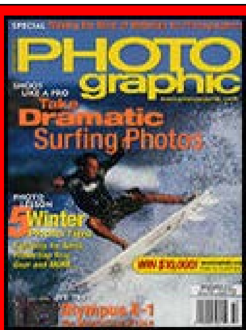

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Photographic Super Course: Macro Photograqphy

The Editors, April, 2003

Scarlet Macaw feathers were photographed at 1:2 (half life size) using a Nikon 105mm macro lens at f/32, with illumination from an off-camera electronic flash unit connected with a sync extension cord.

Tree frog, 60mm Micro-Nikkor lens, 1:2, off-camera flash.

Cactus flower at 1:2, 1:1 and 2:1 (the latter achieved by adding a tele-extender to the 105mm Micro-Nikkor lens).

Photos by Jack and Sue Drafahl

One of the most common bits of advice drummed into new photographers is "get closer to your subject!" In that context, it means that novice shooters generally shoot from too far away, so their subject is lost among all the other stuff in the picture. Macro (or close-up) photography takes this to the extreme: shooting subjects from closer than is possible with normal camera lenses. Macro photography lets you explore new worlds, and create exciting photos as you do so. You can zero-in on a small portion of a large subject to create an interesting abstract image, or fill the frame with a tiny subject. Either way, close-up photography enables you to produce images that you can't see easily with your unaided eye.

Close-up photography does require some special equipment. But this equipment isn't all costly. There are a number of ways to get closer: close-up lenses, extension tubes, bellows units, macro lenses and more. Here are the pluses and minuses of the various ways to get close.

Macro Lenses

The easiest (albeit not the least costly) way to do close-up photography is with a macro lens, because you operate in the same manner as for normal photography—the macro lens just focuses a lot closer than standard non-macro lenses do. Most macro lenses today will focus close enough to produce life-size (1:1) images on the film (most of those that don't come with a "life-size adapter," a short short extension tube—more on extension tubes in a bit—that enables them to do so), but they'll also focus out to infinity just as standard lenses do, something

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Digital Camera HQ: See prices and reviews of digital cameras.

Macro lenses focus much closer than standard lenses of similar focal length, generally close enough to produce a life-size (1:1) image of the subject on film. Shown is Tamron's SP AF90mm f/2.8, a short-telephoto macro lens whose focal length is also ideal for portraits.

Longer macro lenses, such as this Pentax SMCP-FA Macro 200mm f/4 ED[IF], allow you to put more space between you and your subject—handy when the subject is hazardous, or you want more lighting flexibility.

While many zoom lenses are touted as "macro" zooms, few provide true macrofocusing capability. This AF Zoom Micro-Nikkor ED 70-180mm f/4.5-5.6 actually does: it focuses down to larger than 1/2 life size.

Close-up lenses screw onto the lens' front just like filters.

that can't be done with other close-up devices. Macro lenses are also optically optimized for close shooting distances, so they produce great image quality in close-ups (as well as excellent results at normal shooting distances).

Macro lenses come in standard (50-60mm), short telephoto (90-105mm) and moderate telephoto (180-200mm) focal lengths. Longer macro lenses will produce a given magnification from farther away than a shorter macro lens will. A 200mm macro lens will produce a life-size image from 4X as far away as a 50mm macro lens—handy if your subject is a deadly snake or a skittish insect, and giving you more room to position your light source (if you're using artificial lighting, such as electronic flash). If you're interested in close-up work, and don't already have a telephoto lens, a macro tele would be a great choice (the short macro teles are great for portraits, and the longer macro teles are great for action shooting, too).

Of course, nothing is without its drawbacks, and macro lenses have theirs: lack of lens speed compared to nonmacro lenses of equal focal length (most have a maximum aperture of f/2.8, which is pretty slow for a 50-60mm lens), added bulk, and higher cost.

Many zoom lenses are touted as being "macro." Most really aren't—they'll focus only close enough to produce 1/4- or 1/5-life-size images on the film, and macro really means life-size (or at least half life-size) images on the film. But there are a few that come close to true macro, including Nikon's AF Zoom-Micro Nikkor 70-180mm f/4.5-5.6D ED, which focuses down to 1:1.32 (3/4 life-size), and Sigma's 70-210mm f/3.5-4.5 APO Zoom Macro, which provides a 1:2 (half-life-size) image size at its macro setting.

A No. 1 close-up lens lets you focus one meter away, a No. 4 lets you focus 1/4 meter away, and a No. 1 plus a No. 4 equal a No. 5 and let you focus 1/5 meter away from the subject. These distances apply when the camera lens is focused at infinity, and hold no matter what the focal length of the camera lens. So this No. 1-No. 4 combo on a 200mm lens lets you focus down to 1/5 meter (about 8 inches)—lots of magnification from a 200mm lens.

A split-field lens is just a close-up lens cut in half and mounted in a threaded ring. Like close-up lenses, split-field lenses are available from several manufacturers, including the producer of this one, Hoya.

Close-Up Lenses

Close-up lenses are the simplest and least-expensive way to get your camera lens to focus closer than its normal minimum focusing distance. These filter-like devices are actually plus-diopter elements similar to those used in eyeglasses to correct farsightedness, and just as the eyeglasses enable the eyes to focus on closer objects than they normally can, close-up lenses enable the camera lens to focus on closer objects than it normally can. Like filters, close-up lenses screw into the front of the camera lens.

The strength of a close-up lens is expressed as a diopter number. The diopter number indicates how close your camera lens can focus with the close-up lens attached, in fractions of a meter. A +2 close-up lens will let you focus 1/2 meter away, a +3 close-up lens 1/3 meter away, and so on. These distances apply regardless of the focal length of the camera lens—a +4 close-up lens will let you focus 1/4 meter away whether attached to a 50mm lens or a 200mm lens. Note: These focused distances are based on the camera lens being set at infinity. When the camera lens is focused closer than its infinity setting, the combination of camera lens and close-up lens will focus even closer.

Close-up lenses are available individually or in handy sets that contain three lenses: +1, +2, and +3 or +4. To focus even closer, you can combine close-up lenses: for example, a +1 and a +4 equal a +5 (you can focus 1/5 meter away). Attach the higher-numbered close-up lens to the camera lens, and the lower-numbered close-up lens to the higher-numbered one for best results.

Naturally, the longer the focal length of the camera lens, the larger the image at a given camera-to-subject distance. A +2 close-up lens attached to a 200mm camera lens will produce a much greater magnification than the same +2 close-up lens attached to a 50mm camera lens.

Close-up lenses offer the advantages of simplicity, relatively low cost and no exposure compensation required, but they also have a couple of limitations. First, close-up lenses won't give you much more than life-size (1:1) magnification, and second, close-up lenses cause a loss of image quality, especially around the edges. This loss of sharpness becomes greater as the strength of the close-up lens increases. For really serious close-up work, extension tubes and bellows are better choices. (Note: Stopping the camera lens down improves sharpness when using close-up lenses. And there are two-element close-up lenses that provide better image quality, especially with telephoto lenses.)

There are some neat devices called spit-field lenses. These are close-up lenses cut in half and mounted in a threaded mounting ring. They allow you to focus on a very near subject (through the close-up lens half) and a distant one (through the empty half) simultaneously.

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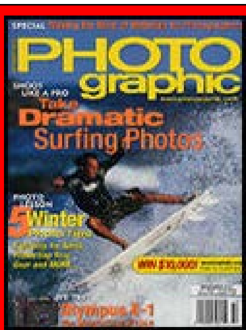

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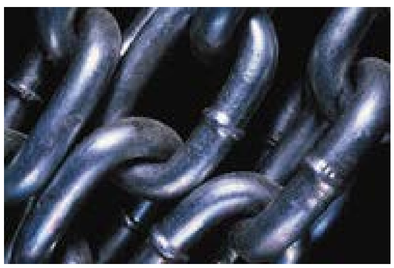
A 5:1 magnification of tips of a very small succulent plant, taken with Canon's unique MP-E 65mm 1-5X Macro Photo lens.



A 1:2 shot of a small chain, like the shot at left taken with a Canon EOS Rebel camera and MP-E 65mm 1-5X Macro Photo lens. Lighting for both shots was from a flash unit held off to one side.

Extension tubes are just spacers that fit between the camera body and the lens. They increase the distance between the optical center of the lens and the film, allowing you to focus closer and thus increasing magnification. The longer the extension tube (or the shorter the camera lens), the greater the magnification. You can combine extension tubes to increase magnification.

1. $F = FL/A$
2. $FL = 50mm\ LENS + 50mm\ EXTENSION\ (100mm)$
3. $A = 50mm/f/8 = 6.25$
4. $F = 100/6.25 = f/16$

When you increase the distance between the optical center of the lens and the film plane, as when using extension tubes, you

Extension Tubes

Not terribly exotic in theory, extension tubes are just light-tight spacers that fit between the camera body and the lens. They don't contain any glass elements; they merely increase the distance between the optical center of the lens and the film, thus producing magnification of the image. Since they contain no glass elements, extension tubes don't degrade image quality as close-up lenses do. For greater extension (and thus, greater magnification), you can combine two or more extension tubes.

The extension tube attaches to the camera body; the lens attaches to the extension tube. The degree of magnification depends on the length of the extension tube relative to the focal length of the lens being used with it. When the extension tube is the same length as the focal length of the lens attached to it (for example, a 50mm extension tube with a 50mm lens), a life-size or 1:1 reproduction ratio results: the image of the subject will appear life-size on the film. If the extension tube is longer than the focal length of the lens, greater-than-life-size magnification is achieved.

From the foregoing, you can deduce that the shorter the focal length of the camera lens, the greater the magnification produced by a given extension tube. A 50mm extension tube with a 50mm lens yields a life-size image on the film; the 50mm tube with a 24mm lens yields a twice-life-size (2:1) image. The instruction manual that comes with the extension tubes contains tables that indicate what the magnification will be with a given tube and various camera-lens focal lengths, but it's easy to calculate for yourself: Just divide the length of the extension tube by the focal length of the lens, and the result is the magnification produced by the

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also decrease the effective aperture of the lens. Through-the-lens metering will handle this automatically, but if you use a handheld meter, you must compensate. Here's the formula, and an example, using a 50mm lens and 50mm extension tube. (One wag pointed out that you could use a 20-foot pipe as an extension tube—if you could figure out how to attach the camera and lens to its ends—and get an incredible amount of magnification. But the light loss would be so great, the exposure would be Saturday at f/8.)

Life-size (1:1) bumble bee on flower, courtesy of a 105mm Micro-Nikkor lens. Lighting was from a single flash unit held to one side and connected to the camera via an extension sync cord.

Blacklit fluorescent crayons were recorded with a 60mm Micro-Nikkor lens on ISO 1600 color-print film. The exposure was 2 seconds at f/16; the camera was mounted on a tripod for the long exposure.

A bellows unit if in effect a flexible, variable-length extension tube.

combination (for example, a 50mm tube divided by a 200mm lens focal length equals an 0.25X or 1/4-life-size "magnification").

When you increase the distance between the film and the optical center of the lens (as is the case when you are using extension tubes or the soon-to-be-discussed bellows units), you also reduce the amount of light transmitted to the film, because the diameter of the lens aperture is smaller relative to the overall focal length of the lens/extension combination. Fortunately, your camera's built-in through-the-lens exposure meter will automatically compensate for this loss of light. But if you use a hand-held meter, you must remember to compensate for the loss of light caused by using the extension tube(s) or bellows. The formula to do this is fairly simple: f = FL/A, where f is the effective f-number of the lens/extension-tube combination, FL is the effective focal length of the combination and A is the diameter of the lens aperture. Here's an example: If you're using a 50mm extension tube with a 50mm camera lens set at f/8, FL = 100mm (50mm lens plus 50mm tube), and A = 6.25mm (50mm lens divided by the set f number of f/8). Therefore, f = 16 (100 divided by 6.25). This means that, when the 50mm lens is set at f/8 and attached to a 50mm extension tube, the effective f-stop of the combination if f/16—two stops smaller than f/8. So you must give the shot two stops of additional exposure to compensate for the light lost due to the extension. Aren't you glad that 35mm SLRs come with built-in TTL meters that compensate for this light loss automatically?

Some extension tubes and bellows are not "automatic." This means the linkage between the camera and lens that tells the built-in meter which aperture the lens is set at is disconnected. With nonautomatic extension tubes, you must use stopped-down metering, whereby you stop the lens down manually to the selected aperture, so the meter can read the light actually transmitted by the lens/extension-tube combination at that aperture. See your camera or extension-tube manual for specifics.

Aside from the light loss caused by the

The camera attaches to the bellows unit's rear standard, the lens attaches to the front standard, and the bellows unit attaches to a focusing rail that mounts on a tripod.

A very useful bellows accessory is a macro stand, which holds both camera and subject in position for sharp, precise close-up images. Special bellows lenses, such as the one shown here, can yield magnifications up to 25X with the bellows unit.

extension, the biggest drawback to extension tubes is that the lens won't focus out to infinity when attached to one—but, then, you aren't using extension tubes to shoot distant subjects; you're using them for close-up work. Note: The camera lens won't focus out to infinity when a close-up lens or bellows is attached, either.

Bellows Units Essentially a flexible, variable-length extension tube, a bellows unit will provide magnifications up to about 4X life size on the film with a standard 50mm camera lens, and up to 25X life size with a special bellows lens.

The unit consists of an accordionlike bellows with a camera mount on one end and a lens mount on the other, and a support rod to hold the mounts. The camera body attaches to the camera mount (generally referred to as the rear standard). Some bellows permit the camera body to be rotated for easy vertical-format shots. The lens attaches to the bellows' front standard.

The entire bellows assembly attaches to a focusing rail, which in turn attaches the assembly to a tripod. The knob on the focusing rail gradually moves the whole assembly forward or backward for precise control of focusing. The focusing rail is marked in millimeters so you can readily figure out how much extension is being used, and set the desired amount. Tables in the bellows instruction manual tell you how much extension to use to produce a given magnification with a given lens, and how much exposure compensation is necessary. You can mount the bellows on the focusing rail sideways and use the focusing rail to move the camera to shoot several frames of a subject that is too large to cover in one shot, while retaining a precise magnification.

A rotating lens standard, available on some bellows units, allows you to reverse the lens so that it points toward the camera with its rear element facing out. Reversing a normal lens provides slightly greater magnification, and sharper results in close-up work.

For extreme magnification, there are special bellows lenses. These have no focusing mounts of their own; they rely on physical movement toward or away from the subject for focusing. But in practice, so does any lens attached to a bellows. Bellows lenses are optimized for high-magnification work, and are a good choice for really serious macro shooters.

The main disadvantage of a bellows is the same as an extension tube's—loss of light due to the extension of the lens-to-film distance. As with extension tubes, a 35mm SLR's through-the-lens exposure meter will compensate for this with auto bellows units. Also, the bellows instruction manual includes exposure-compensation tables for various magnifications.

Slide copiers attach to the bellows-mounted lens and permit not only copying slides, but cropping in on them and adding special effects with filters. Note: Simple self-contained slide-duplicators that attach directly to the camera are also available. These are less costly and less versatile than bellows slide copiers. Another very useful bellows accessory is the macro stand, which holds both bellows and subject in position for sharp, precise close-up images.

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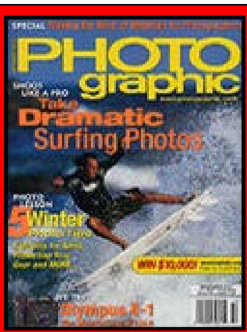


From the Archives

Strawberry a la huge, courtesy of 105mm Micro-Nikkor lens and off-camera electronic flash.

A 1:1 shot of an office date/time stamp, made with the 105mm Micro-Nikkor lens on a Fuji S1 Pro digital SLR and off-camera flash.

Tele-converters, like extension tubes, fit between the camera body and lens. But unlike extension tubes, converters do contain glass elements. Tele-converters increase the focal length of the camera lens, while retaining its original minimum focusing distance, thus providing greater magnification ideal for close-up work

Reversing Rings
A lens-reversing ring is simply a small metal ring with a camera-body mount on one side and a threaded ring into which the front of the camera lens screws on the other. The reversing ring attaches to the camera, extension tube or bellows, just like a lens. The front of the camera lens screws into the reversing ring.

Why use the lens reversed? Because standard (nonmacro) lenses are optically optimized for normal shooting distances, they produce somewhat below-optimum image quality at close-up distances—particularly edge softness due to curvature of field. Reversing the lens produces better results for close-up work, and greater magnification with normal and wide-angle lenses.

Tele-Converters
Also known as a tele-extender, the tele-converter is a handy device that mounts between the camera body and lens and increases the effective focal length of the lens. If you attach a 2X tele-converter to a 50mm lens, you'll have a 100mm lens; attach a 200mm lens to the converter and you'll get a 400mm lens. The most popular converter strengths are 1.4X and 2X.

Most major-brand tele-converters produce good results. There is a slight loss of image quality, but not a lot. Some manufacturers offer matched tele-converters, made specifically for use with a particular lens (or a specific focal-length range). These can produce even better photographic results than general-purpose converters.

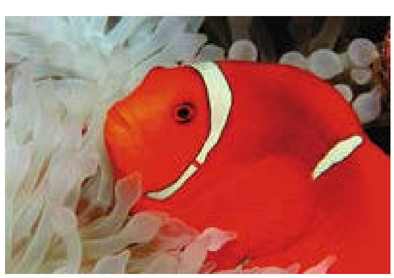
The main drawback of tele-converters is they cause a loss of lens speed. When you attach a 2X tele-converter, the lens becomes effectively two stops slower. For example, attach a 50mm f/1.4 lens to a 2X converter, and you've

CONVERTER	LIGHT LOSS
1.4x	1 stop
1.7x	1.5 stops
2x	2 stops
3x	3.3 stops

The main drawback of tele-converters is that, like extension tubes, they reduce the amount of light transmitted to the film. TTL metering will automatically compensate for this, but when using a hand-held meter, you must increase exposure over the meter's recommendation. This chart tells how much to increase exposure when using various popular tele-converters.

A lens-reversing ring lets you mount the lens on the camera "backwards"—with the mount end out. With normal and wide-angle camera lenses, this results in greater magnification and sharper images, especially at the edges. Just attach the reversing ring to the camera, then screw the lens front-first into the reversing ring.

Here's a 1:1 shot of a shaver head, made with the Canon MP-E 65mm Macro Photo lens and lit with a single flash unit on-camera with a diffusion head.



Rare clown fish captured with 105mm Micro-Nikkor lens, underwater housing, single underwater flash unit with extension cord.

got a 100mm f/2.8 lens. Attach a 200mm f/4 lens, and it becomes a 400mm f/8. Automatic converters that connect to the the camera's metering system will automatically compensate for this loss of light transmission when the camera's through-the-lens metering is used. With other converters, you must meter in the stopped-down mode. When using a separate hand-held meter and a 2X tele-converter, set the lens to an aperture two stops larger than the meter reading calls for: If the meter calls for f/11, set the lens aperture ring to f/5.6 (or increase exposure two stops by slowing the shutter speed).

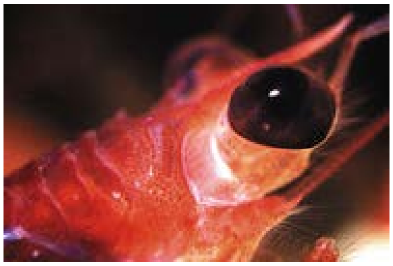
The reason that tele-converters are included here is that the lens's minimum focusing distance remains the same when a converter is used. Thus, if you have a 300mm lens that focuses down to 8.5 feet, it becomes a 600mm lens that focuses down to 4.5 feet when attached to a 2X tele-converter. Because of this, you can get some great close-up images by using a tele-converter.

Close-Up Shooting Tips

When you move in close, you magnify everything—the subject, and the effects of camera and subject movement. To minimize camera movement, it's a good idea to attach the camera to a sturdy tripod whenever possible for close-up work. And trip the shutter with a cable release (or the camera's self-timer, if precise timing of the moment of exposure isn't essential)—the mere act of pushing the shutter button with your finger can introduce enough camera movement to reduce sharpness.

A mirror prelock (if your camera has this feature) will lock the mirror in the up position before shooting, so you can let the vibration caused by the mirror flipping up out of the film path to settle down before you make the exposure. This vibration, although minimal, can reduce image quality when working at high magnifications, especially at

Underwater sea slug, 50mm macro lens, underwater housing and flash.



Extremely rare red crab , photographed with Nikonos-V UW camera, extension tubes, UW flash.

shutter speeds in the one second to 1/30 range. Of course, you won't be able to see through the viewfinder while the mirror is locked up, but for most close-up work, you'll have your composition and focus locked in with the tripod before you make the exposure, so that won't matter.

For hand-held close-up work it's easier to move the camera slowly toward the subject until it comes into focus, rather than trying to adjust focus via the lens' focusing ring. If a specific magnification is desired, set focus for that, then move in on the subject until it comes into focus.

When using extension tubes or bellows, you'll find the image in the viewfinder quite dark because of the extension. To make focusing easier, don't use the central split-image—it will black out. Instead, use the plain ground glass area of the viewfinder. You might carry a small flashlight to help illuminate your subjects for easier focusing.

To minimize blur due to subject movement, use the fastest shutter speed the light level will permit. And since depth of field is extremely limited at close-up shooting distances, you'll generally want to shoot at the smallest aperture possible to maximize it. Of course, short shutter speeds require larger apertures, and vice versa. One answer is fast film—today's ISO 400 films are by and large excellent.

If there's a breeze, you can use a sheet of poster board to shield your subject from it. White poster board makes a good reflector. Dark poster board can be used to block harsh sunlight from the subject.

If you want to use slower, finer-grain (and richer-color) films, there is a way around the fast shutter speed/small lens aperture dilemma: electronic flash. Used at close range, a simple electronic flash unit provides enough light to permit stopping the lens way down to maximize depth of field, while its brief flash duration minimizes the effects of camera and subject movement. An off-camera sync cord lets you move the flash unit off the camera's hot-shoe for more lighting flexibility.

A ringlight flash literally surrounds the lens with light, providing soft, even, shadowless lighting on the subject when such lighting is desired.

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