CHAPTER 5
Focus, Depth of Field, and Lenses

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Key Terms
1:1 Magnification Ratio
Acutance
Aberrations
APS-C Digital Sensors
Barrel Distortion
Circles of Confusion
Close-Up Filter Set
Depth of Field
Depth-of-Field Scale (DOF Scale)
Diffraction
Extension Tube
Focal Length
Focal Length Multiplier
Hyperfocal Focusing
Hyperfocal Distance
Image Stabilization
Macro Lenses
Organization of Scientific Area Committees (OSACs)
Pincushion Distortion
Resolution
Scientific Working Group on Imaging Technology (SWGIT)
Scientific Working Group on Shoe Prints and Tire Tracks (SWGTRAC)
Scientific Working Group on Friction Ridge Analysis, Study and Technology (SGWFAST)
Telephoto Lenses
Vibration Reduction
Wide-Angle Lenses
Zone Focusing
Learning Objectives

On completion of this chapter, you will be able to:

1. Explain the terms “Resolution,” “Acutance,” and “sharpness”;
2. Explain the concept of the “Circles of Confusion”;
3. Explain how to hyperfocal focus on a scene by use of a Depth-of-Field Scale;
4. Explain how to hyperfocal focus on a scene without the use of a depth-of-field scale;
5. Explain how to zone focus on a scene by use of a depth-of-field scale;
6. Explain how to zone focus on a scene without the use of a depth-of-field scale;
7. Explain the three factors that affect Depth of Field;
8. Explain the techniques to maximize depth of field;
9. Explain the various designations of lenses: Focal Length, “fast” or “slow,” and the widest aperture of the particular lens;
10. Explain what a reference to a “normal” lens means;
11. Explain the effects on a photograph produced by Telephoto Lenses;
12. Explain the effects on a photograph produced by Wide-Angle Lenses;
13. Explain the Magnification Ratios related to Macro Lenses;
14. Explain the meaning of the term “Diffraction” and how to minimize its effects on images;
15. Explain the difference between pincushion and Barrel Distortion.

FOCUS

An entire chapter devoted to focusing! How can that be? All you have to do is (1) look through the viewfinder, rotate the focus ring until your subject becomes clear, and take the shot; or (2) set the lens to autofocus, look through the viewfinder, depress the shutter button halfway to have the lens set the focus for the subject, and take the shot.

If the process were that simple, we could move on to the section Lenses. But it is not.

Although situations certainly exist when focusing with one of the preceding two methods is appropriate, on many more occasions different focusing techniques are better choices.

Snapshot shooters will find it unbelievable, but many times it is best to (1) focus the camera without looking through the viewfinder or (2) look through the viewfinder and focus at a location where no evidence exists.

Experienced crime scene photographers understand the concept of focusing on particular areas rather than just individual objects, but others may be confused.

The best way to introduce these new ideas is to point out the obvious. When arriving at a major crime scene or major accident scene, law enforcement photographers photograph not only individual items of evidence within the scene but also the scene itself. The scene itself is an area within which the individual items of evidence are located. Crime scene photographers photograph both crime scenes and accident scenes (areas) and individual objects.

The photographs taken by most people not in law enforcement are very different. Most photographs captured by the general public are of individual items. We photograph our family members, our boyfriends or girlfriends, our pets, a birthday cake, and the turkey on Thanksgiving. Even when the general public photographs more than one individual or object, it frequently is really just “one” thing. Two or three buddies shoulder-to-shoulder are a pair or a trio—one pair or one trio; one grouping. Four bridesmaids lined up for a photograph are more often than not in a tight group or a single line—one group or one line. When we photograph a line of trophies on the mantle, that really is just one grouping of several items.

But crime scene photographers must spend considerable effort capturing images of medium and large crime scenes, as well as individual items within the crime scenes. These crime scenes differ from the subject matter of most photographs. Foreground detail and background detail are present, and all the items of evidence within this area are present.

A new Rule of Thumb is appropriate here.

RULE OF THUMB 5.1

The entire scene, and all the evidence within the crime scene, should be in focus. If you know a part of the scene will be out of focus if the photograph is captured as composed, you should attempt to recompose the scene so the out-of-focus area is no longer in the field of view.
Ensuring an entire area, from foreground to background, is in focus requires very different focusing skills. It is relatively easy to focus on just one item. How do you, however, focus on an area that is 10’, 15’, or 40’ deep? That is partially what this chapter is about.

Why is ensuring that the entire crime scene is in focus important? Ultimately, crime scene photographers take photographs at crime and accident scenes so that, if needed, they will be admissible in court as evidence. A chapter on the admissibility of photographs in court as evidence is provided later in this text. For now, consider just three possible objections a defense attorney might be able to come up with when crime scene photographers try to offer the court a partially out-of-focus image as evidence. The following three “objections” have been created by the author to emphasize the importance of ensuring as much of your image as possible is in focus. The list of court citations in chapter “Legal Issues Related to Photographs and Digital Images,” related to the admissibility of images, both film and digital, do not contain one case in which an image was held to be inadmissible only because it was out of focus. Nevertheless, this author is using these fictitious objections as a means to highlight the importance of focusing to maximize your depth of field (DOF), which is one of this author’s Cardinal Rules.

“Your Honor, I object to this image. It is clearly out of focus” (in the foreground, or the background, or somewhere). “When this photographer was at the crime scene, as he or she looked around the scene, it was all seen in focus. Why are we not afforded the same opportunity to see the scene completely in focus? A partially out-of-focus photograph does not meet the standard of being a fair and accurate representation of the scene. How can it be fair or accurate if parts of the image are out of focus? Exclude this image!”

“Your Honor, I object to this image. It is clearly out of focus” (in the foreground, or the background, or somewhere). “I submit that the crime scene photographer intentionally blurred part of this scene to hide certain items of evidence from us. He made certain that the evidence he thought was important was in focus. How can we ascertain whether other evidence, possibly exculpatory to my client, was intentionally blurred because it did not coincide with his or her premature conclusion that only my client was guilty of this crime? It is common knowledge that photographers intentionally blur parts of photographs to force the viewer to look at just one part of the image area, while hiding other areas of the image area in blur. This photographic trick highlights part of the image and hides other parts. Do not be tricked by this photographer. Exclude this image!”

“Your Honor, I object to this image. It is clearly out of focus” (in the foreground, or the background, or somewhere). “Either the photographer is trying to trick us by intentionally hiding aspects of the crime scene (as in the objection immediately preceding), or the photographer is incompetent, in which case this image should not be admissible as evidence, because you should not allow inferior representations of the crime scene into this trial. If the (insert your own agency name here) thought an aspect of this crime scene was important enough to photograph and to offer it as evidence in this trial, they would have sent an experienced and competent photographer to do the job. Judge, do not accept mediocre work. A blurry photograph is neither a fair nor an accurate depiction of the crime scene. Exclude this photograph!”

Again, these are all fictitious objections. However, they do set the groundwork for the remainder of this chapter, which emphasizes focusing and DOF.

Focusing on individual items of evidence and entire crime scene areas are two different skill sets. Both are critical.

**Resolution, Acutance, and Sharpness**

Before focusing techniques are explained, you must first understand what it is to be “in focus.” To do this, it is necessary to differentiate three terms: “resolution,” “acutance,” and “sharpness.” Images are often said to be “in focus” or “sharp” or “clear” as if these words all meant the same. Let us be a bit more precise.

**Resolution**

Camera resolution is the ability of the camera system, which includes the lens optics, camera sensor, and image-processing software, to distinguish, or “resolve” groups of alternating line pairs as the lines become increasingly thinner and they become increasingly closer together.

The classic line pair consists of a black line and a white line. As multiple line pairs become thinner and closer together, at some point the distinction between the black lines and the white lines will become less distinct; the result becomes a blending into gray.

A variety of resolution charts are available to measure relative resolution. Fig. 5.1 shows an example. In Fig. 5.1A, a section of a resolution chart is encircled with a red oval, which is enlarged in Fig. 5.1B. The blending of the white and
black lines into gray is not an example of blurring from motion; it is an example of the inability to properly “resolve”
the individual white and black lines.

You can compare the relative resolution capacity of different lenses when used on the same camera body or the same
lenses when used on different camera bodies. You can also compare one manufacturer’s camera body with its highest
grade of lens at one particular focal length with another manufacturer’s camera body and lens.

At one time, the particular interest in most photography magazines found on grocery store and drugstore shelves was
the comparison of resolution between film cameras and digital cameras. Digital camera websites were also frequently
discussing this question. Law enforcement agencies had also constantly asked, “Do digital cameras have the same
resolution as film cameras yet?” The answer to those questions has been determined: digital cameras with megapixel
counts at or above the 13.5-MP level certainly can match the resolution once enjoyed exclusively by only film cameras.

RESOLUTION STANDARDS/GUIDELINES

Are official standards offered for the minimal digital resolution necessary to do a particular job? Yes. One standard is
not used for crime scene photography, however. It relates only to the electronic transmission of 10-print facsimiles.

When Automated Fingerprint Identification System (AFIS) computer networks were developed, it was necessary to develop
a standard by which copies/facsimiles (faxes) of 10-print cards could be sent from one jurisdiction to another. One jurisdic-
tion may have a freshly developed a latent fingerprint from a crime scene that was tentatively “matched” to a known print in
the files in another jurisdiction. As a point of clarification, AFIS systems do not make “matches.” They come up with a list of
“candidates” that have similarities to a latent print of interest. Only latent print examiners can make identifications. Unfor-
tunately, in the popular media, such a “candidate” is frequently misnamed an “identification.” So that a latent print expert
could confirm this “match,” the 10-print card had to be faxed to the jurisdiction holding the crime scene print. A minimum
standard for the quality and resolution for the fax machine had to be developed. The National Institute of Standards and
Technology (NIST) ultimately decided on 1000 pixels per inch (ppi) at 1:1 as the minimum resolution.

A 1:1 Magnification Ratio occurs when an item of evidence is life size on a sensor. As stated previously, the full-sized
digital sensor is 24 × 36 mm in size, the same as film had been. A single-digit fingerprint fits nicely within the bounds
of a 24 × 36 mm area, also understood to be 1” × 1.5” (Fig. 5.2).

As long as the fax could produce 1000 ppi resolution, it could adequately transfer copies of 10-print cards through the
wires. It is probably improper, however, to consider this fax resolution a standard to apply to crime scene photography.
Therefore, (1”) (1000) × (1.5”) (1000) would be the necessary resolution for a digital camera to adequately capture a
single-digit fingerprint; 1000 × 1500 = 1,500,000, or 1.5 MP.

Today, when single lens reflex (SLR) digital cameras are readily available in 16 MP up to 24 MP, this seems like an easy
standard to be bound by. It is a deceiving standard, however. What if the evidence necessary to be captured by a digital
camera is larger than (1”) × (1.5”)? If this same standard was used, what would this mean if an item of evidence fits
within a (2”) × (3”) area? Because this area is twice the area of (1”) × (1.5”), does this not also mean the digital resolu-
tion is simply doubled to require a 3-MP camera? No.

Consider this: 2” (1000) × 3” (1000) = 2000 × 3000 = 6,000,000, or 6 MP. Doubling the size of the evidence requires
quadrupling the resolution of the digital sensor. That means photographing two adjacent fingerprints would require
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It must be mentioned that as this third edition is being prepared for publication, in the summer of 2016, all the previous Scientific Working Groups have been reimagined into the US Department of Justice (DOJ) and the NIST Organization of Scientific Area Committees (OSACs). A specific SAC covers disciplines related to Physics/Patterns, including subcommittees on Friction Ridges and Footwear and Tire Treads. New guidelines from these two committees have not yet emerged. It is expected that they will be considering issues of the minimum digital camera resolution for various jobs, and printer resolutions necessary to enable the high-quality digital images are replicated in printed photos.

It is interesting to note that just 5 years ago, we were still struggling with determining just when a digital camera had the resolution that film once had. Now, just the opposite has become true. Nikon and Canon cameras can now be found with 36 and 51 MP, respectively.

In a recent photo of a ninhydrin-treated latent print, a 36.3-MP Nikon D810 was used to fill the frame with the image, and the image was captured as RAW + JPG. When the RAW image was processed, it showed the friction ridges just fine but also captured the ninhydrin-stained paper pulp at the same time. Now photographers may have the same problem as DNA analysts are having with “touch” DNA. The DNA technology is becoming so advanced that mixtures are also being recovered. As the resolution of our digital cameras become higher and higher, this may become a constant interference we will have to learn to deal with. How was this background interference dealt with? When the JPG image file was opened, its compression of some of the detail of the image eliminated any view of the stained paper pulp. Who would have imagined we have come to the place where having too much resolution becomes a problem, and the solution is to use a JPG?

Acutance

Acutance refers to the camera’s ability to render a sharp edge of the subject as a sharp edge in the photograph.

This is obviously part of what we think of when we speak of sharp focus and good resolution. Acutance means a clear and precise distinction exists between the edge of one object and the beginning of the adjacent substrate it is on. Referring back to resolution and the line pairs it deals with, if a white line were adjacent to a black line, the edge between them would be crisp and well defined, with no overlap between the two.
The concept of edge sharpness will be revisited in the section Diffraction. Images of sharp-edged items will be shown that do not replicate the sharp edges of the object. The causes and possible solutions to this problem will be discussed later in this chapter.

**Sharpness or Being in Focus**

When you think of an image being in focus, you usually think of light coming into the camera through the lens and converging at the sensor at a precise point. As light makes its way through the lens, it becomes a smaller and smaller circle, which looks like the converging ellipses in Fig. 5.3. When the light comes together as a point on the sensor, that is called “being in focus.”

Fig. 5.4 shows the light coming together at a point in front of the sensor and then continuing on until it strikes the sensor as a small circle. In this case, the image will technically be “out of focus.”

Fig. 5.5 shows the light unfocused until some distance after the sensor. Of course, the light cannot travel through the sensor to focus behind it. But, when it strikes the sensor, it is also a small circle. In this case, again, the image will technically be “out of focus.”

These simplistic graphics are presented to introduce the concept of the circles of confusion. Simply stated, as long as the light, reflected from a single point in space, enters the lens and remains a circle, rather than coming together at the sensor at a specific point, the image can be considered “confused” and “out of focus.” It does not matter whether the light would have become a point in front of or after the sensor. If a circle of light is formed on the sensor, the result is an “out-of-focus” image.
Of course, the concept of DOF is temporarily being ignored, which is the extended area in front of and behind the plane of precise focus that still appears to the eye to be in focus.

Consider this explanation of the circles of confusion to be the purely mechanical definition of a point in critical focus. We will get to DOF soon.

**Manual Focusing**

When the word “focusing” is mentioned, most people think of the manual focusing technique. To manually focus a camera, you simply rotate the focus ring while looking through the viewfinder until the object/person of interest comes into focus, which is the way most people focus a camera. However, whenever more than one object/person, at different distances from the camera, is of interest, then you need a different strategy to ensure all the items/people are in focus at the same time.

Focusing on just one item at a time is the perfect situation for using the manual focusing technique, which presumes, of course, that the item is composed with the film plane parallel to the item of evidence. That Cardinal Rule certainly applies here. If, and only if, the entire item of evidence is composed with the film plane parallel to it, manual focusing will be successful. If the item of evidence is (mistakenly) composed from a diagonal point of view, the manual focusing technique may not be successful.

Fig. 5.6A shows a photo of a semiautomatic pistol taken with the film plane parallel to the top surface of the weapon. Because the entire surface of the pistol is the same distance from the camera, it is completely in focus. You expect an
entire item to be in focus when a photograph is taken. But, sometimes, expectations are not met. Fig. 5.6B shows the same pistol. In this shot, however, the photographer assumed a diagonal point of view to the pistol. The focus point was the near end of the muzzle. The muzzle is closer to the photographer than the pistol’s grip. It is evident that as you look further along the pistol, from front to rear, the weapon begins to become “softer.” The entire pistol is not in focus. The carpeting just beyond the grip is noticeably “softer” also.

The series of images in Fig. 5.7 show another variation of this. This knife is a bit smaller than the pistol in Fig. 5.6. To fill the frame with the knife, one would have to get closer to it. As we will learn later in this chapter, as one gets closer to an item, the DOF gets shorter. Now, we can see in Fig. 5.7B that when one focuses on the name of the blade the handle can become very “soft,” and when focuses on the back of the handle (Fig. 5.7B), the tip of the blade can go “soft.”

Manual focusing on single items of evidence is best done with the film plane parallel to the top surface of the evidence.
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Automatic Focusing

Many newer cameras have autofocusing capabilities. Basically, when the shutter button is depressed halfway, these cameras usually focus on the object in the center of the viewfinder, although the location of the autofocusing point can be changed in the viewfinder. Different camera manufacturers have different methods of indicating just what this autofocus point is. Frequently, it is designated by a small rectangle or circle in the center of the viewfinder. Consult your camera manual for these variations.

Caution, however, should be used when using autofocus. The improper use of autofocus is often the explanation for out-of-focus photographs. How can this be?

An example may help. At a homicide by throat slashing, a crime scene photographer tried to photograph a gaping wound to the victim’s neck, and this crime scene photographer was in the habit of using the autofocus capability of the camera. All of the photographs came back with the chin of the victim in focus and the wound out of focus. What happened? The autofocus locked on the chin, without the crime scene photographer noticing it. The proper use of the autofocus capability of the camera would have resulted in a better image. But, in this case, the crime scene photographer relied on the automation of the camera to do his job for him. The camera did, in fact, attain focus on part of the scene, just not on what the photographer was really interested in.

Many teachers of basic photography techniques require their students to use only manual camera settings. It is best for students to learn to be totally responsible for the net product of their efforts. Relinquishing responsibility for any of the camera’s functions to a camera’s automatic functions is not the proper way to learn photography. It is better to have well-trained crime scene photographers than to have “intelligent” cameras making decisions which the photographer should be making. Teachers often tell students that we can either teach them photographic theories and principles, or the students can just leave their “smart” cameras in class and then go home. It is much better for photographers to learn how to use every facet of the camera kit than for them to rely on the camera to make certain decisions for them.

Moral: The photographer is responsible for the final quality of the image. Blaming an automatic feature of the camera equipment for a marginal or unacceptable photograph is a poor excuse. If you choose to use any feature of a camera, you must use it correctly and be responsible for the results.

The autofocusing capability of a camera can be used effectively; it is just important to be aware of what the camera has locked onto before the shutter is fully depressed to capture the image.

When to Use Autofocus

When many purchasers are willing to spend additional money on an autofocus camera, how can anyone justify a recommendation not to use it? It is certainly a valued feature of many cameras. However, many general-purpose camera purchasers also demand a camera with autoexposure, or program exposure mode. It is said that many purchasers of cameras want the camera to automatically make all the “complicated” decisions for them so that they can concentrate on more “creative” aspects of photography. Crime scene photographers usually fall into a different class. The images the crime scene photographers capture can help put someone in prison. The images the crime scene photographers capture can help convict a defendant ultimately sentenced to death. These images usually are more purposeful than those captured by the general public.

When would the autofocus mode be appropriate for crime scene photography? Certainly, when only one main subject is in the field of view, autofocus may speed things up a bit without having the photographer relinquish any responsibility.

In a surveillance situation, when it can be anticipated that the subject will be moving toward the camera or away from the camera, predictive autofocus may be the only way to capture the image. Predictive autofocus enables the camera to track a moving subject at different times at different distances from the camera. Presuming that the subject is moving at a more or less constant rate, the camera’s computer can determine the anticipated distance change in a given amount of time and automatically focus the camera for the position where the subject will be in the next instant. It would be impossible to hold the camera and continually make fine refinements to the focusing in situations like this, which is one time the technology must be used to capture the desired image.

An experienced photographer, knowledgeable about when auto-focus is likely to be unsuccessful in attaining accurate focus, can also use autofocus. With more awareness on the part of the photographer imaging, the slit neck in the homicide situation mentioned previously, autofocus could have been successful. Achieving the right result just takes a photographer aware of what the camera is doing.
Difficult-to-Focus Subjects for Autofocus

When is autofocus likely to fail? Some autofocus cameras require subject matter that has prominent vertical elements, and some require prominent horizontal elements. Check your camera’s manual. In either case, when the subject matter lacks distinct detail for the camera’s focusing system to lock onto, the autofocus capability of a camera may fail, which can usually be noticed by the focusing system continually searching for something to grab onto, moving throughout its focusing continuum and never locking at any one distance. Frequently encountered examples of this type of subject matter are a uniformly blue sky or an interior wall with a single color on it.

If the camera’s focusing system fails to lock onto something, usually two options exist: attempt to find a substitute object to focus on at approximately the same distance from the camera. Focus on it, by depressing the shutter button down halfway, keep the shutter button partially depressed, swing the camera around to the primary subject, and depress the shutter button the rest of the way. Or, switch to manual focus.

Autofocus may also fail in dim, low-light conditions. Under these conditions, some cameras may have the capability of emitting an infrared pattern that projects onto the subject, and the camera then focuses on this infrared pattern. If your camera does not have this capability, switching to manual focus may be your only alternative.

Conversely, bright lights or strongly backlit scenes may “confuse” a camera’s autofocus system. If a surface is reflecting specular elements, the autofocus system may fail.

When nearby and distant elements are near the center of the viewfinder, the autofocus system may not be able to decide which is the intended target and give up trying. One example is a caged animal in a zoo. If the bars or wiring are too close to the animal in the field of view, the camera may not be able to decide if the relatively close cage or the distant animal is the prime subject matter. In these situations, you may have to switch to manual focus.

Finally, if two distinct types of subject matter are near each other, the autofocus system may successfully focus on one of them when it was really the other object you were concerned with. Remember the chin and slit neck situation mentioned earlier. Double-check that the autofocus system is focusing on what is important to you. Or, rely on manual focus and feel assured you will infrequently focus on an aspect of the scene unimportant to you.

Focusing With a Zoom Lens

Many crime scene photographers have a zoom lens as their primary lens. Frequently encountered are zoom lenses like 35–80 mm or 28–105 mm. Many years ago, a distinct advantage existed to the use of a prime lens with only one focal length. Such lenses were clearly sharper and had fewer lens Aberrations.

Lens design and construction has significantly improved to the point where there is no longer a negative stigma attached to using a zoom lens. Indeed, some excellent zoom lenses are on the market. However, there are still some unwanted effects of using either the wide angle or telephoto options on these zoom lenses. This is very important to remember when doing examination quality photographs: especially when doing photos of fingerprints, shoe prints and tire tracks. When these types of photos are being taken, try to stay with the “normal” focal length to the extent you can. Wide-angle lenses are known to suffer from “barrel” distortion. See Fig. 5.8. Barrel distortion is characterized by straight lines near the periphery of an image bending outward. Now consider taking a close-up of a bloody shoe print pattern with a zoom lens. If you select a wide-angle focal length to capture this close-up, you may be changing the shape of the shoe print to the extent it cannot be compared to a suspect’s shoe.

Consider taking that photo with the zoom lens set to its telephoto focal lengths. Telephoto lenses are known to distort images with a “pincushion” look which has straight lines at the edges of an image seeming pinched in a bit; see Fig. 5.9. True, using the tele setting of the lens would enable you to stand at your full height to focus through the viewfinder, rather than bending over, but is this benefit worth the price?

If a zoom lens is regularly your lens of choice, or if it is what your agency has provided you for the job, how can you use it to maximize your focusing task? As mentioned previously, many zoom lenses include a wide-angle range and a telephoto range. One of the known benefits of telephoto lenses is their magnification capability. Would you rather focus on an object when it is small and difficult to see, or when it is larger and more clearly defined? Obviously, the latter. If a zoom lens is the tool you are currently using, use it efficiently. To focus on any subject, zoom the lens to its telephoto setting to use its magnification capability. Focus. Reset the lens to the focal length you want to use, and be comforted in the knowledge that once you have focused the lens at any focal length setting, selecting a different focal length does not defocus the lens. Know the tool, and use it appropriately.
Prefocus

This author once worked with a crime scene technician who would enter a crime scene, raise the camera to his eye, and then move forward and backward until the subject became sharp. Definitely, not the normal way of focusing. However, under one circumstance, this is exactly the best way to focus a camera. Have the camera prefocused, and then move the camera toward and away from the subject until the subject matter becomes sharp.

What is this circumstance? It is when you intend to take a series of bracketed images of a fingerprint. In this circumstance, you will set the camera so it captures a 1:1 magnification of the fingerprint, which is when the single fingerprint fills the frame in the field of view, also ensuring the fingerprint is life-sized on the sensor. Consider the images in Fig. 5.10. A single-digit fingerprint nicely fills the frame when magnified to 1:1.

Why prefocus? For two reasons.

One alternative is to put your camera on a tripod, set the tripod down an arbitrary distance from the fingerprint, and then begin focusing by turning the focus ring. You may focus and focus and focus, and then eventually realize the camera is too close to the fingerprint to ever achieve proper focus. Every lens has a close focusing distance. Closer than this distance, the lens cannot focus. Placing the tripod down at this distance is a waste of time and makes you look as though you do not understand your own equipment. Not a good way to earn the respect of your peers.
If you place the tripod too far from the fingerprint, the camera will eventually be able to focus. However, if you are further than need be, when you do achieve focus, the fingerprint will be smaller than optimal. Remember the Cardinal Rule, Fill the Frame? In this situation, it counts. If the camera is further from the fingerprint than necessary, the fingerprint is smaller on the negative. If the fingerprint is not as large as possible, you are using too many digital pixels capturing nonfingerprint detail. Why waste your sensor’s ability to capture detail of irrelevant space?

Prefocus the camera to its closest focus distance. One end of the focusing continuum is infinity; the other end is the lens’ closest focusing distance. This can be done without looking through the viewfinder. Just look down on the lens and adjust the focusing ring until it stops at the short end of its distance scale. Having prefocused the camera, move the camera mounted on a tripod toward the fingerprint until the fingerprint comes into focus while you look through the viewfinder. In this situation, all other focusing techniques are second best.

**Hyperfocal Focusing**

Many times crime scene photographers must capture entire crime scenes and areas in focus rather than individual items of evidence. As mentioned earlier, focusing on areas requires a different skill set. In the normal sequence of crime scene photography, photographers frequently must capture images of large outdoor crime scenes. If the crime occurred indoors, photographers frequently begin by photographing the exterior of the building in which the crime occurred and the surrounding areas by which any suspects could have gained ingress and egress. These are large areas. What is the proper technique to maximize the DOF with large exterior crime scene photographs?

It might be good to revisit the definition for DOF. DOF is the variable area, from foreground to background, of what appears to be in focus to the eye. It is a variable area because photographers can select camera variables that restrict the DOF to just one plane or just one distance from them. Or, photographers can select camera variables that maximize the DOF, ensuring large areas are in focus when the photographic print is eventually made.

This situation is made more complicated because the camera usually shows only one plane, or one distance from the camera, to be in focus at a time. When looking through the viewfinder, you usually see only one area of the scene in focus at a time. Why is that? Did you know that until you depress the shutter button the whole way, the lens is automatically set to its widest aperture? This is so that you can see the scene with enough light to be able to focus. Using any aperture, but the widest one, makes it more difficult to see and focus on the scene. Well-trained crime scene photographers, however, will be confident that when the image is printed, more than what they saw through the viewfinder will be in focus.

The three images of Fig. 5.11–5.13 show this ability to manipulate the area in focus to suit the photographer’s needs. Fig. 5.11 shows a restricted DOF, with only the front of the numbered evidence markers in focus. Fig. 5.12 transfers this narrow area that is in focus to the rear numbers. Finally, by choosing the correct camera variables, the photographer can maximize the DOF range and have all the numbers in focus at the same time, as in Fig. 5.13.
FIGURE 5.11
Wide aperture, focused on #1.

FIGURE 5.12
Wide aperture, focused on #15.

FIGURE 5.13
Small aperture, all in focus.
An astute student asked why, when the first evidence marker was focused on, there appears to be more out of focus evidence markers than when focused on the last one, even when the same f/stop was used for both. Think about that a bit, and it will eventually be answered.

Here, then, is a new Rule of Thumb.

**RULE OF THUMB 5.2**

If you are composing on an area as your “primary subject,” that entire area should be in focus.

Why include an area in your composition if you know it will be out of focus? Another way of saying the same thing is this: if you know an area will be out of focus, exclude it from your composition. Do not give anyone the opportunity to criticize your photographs because areas are out of focus.

This may be the first time this author’s pedagogical style has been so blatant. Crime scene photographers capture very important images. The consequences to the defendant are enormous. The responsibility of photographers is, therefore, just as weighty. The chapter “Composition and Cardinal Rules” mentioned the photographer’s full field-of-view responsibility. Do not take this lightly. Purposefully include in your photographs only the details you wish in them; exclude from your images as much as is irrelevant as possible. Once you have decided what will appear in your field of view, you now have the obligation to ensure it is well exposed. But achieving a proper exposure is not sufficient. It is just as important to ensure it will be in focus. Certainly, you will not be considered much of a photographer if your well-exposed detail is out of focus. So, too, having in-focus detail improperly exposed is just as problematic. Photographers have the responsibility to compose, expose, and focus properly on their subject matter.

**Hyperfocal Focusing** is the technique to maximize the DOF when infinity is composed in the background. Infinity (∞) is normally considered an unimaginable large number, a large distance, or a large quantity. On a camera’s focusing ring, however, infinity is more mundane.

In the two images of Fig. 5.14, the top two rows of numbers are distance indicators, one in feet (top row/green) and one in meters (second row/white). Notice that infinity (∞) is the next figure after the 10-m mark. As the distance indications move from left to right, they seem to be getting progressively closer together. The space between the 2-m mark and the 3-m mark is larger than between 3 and 5 m. The space between 5 and 10 m is smaller yet, which suggests that if an actual number had been printed on the distance scale in place of the infinity symbol, it would be perhaps 20–30 m or so. What this means, for all practical purposes, is that as far as the camera is concerned, infinity is the equivalent of about 60–90 ft and beyond.

![Figure 5.14](image_url)

(A) Depth-of-field scale: pairs of numbers opposite the orange line. (B) Focused on infinity.
Thinking like a camera, then, you can place photographs into three rough categories:

1. Large scenes, with infinity in the background.
2. Medium distance scenes, where infinity is not in the background.
3. Small areas and close-up images of individual items of evidence.

Hyperfocal focusing is the focusing technique for the first category, when maximizing DOF is the primary concern. If you accept Rule of Thumb 5.2 and wish to ensure that infinity must be in focus if it is in the field of view, you may be tempted to actually focus on infinity.

Look at Fig. 5.14B above, which shows a camera focused on infinity. The focusing line is aligned with the infinity symbol, which is the most efficient way to ensure infinity will be in focus, right? Wrong.

Fig. 5.14 also shows a third row of numbers beneath the distance rows. These are pairs of numbers on either side of the focusing point called the depth-of-field scale (DOF scale).

Some lens manufacturers include this very handy scale on their lenses. Unfortunately, a trend to omit this scale on many newer lenses seems to exist. Do not fear. This text will provide suggestions for hyperfocal focusing whether or not your particular lens actually has a DOF scale.

What is the DOF scale? The DOF scale is a tool to enable photographers to determine the DOF, the area that will appear to be in focus when the image is processed. Remember, when you are looking through the viewfinder, only one distance from the camera appears to be in focus at any time. You must somehow know that more than just one distance will be in focus when the image is printed, depending on the camera controls selected.

As previously indicated, only one point exists where the light coming in through the lens will come together to form an exact point on the sensor. If the light coming in through the viewfinder formed a circle when it reached the sensor, as indicated previously, the result would be an out-of-focus image. Now is the proper time to refine that simplistic explanation of focusing. To do this, we must understand the concept of the circles of confusion in more depth.

The notion that being in focus only occurs when light meets at a single point on the sensor is a very mechanical explanation. In fact, the eye is a very remarkable sensor. It can actually detect some of the light striking the sensor as small circles as being in focus, which means that instead of a single distance from the camera appearing to the viewer as being in focus, an area before the point of exact focus appears to the viewer to be in focus, and an area behind the point of exact focus also appears to the viewer to be in focus. Some of the light striking the sensor as small circles is perceived to the viewer as being in focus, just as the light striking the sensor at a single point.

Research has shown that circles striking the sensor as large as 0.025” to 0.033” in diameter will appear to the eye to be in focus. You may not be able to imagine circles with that diameter range, so it is difficult to grasp this concept with just this information. Graphics help immensely, and perhaps they will make the concept easier for us to understand.

Although the circumstances in Fig. 5.15 cannot exist in reality, because light cannot travel past the sensor, this graphic does make it somewhat easier to understand DOF. Consider the small shaded circles to have a diameter of between
0.025" to 0.033", which is the resolution limit of the eye. Light coming together at the sensor that is not in perfect mechanical focus, forming circles of this size, or smaller, will still appear to the eye as being in focus. Naturally, the point at which light actually intersects the sensor at a point will be seen as being in focus. For the sake of discussion, consider this distance as being an object in the crime scene 20' from the camera. Light coming from a distance of about 24' will not intersect at the sensor. It will actually intersect before the sensor, cross over, and continue until it strikes the sensor as a small circle. Imagine this small circle as the left shaded circle in Fig. 5.15. Light coming from a distance of 18' will not intersect at the sensor. If it could, it would intersect behind the sensor. At the sensor, it is still a circle. Imagine this small shaded circle as the right shaded circle in Fig. 5.15.

DOF is the range, in front of and behind the plane of exact focus, of what also appears to the eye to be in focus. Therefore, not only will the item at 20' appear in focus, but also anything between 18' and 24'. Anything closer than 18' and anything beyond 24' will appear to be out of focus because at the sensor they would create a circle of confusion larger than what the resolution limit of the eye will detect as being in focus. These distances are depicted as clear ellipses in Fig. 5.15. If light forms a circle larger than 0.025" to 0.033" on the film plane, the image at those distances appears to the eye to be “confused” or blurred.

In Fig. 5.15, the light is coming from the extreme edges of the lens, intending to suggest the widest aperture of the lens. Consider this aperture to be f/2 for the time being. What would occur if the light entered the lens when a smaller f/stop is being used? Fig. 5.16 shows this situation. The shaded circles of confusion are the same size in both Figs. 5.15 and 5.16.

Notice that as the aperture becomes smaller, from f/2 to f/22, the circles of confusion, perceived by the eye to be in focus, move further away from the film plane, which is the explanation for the larger DOF produced by using smaller apertures. Fig. 5.15 shows the equivalent of an f/2 aperture. Fig. 5.16 shows the equivalent of perhaps an f/11 aperture. The use of an f/11 would give the appearance to the eye as having more in focus. In this case, the DOF range would be something like 12' to 36' when focused on 20'.

One of the camera's variables that affect DOF is the f/stop selection. With this information, let us return to the DOF scale in Fig. 5.14. The DOF scale is designed to be used in conjunction with the distance scale. The DOF scale is composed of pairs of f/stop numbers radiating outward from the point of exact focus. Some lenses do not show as many f/stop numbers as are depicted in Fig. 5.14. Some lenses do not have a DOF scale at all. Fig. 5.14 is a good training tool to explain DOF.

Once the f/stop for a proper exposure has been determined, the photographer can then refer to the DOF scale to determine exactly how much of the crime scene will be in focus when the image is printed. With the top image of Fig. 5.14A, it is evident that the photographer has focused at about the 12' distance (follow the orange line up to the green distance scale). Aligning the DOF scale with the distance scale, the photographer can then see what the DOF range will be. The distance that falls between the pair of f/stop numbers on the DOF scale is the DOF range. With each f/stop, then, you see the following DOF ranges, when the camera is focused at 12':

1. f/22: 6' to ∞
2. f/16: 7' to 30'
3. f/11: 8' to 25'
4. f/8: 9' to 20'
5. f/5.6: (not shown)
6. f/4: 10' to 14'

Wider apertures result in narrower DOF ranges; smaller apertures result in progressively longer DOF ranges.

The DOF scale is a great tool if you have it. But, what if your lens does not have a DOF scale? Here is how to hyperfocal focus without a DOF scale. To begin, consider the images in Fig. 5.14 again.

**FIGURE 5.16**
Circles of confusion, small aperture.
The Fig. 5.14B shows one way to ensure infinity will be in focus. Simply focus on the infinity symbol. Now, by use of the DOF scale, you can determine what will be in focus when the print is made. If the lighting enables an f/22 to be used for a proper exposure, the distances between the two 22s will be in focus when the print is made. The Fig. 5.14B shows this to be 12′ to infinity. Not bad. Notice all the distance between the infinity symbol and 22 on the right side of the DOF scale, which is, in effect, wasted DOF.

Hyperfocal focusing is the technique to maximize the DOF, when infinity is in the field of view. To hyperfocal focus, first determine the f/stop required for the lighting at the scene. Once the f/stop has been determined, align that f/stop, on the DOF scale, with the infinity symbol on the distance scale. Presume it is a bright sunny day, and the meter reading indicates an f/22 can be used to properly expose the scene. The Fig. 5.14A shows the result. The infinity symbol is now aligned with the right 22 on the DOF scale. The DOF range will be the distance between the two 22s as they align with the distance scale. The Fig. 5.14A indicates the new DOF range is 6′ to infinity. That is a net gain of 6′ that will be in focus when the image is printed.

With both focusing techniques, infinity will be in focus. With hyperfocal focusing, you have also maximized the DOF. Hyperfocal focusing increases the DOF range in the foreground.

No other focusing technique will provide better DOF when infinity is in the background.

Let us also examine the hyperfocal focusing range with f/16, f/11, and f/8. This may perhaps be best understood in Table 5.1. The four images of Fig. 5.17 show the result of hyperfocal focusing with an f/22, f/16, f/11, and f/8.

Notice that the point of exact focus, the Hyperfocal Focusing Distance, is always double the short end of the DOF range. We will use that fact momentarily.

Having a lens with a DOF scale is certainly very convenient. However, as mentioned earlier, many recently manufactured lenses do not have this handy tool. In many situations having a DOF scale would make the job easier on crime scene photographers. It comes down to this: is there a way to hyperfocal focus without a DOF scale? Yes.

Lens construction standards are so uniform that even if your particular lens does not have a DOF scale, you can still use the theory of hyperfocal focusing to maximize your DOF when photographing large exterior crime scenes when infinity is in the background. How? First, determine the f/stop required for the lighting of your scene. Then focus at one of the following distances appropriate for your f/stop (again, see Fig. 5.17. Notice the point of exact focus for each of them.):

- If using an f/22, focus the lens at 12′.
- If using an f/16, focus the lens at 16′.
- If using an f/11, focus the lens at 24′.
- If using an f/8, focus the lens at 30′.

This is important enough to memorize which distances to focus at for the f/stop required for the lighting at the scene.

You can focus the lens by using the distance scale, by aligning the focusing point of the lens with the correct distance on the distance scale. Or, you can find a surrogate item somewhere in the crime scene the prescribed distance you need and focus at it. Remember, hyperfocal focusing is the optimal focusing technique for this particular focusing situation. Any other focusing technique will result in either the background (∞) being out of focus or less of the foreground being in focus. Neither of these options is desirable.

Why are hyperfocal focusing ranges for the other f/stops not provided? Remember, these are images of large outdoor crime scenes, when it is necessary to have infinity in the field of view. Using wider apertures results in a smaller DOF range, making it more difficult to have any evidence relatively close to the camera be in focus while maintaining infinity in focus at the same time.
Some writers feel the DOF scale on lenses does not really ensure that the DOF range indicated as written above will truly be in focus. Here is a recommendation. With your particular camera and lens, set up a series of test distances. Test the f/22 hyperfocal focusing range by placing objects 6’, 8’, and 10’ from the camera. Focus at 12’. Take the photograph. When the photograph is printed, check to see whether the object at 6’ looks to be a bit “soft” or slightly out of focus. If so, it is hoped the object at 8’ looks sharp. If the object at 8’ looks sharper than the object at 6’ just bump up the hyperfocal focusing recommendations one notch.

- Consider the f/22 DOF range to be 8’ to ∞ when focused on 12’.
- Consider the f/16 DOF range to be 12’ to ∞ when focused on 16’.
- Consider the f/11 DOF range to be 15’ to ∞ when focused on 24’.
- Consider the f/8 DOF range to be 20’ to ∞ when focused on 30’.

The preceding description effectively “calibrates” the hyperfocal focusing concept for your specific camera and lens.

**Zone Focusing**

Infinity is not always in the background of outdoor crime scenes. An obstruction, like the wall of a building, may be present 30’, 40’, or 50’ from the camera. If, when you look through the viewfinder, infinity is not in the background, hyperfocal focusing is not applicable. How do you maximize the DOF when infinity is not an issue?
For instance, on a bright sunny day, you may want to photograph a scene between you and a wall about 30′ away. Nothing in the field of view will be farther away than the 30′ distance of the wall. Now, it is not important to ensure that ∞ is in focus. You just need to ensure the wall, as the background of the photograph, is in focus.

Zone Focusing is the technique to maximize the DOF for an area when infinity is not in the background. The zone focusing technique is a bit like the hyperfocal focusing technique. This technique also relies on your lens having a DOF scale. As in the hyperfocal focusing technique, the first step is to determine the f/stop required for the lighting at the scene, which is done by simply taking a meter reading of the crime scene. The second step is to determine the distance of the background of this particular crime scene, which may be a real obstruction, like a wall, or it may be the distance from your camera you decide will be the top of your field of view when you compose this image. Look at Fig. 5.18.

Fig. 5.18 shows the scene, with the top of the image, the wall, 30′ from the camera. In this case, it is not necessary to have anything beyond 30′ be in focus.

With zone focusing, it is necessary to determine the distance of the background. Manually focus on the wall to determine its exact distance. Focus on the wall and then look at your distance scale and note the distance shown. Had your crime scene been the one shown in either Fig. 5.18, this distance would be 30′.

If no wall or other fixed object is in the background, determine the distance of the top edge of your composition. Consider Fig. 5.18. Make a mental note of what is at the top of your composition; then swing your camera up so that area is now in the center of your viewfinder, and manually focus the camera. To make this easier, consider the previous suggestion to use the telephoto end of your zoom lens. Set the focal length to your lens’ most extreme telephoto focal length. For instance, if your zoom lens has a 28 to 105 mm zoom range, set the lens to 105 mm. That will magnify all areas in your viewfinder. Focus at the distance that will eventually be the top of your composition when viewed with a 50 mm lens setting. Check the distance scale of your camera to see the exact distance of this area. Again, if Fig. 5.18 was your crime scene, 30′ should show on your distance scale. That distance will then be aligned with the f/stop required for the lighting of the scene on the DOF scale.
If the lighting will permit the use of an f/22, align the right 22 over the 30’ mark. See Fig. 5.19 for the alignment of the DOF scale and the distance scale to zone focus at 30’ with f/22, f/16, f/11, and f/8.

- If the lighting requires an f/22, the DOF range is 5’ to 30’.
- If the lighting requires an f/16, the DOF range is 6.5’ to 30’.
- If the lighting requires an f/11, the DOF range is 9’ to 30’.
- If the lighting requires an f/8, the DOF range is 11’ to 30’.

In each of these lighting conditions, it would be important to make sure the bottom edge of your photograph does not include anything in the field of view in front of the short end of your DOF range.

- If using an f/22, do not include detail before 5’.
- If using an f/16, do not include detail before 6.5’.
- If using an f/11, do not include detail before 9’.
- If using an f/8, do not include detail before 11’.

Simply compose your image so the bottom of your field of view matches the short end of your DOF range, which you do by raising and lowering your camera while you look through the viewfinder.

No other focusing technique maximizes the DOF better when it is not critical that infinity be in focus.

You may now be imagining a situation in which raising the camera to one of these prescribed near-end distances forces the top edge of the field of view to include more than the 30’ we began this discussion with. Aligning the top of the field of view at 30’ may force more into the near end of the field of view than the preceding distances. What to do then? These situations may occur at real crime scenes, depending on the lighting at the scene. Although it is a Cardinal Rule to attempt to maximize the DOF at all times, nothing guarantees that everything in your field of view will be in focus for every image you capture. That is the goal, and sometimes this goal is not achievable, particularly when the lighting becomes dimmer. The question remains: what should you do? If the choice is between obviously out-of-focus foreground and obviously out-of-focus background, this author usually opts for the out-of-focus background because it is slightly less noticeable.
### Focusing by the Rule of Thirds

What if your camera equipment does not have the DOF scale on the lens? Many lenses do not have this feature. How should you zone focus then?

First, be aware that the DOF range is not usually the same in front of and behind the plane of exact focus. For instance, if you are focused on a point 10′ from the camera, while using an f/16 for the lighting, the DOF range will be almost 14′ in total. This 14′ is not divided by 2 resulting in 7′ in front of the 10′ focus point being in focus, and 7′ behind the 10′ focus point being in focus. It certainly would be nice if this were the case, but it is not the case. Usually, more of the DOF range exists behind the point of exact focus than in front of it.

At this point, many other authors insert a dictum that the DOF range extends one-third of the total range in front of the point of exact focus, and two-thirds of the total range behind the point of exact focus. In fact, this is often presented as a Rule of Thumb.

#### RULE OF THUMB 5.3

The depth of field usually extends one-third in front of the point of exact focus and two-thirds behind the point of exact focus.

Although this is a handy rule of thumb in some circumstances, it is certainly incorrect in many instances.

In all hyperfocal focusing situations, you can immediately see that the DOF range behind the point of exact focus is much more than double the DOF range in front of the point of exact focus. Recall that an f/22 will result in a DOF range of 6′ to infinity when focused at 12′. That is 6′ in focus in front of the exact point of focus and 12′ to infinity in focus behind the point of exact focus. Certainly not a one-third and two-thirds ratio.

When you are zone focusing with background distances at 30′ or beyond, it is again clear that a one-third and two-thirds ratio does not apply. See Fig. 5.19 again. With an f/22, the DOF range is 5′ to 30′ when focused at 9′. That is 4′ in front of the point of exact focus and 21′ behind the point of exact focus: almost a one-sixth and five-sixths ratio.

However, when the maximum background distance in the field of view is reduced to between 5′ and 20′, the one-third and two-thirds ratio is pretty closely approximated.

When closer than 3′, the ratio approaches ½ and ½. This is certainly the DOF ratio for all close-up photographs. As much will be in focus in front of the plane of exact focus as will be behind it. This point is extremely important to remember if you photograph fingerprints on a curved surface. Do not be misled by the Rule of Thumb, one-third and two-thirds DOF range, in this situation.

Finally, if you take many photographs through a microscope, you should know that the DOF range changes again, and this time the DOF range approaches two-thirds in front of the plane of exact focus and just one-third behind the plane of exact focus.

Back to the Rule of Thirds as a focusing technique: This author has crunched the numbers at each distance between 3′ and 30′ and with the f/stops f/8 through f/22. The results follow. Do not be too concerned with these numbers and percentages. You do not need to memorize them. A very easy method to zone focus will soon be indicated. This information is presented to further indicate that the one-third and two-thirds ratio of the area in focus around the point of exact focus is not very precise.

- If 30′ is the background distance, the average ratio of foreground-to-background area in focus is 20% in front and 80% behind.
- If 20′ is the background distance, the average ratio of foreground-to-background area in focus is 28% in front and 72% behind.
- If 15′ is the background distance, the average ratio of foreground-to-background area in focus is 28% in front and 72% behind.
- If 10′ is the background distance, the average ratio of foreground-to-background area in focus is 36% in front and 64% behind.
- If 5′ is the background distance, the average ratio of foreground-to-background area in focus is 40% in front and 60% behind.
How does this information help you zone focus if your lens does not have a DOF scale? Representative images of each of the preceding scenes will make it more obvious; see Figs. 5.20 and 5.21.

In each of these images, a pen was placed at the prescribed distance indicated in the preceding list. Even as the precise ratio of what is in front of the plane of exact focus and what is behind the plane of exact focus changes with each distance, one very obvious similarity exists in each of the photographs. The pen appears to be positioned at approximately the midpoint of each image. The pen actually appears to be positioned halfway between the top of each image and the bottom of each image. This is not necessarily halfway between the foreground and the background in each image.

How can you put this information to use at crime scenes?

If you have a DOF scale, use it. That is the easiest way to maximize the DOF whether you are hyperfocal focusing or zone focusing. But if you are in a zone focusing situation, and your lens does not have a DOF scale, the quickest, most accurate method of focusing to maximize the DOF is to focus at the distance that is midway between the top of the composed image in the viewfinder and the bottom of the composed image in the viewfinder.

Crime scene photography is already a very stressful situation. Rather than making crime scene photography procedures more difficult, a good text should make them easier to understand and apply. The best way to zone focus is to focus at a distance that appears to be midway between the top and bottom of the composed image. Let us make this a revised Rule of Thumb.

**RULE OF THUMB 5.4**

When you are attempting to maximize the depth of field with crime scenes ranging from 5’ to 30’, the most effective way to do this is to focus at a distance that appears to be midway between the top and the bottom of the composed image in the viewfinder.
Out-of-Focus Images

It is unusual to teach a course on crime scene photography without receiving several out-of-focus photographs from a student. When this fact is pointed out to the student, and they are asked to retake the photographs, the photographs sometimes come back out-of-focus again. It becomes clear that this student is unaware his/her vision needs correction. If the student has never seen anything with clear, sharp focus, that student does not know the difference and turns in what looks to be the best to them. However, over the years, several students have tried to defend their out-of-focus photographs by suggesting the problem must have been an “equipment malfunction.”

This section describes how the conflict can be resolved. The student is set up with a digital SLR camera on a tripod, with the film plane parallel to the object they have had trouble with. The student is asked to manually focus the camera as best they can and take the photograph. With the camera in the same position, the student is told to switch to the autofocus mode and to press the shutter button down halfway and listen closely to determine whether they can hear the camera readjust focus. The student then captures that image. Comparing the two images usually can convince the student that focusing by eye results in an out-of-focus image, whereas the camera’s autofocus results in a better image. Solution: the student is told to get glasses or have current prescriptions updated.

Sometimes a student swears their vision is good, but whenever they look through the camera viewfinder, everything always looks blurry. This may actually happen for a very good reason. They have not yet adjusted their diopter adjustment dial for their own eyesight. It is usually located just to the right of the viewfinder (see Fig. 5.22). It may be a dial or thumb slide that moves up and down. In either case, it allows you to adjust the viewfinder for your own eyes. Usually, it is recommended to look through the viewfinder, select a ceiling or a blank wall, and notice the focus rectangle or circle in the middle of the viewfinder. While looking through the viewfinder, adjust the diopter dial to get the rectangle or circle in focus as best you can. At some point, it should look tack sharp.

Using this diopter adjustment dial is, more or less, the equivalent of trying on various strengths of reading glasses and is often the solution to some focusing issues.

DEPTH OF FIELD
Factors Affecting Depth of Field

Three camera variables directly affect the DOF range. They are:

- F/stop choice
- Lens choice
- Camera-to-subject distance

We will examine each in turn.

F/Stop Selection as a Depth-of-Field Variable

As previously explained, f/stops are a primary exposure control. Along with shutter speeds and ISO selections, they are one of three primary camera controls that affect exposures.
In addition to being an exposure control, f/stops also are one of the camera variables that directly control the DOF range. This fact cannot be overemphasized. DOF, by definition, is the variable range, from foreground to background, of what appears to be in sharp focus.

When considering DOF, remember that it is possible to maximize the DOF range, and it is possible to minimize the DOF range. Obviously, because one of the Cardinal Rules is to maximize the DOF as much as possible, that is the main concern with crime scene photography.

However, understanding the effect of minimizing the DOF range is valuable. This text will offer two situations illustrating when minimizing the DOF will be the goal of the crime scene photographer. One relates to intermediate objects/obstructions between the photographer and the subject matter considered the primary subject. In such a situation, if the photographer can create a small DOF range and place it on a distant subject, intermediate details will fall outside the DOF range and become blurred and out of focus. This intentional blurring of intermediate detail can be so pronounced as to make the intermediate detail so blurred as to become almost invisible. Making an intermediate obstruction so blurred as to become almost invisible allows you to see the primary subject better.

In another situation, the background of an image may be detracting from an item of evidence in the foreground. Blurring the background, by creating a small DOF range, when focused on the foreground can make a great improvement on the image.

These two situations when minimizing the DOF range is a clear advantage are as follows:

- In daytime surveillance situations, positioning the camera behind a bush or other obstruction is necessary to prevent the photographer from being seen by the subject of the surveillance. In this case, having the bush in front of the camera is both good and bad. It is a good visual obstruction in that it makes it difficult or impossible for the subject of the surveillance to see the photographer. It can be bad if the same bush makes it difficult for the camera to acquire a good image of the subject of the surveillance. See the images in Fig. 5.23.

![Figure 5.23](image-url) Minimizing the depth of field to photograph a license plate.
At a crime scene, a latent print is powder processed and visualized on window glass. Before lifting this print, it is decided to photograph it first. When composing a close-up photograph of the latent, it is noticed that details outside appear behind the fingerprint, making the fingerprint ridge detail difficult to see. If the details outside can be blurred by minimizing the DOF, then the print will be more clear and easier to see. If that, by itself, is not enough, then just a bit of Photoshop processing may be required. See both images of Fig. 5.24. Fig. 5.24, left, is an attempt to blur the background to improve the view of the fingerprint. Fig. 5.24, right, is a Photoshop-processed image of the same fingerprint.

What is the effect of using a wide aperture? With a wide aperture, the DOF range can be very short. One object/person can appear to be in focus, with everything else, both in front of and behind that object/person, appearing to be out of focus. This short DOF range can be placed in the foreground, in the mid-ground, or in the background. Wide apertures, like those produced with f/2, f/2.8, and f/4, create very short ranges of DOF.

Fig. 5.25A shows the effect of using an f/1.8, a very wide aperture, while focusing on the #1 in the photograph. The #1 is obviously in focus, whereas the focus quickly deteriorates behind the #1. Fig. 5.25B moves the point of focus to the #2. Now, both #1 and #3 appear “soft” or out of focus. Fig. 5.26A moves the point of focus to the #3. Both #1 and #2 now appear “soft” or out of focus.

Fig. 5.26B shows the effect of using an f/22, a very small aperture, on the same scene. Through the use of zone focusing, the entire area appears to be in focus. All three numbers are sharp. Fig. 5.27 makes the same point. With a wide aperture, the DOF range can encompass just one item, like the balls in the top-left, top-right, and lower-left images. With a small aperture, like f/22, the DOF range can encompass almost everything in the field of view, like the lower-right image.

Recall Figs. 5.15 and 5.16. When the aperture is wide, the circles of confusion perceived by the eye to still be in focus are relatively close to the point of exact focus. The DOF range, then, will be very small. When the aperture is very small, the circles of confusion perceived by the eye to still be in focus are relatively far apart. The DOF range, then, will be very long.

With either wide or narrow f/stops, you would be able to focus on an object/person at any distance, and they would be in perfect focus in the resulting photograph. As the two graphics show, with either a wide or narrow f/stop selection, the light rays can be brought into focus where the lines meet at the film plane. As the light rays travel from the lens opening, on the left, to the point of perfect focus, they are converging down their respective cones, until the light rays meet at the film. At the film plane, the light rays are in perfect focus.
FIGURE 5.25
(A) Focused on #1. (B) Focused on #2.

FIGURE 5.26
(A) Focused on #3. (B) Zone focused with f/22.
The DOF range will increase as f/stops are changed, moving on a continuum from f/2 to f/22. F/stops representing large lens openings produce relatively short DOF ranges, and f/stops representing small lens openings produce relatively long DOF ranges. This is purely a function of the way the lenses bend light to converge at the film plane and the relative distance of the circles of confusion, still appearing to be in focus to the eye, are from the point of exact focus at the film plane.

In summary, considering an f/stop range from f/2 to f/22, which is common with many lenses, the f/2 results in the shortest DOF range. The DOF range progressively increases as you move toward the f/22 lens opening.

**Lens Choice as a Depth-of-Field Variable**

How can the lens choice affect the DOF? Examine Fig. 5.28.

The f/stop number has a relationship to the focal length of a lens. This equation shows the relationship: FLL/f-stop = DOD, where,

- **FLL** equals the focal length of the lens.
- **F/stop** is the particular f/stop number.
- **DOD** is the diameter of the diaphragm or the size of the lens opening.

This equation can also be written as either FLL/DOD = f/stop, or DOD (f/stop) = FLL.

1. The diameter of the diaphragm can be determined by dividing the FLL by the f/stop.
2. The f/stop number comes from dividing the FLL by the size of the lens opening.
3. The FLL is the product of multiplying the f/stop number and size of the lens opening.

The graphic in Fig. 5.28 is a visual demonstration that, at any f/stop, wide-angle lenses will have a better DOF range than “normal” lenses, and “normal” lenses will have a better DOF than telephoto lenses.

Another way of saying this is to state that the same f/stop number will result in different lens apertures/openings, depending on which focal length of lens is being used.

To make this clear, let us begin by examining an f/stop of f/8. Notice the relative DODs that result with different lenses. In the example in Fig. 5.28, lenses of 24, 50, and 100 mm are compared, but the theory would hold for any lenses.
Depth of Field as a Function of Lens Choice

Since: F-Stop# = FLL/DOD (Focal Length of the Lens/Diameter of the Diaphragm),

Then: DOD = FLL/F-stop#

Therefore, if 24 mm, 50 mm and 100 mm lenses are set to F-8, this is the result:

a. The DOD for a 24 mm lens at F-8 = 3 mm  
b. The DOD for a 50 mm lens at F-8 = 6.25 mm  
c. The DOD for a 100 mm lens at F-8 = 12.5 mm

Because the DOD of each lens is a different size, as light travels from the front of the lens and diaphragm opening to the sensor, figures similar to the graphic are produced. Even though the same f/stop has been selected for all three focal lengths, the effective size of the lens opening to the light that will be entering the camera will change. As already determined with the examination of f/stops, the DOF range is improved with smaller lens openings, which is shown by the pairs of small ellipses shown in all three examples. They represent the circle of confusion perceived by the eye to still be **in focus**. In each example, the pairs of small ellipses appear to be different distances from the point of exact focus or the point where the lines intersect in the middle of each figure. As the ellipses get further apart, the DOF range increases.

Therefore, because wide-angle lenses produce smaller lens openings than “normal” and Telephoto Lenses, the resultant DOF range will be greater. Because “normal” lenses produce smaller lens openings than Telephoto Lenses, their resultant DOF range will be greater.
Focus, Depth of Field, and Lenses

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Camera-to-Subject Distance

How can camera-to-subject distance affect DOF? As you will recall, through the use of hyperfocal focusing with an f/22, the resulting DOF range is 6′ to infinity. No other f/stop will provide more DOF when hyperfocal focusing. When you are zone focusing with a background of 30′, that same f/22 will result in a DOF range of 5′ to 30′, quite a substantial reduction in the DOF range. When you are zone focusing with a background of 10′, that same f/22 will result in a DOF range of 3.8′ to 10′. Again, the DOF range has been reduced. Let us jump to a situation in which you need to capture a close-up photograph of a 0.45-caliber cartridge casing at a crime scene. Using close-up equipment, which will be explained later in this chapter, you can fill the frame with the cartridge casing. An f/22 can also be used in this situation. You would expect a pretty good DOF by using the f/22, would you not? If you find yourself nodding in agreement to that last sentence, you would be wrong.

A 0.45-caliber cartridge casing is 45/100″ wide, or just shy of ½″. That means the surface the casing is sitting on is 24/100″ farther from the sensor than the top of the casing that is being focused on. Surely, the DOF range with an f/22 would cover this distance. Wrong again.

Fig. 5.29A shows a 0.45-caliber cartridge flanked by two scales. The scale on the left has been raised up to the level of the top of the casing; the scale on the right has just been laid next to the casing. Fig. 5.29B shows the same positioning of scales, but this viewpoint makes the difference in height between the two scales clear. As you examine Fig. 5.29A more closely, do you notice any difference in the two scales? If you have very good eyes, you might notice that the word “inches” appears a bit “soft” or slightly out-of-focus. Why? Because the DOF range in a close-up situation like this is less than the ½″ difference between the top of the left scale and the right scale.
Let us make this more obvious with more extreme close-ups of another 0.45-caliber casing. The photo in Fig. 5.30A shows the mouth of the casing and the background fabric. Various stria are plainly visible on the mouth of the casing because focus was adjusted for the top of the casing. Notice in this image that the fabric is more obviously “soft” from being a bit out of focus.

But in Fig. 5.30B, the focus was adjusted to the surface of the cloth. Now, the fabric is much sharper, but the stria on the mouth of the casing have become blurred. Why? The difference is simply that the DOF range with an f/22 does not encompass both distances when close-up photographs are taken.

An f/22 can provide a DOF range of 6′ to infinity when you hyperfocal focus, and this same f/22 has less than a ½″ DOF range when extreme close-ups are taken. This should make you extremely cautious whenever you take close-up photographs, and this caution is well deserved. As you get closer and closer to your subject matter, the DOF range begins to collapse.

It would now be good to relate two seemingly unrelated topics: focusing on infinity and close focusing on small objects. They are related. Focusing on infinity wasted DOF in the foreground; hence, the recommendation is to hyperfocal focusing instead. Both focusing on infinity and hyperfocal focusing ensured infinity would be in focus. What is the practical difference? Hyperfocal focusing provided for more focus in the foreground.

With Fig. 5.30 still fresh in your mind, you may see the link and realize that focusing on top of any cartridge casing may actually be wasting some of the available DOF range. If, in fact, the DOF range for extreme close-ups is less than ½″ in front of the plane of exact focus and ½″ behind the plane of exact focus, then focusing on top of the cartridge casing wastes some of the DOF range! It would actually be more effective to focus a little down the side of the cartridge casing. That way, the near DOF range could include the top of the casing, and the far DOF range would proceed further down the casing, which would be extremely relevant when a fingerprint is on the cartridge casing and you want to make sure as much of the fingerprint on the same casing is in focus as possible, which would also be applicable whenever any critical evidence is on a curved surface and maximizing the DOF range is important. In these situations, bracketing by changing the focus point instead of the exposure value would be warranted. But, certainly, just automatically focusing on the top of the cartridge casing, as crime scene photographers are all instinctively prone to do, would actually be counterproductive if you wished to maximize the DOF for a close-up image.
Tips to Maximize Depth of Field

The DOF is the variable range, from foreground to background, of what appears to be in acceptable focus. That is its definition. When you are photographing crime scenes, accident scenes, and the evidence within those scenes, can you think of any time, which has not already been covered in this chapter, when you would intentionally want part of those photographs to be out of focus? For the most part, you should follow the Cardinal Rule: Maximize DOF whenever possible. An out-of-focus photograph may not be acceptable in court as evidence, which will be emphasized again when legal matters concerning photographs are discussed. However, this point cannot be overstated: maximizing the DOF should be one of your constant concerns when engaged in crime/accident scene and evidence photography.

Here are several techniques to ensure the DOF is maximized. We have already dealt with three of them.

1. Hyperfocal focus when taking photographs of large outdoor crime scenes when infinity is in the background.
2. Zone focus when taking photographs of large crime scenes but infinity is not in the background, which will require having a DOF scale.
3. Focus by the rule of thirds when taking photographs of large crime scenes when infinity is not in the background, and you do not have a DOF scale.

A few more ideas will help ensure the DOF is maxed out most of the time.

4. Select the ISO film speed/digital equivalent to maximize the DOF.

Because the f/stop selection is one of the critical factors affecting the DOF, and the small f/stops (f/22, f/16, f/11, and f/8) always provide for better DOF ranges than the wide f/stops (f/2, f/2.8, f/4), how do you choose an ISO that will ensure the use of these smaller apertures? With digital cameras, there is no cost to varying the ISO selections. So, what is the slowest ISO that will allow photography with the small apertures?

**RULE OF THUMB 5.5**

On bright sunny days, ISO 100 will allow photography with the smaller f/stops. Otherwise, on cloudy or dark days, at nighttime, or indoors when using electronic flash, use a faster ISO like ISO 400.

With the steady trend toward digital imaging at crime scenes, all crime scene photographers will now have digital 35 mm SLR cameras as their standard tool and will be able to select any ISO film equivalent for each and every image.

However, why was ISO 100 recommended for bright sunny days? If you recall the f/16 sunny day rule, it recommended using an f/16 on a bright sunny day and converting the chosen film speed into a shutter speed. If ISO 100 was used, the shutter speed became 1/125th of a second. By the theory of reciprocity, f/16 and 1/125 could be changed to f/22 and 1/60th of a second. These result in better DOF and the same exposure.

For other lighting conditions, ISO 400 was recommended, because in those circumstances, you would be able to close down the aperture 2 stops from what an ISO 100 could provide. For example, on an overcast day, an f/8 was recommended with a 1/125th of a second shutter speed if using ISO 100 film. By reciprocity, this could be changed to 1/60th of a second shutter speed and f/11. When an ISO 200 is used, the f/8 would be paired with a 1/250th second shutter speed, and reciprocity would allow this to be changed to 1/60th of a second shutter speed and f/16, a 1-stop improvement. However, if ISO 400 was being used, the beginning point would be f/8 with a 1/500th of a second shutter speed, which by reciprocity could be changed to 1/60th of a second shutter speed and f/22—the same exposure with a much better DOF.

With digital imaging, you can select a different ISO film speed equivalent for each and every shot you take.

Finally, it should be mentioned that many cameras have a DOF preview button. This needs some initial explanation. Most modern lenses are designed so that when mounted onto the camera body, they are automatically set to the widest aperture the lens has. You may select a different f/stop to take a particular image, but until the shutter is depressed, the lens remains at its widest aperture. Once the shutter button is depressed, the lens shuts down to the selected f/stop. The shutter will immediately open up to its widest aperture after the image is captured. Two main reasons exist for this lens design feature. It is easier to see and compose on an image when the aperture is wide and the scene is well lit. It is also easier to focus the camera when the aperture is wide and the scene is well lit.
If the lens has an f/stop range from f/2 through f/22, the lens is designed to be at the f/2 aperture at the time the camera is composed and focused. Then, just as the shutter is depressed, the lens momentarily shuts down to the pre-selected aperture as the image is captured. Immediately, the lens will return to the f/2 aperture so the next image can be composed and focused.

The downside to this lens design is that the DOF with an f/2 is minimal, and you will see only one distance in focus, while the foreground and background will appear to be out of focus in the viewfinder.

To enable the photographer to be able to see the true DOF range, the DOF preview button, if your camera has one, allows the lens to shut down to the preselected f/stop before the picture is taken. The main complaint is that by having the lens shut down to an f/22 aperture, for example, so much light is cut out from the viewfinder that it is frequently too dark to see the now apparent DOF range. Many find this situation to be too frustrating to effectively use. So, many do not use the DOF preview button at all, even if their camera has one.

The DOF preview button is usually located low on the camera body to the left of the lens, if looking at the front of the camera. Fig. 5.31 shows the DOF preview button, in the lower center.

**LENSES**

**Lens Designations**

Walk into a camera store, and you will be amazed by the variety of lenses available. How do you intelligently compare one lens with another on the shelf right next to it? Each lens has characteristics you need to know. Some of the most frequent variations are discussed next.

**Focal Length**

The focal length of the lens is, by definition, the distance in millimeters (mm) between the optical center of a lens and the sensor when the camera is focused on infinity (∞). This aspect of the lens being focused for infinity is important because many lenses extend in length as their focus changes from infinity to their closest focusing distance.

Fig. 5.32 shows a 50 mm lens when focused on infinity (A) and the same lens when focused at its closest focusing position (B). As the lens is focused, various optical elements within the lens may change positions. When focused on infinity, the lens will be at its most compact configuration. The optical center of the lens elements would actually be farther than 50 mm when the lens is focused at any other point. It should be mentioned here that many modern lenses focus internally, without any extension of the end of the lens. The definition of focal length was formed before this modern variation of lenses. It would still be correct because the lens is always at its most compact configuration when focused on infinity.
As zoom lenses having different focal lengths are considered, it should now be obvious that their relative lengths will frequently differ with the selected focal length, which is easily demonstrated by seeing how a zoom lens changes configurations as it is set to different focal lengths. The lenses in Fig. 5.33, by the way, focus internally, so it does not matter that the focus has not been dialed to infinity. The focal lengths of these four lenses begin with 16 mm and then proceeds through 35 mm, 50 mm, and finally 85 mm. As you would expect, the length of the lens progressively gets extended more and more.
**Fig. 5.34**

An 800 mm lens supported by two tripods.

**Fig. 5.34** is a Nikon 400 mm lens with a 2× teleconverter, effectively making it an 800 mm lens. It is a monster. But, if you want to get up close and personal with a bad guy 400′ away from the camera, there are not many alternatives. Because of its size, it has been mounted on two tripods for additional stability.

A 50 mm lens has 50 mm in distance between the optical center of the lens and the sensor when the lens is focused on infinity. With a 100 mm lens, that distance is 100 mm between the sensor and the optical center of the lens. That is why telephoto lenses are longer than most other lenses.

**“Fast” and “Slow” Lenses**

When you are shopping for a lens, the dealer will sometimes refer to a lens as being “fast” or “slow.” Lenses themselves do not have “speeds,” but they do one aspect which affects the ultimate shutter speed that is usable for a particular photograph.

The lenses for 35 mm cameras have within them an adjustable diaphragm, which can be opened to a wide aperture or closed down to a smaller aperture to vary the amount of light that can pass through the lens toward the sensor. Adjusting this diaphragm is usually referred to as “selecting the f/stop.” F/stops are one indicator of the amount of light that is allowed to reach the film.

Together, the shutter speeds and the f/stops control the total quantity of light that is allowed to ultimately reach the sensor for an exposure. The light intensity can be controlled by the amount of light coming through the lens (f/stops) and the time the light enters the camera (shutter speeds).

If a larger volume of light can be transmitted by any particular lens, a proper exposure may be obtained by using a shorter or “faster” shutter speed. If a smaller volume of light can only be transmitted by a particular lens, in the same lighting conditions, that volume will have to be transmitted for a longer time to arrive at the same exposure. It is basically a balancing act. With more light volume or larger diaphragm openings, less time or shorter shutter speeds will be needed for a proper exposure. With less volume or smaller diaphragm openings, more time or longer shutter speeds will be required for the same proper exposure.

An f/stop of f/2 is regarded as the pivotal f/stop for designating 50 mm lenses as being either “fast” or “slow.” If a lens has a wider maximum lens opening than f/2, it is called a “fast” lens, because by letting in a larger volume of light, less time, or a “faster” shutter speed is needed for a proper exposure. An f/1.4 would be an example of a “fast” 50 mm lens. “Fast” lenses are more expensive because photographers value them for enabling nonflash photographs in dim light, thereby maintaining a natural look to a scene. This aspect of “fast” lenses does not have the same value to crime scene photographers because wide apertures produce the worst DOF ranges, and crime scene photographers are usually concerned with maximizing the DOF range.
If a 50 mm lens has a smaller lens opening than f/2 as its maximum lens opening, it is called a “slow” lens because it will require the shutter to remain open longer for the same exposure. A 50 mm lens with its widest aperture of either f/2.8 or f/3.5 would be regarded as a “slow” lens.

This issue of “fast” or “slow” lenses becomes important when you are shopping. The same focal length lens may be available with different maximum apertures. Expect to pay more for the “faster” lenses. If purchasing lenses for your agency, be comforted that “slow” lenses are perfectly suited for crime scene work, and you will save your agency some money.

Zoom lenses typically will not have the same wide apertures as 50 mm lenses. Zoom lenses will often have their widest aperture around f/3.5 or f/4. However, a zoom lens with an f/3.5 aperture as its widest aperture is said to be “faster” than another zoom lens with an f/5.6 as its widest aperture.

**Lenses Are Designated by Their Widest Apertures**

Because of the premium placed on the widest aperture of any particular lens, all lenses are designated by their widest aperture. It is marked on the lens barrel, and it will be marked on the packaging material. You might go shopping for a 50 mm f/1.4 lens that is regarded as very “fast” but have to settle for a more reasonably priced 50 mm f/2 lens.

Zoom lenses will be designated by their widest aperture at each extreme in their focal length. A typical zoom lens that provides for focal lengths between 35 and 105 mm may be designated as a 3.5/4.5 lens. That means the widest aperture at the 35 mm setting is f/3.5, and the widest aperture at the 105 mm setting is f/4.5.

The lens in Fig. 5.35 features focal lengths from 24 to 85 mm. As part of the name of the lens, it is designated, 1:2.8–4. This means the widest aperture at the 24 mm setting is f/2.8 and the widest aperture at the 85 mm setting is f/4.

**The “Normal” Lens**

Different lenses may make the scene viewed in the viewfinder appear to be different than the eye sees the scene. A 50 mm lens is considered to be the “normal” lens for a 35 mm SLR film camera because it portrays a scene in a similar way as the eye saw it. (Be aware that different camera formats will have different “normal” lenses. For instance, the “normal” lens for a medium-format camera will be an 80 mm lens. Many point-and-shoot digital cameras frequently feature a wide-angle lens as their only lens. However, most crime scene photography is done with the 35 mm SLR camera format.) A distant object viewed through a 35 mm camera with a 50 mm lens looks the same distance away as when you directly look at it. A near object, viewed through a 35 mm camera with a 50 mm lens, looks to be the same distance from you as when you look directly at it. The relative distance between the near and far objects looks the same to the eye as when viewed through a 35 mm camera with a 50 mm lens on it.
The “normal” lens for a camera system is “officially” supposed to be determined by using the diagonal of the size of the sensor; the full-frame 35 mm digital sensor is 24 × 36 mm, and Pythagorus would remind us that the hypotenuse of this right triangle would be about 43 mm. He would be correct. For some reason, 35 mm SLR film camera manufacturers have usually called the 50 mm lens the “normal” lens for this camera format. With the 50 mm lens on the camera, view the scene through the viewfinder. Immediately look up above the camera at the scene. Nothing should have changed. The 50 mm lens is supposed to make the world appear the same when you are looking through the viewfinder as when you are looking at the world without a camera in front of your face.

However, some cameras have viewfinders with magnification ratios. Canon’s current top-of-the-line EOS 5DS R, a 50.6-MP camera, has a viewfinder magnification of 0.71×, magnifying everything seen through the viewfinder. Nikon’s D810A, with its 36.5-MP digital sensor, has a 0.70× frame coverage, also narrowing the view somewhat. The net result of these cameras with viewfinder magnifications is that the image you capture will be slightly larger than what you saw through the viewfinder. This should ease your mind if you tightly compose a close-up photograph of a weapon. You will not be likely to have cut off any part of the weapon when the image is printed.

The 50 mm lens, used with a digital SLR camera with a full-frame sensor, is the focal length of choice when it is a crime scene photographer’s intention to offer the photograph of the crime scene in court and maintain that the photograph is “a fair and accurate representation of the scene.” This deserves to be a Rule of Thumb.

**Rule of Thumb 5.6**
The use of a different focal length lens may introduce lens distortion into a photograph. Wide-angle lenses will elongate the distance between the foreground and background. Telephoto lenses will compress the distance between the foreground and background. Only the 50 mm lens will capture the image without this distance distortion.

One other aspect of the 50 mm lens is that it only provides a view of the world that is about 36-degree of the field of view. Items further to the left and to the right will not be included in the field of view unless you back up. In this case, objects will appear smaller because they are now further away. If, however, it is your intent to eliminate extraneous objects from your field of view, all you need to do is move closer to the primary subject until the extraneous items are outside of the 36-degree viewpoint.

**Focal Length Multipliers**
With digital SLR cameras, the concept of the “normal” lens is a bit more complicated. Different digital camera manufacturers produce different sized digital sensors. Some of the digital sensors are the same size as the film negative used to be, 24 × 36 mm. However, at this time, these are normally found on only the more expensive cameras in a manufacturer’s digital camera line. The medium-priced and less-expensive digital SLR cameras use digital sensors that are smaller than a film’s negative was. Why does this matter? Because it has a direct effect on a lens’ angle of view and, therefore, affects what is considered a “normal” focal length for a particular camera.

Nikon makes digital cameras with both sized sensors. Nikon digital cameras with the smaller digital sensor have a 1.5 Focal Length Multiplier on many of its medium- and low-end digital SLR cameras. Sony digital cameras also use a 1.5 focal length multiplier. Canon uses a 1.6 focal length multiplier. All these smaller digital sensors are sometimes referred to as Advanced Photo System-Classic (APS-C) sized sensors, which is a reference to the film size created in 1996, which was 25.1 × 16.7 mm. This is smaller than the 35 mm-sized sensor of 36 × 24 mm. See Fig. 5.36 for Nikon’s relative sensor sizes.

How does this affect the lens’ field of view? Table 5.2 may help. It shows the standard focal lengths of 20, 28, 35, 50, 70, and 100 mm compared with their digital focal length equivalents, when the digital sensor is smaller than the full-sized sensor.

The graphic in Fig. 5.37 will also help you understand this concept.

The effect is that the smaller digital sensor captures less detail than what a full-sized sensor would have. Another way to look at this is that the smaller digital sensor produces a “crop” of the image, equivalent to the effective focal lengths
Focus, Depth of Field, and Lenses

In Table 5.2, for instance, if a camera with a full-sized sensor composes a certain scene with a 50 mm lens on the camera, if you are using a zoom lens, and you zoom the lens to the 75 mm setting, you see less of the scene. This is exactly what you would see when using a digital camera with a 1.5 focal length multiplier. If you are using a zoom lens, and you zoom the lens to the 80 mm setting (assuming it has one), you see less of the scene. This is exactly what you would see when using a digital camera with a 1.6 focal length multiplier. When using a digital camera with a sensor that is smaller than a full-sized digital sensor, the image that is captured resembles a “crop” of what the full-sized sensor would have captured.
To take the first three images shown in Figs. 5.38 and 5.39, a digital camera with a full-frame sensor was placed on a tripod at the door to this kitchen. For the first three images, a zoom lens was set to 28 mm, then 35 mm, and finally 50 mm. Progressive "crops" of the first image are seen in the second and third images. For the fourth image, Fig. 5.39B, the camera was replaced with a digital camera that had an APS-C-sized digital sensor, with a 1.6 focal length multiplier. The same lens was used, and it was set to 50 mm. The focal length multiplier should make the 50 mm lens show the same field of view as an 80 mm lens. The fourth image shows that it does.
For working crime scene photographers wishing to capture a scene as their eyes saw it, which focal length is to be used if working with an APS-C-Sized Digital Sensor in their camera? Return to Table 5.2 for the answer. When you are using a digital camera with either a 1.5 or 1.6 focal length multiplier, and your task is to capture an image equivalent to a 35 mm digital camera with a full-frame sensor, set your lens to about 35 mm. Actually, to be precise, if you have a sensor with a 1.5 focal length multiplier, 50/1.5 = 33.33 mm, or 33 mm. That will be your new “normal” focal length. If your smaller digital sensor has a 1.6 focal length multiplier, 50/1.6 = 31.25 mm, or 31 mm. That will be your new “normal” focal length.
Some might think that the use of a 35 mm lens under these conditions may lead to a wide-angle lens’ “elongation of the scene” effect previously pointed out. Actually, this does not happen. Since a 35 mm view of the world is being “cropped” by the smaller digital sensor, the areas in the foreground, which would show this elongation the most, are being “cropped” out, and the resultant image shows no elongation. The image examples in Fig. 5.40 help to demonstrate this effect.

Both the top-left image and the right image were taken with a digital camera with a full-sized sensor. The right image shows both a wider field of view and a pronounced elongation of the scene. The corridor did not look like this to the eye. (Ever wonder how scenes are elongated/stretched in scary movies? The cinematographer simply rotates the zoom lens from “normal” to wide-angle.) The lower-left image is a crop of the right image, done in Photoshop. Cropping the image taken with the 28 mm lens results in an image that looks “normal” and no longer elongated.

Fig. 5.41 will help make this point stronger.

The top three images of Fig. 5.41 were taken from the same location, using a digital camera with a full-frame sensor. The focal lengths of the lenses are acting “normally.” The 50 mm view can be considered a “crop” of the 28 mm view. The 105 mm view can be considered a “crop” of the 50 mm view. The “crops” on the right just show magnified views. The image taken with the 50 mm lens could have also been captured with a digital camera with a 1.5 focal length multiplier, with this camera set to about 33 mm.
To end this discussion of focal length multipliers, it should now be obvious that anyone wishing to take a photo with a telephoto lens is greatly helped when using a digital camera with an APS-C-sized digital sensor. A 300 mm lens will be acting like a 450 mm lens. A 500 mm lens will be acting like a 750 mm lens. The trade-off is that your wide-angle lenses are not quite so “wide” when used with these cameras. Your 20 mm lens will be acting like a 30 mm or a 32 mm lens depending on your focal length multiplier, 1.5 or 1.6, respectively.

To be perfectly accurate, telephoto lenses do magnify distant subject matter, making them larger. Digital cameras with focal length multipliers, however, only “crop” what would have been captured with a full-frame digital sensor. This “crop” is not technically true magnification. When the cropped shot is printed out at full size, and you see what had been a distant object as a larger image, sometimes you incorrectly think of this as magnification. An enlarged “crop” is not the same as magnification.

Fig. 5.42 shows various angles of view of selected lenses, used with 35 mm digital SLR cameras with full-frame sensors. Lenses range from an ultra-wide fish-eye lens that has a 180-degree view to a super-telephoto 1200 mm lens with just about a 2-degree view. Lenses with focal lengths less than 50 mm are referred to as wide-angle lenses; lenses with focal lengths more than 50 mm are referred to as telephoto lenses.
Telephoto Lenses

Lenses with a focal length longer than 50 mm are called telephoto lenses. They can range from 60 to 1200 mm. The optical centers of these lenses are farther from the film plane than a 50 mm lens distance. This difference produces distinct changes to a photograph, compared with the 50 mm lens look. These differences are as follows:

- Magnification
- Narrower field of view
- Compression of foreground-to-background distances
- Narrower DOF range

Magnification

Telephoto lenses are perhaps best known for their ability to magnify distant objects. This telescopic effect can be determined by dividing the focal length of the telephoto lens by 50 mm. Therefore, a 100 mm lens would be the equivalent of a 2× telescope; a 300 mm lens would be the equivalent of a 6× telescope. The distant subject would be magnified by two times and six times, respectively. This magnification ability is perhaps best suited to surveillance photography, when it is necessary to identify distant subjects by photographing them while the photographer maintains a safe distance so they are not noticed.
Compare two images in Fig. 5.43: one taken with a 50 mm lens; the other, a partial crop and enlargement of the first.

In the center of Fig. 5.43A, you may be able to notice a small, vague, dark-jacketed person. It is extremely difficult to do so because the person is standing 400′ from the camera, and the image was taken with a “normal” 50 mm lens. A 50 mm lens is certainly not sufficient to resolve the detail of the subject. The Fig. 5.43B confirms this. It is a crop and enlargement of the left image, intended to show the subject “better.” The resolution is not adequate to make out the subject, other than to suggest the subject may possibly be a blonde female. Individual characteristics are lacking altogether.

Fig. 5.44A is an image of the same subject standing the same distance from the camera at night. The difference here is that an 800 mm lens was used. Although the subject appears to be underexposed, she is certainly much larger. Fig. 5.44B shows the same image digitally cropped and enlarged, and the underexposure has been corrected in Photoshop. The resolution is sufficient to make out the face and to determine the letters and numbers on the license plate held by the subject. And, it appears the tag has a frame with a name on it: Jerry’s. The author once owned a car from the Jerry’s Ford dealership. Certainly, this focal length lens has adequate magnification for an identification of the individual. For this reason, the next Rule of Thumb has been established.

**RULE OF THUMB 5.7**

In surveillance situations, to be confident magnification will be adequate to recognize either a subject’s face or to read a license plate, you should use a lens that has a focal length of 2 mm of lens per foot of distance between the camera and the subject.

With Fig. 5.44, an 800 mm lens was used for a distance of 400′ between the camera and subject.
To understand this Rule of Thumb better, examine the images shown in Fig. 5.45. On the campus of The George Washington University, you might expect to run into George several times. One of his statues is life-sized. From 50′ away, George was photographed with 24, 50, and 100 mm lenses. With the 100 mm lens, George is the size on the image that is recommended for surveillance situations. (Of course, being just 50′ away from a subject of surveillance may not be a good idea.) When his face is cropped and enlarged, you would still expect to be able to recognize it. Be aware that these images were taken with midday lighting. As the lighting gets more and more problematic, and the distances between the photographer and the subject become longer, the difficulties would increase. But, even in a nighttime situation, 2 mm of lens should be able to resolve distinguishable features. With a zoom lens adjusted to about 50 mm at a 50′ distance, 1 mm of lens per foot of distance is the result. The face is a bit smaller in the image. You would expect enlargements that had the face recognizable to be just a bit more difficult, especially in darker conditions and longer distances. With the zoom lens adjusted to about 24 mm at a 50′ distance, 0.5 mm of lens per foot of distance is the result. The face is smaller yet, compounding any attempt to resolve the face so it is recognizable. Because capturing the facial features in surveillance situations is so critical, you cannot take chances of losing the detail you seek to capture in the first place. The use of 2 mm of lens per foot of distance guarantees this detail will be obtained.
From any viewpoint of an item of evidence, if it is desired to fill the frame with critical aspects of the object, moving closer to the object matter is usually advised. However, at times moving closer is not practical. Other critical evidence may be in the way, prohibiting moving closer to the subject matter of the photograph. Or it may not be safe to step closer to the item of interest. At an arson scene, the floor may be weak just ahead of the place where the crime scene photographer is currently standing. In these situations, you should consider using a zoom lens in its telephoto setting, which will magnify the area of interest, without your having to get physically closer.

Care should be maintained that this use of a telephoto lens merely magnifies or enlarges critical details of the evidence. As explained previously, use of a telephoto lens can distort the relative perspective between objects. Therefore, a zoom lens cannot be used to show “a fair and accurate representation of the scene,” specifically the distance between two or more objects, if a linear point of view has been established. The use of a zoom lens to enlarge an individual element of the scene is, however, permissible.

An example is helpful. At a remote fire scene with fatalities, an electric clock on a wall suggested the time of the fire when the fire damaged the electric cord and stopped the clock. The floor in front of the clock had completely collapsed. The clock could be viewed only from another room that had a wall also burned away. To photograph the clock, the crime scene photographer used a telephoto lens. The clock was magnified and filled the frame of the viewfinder. The telephoto lens was used for its strength: magnification. No other scene details were included in the composition to avoid the tendency of telephoto lenses to compress foreground-to-background distances.

Narrower Field of View

As you can see in the preceding photographs, telephoto lenses also take in a narrower field of view than the 50 mm lens. Although the 50 mm lens takes in 36–46 degrees of the scene, a 100 mm lens takes in only 24-degree, a 300 mm lens takes in only about 8-degree, a 600 mm lens takes in only about 4-degree, and a 1200 mm lens takes in only about a 2-degree view of the scene. This narrower field of view can be useful; by eliminating extraneous items to the left and to the right, the photographer can force the viewer to concentrate on the intended primary subject, rather than being distracted by a myriad of objects in the field of view.

Compression of the Foreground and Background

Because the background will be magnified with a telephoto lens, making it appear enlarged, the relative perceived distance between the camera and the background is necessarily compressed. Objects appear closer together than they really were. This perceived distance between the foreground (the photographer’s position) and a magnified object in the background appears to be shorter.

Consider how this might affect skid marks at a fatal accident scene. If the photographer frames the scene from the beginning of 100’ of skid marks leading to the place where the vehicles are found resting together and uses a 50 mm lens, or its equivalent, to capture the image, the resulting photograph will duplicate the scene as the eye had seen it. If a 100 mm lens is used instead, the vehicles in the background will appear to be closer to the photographer than they had been in reality, and the perceived length of the skid marks will appear to be shorter than they originally were, which distorts reality. The photograph taken with a telephoto lens should not be used in court as “a fair and accurate representation of the scene as it appeared.” An unscrupulous defense attorney, representing the driver who skidded, may be tempted to hire a photographer to take photos of the skid marks using a telephoto lens. The resulting shorter skid marks can be interpreted by the jury as suggestive of less speed just before the accident.

The images in Fig. 5.46 demonstrate this idea, although they are images of double yellow lines instead of skid marks. Fig. 5.46A shows the length of the double yellow lines when photographed with a 50 mm lens, which is also the length of the lines as seen by the eye. Fig. 5.46B shows the same double yellow lines photographed with a 100 mm lens. This lens compacts the apparent true length of the lines, making them appear shorter. Crime scene photographers need to understand that using telephoto lenses with vertically viewed evidence will alter their “fair and accurate” appearance so that they are not tempted to use these lenses in these situations. They also need to be aware of the effect of compacting foreground-to-background distances in case photographs presented by the defense look radically different from their own, so they can explain the differences to the judge and jury in court.
Because of this compression effect, telephoto lenses are used in law enforcement mostly for their magnification qualities: to make it easier to recognize distant objects. The use of telephoto lenses to document overall crime scenes and overall accident scenes is strongly discouraged because of the relative distance distortion they create.

**Narrower Depth of Field**

As mentioned earlier, DOF is the variable area, from foreground to background, of what appears to be in sharp focus. Another effect of using a telephoto lens is a reduction in the DOF area. When using a telephoto lens, less appears to be in focus than when using a 50 mm lens. Why is this?

The same f/stop will produce different diameters of the diaphragm with different focal length lenses. Recall Fig. 5.28.

Should you use an f/8 with a 24 mm lens, a 50 mm lens, and a 100 mm lens, the resulting aperture size will be different with each lens. With a telephoto lens, the diameter of the diaphragm will be the largest compared with either a normal lens or a wide-angle lens. The telephoto lens would, therefore, have its circles of confusion, which are still perceived to be in focus to the eye, closer to the plane of exact focus, which is the sensor. The result is a shorter DOF range.

When used in surveillance situations, this reduced DOF range is usually not a problem because you will be focusing on relatively small areas or on individuals. Even the widest apertures used with telephoto lenses will produce some DOF when distant scenes or subjects are focused on.

**Wide-Angle Lenses**

Lenses with a shorter focal length than 50 mm are called wide-angle lenses. Wide-angle lenses can range from a 35 mm lens to a true fish-eye lens, which can capture 180 degrees of detail. The optical centers of these lenses are significantly closer to the film plane than a 50 mm lens’ distance. This difference produces distinct changes to a photograph compared with the 50 mm lens look. These differences are:

- Wider field of view
- Elongation of foreground-to-background distances
- Increased DOF

**Wider Field of View**

Wide-angle lenses naturally capture wider views of the scene. The relative increase in the field of view can be very close to what a normal 50 mm lens would capture when using a zoom lens set to about 40 or 45 mm. Remember that the true diagonal of a full-sized digital sensor that is 24 mm high and 36 mm long is 43 mm. Therefore, when the scene is viewed from a zoom lens set at about 43 mm, the scene should look exactly the same as when you remove your eye from the viewfinder. If not, some magnification ratio may be set into the viewfinder optics. Check your camera’s manual.
A 35 mm lens, and wider lenses, should begin to show more and more of the scene in the viewfinder, which becomes extremely handy when you have the duty to photograph wide objects, like the exterior façade of a large building. With just a 50 mm lens, you would have to take many more photographs. With a wide-angle lens, you would be able to capture the same overall detail with fewer images. The same would apply when faced with the need to capture interior overall photographs of a room that contains a crime scene. If you want to capture the full 360-degree view of all the walls, using a wide-angle lens would reduce the number of photos required.

Fig. 5.47A shows the view of a kitchen while using a 50 mm lens, which is the typical view that a 50 mm lens offers. Fig. 5.47B was taken from the same position, but with a 28 mm lens. Much more of the scene has been captured from left to right. With moderate wide-angle lenses, such as 35 and 28 mm lenses, one perceived difference in photographs is this wider field of view. The other effect is that the rear of the scene appears to be further from the photographer than it really was, suggesting the room may be larger than it really is. As much wider focal lengths are used, usually at around 20 mm and wider, another effect can also be noticed. Vertical lines at the left and right edges of the image begin to bow outward more and more.

(A) Kitchen area as viewed through a 50 mm lens. (B) Kitchen area as viewed through a 28 mm lens. Courtesy of Dale Rio, GWU MS student.
Notice how all the edges of Fig. 5.48A appear to be bowed outward. This image was captured with a 24 mm lens. The bowing outward of vertical lines at the edges of an image is referred to as barrel distortion, and many photographers use it for its creative effects. Crime scene photographers, however, usually try to avoid this effect. Fig. 5.48B was taken with a normal lens, and the barrel distortion has been eliminated.

Avoiding the widest of the wide-angle lens choices can accomplish this task. Again, the 35 and 28 mm lenses are used most by crime scene photographers because a distinct gain exists in the left-to-right field of view, without incurring the barrel distortion wider-angle focal lengths can sometimes produce.

At times, the barrel distortion is replaced by having the tops of vertical elements at the edges of the image appear to be leaning inward, as in Fig. 5.49. Who has not seen a photo from a wedding where the entire wedding party is standing shoulder-to-shoulder and photographed with a wide-angle lens? Notice how the people at the left and right sides seem to be leaning in toward the center of the image? The culprit: a wide-angle lens.

**FIGURE 5.48**
(A) A wide-angle lens producing barrel distortion. (B) A short telephoto lens eliminates the barrel distortion.
Courtesy of Sarah Reeve, GWU MFS student.

**FIGURE 5.49**
Building edges tilting in with wide-angle lens.
Elongation of Foreground and Background

A wide-angle lens seems to make the background appear further away than it really was. Going back to the example of an accident with skid marks, if the wrecked cars are now appearing to be further away, the skid marks running from the camera’s position to the vehicles appear to be longer than they really were. A juror may interpret longer skid marks as an indication of greater speed. Again, when “a fair and accurate representation of the scene” is the desired goal of the photographer, wide-angle lenses should not be used.

The images of Fig. 5.50 are the same double lines previously considered in the section on telephoto lens effects. Fig. 5.50B, however, shows the same double yellow lines captured with a 28 mm lens. The lines appear to be stretched longer than they appeared to the eye when the photograph was taken, which is certainly not an accurate representation of the scene as it appeared to personnel at the scene. Fig. 5.50A could be used in court; Fig. 5.50B should not be used in court.

As with telephoto lenses, you can use a wide-angle lens for its strength, without incurring its weakness. With telephoto lenses, their strength is magnification. Their weakness is perspective distortion in the form of foreground-to-background compression. The strength of a wide-angle lens is its ability to capture more detail to the left and to the right. The weakness of the wide-angle lens is perspective distortion in the form of foreground-to-background elongation. How can you use its strength without also having the image suffer from its weakness? If you are careful with your composition, by carefully eliminating much foreground-to-background detail in the field of view, you can use a wide-angle lens for its ability to capture more details to the left and right.

Fig. 5.51 shows two foreground-to-background distance variations with different focal length lenses. Fig. 5.51A was taken with a 35 mm lens; the Fig. 5.51B was taken with a 50 mm lens. Both were photographed from the same location. Because the wide-angle lens shows the buildings apparently further away from the photographer, a viewer of only one of the images may incorrectly assume the distance between photographer and the buildings was greater than it is in reality, which is the distance distortion to be avoided with wide-angle lenses. However, the 50 mm lens may not show as wide a scene as desired. Can you have wide views without foreground-to-background distortion? Yes. See Fig. 5.52.

To retain the strength of the wide-angle lens, its ability to capture wider views, without its negative effect, its tendency to elongate the scene causing a misperception of the foreground’s depth, the building is composed to eliminate the foreground. Just raise the camera up until the bottom edge of the viewfinder includes the bottom of the structure you want to photograph. Better to have a bit more sky in the composition than distorted foreground.

Increased Depth of Field

Another effect of using a wide-angle lens is an increase in the DOF. There will appear to be more in focus between the foreground and the background than when using a 50 mm lens. This is again a result of the equation FLL/f/stop = DOD.

FIGURE 5.50
(A) 50 mm lens with double yellow lines. (B) Same double yellow lines with 28 mm lens.
The same f/stop used with different lenses will produce different diameters of the diaphragms: 100 mm/f/8 results in a DOD of 12.5 mm; 50 mm/f/8 = 6.25 mm; and 24 mm/f/8 = 3 mm. Light coming through a smaller aperture will result in the circles of confusion, perceived by the eye to be in focus, to be farther from the plane of exact focus at the sensor. Recall Fig. 5.50.

Unfortunately, this increased DOF is rarely usable by crime scene photographers because at the same time a wide-angle lens is causing the perspective distortion previously mentioned. Despite the Cardinal Rule to maximize DOF, you cannot use wide-angle lenses for most of your photography.
Macro Lenses

Telephoto lenses provide magnification of distant objects, but if the need is to magnify small objects to fill the frame of a photograph, other types of magnification are needed. To put this into perspective, consider that the normal 50 mm lens, when it is focused at its minimum focusing distance, will fill the frame of the viewfinder with an object that is approximately 6" × 9".

Many 50 mm lenses have about 18" as their closest focusing distance. If you position the camera closer than 18" to the object being photographed, the lens will not focus. Therefore, anything smaller than 6" × 9" will require additional enlarging to truly fill the frame.

Magnification With a 1:1 Ratio

Another way this situation is usually explained is by saying that a typical 50 mm lens has only a 1:7 magnification ratio. This means that an object the size of a full-sized digital sensor, photographed with a 50 mm lens at its minimum focusing distance, will be 1/7th of its real size in the viewfinder or when that image is made into a print without enlargement. Or, seven objects the size of a fingerprint will fill the frame when photographed with a 50 mm lens focused to its closest focusing distance. Fig. 5.53 will help clarify this point.

Fig. 5.53 shows that about seven fingerprints, stacked vertically, fill the frame with a 50 mm lens. When equipment providing a 1:1 magnification ratio is used, a single fingerprint fills the frame nicely, as in Fig. 5.54.

These concepts about magnification ratios are made more confusing because lens manufacturers will advertise that a lens has macro capabilities and charge a premium price for it, but when the literature is closely examined, the lens turns out to have only a 1:5 or 1:4 magnification ratio, which is only a slight improvement from what a 50-mm lens provides without any help.

For crime scene work, the macro capability desired is a 1:1 magnification ratio, but a 1:2 ratio is acceptable. Anything less will have small objects appearing small on full-sized prints or will require the darkroom operator to spend a lot of time enlarging small items of evidence. The smaller the evidence is on the negative, the more it will have to be enlarged to have the item appear to fill the frame of a print made from that negative.

Forensic laboratory experts will want a life-sized image to work with to compare to evidence recovered from a suspect. The more the image has to be enlarged to accomplish this, the more loss of detail possible from the enlargement process. Therefore, it should be a crime scene photographer’s constant goal to ensure the evidence appears as large as it can be on the negative when the image is originally captured.

How can these magnification ratios be obtained?

Macro Options

Three common alternatives exist to achieve a 1:1 magnification ratio:

- Use a true macro lens.
- Use an Extension Tube.
- Use close-up filters.
MACRO LENSES

Macro lenses providing a 1:1 or 1:2 magnification ratio can be very expensive. Macro lenses made by Nikon and Canon can cost between $300 and $700.

Macro lenses, however, produce the clearest, crispest close-ups of the three options discussed in this text. They should be your first choice if you have any influence in the purchasing decisions of your agency.

Fig. 5.55 is an example of a macro lens affixed to a camera. The images in Fig. 5.56 show just the lens and the window where specific magnification ratios can be selected. On the left side of the window there appears an orange “1:” designation, and inside the window you can see that the focus point, the gold line above the “R” of “Nikkor,” is aligned with the orange “1.” This represents the classic magnification ration of 1:1, and it will produce an image of a single fingerprint nicely filling the frame, like in Fig. 5.54. This particular macro lens gives the photographer the option of preselecting magnification ratios from between 1:1 to 1:10. With three fingerprints adjacent to each other, the magnification ration of 1:3 would produce an image like Fig. 5.57.
FIGURE 5.56
Macro lens set to 1:1 magnification ratio.

FIGURE 5.57
Three fingerprints with macro lens set to 1:3 magnification ratio.
**EXTENSION TUBES**

Second on your shopping list of equipment providing 1:1 magnification ratios should be an extension tube. An extension tube is a supplemental lens, inserted between the primary lens and the camera body, to move the optical center of the primary lens farther from the sensor’s plane. This results in magnification. See Fig. 5.58. Some manufacturers provide differing lengths of extension tubes to choose from, providing differing magnifications. Extension tubes can cost approximately $75 to $100. The various extension tubes can also be stacked, providing more magnification when used together. Some manufacturers make extension tubes that are completely without any lens elements. You can stick your finger through the center of the tube. Some manufacturers incorporate lens elements into the tube to assist with the magnification process.

Another way to vary the magnification possibilities is to use the extension tube with a zoom lens rather than a prime lens with just one focal length. By altering the focal length, you can control the amount of magnification desired. Fig. 5.59 shows the alignment of camera body, extension tube, and a zoom lens. Fig. 5.60 shows the magnification of the extension tube used with the zoom lens set at 105 mm.

**FIGURE 5.58**
(A) Camera and lens. (B) Extension tube added between the camera and lens.

**FIGURE 5.59**
Lens, extension tube, and camera body.
CLOSE-UP FILTERS/DIOPTERS/SUBLENSSES

A more cost-effective choice, if the budget is limited, which provides magnification ranges from 1:6 to 1:2, is the supplemental Close-Up Filter Set. This set of three filters with differing magnifications can be stacked for different magnification ratios (Fig. 5.61).

The individual filters are usually designated a +1, +2, and +4. The +1 and +2 can be stacked for the equivalent of a +3. The +4 and +2 can be stacked for the equivalent of a +6. When more than one filter is used, it is recommended to screw the highest number onto the primary lens and apply the weaker filter last. Some manufacturers suggest that all three filters should not be used together. Their reasoning is that each addition of glass between the evidence and the digital sensor can potentially degrade the quality of the resulting image.

Another consideration is that many agencies recognize the wisdom of purchasing the best lenses that are currently affordable. After all, the quality of the final image depends greatly on the quality of the lens that captured the image in the first place. But, sometimes, when the decision to purchase close-up filters is made, that same reasoning gets lost. To be consistent and logical, if it makes sense to purchase good-quality lenses, it is just as important to purchase good quality close-up filters. Putting inferior glass on the end of an expensive high-quality lens serves only to degrade the primary lens and its resultant image.

FIGURE 5.60
Magnification with the extension tube and a 105 mm lens.

FIGURE 5.61
Close-up filter set.
Close-up filter sets cost approximately $30 to $50, depending on manufacturer. Being able to stack the lenses in different combinations, changing the magnification ratio to match the size of the object, makes them quite versatile. The sequence of images in Fig. 5.62 shows a 50 mm lens used without any close-up filters, then a +1, +3, +5, and +7 used with a series of nickels placed side by side to show the progressive magnification possibilities as differing combinations of close-up filters are used together.

**FIGURE 5.62**

(A) No close-up filters. Then, (B) a +1, +3, +5, and +7 filters.

**LENSES WITH VIBRATION REDUCTION OR IMAGE STABILIZATION**

Many newer lenses feature what is referred to as either Vibration Reduction (VR) or Image Stabilization (IS). Some cameras will also advertise their camera’s digital sensor has “antishake” technology. To achieve this effect, either the lens elements or the digital sensor itself can gyroscopically move as the camera detects movement, counteracting the camera “shake.” This capability usually becomes a benefit in one of three situations.

- You may want to hand-hold a telephoto lens, or a zoom lens with a telephoto option, rather than put the camera on a tripod. Telephoto lenses usually require faster shutter speeds to avoid blurred images. The normal recommendation when hand-holding a telephoto lens is to use a shutter speed that is the reciprocal of the focal length of the lens. That would mean hand-holding a camera with a 500 mm lens would require using a shutter speed of 1/500th of a second. That shutter speed, however, is problematic in dim lighting conditions because it severely restricts the light entering the camera. Normally, putting the camera with a telephoto lens on a tripod allows the use of slower shutter speeds, making proper exposures in dim lighting with telephoto lenses easier.
When it is cold outside, and the photographer feels shivering may produce blurred images because of the additional camera motion, VR can help avoid the need to go to a faster shutter speed, like 1/125 or 1/250.

You may also want to use a camera with a slower shutter speed. The slower shutter speed may be needed for a proper exposure, as when you are trying to shoot moving subjects in dim lighting or, for creative reasons, when you may want some sense of blur in the image.

In any case, VR and IS systems can usually guarantee the absence of blur when using shutter speeds up to 2 stops slower than “normal.” Manufacturers may also claim the elimination or reduction of blur at 3 to 4 stops slower than a prudent person would use. For static crime scenes, this is usually not an issue. For fast-moving surveillance situations, this capability is particularly well suited.

**DIGITAL LENSES SPECIFICALLY DESIGNED FOR DIGITAL CAMERAS**

When digital SLR cameras first became popular, their sensors were smaller than a film camera’s negative. This is the APS-C digital sensor, previously mentioned. See Fig. 5.63. When lenses, designed to be used on a film camera, were used with these new digital cameras, the focal length multiplier effect was noticed. Because the APS-C digital sensor was smaller than the film negative, the light coming into the camera through a lens created a circle over the APS-C digital sensor much larger than the digital sensor. The digital sensor could record only a portion of the data—hence, the focal length multiplier effect.

Some camera manufacturers decided they could make new lenses specifically for their digital cameras with APS-C-sized sensors. These new lenses would create a circle of light within the camera body that “fit” the smaller digital sensor. Nikon and other manufacturers called these lenses “DX digital lenses”; Canon called the new lenses “EF-S lenses.” These new lenses were smaller, lighter (less glass was needed), sometimes faster (featuring a wider aperture), and less expensive.

The downside to these lenses was that they could not be used with film cameras or digital cameras offering a full-sized digital sensor. This was fine when many digital camera manufacturers did not even make digital cameras with full-sized sensors. And, the cameras that did have full-sized sensors were featured only on the manufacturers’ top-of-the-line expensive digital cameras. However, these full-frame sensors in digital cameras have become very popular, and this feature has migrated to some midline cameras. If this trend continues, and full-framed sensors become the new standard, those with a great collection of DX/EF-S lenses will find themselves having to buy new lenses. Caveat Emptor!\(^1\)

\(^1\)Let the buyer beware!
Reading the future can be very tricky, but regular lenses, designed for film cameras and digital cameras with full-sized sensors, will probably continue to work on both types of digital cameras.

Lens Optical Problems

In the late 1970s, when this author was first taught crime scene photography techniques, the instructor stated that whenever critical comparisons, now called examination quality photographs, were to be taken, the following Rule of Thumb was to be used.

**RULE OF THUMB 5.8**

Never use the two smallest or the two largest apertures of the lens’ f/stop continuum when critical comparison (examination quality) photographs are taken.

The preceding Rule of Thumb was certainly an interesting admonition, so it was fair to ask, “Why not?” The answer received was unsatisfying. He said he was not sure exactly why, but that it was what he was taught when he first learned crime scene photography, so he was passing on the best information he could.

Researching optics and camera lens design suggests the answer. The optics used in camera lenses have the same optical problems suffered by microscopes and telescopes. Despite camera lens manufacturers’ advertising claims, these lens problems can only be minimized through modern lens design and materials; they cannot be totally eliminated. Unfortunately, this information is not readily available from the current crop of resources (books, journals, magazine articles, etc.) dedicated to issues related to crime scene photography.

Where are microscopes and telescopes most frequently used? The fields of medicine, the “hard” sciences (biology, chemistry, and physics), and astronomy use microscopes and telescopes. The theories of lens optics most properly belong in physics courses and physics textbooks. That is where the answers to the preceding Rule of Thumb can be found.

Three problems with camera lenses have been identified:

- Aberrations
- Diffraction
- Distortion

**Aberrations**

Lens aberrations, or defects in an image produced by a lens, account for a reduction in the resolution of an image. Most, but not all, involve the inability of a lens to focus light at a precise point on the sensor. The result is frequently an impression of “softness” to the image and a loss of clarity of the details in the image. As mentioned previously, the word “aberration” is derived from the name of Ernst Abbe, a German physicist who collaborated with lens maker Carl Zeiss in 1866 to try to solve these problems as they occurred in microscopes in the mid-nineteenth century.

Most lens aberrations occur at the widest apertures of a lens. These lens aberrations are usually “cured” by stopping the lens down 2 stops to 3 stops. For instance, if the widest aperture for a particular lens is f/2, then stopping down to f/2.8 and then from f/2.8 to f/4 would almost totally eliminate image problems associated with the aberrations noticed when using an f/2. Actually, it is impossible to totally eliminate lens aberrations. Manufacturing the perfect lens is beyond the skill of lens designers; the best that can realistically be hoped for is that the aberrations are minimized to the point that they do not have an obvious effect on the image.

This is the foundation of Rule of Thumb 5.8, mentioned previously, to avoid the widest apertures of any lens when critical comparisons are being captured. However, as far as crime scene photography is concerned, photographers are usually not tempted to use wide apertures because of their all-consuming concern for maximizing the DOF.

What are the aberrations related to the widest apertures of a lens?

**CHROMATIC ABERRATIONS**

As light travels through the various lens elements, the different colors in white light will refract differently. The primary colors of red, green, and blue will separate and converge near the sensor at different locations, rather than at one precise point. If these colors do not focus at the same point, the image is noticeably “softer,” and the colors may appear to be a bit out of line. Rather than all the colors coming together to form the proper color of an object, a fringe color may be noticed as an unsharp outline of the subject, which can occur two different ways:
as a longitudinal chromatic aberration or as a lateral chromatic aberration. The longitudinal chromatic aberration involves light coming into the lens from directly in front of the camera, which is called on-axis light. The lateral chromatic aberration involves light coming into the lens from the sides of a scene, which is called off-axis light. In both situations, the primary colors will refract/bend to different degrees and come together near the camera’s sensor in different areas.

Figs. 5.64 and 5.65 show graphics of both the longitudinal and lateral form of chromatic aberrations.

Designing color-corrected lens elements is a partial solution to these aberrations. Stopping down the aperture is also required to totally “eliminate” this aberration from appearing in an image.

**SPHERICAL ABERRATIONS**

Similar to chromatic aberrations, the spherical aberration is caused by the different points of light that will converge near the sensor, but this is not related to the colors of white light being refracted by the lens elements. With spherical aberrations, the difference is attributed to the various parts of the lens the light comes through: the outer perimeter of the lens, the midpoint of the lens, or various intermediate distances between the two. With light from different areas of the lens focusing at different points near the sensor, the result is a loss of crispness to the focused image. The image can appear “soft” or a bit out of focus. See Fig. 5.66.

Again, the “cure” for spherical aberrations is to stop down the aperture. Do not use the widest apertures when critical comparison photographs are being taken.
COMA

As spherical aberrations appear somewhat similar to longitudinal chromatic aberrations, coma may seem similar to lateral chromatic aberrations. With coma, light coming into the camera from an off-axis location is focused at different areas of the film plane, depending on what area of the lens it came from: the perimeter, the midpoint, or intermediate distances between those two. See Fig. 5.67.

With coma, the light from a single point in space forms circles of various sizes at the sensor. These overlapping circles suggest the vague shape of a comet with a small trailing tail—hence, the term “coma.” The result of coma is a lack of sharpness, contrast, and resolution on the sensor. The “cure” to coma is to use a smaller diaphragm opening or a smaller f/stop.

Other aberrations include astigmatism and curvature of field. Because these are minimized by better lens design and not aperture selection, they will not be described here.

When a lens is adversely affected by aberrations, it is called aberration limited. A lens can also be diffraction limited.

Diffraction

Diffraction is the bending of light when it strikes an edge. The effect of diffraction is a loss of resolution, a loss of edge sharpness, and a loss of clarity in an image. Diffraction is most severe when using the smallest apertures of a lens’ f/stop continuum. For instance, if a lens has f/stops ranging from f/2 through f/22, the f/16 and f/22 apertures would be most severely affected by diffraction, which is the other basis for Rule of Thumb 5.8. Diffraction is the reason why small apertures are not recommended when images to be used for critical comparisons/examination quality are being captured. When examination quality images are the issue, the aperture of choice should be f/11 or f/8.

As an example, Fig. 5.68 is a fingerprint captured with a macro lens set to a 1:1 magnification ratio. A circle shows an area to be enlarged to show smaller details more clearly. Fig. 5.69 shows the area enlarged when an f/8 was used to capture the full fingerprint. Fig. 5.70 shows the same area when the entire fingerprint was originally captured with an f/22. Aside from a slight exposure difference between the two, you should be able to notice that Fig. 5.70 seems noticeably “softer.” True, even third level details are visible in both images; Fig. 5.69 is just the sharper of the two images.

Even though capturing a single-digit fingerprint with today’s higher-resolution sensors enables a latent print examiner to see first, second, and third level details with both images, the f/8 image is sharper. Spread those same number of pixels out over larger and larger areas, like an entire palm print or a 12” shoe print, and the loss of detail with an f/22 used to capture the image may become the reason fine detail gets lost in the softness caused by diffraction.

What about the Cardinal Rule to maximize the DOF? When you are trying to capture examination quality images/critical comparisons, it will be necessary to modify this Cardinal Rule a bit from the author’s point of view. At times, an image will suffer more from diffraction than it will suffer from a lack of the largest DOF range as provided by the smallest apertures. This point cannot be overemphasized. As desperate as you are for the sharpest, clearest, most in-focus image you can get, when you are trying to capture examination quality images, use of the smallest apertures of a lens is counterproductive.

It is perhaps this emphasis on the adverse effects of diffraction that partially separates this text from many others. If you acquire an understanding of diffraction, it may change the way you capture critical comparison photographs, also called examination quality photographs.

With today’s higher resolution cameras, it is certainly proper to ask if the higher resolution produced by placing more pixels on the evidence outweighs the loss of resolution produced by diffraction.
FIGURE 5.68
Close-up of a fingerprint.

FIGURE 5.69
Cropped area, when the entire print was originally captured with an f/8.

FIGURE 5.70
Cropped area, when the entire print was originally captured with an f/22.
As this text is being written, the NIST OSACs related to friction ridge analysis and shoe wear and tire track analysis are writing drafts on the recommended camera settings to be used when examination quality photographs in their disciplines are captured. Until new OSAC guidelines come out, it is interesting to review the most recent SWGIT guideline related to the photography of footwear and tire marks:

**SECTION 9 GENERAL GUIDELINES FOR PHOTOGRAPHING FOOTWEAR AND TIRE IMPRESSIONS**

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Manually focus on the bottom of the impression and close aperture to optimize depth of field (e.g. generally two stops below the largest f-stop or smallest aperture opening). (Emphasis added by the author, because of its similarity to this text’s Rule of Thumb 5.8.)

It must be reiterated that diffraction is not a type of aberration. Whereas quality lens manufacturing can diminish the effects of most of the aberrations, quality lenses will still suffer from diffraction if the smallest apertures are used. Diffraction is based on the physics of light, not lens manufacturing improvements. The only “cure” to the degradation of an image’s sharpness because of diffraction is to open the aperture at least 2 stops from the smallest aperture of the lens. Most of the time, maximizing the DOF will be your primary concern at crime scenes. When you are capturing examination quality photographs, minimizing the effects of diffraction is more important than using the smallest aperture for the best DOF.

Several years ago, a specialty lens was being demonstrated to show its remarkable DOF range. Although not a lens designed to be used at crime scenes, it was a part of a digital imaging workstation intended for use by examiners working with latent prints on curved or multilevel surfaces, as well as other types of evidence. **Fig. 5.71** exhibits an “impossible” DOF range. A 0.45-caliber casing has been placed on top of a tennis ball, and a scale was placed on the surface supporting the tennis ball. Both the head stamp of the casing and the scale are in focus. Try that with your current macro lens. **Fig. 5.72** shows the Fodis Pro 2D Macro Lens responsible for the great DOF in **Fig. 5.71**.

**FIGURE 5.71**

“Impossible” depth-of-field range.
Courtesy of Tom Beecher, Photograftix, Richmond, VA.
The issue was dodged each time specifications on the lens were requested. A comment was made, however, that caught the attention of this author. It was mentioned that the aperture of the lens was opened up 2 stops from the lens’ smallest aperture “because of diffraction.” Diffraction is not just an abstract idea found in dated physics books. Many professional photographers routinely acknowledge its effect on images. Crime scene photographers will also benefit from a knowledge of its effects and should modify their critical comparison close-up photography procedures because of it.

Aberrations can degrade images captured with the widest apertures of a lens; diffraction can degrade images captured with the smallest apertures of a lens, which can also be expressed by saying lenses can be aberration limited and diffraction limited. The apertures 2 stops to 3 stops in from the extreme f/stops of a lens are called the “sweet spots” of a lens. Depending on the lens, there may be two or three “sweet spot” apertures. If this is so, the Cardinal Rule to maximize the DOF still applies. If a lens’ “sweet spots” include f/4, f/5.6, f/8, and f/11, the Cardinal Rule suggests that f/11 is the aperture that both acknowledges the effects of diffraction and maximizes the DOF from the available “sweet spot” apertures.

**Distortion**

Two other effects that lenses can have on an image are barrel distortion and pincushion distortion. These are usually effects caused by the use of wide-angle and telephoto lenses, respectively.
BARREL DISTORTION

Barrel distortion is usually an effect of using a wide-angle lens. The result is that straight lines appearing at the edges of an image may appear to be bent outward a bit. Photoshop and other imaging software programs may be able to correct for barrel distortion. Otherwise, not much can be done to avoid this type of distortion other than trying to avoid composing linear objects at the periphery of an image. If it is your current task to compose an entire building that is the site of a crime scene, this may be impossible. See Fig. 5.73. The top and right side of this building appears to be bowed outward.

PINCUSHION DISTORTION

Pincushion distortion is usually an effect of using a telephoto lens. The result is that straight lines appearing at the edges of an image may appear to be bent inward a bit. Again, some imaging software programs may be able to correct for this distortion. It occurs only at the periphery of an image captured when a telephoto lens is used. Fig. 5.74 shows the same spacing between buildings. Both sides of the two buildings appear to be bending toward the center of the image.

FIGURE 5.73
Building showing barrel distortion.

FIGURE 5.74
Buildings showing pincushion distortion.
Many times, the eye may not even notice these distortions because you have become so accustomed to the effects of these lenses. They are, however, inaccurate representations of a scene that you may be asked to explain in court. It is best to be familiar with your “tools” and the effects they will have on your crime scene images.

LEARNING OBJECTIVES, REVISITED

When a layman speaks about wanting a camera with good resolution so that the images produced by it are clear and sharp, that person is usually oblivious to the precise meanings of such terms as “resolution,” “acutance,” and “sharpness.” This chapter explained each of these terms. Also, when you are asked whether a particular camera has sufficient resolution to be used as the primary camera at a crime scene, this chapter provides the means to answer that question.

Most laymen focus their cameras on individual objects. Because photographing crime scenes also requires that large and small areas fall within the DOF range, methods to focus on areas, rather than on individual objects, were discussed and explained.

DOF was defined, and the three factors that affect DOF were explained.

Lenses were distinguished and their differences explained. The effects of each lens type also were presented.

Lenses can suffer from aberrations, diffraction, and distortion, despite the high quality of modern lens-manufacturing techniques. Each was explained. Because diffraction can adversely affect your most critical images, suggestions for minimizing its effect were provided.

DISCUSSION QUESTIONS

1. Briefly explain the nuances of each of these terms: “resolution,” “acutance,” and “sharpness.”
2. Automatic focus has difficulties locking in on some types of scenes. Explain two situations in which it may be better to use manual focusing.
3. Explain the concept of the circles of confusion. How are they related to different apertures? How are they related to different focal lengths?
4. Explain hyperfocal focusing. Include an explanation of how to use the technique when you do have a depth of scale on your lens and when you do not.
5. Explain zone focusing. Include an explanation of how to use the technique when you do have a depth of scale on your lens and when you do not.
6. Explain the camera variables that affect depth of field, that maximize depth of field, and that minimize depth of field.
7. Explain which focal length of lens is most appropriate for most crime scene photography and why this is so.
8. Most of the time depth of field is the most important concern. When does diffraction most affect crime scene photographs? What is its effect? What is the “cure”?

EXERCISES (ALL NONFLASH SHOTS)

1. Create a single-digit fingerprint on an outside surface that is fully sunlit. Place the camera on a tripod; prefocus the lens so it will produce a 1:1 or 1:2 magnification ratio; include a scale; and take a set of three exposures at 0, +1, and −1.
2. Hyperfocal focus on a large outdoor scene where infinity is in the background.
3. Zone focus on an area in front of a building façade that is 30′ from the camera.
4. Zone focus on an area in front of a building façade that is 20′ from the camera.
5. With the widest aperture of the lens, focus on an object 20′ away. Use a 50 mm lens.
6. With the smallest aperture of the lens, focus on the same object 20′ away. Use a 50 mm lens.
7. With the smallest aperture of the lens, focus on the same object 20′ away. Use the widest-angle lens available.
8. With the smallest aperture of the lens, focus on the same object 20′ away. Use the longest telephoto lens available.
9. Place a coin on the sidewalk with the mint designation or date plainly visible. With the camera on a tripod, determine the best exposure using an f/22.
10. Same as No. 9, but use an f/16.
11. Same as No. 9, but use an f/11.
12. Same as No. 9, but use an f/8.
13. Enlarge Nos. 9 through 12 so the mint letter or date is greatly enlarged. Which seems to have the best definition? Why?
Further Reading


