth. In this way there will be no gap in your focus range and no fruitless overlap either. The focal length of a supplementary, when main lens is set for infinity, is one metre divided by dioptre power. NB… Focal length is always taken from the **F**ocal **P**lane (**FP** *film plane*, usually marked on the camera body, this is where the sensor is positioned… *46.5 mm from lens flange in Nikons to provide space for the mirror/shutter box*).

4) Extension tubes

The most readily available means, with a DSLR, of extending the focal length of a lens to obtain greater magnification, is by the use of extension tubes. They are cheap, compact and simple to produce with retention of the auto-diaphragm coupling (but not necessarily auto-focus!). With a non DSLR they can also be used effectively (if the lens is removable), since their length is fixed unlike bellows; therefore a field frame to indicate the distance to the subject and its area; is all that is required to enable subjects to be composed and focused.

Tubes share the same disadvantages as bellows; namely loss of effective exposure (because you are moving the diaphragm that controls the aperture further away from the film plane) and some degree of decrease in optical quality. The latter is caused by any lens design having good correction when working at its intended focal length (i.e. when focused at or near infinity); but performance falling of badly, when rays of light from the subject are no longer parallel due to the closer subject proximity. **Chromic aberration** is the chief problem of lens extension, please look this up because these notes are already becoming rather too long.

Extension tubes are also great for making Pinhole Cameras!

5) Bellows

This method is often confined to use indoors, as bellows are not very portable and are easily damaged. However this is no drawback, as I strongly recommend that, if possible, most subjects should be brought indoors away from wind-shake. A close-up can usually be much better lit and composed on a table top.

The chief advantage of the bellows is that the subject distance is not fixed; this is not the case with extension tubes where only a small degree of variation is possible, by using the focusing ring on the lens. A combination of both extension methods is usually used for extreme close-ups. Unfortunately Nikon was just about the only manufacturer who still made bellows and they have now ceased manufacture. However, if you have a redundant enlarger, you can easily make a bellows adapter for your camera by using those camera body mounts made by cheap independent lens makers. You will also find that the old enlarger lens is a pretty good macro lens.

6) Close-focusing prime lenses (Macros)

Many modern lenses do focus closer than the 20:1 upper limit, e.g., some 50 mm standard lenses go down to half a metre about 10:1, and are thus a good proposition for the larger close-ups.

The problem with going closer for a normal lens is that the degree of extension required rapidly increases toward this end of the scale; soon becoming impossible with conventional helical focusing rings.

Similarly the exposure alters rapidly; one loses 1/10th of a stop when focused down to 20:1, increasing to ¼ of a stop at 10:1. This loss can be disregarded, but beyond this point the effective aperture is altered so much as to noticeably affect exposure and a camera has to become more complicated to cope with this.

However, there are special prime lenses called **Macro Lenses** designed for extra extension with auto correction of the exposures; these usually focus from infinity down to 2:1 or even 1:1, but are expensive. They undoubtedly take very good close-ups, but seldom extend into the realm of extreme close-up. As they are designed for the purpose, they are much better at short ranges than normal lenses.

In choosing one, look for a macro lens with as small as possible minimum aperture (f32 or more), the maximum aperture is unimportant, except for the fact that large apertures make focussing easier (particularly autofocus, which will not even work with apertures smaller than f8). Typical macro-lenses for full frame 35mm are made from 50 to 200mm focal lengths; the longer ones are handy as they have greater separation between the front of the lens and the subject. Because of the complexity, there are only a few good macro-zoom-lenses, though I can recommend the AF Micro Nikkor ED 70-180mm f 4.5/5.6.

The AF- Micro Nikkor 105 mm f 2.8 G is unique because it works well with the latest Nikon Mk3 teleconvertors, except for minor auto-focus problems at very close range.

PC Macro lenses are also made and by shifting a lens off-centre it is possible to alter the DoF dramatically.

Ultra-wide and fisheye lenses are often able to focus very close, because it is easy to provide a 14mm lens with 14mm of travel in its focussing mount, and this would be enough to enable it to focus to 1:1. However, a 50mm lens has to move 50mm to focus to life-size and likewise a 400mm lens would have to become 800mm long to give the same life-size magnification. If you use an ultra-wide lens, (particularly if it's a prime and not a zoom), you can focus on macro subjects a few inches away but also because of the wide perspective you can capture the background detail as well. This gives very wide angle lenses a useful macro role.

7) Projected Subjects

That old slide projector or even better, an enlarger from the pre-digital age, can be helpful. You can place a suitable subject, either on a microscope slide, or between the two glasses of a transparency mount and then into an enlarger tray to make a print; either negative on bromide paper or positive on slow sheet film like Kodaprove. This is, strictly speaking, a photogram; but it could be printed with a straight negative to make an interesting combination. Or you can re-photograph the projected image with a digital camera.

With coloured subjects, like small flower petals, I often project the pressed subject onto a flat matt-white wall and photograph this to make a digital picture. For this one needs a sturdy tripod and camera set up as close as possible to line of the projector. With 200 ISO exposures will be around 1 second at f/4 to f/8, so a camera with slow shutter speeds is needed. Also use the artificial light white balance (T) (or a blue light-balancing filter, if your camera settings cannot alter the white balance) otherwise the results will look terrible!

Alternatively one may use a slide duplicator to copy the pressed subject. Recently very high ISO speeds are becoming available; the Nikon D3 for instance can reach 25,600 ISO and the Nikon D4 and Df can both reach 204,800 ISO; so now photographing a projected image is much easier, even if it is moving!

Your enlarger or a large format non-auto slide projector can take a **Wet Cell**. Which is, quite simply, two glass plates bound together, but kept apart by a length of thick walled rubber tube shaped into a "U" or even a suitable "O" Ring seal such as fitted on high pressure joints. Thus a thin mini-aquarium is formed and can be filled with small live aquatic insects, etcetera. So now you can have real fun projecting live organisms onto a wall or floor and take shots with a high-speed digital camera; they often look like beasts from Alien! This is also a good technique for movies, (but it is best slow the action down with a fast frames per second speed if your video camera allows this).

8) Lens Reversing Ring

To overcome the optical disadvantage of extending a lens with tubes or bellows, many manufacturers supply a reversing ring, for use when extending lenses; especially for greater than 1:1 magnification. Since the rear of the lens becomes the front, light rays from the subject will travel in directions closer to those for which the lens corrections were calculated. This often improves performance dramatically. One must remember to manually stop down the lens before each exposure, because the auto diaphragm cannot be tripped by the camera if the lens is reversed.

Also if you have a reversing ring you can just slip it in your pocket and use it for rapidly converting any prime lens to a close-up device. Most lenses (except telephotos) if put on backwards have a magnifying effect, (particularly if they are wide angle), depending on the distance from the first element to the ring. However, focussing is seldom possible because the front element is usually fixed. Therefore, it is best to move the camera in and out to achieve focus and a **focus-slide** (a rack that tracks the camera back and forth) is very helpful for this.

A small reversing ring used like this on its own is very handy for an SLR user because it is harder to break than a supplementary lens. However, recently manufacturers have caused a problem in removing the aperture setting ring from the lens. So now, new lenses frequently stop themselves down as soon as they are removed from the DSLR and become hard to focus and adjust for aperture.

A **Focus Slide** is also essential for **focus stacking**. This is a multiple exposure technique where repeated exposures of a subject are taken at different focus settings and then combined to give greater DoF. By my own experiment this is best done in the case of Macro photography by moving the subject on a focus slide in steps toward the fixed camera. The other ways would be to move the camera towards the stationary subject or change the focus between exposures using bellows. **HDR (High Dynamic Range)** is another multiple exposure stacking technique, but in this case different exposure values are used to give a wider tonal range and no change of focus is employed. HDR is seldom employed in close-up photography, whereas focus stacking is popular. However, at higher magnification than 6:1, I think, you would need a very heavy camera and subject precision optical bench. Between 20:1 and 6:1 **Focus Stacking** is well worth trying as I am sure Graeme will tell us.

9) **Putting a wide-angle lens in front of the prime lens with a double-male filter ring to make a compound lens system.**

Of course it is quite possible to use one of your wide-angle lenses as a supplementary lens in front of your normal or telephoto lens if you can find a suitable male to male filter thread adapter. In this technique it is usual to put the longer lens on the camera and the wider lens in front because mounting the other way around will cause vignetting. Wide angle lenses have a high dioptre power and hence give good magnification. It is well worth trying out this double lens technique, if you own several lenses a cheap adapter is all you need to link them together. The front lens should be left wide open and this is a problem with some newer lenses that stop down to minimum aperture by default and have no aperture ring on the lens to open them up again.

It is possible to separate the two lenses with a bellows to make them far apart and therefore higher magnifying, exactly like a microscope. However this usually results in extensive vignetting and is totally impractical.

In theory, you could also make a three-lens compound-optical system. This is what happens when you look down a microscope, as you have the objective lens, the eyepiece lens and the lens in your own eye. However, a three lens camera system would lead to empty magnification, unless it was very well-designed. In fact, Carl Zeiss Inc. make a complex photo-microscope that does use a triple compound optical system. (It's not cheap!!!)

10) **Microscopes and other special optical systems**

For greater that 1:4 magnification, it is best to use a special tool like a dental or opticians' camera or a wide-field (dissecting) microscope or standard microscope. This is only touched on by my present talk, because it is a vast subject. However, there is one gadget that makes a good job of photographing microscope slides… that is the digital slide copier. They cost under NZ$ 200, connect to the USB port, and can photograph up to at least 800 dpi. They can take standard glass micro-slides but suffer from limited DoF and the inability to shift focus.

Finally I leave you with an important note about DoF. If you can understand this simple scientific fact, it will make you a far better photographer…

How does Depth of Field vary with different lenses?

This is a trick question, because ***DoF never varies,*** **if you stick with similar quality lenses of different focal lengths.**

If you take a 50 mm lens on a plate camera (10" x 8") it is a fisheye and for a given magnification say 20:1 it will have a DoF between 90 cms and 110 cms at f8. You will still have the same DoF of about 20 cms on a 6x7 camera but it will now be an 85° wide angle. On a 35mm camera it will be a 46° normal lens but still have 20 cms at f8 when the magnification is 20:1 (i.e. focussed at one metre from the Film Plane). And so on down the scale until on a phone camera the 50mm lens would act like a 1,000mm telephoto! All that changes is the camera to subject distance to enable the degree of magnification required, (and the perspective width).

What the above means, is that there is an optimum f stop to allow sufficient DoF for any given subject depending on how close you must get to the subject to fill the frame. For instance, if you use a 50mm lens to make a head and shoulders portrait, you can use f8 to ensure enough DoF to bracket the whole head in focus from one metre away. If you move back to two metres, you will have to change to a 100mm telephoto to fill the frame to the same amount (head and shoulders only) and at two metres and f8 the 100mm lens gives the same DoF as you get with a 50mm lens focused at one metre, or for that matter a 25mm wide-angle lens focussed at half a metre (to frame the same head and shoulders only). The DoF never changes for any given aperture, **regardless of the focal length used** assuming you move to whatever distance (subject to camera) to fill the film frame with the subject. (And assuming you use the lens straight… *see PC lens below).*That is not to say all lenses are equally sharp. Good sharp lenses cover bigger and bigger formats. However, DoF is due to the angle of the light hitting the sensor, as determined by the size of hole it passes through; not simply the sharpness of the lens. Also, the DoF is set by a subjective value called the acceptable circle of confusion, so in the case of high quality lenses images have better contrast and focus than cheaper lenses overall and DoF limitations are less noticeable and greater enlargement by cropping is possible.

This means that aperture setting is the most important consideration when getting close to the subject. Most subjects have an ideal aperture to enable them to be completely in focus but sufficiently out of focus from the background, if you intend to fill the frame. For instance, f8 is okay for human portraits but f11 is needed for small pets, f16 for little birds, f22, for big insects, f32 for spiders (with their long legs), and even f45 will only give you a couple of millimetres DoF at 1:1. All this is true whatever the focal length of lens you choose, provided it is good quality. I am not saying that all possible lenses have similar DoF at a given f stop, merely that if you have a focal range of similar quality lens by the same manufacture, then DoF follows closely with the chosen aperture <u>for a given magnification</u>. What causes poor enlargement and bad DoF is low resolution lenses like those plastic ones on a mobile phone, despite the fact that they require no focussing because their apertures are so small.

The best solution to low DoF in close-ups might seem to be focus stacking. However, **lens tilting** to move the point-of-focus off axis would probably be a better solution. Nikon now make **24mm, 45mm and 85mm Perspective Control macro-lenses**, to enhance the DoF by shifting, but I have not tried them yet.

Good luck with your own micro-world exploration… Andy