Barbara LONDON | Jim STONE

A Short Course in Photography DIGITAL

Fourth Edition

Fourth Edition

A Short Course in PHOTOGRAPHY

Digital

AN INTRODUCTION TO PHOTOGRAPHIC TECHNIQUE

Edward Bateman

Barbara London Jim Stone

Pearson

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Opposite page: Teun Hocks, Untitled, 2000. Courtesy of the artist and Torch Gallery, Amsterdam

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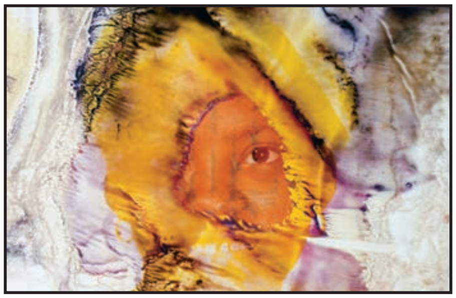

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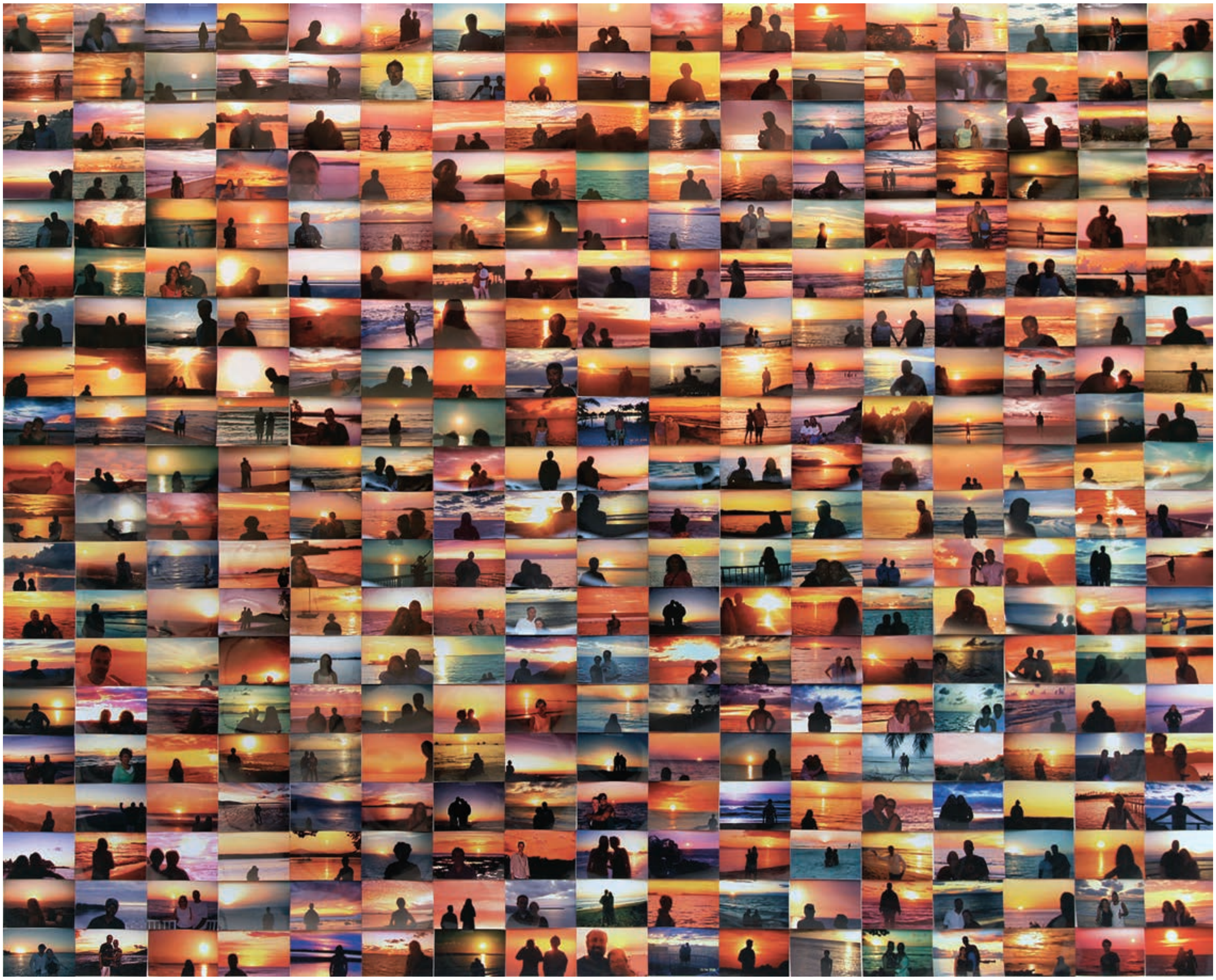

Penelope Umbrico. *Sunset Portraits from 8,462,359 Flickr Sunsets on 12/21/10, 2010.* ***Photography can be your subject, as well as your medium.*** *Umbrico began searching the Web in 2006 for the most-often-photographed subject, finding it to be sunsets (541,795 pictures posted on the popular photo-sharing site Flickr at that time).*

Umbrico had 4 × 6-inch machine prints made from an "appropriated" selection (this 2010 piece includes only those sunsets with silhouetted figures), and exhibits them in grid form, about 8 feet tall. For a 2011 gallery show, she showed 1,058 4 × 6-inch sunset portraits; by then the total number of sunsets on Flickr had grown to 9,623,557.

As you make your own photographs, it is worth asking yourself questions. What are the ways you can improve the photographs you are now making? If others have already photographed your subject, how will your pictures be different? If you magnify the meaning your images have for you, will you also increase the impact they have on others? Read on.

Preface

If you don't know anything about photography and would like to learn, or if you want to make better pictures than the ones you are making now, *A Short Course in Photography: Digital* will help you. This book is modeled after the widely used film-and-darkroom edition of *A Short Course in Photography*, but presents the medium in its current, electronic form.

We present here, in depth, the basic techniques of photography:

- How to get a good exposure
- How to adjust the focus, shutter speed, and aperture (the size of the lens opening) to produce the results you want
- How to transfer your pictures to a computer and make sure they are organized and safe from loss
- How to use computer software to make your photographs look their best

Almost all of today's cameras incorporate automatic features, but that doesn't mean that they automatically produce the results you want. This edition of *A Short Course in Photography* devotes special attention to:

- Automatic focus and automatic exposure—what they do and, particularly, how to override them when it is better to adjust the camera manually

Some of the book's highlights include:

- Getting Started. If you are brand new to photography, this section will walk you through the first steps of selecting and installing a memory card, setting the camera's menu options, focusing sharply, adjusting the exposure, and making your first pictures. See pages 4–9.
- Projects. These projects are designed to help develop your technical and expressive skills. See page 136 or 155.
- Making Better Prints. This includes information about how to adjust your photographs with image-editing software (pages 92–111), select ink and paper for them (page 117), print them (page 118), and then display them in a mat and frame (pages 120–127).
- Types of lenses (pages 31–41), cameras (pages 10–13), lighting (pages 134–151), and software for organizing and archiving (pages 131–133).
- History of Photography. The medium has been used for documentation, persuasion, and personal expression since its 19th-century invention. See pages 180–213.

Photography is a subjective undertaking. *A Short Course in Photography* emphasizes your choices in picture making:

- How to look at a scene in the way a camera can record it
- How to select the shutter speed, point of view, and other elements that can make the difference between an ordinary snapshot and an exciting photograph
- Chapter 9, Seeing Like a Camera, explores your choices in selecting and adjusting the image and presents ways to photograph subjects such as people and landscapes.
- An updated Chapter 10, The History of Photography, traces the technical, social, and artistic development of the medium since its inception.

New in this fourth edition are:

- The latest on camera technology and software, integration of workflow applications—including Capture One Pro—at every step, and expanded coverage of a Camera Raw workflow.
- New photographs by great contemporary artists, including Edward Bateman, Ian van Coller, Sam Comen, John Divola, Filip Dujardin, Adam Ekberg, Kate Joyce, David Leventi, Martina Lopez, Christoph Oberschneider, Todd Owyoung, Christian Richter, and Geoffrey Robinson.
- The 1970s explosion of color photography is explained in the History of Photography, Chapter 10.
- Current product and technical information throughout, with updated demonstration and example photographs.

This book is designed to make learning photography as easy as possible:

- Every two facing pages completes a single topic
- Detailed step-by-step instructions clarify each stage of extended procedures
- Boldfaced headings make subtopics easy to spot
- Numerous photographs and drawings illustrate each topic

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Many people gave generously of their time and effort in the production of this book. Feedback from instructors helps confirm the direction of the book and determine the new elements in each edition. The authors are grateful to all those who reviewed previous editions and forwarded comments. At Pearson Education, Roth Wilkofsky provided editorial support. Annemarie Franklin, Steve Martel, and the team at SPi Global supervised the production of the book from manuscript to printer and caught our (extremely few, of course) errors. Amber, Jade, and Skye Stone gave their dad time to finish the book. If you have suggestions, please send them to Photography Editor, Pearson Education, 221 River Street, Hoboken, NJ 07030. They will be sincerely welcomed.

Jim Stone
Barbara London

Annie Leibovitz
Yo Yo Ma, 1998. ***Framing is a basic control*** *you have in making a photograph. The two photographs on this page and opposite are about music. Would you center your subject or use a corner? Do you want action or repose? Black and white or color? Horizontal, vertical, or square? Candid or posed? Viewed from above, below, or straight on? More about framing on pages 154–155.*

Camera  1

In this chapter you'll learn…

- the basic controls of your camera and what they do.
- the categories of cameras, and their characteristics, so you can choose the right one for your purposes.
- the first steps of getting a camera ready, focusing an image, and adjusting the camera's settings.

Project:
EXPOSE SOME PICTURES

YOU WILL NEED

Camera. We suggest one with adjustable controls.

Output. To evaluate your work, it's good to see exactly what you did. Your digital pictures can be viewed on the camera's small monitor but they are easier to evaluate on a computer screen. Pages 8 and 88 tell you how to download photographs from your camera to a computer. Once they are on a computer, your unedited photographs can also be displayed large with a digital projector or on a wide-screen television so you can easily see small details and imagine what they might look like printed at a large size. If you shoot 35mm film you can take it to the photo lab in a drug store or supermarket chain for overnight processing and printing.

Pencil and notepad or smartphone to keep track of what you do. Optional, but highly recommended for all the projects.

PROCEDURE See pages 4–9 if you are just beginning to photograph. Those pages walk you through the first steps of setting up your camera, focusing an image sharply, adjusting the camera settings so your photographs won't be too light or too dark, and making your first pictures. See pages 10–13 for more about the kinds of cameras.

Have some variety in the scenes when you shoot. For example, photograph subjects near and far, indoors and outside, in the shade and in the sun. Photograph different types of subjects, such as a portrait, a landscape, and an action scene. Page 9 gives some suggestions.

HOW DID YOU DO? Which pictures did you like best? Why? Were some different from what you expected to get? Did some of your camera's operations cause confusion? It helps to read your instruction book all the way through or to ask for help from someone familiar with your camera.

All cameras have four things in common: an image-forming lens; a light-sensitive surface (film or a digital sensor) to record the light that forms an image; a light-tight container (the camera's body) to keep other light out; and two important controls to adjust the amount of picture-making light (the exposure) that reaches the light-sensitive surface.

This chapter describes those light controls and how you can take charge of them, instead of letting them control you. Almost all current cameras are equipped with automatic exposure and automatic focus, and many have automatic flash. If you are interested in making better pictures, however, you should know how your camera makes its decisions, even if the automatic features can't be turned off. If they can, you will want to override your camera's automatic decisions from time to time and make your own choices.

- You may want to blur the motion of a moving subject or freeze its motion sharply. Pages 18–19 show how.
- You may want a scene sharp from foreground to background or the foreground sharp but the background out of focus. See pages 44–45.
- You may want to override your camera's automatic focus mechanism so that only a certain part of a scene is sharp. Page 43 tells when and how to do so.
- You may decide to silhouette a subject against a bright background, or perhaps you want to make sure that you don't end up with a silhouette. See page 72.

Most professional photographers use cameras with automatic features, but they know how their cameras operate manually as well as automatically so they can choose which is best for a particular situation. You will want to do the same because the more you know about how your camera operates, the better you will be able to get the results you want.

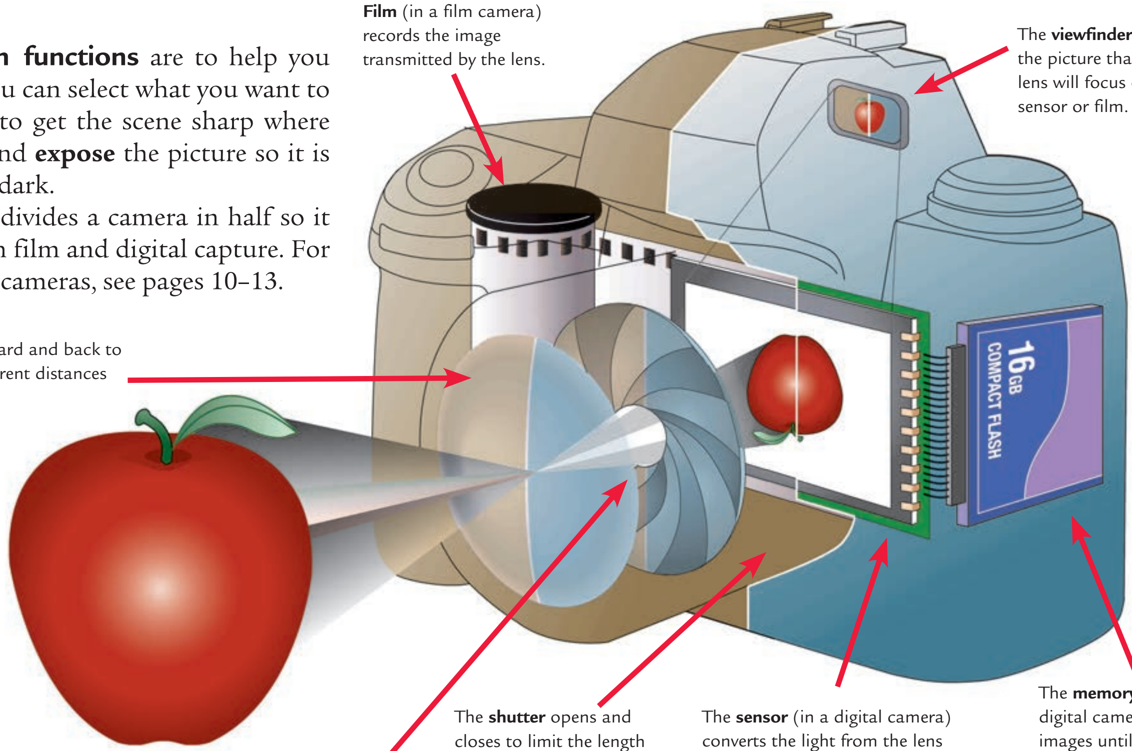
***Todd Owyoung**. Drummer Questlove performing with the Roots, Fox Theater, St. Louis, Missouri, 2008.*

Getting Started

GETTING YOUR CAMERA READY

A camera's main functions are to help you **view** the scene so you can select what you want to photograph, **focus** to get the scene sharp where you want it to be, and **expose** the picture so it is not too light or too dark.

This illustration divides a camera in half so it shows parts for both film and digital capture. For more about specific cameras, see pages 10–13.



Film (in a film camera) records the image transmitted by the lens.

The **viewfinder** shows the picture that the lens will focus on the sensor or film.

The **lens** moves forward and back to bring objects at different distances into sharp focus.

The **aperture** adjusts from larger (letting more light pass from the lens to the light-sensitive surface) to smaller (letting less light pass).

The **shutter** opens and closes to limit the length of time that light strikes the light-sensitive surface.

The **sensor** (in a digital camera) converts the light from the lens into electrical signals that are sent to the memory card.

The **memory card** (in a digital camera) stores images until they can be printed or transferred to a computer or other storage device.

More about camera controls on pages 14–27.

Choose a Memory Card

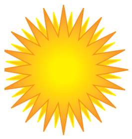
CF (Compact Flash)

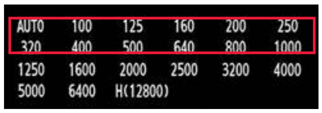
SD (Secure Digital)

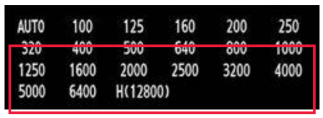
microSD

Digital cameras store pictures on memory cards that vary in capacity and speed. Because there are several types that are not interchangeable, make sure you have one that fits your camera.

Select an ISO







ISO speed (100, 200, 400, and so on) describes a sensor's (or film's) sensitivity to light. The higher the number, the less light it needs for a correct exposure (for a picture that is not too light or too dark). With a digital camera, you may select an ISO setting within that camera's range. You may choose a different ISO for each picture, or you may set your camera to do so automatically. Lower numbers will generally result in higher-quality pictures (see Noise, page 75).

Set an ISO of 50 to 800 for shooting outdoors in sunny conditions. In dimmer light, such as indoors, use an ISO of 800 or higher. Film is made with a fixed ISO; an entire roll must be exposed at that speed. 400 speed film is a good all-purpose choice.

Check the Batteries

Make sure your camera's batteries have a fresh charge. No digital cameras and few film cameras will operate without power. A half-empty symbol will let you know when the battery is low. Carry a fully-charged spare if you can.

Many cameras use proprietary battery packs that must be recharged with the manufacturer's matching charger. Some compact cameras have built-in batteries that limit your shooting while they recharge.

Some cameras use standard batteries that you can buy nearly anywhere. Most conventional sizes are available in money-saving rechargeable versions.

Insert a Memory Card

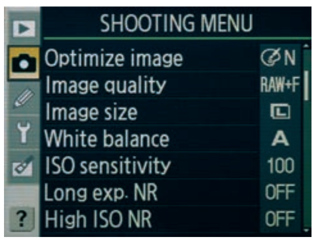
Insert the memory card only with the camera's power turned off. Then turn on the camera. Make sure you are using the right kind of card for your camera and one with enough capacity. Cards intended for another camera may not operate correctly in yours.

Keep cards protected when they are not in the camera. Memory cards are vulnerable to dust and moisture as well as magnetic fields, heat, and shock. Try not to touch the electrical contacts.

Display the Menu

Open the options menu. Turn the camera on and press the button to display the menu on the camera's monitor.

Review the defaults. In your camera's manual, read through the list of settings that can be changed by the operator. Decide which of them you would like to change from the camera's defaults, the way those options have been set by the factory.



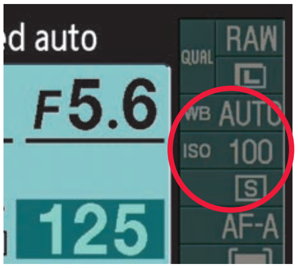
Select a menu item with the control wheel on the camera's back, then use the jog dial (also on the back) to reveal a list of settings or choices for that item.

Getting Started

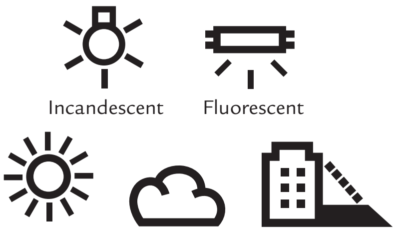
FOCUSING AND SETTING THE EXPOSURE

Set Basic Menu Options

Select the file type and resolution. The menu item may be called "image quality," because visual fidelity is affected by your choice. A lower resolution or compressed file lets you store more pictures on your memory card, but at some loss of quality. Saving pictures in the camera's raw format, at its highest resolution, keeps the quality highest.



Choose an ISO speed. It can be different for each picture. Higher numbers let you shoot in lower light but produce an image with more noise (see page 75).

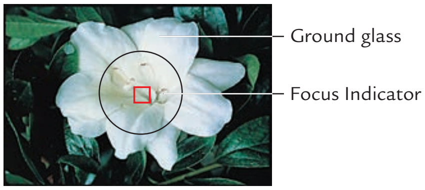


Select the white balance (color temperature) of the dominant light source in which you are shooting, such as incandescent (tungsten) bulbs, sunlight, or outdoor shade. A camera set on automatic makes these adjustments for you. If your camera has a raw format option, it leaves the white balance choice until you edit the file.

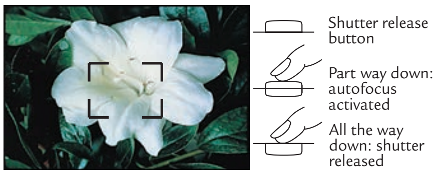
More about ISO speed on page 75.

Focus

Focus on the most important part of your scene to make sure it will be sharp in the photograph. Practice focusing on objects at different distances as you look through the viewfinder so that you become familiar with the way the camera focuses.



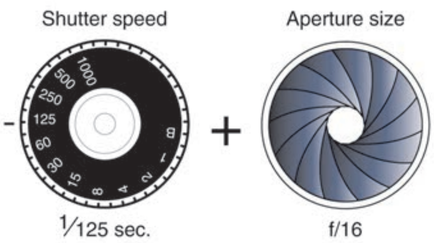
Manual focusing. As you look through the viewfinder, rotate the focusing ring at the front of the lens. The viewfinder of a single-lens reflex camera has a ground-glass screen that shows which parts of the scene are most sharply focused. Some cameras also have a microprism, a small ring at the center of the screen in which an object appears coarsely dotted until it is focused. An advanced or *system* DSLR may offer a choice of focusing screens.

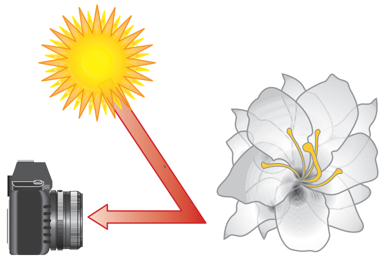


Automatic focusing. Usually this is done by centering the focusing brackets (visible in the middle of the viewfinder) on your subject as you depress the shutter release part way. The camera adjusts the lens for you to bring the bracketed object into focus. Don't push the shutter release all the way down until you are ready to take a picture.

More about focus and when and how to override automatic focus on page 43.

Set the Exposure





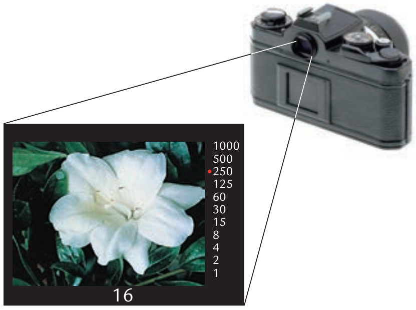
To get a correctly exposed picture, one that is not too light (overexposed) or too dark (underexposed), you—or the camera—must set the shutter speed and the aperture according to the selected ISO sensitivity and how light or dark your subject is. The shutter speed determines the length of time that light strikes the sensor; the aperture size determines how bright the light is that passes through the lens and shutter to the light-sensitive surface.

More about shutter speed and aperture on pages 18–27 and about exposure and metering on pages 62–73.

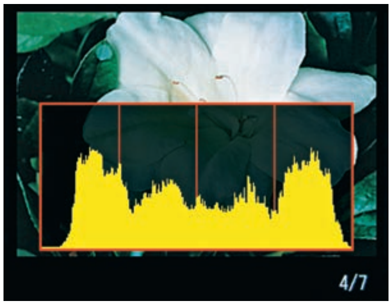
EXPOSURE READOUT

Exposure Readout

A data panel appears on the body of some cameras, displaying shutter speed and aperture settings (here, 1/250 sec. shutter speed, f/16 aperture), as well as other information.



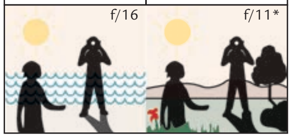
The shutter speed and aperture settings appear in the viewfinder of some cameras (here, 1/250 sec. shutter speed, f/16 aperture).



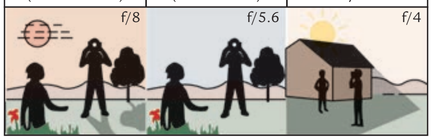
A histogram is an accurate representation of exposure that most cameras can display on the monitor after you take each photograph. If your subject is not moving or is otherwise cooperative, make a test exposure of the scene first. Over- or underexposed tests can be deleted. More about histograms on pages 60–61.

Manually Setting the Exposure

ISO 100: Average subjects outdoors	
Shutter speed 1/250 second	
Bright or hazy sun on sand or snow	Bright or hazy sun (distinct shadows)
f/16	f/11*



Shutter speed 1/125 second		
Weak, hazy sun (soft shadows)	Cloudy bright (no shadows)	Open shade or heavy overcast
f/8	f/5.6	f/4



*f/5.6 for backlighted close-up subjects. Subject shaded from sun but lighted by a large area of sky.

With manual exposure, you set both the shutter speed and aperture yourself. How do you know which settings to use? At the simplest level you can use a chart like the one above. Decide what kind of light illuminates the scene, and set the aperture (the f-number shown on the chart) and the shutter speed accordingly.

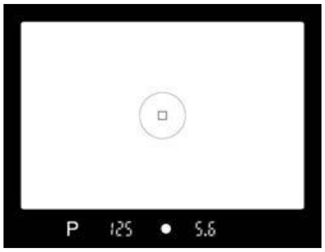
Notice that the recommended shutter speed on the chart is 1/250 sec. or 1/125 sec. These relatively fast shutter speeds make it easier for you to get a sharp picture when hand holding the camera (when it is not on a tripod). At slow shutter speeds, such as 1/30 sec. or slower, the shutter is open long enough for the picture to be blurred if you move the camera slightly during the exposure.

You can use a camera's built-in meter for manual exposure. Point the camera at the most important part of the scene and activate the meter. The viewfinder will show whether the exposure is correct. If it isn't, change the shutter speed and/or aperture until it is. Here, plus numbers signal overexposure, minus means underexposure. Lining up the red arrow with the dot in the center indicates the exposure is right.

To prevent blur caused by the camera moving during the exposure (if the camera is not on a tripod), select a shutter speed of at least 1/60 sec. A shutter speed of 1/125 sec. is safer.

Automatically Setting the Exposure

With automatic exposure, the camera sets the shutter speed or aperture, or both, for you.



With programmed (fully automatic) exposure, each time you press the shutter release button, the camera automatically meters the light, then sets both shutter speed and aperture.

With shutter-priority automatic exposure, you set the shutter speed and the camera sets the aperture. To prevent blur from camera motion if you are hand holding the camera, select a shutter speed of 1/60 sec. or faster.

With aperture-priority automatic exposure, you set the aperture and the camera sets the shutter speed. To keep the picture sharp when you hand hold the camera, check that the shutter speed is 1/60 sec. or faster. If it is not, set the aperture to a larger opening (a smaller f-number).

More about how to override automatic exposure on page 66.

Getting Started

EXPOSING IMAGES

Hold the Camera Steady

For horizontal photographs (sometimes called *"landscape"* mode), keep your arms against your body to steady the camera. Use your right hand to hold the camera and your right forefinger to press the shutter release. Use your left hand to help support the camera or to focus or make other camera adjustments.

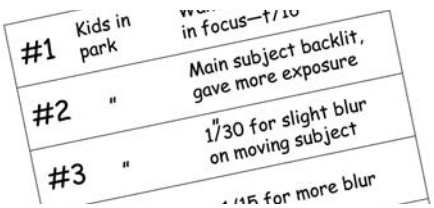
For vertical photographs (*"portrait"* mode), support the camera from below in either your right or left hand. Keep that elbow against your body to steady the camera.

A tripod steadies the camera for you and lets you use slow shutter speeds for night scenes or other situations when the light is dim. Make sure to use a cable release, remote trigger, or self-timer with it.

Expose Some Images

Make an exposure. Recheck the focus and composition just before exposure. When you are ready to take a picture, stabilize your camera and yourself and gently press the shutter release all the way down. Most cameras prefocus automatically when you press the shutter button halfway down. If your subject cooperates, try several different exposures of the same scene, perhaps from different angles.

An LCD monitor shows exact framing and lets you check to see that the picture is not too light or too dark after you take it. Most digital cameras will also let you zoom in the monitor display on a small part of the saved picture to check precise focus.



You'll learn faster if you keep a record as you are shooting. Digital cameras automatically save camera and exposure information—like the aperture, shutter speed, and ISO—and store it with each picture. But it helps to note your reasons for those choices: the way a subject was moving, for example, or the direction and quality of light. This will let you identify the paths to your successful images and help you make great pictures more often.

Download the Pictures

Transfer your pictures to another storage device, usually a computer's hard drive, at the end of a day's shooting or whenever you want to review them in detail. This transfer is called *downloading*. You can remove the memory card and plug it into a card reader, as shown above, or connect the camera and computer directly with a cable, below. Some cameras can transfer images wirelessly.

Download your pictures directly to a computer if it's convenient. If you are shooting on location you can transfer them to a portable hard drive or other device made for reading cards. Don't erase the memory card until you are sure all your images are secure and, if possible, duplicated in at least two places.

You can delete unwanted images from the card using the camera, but—unless you are running out of room on the card during a shoot—it is safer to save that editing step until after all your images have been downloaded.


Bob Simons

Where do you start? One place to start is by looking around through the viewfinder. A subject often looks different isolated in a viewfinder than it does when you see it surrounded by other objects. What interests you about this scene? What is it that you want to make into a photograph?

Get closer (usually). Often people photograph from too far away. What part of the scene attracted you? Do you want to see the whole deck, the whole back yard, or are you more interested in the person cooking? Do you want the whole wall of a building, or was it only the graffiti on it that caught your attention?


Kyle Bajakian

Try a different angle. Instead of always shooting from normal eye-level height, try getting up high and looking down on your subject or kneeling and looking up.

Look at the background (and the foreground). How does your subject relate to its surroundings? Do you want the subject centered or off to one side to show more of the setting? Is there a distraction (like bright sunlight or a sign directly behind someone's head) that you could avoid by changing position? Take a look.

More about backgrounds and the image frame on pages 154–157.


Karl Baden

Check the lighting. At first, you are more likely to get a good exposure if you photograph a more or less evenly lit scene, not one where the subject is against a very light background, such as a bright sky.

More about lighting on pages 134–151.


Karl Baden


Ray K. Metzker

Don't be afraid to experiment, too. Include a bright light source or bright sky in the picture (just don't stare directly at the sun through the viewfinder). In the resulting photograph, darker parts of the scene may appear completely black, or the subject itself may be silhouetted against a brighter background.

Types of Cameras

FILM CAMERAS

What kind of camera is best for you? For occasional snapshots of family and friends, an inexpensive, completely automatic, nonadjustable camera that you just point and shoot will probably be satisfactory. But if you have become interested enough in photography to take a class or buy a book, you will want an adjustable camera because it will give you greater creative control. If you buy a camera with automatic features, make sure it is one that allows you to manually override them when you want to make exposure and focus choices yourself.

Film camera designs evolved as tools for specific tasks, and followed the slow evolution of film (see Chapter 10, pages 184–186). Here are the major styles, which are useful to know about because many elements of these designs have been incorporated into their digital counterparts.

Single-lens reflex cameras (SLRs) show you a scene directly through the lens, so you can preview what will be recorded. You can see exactly what the lens is focused on; with some cameras, you can check the depth of field (how much of the scene from foreground to background will be sharp). Through-the-lens viewing is a definite advantage with telephoto lenses, for close-ups, or for any work when you want a precise view of a scene.

Very early SLRs used large glass plates or film sheets but since the 1950s almost all were made to accept 35mm film. A few models aimed at (and priced for) professional photographers used larger roll film. Recent SLRs incorporate automatic exposure, automatic focus, and automatic flash but allow manual control. Many different interchangeable lenses for SLRs are available.

Digital SLRs (DSLRs) resemble their 35mm film ancestors. Some SLR cameras made for 2¼-inch-wide roll film (called medium-format) may be used with accessory digital capture backs. Digital-only models, also called medium-format, are also available.

SLRs have long been very popular with professionals, such as photojournalists or fashion photographers, or with anyone who wants to move beyond making snapshots.

Rangefinder cameras are viewfinder film cameras. This means they have a peephole, or window, separate from the lens, through which you view the scene. Inexpensive "point-and-shoot" viewfinder cameras simply show the approximate framing through the window. A rangefinder camera is more complex, with a visual focusing system that you use as you look through the viewfinder window. The window shows a split image when an object is not in focus. As you rotate the focusing ring, the split image comes together when the object is focused sharply. Rangefinder cameras let you focus precisely, even in dim light, but you cannot visually assess the depth of field because all parts of the scene, even the split image, look equally sharp in the viewfinder.

Because the viewfinder is in a different position from the lens that exposes the film, you do not see exactly what the lens sees. This difference between the viewfinder image and the lens image is called *parallax* error, and is greater for objects that are closer to the camera. Better rangefinder cameras correct for parallax error and have interchangeable lenses, although usually not in as many focal lengths as are avail-

Rangefinder Film Camera

Single-lens Reflex Camera

able for SLRs. Most use 35mm film; ones called medium format are for wider roll film, few are digital. Rangefinder cameras are fast, reliable, quiet in operation, and relatively small.

Filipe N. Marques

Twin-lens Reflex Camera

Twin-lens reflex cameras (TLRs), except for a couple novelty "retro" digital versions, are all film cameras. New ones are made by a few companies, but secondhand models are widely available. They cannot easily be adapted to digital capture. Each camera has two lenses: one for viewing the scene and another just below it that exposes the film.

A large film format (2¼ inches square) is the TLR's advantage. Its disadvantages are parallax error and a viewfinder image that is reversed left to right. Some now-discontinued TLRs had interchangeable lenses; adjustments on all models are completely manual.

View cameras have a lens in the front, a ground-glass viewing screen in the back, and a flexible, accordion-like bellows in between. The camera's most valuable feature is its adjustability: the camera's parts can be moved freely in relation to each other, which lets you alter perspective and sharpness to suit each scene. You can change lenses and even the camera's back; for example, you can attach a back to use self-developing film or one to record a digital image.

Each film exposure is made on a separate sheet, so you can make one shot in color and the next in black and white, or develop each sheet differently. Film size is large—4 × 5 inches and larger—for crisp and sharp detail even in a big print.

Using a view camera can be a more considered process because they are slow to use compared to smaller hand-held cameras. They are large and heavy and must be mounted on a tripod. The image on the viewing screen is upside down, and it is usually so dim that you have to put a focusing cloth over your head and the screen to see the image clearly. When you want complete control of an image, such as for architectural or product photography or for personal work, the view camera's advantages outweigh what some might see as inconveniences.

View Camera

Some cameras are made to fill a specialized need.

Panoramic cameras make a long, narrow photograph that can be effective, for example, with landscapes. Some of these cameras crop out part of the normal image rectangle to make a panoramic shape. Others use a wider-than-normal section of roll film; some may rotate the lens from side to side during the exposure.

Digital panoramas can be made during editing by stitching several individual frames together, either from digital capture or from scanned film, so special-purpose panoramic cameras are no longer common. Some digital cameras can display a segment of the previous frame on the side of the monitor to help align the next shot for more seamless reassembly later. Other cameras (and smart phones) have a "sweep" mode that can capture a panoramic image with one press of the button when moved across a scene.

Stereo or *3-D cameras* take two pictures at the same time through two side-by-side lenses. The resulting pair of images, a *stereograph,* gives the illusion of three dimensions when seen in a stereo viewer.

Underwater cameras are not only for use underwater but for any situation in which a camera is likely to get wet. Some cameras are water resistant, rather than usable underwater. Specially-made underwater housings are available for professional use or larger camera models.

Types of Cameras

DIGITAL CAMERAS

Digital camera designs are continually evolving and the array of available models can be overwhelming. With so many options, you can usually choose a camera based on the combination of features you need, but you may have to compromise. To get the most out of this book (and your photography) choose a camera that offers you the option to control focus and exposure manually.

Compact Camera

Size is often the first consideration in choosing a camera. Your camera shouldn't be so large or so small that it gets in the way of your photography.

Digital single-lens reflex (DSLR) cameras are the most versatile choice but they are big enough that you'll probably carry one only when you are meaning to use it. Professional models can be relatively heavy, but taking even the smallest and lightest SLR out for a walk requires a shoulder strap or camera bag. Using one in public suggests to others that you are not a casual snapshooter, that you are photographing seriously.

Compact cameras are mostly designed for amateur photographers but vary considerably in quality. The smaller the camera, the more likely its features will be limited. Some compacts are good enough to be used by professionals when they don't want to carry a larger camera; some are made to be used a few times and then set aside. Most compact digital cameras are a bit too large and heavy for your pocket, but fit well in a small shoulder bag along with your phone and sunglasses.

Subcompact digital cameras can be carried in a pocket so you are ready to make pictures anywhere, any time.

Compact Action Camera

With image quality and features that compare poorly to larger cameras, the market for subcompacts is giving way to smart phones.

Lens. Do you need interchangeable lenses? One common characteristic of a camera made for serious photographers is that a wide assortment of lenses can be attached. An arsenal of specialized lenses can be expensive to acquire and cumbersome to carry. A fixed lens may be all you need, especially if it is a zoom that covers the range you'd expect to use (see pages 32–33).

Viewing system. The purpose of a camera's viewing system is to let you frame and preview, as accurately as possible, the photograph you are about to capture.

A *single-lens reflex camera* projects the image-forming light directly from your lens onto a mirror and then to your eye through a pentaprism (see page 17) so you see what the lens sees. Because the viewfinder is held to your eye, it is relatively easy to follow action. But the mirror must swing out of the way for the moment of exposure, so you don't actually see the exact image you have captured. And the mirror's motion can cause unwanted vibration that causes slight blurring.

Mirrorless cameras most often have a small monitor or LCD screen on the back of the camera that displays what the lens is seeing, transmitted directly from the image sensor. This image, called *live view*, is used for framing and focusing, and is replaced momentarily with a view of each captured image immediately after being taken.

Medium-format Digital SLR

The monitor on some cameras is articulated, or tiltable, for viewing from unusual angles, such as overhead or waist level.

Mirrorless cameras may have an *electronic viewfinder*, or EVF. This viewfinder is a smaller version of the LCD monitor that is located inside the camera. It can be seen when holding the camera to your eye rather than at arm's length. SLR-style mirrorless cameras have a characteristic pentaprism; other cameras resemble rangefinder film cameras with the EVF visible through a peephole located in a corner of the camera's back.

An EVF display can be made lighter and darker to compensate for the brightness of a scene or for setting different apertures (page 22). Some cameras can show in the viewfinder an outline of the areas of best focus, sometimes called *focus peaking*, or fill the frame with a very small section of the scene to allow more precise visual focusing.

Resolution. The maximum number of pixels a camera's sensor can capture is called its resolution. A camera, for example, may be 12, 16, or 24 megapixels (MP). An image file

Mirrorless EVF Camera

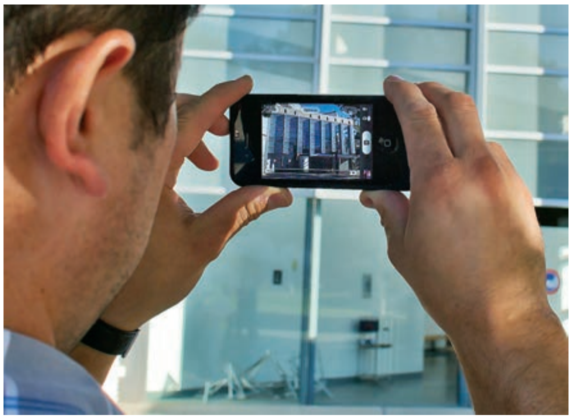
captured by almost any current digital camera can make a satisfactory letter-size (8½ × 11) print. Generally, to keep the same image quality, the larger the print, the higher the resolution needed (see page 55). If you aren't planning to make large prints, you probably don't need the highest megapixel count.

Sensor size also affects image quality. A 12MP sensor can be physically large or small. If it is small, to have the same number of individual light-sensing elements as a large 12MP sensor, the elements must also be smaller and more tightly packed. The larger and less crowded these elements are on the sensor, the higher the quality of the image (see noise, page 75). Most subcompact cameras and all cell phones have very small sensors and, therefore, produce images of somewhat lower quality.

A sensor the same size as a 35mm film frame is called *full frame*. Larger sensors are made for medium-format digital cameras, priced for well-paid professional photographers. Some common sensor sizes smaller than full frame are (in descending order of size) APS-C, Four-Thirds, 2/3", 1/1.8" (see the chart on page 45).

Other features may be a factor in your choice. Most cameras have a built-in flash for use in dim light. A few have built-in Wi-Fi that can transfer image files wirelessly to a computer as you shoot. Some cameras can be remotely controlled with built-in Wi-Fi, Bluetooth, infrared, or radio receivers. Many cameras will capture video at very high quality levels. They have built-in microphones to record sound and many allow external microphones to be connected. To record an active lifestyle, there are action sports cameras (opposite page, top) that are waterproof, shock resistant, and can be helmet or surfboard mounted.

Cell phone cameras now outnumber all other types by a wide margin, and they capture a majority of the photographs made daily, worldwide. Most take only low-resolution images and allow the user no control other than where it points and when it shoots, but the best camera is always the one you have with you.



Basic Camera Controls

Get the pictures you want. Cameras don't quite "see" the way the human eye does, so at first the pictures you get may not be the ones you expected. This book will help you gain control over the picture-making process by showing you how to visualize the scene the camera will capture and how to use the camera's controls to make the picture you have in mind. Digital cameras are shown here. A film camera will have some or all of these same controls.

Controls and data panels *appear on both this entry-level single-lens reflex camera (above) and the more sophisticated "system" camera (right) aimed at professionals. Both can be equipped with a wide variety of special-purpose lenses and accessories. Push-buttons and dials let you select the shutter speed (the length of time the shutter remains open) and the aperture (the size of the opening inside the lens). With either camera, you can exchange one lens for another. Top-of-the-line cameras often do not have built-in flash.*

On these fully-automatic cameras, *you can press the shutter release and have the camera automatically focus the lens (autofocus) and set the shutter speed and aperture (autoexposure). When you want to choose camera settings yourself, you can manually override the automatic functions.*

Focusing. *Through the viewfinder window you see the scene that will be recorded, including the sharpest part of the scene, the part on which the camera is focused. A particular part of a scene can be focused sharply by manually turning the focusing ring on the lens, or you can let an autofocus camera adjust the lens automatically.* *More about focusing and sharpness appears on pages 42–45.*

Keith Johnson

Shutter-speed control. *Moving objects can be shown crisply sharp, frozen in mid-motion, or blurred either a little bit or a lot. The faster the shutter speed, the sharper the moving object will appear.* *Turn to pages 18–19 for information about shutter speeds, motion, and blur.*

Aperture control. *Do you want part of the picture sharp and part out of focus or do you want the whole picture sharp from foreground to back-ground? Changing the size of the aperture (the lens opening) is one way to control sharpness. The smaller the aperture, the more of the picture that will be sharp.* *See pages 22–25.*

Lens focal length. *Your lens's focal length controls the size of objects in a scene and how much of that scene is shown. The longer the focal length, the larger the objects will appear.* *See pages 32–39 for more about focal length.*

More about Camera Controls

Automatic exposure is a basic feature in almost all cameras. The purpose is to let in a controlled amount of light so that the resulting image is neither too light nor too dark. The camera's built-in meter measures the brightness of the scene and then sets shutter speed, aperture (lens opening), or both in order to let the right amount of light reach the camera's recording sensor (or the film in a film camera). As you become more experienced, you will want to set the exposure manually in certain cases, instead of always relying on the camera. Read more about exposure in Chapter 3, pages 60–73.

You have a choice of exposure modes with many cameras. Read your camera's instruction manual to find out which exposure features your model has and how they work. You may be able to download a replacement manual from the manufacturer's Web site, if you don't have one.

With programmed (fully automatic) exposure, the camera selects both the shutter speed and the aperture based on a program built into the camera by the manufacturer. This automatic operation can be useful in rapidly changing situations because it allows you simply to respond to the subject, focus, and shoot.

In shutter-priority mode, you set the shutter speed and the camera automatically sets the correct aperture. This mode is useful when the motion of subjects is important, as at sporting events, because the shutter speed determines whether moving objects will be sharp or blurred.

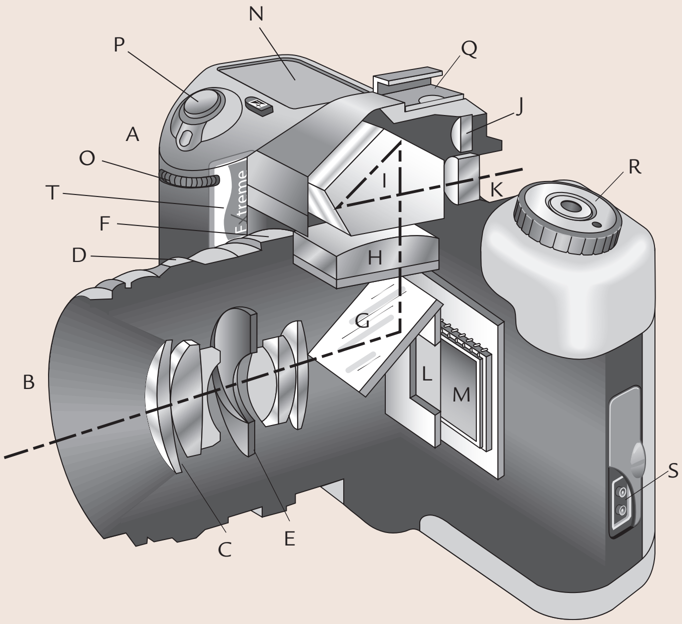
In aperture-priority mode, you set the lens opening and the camera automatically sets the shutter speed. This mode is useful when you want to control the depth of field (the sharpness of the image from foreground to background) because the size of the lens opening is a major factor affecting sharpness.

Manual exposure is also a choice with many automatic cameras. You set both the lens opening and shutter speed yourself using, if you wish, the camera's built-in light meter to measure the brightness of the light.

***Exposure information** appears in the viewfinder of many cameras. This viewfinder shows the shutter speed (here, $1/250$ sec.) and aperture (f/5.6). Displays also show you when the flash is ready to fire and give you warnings of under- or overexposure.*

***Some cameras also have a data panel** on the body of the camera that shows the same information—shutter speed and aperture—as well as exposure, autofocus, and ISO modes and the number of exposures remaining on the memory card (here 123).*

INSIDE A DIGITAL SINGLE-LENS REFLEX CAMERA



***A simplified look** inside a digital single-lens reflex camera or DSLR (designs vary in different models). The camera takes its name from its single lens (another kind of reflex film camera has two lenses) and from its reflection of light upward for viewing the image.*

All cameras have the same basic features:

- A light-tight box to hold the camera parts and a recording sensor or film
- A viewing system that lets you aim the camera accurately
- A lens to form an image and a mechanism to focus it sharply
- A shutter and lens aperture to control the amount of light that reaches the recording surface
- A means to hold a memory card that saves its captured information or to hold and advance film

A. **Body.** The light-tight box that contains the camera's mechanisms and protects the light-sensitive surface (sensor or film) from exposure to light until you are ready to make a photograph.

B. **Lens.** Focuses an image in the viewfinder and on the light-sensitive recording surface.

C. **Lens elements.** The optical glass lens components that produce the image.

D. **Focusing ring.** Turning the ring focuses the image by adjusting the distance of the lens from the recording surface. Some cameras focus automatically.

E. **Diaphragm.** A circle of overlapping leaves inside the lens that adjusts the size of the aperture (lens opening). It opens up to increase (or closes down to decrease) the amount of light reaching the recording surface.

F. **Aperture ring or button.** Setting the ring or turning a command dial (O) determines the size of the diaphragm during exposure.

G. **Mirror.** During viewing, the mirror reflects light from the lens upward onto the viewing screen. During an exposure, the mirror swings out of the way so light can pass straight to the recording surface.

H. **Viewing screen.** A ground-glass (or similar) surface on which the focused image appears.

I. **Pentaprism.** A five-sided optical device that reflects the image from the viewing screen into the viewfinder.

J. **Metering cell.** Measures the brightness of the scene being photographed.

K. **Viewfinder eyepiece.** A window through which the image from the pentaprism is visible.

L. **Shutter.** Keeps light from the recording surface until you are ready to take a picture. Pressing the shutter release opens and closes the shutter to let a measured amount of light reach the sensor.

M. **Sensor.** A grid (usually called a CCD or CMOS array or chip) comprising millions of tiny light-sensitive electronic devices (photosites) that record the image. The ISO (or light sensitivity) of the sensor is adjustable, and is set into the camera by a dial or menu setting.

N. **Data panel.** A display (most often an LCD screen) for such information as shutter speed, aperture, ISO, exposure and metering modes, and the number of exposures remaining on the memory card.

O. **Command dial.** Selects the shutter speed, the length of time the shutter remains open. On some models, it also sets the mode of automatic exposure operation. In some locations, it is called a thumbwheel or jog dial.

P. **Shutter release.** A button that activates the exposure sequence in which the aperture adjusts, the mirror rises, the shutter opens, light strikes the recording surface, and the shutter closes.

Q. **Hot shoe.** A bracket that attaches a flash unit to the camera and provides an electrical linking that synchronizes camera and flash.

R. **Mode dial.** Sets a manual or one of several automatic exposure modes. On film cameras, a crank to rewind an exposed roll of film may be located here. Most new film cameras rewind automatically.

S. **Cable connections.** Plug in cables that, for example, connect external power or a computer, or control the camera remotely.

T. **Memory card.** Stores image files. May be erased and reused; capacity varies. Can be removed to facilitate transferring files to a computer or other storage device.

Shutter Speed

AFFECTS LIGHT AND MOTION

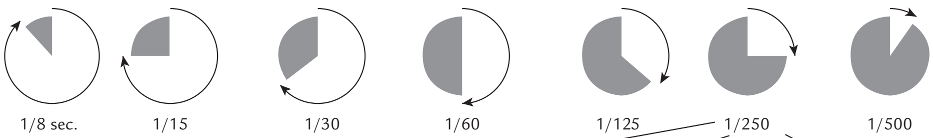
Light and the shutter speed. To make a correct exposure, so that your picture is neither too light nor too dark, you need to control the amount of light that reaches the digital image sensor (or film). The shutter speed (the amount of time the shutter remains open) is one of two controls your camera has over the amount of light. The aperture size (page 22) is the other. In automatic operation, the camera sets the shutter speed, aperture, or both. In manual operation, you choose both settings. The shutter-speed dial (a push button on some cameras) sets the shutter so that it opens for a given fraction of a second after the shutter release has been pressed. The B (or bulb) setting keeps the shutter open as long as the shutter release is held down.

Motion and the shutter speed. In addition to controlling the amount of light that enters the camera, the shutter speed also affects the way that moving objects are shown. A fast shutter speed can freeze motion—1/250 sec. is more than fast enough for most scenes. A very slow shutter speed will record even a slow-moving object with some blur. The important factor is how much the image actually moves across the recording surface. The more of that surface it crosses while the shutter is open, the more the image will be blurred, so the shutter speed needed to freeze motion depends in part on the direction in which the subject is moving in relation to the camera (see opposite page).

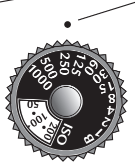
The lens focal length and the distance of the subject from the camera also affect the size of the image on the sensor (or film) and thus how much it will blur. A subject will be enlarged if it is photographed with a long-focal-length lens or if it is close to the camera; it has to move only a little before its image crosses enough of the recording surface to be blurred.

Obviously, the speed of the motion is also important: all other things being equal, a darting swallow needs a faster shutter speed than does a hovering hawk. Even a fast-moving subject, however, may have a peak in its movement, when the motion slows just before it reverses. A gymnast at the height of a jump, for instance, or a motorcycle negotiating a sharp curve is moving slower than at other times and so can be sharply photographed at a relatively slow shutter speed.

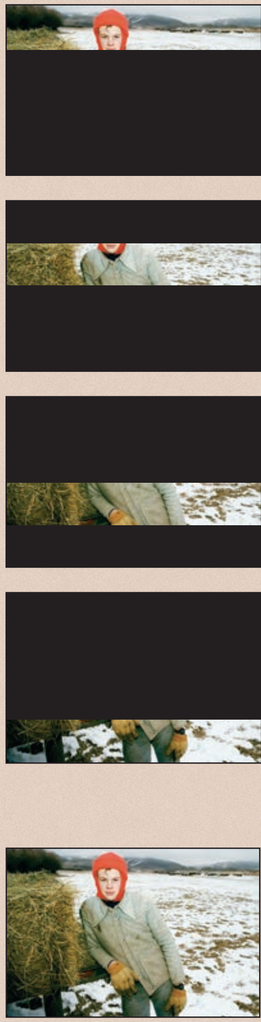
See the project on motion, page 161.



Shutter speeds appear in the camera's viewfinder (near right), on the shutter-speed dial (center), or as data panel readout (far right). Here, the camera is set to 1/250 sec. Notice that only the bottom number of the fraction is shown on the camera.



Shutter-speed settings *are in seconds or fractions of a second: 1 sec., 1/2 sec., 1/4, 1/8, 1/15, 1/30, 1/60, 1/125, 1/250, 1/500, 1/1000, and sometimes 1/2000, 1/4000, and 1/8000. Each setting lets in twice as much light as the next faster setting, half as much as the next slower setting: 1/250 sec. lets in twice as much light as 1/500 sec., half as much as 1/125 sec. With many cameras, especially in automatic operation, shutter speeds are "stepless;" the camera can set the shutter to 1/225 sec., 1/200 sec., or whatever speed it calculates will produce a correct exposure.*



Drex Brooks

A focal-plane shutter *consists of a pair of curtains usually located in the camera body just in front of the sensor. During exposure, the curtains open to form a slit that moves across the light-sensitive surface.*

The size of the slit is adjustable: the wider the slit, the longer the exposure time and the more light that reaches the sensor or film. Focal-plane shutters are found in most single-lens reflex cameras and some rangefinder cameras.

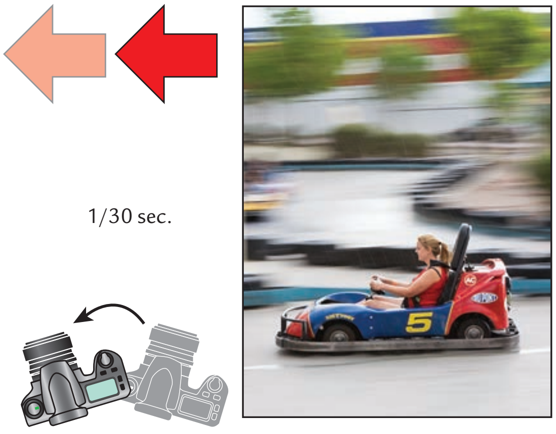
A leaf shutter *is usually built into the lens instead of the camera body. The shutter consists of overlapping leaves that open during the exposure, then close again.*

The longer the shutter stays open, the more light that reaches the light-sensitive surface. Leaf shutters are found on most compact, point-and-shoot, rangefinder, and twin-lens reflex cameras, view-camera lenses, and some medium-format single-lens reflex cameras.

Slow shutter speed, subject blurred. *The direction a subject is moving in relation to the camera can affect the sharpness of the picture. At a slow shutter speed, a driver moving from right to left is not sharp.*

Fast shutter speed, subject sharp. *Photographed at a faster shutter speed, the same driver moving in the same direction is sharp. During the shorter exposure, her image did not cross enough of the recording surface to blur.*

Slow shutter speed, subject sharp. *Here the driver is sharp even though photographed at the slow shutter speed that recorded blur in the first picture (top left). She was moving directly toward the camera, so her image did not cross enough of the recording surface to blur. The other go-kart, turning to move across the frame, becomes blurred.*



Panning *with the vehicle is another way to keep it and the driver relatively sharp. During the exposure, the photographer moved the camera in the same direction that the go-kart was moving (a horizontal sweep from right to left). Notice the streaky look of the background, characteristic of a panned shot.*

Blurring to show motion. Freezing motion is one way of representing it, but it is not the only way. In fact, freezing motion sometimes eliminates the feeling of movement altogether so that the subject seems to be at rest. Allowing the subject to blur can be a graphic means of showing that it is moving.

Panning to show motion. Panning the camera—moving it in the same direction as the subject's movement during the exposure—is another way of showing motion (bottom right). The background will be blurred, but the subject will be sharper than it would be if the camera were held steady.

Shutter Speed

USE IT CREATIVELY

Make a decision about shutter speed for every shot; don't simply inherit one from your previous exposure or let the camera choose for you. Experiment with arresting motion, like the photographs on the opposite page, and with the possibilities of blur. Try making a long exposure of a moving subject with a motionless camera, as shown on page 160, and by panning, as above. Every photograph you decide to make can capture multiple variations of movement, and each can still be a correct exposure.

John Divola. *D07F12, from the series* Dogs Chasing My Car in the Desert*, Morongo Valley, California, 1997.* ***Creating blur can effectively suggest motion*** *and can often be a better choice than freezing a moving subject. Panning (page 19) is most often accomplished by sweeping the camera across the field of view from a fixed vantage point. Divola held his camera out the window of his moving car; the dog cooperated by matching the speed of the vehicle.*

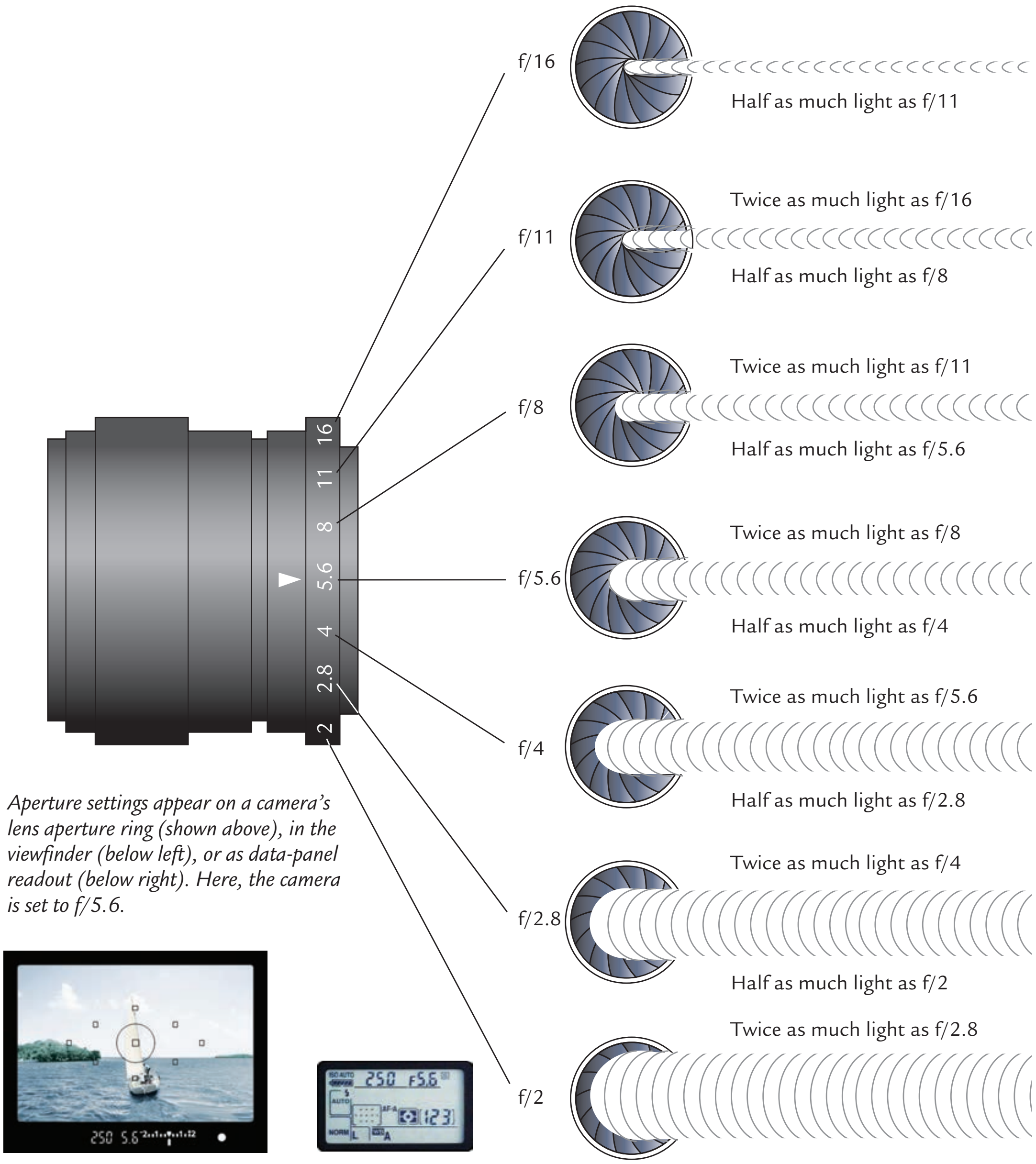
Josef Koudelka. *Spain, 1971.* ***A shutter speed that captures rapid motion also freezes anything slower.*** *The posture and gestures of the participants in this event are held in place for our close inspection.*

Naoya Hatakeyama. *Blast #5416, 1998.* ***The shutter arrests action*** *but it doesn't protect the photographer. For his own safety, making this series of pictures of explosions at a quarry, Hatakeyama used a remote control to trigger the 1/1000-sec. exposures. He relied on advice from the blasting engineer, who understood the "nature" of the rock, to locate his camera to capture the "nature" of violence without damage.*

Aperture

AFFECTS LIGHT AND DEPTH OF FIELD

Light and the aperture. The aperture, or lens opening, is the other control that you can use in addition to shutter speed to adjust the amount of light that reaches the digital image sensor or film. Turning a ring on the outside of the lens (pushing a button on some cameras) changes the size of the *diaphragm*, a ring of overlapping metal leaves inside the lens. (In automatic operation, the camera can do this for you.) Like the iris of your eye, the diaphragm can get larger (open up) to let more light in; it can get smaller (stop down) to decrease the amount of light.



Aperture settings appear on a camera's lens aperture ring (shown above), in the viewfinder (below left), or as data-panel readout (below right). Here, the camera is set to f/5.6.

Light and the aperture. *The size of the lens opening—the aperture, or f-stop—controls the amount of light that passes through the lens. Each aperture is one "stop" from the next; that is, each lets in twice as much light as the next smaller opening, half as much light as the next larger opening. Notice that the lower the f-stop number, the wider the lens opening and the more light that is let in. For example, f/8 is a wider opening and lets in more light than f/11, which lets in more light than does f/16, and so on.*

Aperture settings (f-stops). Aperture settings, from larger lens openings to smaller ones, are f/1, f/1.4, f/2, f/2.8, f/4, f/5.6, f/8, f/11, f/16, f/22, and f/32. Settings beyond f/32 are usually found only on some view-camera lenses.

The lower the f-stop number, the wider the lens opening; each setting lets in twice as much light as the next f-stop number up the scale, half as much light as the next number down the scale. For example, f/11 lets in double the light of f/16, half as much as f/8. Larger openings have smaller numbers because the f/ number is a ratio: the lens focal length divided by the diameter of the lens opening.

Referring to a *stop* (without the "f") is a shorthand way of stating this half-or-double relationship. You can give one stop more (twice as much) exposure by setting the aperture to its next wider opening, one stop less (half as much) exposure by *stopping* (closing) down the aperture to its next smaller opening.

No lens has the entire range of f-stops; most have about seven. A 50mm lens may range from f/2 at its widest opening to f/16 at its smallest, a 200mm lens may range from f/4 to f/22. Most lenses can set intermediate f-stops partway between the whole stops, often in one-third-stop increments. The widest lens setting may be an intermediate stop, for example, f/1.8.

Depth of field and the aperture. The size of the aperture setting also affects how much of the image will be sharp. This is known as the depth of field. As the aperture opening gets smaller, the depth of field increases and more of the scene from near to far appears sharp in the photograph (see photos below and pages 42 and 45). See the depth of field project on page 159.

Small Aperture
More Depth of Field

Depth of field and the aperture. *The smaller the aperture opening, the greater the depth of field. At f/16 (left, top), with the hands and string in the foreground crisply in focus, the face in the background is also sharp. At a much larger aperture, f/1.4 (left, bottom), there is very little depth of field. The face in the background is completely out of focus.*

Large Aperture
Less Depth of Field

Aperture

USE IT CREATIVELY

A choice about aperture is a choice about focus, one of the most important decisions you can make about a picture. For all the similarities, a camera doesn't really see the way your eye does. A picture freezes focus; sharp parts stay sharp, blur and softness remain no matter how much we stare at a photograph. Our vision, though, is fluid. Our eyes dart around a scene so we can perceive it as a whole, and they are constantly—and involuntarily—refocusing. Knowing the difference between human vision and photographic vision can be a powerful tool, as these examples show.

Joel Sternfeld. *The Space Shuttle Columbia Lands at Kelly Air Force Base, San Antonio, Texas, March 1979.* ***A small aperture gives great depth of field*** *that can make all parts of an image equally sharp. This can seem, as here, to flatten three dimensions into two. Sternfeld uses that flatness for a playful ambiguity. The foreground spectator appears to be inspecting a wall-sized photograph or watching a giant television.*

Terri Weifenbach. *Untitled, 2014.* ***A large aperture creates a narrow band of focus*** *that can slice through the middle of a scene, leaving objects blurry both in front and behind. This image—of an evergreen that produces red winter berries—was the "sign-off" at the end of a long visual conversation carried out via email between Weifenbach in the US and another artist in Japan.*

Shutter Speed and Aperture

BLUR VS. DEPTH OF FIELD

Controlling the exposure. Both shutter speed and aperture affect the amount of light reaching the camera's light-sensitive recording surface. To get a correctly exposed picture, one that is neither too light nor too dark, you need to find a combination of shutter speed and aperture that will let in the right amount of light for a particular scene and ISO setting. (Pages 60–73 explain how to do this.)

Equivalent exposures. Once you know a correct combination of shutter speed and aperture, you can change one setting and still keep the exposure the same as long as you change the other setting the same amount in the opposite direction. If you want to use a smaller aperture (which lets in less light), you can keep the exposure the same by using a slower shutter speed (which lets in more light), and vice versa.

A stop of exposure change. Each full f-stop setting of the aperture lets in half (or double) the amount of light as the next full setting, a one-stop difference. Each shutter-speed setting does the same. The term stop is used whether the aperture or shutter speed is changed. The exposure stays constant if, for example, a move to the next faster shutter speed (one stop less exposure) is matched by a move to the next larger aperture (one stop more exposure).

Which combination do you choose? Any of several combinations of shutter speed and aperture could make a good exposure, but the effect on the appearance of the image will be different. Shutter speed affects the sharpness of moving objects; aperture size affects depth of field (the sharpness of a scene from near to far). Shutter speed also helps prevent blur caused by camera motion during the exposure. If you are holding the camera in your hands, you need a faster shutter speed than if you have the camera on a tripod (see page 28 for details).

You can decide for each picture whether stopped motion or depth of field is more important. More depth of field and near-to-far sharpness with a smaller aperture means you would be using a slower shutter speed and so risking that motion would blur. Using a faster shutter speed to freeze motion means you would be using a larger aperture, with less of the scene sharp near to far. Depending on the situation, you may have to compromise on a moderate amount of depth of field with some possibility of blur.

Cameras set shutter speeds between whole stops. *Older shutters only had full stops, each double the amount of time of the shutter speed before it or half that of the one after it. Today's shutters set shutter speeds in increments of one-half or one-third stops. This chart shows, in gray, those fractional stops.*

Some cameras allow you to choose among different ways to set shutter speeds (and apertures), use full stops while learning.

Speeds a camera displays; these are fractions, 8 on a display is 1/8 sec.

1/3 STOP	1/2 STOP
1	1
1.3	1.5
1.6	
2	2
2.5	3
3	
4	4
5	6
6	
8	8
10	11
13	
15	15
20	20
25	
30	30
40	45
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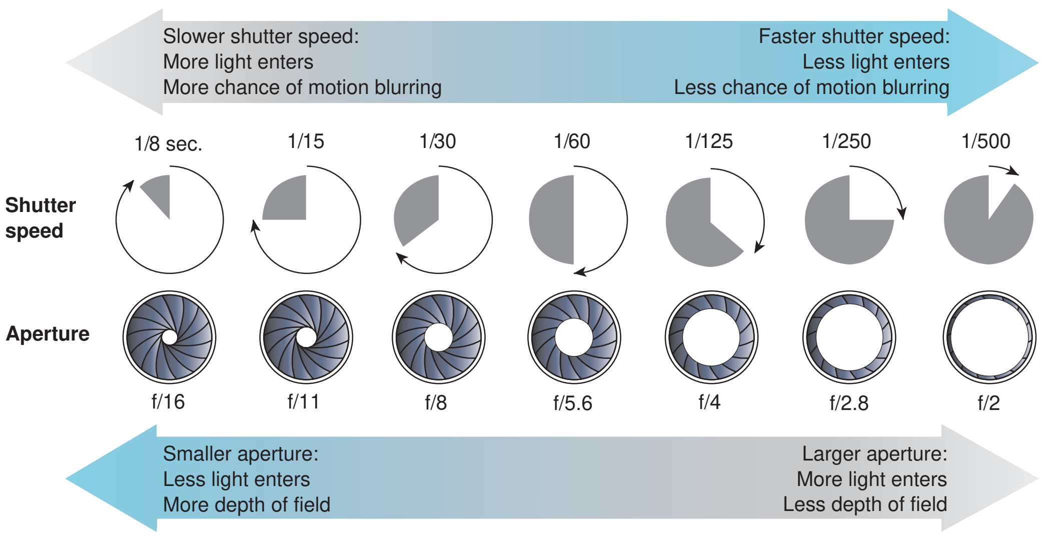
60	60
80	90
100	
125	125
160	180
200	
250	250
320	350
400	
500	500

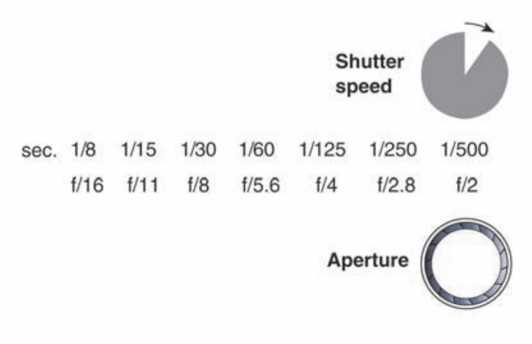


Shutter speed and aperture combinations. *Both the shutter speed and the aperture size control the amount of light. Each setting lets in half (or double) the amount of light as the adjacent setting—a one-stop difference.*

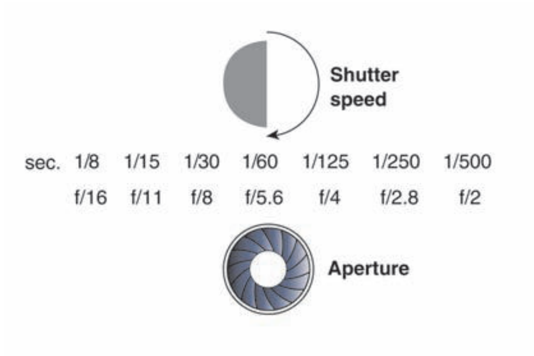
If you decrease the amount of light one stop by moving to the next smaller aperture setting, you can keep the exposure constant by also moving to the next slower shutter speed. In automatic operation, the camera makes these changes for you.

Each combination of aperture and shutter speed shown at left lets in the same amount of light, but see the photographs on the opposite page: the combinations change the sharpness of the picture in different ways.

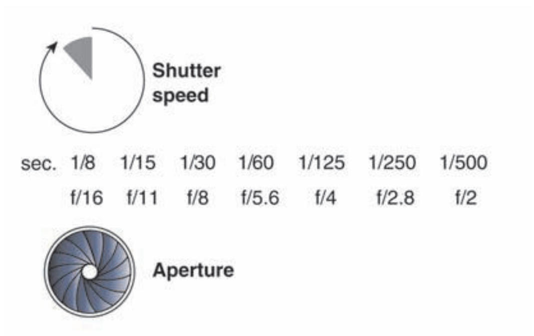
Fast shutter speed *(1/500 sec.): the moving swing is sharp.* ***Wide aperture*** *(f/2): the trees, picnic table, and person in the background are out of focus. Only objects the same distance as the foreground posts, on which the lens was focused, are sharp.*



Medium-fast shutter speed *(1/60 sec.): the moving swing shows some blur.* ***Medium-wide aperture*** *(f/5.6): the background is still a little fuzzy but the middle ground appears in focus.*



Slow shutter speed *(1/8 sec.): the moving swing is completely blurred.* ***Small aperture*** *(f/16): the middle- and background are completely sharp.*



This image was intentionally removed for this version.

Shutter speed and aperture combinations. *Each of the exposure combinations for this scene lets in the same total amount of light, so the overall exposure stays the same. But the motion of the swing is blurred with a slow shutter speed, sharp with a fast shutter speed. The depth of field (overall sharpness of near-to-far objects) is shallow with a larger aperture, extends farther with a small aperture.*

Getting the Most from Your Camera and Lens

Camera motion causes blur. Though some photographers claim to be able to hand hold a camera steady at slow shutter speeds—1⁄15 sec. or even slower—it takes only a slight amount of camera motion during exposure to cause a noticeable blur in an image. If a sharp picture is your aim, using a fast shutter speed or supporting the camera on a tripod is a much surer way to produce a sharp image.

When hand holding the camera (see right, top and center), use the focal length of your lens as a guide to how fast your shutter speed should be. The longer the focal length, the faster the shutter speed must be, because a long lens magnifies any motion of the lens during the exposure just as it magnifies the size of the objects photographed.

As a general rule, the slowest shutter speed that is safe to hand hold is matched to the focal length of the lens. That is, a 50mm lens should be hand held at a shutter speed of 1⁄50 sec. or faster, a 100mm lens at 1⁄100 sec. or faster, and so on. This doesn't mean that the camera can be freely moved during the exposure. At these speeds, the camera can be hand held, but with care. At the moment of exposure, hold your breath and squeeze the shutter release smoothly.

The camera itself can affect your ability to hand hold it; some cameras vibrate more than others during exposure. A single-lens reflex camera, with its moving mirror, for example, vibrates more than a rangefinder or compact camera. Some lenses and camera bodies have electronic stabilization systems that help you take sharp photographs at longer exposures.

A tripod and cable release (shown right, bottom) will keep the camera absolutely still during an exposure. The tripod supports the camera steadily; the cable release lets you trigger the shutter without having to touch the camera directly. A tripod and cable release are useful when you need a slower shutter speed than is feasible for hand holding; for example, at dusk when the light is dim. They also help when you want to compose a picture carefully or do close-up work. They are always used for copy work, such as photographing a painting, another photograph, or something from a book, because hand holding at even a fast shutter speed will not produce critical sharpness for fine details. A view camera is always used on a tripod.

The job of a cable release, to trigger the shutter without transmitting movement, may also be accomplished at a distance with a variety of remote wireless triggers that use radio or infrared signals.

To protect a camera in use, use a neck strap, either worn around your neck or wound around your wrist. It keeps the camera handy and makes you less likely to drop it. Lenses can be kept in lens cases or plastic bags to protect them from dust, with lens caps both back and front for additional protection of lens surfaces.

A padded bag, case, or backpack will protect your equipment from bumps and jolts when it is carried or moved, a camera bag makes your accessories and extra film readily available. Aluminum or molded plastic cases with fitted foam compartments provide the best protection; some are even waterproof. Their disadvantage is that they are bulky, not conveniently carried on a shoulder strap, and the camera may not be rapidly accessible.

Battery power is essential to the functioning of most cameras. If your viewfinder display or other data display begins to act erratically, the batteries may be getting weak. Many cameras have a battery check that will let you test battery strength or an indicator that warns of low power. It's a good idea to check batteries before beginning a day's shooting or a vacation outing and to carry spares in your camera bag. If you don't have spares and the batteries fail, try cleaning the ends of the batteries and the battery contacts in the camera with a pencil eraser or cloth; the problem may just be poor electrical contact. Warming the batteries in the palm of your hand might also bring them back to life temporarily.

To hand hold a camera, *keep feet apart, rest the camera lightly against your face. Hold your breath as you squeeze the shutter release slowly.*

With the camera in a vertical position, *the left hand holds and focuses the lens; the right hand releases the shutter.*

A tripod and cable release *are essential if you want a sharp image at slow shutter speeds. Keep some slack in the cable release so it doesn't tug the camera.*

Clean the sensor and inside the camera *very carefully. When you blow air inside the camera, tip the camera so the dust falls out and isn't pushed into the mechanism. Don't touch anything, even with a brush, unless absolutely necessary.*

Clean the lens. *First, blow then brush any visible dust off the lens surface. Hold the lens upside down to let the dust fall off the surface instead of just circulating on it.*

Use lens cleaning fluid. *Dampen a wadded piece of lens-cleaning tissue with the fluid and gently wipe the lens with a circular motion. Don't put lens fluid directly on the lens because it can run to the edge and soak into the barrel. Finish with a gentle, circular wipe using a dry lens tissue.*

Cameras and memory cards in transit should be protected from strong magnetic fields, shock, excessive heat, and sudden temperature changes. Avoid leaving equipment in a car on a sunny day. Excessive heat can soften the oil lubricant in the camera, causing the oil to run out and create problems, such as jamming lens diaphragm blades. At very low temperatures, moving mechanisms, both oil-lubricated and dry, as well as camera, flash, and meter batteries may be sluggish, so on a cold day it is a good idea to keep the camera warm by carrying it under your coat until you're ready to take a picture. When you bring a camera in from the cold, let it warm up before removing the lens cap to keep condensation off the lens. On the beach, protection from salt spray and sand is vital.

If a camera will not be used for a while, turn off any on/off switches, and store the camera away from excessive heat, humidity, and dust. For long-term storage, remove batteries because they can corrode and leak. Return the batteries temporarily and operate the shutter occasionally because it can become balky if not used.

Protect your camera from dust and dirt. Replace memory cards and change lenses in a dust-free place if you possibly can. You should blow occasional dust off the focusing mirror or screen, but it's wise to let a competent camera technician do any work beyond this.

Dust and specks that appear in your viewfinder are usually outside the optical path and will likely not appear in your photographs. However, any dust or dirt on a digital sensor (actually, on the built-in glass filter that covers it) will appear on each picture. Some cameras have a built-in mechanism to shake the sensor clean but when you see unwanted marks in the same location on all your pictures, consider cleaning the sensor.

Digital SLRs have a menu command for sensor cleaning, which locks the mirror up so you can access the sensor by removing the lens. It also cuts the sensor power to reduce static charge.

Touching the sensor can be risky; scratches are permanent. Start by trying to blow off unwanted dust gently. A rubber squeeze bulb is safer than a can of compressed gas that may produce enough force to damage components. A squeeze bulb that blows ionized air will do a better job of removing dust held by an electrostatic charge.

If your camera's sensor needs a more thorough cleaning, special brushes, pads, or swabs are available. But touching the sensor may make permanent marks, and voids a camera's warranty; you may want to have your sensor cleaned professionally.

Any lens surface must be clean for best performance, but keeping dirt off in the first place is much better than frequent cleaning, which can damage the delicate lens coating. Avoid touching the lens surface with your fingers because they leave oily prints that etch into the coating. Keep a lens cap on the front of the lens when it is not in use and one on the back of the lens when it is removed from the camera. Clean back caps thoroughly before using them; dust on the cap will often find its way to your sensor.

During use, a lens hood helps protect the lens surface in addition to shielding the lens from stray light that may degrade the image. A UV (ultraviolet) or 1A filter will have very little effect on the image; some photographers leave one on the lens all the time for protection against dirt and accidental damage.

To clean the lens you will need a rubber squeeze bulb or a can of compressed gas, a soft brush, lens tissue, and lens cleaning fluid. Use a squeeze bulb or compressed gas to remove dust, lens cleaning fluid and tissue if you have fingerprints or smears. Cans of compressed gas may spray propellant if tilted; keep them vertical for use. Avoid using cleaning products made for eyeglasses, particularly any treated cloths; they are too harsh for lens surfaces. A clean cotton cloth or paper tissue is usable in an emergency, but lens tissue or an untreated microfiber cloth will be much better.

Geoffrey Robinson
Press photographers outside Buckingham Palace on the royal wedding day of Prince William and Kate Middleton, London, 2011.
Working photographers are often constrained to a prearranged location at major events. *Robinson shows us why it can be difficult to report the news from an unusual vantage point.*

Lens  2

In this chapter you'll learn…

- the focal length of a lens is the most important difference between lenses, the longer the focal length, the larger a subject appears.
- that a viewer almost always looks at the sharpest part of a photograph first, and you can control your photograph's sharpness in several ways.
- perspective is the impression of depth in a two-dimensional image; we gauge it by the relative sizes of objects, determined by your lens and its distance from your subject.

Forming an image. Although a good lens is essential for making crisp, sharp photographs, you don't actually need one to take pictures. A primitive camera can be constructed from little more than a shoe box with a tiny pinhole at one end and a digital sensor, a piece of film, or a sheet of light-sensitive photographic paper at the other. A pinhole won't make as clear a picture as a glass lens, but it does form an image of objects in front of it.

A simple lens, such as a magnifying glass, will form an image that is brighter and sharper than an image formed by a pinhole. But a simple lens has many optical defects (called *aberrations*) that prevent it from forming an image that is sharp and accurate. A modern compound lens subdues these aberrations by combining several simple lens elements made of different kinds of glass and ground to different thicknesses and curvatures so that they cancel out each other's aberrations.

The main function of a lens is to project a sharp, undistorted image onto the light-sensitive surface. Lenses vary in design, and different types perform some jobs better than others. Two major differences in lens characteristics are focal length and speed.

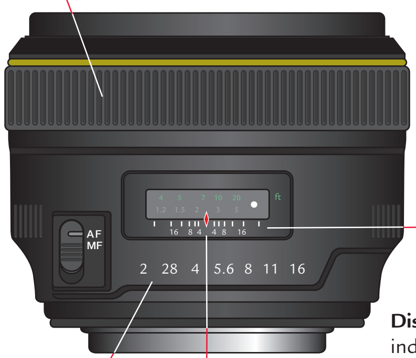
Lens focal length is, for a photographer, the most important characteristic of a lens. One of the primary advantages of a single-lens reflex camera or a view camera is the interchangeability of its lenses; many photographers own more than one lens so they can change lens focal length. More about focal length appears on the following pages.

Lens speed is not the same as shutter speed. More correctly called *maximum aperture*, it is the widest aperture to which the lens diaphragm can be opened. A lens that is "faster" than another opens to a wider aperture and admits more light; it can be used in dimmer light or with a faster shutter speed.

***On the lens barrel** (as shown below) are controls such as a ring that focuses the lens. Cameras and lenses vary in design, so check the features of your own camera. For example, many cameras have push-button or dial controls on the camera body instead of an aperture control ring on the lens. Markings on the lens (shown below, right) always include its focal length and maximum aperture (or a range for each if it is a zoom), usually along with a serial number and the maker's name.*

Focusing ring rotates to bring different parts of the scene into focus.

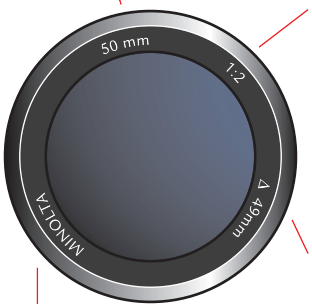
Depth-of-field scale shows how much of the scene will be sharp at a given aperture (explained on page 46).



Distance marker indicates on the **distance scale** the distance in feet and meters on which the lens is focused.

Aperture-control ring selects the f-stop or size of the lens opening.

Focal length. The shorter the focal length, the wider the view of a scene. The longer the focal length, the narrower the view and the more the subject is magnified.



Maximum aperture. The lens's widest opening or speed. Appears as a ratio, here 1:2. The maximum aperture is the last part of the ratio, f/2.

Filter size. The diameter in mm of the lens, and so the size of filter needed when one is added onto the lens.

Manufacturer

Lens Focal Length

THE BASIC DIFFERENCE BETWEEN LENSES

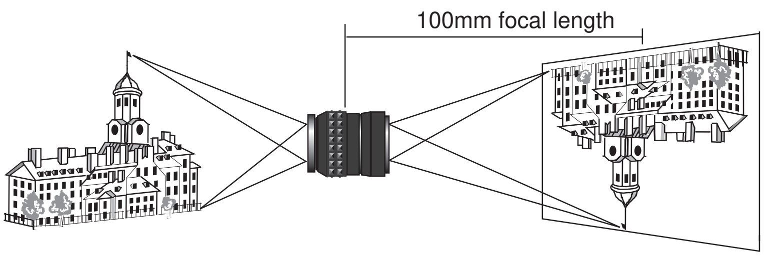
Photographers describe lenses in terms of their focal length; generally they refer to a normal, long, or short lens, a 50mm lens, a 24–105mm zoom lens, and so on. Focal length affects the image formed on the sensor or film in two important and related ways: the amount of the scene shown (the *angle of view*) and thus the size of objects (their magnification). A lens with a single, or fixed, focal length is called a *prime* lens; a variable or adjustable focal-length lens is called a *zoom* lens.

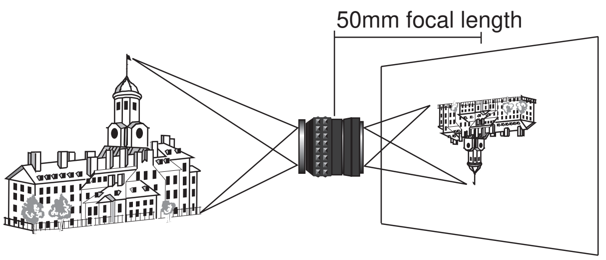
How focal length affects an image. The shorter the focal length of a lens, the more of a scene the lens takes in and the smaller it makes each object in the scene appear in the image. You can demonstrate this by looking through a circle formed by your thumb and forefinger. The shorter the distance between your hand (the lens) and your eye (the digital sensor or film), the more of the scene you will see (the wider the angle of view). The more objects that are shown on the same size sensor (or negative), the smaller all of them will have to be (the less magnification). Similarly, you could fill a sensor either with an image of one person's head or with a group of twenty people. In the group portrait, each person's head must be smaller.

The size of the recording surface affects the angle of view. With the same lens, a smaller sensor will capture less of a scene. Some digital sensors are the same size as a frame of 35mm film (24 × 36mm); these are called *full-frame* sensors and are usually found on relatively expensive cameras marketed to professionals. With cameras that use other, usually smaller, size sensors, lens focal lengths are often given in terms of a *35mm equivalent*. A camera with an APS-C sensor (about 15 × 22mm) using a 31mm lens has the same angle of view as a full-frame camera with a 50mm lens (see the opposite page). Focal lengths in this book are given as 35mm equivalents. A camera with an APS-C sensor is also said to have a *crop factor* of 1.6. Multiplying its lens focal length by 1.6 will give the 35mm equivalent.

Interchangeable lenses are convenient. The amount of a scene shown and the size of objects can be changed by moving the camera closer to or farther from the subject, but the option of changing lens focal length gives you more flexibility and control. Sometimes you can't easily get closer to your subject—for example, standing on shore photographing a boat on a lake. Sometimes you can't get far enough away, as when you are photographing a large group of people in a small room.

With a camera that accepts different lenses, such as a single-lens reflex camera, you can remove one lens and put on another when you want to change focal length. Interchangeable lenses range from super-wide-angle fisheye lenses to extra-long telephotos.





Focal length *is measured from an optical point near the back of a lens to the image it forms on the film or digital image sensor. It is measured when the lens is sharply focused on an object in the far distance (technically known as infinity). Magnification, the size of an object in an image, is directly related to focal length. As the focal length increases, the image size of the object increases. A 100mm lens produces an image twice as large as one produced by a 50mm lens.*

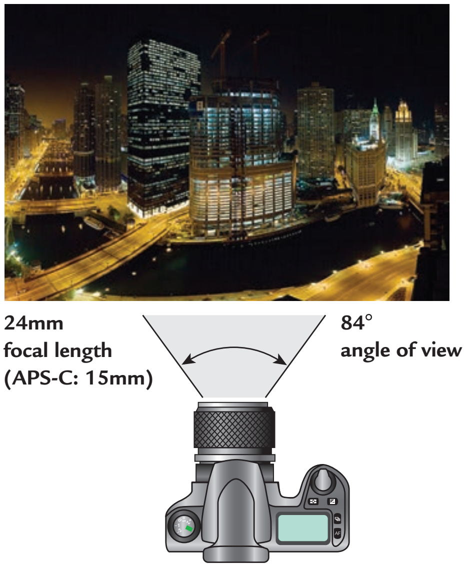
Project: LENS FOCAL LENGTH

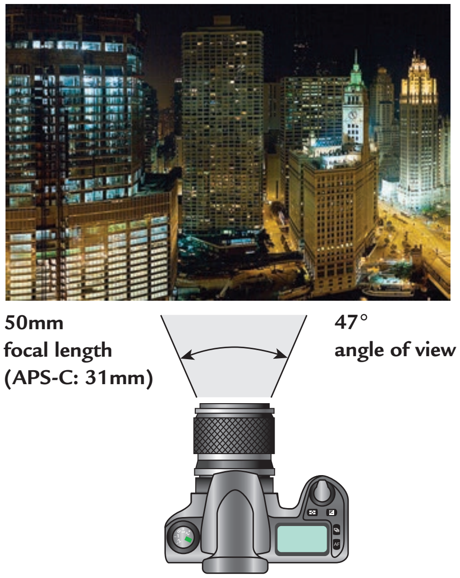
YOU WILL NEED
A camera either with a zoom lens or with lenses of two different focal lengths. The greater the difference in focal lengths, the easier it will be to see the difference between them. If you can, use a short-focal-length lens (35mm or shorter) and a long lens (85mm or longer).

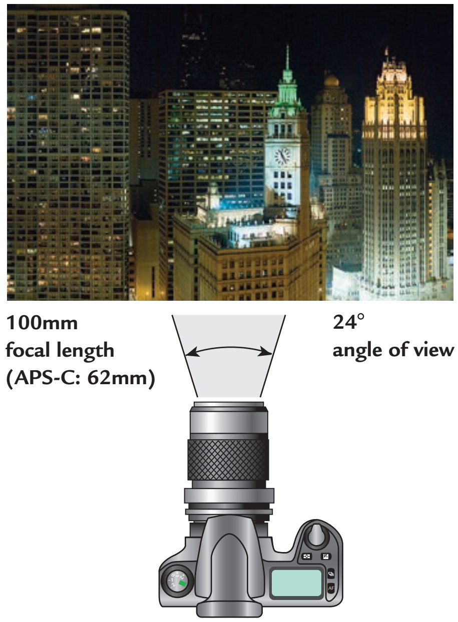
PROCEDURE
Put the shorter lens on the camera or adjust the zoom lens to its shortest focal length (its widest view). Make a head-to-toe photograph of a friend. Note the distance you have to stand from your subject to have his or her feet just touch the bottom edge of the viewfinder frame while the top of the head grazes its upper edge.

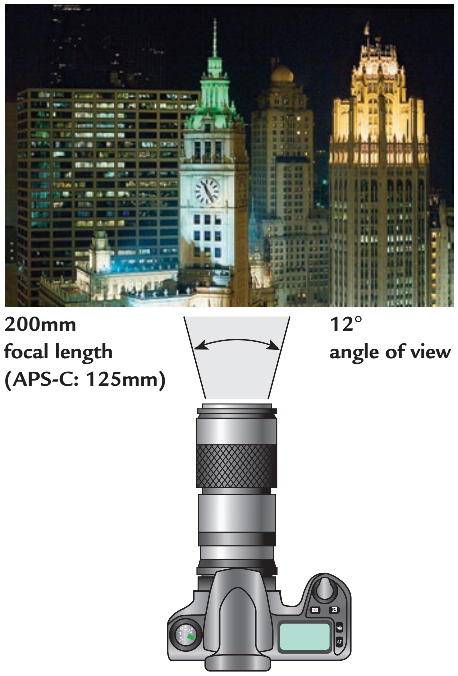
Do the same with the longer lens or with the zoom lens adjusted to its longest focal length (its narrowest view). Make a similar pair of views of a house or a chair, fitting your subject exactly into the image frame.

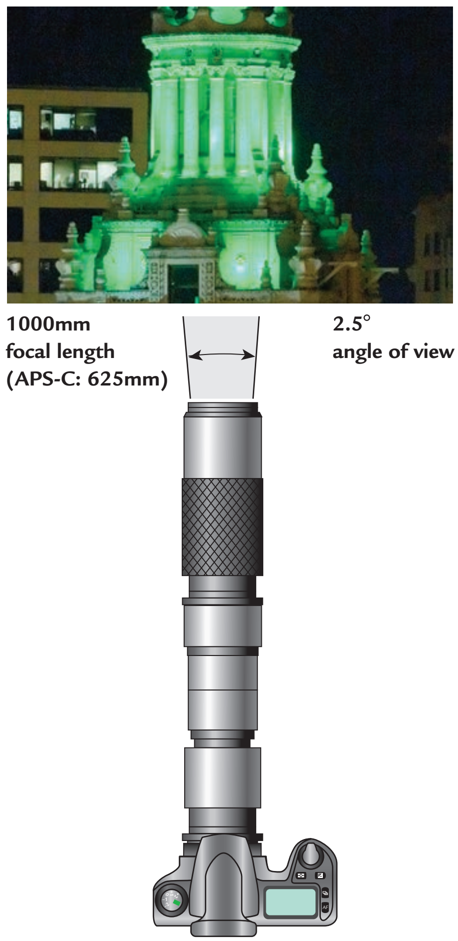
HOW DID YOU DO?
Compare the pairs of views. How did the distances you had to be from your subject with the short lens compare to those needed with the long lens? How do the backgrounds in the pairs of views differ? Did the impression of depth in the photographs change when you switched from the short to the long lens? What else changed?











What happens when you change lens focal length? *If everything else stays the same, changing the focal length of the lens changes both the amount of a scene included in the image (angle of view) and the size of objects (magnification). To make this sequence, the photographer changed only the focal length of the lenses; the distance from lens to subject remained the same. As the focal length increases (for example, from 24mm to 50mm), the angle of view narrows and the size of objects increases.*

These illustrations are accurate for comparing angles of view on a full-frame digital or 35mm film camera or when using "35mm equivalent" focal lengths. Focal lengths that match the angle of view on an APS-C camera are shown in parentheses.

Normal Focal Length

THE MOST LIKE HUMAN VISION

A **lens of normal focal length,** as you might expect from the name, produces an image that seems normal when compared with human vision. The image includes about the same angle of view as the human eye sees clearly when looking straight ahead, and the relative size and spacing of near and far objects appear normal. For full-frame cameras (or a 35mm film camera), this effect is produced by a lens of about 50mm focal length. Manufacturers that supply their cameras with a prime lens usually fit a lens of that length.

The size of the light-sensitive surface used in a particular camera determines what focal length is normal for it; a normal lens has a focal length approximately equal to the diagonal of the sensor or film frame. The normal focal length for a view camera with 4 × 5-inch film, for example, is 150mm. Most digital sensors are smaller than full frame so their normal lens is shorter than one for a full-frame or 35mm camera. See the size chart at the bottom of page 45.

Normal lenses have many advantages. Compared with lenses of much shorter or much longer focal length, normal lenses are generally faster; they can be designed with wider maximum apertures to admit the maximum amount of light. Therefore, they are convenient for use in dim light,

Alison Carey. *Graze, 2009.* ***A normal-focal-length lens*** *is a useful all-purpose lens in the studio. Carey fabricates her imagined landscapes indoors on a small scale with clay and paint. Carefully controlled artificial light and a painted backdrop help mimic reality. Her normal-focal-length lens provides a comfortable working distance and opens to a wide aperture when she wants shallow depth of field.*

especially where action is involved, as in theater or indoor sports scenes or in low light levels outdoors. They are a good choice if the camera is to be hand held because a wide maximum aperture permits a shutter speed fast enough to prevent blur caused by camera movement during exposure. Generally, the normal lens is more compact and lighter, as well as somewhat less expensive, than lenses of much longer or much shorter focal length.

Choice of focal length is a matter of personal preference. Many photographers with full-frame cameras regularly use a lens with a focal length of 35mm rather than 50mm because they like the wider view and greater depth of field that a 35mm lens has compared to a 50mm lens. Some photographers use an 85mm lens because they prefer its narrower view, which can concentrate the image on the central objects of interest in the scene.

Henri Cartier-Bresson. *Greece, 1961.* ***A lens of normal focal length*** *produces an image that appears similar to that of normal human vision. Cartier-Bresson made many of his best-known photographs with a 50mm lens on his 35mm Leica camera. The amount of the scene included in the image and the relative size and placement of near and far objects are what you would expect to see if you were standing next to the camera. The scene does not appear exaggerated in depth, as it might with a short-focal-length lens, nor do the objects seem compressed and too close together, as sometimes happens with a long-focal-length lens.*

Long Focal Length

TELEPHOTO LENSES

A prime lens of long focal length seems to bring things closer, just as a telescope does. As the focal length gets longer, less of the scene is shown (the angle of view narrows), and what is shown is enlarged (the magnification increases). This is useful when you are so far from the subject that a lens of normal focal length produces an image that is too small. Sometimes you can't get really close—at a sports event, for example. Sometimes it is better to stay at a distance, as in nature photography. An Olympic finish line, the president descending from Air Force One, and an erupting volcano are all possible subjects for which you might want a long lens.

How long is a long lens? A popular medium-long lens for a full-frame camera is 105mm; this focal length magnifies your view significantly but not so much that the lens's usefulness is limited to special situations. A lens of 65mm has a comparably long focal length for an APS-C camera with a 1.6x crop (or *lens conversion*) factor (see page 32), so does a 300mm lens on a 4 × 5 view camera. The difference between a medium-long lens and an extremely long one (for example, a 500mm lens with a full-frame camera) is rather like that between a pair of binoculars and a high-power telescope. You may want a telescope occasionally, but usually binoculars will do.

A long lens provides relatively little depth of field. When you use long lenses, you'll notice that as the focal length increases, depth of field decreases so that less of the scene is in focus at any given f-stop. For example, when focused at the same distance, a 200mm lens at f/8 has less

Ed Jones. *Fisherman's Dragon Boat Race, Hong Kong, 2010.* ***A long lens can seem to compress space.*** *Forced to shoot from shore, Jones chose a 500mm lens to fill his frame with the action. The boats and oarsmen seem to be stacked on top of one another in a jumble of action and color. When do you get this effect and why? See pages 48–49 to find out.*

Andreas Feininger. *The Ocean Liner* Queen Mary, *New York City, 1946.* ***A long lens magnifies a distant subject,*** *letting you shoot from a distance. Feininger used a 1000mm lens to shoot across the Hudson River from the New Jersey shore, two miles away. Built as a luxury liner, the* Queen Mary *served through the war as a troop transport beginning in 1940, and was decommissioned shortly after this photograph was taken.*

depth of field than a 100mm lens at f/8. This can be inconvenient—for example, if you want objects to be sharp both in the foreground of a scene and in the background. But it can also work to your advantage by permitting you to minimize unimportant details or a busy background by having them out of focus.

A medium-long lens is useful for portraits because the photographer can be relatively far from the subject and still fill the image frame. Many people feel more at ease when photographed if the camera is not too close. Also, a moderate distance between camera and subject prevents the exaggerated size of facial features closest to the camera that occurs when a lens is very close. A good working distance for a head-and-shoulders portrait is 6–8 ft. (2–2.5 m), easy to do with a medium-long lens—from 85mm to 135mm focal length.

A long prime lens, compared with one of normal focal length, is larger, heavier, and somewhat more expensive. Its largest aperture is relatively small; f/4 or f/5.6 is common. It must be focused carefully because with its shallow depth of field there will be a distinct difference between objects that are sharply focused and those that are not. A faster shutter speed is needed to keep the image sharp while hand holding the camera (or a tripod should be used for support) because the enlarged image magnifies the effect of even a slight movement of the lens during exposure. These disadvantages increase as the focal length increases, but so do the long lens's unique image-forming characteristics.

Photographers often call any long lens a telephoto lens, or tele, although not all long-focal-length lenses are actually of telephoto design. The optics of a true telephoto make it smaller than a conventional long lens of the same focal length. A tele-extender, or teleconverter, contains an optical element that increases the effective focal length of a lens. It attaches between the lens and the camera. The optical performance, however, will not be as good as the equivalent long lens.

Short Focal Length

WIDE-ANGLE LENSES

Lenses of short focal length are also called wide-angle or sometimes wide-field lenses, which describes their most important feature—they view a wider angle of a scene than normal. A lens of normal focal length records what you see when you look at a scene with eyes fixed in one position. A 35mm wide-angle lens records the 63° angle of view that you see if you move your eyes slightly from side to side. A 7.5mm fisheye lens records the 180° angle you see if you turn your whole head to look over your left shoulder and then over your right shoulder.

A popular short lens for a full-frame camera is 28mm. Comparable focal lengths are 55mm for a medium-format film camera with 6 × 7cm format, and 90mm for a 4 × 5-inch view camera.

David Leventi. *Opéra de Monte-Carlo, Monaco, 2009.* ***A shorter-focal-length lens lets you show a more complete view of the scene from any viewpoint.*** *For his book* Opera*, Leventi photographed the world's great opera houses—this one opened in 1879—all from the central vantage point of a solo performer. Using a wide lens he could gather, from his fixed location, nearly the entire ornate interior.*

Wide-angle lenses are also popular with photojournalists, feature photographers, and others who shoot in fast-moving and sometimes crowded situations. For example, many photojournalists regularly use 35mm or 28mm as their "normal" lens instead of a 50mm lens. These medium-short lenses give a wider angle of view than does a 50mm lens, which makes it easier to include the setting in close quarters. Shorter lenses also give you more depth of field, which can let a photographer focus the lens approximately instead of having to fine-focus every shot.

Short lenses show a wide view. *Short-focal-length lenses are useful for including a wide view of an area. They are capable of great depth of field so that objects both close to the lens and far from it will be in focus, even at a relatively large aperture.*

Karl Baden

Objects up close appear larger. *A short lens can produce strange perspective effects. Because it can be focused at very close range, it can make objects in the foreground large in relation to those in the background. With the lens close to the resting man's feet, they look monumental, making a photograph with an entirely different meaning than the one above.*

A short lens can give great depth of field. The shorter the focal length of a lens, the more of a scene will be sharp (if the f-stop and distance from the subject remain unchanged). A 28mm lens, for example, when stopped down to f/8 can produce an image that is sharp from less than 6.5 ft. (2 m) to infinity (as far as the eye or lens can see), which often will eliminate the need for further focusing as long as the subject is within the range of distances that will be sharp.

The focal length of what's called a wide (or normal or long) lens depends on the size or format of the film or digital sensor you are using. The light-sensitive recording chip in many digital cameras is smaller than full frame and, if it is, it will capture any given angle of view with a shorter-focal-length lens.

Depth of field, on the other hand, depends on the actual focal length of the lens; if everything else stays the same, a shorter lens will always give you greater depth of field. The compact camera on page 12, left, has a fixed zoom lens (see page 40) with a focal length of 4.3–86mm. Because of the small sensor size, its 35mm equivalent is a 24–480mm zoom. Using that camera, you would get much greater depth of field for any photograph than you would using its 35mm-equivalent lens with a full-frame camera.

Wide-angle "distortion." A wide-angle lens can seem to distort an image and produce strange perspective effects. Sometimes these effects are actually caused by the lens, as with a fisheye lens (page 41 bottom). But, more often, what seems to be distortion in an image made with a wide-angle lens is caused by the photographer shooting very close to the subject.

A 28mm lens, for example, will focus as close as 1 ft. (0.3 m), and shorter lenses even closer. Any object seen from close up appears larger than an object of the same size that is at a distance. While you are at a scene, your brain knows whether you are very close to an object, and ordinarily you would not notice any visual exaggeration. In a photograph, however, you notice size comparisons immediately. Our impression of perspective is based on size relationships that depend on lens-to-subject distance. See the photographs at left.

Zoom, Macro, and Fisheye Lenses

Other lenses can view a scene in a new way or solve certain problems with ease.

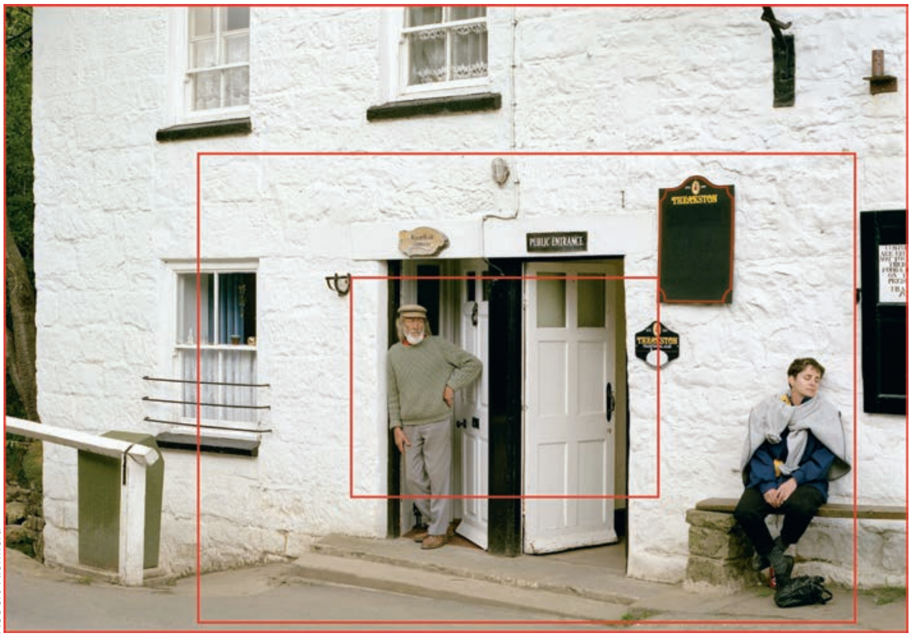
Zoom lenses are popular because they combine a range of focal lengths into one lens (see below). The glass elements of the lens can be moved in relation to each other; thus infinitely variable focal lengths are available within the limits of the zooming range. Using a 50–135mm zoom, for example, is like having a 50mm, 85mm, 105mm, and 135mm lens instantly available, plus any focal length in between. Compared to prime, or fixed-focal-length, lenses, zooms are somewhat more expensive, bulkier, and heavier, but one of them will replace two or more fixed-focal-length lenses. Zoom lenses are best used where light is ample because they have a relatively small maximum aperture. Older zoom lenses were significantly less sharp than fixed-focal-length lenses but new designs nearly match them. The "kit" lenses sold as a package with DSLRs are usually zooms. Most current zoom lenses are also autofocus.

"Digital" zoom, a feature found on some digital cameras marketed to amateurs, only crops the image, enlarging the pixels in the part of the image that's left. Quality is less than you'd get by using a longer lens or moving closer for the shot.

Macro lenses are used for close-up photography (opposite, top). Their optical design corrects for the lens aberrations that cause problems at very short focusing distances, but they can also be used at normal distances. Their disadvantages are a slightly smaller maximum aperture, often f/2.8 for a 50mm lens, and slightly higher cost. (More about making close-up photographs on page 50.) Longer-focal-length macro lenses let you magnify an image, like the one opposite, top, without disturbing the subject.

Macro-zoom lenses combine both macro and zoom features. They focus relatively close, although usually not as close as a fixed-focal-length macro lens, and give a range of focal length choices in one lens.

Fisheye lenses have a very wide angle of view—up to 180°—and they exaggerate to an extreme degree differences in size between objects that are close to the camera and those that are farther away. They actually distort the image by bending straight lines at the edges of the picture (opposite, bottom). Fisheye lenses, because of their very short focal length, also produce a great deal of depth of field: objects within inches of the lens and those in the far distance will be sharp.



Robert Richfield

***A zoom lens** gives you a choice of different focal lengths within the same lens. The rectangles overlaid on the picture show you some of the very different ways you could have made this photograph by zooming in to shoot at a long focal length or zooming back to shoot at a shorter one.*

Stanley Rowin. *Acupuncture, 1995.* ***The therapist's hands were shot with a macro lens.*** *The background was purposefully rendered dark and featureless to avoid distracting from the subject.*

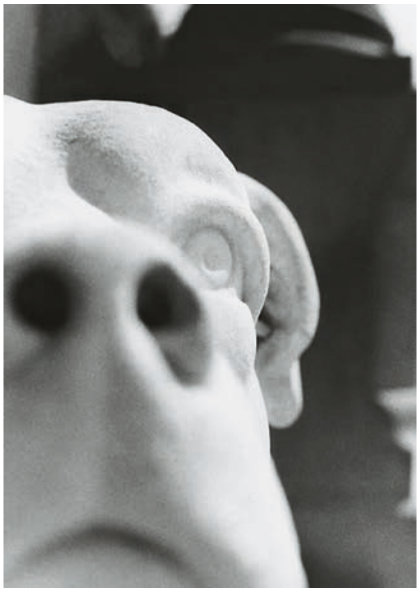
Donald Miralle. *Woodlake Rodeo, California, 2005.* ***A fisheye lens*** *and unusual vantage point help capture the fury of a bull breaking from the gate at the start of a bull-riding competition. The fence is bent into a curve by the lens. Objects at the edge of the fisheye's image circle are distorted more than those at the center.*

Focus and Depth of Field

Sharp focus attracts the eye. Sharp focus acts as a signal to pay attention to a particular part of a photograph, especially if other parts of the image are not as sharp. If part of a picture is sharp and part is out of focus, it is natural to look first at the sharply focused area (see photographs, pages 158–159). When you are photographing, it is also natural to focus the camera sharply on the most important area. You can select and, to a certain extent, control which parts of a scene will be sharp.

When you focus a camera on an object, the distance between lens and film (or digital image sensor) is adjusted, automatically with an internal motor or manually by your rotating a ring on the lens barrel, until the object appears sharp on the viewing screen. You focus manually by turning that focusing ring until the object appears sharp in your viewfinder or a mark on the lens barrel corresponding to its distance aligns with a focusing mark. If you are using an automatic-focus camera, you focus by aiming the focus indicator in your viewfinder (usually a spot in the center) at the object and partially depressing the shutter-release button. The motor in the lens moves the lens elements away from or closer to the film or sensor until that spot is in focus.

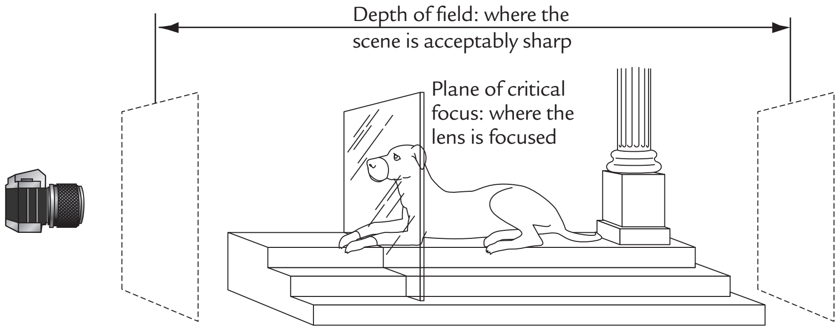
Depth of field. In theory, a lens can only focus on a flat plane at one single distance at a time and objects at all other distances will be less sharp. The distance from your lens to that plane, the *plane of critical focus*, is called the *object distance* and is usually indicated by a distance scale on the lens. In most cases, however, part of the scene will be acceptably sharp both in front of and behind the most sharply focused plane. Objects will gradually become more and more out of focus the farther they are from the most sharply focused area. This region within which objects appear acceptably sharp in the image—the depth of field—can be increased or decreased (see pages 44–45).



Karl Baden

Depth of field is the part of a scene that appears acceptably sharp in a photograph. *Depth of field can be deep, with everything sharp from near to far. In the photograph above, left, it extends from the dog's paws in the foreground to the fluted column behind him. The photographer actually focused on the dog's eye.*

For another picture, above right, the photographer wanted shallow depth of field, with only some of the scene sharp. Here the only sharp part of the picture is the eye on which the lens was focused.



Imagine the plane of critical focus *(the distance on which you focus the lens) to be something like a pane of glass stretched from one side of the scene to the other. Objects that lie along that plane will be sharp. In front of and behind the plane of critical focus lies the depth of field, the area that will appear acceptably sharp. The farther objects are from the plane of critical focus in a particular photograph, either toward the camera or away from it, the less sharp they will be. If objects are far enough from the plane of critical focus to be outside the depth of field, they will appear noticeably out of focus.*

Notice that the depth of field extends about one-third in front of the plane of critical focus, two-thirds behind it. This is true at normal focusing distances, but when focusing very close to a subject, the depth of field is more evenly divided, about half in front and half behind the plane of critical focus.

Automatic Focus

Auto focus can mean out of focus *when a scene has a main subject (or subjects) off to one side and at a different distance from whatever object is at the center. Most autofocus cameras will focus on the object at the center of the frame, here within the small bracketed area, over the shoulder of the subject.*

To correct this, *first choose the focusing distance by placing the autofocus brackets on the main subject and partially pressing down the shutter-release button. Lock the focus by keeping partial pressure on the shutter release.*

Reframe your picture *while keeping partial pressure on the shutter release. Push the shutter button all the way down to make the exposure.*

Automatic focus used to be found only on point-and-shoot snapshot cameras. But now it is standard equipment on almost all cameras. When you push down the shutter-release button part way, the camera adjusts the lens to focus sharply on what it thinks is your subject—usually whatever object is at the center of the viewing screen.

Sometimes you will want to focus the camera manually. Just as with automatic exposure, there will be times when you will want to override the automatic mechanism and focus the camera yourself. Most single-lens reflex and full-featured compact cameras with automatic focus will also let you focus manually.

The most common problem occurs when your subject is at the side of the frame, not at the center (see photos, left). A camera may also have problems focusing through glass, or if a subject has very low contrast, is in very dim light, or consists of a repetitive pattern.

Moving subjects can also cause problems. The adjustment of the autofocus mechanism can sometimes take long enough for a fast-moving subject, such as a race car, to move out of range. The lens may "hunt" back and forth, unable to focus at all or may make an exposure with the subject out of focus.

Some cameras have more sophisticated electronics to deal with these problems better. Automatic focus is more rapid, for example, when the focusing motor is located in the lens instead of the camera body. Some cameras can be set so the lens, once it is focused on a moving object, will keep it in focus for a series of exposures. Read the instructions for your camera and lens so you know how the autofocus mechanism operates.

Take a moment to evaluate each situation. Override the automatic system when it is better to do so, rather than assume that the right part of the picture will be sharp simply because you are set for automatic focus.

Depth of Field

CONTROLLING SHARPNESS IN A PHOTOGRAPH

Depth of field. Completely sharp from foreground to background, totally out of focus except for a shallow zone, or sharp to any extent in between—you get to choose how much of your image will be sharp. When you make a picture, you can manipulate three factors that affect the depth of field (the distance in a scene between the nearest and farthest points that appear sharp in a photograph). Notice in the illustrations opposite that doing so may change the image in other ways.

Aperture size. Stopping down the lens to a smaller aperture, for example, from f/2 to f/16, increases the depth of field. As the aperture gets smaller, more of the scene will be sharp in the photograph.

Focal length. Using a shorter-focal-length lens also increases the depth of field at any given aperture. For example, more of a scene will be sharp when photographed with a 50mm lens at f/8 than with a 200mm lens at f/8.

Lens-to-subject distance. Moving farther away from the subject increases the depth of field most of all, particularly if you started out very close to the subject.

Marc PoKempner. Rev. Ike, Chicago, 1975. ***Shallow depth of field lets you draw immediate attention to one area;*** *we tend to look first at the sharpest objects in a photograph. The message of preacher Reverend Ike is that God is generous and will give you exactly what you ask for, including, for example, a diamond-studded watch, ring, and cuff links, on which the photographer focused.*

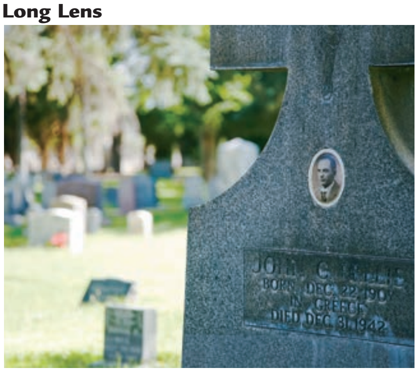
The smaller the aperture (with a given lens), the greater the depth of field. *Using a smaller aperture for the picture on the far right increased the depth of field and made the image much sharper overall. With the smaller aperture, the amount of light entering the camera decreased, so a slower shutter speed had to be used to keep the total exposure the same.*

Large Aperture

Small Aperture

The shorter the focal length of the lens, the greater the depth of field. *Both of these photographs were taken from the same position and at the same aperture. Notice that changing to a shorter focal length for the picture on the far right not only increased the depth of field but also changed the angle of view (the amount of the scene shown) and the magnification of objects in the scene.*

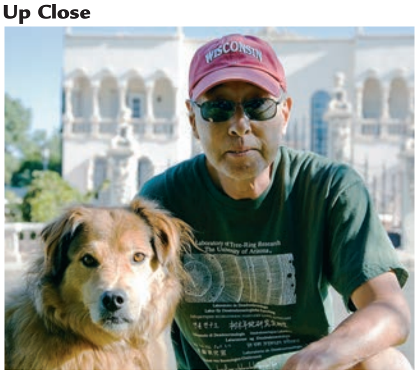
Long Lens



Short Lens

The farther you are from a subject, the greater the depth of field, *at any given focal length and aperture. The photographer stepped back to take the picture on the far right. If you focus on an object far enough away, the lens will form a sharp image of all objects from that point out to infinity.*

Up Close



Farther Back

Small Sensor = Great Depth of Field

Digital cameras with small sensors can give you unexpected depth of field. The shorter a lens's focal length (at the same aperture and distance from the subject), the greater the depth of field. The size of a camera's sensor affects what is considered a normal-, short-, or long-focal-length lens for that camera.

A "normal" lens for a camera (see page 34) is one with a focal length about the same as the length of a diagonal line across the light-sensitive surface in the camera. A full-frame digital or 35mm film camera has a 24 × 36mm light-sensitive surface: a normal lens for that camera is 50mm.

The sensor in most digital cameras is smaller—in many cases, considerably smaller. A normal lens for that type of camera will be shorter than the 50mm lens that is normal for a full-frame camera, and so will have more depth of field. The compact digital camera pictured on page 12, top, for example, has a sensor of 6.2 × 4.55mm. The normal focal length is 8mm. If everything else is equal, the 8mm lens will give you much greater depth of field than the 50mm lens.

Small sensors use an obscure naming system *devised for TV camera tubes in the 1950s. Here are sensor diagonals—hence normal lens lengths—for some common sizes.*

Sensor Name	Diagonal
1/2″	8.0mm
1/1.8″	8.9mm
2/3″	11.0mm
Four Thirds″	22.5mm
1.8″ (APS-C)	28.4mm

More about Depth of Field

HOW TO PREVIEW IT

Know the extent of the depth of field when photographing a scene—how much of the scene from near to far will be sharp—to make better pictures. You may want to be sure that certain objects are sharp. Or you may want something deliberately out of focus, such as a distracting background. To control what is sharp, it is useful to have some way of gauging the depth of field.

Checking the depth of field. With a single-lens reflex camera, you view the scene through the lens. No matter what aperture setting you have selected, the lens is ordinarily wide open for viewing to make the viewfinder image as bright and easy to see as possible. However, the large aperture size means that you see the scene with depth of field at its shallowest. When you press the shutter release, the lens automatically closes down to the taking aperture. Unless you are taking a picture using the widest aperture, the viewfinder image will not have the same depth of field as the final photograph. Some single-lens reflex cameras have a previewing mechanism that lets you, if you wish, stop down the lens to view the scene at the taking aperture and see how much will be sharp.

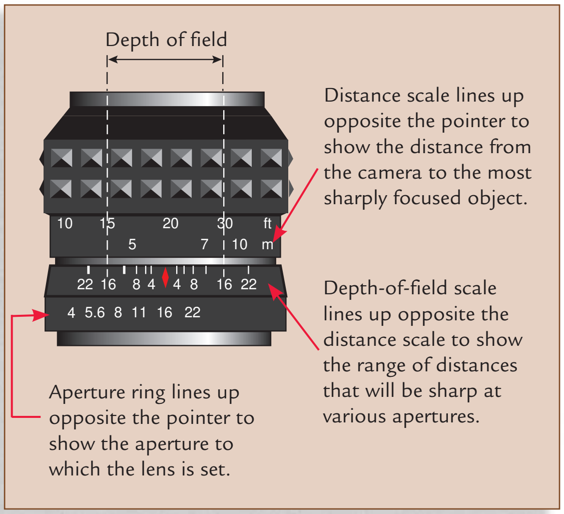
Unfortunately, if the lens is set to a very small aperture, the stopped-down image on the viewing screen may be too dark to be seen clearly. If so, or if your camera doesn't have a preview feature, you may be able to read the near and far limits of good focus on a depth-of-field scale on the lens barrel (this page, bottom). Many newer autofocus lenses don't have them, but you can use tables showing the depth of field for different lenses at various focusing distances and f-stops. Such tables were originally printed in books, now online and portable calculators and smartphones provide the same information (see opposite page).

A rangefinder or viewfinder camera shows you the scene through a small window in the camera body through which all objects look equally sharp. Some digital cameras without a viewfinder window let you zoom in to a test shot on the monitor to judge depth of field very accurately. You can also use a depth-of-field scale on the lens barrel, a printed table, or a calculator to estimate depth of field with these cameras as well. An electronic viewfinder can preview depth of field.

Zone focusing for action. Know the depth of field in advance when you want to preset the lens to be ready for an action shot without last-minute focusing. Zone focusing uses a table or the depth-of-field scale on the lens to preset manual focus and aperture so that the action will be photographed well within the depth of field (see below and right).

Christoph Oberschneider. *Dolomites, Italy, 2015.* ***With zone focusing*** *you can be ready for an action shot by manually focusing in advance, if you know approximately where the action will take place. Suppose you are on a ski slope and you want to photograph a skier coming down the hill. The nearest point at which you might want to take the picture is 15 ft. (4.5 m) from the action; the farthest is 30 ft. (9 m).*

Line up the distance scale so that these two distances are opposite a pair of f-stop indicators on the depth-of-field scale (with the lens shown at left, the two distances fall opposite the f/16 indicators). Now, if your aperture is set to f/16, everything from 15ft. to 30 ft. (4.5–9 m) will be within the depth of field and in focus. It doesn't matter exactly where the subject is when you shoot, as long as it is somewhere within these distances. Prefocus an autofocus lens by aiming at a spot the same distance the action will be and holding the shutter button down halfway until you frame and press it the rest of the way.

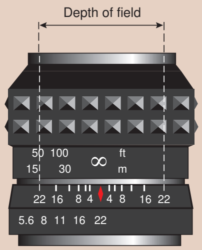


Ansel Adams. *Tetons and the Snake River, Wyoming, 1942.* ***The smaller the aperture the greater the depth of field.*** *Everything in the picture at right is sharp. Adams usually used a view camera (page 11), which offers additional control over focus, and he preferred its large-format film for making prints of greater clarity.*

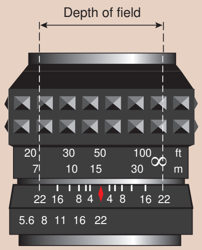
View cameras are always used on a tripod. Even if you are using a small camera, a tripod is a good idea to avoid motion blur when the aperture is small and the shutter speed is correspondingly slow.

Focusing for the greatest depth of field. When you are shooting a scene that includes important objects at a distance as well as close up, you will want maximum depth of field. Shown in the box at right is a way of setting the lens to permit as much as possible of the scene to be sharp. It is easy if you have a lens that has a depth-of-field scale. If not, you can look up the depth of field in a printed table or by using a depth of field application (see below).

Depth-of-field tables *list, for each lens focal length, focusing distance, and aperture, the near and far limits of good focus and the hyperfocal distance (see the box at right). At one time only available as a lengthy book, a full set of depth-of-field tables can now be downloaded as an app (a software program) for your smartphone. You can have complete focus information handy wherever you are. At left is* Simple D-o-F Calculator *on an iPhone.*



When the lens is focused at infinity *(∞ on the lens distance scale), everything at some distance away and farther will be sharp: with this lens at f/22 everything will be sharp from 50 ft. (16 m) to infinity (as far as the eye can see).*



You can increase the depth of field *even more if, instead of focusing on infinity, you set the infinity mark (∞) opposite the point on the depth-of-field scale (22) that shows the f-stop you are using (f/22). You are now focused on a distance (50 ft., 16 m) slightly closer than infinity (technically called the* hyperfocal distance*). Now everything from 23 ft. (7 m) to the far background is within the depth of field and will be sharp in the image.*

Perspective

HOW A PHOTOGRAPH SHOWS DEPTH

Perspective: the impression of depth. Few lenses (except the fisheye) noticeably distort the scene they show. The perspective in a photograph—the apparent size and shape of objects and the impression of depth—is what you would see if you were standing at the camera position. Why then do some photographs seem to have an exaggerated depth, with the subject appearing stretched and expanded (this page, top), whereas other photographs seem to show a compressed space, with objects crowded very close together (this page, bottom)? The brain judges depth in a photograph mostly by comparing objects in the foreground with those in the background; the greater the size differences perceived, the greater the impression of depth. When viewing an actual scene, the brain has other clues to the distances. But, when looking at a photograph, the brain relies primarily on relative sizes.

Perspective can be controlled in a photograph. Any lens very close to the foreground of a scene increases the impression of depth by increasing the size of foreground objects relative to objects in the background. As shown on the opposite page, perspective is not affected by changing the focal length of the lens if the camera remains in the same position. However, the relative sizes of objects do change if the distance from lens to subject is changed.

Perspective can be exaggerated if you change both focal length and lens-to-subject distance. A short-focal-length lens used close to the subject increases differences in size because it is much closer to foreground objects than to those in the background. This increases the impression of depth. Distances appear expanded and sizes and shapes may appear distorted.

The opposite effect occurs with a long-focal-length lens used far from the subject. Differences in sizes are decreased because the lens is relatively far from all objects. This decreases the apparent depth and sometimes seems to squeeze objects into a smaller space than they could occupy in reality.

Walter Iooss. *Ali vs. Terrell, Houston, 1967.* ***Expanded perspective*** *seems to result from the very wide lens. But using any lens this close to a subject stretches distances because it magnifies objects near the lens in relation to those that are far from the lens.*

Walter Iooss. *100 m start, Los Angeles, 1983.* ***Compressed perspective*** *is usually associated with a long-focal-length lens. It is because the lens is relatively far from both foreground and background that size differences between near and far parts of the scene are minimized, as is the impression of depth.*