CHAPTER/THREE lens

A simple pinhole will form an image, but a lens forms a sharper one.

Lens focal length is probably the most important difference between lenses. The longer the focal length, the larger a subject will appear.

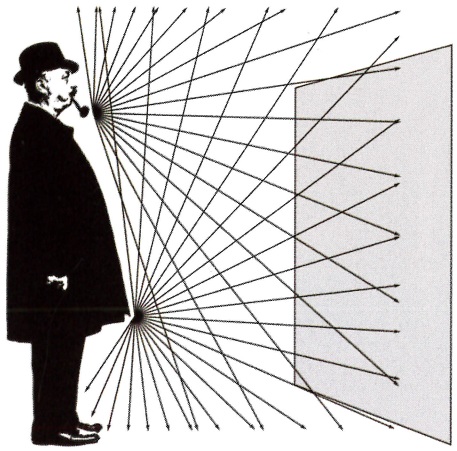
A viewer will almost always look first at the sharpest part of a photograph, the part on which you have manually focused or the camera has automatically focused.

How sharp an image appears is also affected by the depth of field, the area from near to far that is acceptably sharp in a photograph.

Perspective, the apparent size and shape of objects and the impression of depth, is affected not just by the lens you use but by where you position the lens.

You have options in selecting a lens. Here is help understanding them and then getting the most from your lens and camera.

Mary Ellen Mark brings a personal contact to her subject matter.



Light must be controlled if our eyes or our cameras are to form images of objects. *You can't simply place a rectangle of sensitized film or an array of light-sensitive diodes in front of a subject and wait for an image to appear. Light reflecting from the subject would hit the surface in a random jumble, resulting not in a picture but in a uniform exposure over the entire surface.*

Light acts both like rays and like waves. For simplicity's sake, this drawing shows it as rays—only a few coming from just two points on the man. But their random distribution over the surface makes it clear that they are not going to produce a useful image. What is needed is some sort of light-control device between the subject and the digital sensor or film that will select and aim the rays, placing the rays from each part of the image where they belong, resulting in a clear picture.

All photographic lenses do the same basic job: they collect light emanating from a scene in front of the camera and project it as an image onto a light-sensitive surface (a piece of film or a digital sensor) at the back of the camera. This chapter explains how you can use lens focus (which adjusts the sharpest part of an image), lens focal length (which controls the magnification of a scene), lens aperture, and subject distance to make the kinds of pictures you want. Lenses for both digital and film cameras follow the same principles of optics.

Light acts in some ways like rays and in some ways like waves. All points in any scene emanate or reflect rays or waves in all directions. All the light reflected from a point or an object isn't necessary to produce an image, a selection of it will do.

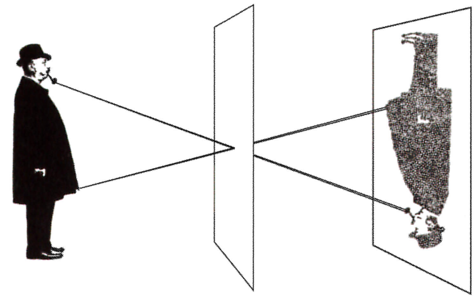
When light from an object reaches a barrier with a small pinhole in it, like that in the drawings on the far right, all but a few rays from each emanating point are deflected by the barrier. Those few rays that do get through, traveling in straight lines from the subject, can make an image when they reach a flat surface, like film at the back of a camera. The image is rotated upside down. Everything that was at the top of the subject appears at the bottom of the image and everything at the bottom appears at the top. Similarly, left becomes right and right becomes left.

The trouble with using a pinhole as a lens is its tiny opening. It admits so little light that very long exposures are needed to register an image on film or a sensor. If the hole is enlarged, the exposure becomes shorter, but the image becomes much less sharp, like the center photograph at right.

A pinhole, small as it is, actually admits a cluster of light rays. Coming at slightly different angles, these rays continue through the hole in slightly different directions. They fan out, so that when they hit a surface, like film, the rays from a point on the subject make a tiny, blurry circle instead of forming a point again. As the size of the hole is increased, a larger cluster of light rays gets through to the film or sensor and makes a wider, even blurrier circle. These circles overlap, so the wider each circle becomes, the less clear the picture will be.

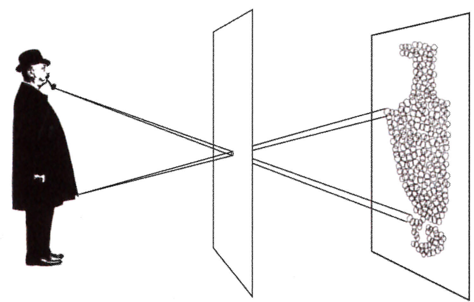
A lens creates a sharp image with a relatively short exposure. To get sharp pictures, the image of a small point should also be a small point. But there is no way to achieve that using a pinhole on a camera. Even a tiny opening, which admits little light and requires long exposure times, will not make a very sharp image. To admit more light and to make a sharper picture than even the smallest pinhole, a different method of image formation is needed. That is what a lens provides.

Photograph made with small pinhole



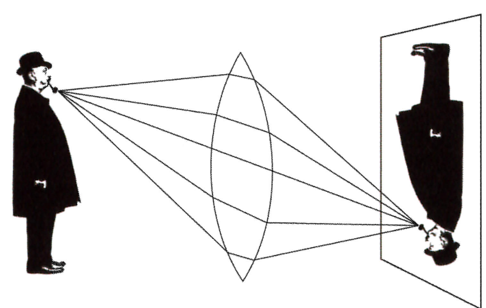
To make this picture, the lens of a camera was replaced with a thin metal disk pierced by a tiny pinhole, *equivalent in size to an aperture of f/182. Only a few rays of light from each point on the subject got through the tiny opening, producing a soft but acceptably clear photograph. Because of the small size of the pinhole, the exposure had to be 6 sec long.*

Photograph made with larger pinhole

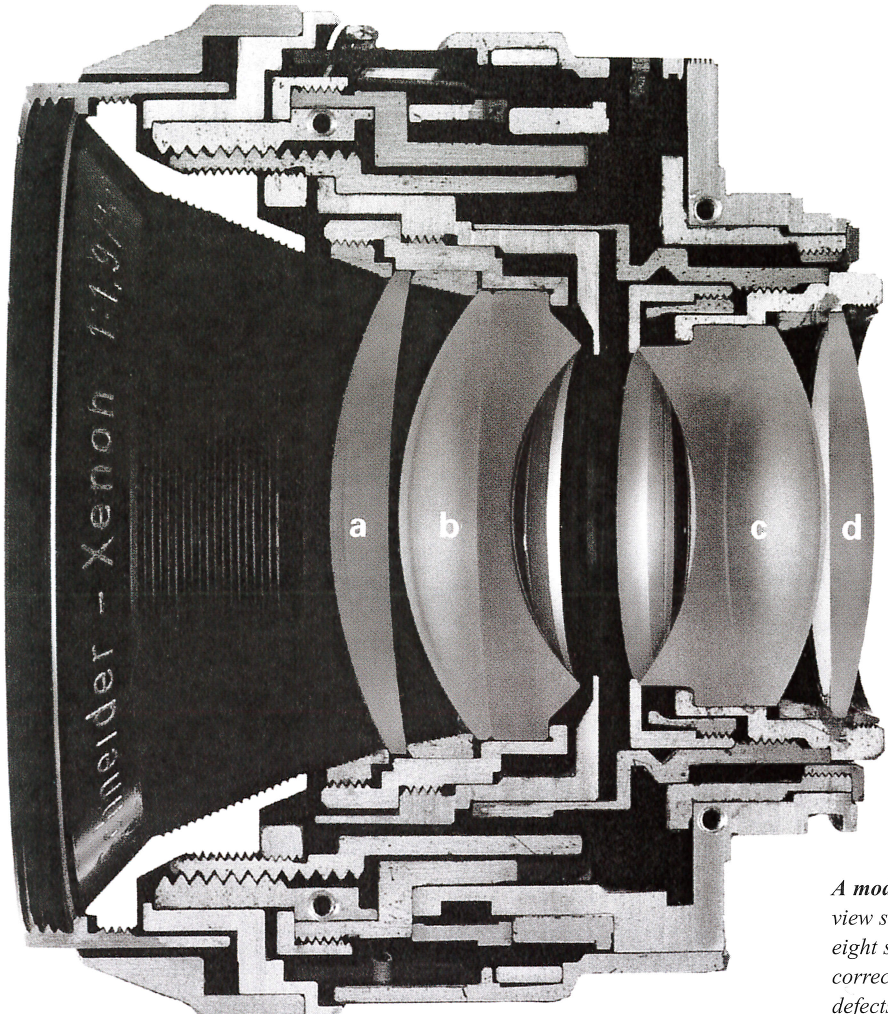


When the size of the pinhole was increased to f/65, the result was an exposure of only 1/5 sec, *but an extremely out-of-focus image. The larger hole let through more rays from each point on the subject. These rays spread widely before reaching the light-sensitive surface, making large circles that overlapped one another creating a very unclear image.*

Photograph made with lens

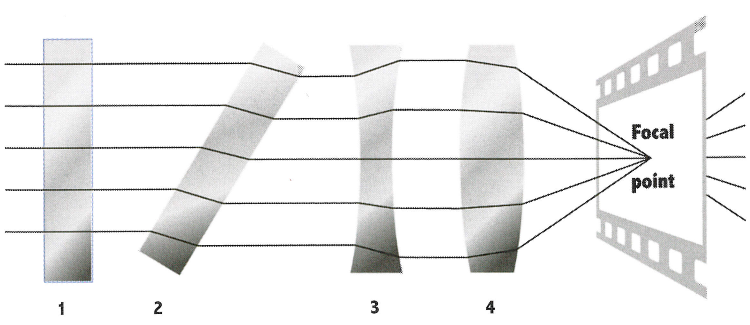


This time, using a simple convex lens with an f/16 aperture, *the scene appeared sharper than the one taken with the smaller pinhole, and the exposure time was much shorter, only 1/100 sec. The lens opening was much bigger than the pinhole, letting in far more light, but it focused the rays from each point on the subject precisely so that they were sharp.*



A modern compound lens, as this cutaway view shows, is usually made up of six or eight separate lenses. Each lens is added to correct some of the aberrations or focusing defects in the others. This lens has six elements in four groups. An element is a simple lens with two curved sides or one curved and one flat side. A group may be a single element, like (a) or (d), or it may be two or more elements cemented together, like (b) and (c).

Because lens aberrations are mathematically predictable, some of these focusing defects can be eliminated digitally from the picture after it has been made, but using a well-designed lens is always the best start.



How refraction works is shown in this diagram of light rays passing through four glass blocks. *The rays, entering from the left, strike the first block head on (1) and therefore pass straight through. The next block (2) has been placed at an angle; the rays are bent, but as they exit the block they are bent back to resume their former direction. The concave surfaces of the third block (3) spread the rays apart, but the last block (4)—a convex lens like the basic light-gathering lenses used in cameras—draws the rays back together so that they cross each other at the point of focus.*

Most modern photographic lenses are based on the convex lens. Thicker in the middle than at the edges, a convex lens collects a large number of light rays from any single point on an object in front of the lens and refracts, or bends, them toward each other so that they converge at a corresponding single point (diagram, left) behind the lens. Each point in the scene (object point) corresponds to a point behind the lens (image point). Inside a camera, a strip of film is stretched flat (or a flat digital sensor is positioned) across the image plane, sometimes called the film plane. All the points in a corresponding object plane in the scene will focus as points on that surface, so the picture will be sharp for everything in that plane.

How does a lens refract (bend) light to form an image? When light rays pass from one transparent medium, such as air, into a different transparent medium, such as water or glass, the rays refract, or bend. Look at the shape of a spoon half submerged in a glass of water and you will see a common example of refraction: light rays reflected from the spoon are bent by the water and glass so that part of the spoon appears displaced.

For refraction to take place, light must strike the new medium at an angle. If light rays are perpendicular to the surface when they enter and leave the medium (diagram left, (1), the rays will pass straight through. But if they enter or leave at an oblique angle (2), the rays will be bent to a predictable degree. The farther from the perpendicular they strike, the more they will be bent.

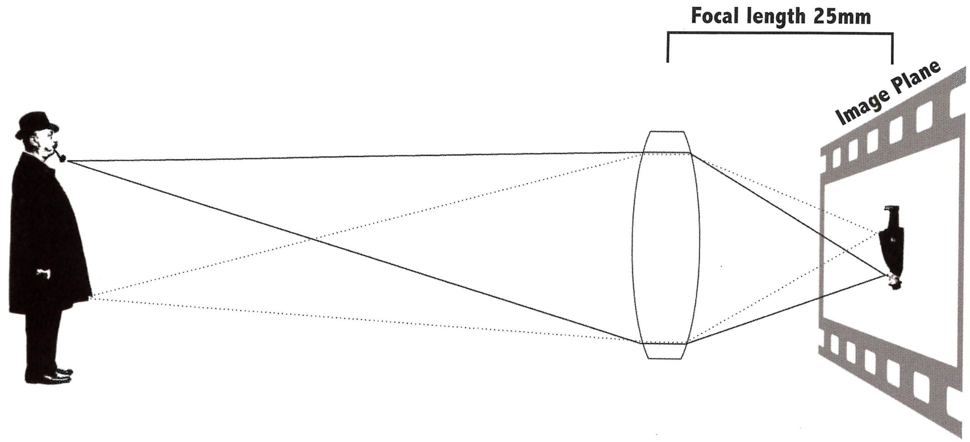
When light strikes a transparent medium with a curved surface, such as a lens, the rays will be bent at a number of angles depending on the angle at which each ray enters and leaves the lens surface. They will be spread apart by concave surfaces (3) and directed toward each other by convex surfaces (4). Rays coming from a single point on an object and passing through a convex lens (the simplest form of camera lens) will cross each other—and be focused—at the image point.

Lens Focal Length

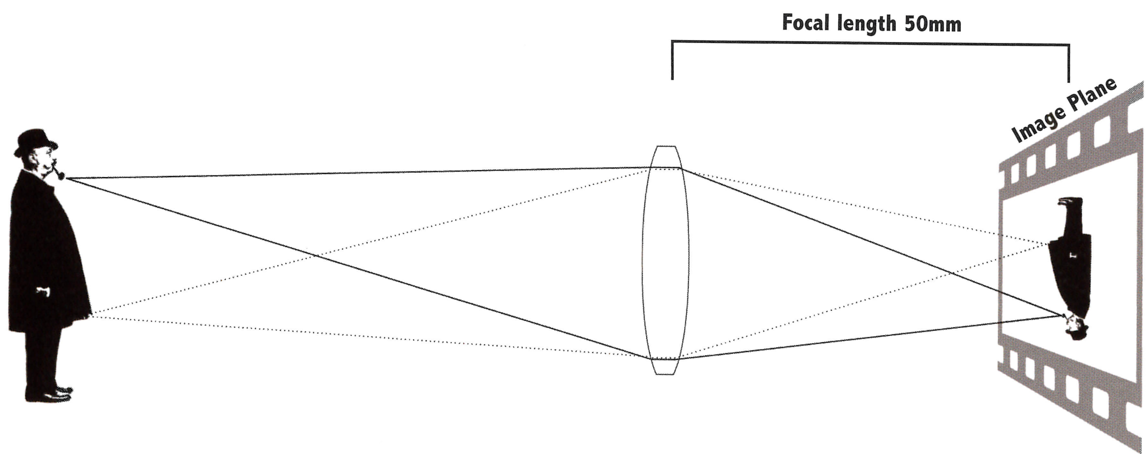
The most important way lenses differ is in their focal length. Because the camera you are most likely to choose can be used with interchangeable lenses, you can also choose which lens to buy or use. A lens is often described in terms of its focal length (a 50mm lens, a 12-inch lens) or its relative focal length (normal, long, or short). Technically, focal length is the distance between the lens's rear nodal point and the focal (image) plane when the lens is focused at infinity. Theoretically, infinity is a distance immeasurably far away, beyond the edge of the universe. In photographic terms, infinity is a distance from which light enters the lens in parallel rays. Lens designers call the image point where those rays come together the focal point.

Focal length controls magnification, the size of the image formed by the lens. The longer the lens, the greater the size of objects in the image (see diagrams, right).

Focal length also controls angle of view, the amount of the scene shown on a given size of sensor or film (see photographs opposite). A long-focal-length lens forms a larger image of an object than a short lens. As a result, on a given size of sensor or film, the long lens includes less of the scene in which the object appears. If you make a circle with your thumb and forefinger and hold it close to your eye, you will see most of the scene in front of you—the equivalent of a short lens. If you move your hand farther from your eye—the equivalent of a longer lens—the circle will be filled by a smaller part of the scene. You will have decreased the angle of view seen through your fingers. In the same way, the longer the focal length, the smaller the angle of view seen by the lens.



A lens of short focal length bends light sharply. *The rays of light focus close behind the lens and form a small image of the subject.*



A lens of longer focal length bends light rays less than a short lens does. *The longer the focal length, the less the rays are bent, the farther behind the lens the image is focused, and the more the image is magnified. The size of the image increases in proportion to the focal length. If the subject remains at the same distance from the lens, the image formed by a 50mm lens will be twice as big as that from a 25mm lens.*

17mm

28mm

50mm

85mm

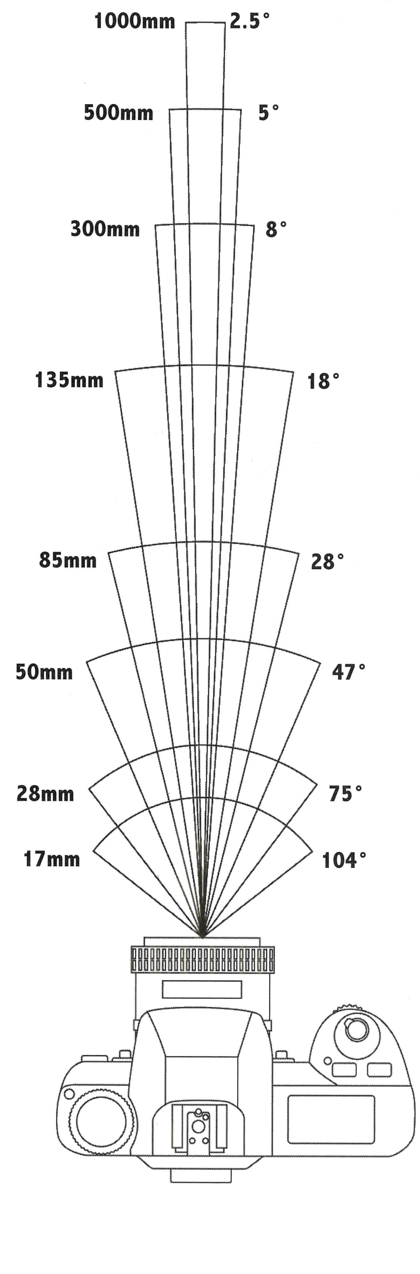
135mm

300mm

500mm

1000mm

The effect of increasing focal length while keeping the same lens-to-subject distance is an increase in magnification and a decrease in angle of view. *Since the photographer did not change position, the sizes of objects within the scene remained the same in relation to each other. The diagram below shows the angle of view of some of the lens focal lengths that can be used with a 35mm or "full-frame" digital camera. The lens focal length for other digital cameras is often stated as a "35mm equivalent."*



A normal-focal-length lens, also called a standard-focal-length lens, approximates the impression human vision gives. One of the greatest of modern photographers, Henri Cartier-Bresson, who described the camera as "an extension of my eye," often used a normal lens. His picture opposite includes as much of the scene as you would probably be paying attention to if you were there, the angle of view seems natural, and the relative size of near and far objects seems normal.

A lens that is a normal focal length for one camera can be a long focal length for another camera. Sensor or film size determines what will be a normal focal length. The larger the size, the longer the focal length of a normal lens for that format; it corresponds roughly to the measurement of a diagonal line across the sensor surface or film frame (see below).

A camera using 35mm film takes a 50mm lens as a normal focal length (50mm is about two inches). It is also normal for a 24 x 36mm (full-frame) digital sensor, the same size as a 35mm film frame. For a camera using 4 x 5-inch film, a 150mm lens is normal. The sensors in most digital cameras are smaller than a 35mm frame, so their normal lenses are shorter than 50mm. Usage varies somewhat: for example, lenses from about 40mm to 58mm can be referred to as normal focal lengths for a 35mm camera.

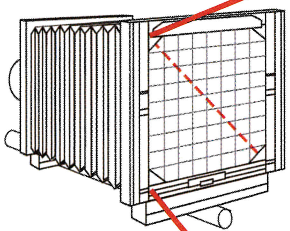
A lens of normal focal length has certain advantages over lenses of longer or shorter focal length. Most normal lenses are faster; that is, they open to a wider maximum aperture, so can be used with faster shutter speeds or in dimmer light than lenses that do not open as wide. They often are less expensive, more compact, and lighter in weight.

Choice of focal length is a matter of personal preference. Some photographers habitually use a shorter focal length because they want a wide angle of view most of the time; others prefer a longer focal length that narrows the angle of view to the central objects in a scene. If you aren't sure, start with a normal-focal-length lens.

***A lens of a given focal length** may be considered normal, short, or long, depending on the size of the film you are using or the sensor in your digital camera. If the focal length of a lens is about the same as the diagonal measurement of the light-sensitive surface (broken line), the lens is considered "normal." It collects light rays from an angle of view of about 50°.*

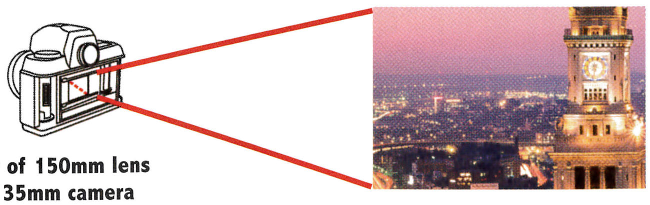
The photograph on the right was taken with a 4 x 5 view camera using a 150mm lens. The diagonal measurement of 4 x 5-inch film is about 150mm, so a 150mm lens is a normal focal length for that size film.

But 150mm is much longer than the diagonal of 35mm film. A 150mm lens is a long-focal-length lens for a 35mm camera and—because few digital sensors are as big as a 35mm frame—it is very long for most DSLRs (see bottom photos, right).

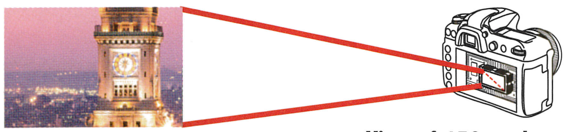


View of 150mm lens on a 4 x 5-inch view camera

PETER VANDERWARKER Custom House Tower and Central Artery, Boston, 1989



View of 150mm lens on a 35mm camera



View of 150mm lens on a DSLR camera with a 23.6 x 15.8mm sensor.

HENRI CARTIER-BRESSON Place de l'Europe, Paris, 1932

Using a normal-focal-length lens is a way for the photographer to let the subject speak. *Wide and long lenses make a stronger statement about the technical decisions a photographer must make, such as about perspective or depth of field.*

Although Cartier-Bresson resisted discussing technique, it is known that he frequently used a normal (50mm) lens on his 35mm Leica camera. In this case, the size relationships in the frame—clues that give us our sense of perspective—are not unusual. We are drawn to what the photographer wants us to notice, the poetry of an instant snatched from the fabric of time itself. Cartier-Bresson called this a "decisive moment."

Long Focal Length

A long-focal-length lens provides greater image magnification and a narrower angle of view than a normal lens. For a 35mm camera (or a DSLR camera that uses a full-frame sensor) a popular and useful long focal length is 105mm. For a camera using 120 film for 6 x 7cm negatives, a popular comparable focal length is 150mm; for a 4 x 5 view camera, it is about 300mm. Most DSLR and compact digital cameras have sensors smaller than a 35mm frame; there is a multiplier factor you can use to compare angles of view to lenses for 35mm use. A digital camera with a 22.5 x 15mm sensor has a multiplier of 1.6; any lens on that camera will have the same angle of view as a lens with a 1.6 times longer focal length on a 35mm film camera. For example, a 65mm lens used with a 22.5 x 15mm sensor will be comparable to a 105mm lens used on a 35mm film camera.

Long lenses are excellent when you cannot or do not want to get close to the subject. In the photograph opposite, the photographer seems to be in the middle of the action even though he is not. Long lenses make it possible to photograph birds and animals from enough distance that they are not disturbed. Medium-long lenses are excellent for portraiture; most people become self-conscious when a camera is too close to them so their expressions are often artificial. A long lens used at a moderate distance also avoids the kind of distortion that occurs when shorter lenses used close to a subject exaggerate the size of whatever is nearest the camera—in a portrait, usually the nose (see below).

There are subtle qualities that can be exploited when you use a long lens. Because a long lens has less depth of field, objects in the foreground or background can be photographed out of focus so that the sharply focused subject stands out clearly. (See opposite page.) Also, a long lens can be used to achieve an unusual perspective in which objects seem to be closer together than they really are (see page 61).

Long lenses have some disadvantages, and the longer the lens the more noticeable the disadvantages become. Compared to lenses of normal focal length, they usually are heavier, bulkier, and more expensive, especially telephotos with wide apertures. Because they have relatively shallow depth of field, they must be focused accurately. They are difficult to use for hand-held shots because they magnify lens movements as well as subject size. The shutter speed for a medium-long lens, such as a 105mm lens on a 35mm camera, should be at least 1/125 second if the camera is hand held. For a 200mm lens, you will need at least 1/250 sec. Otherwise, camera movement may cause blurring. A tripod or other support is your best protection against blurry photos caused by camera movement.

Photographers commonly call any long lens a telephoto, or tele, although not all long lenses are actually of telephoto design. A true telephoto has an effective focal length that is greater than the actual distance from lens to film plane. This design makes the lens shorter and easier to handle. A tele-extender or teleconverter contains an optical element that increases the effective focal length of any lens. It attaches between the lens and the camera body and magnifies the image from the lens onto the film. With these devices, the effective length of the lens increases, but less light reaches the film. A converter that doubles the lens focal length, for example, loses two f-stops of light.

Long lenses often produce better portraits. *A moderately long lens such as an 85mm or 105mm lens (35mm equivalent) used at least 6 ft from the subject (near right) makes a better portrait than a shorter lens used close to the subject (far right). Compare the size and shape of nose and chin in the two pictures of the same subject. Photographing a person at too close a lens-to-subject distance makes features nearest the camera appear too large and gives an unnatural-looking dimension to the head.*

Long lens, moderate distance

Short lens, up close

LOU JONES Women Swimming, 1998

Athletes at sporting events, like these swimmers, can be at a considerable distance. *Photographers often rely on long lenses—like the 600mm telephoto used here—to come in tight on the action. Jones set his lens to the next-to-widest aperture so he could use a very high shutter speed. The shallow depth of field resulting from that wide aperture blurs out the background and calls attention to the sharply-focused swimmer in the foreground.*

Short Focal Length

A short-focal-length lens increases the angle of view and shows more of a scene than a normal lens used from the same position. A short lens (commonly called a wide-angle lens) is useful when you are physically prevented (as by the walls of a room) from moving back as much as would be necessary with a normal lens.

For a full-frame digital or 35mm camera, a commonly used short focal length is 28mm. A comparable lens for a 6 x 7cm film camera is 55mm. For a 4 x 5 view camera, it is 90mm.

Wide-angle lenses have considerable depth of field. A 24mm lens focused on an object 7 feet away and stopped down to f/8 will show everything from 4 feet to infinity in sharp focus. Photographers who work in fast-moving situations often use a moderately wide lens, such as a 35mm lens on a full-frame digital or 35mm film camera, as their normal lens. They don't have to pause to refocus for every shot because with this type of lens so much of a scene is sharp. At the same time it does not display too much distortion.

Pictures taken with a wide-angle lens can show both real and apparent distortions. Genuine aberrations of the lens itself such as curvilinear distortion are inherent in extremely curved or wide elements made of thick pieces of glass, which are often used in wide-angle lenses. While most aberrations can be corrected in a lens of a moderate angle of view and speed, the wider or faster the lens, the more difficult and/or expensive that correction becomes. Some curvilinear distortion (straight lines near the edges of the frame becoming curved) can be corrected with software, but the results are generally better if no distortion is introduced by the lens.

SLR cameras need a special kind of wide lens called a retrofocus, to leave room behind the lens for the reflex mirror to move. It is more difficult to correct aberrations in this kind of lens; wide-angle lenses for cameras without mirrors—rangefinders and view cameras—often perform better.

A wide-angle lens can also show an apparent distortion of perspective, but this is actually caused by the position of the photographer, not by the lens. An object that is close to a lens (or your eye) appears larger than an object of the same size that is farther away. Since a wide-angle lens is often used very close to an object, it is easy to exaggerate this size relationship (below and right). The cure is to learn to see what the camera sees and either minimize the distortion, or use it intentionally (page 61 right).

KARL BADEN
Amelia, 1995

A wide lens lets you work in close quarters, like this child's bedroom. *The unusual perspective, caused by a very short distance between lens and feet, creates a vision that is both amusing and a bit disorienting.*

DAVID MUENCH
Paria-Vermillion Cliffs Wilderness, Utah, 1996

With a 75mm lens on his 4 x 5 view camera (a wide-angle lens for that format), *David Muench positioned his camera relatively close to the tiny desert plants in the foreground. The result was to increase the apparent size of the petrified-sand rock face nearest the camera and to create an impression of great distance from foreground to background.*

Zoom Lenses

Zoom lenses are popular because they combine a range of focal lengths into one lens. Using a 24–105mm zoom, for example, is like having a 24mm, 28mm, 50mm, 85mm, and 105mm lens instantly available, plus any focal length in between. The lens elements inside a zoom can be moved in relation to one another; this changes the focal length and therefore the size of the image.

It is convenient to be able to frame an image merely by zooming to another focal length, rather than by changing your lens or position. Some photographers carry only two lenses: a 24–80mm zoom and a longer 80–200mm zoom. A zoom lens is useful for getting the image right the first time, since cropping a photograph after the exposure and then enlarging it degrades quality.

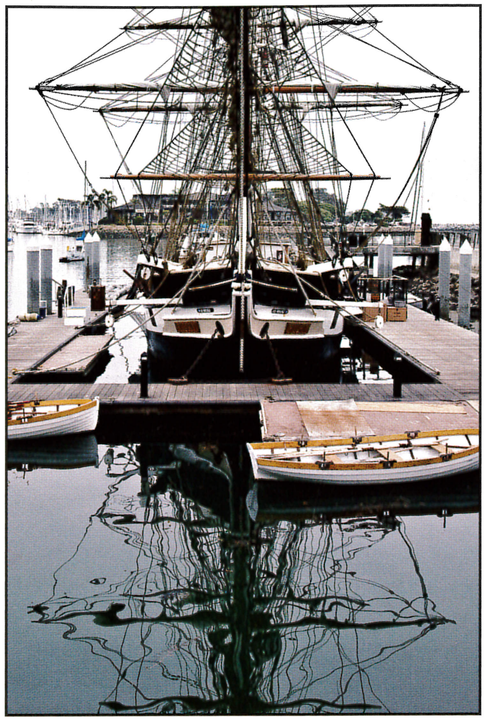
A zoom has some disadvantages. Compared to fixed-focal-length (sometimes called "prime") lenses, zooms are often more expensive, bulkier, heavier, and they can be optically inferior. But one zoom lens will replace two or more fixed-focal-length lenses.

The best prices and fewest drawbacks are found with a modest zooming range, from 35mm to 105mm, for example. The greater the range, the more evident the disadvantages become.

Some zoom lenses are best used where light is ample because they have a relatively small maximum aperture. Zooms that keep the same maximum aperture at all focal lengths are complex designs and therefore relatively expensive; most reduce the size of the maximum aperture as their focal length increases. For example, a 28–105mm zoom may open to f/4 when it is set to 28mm, but only to f/5.6 at its 105mm focal length.

TIP: With a zoom, be especially careful to make sure your shutter speed is fast enough to avoid blur caused by camera movement. With the lens at 28mm, you can safely hand hold a shutter speed of 1/30 second, but when you zoom out to 100mm, you will need at least 1/125 second unless you have the camera on a tripod.

Used outdoors during the day, most zoom lenses work fine. However, to shoot indoors with available light you may want a zoom that stays at a minimum of f/2.8 over its entire range.



A zoom lens gives you a choice of different focal lengths. Here, the photographer used the widest focal length for the picture on the left, then took the center picture, below, at a focal length near normal. The third photograph, bottom, used the longest focal length of the lens. All three photographs were made while standing in the same position.

MARTIN PARR
Taunton, England, 1998

A macro lens is useful for photographing very close to a subject *without having to use other accessories such as extension tubes. When you photograph close to a subject, depth of field is very shallow—only a narrow distance from near to far will be sharp.*

Parr finds he can say more about a subject by coming in close and showing a detail. He says, "How on earth a one-eyed candy can tell us about the modern condition, I will never know, but it seems to work. Such are the riddles of photography."

CHIP SIMONS
Too Much Sugar, 1995

A fisheye lens distorted space *to illustrate an article on hyperactive youth. The photograph shows a fisheye lens's typical characteristics: very deep depth of field, pronounced differences in size between objects very close to the camera and those in the background, and barrel distortion curving straight lines in the image. Simons chose the lens for its radical rendering and then enhanced the viewer's vertigo by putting gels over the studio strobe lights for saturated, surreal colors.*

A macro lens is useful for extremely close shots (left, top). The lens lets you focus at a very close range and is corrected for aberrations that occur at close focusing distances. The lens is occasionally called, somewhat inaccurately, a micro lens. Some zoom lenses have a macro feature. They focus closer than a non-macro zoom but not as close as a fixed-focal-length macro lens.

For the widest of wide-angle views, consider the fisheye lens. A fisheye has a very wide angle of view—some even more than 180°—and exaggerates to an extreme degree differences in size between objects that are near to the camera and those that are farther away. Inherent in its design is barrel distortion, an optical aberration that bends straight lines into curves at the edges of an image. Fisheye lenses also produce great depth of field. Objects within inches of the lens and those in the far distance will be sharp. It is not a lens for every—or even many—situations, but it can produce startling and effective views (bottom left).

Aberrations are deliberately introduced in a soft-focus lens, also called a portrait lens. The goal is to produce an image that will diffuse and soften details such as facial wrinkles.

A perspective-control lens brings some view-camera adjustments to other types of cameras. The lens shifts up, down, or sideways to prevent parallel lines, such as the sides of a building, from tilting toward each other if the camera is tilted.

A catadioptric, or mirror, lens is similar in design to a reflecting telescope. It incorporates curved mirrors as well as glass elements within the lens. The result is a lens with a very long focal length but modest size, one much smaller and lighter than a lens of equivalent focal length that uses only glass elements. A unique effect caused by the front mirror is that out-of-focus highlights take on a donut shape. A "cat" lens has a fixed aperture, usually rather small—f/8 or f/11 is typical.

Image stabilization can be built in to a lens. Micromotors adjust the position of special floating lens elements. Sometimes the same lens is also available in a less-expensive version without stabilization.

With manual focus, you select the part of the scene you want to be the sharpest. What is the most important part of the scene to be sharp? What do you want to emphasize? What do you expect viewers to look at first? If you are photographing a person, focus on the eye. If the person is at an angle and you are up close, both eyes may not be sharp in the photograph. Depending on the scene, it may be more important to have the near eye or the far eye sharp.

The nearer you are, the more important it is to focus critically. If you are 2 feet away, focus is critical, because depth of field will be shallow, with only a narrow area from near to far appearing sharp. If you focus on something 200 feet away, everything at that distance and beyond will be sharp.

Focus manually like you might tune a guitar. Go a little past the point you think is correct, then come back. If you adjust the focus until the image looks sharp, then adjust it a little more until the subject looks unsharp, then go back to sharp, you'll know exactly when your subject is at its sharpest.

Live view lets you focus using a digital camera's monitor. All compact digital cameras show the image projected onto the sensor, in real time, on a small monitor so you can view and frame your shots. Some DSLRs can be set for the same kind of display, although it usually requires locking the reflex mirror out of the way. Often, this live view, or live preview, can be greatly magnified to allow very precise manual focusing on the magnified section of the scene. This is particularly useful for tripod-mounted shooting such as still-lifes. Any SLR camera with the mirror locked up will vibrate less during an exposure and the image is likely to be slightly sharper, even when a tripod is used.

Follow focus is a technique that lets you keep a subject that is moving toward you well focused. If a runner is coming toward you, you have to adjust the focus at about the same rate that the runner's distance is changing.

One way to learn how to follow focus is to practice focusing on people moving toward and away from you. Then practice on faster things, such as the license plates of moving cars. You don't need this skill if still lifes are your only subject, but it is vital if you want to photograph football games, auto races, dancers, or anything else that moves fast.

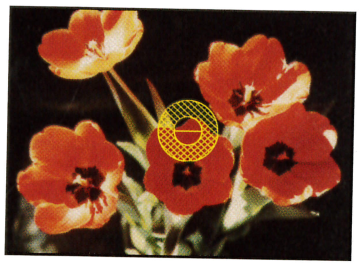
NOTE: Don't forget that shutter speed and aperture also play an important role in making objects appear sharp in the final picture. If your shutter speed isn't fast enough, a moving object will appear blurred in a photograph, no matter how sharply focused it was. This applies to autofocus as well. If your aperture isn't small enough, you may have focused on an important area, but an equally important nearby area may be out of focus. See, for example, the photographs on pages 26–27.

Sharp focus attracts the eye. *When you are photographing, it is natural to focus your eyes—and the camera—on the most important area of a scene.*

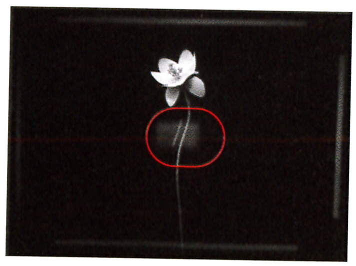
Sharp focus is a signal to pay attention to a particular part of an image, especially if other parts are not sharp.

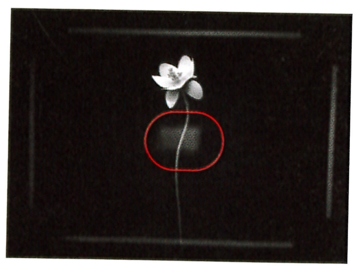
VIEWFINDER SCREENS FOR MANUAL FOCUS

Single-lens reflex and view cameras use ground-glass viewing screens. Light coming through the lens hits a pane of glass that is etched, or ground, to be translucent. This ground glass creates a surface on which a viewer, looking at it from the other side, can see an image and focus it. As you move your lens in and out to focus—usually by rotating it—the ground-glass screen shows clearly when a scene is sharp and in focus (left, above) and when it is not (left).



Reflex cameras may also include a microprism, a circle that appears dotted until it is focused, and sometimes a split-image focusing aid that appears offset until the image is focused.





Rangefinder cameras have split-image focusing, which operates by superimposing two images of the same subject on the focusing screen (left). One image passes through a viewfinder and one is reflected by a rotating prism connected to the lens. The two images appear exactly superimposed (left, below) only when the lens focuses sharply on the subject. The red circles on the images here call attention to the focusing aid. They would not appear in the viewfinder.

NOTE: If you have vision problems, you might find manual focusing difficult at times. Some cameras come with a viewfinder adjustment that allows you to dial in a correction (called a diopter) like prescription glasses. Other cameras offer an accessory called a diopter lens, available in several strengths, that screws directly onto the eyepiece to do the same. Your optometrist can tell you the appropriate correction to buy.

ELLIOTT ERWITT New York, 1946

With everything in the photo soft except the dog and feet, *which are in the same plane of focus, the photographer leaves no doubt about where he wants the viewer's eye to go. The human brain looks for sharpness in a scene or in a photograph. By controlling focus, photographers also can control where people look when an image is viewed.*

Automatic focus (AF) does the focusing for you. In the simplest designs, you press the shutter-release button and the lens brings the image into focus. The camera adjusts the lens to focus sharply on whatever object is at the center of the viewfinder or within the focusing brackets. This type of autofocus works well in situations where the main subject is—and stays—in the middle of the picture. The camera may beep or display a confirmation light when it has focused, but the presence of a light does not assure that the picture will be sharp overall.

If your subject is not in the center, you can use autofocus lock to make it sharp. Frame the subject within the focusing brackets or simply point the camera straight at it. To temporarily lock in the focus, press the shutter release halfway down. Keeping the shutter button partially pressed, reframe the scene, then press the shutter release all the way down for an exposure (see photos, right).

Wide-area focus systems provide more options. Some viewfinders display several focusing brackets. By rotating a dial or thumbwheel on the camera back, you select a bracket that covers the subject you want to be sharp. When you press the shutter, the camera focuses on the selected area—allowing you to maintain your framing without having to center, lock, and reframe each picture. This allows you to shoot fast-moving subjects that are not in the center of the frame (see photo, opposite page, below right).

Some wide-area autofocus systems use light reflected off your eye to identify your subject by the direction you are looking, and therefore what area of the picture to bring into sharp focus. Other systems automatically select the nearest subject in the picture; some can be set to identify a face and focus there.

Once you lock onto a subject, some cameras predict where the subject is likely to be next, keeping the subject in focus even if it moves across the frame. These tracking systems can lock onto a subject, adjusting the focus as the subject moves closer to, or farther from, the camera. These systems work especially well if the subject, like a race car, is traveling at a constant speed toward or away from the camera.

Some cameras have two autofocus systems. Active autofocus sends out a beam of infrared waves. The camera uses the part of the beam that bounces back to measure the distance to the subject. Passive autofocus looks instead at the image inside the camera, using the principle that contrast on the focal plane is greatest when the subject is sharpest.

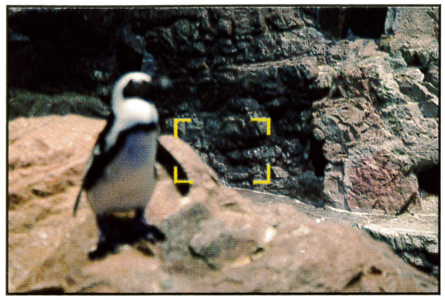
Both are used because neither one works in every situation. The infrared beam in active autofocus, for example, will bounce back from the glass in a window instead of from a subject on the other side of the glass. Passive autofocus may miss the focus if a subject has very low contrast, is in very dim light, or consists of a repetitive pattern like window blinds or plaid. Cameras that employ both systems are more likely to find maximum sharpness under most conditions.

An autofocus system can be fooled. If you are photographing a soccer game focusing on the goalie, for example, and the referee moves in front of your camera, autofocus may track the referee and not the player. The camera does not know what you are trying to photograph, so unwanted subjects can cause the lens to focus incorrectly.

Your camera may let you select among its several focus modes. Manual focus is frequently supplemented by two other options—single-shot autofocus, sometimes called focus priority, and continuous focus. With a modern camera, if you want the machine to make quick and accurate decisions for you, you must understand its methods.

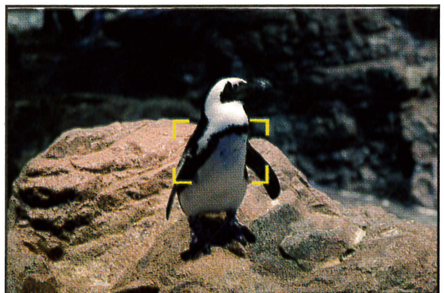
Read your camera's instructions so you know how its autofocus mechanism operates and when you would be better off focusing manually.

CENTER-WEIGHTED AUTOFOCUS LOCK



Shutter-release button

Subject off center, out of focus. Autofocus cameras often focus on the center of a scene. This can make an off-center main subject out of focus if it is at a different distance from whatever is at the center. Above, brackets at the center indicate the focused area.



Halfway down, autofocus activated

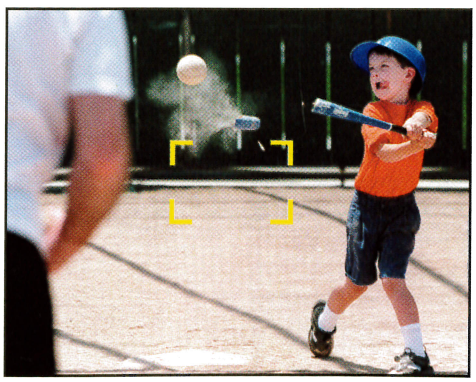
Focus on the main subject. In autofocus mode, first focus by placing the autofocus brackets on the main subject; with many cameras, you press the shutter button part way. Keep partial pressure on the release to lock focus.

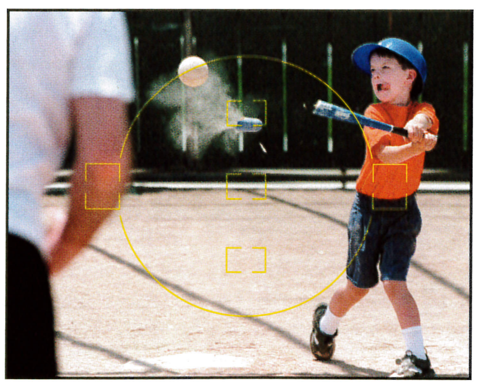
All the way down, shutter released

Hold focus and reframe. Next, reframe your picture while keeping partial pressure on the shutter release. Push the shutter button all the way down to make the exposure. You can get the same results—a sharply focused main subject—simply by focusing the camera manually if your camera allows that.

JAMES GLOVER II Batter Up—Bat Out, 1999

Center-weighted autofocus can be fooled in a situation like this one, *where it might have focused on the fence in the background instead of the batter. You can use autofocus lock (see opposite page) to lock focus on the batter and then reframe the picture.*





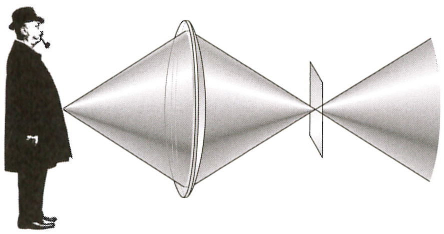
Wide-area autofocus allows you to stay framed on the situation *while using a dial or other camera control to select the part of the image you want to be in focus, in this case, the batter. You could have selected the left-hand segment of the focusing brackets to focus on the person in the left-hand part of the frame. Some systems offer even more precise control.*

Focus and Depth of Field

What exactly is sharpness, and how much can it be controlled? In theory, a lens can only focus on a flat plane at one single distance at a time (the plane of focus) and objects at all other distances will be less sharp. But, in most cases, 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.

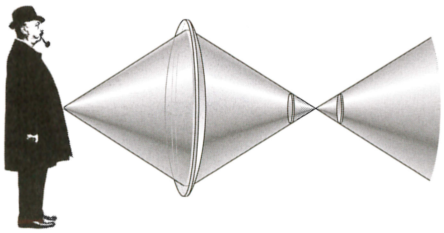
Depth of field is the part of a scene that appears acceptably sharp in a photograph. Depth of field can be shallow, with only a narrow band across the scene appearing to be sharp (photo, opposite), or it can be deep, with everything sharp from near to far (photo, right). To a large extent, you can control how much of it will be sharp. There are no definite endings to the depth of field; objects gradually change from sharp to soft the farther they are from the focused distance.

The circle of confusion affects the depth of field. *Light from a single point on the subject reaches the lens in the shape of a cone. Behind the lens, that same light converges, again in the shape of a cone, to a corresponding image point. If your film or sensor is located at the tip of that cone of light, that image point will be exactly in focus (see diagram, below).*

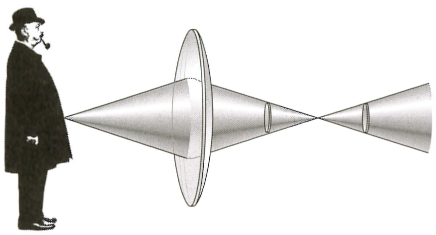


If the recording surface is not at the tip of the cone and instead slices through the cone in front of or behind the focus point, it wll record a small circle instead of a point (diagram, below).

A circle can be just small enough that you can't see that it's a circle instead of a point. This size is called a circle of confusion. Any points in the recorded image that make a circle this size or smaller will appear to be in focus. Any points within this range are inside the depth of field.



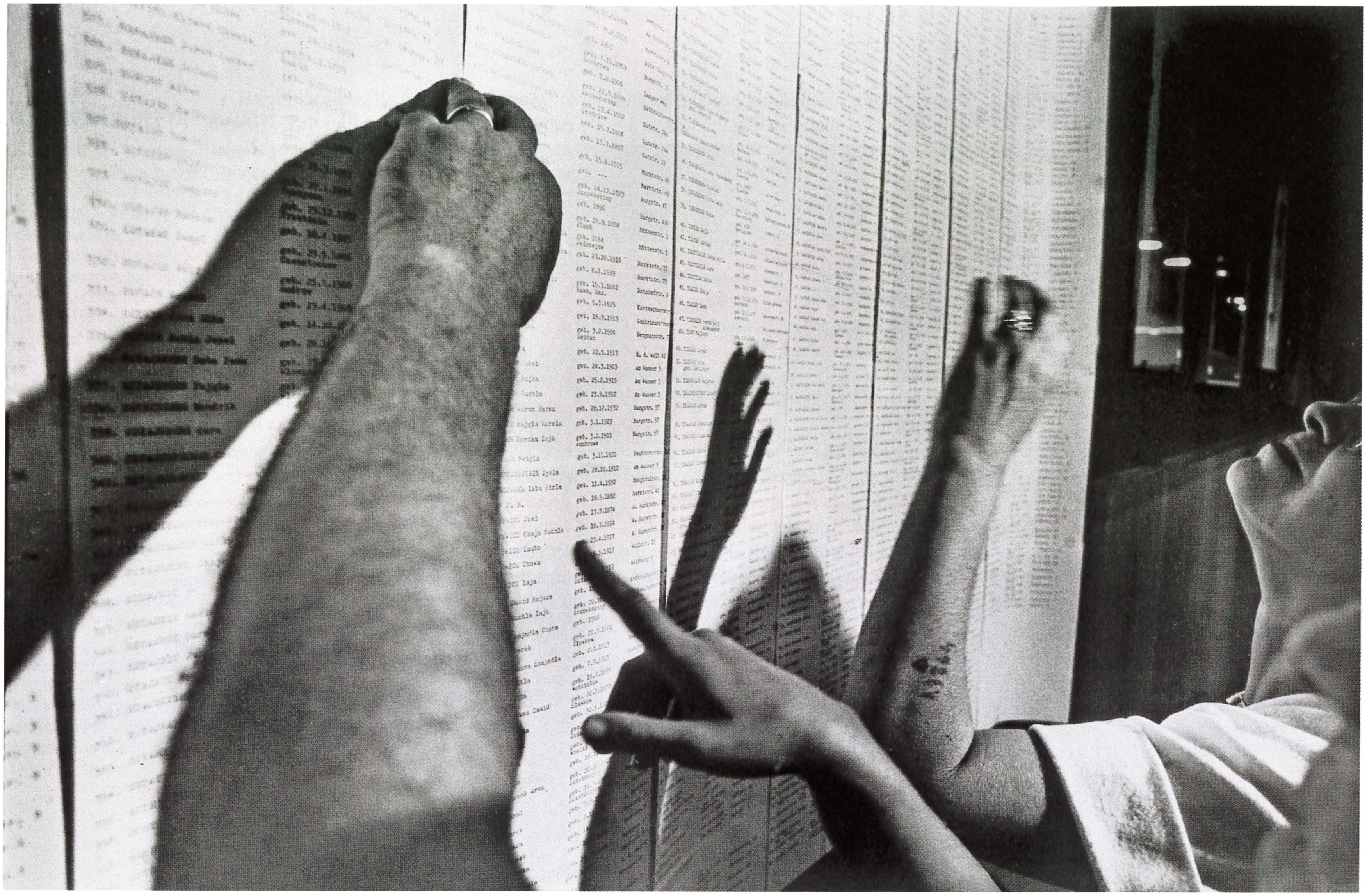
Reducing the size of the lens aperture makes the base of each cone of light smaller and its angle narrower (diagram, below). The same size circle of confusion can be recorded farther from the focus point. So, even though a smaller aperture doesn't change the actual location of the plane of focus, it widens the range of points that appear to be in focus, thus increasing the depth of field.



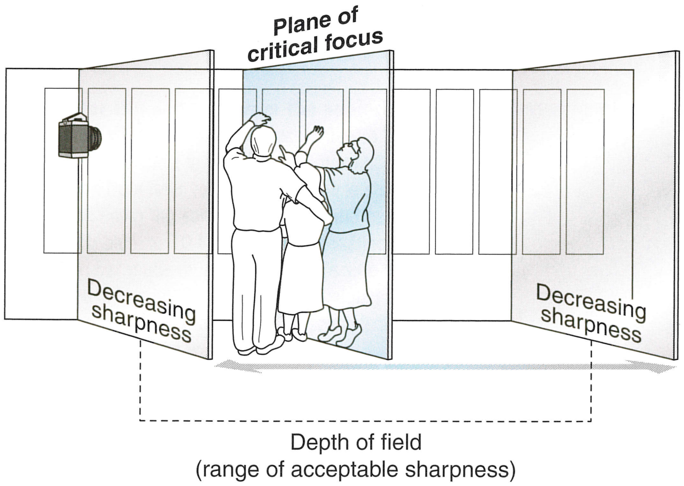
In general, the more a print is enlarged, the less sharp it seems because the enlargement increases the size of each image point, making more of them larger than the circle of confusion and no longer appearing to be sharp points. But sharpness is also affected by viewing distance, something we unconsiously adjust. A mural-size print viewed at a comfortable distance of 15 feet may appear sharp; the same print viewed up close may not.

MARTINE FRANCK Hauts de Seine, Meudon, France, 1991

***Depth of field**, the area in a scene in which objects appear sharp, can be deep or shallow. In the photograph above, everything is sharp from the nearest tree to beyond the figure in the background. The smaller the aperture, the greater the depth of field.*



MICHA BAR-AM Yad Vashem Holocaust Memorial, Jerusalem, 1981



A lens focuses on the plane of critical focus, *also called the image plane; in this case, it is a column of names at the memorial in Jerusalem that commemorates the six million Jews killed in World War II. Imagine the distance on which your lens is focused as a pane of glass—parallel to the camera's light-sensitive surface—stretched across the scene in front of you. Everything at this distance (all points in the plane of critical focus) will be sharp in the photograph. That's why the face on the right is in focus too; it is the same distance from the camera as the text on the left that is in focus. In front of and in back of the plane lies the depth of field, the area that appears acceptably sharp.*

The farther that objects are from the plane of critical focus, either toward the camera or away from it, the less sharp they will be. When objects are far enough from the plane of critical focus, they lie outside the depth of field and will appear noticeably out of focus. At normal focusing distances, the depth of field extends about one-third in front of the plane of critical focus, two-thirds behind it. 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.

The search for missing relatives continues to this day. Hand and Name is the literal meaning of Yad Vashem; yad also means memorial. Journalist Bar-Am has been photographing Israel since its independence in 1948.

Evaluating and controlling the depth of field is more important in some situations than in others. If you are relatively far from the subject, the depth of field (the distance between the nearest and farthest points in a scene that appear sharp in a photograph) will be greater than if you are up close. If you are using a short-focal-length lens, you will have more depth of field than with a long lens. If the important parts of the scene are more or less on the same plane left to right, they are all likely to appear sharp as long as you have focused on one of them.

But when you photograph a scene up close, with a long lens, or with important parts of the subject both near and far, you may want to increase the depth of field so that parts of the scene in front of and behind the point on which you focused will also be sharp.

Sometimes, though, you will want to blur a distracting background that draws attention from the main subject. You can accomplish this by decreasing the depth of field.

You can use the aperture to control depth of field. To increase the depth of field so that more of a scene in front of and behind your subject is sharp, setting the lens to a smaller aperture is almost always the first choice. Select f/16 or f/22, for example, instead of f/2.8 or f/4. This is the case even though you have to use a correspondingly slower shutter speed to maintain the same exposure. A slow shutter speed can be a problem if you are photographing moving objects or shooting in low light.

To decrease the depth of field and make less of the scene in front of and behind the subject sharp, use a wider aperture, like f/2.8 or f/4.

There are other ways to control depth of field. You can increase the depth of field by changing to a shorter focal length lens or stepping back from the subject, although both of those choices will change the picture in other ways as well (see opposite).

To decrease the depth of field and make less of the scene in front of and behind your subject sharp, you can use a longer lens or move closer to the subject. These alternatives will also change the composition of the picture (see opposite).

Most DSLRs and all compact digital cameras have sensors smaller than a 35mm frame. For them, a lens with a given angle of view (for example, its normal lens) will have a shorter focal length and give more depth of field at any given aperture than a lens with the same angle of view—in this case, a 50mm lens—on a 35mm camera. This is an advantage if you want everything in your picture to be in focus, but a limitation if you want to set a subject apart from its background (see pages 310 and 319).

Why does a lens of longer focal length produce less depth of field than a shorter lens used at the same f-stop? The answer relates to the diameter of the aperture opening. The relative aperture (the same f-stop setting for lenses of different focal lengths) is a larger opening on a longer lens than it is on a shorter lens (see below).

Different lenses go out of focus differently. The word *bokeh* (Japanese for blurring) refers to the way an out-of-focus subject looks in a photograph, which depends on both the shape of the aperture and the design of the lens.

LENS FOCAL LENGTHS, APERTURES, AND LIGHT

The two lenses below, both set at f/4, let in the same amount of light, even though the actual opening in the 100mm lens (left) is physically smaller than the opening in the longer 200mm lens (right).

The longer the focal length, the less light that reaches the sensor or film, therefore a long lens will form a dimmer image than a short lens unless more light is admitted by the aperture.

The sizes of the aperture openings are determined so that at a given f-stop number the same amount of light reaches the film, no matter what the focal length of the lens. The f-stop number, also called the relative aperture, equals the focal length of the lens divided by the aperture diameter.

$$\text{f-stop} = \frac{\text{lens focal length}}{\text{aperture diameter}}$$

If the focal length of the lens is 100mm, you need a lens opening of 25mm to produce an f/4 aperture.

$$\frac{\text{100mm lens}}{\text{25mm lens opening}} = \frac{100}{25} = f/4$$

If the focal length of the lens is 200mm, you need a lens opening of 50mm to produce an f/4 aperture.

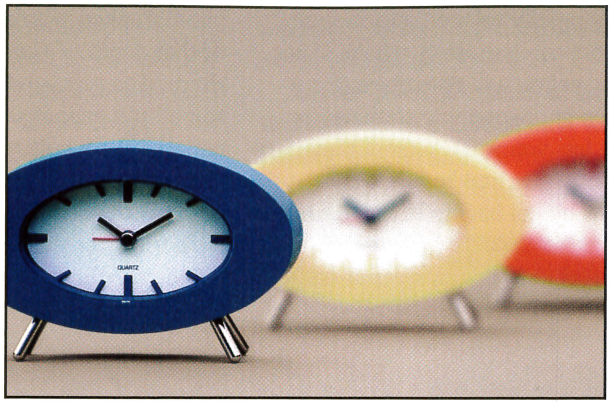
$$\frac{\text{200mm lens}}{\text{50mm lens opening}} = \frac{200}{50} = f/4$$

SHARPNESS & DEPTH OF FIELD

The smaller the aperture, the greater the depth of field. Here the photographer focused on the front clock. Near right: with a wide aperture, f/2, the depth of field is relatively shallow; other clocks that are farther away are out of focus.

Far right: using the same focal length and staying at the same distance, only the aperture was changed—to a much smaller one, f/16. Much more of the scene is now sharp. Changing the aperture is the best way to change the depth of field because it does not affect other aspects of the photograph.

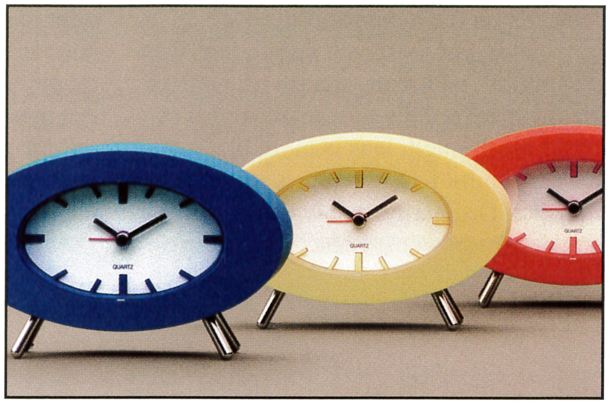
LESS DEPTH OF FIELD



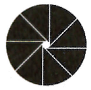
Wider aperture

f/2

MORE DEPTH OF FIELD



Smaller aperture



f/16

The shorter the focal length of the lens, the greater the depth of field. Near right: with a 135mm lens, only the first subject is sharp.

Far right: with a 50mm lens at the same distance, set to the same aperture, and focused on the same point as the previous shot, the person in the background is sharper. Notice that changing the focal length changes the angle of view (the amount of the scene shown) and changes the magnification of everything in the scene. The kind of picture has changed as well as the sharpness of it.

Longer focal length

135mm

Shorter focal length

50mm

The greater the distance from the subject, the greater the depth of field. Near right: with the lens focused on the subject in front about 3 ft away, only a narrow band from near to far in the scene is sharp.

Far right: using the same focal length and aperture, but stepping back to 10 ft from the front subject and re-focusing on her made much more of the scene sharp. Stepping back has an effect similar to changing to a shorter focal length lens: more of the scene is shown, and more of the scene is sharp.

Closer to subject

3 feet

Farther from subject

10 feet

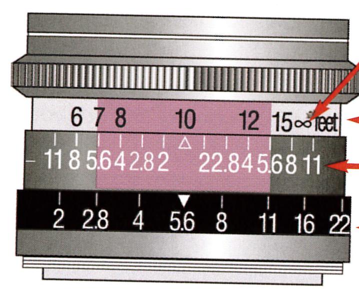
Two more techniques let you control depth of field, zone focusing (this page) and focusing on the hyperfocal distance (opposite). For these you need a lens with a depth-of-field scale or a set of depth-of-field tables (see the box below, right). A fixed-focal-length lens is more likely to have a depth-of-field scale; a zoom lens may not. Ordinarily, you will need a lens that can be focused manually, although a few autofocus cameras let you adjust the lens appropriately.

Zone focusing lets you set depth of field in advance of shooting. It is useful when you want to shoot rapidly without refocusing, and can predict approximately where, if not exactly when, action will take place (for example when photographing strangers on the street). It lets you work without thinking as much about focus, and be relatively inconspicuous by not having to spend time focusing with your camera to your eye.

To zone focus, use a lens's depth-of-field scale (or a table) to find the f-stop settings that will give you adequate depth of field (see lens diagram, below). Everything photographed within the near and far limits of that depth of field will be acceptably sharp. The precise distance at which something happens is not important because the whole area will be sharp. Generally, zone focus works best with normal- or short-focal-length lenses. A long-focal-length lens may have too little depth of field to make the technique practical.

HELEN LEVITT New York, c. 1942

Helen Levitt made many photographs of children *playing on New York City streets, zone focusing so she could work quickly. Ben Maddow wrote of her work, "She sees, trails, hunts, and seizes hold of those dances that ordinary people do on their own turf."*



Use a lens's depth-of-field scale so you can be ready to shoot without focusing before every shot. Suppose the nearest focus point you want sharp is 7 ft away, and the farthest is 13 ft away. Turn the focusing ring until those distances on the distance scale fall opposite a matched pair of f-stops on the depth-of-field scale. If you set your lens aperture to that f-stop, objects between the two distances will be in focus.

Here, the two distances fall opposite a pair of f/5.6 marks. With this lens set to f/5.6 or a smaller aperture, such as f/8 or f/11, everything between 7 ft and 13 ft will remain sharp. You will not need to refocus as long as the action stays between those distances.

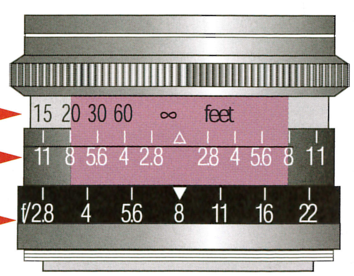
LOOK UP YOUR DEPTH OF FIELD

You can use depth-of-field tables *for zone focusing and to find the hyperfocal distance (opposite page). For each focal length, focus distance, and aperture, a table lists the near and far limits of depth of field. Use it to find the area that will be sharp in front of and behind the focus point. At one time available only as a lengthy book, a full set of depth-of-field tables can now be downloaded as an app (a software program) for your smart phone. You can have complete focus information handy wherever you are. Shown here is* Simple D-o-F *on an iPhone.*

Focusing on the hyperfocal distance will give you maximum depth of field for the lens you're using, with objects as sharp as possible from the foreground to the far distance. When a scene extends into the distance, you may find that you focus visually on the part of the scene that is quite far away. In photographic terms, you have probably focused on infinity, which is as far as the eye can see and as close as the lens usefully gets to the film. (Infinity is marked ∞ on the lens distance scale.)

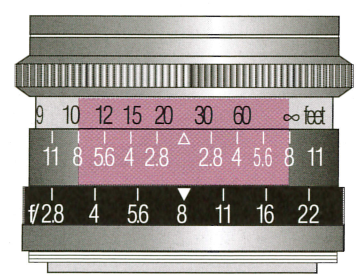
But for maximum depth of field in a scene that extends to a far distance, don't focus on infinity. Instead turn the focusing ring so that the infinity mark falls just within the depth of field for the f-stop you are using (see lenses, below). You are now focused on the hyperfocal distance, a distance that is closer to the lens than infinity. Everything far will still be sharp, but more of the foreground will also be in focus. The hyperfocal distance, different for every aperture, gives you the most possible depth of field every time.

JOHN PFAHL Vernal Falls, Yosemite National Park, California, 1992



For maximum depth of field in a scene that extends to the far distance *(infinity in photographic terms, ∞ on the lens distance scale), do not focus on the infinity symbol. With the lens to the left, if the aperture is f/8 and the lens is focused on infinity, everything from 20 ft to infinity will be sharp.*

Instead, as has been done with the lens to the right, set the distance scale so that the infinity mark lines up opposite your chosen f-stop on the depth-of-field scale (f/8 in this example). Now, with the lens still set to f/8, everything from 10 ft to infinity will be sharp.



Perspective

The camera image can seem surprisingly different from reality, so it is vital to see things the way the camera sees them. A long lens used far from a subject gives a so-called telephoto effect. In the photo opposite left, for example, the people and traffic seem impossibly compressed. A short lens used close to a subject produces what is known as wide-angle distortion. Opposite right, it enlarges part of the human form to unnatural proportions. These photographs seem to show distortions in perspective.

Perspective is the way the brain judges depth in a two-dimensional representation. Depth is perceived mostly by comparing the sizes of objects, so it seems to increase if foreground objects appear larger than background ones.

Perspective is affected by the lens-to-subject distance, not by lens focal length. Moving your camera closer to a subject will make objects in the foreground larger relative to those in the background.

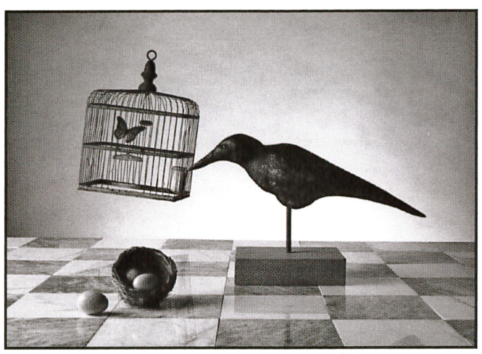
Below, the pictures in the top row were taken from the same distance with lenses of different focal lengths. The shortest lens produces the widest view; the longest lens gives the narrowest view, but is simply an enlargement of the scene. The relative sizes of the eggs in the foreground and the bird remain constant because all three pictures were taken from the same distance.

The pictures in the bottom row were taken with the same lens from different distances. The closer the lens came, the bigger the foreground objects (the eggs and nest) appear relative to the background one (the cage).

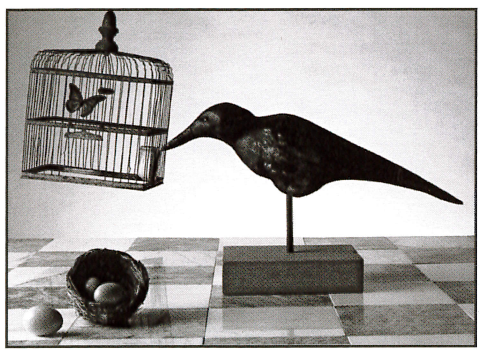
In only one sense does the focal length of a lens affect the perspective. A short lens can focus closer to an object than a long lens, and it doesn't eliminate most of the scene from view when you move in close. Consequently, a short lens can produce wide-angle distortion because it is easy to use it up close. A long lens can produce a telephoto effect because you are more likely to shoot from relatively far away. But the lens isn't creating the effect; the distance from the subject is doing so.

FOCAL LENGTH CHANGES, CAMERA POSITION STAYS THE SAME

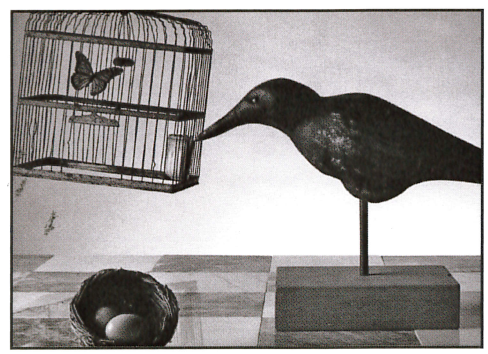
Short-focal-length lens, far from subject

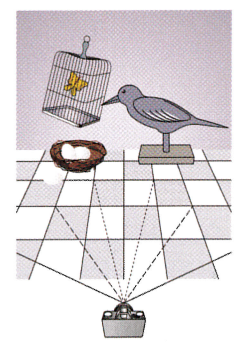


Medium-focal-length lens, far from subject



Long-focal-length lens, far from subject

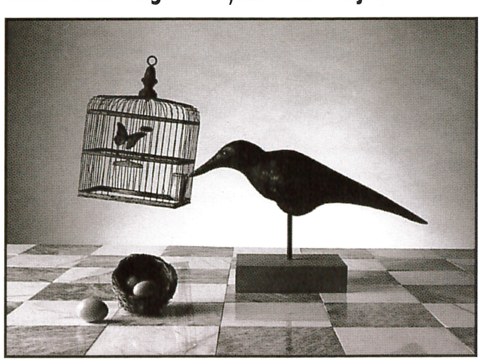




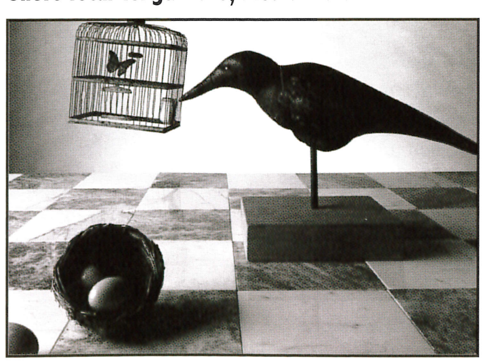
Lenses of different focal lengths change the size of all the objects, *not the size of one compared to another. Each photo above was shot from the same position but with a longer-focal-length lens each time. Eggs, bird, and cage all increased in size the same amount.*

FOCAL LENGTH STAYS THE SAME, CAMERA POSITION CHANGES

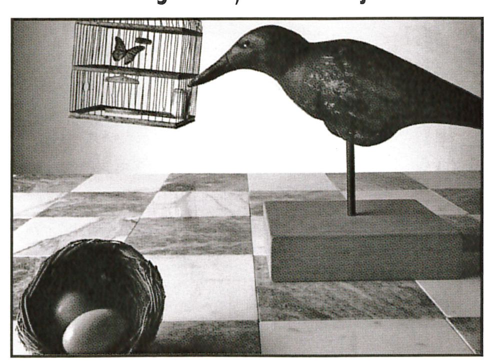
Short-focal-length lens, far from subject

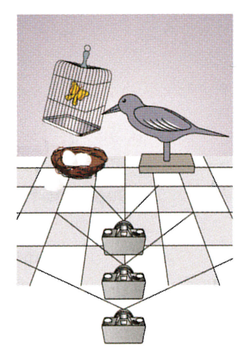


Short-focal-length lens, medium distance



Short-focal-length lens, close to subject





Changes in a lens's distance from a scene change the relative size of near and far objects. *As the lens came closer, foreground objects enlarged more than background ones to give three different perspectives. The nest is smaller than the cage in the first picture, bigger than the cage in the last picture.*

ANDREAS FEININGER Midtown Fifth Avenue at Lunch Hour, New York, 1950

A long-focal-length lens used far from a subject *produces the so-called telephoto effect. Although caused by the distance and not by the lens, it seems to compress the objects in a scene into a crowded mass. Andreas Feininger made many photographs of New York that conveyed its beehive crowding and intense activity. The super-long lens he used for these pictures was so long that he had to add a two-legged extension to his tripod to support the lens.*

Exaggerated perspective, the impression of compressed or expanded space in a photograph, is one way to add impact to an image or to communicate an idea visually.

ART KANE Joe Louis, 1961

A short-focal-length lens used up close *increases the apparent size of the part of the subject that is closest to the camera, producing what is sometimes called wide-angle distortion. Like the compressed appearance of the photograph at left, this is caused by the distance from the lens to the subject, not by the lens itself.*

The fists that brought the world heavyweight championship to Joe Louis are emphasized in this brooding portrait taken after the fighter had lost his title and fallen on hard times.

Start with a normal lens or a zoom lens with a moderate-focal-length range if you are getting a camera with interchangeable lenses. Don't buy more lenses until you feel a strong need to take the different kinds of pictures that other focal lengths can provide.

Get your lenses one at a time and think ahead to the assortment you may someday need. Begin by buying lenses in increments of more-or-less two times the focal length; for example, a good combination for a 35mm camera is a 50mm normal lens for general use, a 28mm wide-angle lens for close-in work, and a 105mm long lens for portraits and for magnifying more distant subjects. Be wary of ultra-wide-angle (24mm or below) and extra-long (above 200mm) lenses. They may be a lot more expensive than the others and are so specialized that their usefulness is limited.

Also, when buying a zoom lens, beware of the ones that reduce the aperture as you increase their focal length. Many are relatively cheap but don't let in enough light to shoot indoors without flash or without a tripod when they are extended to their longer focal lengths.

Don't spend money on extra-fast lenses unless you have unusual requirements. Buying a lens with a couple extra f-stops—or one with image stabilization—may cost you an extra couple of hundred dollars. With today's high-speed films and sensors that reach higher ISOs in digital cameras, a lens that can open to f/2.8 is adequate in all but the dimmest light. With this lens, you can take pictures indoors without flash.

NOTE: Lenses made by reputable manufacturers can be assumed to be reasonably good. And yet two lenses of the same focal length, perhaps even made by the same company, may vary widely in price. This price difference usually reflects a difference in the speed of the lens. The faster and more expensive lens will have a wider maximum aperture and admit more light. It can be used over a wider range of lighting conditions than the slower lens, but otherwise may perform no better. It may, in fact, perform less well at its widest aperture because of increased optical aberrations.

Consider a secondhand lens. Many reputable dealers take used lenses in trade, and they may be bargains. But look for signs of hard use, such as surface wear, a dented barrel, scratched lens surface, or a slight rattling that may indicate loose parts, and be sure to check the diaphragm to see that it opens smoothly to each f-stop over the entire range of settings.

Test your lens. The only sure way is to take pictures with it on your own camera at various f-stops, so insist on a trial period or a return guarantee. If you plan to buy several lenses eventually, a good investment is a standardized test chart that can give an accurate reading of a lens's sharpness.

A lens shade is a very desirable accessory to attach to the front of the lens to prevent flare. Buy one that is matched to the focal length of the lens; too wide a shade is inefficient, too narrow a shade will vignette or cut into the image area. This is more likely to be a problem with wide-angle lenses.

Maximum aperture. The lens's widest opening or speed. Appears here as the ratio 1:1.8. The maximum aperture is f/1.8, the last part of the ratio.

Manufacturer

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.

Engraved around the front of the lens (above) are its focal length, maximum aperture, and other information. Some lenses also indicate the filter size. A 50mm lens, for example, may require a 49mm filter, expressed on the lens rim as Ø49mm.

On the lens barrel (below) are controls such as a ring that focuses the lens and a switch to turn off autofocus. Cameras and lenses vary in design, so check the features of yours. For example, some cameras have push-button controls on the camera body instead of an aperture control ring on the lens.

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

Distance marker indicates the distance at which the lens is focused.

Depth-of-field scale shows how much of the scene will be sharp at a given aperture. Not all modern lenses have this feature.

Aperture-control ring rotates to let you select the f-stop (size of the lens opening).

TYPICAL FOCAL LENGTHS FOR CAMERAS USING VARIOUS FRAME SIZES

Focal lengths are usually stated in millimeters, or sometimes, with very old lenses, in inches or centimeters. There are approximately 25mm to an inch.

Frame size	23.7 x 15.6mm digital sensor (1.5 lens multiplier factor) DSLR	35mm	6 x 4.5cm (2 1/4 x 1 5/8 in) or 6 x 6cm (2 1/4 x 2 1/4 in) 120 Film	6 x 7cm (2 1/4 x 2 3/4 in) or 6 x 9cm (2 1/4 x 3 1/4 in) 120 Film	4 x 5 in
Short focal length	24mm or shorter	35mm or shorter	55mm or shorter	65mm or shorter	90mm or shorter
Normal focal length	35mm	50mm	75mm, 80mm	80mm, 90mm	150mm (6 in)
Long focal length	55mm or longer	85mm or longer	120mm or longer	150mm or longer	210mm (8 1/2 in) or longer

PROTECTING AND CLEANING YOUR CAMERA AND LENS

Cleaning inside a film camera. If you are cleaning the lens or changing film, also check inside the camera for dust that can settle on the film and cause specks on the final image. Blow or gently dust along the film path, particularly along the winding mechanisms, tilting the camera so the dust falls out and isn't pushed farther into the camera. With a single-lens reflex, be careful not to damage the shutter curtain in the body of the camera or the film pressure plate on its back. The shutter curtain is particularly delicate; don't touch it at all unless absolutely necessary.

Cleaning a digital sensor—actually, cleaning the low-pass filter that covers the sensor—is risky and should be done very carefully. Follow your owner's manual to enter the camera's cleaning mode. Blow air gently from a bulb (above) to remove loose dust. Special cleaning products can be used to clean streaks and particles that have become attached to the surface, but you may want to leave that to trained repair personnel.

Cleaning the lens. First, blow or brush any visible dust off the lens surface (above). Holding the lens upside down helps the dust fall off the surface instead of just circulating on it. Be especially careful with granular dirt, like sand, which can scratch the lens surface badly. To clean grease or water spots from the lens, wad a clean piece of camera lens tissue or a clean microfiber cloth into a loose ball and moisten it with a drop or two of lens cleaner solution. Don't put drops of solution directly on the lens; they can seep along the edges of the lens to the inside. Wipe the lens gently with a circular motion (right). Finish with a gentle, circular wipe using a dry lens tissue. **NOTE:** Don't use any products designed for cleaning eyeglasses.

Protect from dust and dirt. The best way to keep equipment clean is not to get it dirty in the first place. Cases and bags protect cameras and lenses from bangs and scratches as well as keep them clean. Sand is a particular menace; clean your equipment well after using it on the beach. **NOTE:** A UV or skylight filter on the lens can help protect it. If you scratch a protective filter, it is much less expensive to replace than a lens. When you take a lens off a camera, protect both front and back lens surfaces either by placing the lens in a separate lens container or by capping both ends.

Protect from moisture. Modern cameras are packed with electronic components that can corrode and malfunction if exposed to excessive humidity or moisture, especially salt water. On a boat or at the beach, keep equipment inside a case when it is not in use. If you use it where salt spray will get on it, wrap it in a plastic bag so just the lens pokes out. Digital cameras are particularly sensitve to high humidity.

Protect from temperature extremes. Excessive heat is the worst enemy. It can cause parts to warp, lubricating oil inside the camera to flow into places it should not be, and memory cards and film to deteriorate. Avoid storage in places where heat builds up: in the sun, inside an auto trunk or glove compartment on a hot summer day, or near a radiator in winter.

Excessive cold is less likely to cause damage but can make batteries sluggish and lubricants stiff. If you photograph outdoors on a very cold day, keep your camera warm inside your coat until you are ready to use it, then return it afterward. Moisture can condense on a camera, just as it does on eyeglasses. Any metal or glass that has gotten cold outdoors will get damp when it comes indoors and meets warm, humid air. Keep a cold camera wrapped up and lenses capped long enough to reach room temperature.

Protect during storage. If you won't be using the camera for a while, release the shutter, make sure the power is off, and store in a clean, dry place. If humidity is high, ventilation should be good to prevent a buildup of moisture on electronic components. Wind and release the shutter once in a while; it can become balky if not used for long periods of time. For longer term storage, remove batteries to prevent possible damage from corrosion.

Check the battery strength regularly (see manufacturer's instructions). Most film cameras and all digital cameras need electric power to operate. Lithium ion (Li-Ion) and nickel metal hydride (NiMH) batteries are rechargable and last longer, but check the manufacturer's directions, because not all models accept them.

Use professional care for all but basic maintenance. Never lubricate any part of a camera yourself or disassemble anything for which the manufacturer's manual does not give instructions. Cameras are easier to take apart than they are to reassemble.

Cameras and lenses are rugged, considering what precision instruments they are. Commonsense care and a little simple maintenance will help keep them running smoothly and performing well.

A clean lens performs better than a dirty one. Dust, grease, and drops of moisture all scatter the light that passes through a lens and soften the sharpness and contrast of the image. **NOTE:** Although a lens should be kept clean, too frequent or too energetic cleaning can produce a maze of fine scratches or rub away part of the lens coating. Manufacturers coat lens surfaces with a very thin layer of a metallic fluoride that helps reduce reflections and subsequent flare. The coatings are extremely thin, as little as 0.0001mm, and relatively delicate. Treat them with care when cleaning the lens.

A clean lens is crucial with compact digital cameras. Depth of field is often so great that dust on the lens can appear as a spot.

Stopping down the lens aperture often improves the image by eliminating rays from the edges of the lens where certain aberrations increase. Even a well-designed lens will have some aberrations that were impossible to overcome in design. This is especially so if it is a zoom, extremely wide-angle, or telephoto lens, or if it has a very wide maximum aperture.

There is a limit to the improvement that comes with stopping down. As light rays pass across a sharp, opaque edge, like the edge of the diaphragm opening, the rays scatter slightly. As the lens is stopped down and the aperture becomes smaller, this scattering—called diffraction—increases, reducing sharpness and contrast over the entire image.

Most lenses are sharpest, because lens aberrations are reduced the most, at an aperture closed down one or two f-stops from the widest. Diffraction, at this point, is not a noticeable problem. But closing down the aperture past this point, even though depth of field increases, decreases sharpness (remember that lens sharpness is not the same as depth of field). In general, you should close down the aperture far enough for the depth of field you need, but no farther.

photographer at WORK

Documentary Photographer Mary Ellen Mark

Mary Ellen Mark has been called a documentary photographer, a social documentarist, a documentary portraitist, and even a psychodocumentist. She has photographed prostitutes and circus performers in India; mental patients in Oregon; runaway teenagers in Seattle; and a homeless family living in a car in North Hollywood, California. "I like feeling that I'm able to be a voice for those people who do not have a voice," she says, "the people that don't have the great opportunities."

Many documentary photographers try to get to know their subjects before taking pictures. Despite her uncannily intimate photographs, Mark does not. "I start shooting right away—always," she says. "If you don't, you're misrepresenting your role in the relationship. You are there to take pictures." In fact, most of Mark's subjects look steadily into the camera's lens. "I don't often like it when people smile for the camera. Sure, sometimes when they laugh it can be beautiful. Often, though, a smile is a defense—people are uncomfortable. If someone has a fake smile I would tell them not to smile."

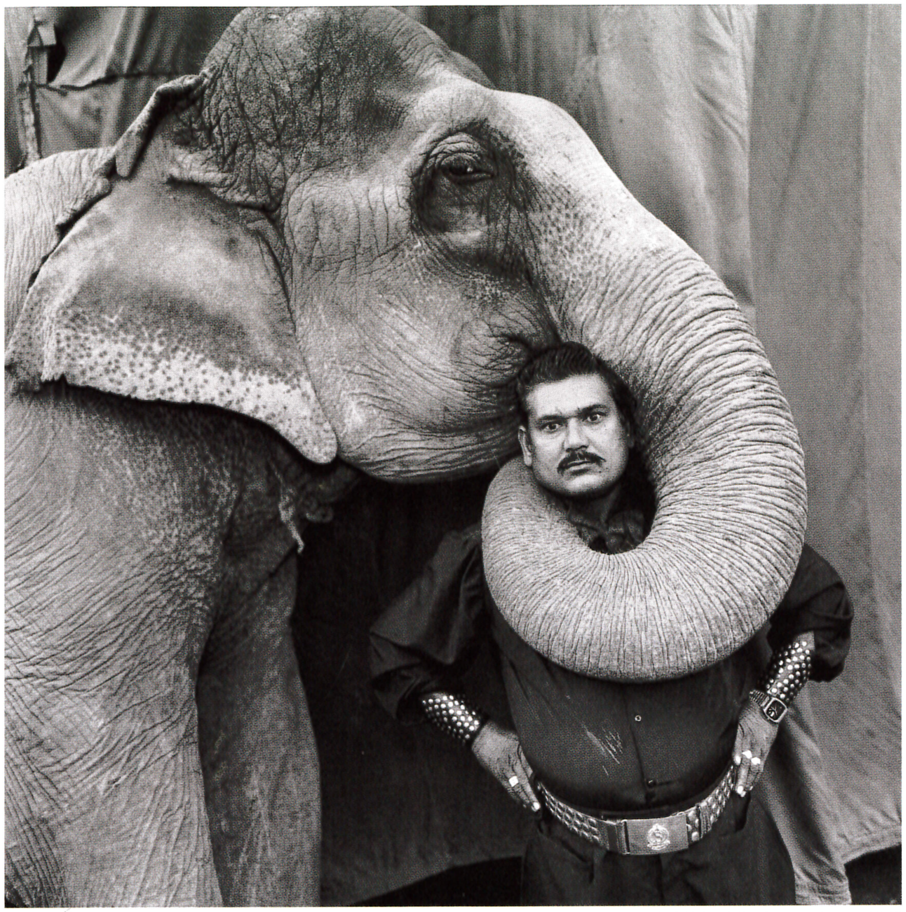
Mark approaches her subjects with a wide-angle lens and moves in close. They know she is there. She also likes the sense of place that a 28mm lens (on her 35mm film camera) provides. She often shoots for months on end, returning daily to finally overcome her subjects' initial hesitance at being photographed.

Mark's project on Indian prostitutes demonstrates her persistence. Bombay's Falkland Road is notorious for its brothels. In the book she produced about Falkland Road, Mark writes, "Every day I had to brace myself, as though I were about to jump into freezing water. But once I was there, pacing up and down the street, I was overwhelmed, caught up in the high energy and emotion of the quarter. And as the days passed and people saw my persistence, they began to get curious. Some of the women thought I was crazy, but a few were surprised by my interest in and acceptance of them. And slowly, very slowly, I began to make friends."

Although this project is in color, most of Mark's work is black and white. "The difficulty with color is to go beyond the fact that it's color," she observes. "To have it be not just a colorful picture but really be a picture about something."

Mark is obsessed with her subjects, not with her equipment. Still, she relies on a variety of tools. While photographing the Indian circus she carried four Nikon bodies and seven lenses, four Leicas, five Leitz lenses, four Hasselblads with six lenses, a Polaroid, several flash units, and a half-dozen assorted light meters.

She likes the detail of a large-format camera but cherishes the spontaneity of a hand-held one. "I want to take strong documentary photographs that are as good technically as any of the best technical photographs, and as creative as any of the best fine-art. I take images that I think other people will want to see. I don't take pictures to put in a box and hide them. I want as many people to see them as possible."



MARY ELLEN MARK Indian Circus, 1990

NANCY STROGOFF Mary Ellen Mark at Work

MARY ELLEN MARK Two Women, Bombay, India, 1978

Mary Ellen Mark seeks to show people "immersed in their environments"*—here, a sensitive portrait of two prostitutes in Bombay's Falkland Road brothel area. Above the women's heads are the wooden boxes in which each puts her daily earnings. "I look for a sense of irony," she says, "of humor and sadness at the same time," a combination also present in the photo opposite, top.*