The camera's design is a basic part of the photographer's visual language. Although a camera may shape the construction of an image, it is the private individual response to a situation that gives an image its power. It is up to each photographer to understand and apply a camera's capabilities, to learn its characteristics, and to know when to use different cameras to achieve the desired results.

WHAT IS A CAMERA?

This chapter describes the key camera components and covers the four essentials that make up every camera image: aperture, focal length, focus, and shutter speed. The digital single-lens reflex camera (DSLR) is the nucleus of discussion, but its fundamental principles can be applied to any camera, including point-and-shoot digital and cell phone cameras (which are selling at twice the rate of all digital cameras combined) and scanners. Cell phone cameras are becoming omnipresent, giving individuals the ability and power to record and transmit out into the world whatever is happening in their presence. During historic events, such as the hanging of Saddam Hussein in 2006, the images can have worldwide consequences.

A traditional camera, from a room-size camera obscura to the latest hand-held digital, is essentially a light-tight box. A hole (aperture) is made at one end to admit light, and light-sensitive material is placed inside the box opposite the hole. The camera's purpose is to enable the light to form an image on the light-sensitive material, in this case a light-sensitive sensor. This can be accomplished in a variety of ways, but most new digital cameras have the same basic components:

- A lens that focuses the rays of light to form a sharp image on the light-sensitive sensor.

3.1 Recognizing that more images are being made with cell phone cameras than any other means, Sony Ericcson commissioned Martin Parr to photograph while traveling with their equipment. The images from the resulting project, *Road Trip*, were posted to a website along with tips by Parr on how to make better cell phone photos. Additionally, the public was invited to upload their cell phone images to the site.

© Martin Parr. *Singapore,* from the series *Road Trip*, 2005. Digital file. Screen shot from www.sonyericcson.com/k750/. Courtesy of Sony Ericsson Mobile Communications.

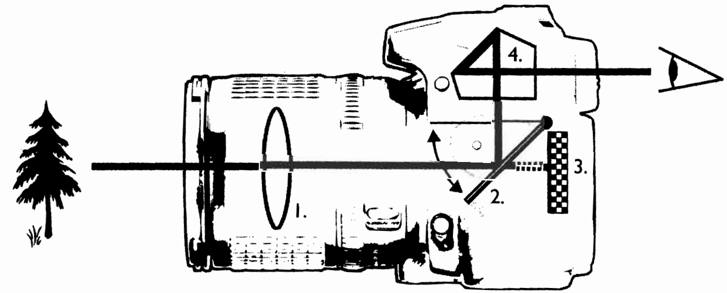
- An optical viewing system and/or monitor for image composition and review.
- An electronic shutter mechanism that prevents light from reaching the image sensor until the shutter is released. The shutter opens for a measured amount of time, allowing the light to strike the sensor. When the time has elapsed, the shutter closes, preventing any additional light from reaching the sensor.
- A light-sensitive sensor that electronically records the image created by the light onto a memory card. The inside of a camera must be completely dark so that rays of light reach the sensor only through the aperture.

- A control data-panel display that shows the camera's functions including aperture, shutter speed, battery life, flash, focus, sensitivity, white balance, and metering modes.
- A Mode dial that allows control over camera settings, including aperture, shutter speed, flash, and camera menus. The camera may also have programs designed for specific situations such as close-ups, landscapes, and portraits.
- A Sensitivity setting (ISO equivalency) that controls the light sensitivity of the sensor by electronically amplifying the signal.
- A memory card and memory card slot.
- An image advance mechanism to automatically go to the next free space on the memory card.
- A light metering system built into the body of the camera that measures the intensity of the light and then automatically sets the exposure. Cameras generally have numerous exposure modes, including a manual setting.
- A small built-in electronic flash, which can be controlled automatically or manually, depending on the camera.
- Battery to power all the camera functions.
- A tripod socket.

How a Camera Imaging System Works

Photography begins and ends with light. There are five principal steps in making a photographic image: (A) capturing light rays, (B) focusing the image, (C) exposure (also known as *image capture* or *capture*), which records the image on the sensor array and stores it on a memory card, (D) processing the digital image, and (E) making a print or displaying the image on a screen (see Figure 3.2).

Digital Single Lens Reflex (DSLR) Camera



3.2 How a DSLR camera works with light.

A typical imaging system requires integrating many elements into confined space.

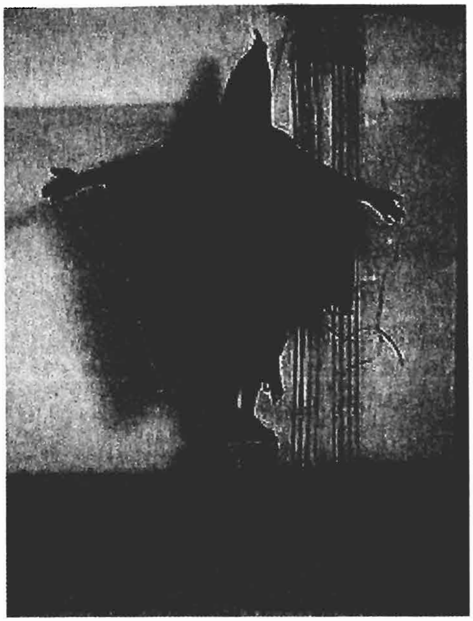
1. *Lens:* Light passing through the lens forms an image, which is inverted (laterally reversed).
2. *Mirror with reflex action:* The mirror stays in the down position for focusing and framing of a scene. When the shutter button is depressed, the mirror instantly retracks upward, allowing the digital image sensor to capture the image.
3. *Digital sensor array:* The image sensor converts light into digital information (pixels), which are measured in megapixels (1 million pixels equals 1 megapixel).
4. *Pentaprism:* A five-sided reflecting prism is used to internally reflect a beam of light by 90 degrees twice. The pentaprism, together with the mirror, creates an exact reflection of what is seen in the viewfinder. The pentaprism also corrects (turns around) the lateral orientation of the image.

DIGITAL CAMERAS

The first commercial digital cameras debuted in the 1980s. They were expensive and produced images that were not as good as those made by inexpensive film cameras. Today, advances in electronic technology have resulted in digital cameras that equal or surpass the quality of film cameras. They have also become affordable and now outsell film cameras. Their ease of use, ability to make acceptable images in a wide variety of situations, new features, and the elimination of certain film camera design elements, such as a prominent shutter speed dial, f-stop clicks, depth-of-field guide on the lens barrel, and in some cases even the traditional optical viewfinder, permit a streamlined way of working that was not previously possible. Most digital cameras share common components, which are discussed below. However, it is essential for you to read your specific camera manual to learn the specific camera architecture and how the manufacturer has set up the controls and features. There is a danger in letting a camera make all its preprogrammed decisions for you: that is, the resulting images tend to share a certain "cookie-cutter" sameness due to the loss of quirky, individual decision making.

Digital Observations

What is the best way to make images your own? Once you become familiar with your camera's basic functions, you can start customizing its functions to reflect your personal aesthetics and shooting requirements. Digital technology offers new tools for observing and thinking. It can be an enabling technology, permitting more people to create and then circulate images via the Internet, which is doubling in size every year. In the past, professional photojournalists and their



3.3 The Abu Ghraib prison (20 miles/32 km west of Baghdad) was known as a place where Saddam Hussein's government tortured and executed dissidents. It achieved additional infamy when cell phone camera photographs made by guards portraying abuse of Iraqi detainees by the U.S. military circulated on the Internet. Here a hooded prisoner had wires attached to his hands and genitalia and was reportedly told that he would be electrocuted if he fell off the box he was standing on. When this image became public, U.S. officials stated that the wires were not actually electrified. This was later denied by the person in the photograph, who stated in an interview that the wires were electrified and had been used to give shocks.

© Unknown photographer. Prisoner Being Tortured, Abu Ghraib Prison, 2004. Digital file. Screen capture from the internet.

networks of commercial distribution provided the photographs the public would see — for example, of any given war. Now, digital imaging allows soldiers themselves to document and tell their uncensored stories of war. The grainy, amateur snapshots made of prisoners being abused by the guards in Abu Ghraib prison in Iraq, distributed by email and eventually on the Internet, were deemed so powerful that the U.S. government tried to suppress them (see Figure 3.3). Changes in who is making and circulating pictures is evolving with the widespread use of web logs (blogs) and alternative news and open reference websites. The character of imagemaking and its distribution is challenging old photographic approaches and creating new, fresh, and diverse ways of seeing, understanding, and knowing our world.

Image Sensors: CCD and CMOS

Digital cameras generate images by focusing a scene through a lens, like a traditional film camera. When a photographer makes an exposure with a digital camera, the focused image is captured with a sensor, often a charge-coupled device (CCD sensor), and a postage-stamp-size electronic wafer that converts light into electrical current. It is positioned where the film would normally be in a conventional camera. Complementary metal-oxide semiconductor (CMOS sensor) technology is another type of digital camera sensor that performs the same function. CCD and CMOS are the most common types of light-sensitive chips used for image gathering. The CCD is composed of many light-sensitive photocells. When light strikes these cells, the properties of the light, such as brightness and color, are converted into electrical signals and broken down into pixels (picture elements). These tiny squares of color are represented in binary form using combinations of the digits one (1) and zero (0) and are known as *bits*. Bits are the smallest units into which the camera is able to digitally divide the visual information. The bits are arranged in a grid pattern, like squares on a sheet of graph paper, and are recorded onto a memory card in the camera. CCD sensors are devoted to light capture only and rely on the onboard camera computer to complete the imaging process into bits. CMOS sensors include light sensors with digitization circuits so that the chip directly outputs digital bits to the camera computer, requiring less camera circuitry.

An image sensor has millions of tiny light-sensitive cells called *silicon photodiodes* (SPDs), also known as *photosites*, arranged in a grid. Each SPD accumulates an electrical charge according to the amount of light that strikes it. When an exposure is made, the lens focuses light on the sensor, and each cell, which has either a red, green, or blue filter (known as *RGB*) in front of it, measures the intensity of the light that falls on it. Every position on the grid is recorded as a solid-toned picture element, or pixel, with its color, brightness, and position given as a binary series of ones (1) and zeros (0). Each pixel corresponds to an SPD on the sensor (see following section on pixels).

Color Filter Array: Bayer Filter Mosaic

Color accuracy and rendering are determined by the color filter array (CFA) pattern. A CFA is a grid pattern of tiny color filters placed over the sensor so that individual RGB filters match up with individual SPDs. Some cameras use three different filters that rotate in front of a single sensor. Others have a fixed color filter array over each individual single sensor.

The most common CFA pattern is the Bayer, used in most single-chip digital cameras. A Bayer filter mosaic is a CFA for arranging RGB color filters on a square grid of photosensors. Each sensor pixel is covered by RGB colored filters. The combinations of these three RGB colors result in an accurate reproduction of the images' actual colors. Each filter allows only red light, green light, or blue light to pass through to its SPD. There are twice as many green filters as there are red or blue filters, because the human eye is more sensitive to green light. Each pixel contains a single primary color and is missing the other two colors. Through a process known as *interpolation*, a mathematical method of creating missing data, the camera guesses the absent color information in each pixel by examining nearby pixels and thus is able to generate accurate colors.

Once an image is recorded (digitized), imaging software can be used to select and alter the color, brightness, and position of any pixels.

Pixels

A pixel, short for picture element, is essentially an electronic point with a given color and brightness value (data) that is the smallest component of a digital image. A typical digital image is composed of an array containing millions of pixels. A million pixels are known as a *megapixel*. When the sensor grid is made up of millions of these tiny pixels, it is perceived by your eye in continuous tones, just as it would with a film-based photograph. The more pixels the image contains, the sharper the image and the higher its resolution (amount of detail).

Image Resolution

Image resolution describes the amount of detail any particular image can display. The measurement of image resolution varies dramatically and is specific to a specific medium, such as inkjet/laserjet printing, TV/video, film or computer monitors. In any digital medium, higher numbers translate into higher resolving power or ability to reveal image detail. Television/video uses the number of scan lines to determine image resolution. Film and photography utilize an analog standard in which lower numbers indicate higher resolving power. Computer monitors use dot pitch. Digital cameras use pixels per square inch (PPI), and inkjet/laserjet printing technology uses dots per square inch (DPI). Regardless of the medium, accepted resolution standards are dependent on the ability of the human eye to resolve or see detail and the quality of the equipment and materials being used.

PPI: Pixels per Square Inch and Digital Camera Resolution

Digital cameras can capture images in different resolutions. Low-resolution images are appropriate for display on a website, but not for making photographic-quality images. A 6-megapixel digital camera refers to the maximum number of pixels (PPI) such a camera is capable of capturing. The PPI is the number of pixels displayed in the image file, which directly refers to image resolution. Digital cameras have capture settings that can be set to less than the maximum PPI. For example, most digital cameras have image size or PPI settings usually described as large, medium, and small. The *Large* setting represents the maximum allowable image resolution for that particular camera and will always produce a larger image file than the *Small* setting. Hence, a 10-megabyte image file created with the *Large* setting will always contain more pixel information than a 1-megabyte image file created with the *Small* setting.

A 10-megapixel camera using the *Large* setting might have a PPI setting of (width) 3888 × (height) 2592, which will have sufficient resolution for 11 × 14 inch photographic-quality prints, which is usually adequate for most amateurs. A *Small* setting might be adequate only for use on the Web. A computer with image processing software can reassemble the PPI from large, medium, and small image files for printing, emailing, or posting to a website. It is always best to shoot "large" and reduce the PPI for the Web or other uses, rather than to shoot "small" and increase PPI to print, because the resulting quality will be less than optimal.

DPI: Dots per Square Inch and Printer Resolution

DPI, dots per square inch, refers to printer resolution. In general, the more dots the printer can physically produce per linear inch, the better and sharper the image. DPI and PPI are both key controlling factors in producing high-quality photographic prints, but ultimately it is the printer resolution or DPI setting that has the greatest effect on the final image resolution. Looking at a photograph on paper is an analog experience because our eyes convert value and detail into recognizable shapes. Hence, it is the number and size of the dots physically applied to the paper that give a viewer the final visual experience.

The Differences between PPI and DPI

Although PPI and DPI control image quality in similar ways, they are very different, and it is critical that these distinctions be clearly understood. PPI refers to pixel density or pixel dimensions and is usually measured in pixel height and width. For imagemaking purposes, think of PPI as digital information that only relates to the resolution of your camera's capture mode, and DPI as it correlates to the resolution of your printer's output. The mantra to remember is: For PPI, think of your camera; for DPI, think of your printer. (See Box 3.1 and Chapter 8 for more information about PPI and DPI.)

Box 3.1 PPI and DPI Mantra

PPI = Input/camera

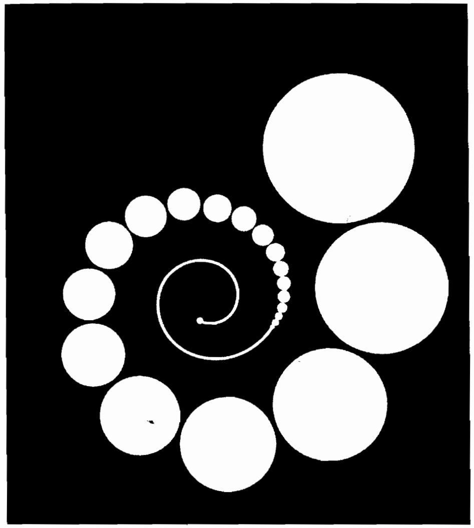
DPI = Output/printer

Visual Acuity and 300 DPI

Visual acuity is the capability of the human eye to resolve detail, but this power of human vision to recognize fine detail has limits. When it comes to digital imaging, the point where dots, lines, and spaces are seen by the human eye as continuous tone is approximately 300 dots per inch (DPI). This is why photographic printers, known for high-quality output, have resolutions of 300 DPI and higher. There are many variables, such as individual differences in visual acuity, lighting conditions, and viewing distance, but generally 300 DPI is considered acceptable for replicating continuous tone. An 8 × 10 inch digital print at 300 DPI and viewed at 12 inches (30 cm) easily allows the dots to be seen as a continuous tone to the average eye. As prints are made larger, the standard viewing distance increases, which theoretically means the DPI could be reduced and the average eye would still see it as a continuous tone (see Figure 3.4).

Printers create images in a variety of ways. Depending on the way a printer lays down its dots on a page, a print made at 200 DPI on one printer can look finer than a print made at 400 DPI on another. Regardless of what printer you use, 300 DPI has become the common standard that photographers and publishers use for making image files for general reproduction. Those with a more demanding critical eye, such as professionals intending to greatly enlarge their digital files and still maintain continuous tone quality at close viewing distances, will require higher DPI output, such as 600 to 8000 DPI (see Box 3.1).

As previously discussed, printing at 300 DPI is the standard for photographic quality, so be careful not to let inkjet printers rated at 1440/2880/4800 DPI impress you. Inkjet printers rely on technology that applies many tiny droplets of color for each dot. Manufacturers are literally counting each and every one of those minuscule droplets, which can be misleading. Visually, a dot is a dot regardless of whether one dot is composed of a cluster of eight minuscule color droplets and another is not. Some manufacturers count the eight minuscule droplets as separate dots to inflate their DPI figures. Inkjet technology is changing rapidly; droplets are getting so small that their blending on the page obscures the individual droplets altogether. This improvement in inkjet printer technology does offer better color control, but only has a minimal impact on actual image resolution.



3.4 Dots to continuous line.

Types of Cameras

Digital cameras are the most direct method of capturing images for digital manipulation or printing. Combining the mechanics of cameras and the technology of scanners, digitally captured images may be stored on a disk within the camera and later transferred to a computer, or the camera may be directly connected to a computer and the image transferred as the picture is taken. Exposure times in digital cameras can vary from a fraction of a second to several minutes. Digital cameras come in two styles: the all-in-one digital camera and the professional-level scanning back. Scanning backs connect to traditional, larger-format cameras. The camera makes the exposure, and the scanning back converts the image into digital data. (These are used to make high-end professional images and will not be covered here.) The sensor stores images as electronic data, which can be downloaded into a computer. In the computer, a digital imaging software program allows changes to be made to the image, which can be saved and then printed or transmitted via email as a digital file or posted on a website. Often digital images are never printed and remain strictly as electronic information.

Compact Digital Cameras

Compact digital cameras, also known as *point-and-shoot cameras*, have become the choice of casual photographers. Compacts are called point-and-shoot cameras because their functions are automatic and they simply require users to compose the scene and press the shutter release. Basic inexpensive point-and-shoot cameras have a fixed focus, which relies on a small aperture and a wide-angle lens to ensure that everything within a certain range of distance from the lens (about 6 feet to infinity) is in acceptable focus. Other point-and-shoot cameras may have a limited focusing range indicated on the camera body. With these, the user guesses the distance to the subject and adjusts the focus accordingly. On some cameras, the focusing range is indicated by graphic symbols (head-and-shoulders; two people standing upright; one tree; mountains). Such lightweight point-and-shoot cameras have a viewing system that is separate from the lens. Generally, the viewfinder is a small window above or to one side of the lens. More expensive compact cameras have a rangefinder; an angled mirror behind the lens reflects a second image of the subject into the viewfinder. To focus, a person looks through the viewfinder and adjusts the focusing mechanism until the two images come together. The focused image in the viewfinder differs slightly from the image on the sensor or film. This difference is called *parallax error*. To help correct for parallax error, the viewfinder has lines that frame the subject area seen by the lens.

Compact digital cameras may have a monitor instead of a viewfinder, or both. Many make use of an electronic viewfinder (EVF). An EVF relies on a miniature monitor inside the back of the camera. The photographer looks at the monitor through a small window and sees the scene from the same viewpoint as the lens. Thus, parallax error is avoided.

Compact digital cameras usually have many features and creative controls, including variable focal length zoom lenses, automatic focus, and software programs to cover situations such as close-ups and nighttime exposures. Some even permit Wi-Fi (short for wireless fidelity) picture transmission which sends pictures directly from a camera to a computer without wires. Higher-quality digital cameras have greater resolution (the amount of image detail the camera is capable of recording), which results in sharper images.

Digital Single-Lens Reflex Cameras

Digital single-lens reflex cameras (DSLRs) are the most common type of camera used by professional and serious photographers because they allow one to look at a subject directly through the lens. A mirror mechanism between the lens and the sensor reflects the image onto a viewing screen. When the shutter release button is pressed, the mirror rises out of the way so that the light makes an exposure on the sensor. Thus, the photographer sees the image almost exactly as it is recorded on the sensor, and parallax error is avoided.

Single-lens reflex cameras are heavier and more expensive than other digital models. DSLRs are more versatile than compacts, with most offering both manual and automatic controls and the ability to utilize a variety of interchangeable lenses. Their standard lens can be replaced with lenses that change the size and depth relationships of objects in a scene. Such lenses include wide-angle lenses, telephoto lenses, macro lenses, and zoom lenses. Professional and pro-consumer DSLRs offer numerous creative controls and feature larger and more accurate imaging sensors which provide for greater picture resolution, less noise, and more color accuracy.

3.5 Nikon DSLR Courtesy of Nikon Inc. USA.

3.6 Hasselblad medium-format DSLR with digital back. Courtesy of Hasselblad USA.

There are also special-use DSLRs capable of taking photographs in the ultraviolet and infrared light spectrums, which have been designed for use in the science, medical, law enforcement, and fine art fields.

Other Camera Types

Medium-format cameras are often preferred by professional photographers because their larger sensor or digital back can capture bigger files (more pixels) and thereby provide more precise and detailed images than their smaller counterparts — though at more expense, bulk, and weight. Medium-format cameras can also be shot in a variety of aspect ratios — that is, the ratio of its longest dimension to its shortest dimension — which differs depending on the camera or frame insert used. The most common aspect ratios are 6 × 4.5 cm (also known as 645, or rectangular) and 6 × 6 cm (also known as 2-1/4, or square). Other frequently used aspect ratios are 6 × 7 cm, 6 × 9 cm, and 6 × 17 cm (panoramic). *Panoramic* refers to any high aspect ratio (1.85 or greater) or wide-screen image or film format, which is especially suitable for scenic, horizontal landscapes. Some cameras have a switch that allows you to switch between different aspect ratios.

View cameras, such as the 4 × 5 inch, 5 × 7 inch, and 8 × 10 inch, have many additional adjustments that give serious photographers more creative control in setting up their compositions. They provide a lot of perspective control, but do require a tripod. Most such cameras use large digital backs or sheets of film to capture images of the highest resolution.

3.7 "I use my camera's built-in panorama mode to shoot and then stitch the images together to represent my interest in the appearance and meaning of our persistent attempts to dominate nature — the human impulse to impose geometric structure upon perceived chaos — and in nature's equally relentless attempts to absorb our imprint into its own larger order. In this particular image, I wanted the rising sun to appear exactly in the center, shining directly into the lens, so I started with the sun directly at my back, which allowed me to include my shadow as a point of self-reference, and work my way back around to the beginning. I utilize this bookend approach as a way of creating a sense of slightly distorted symmetry."

© Steven P. Mosch. *Tabby Ruins #3*, Spring Island, SC, 2002. 1-1/2 × 16 inches. Inkjet print.

Digital camera backs, designed for commercial applications, are available for 645, 2-1/4, and 4 × 5 film cameras, and their sensors offer unparalleled digital image capture. The digital back simply replaces the conventional film back.

Instant cameras use self-developing film, capable of delivering an image in under a minute and have largely been replaced by inexpensive digital cameras.

Disposable cameras offer an inexpensive way to experiment with different image-making devices, including waterproof, underwater, and panorama models.

Panoramic cameras are specifically designed to create images with exceptionally wide fields of view by means of a high aspect ratio, in which the length of the image is much greater than its height. The lens of a true panoramic camera rotates to scan a scene, which is captured on a wide sensor or on film. The broad sweep of the rotating lens records the scene with minimum distortion and is useful for photographing expansive landscape and large groups of people. True panoramic images capture a field of view comparable to, or greater than, that of the human eye — about 160 × 75 degrees. There are software programs that will "stitch" images made with wide-angle lenses into panoramas. In addition, there are digital cameras that offer different aspect ratios, including panoramic (see Figure 3.7).

Sequence cameras make a series of exposures over a specific amount of time, on either one frame or on consecutive frames.

Stereo cameras have twin lenses, 2-1/2 inches apart, which allow imagemakers to work with the illusion of depth.

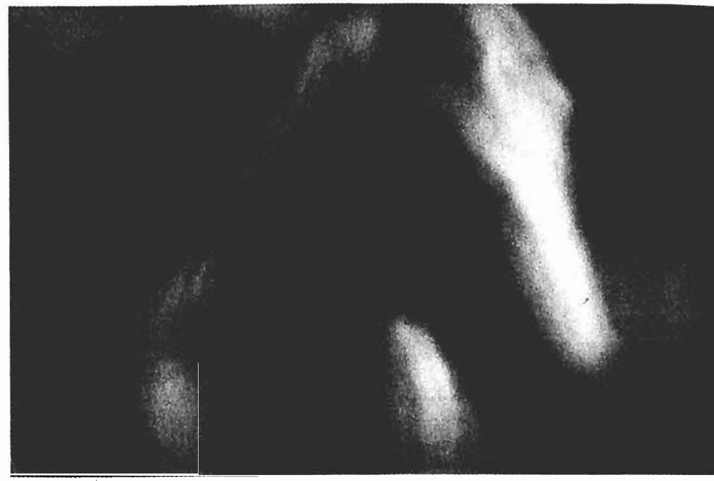
Toy cameras, such as the Holga, challenge the accepted standards of image quality and encourage playfulness and simplicity.

Underwater cameras have a watertight seal or special housing that allows them to be used when swimming, snorkeling, or scuba diving (see Figure 3.8).

Pinhole cameras do not have a lens and can be made out of an oatmeal box or a coffee can. The light producing the image passes through a small aperture, which can be made with a small sewing needle. The shutter usually consists of a hand-operated flap of heavy, black tape to cover and uncover the pinhole. Pinhole cameras need much

3.8 "I explore the relationship between people and water. I am interested in the distortions caused by reflection and refraction of light, as well as the color and texture of the water itself. The drenched people inside the watery world create an insular and timeless environment of immersion. After scanning the negatives, I put this image together using layer masks and adjustment layers to make it seamless. I elongated the figures to make them have an eerie effect. My goal was to show a group of similarly attired, but diverse colors of clothes on people who are gathered together. My hope is that viewers will make connections with current events, such as Muslim women wearing the chador or other coverings, or with ideas such as the types of clothes worn by women in Margaret Atwood's book, *A Handmaiden's Tale* (1985)."

© Anne C. Savedge. *Gathering*, 2006. 24 × 40 inches. Inkjet print.



3.9 Spencer made this 1-second exposure by putting a pinhole body cap on her DSLR in place of a lens. "To use a pinhole body cap on my digital camera, I set the camera to the Manual exposure mode and find the correct exposure by trial and error. For me, the white horse is an archetype representing power, transience, and freedom. The black horse that appears in the shadow of the neck of the white horse was a gift from the pinhole gods. I didn't see it until I printed the image."

© Nancy Spencer. *White Horse, Black Horse*, 2006. 10 × 15 inches. Inkjet print.

longer exposure times than conventional cameras because of the small aperture; typical exposure times can range from a few seconds to more than an hour.

Pinhole cameras with CCDs are sometimes used as spy cameras for surveillance work because of their small size. A pinhole drilled into a camera body plate cap that screws into the camera's lens mount in place of a lens can convert a digital camera into a pinhole camera (see Figure 3.9). Precision-made pinhole body caps are commercially available from sources such as the Pinhole Resource (www.pinholeresource.com) and fit many cameras, including view cameras. To prevent dust from getting on the sensor, you hold the camera face down and quickly change to the body cap.

Homemade cameras can be specifically constructed to meet your own unique way of seeing (see Figure 3.10).

3.10 Taft made this 15-second exposure with a self-made camera that uses a lens and bellows connected to a converted flatbed scanner powered by a laptop computer. This arrangement allows Taft to move the lens board during exposures, "almost like playing an accordion and experimenting with anamorphosis [distortion]." Taft also added an infrared filter to the lens to take advantage of the scanner's high sensitivity to the infrared spectrum. Depending on the direction of the movement relative to the direction in which the scan head travels, image segments are either stretched or compressed, while stationary objects remain unaffected.

© Steven Taft. *Kandice*, 2006. 6-3/4 × 7-3/4 inches. Inkjet print.

Spy or *hidden cameras*, commonly found in banks and stores, are used to make still or video recordings of people without their consent or knowledge. They have also been used in "reality" television shows to capture unsuspecting people in unusual or embarrassing situations.

A *web camera* or *webcam* is a real-time camera whose images can be accessed using the World Wide Web (WWW), instant messaging, or with a computer video-calling application. Generally, a digital camera delivers images to a web server, either continuously (streaming) or at regular intervals. Today, webcams provide views into homes and buildings as well as views of bridges, cities, and the countryside. Webcams also monitor traffic and weather and are used by police for public safety and surveillance purposes.

Camera phones are the fastest-growing kind of digital camera. Their incorporation into mobile phones and other personal digital assistants (PDAs) allows one to take and transmit still or video images with a few keystrokes.

Multimedia cameras merge media boundaries with features such as digital still cameras, video recorders and players, plus MP3 players, all in a single device.

Additionally, photomicrographs can be made by means of a special apparatus that permits a camera to be attached to a microscope. Telescopes equipped with a clock drive and a camera-body attachment mount can be used to make images of the sky at night. Intriguing results can also be obtained by simply pressing the camera lens up to the eyepiece of either instrument and then reviewing and adjusting after each exposure (see Figure 3.11).

When the opportunity presents itself, it's a good idea to work with a camera format different from the one you normally use and compare

3.11 To make her birding images, Pearce places her digital camera next to the telescope eyepiece without an adapter "to encourage some lens feedback and odd reflections. Mode is set to aperture priority, and exposure is determined through the lenses of both the camera and telescope. The resulting capture is presented in a circle with a variety of colored vignetted edges. Why birds? I have a fascination with their ability to adapt using their amazing navigation skills, and they are omnipresent in myths, fairytales, and symbolism. Besides, they are just cool to watch and allow me to take the time to relax."
© Jeannie Pearce. *Female Blackbird*, 2006. 16 × 16 inches. Inkjet print.

the resulting images. Become aware of how the camera itself affects what you look at and how you see, and then interpret the results.

Choosing a Camera

Before choosing a camera, ask yourself: (1) How will I use this camera? (2) What types of pictures do I plan to take? (3) What will I do with the pictures? (4) How much can I afford to spend? These factors allow one to determine the resolution, size, ease of use, degree of creative control desired over the camera, and cost. Unless there are special circumstances or requirements, everyone should consider a digital camera because of their ease of use, the portability of your pictures as electronic data, and the convenience of organizing, controlling, and storing them electronically.

Camera File Formats

Any digital file uses a binary code to electronically record data, whether it is an image or text, which allows it to be stored, processed, and manipulated in a computer. Although all images are written in binary code, there are a variety of file formats for capturing and storing images. Each format has a unique method of translating resolution, sharpness, value, and color of a digital image, and each has its uses, advantages, and limitations. For this reason, it is important to select the file format that is best for your particular needs before making any images, as changes made later to the original format can result in loss of image quality (see section on Major Image File Formats).

Most digital cameras provide several file format options, such as JPEG, TIFF, and RAW, plus a range of quality settings in a variety of resolutions such as low, medium, and high which can be set to meet the needs of a particular situation. One must know the differences between various file formats and quality settings, as well as the final print size, to get the desired results.

Image Compression Algorithms: Lossless and Lossy

To select the right file format for the image quality you need, it is essential to understand image compression. Compression algorithms, a set of mathematical program instructions, are designed to reduce the original file size to create extra storage space or to speed up file transfer over a network. Digital cameras can compress images to save file space on the memory card.

There are numerous file compression types, but they all fit into two basic categories: lossless and lossy. Lossless compression uses an algorithm that allows a compressed file to recover all the original data when the file is uncompressed. Lossy compression, by contrast, permanently reduces a file's size by eliminating redundant data or data not visible to the average eye, and this data cannot be recovered. The loss of image quality in lossy compression is proportional to the amount of compression. Most lossy file types give you options for setting the amount of compression. Different file types are best for different applications (see Box 3.2, Other Major File Types).

Major Image File Formats

Quality cameras can save images in three file formats: JPEG (compressed), TIFF (uncompressed), and RAW (unprocessed), which are explained below.

JPEG

JPEG, which stands for "Joint Photographic Experts Group," is the default file format used on most digital cameras because it allows for

Box 3.2 Other Major Digital File Types

- GIF *stands for Graphics Interchange Format and is a lossy format primarily used for the Web. GIF is excellent for flat color graphics but is not ideal for photographs.*
- PNG, *or Portable Network Graphics, format was designed to supplant the older GIF format. A lossless file format with good compression, its two major uses are the World Wide Web and image editing. It is a substitute format for many of the common uses of the TIFF format.*
- EPS *is short for Encapsulated PostScript. EPS files were designed for saving high-resolution documents, illustrations, and photographs for electronic prepress for page layout software in the printing industry.*
- PICT *is encoded in Macintosh's native graphics language. PICT files are lossless, can be opened on the Windows platform, and can be saved in most software applications.*
- BMP *is the standard Windows image format. It is lossless and designed for pictures or graphics.*
- *Program-specific file types, such as Photoshop (.psd) or Illustrator (.ai), are native file formats that contain the maximum amount of information about an image for use in its own native program. Sometimes these native files are much larger than similar common file formats because the program-specific features are saved only in native file formats. When saving an image to a common file format, which is sometimes called a* non-native file format, *the image's layers may have to be combined, and certain formatting information may be eliminated.*

the maximum number of pictures per megabyte of camera memory. JPEG is a compression format that uses *Basic*, *Normal*, and *Fine* settings on the camera to manage both the amount of compression and the resulting image quality. Do not confuse JPEG settings, which control image quality through compression, with the image size settings *Large*, *Medium*, and *Small*, which control document size.

JPEG is an excellent file format, but images cannot be restored to their original file size because information has been permanently eliminated. The JPEG image file format uses a lossy compression scheme and is commonly used for low-resolution, continuous-tone images on the Web. JPEG compression also allows the creator to decide the trade-off between file size and image quality: higher quality means larger file size, and smaller file size means lower image quality. JPEG files should not be opened and resaved multiple times because images will slowly deteriorate (due to the lossy compression scheme) and become soft and pixilated. Compression is like crushing an eggshell and gluing it back together. During the rebuilding process, tiny pieces are lost, the glue smears, and the shape is not quite smooth. The more you crush, the more noticeable the defects: abrupt color and highlight gradations, loss of sharpness, jagged lines, and swirling patterns are a few such problems, known as *artifacts*. It is always best to go back and work from your original file format (RAW, TIFF, PSD [Photoshop file]) when remaking JPEG files.

TIFF

An acronym for Tag Image File Format, TIFF saves a file without compression and is the current standard in the graphics and printing fields and in cases where an image needs to be examined digitally in detail. The TIFF format is used to exchange files between applications, computer platforms, and for high-quality printing. Lossless compression options are available for TIFF files, but generally are not used because many high-quality output devices will only accept uncompressed TIFF files. Even compressed, TIFF files are much larger than inherently compressed GIF or JPEG files. TIFF is known as an interchange format, easily opened on any platform, and is considered one of the most universally accepted high-resolution file formats.

RAW and Post-Processing

The RAW file format is a type of import/export format rather than a storage format. RAW files are made up of unprocessed sensor data. The RAW file format can be considered a pure "digital negative" because it contains unmanipulated binary files with information pertaining only to individual pixels from the image sensor. When a RAW image format is saved (shutter released), only the sensor data is saved; there is no post-processing for color balance, color palette compression, size, white balancing, or sharpening that is required with other file formats. The data is not formatted for a specific application, and the main advantage of these files is that they are uncompressed and smaller than TIFF files. All image processing is done later using computer imaging software; this allows for unparalleled control over the interpretation of the image in terms of tonal rendition, color balance and saturation, and detail rendering (noise reduction and sharpening). Professional photographers prefer making and using the RAW file format because its pure, unprocessed pixel data gives them the most flexibility and control when converting to other file formats (see Chapter 8's section on Working with RAW File Formats).

DNG

When the RAW format was introduced, it came not from a central source, but rather from various DSLR makers who produced their own competing proprietary systems and software. Since their specifications are not publicly available, not every RAW file can be read by a variety of software applications. The Digital Negative (DNG) format is Adobe's attempt to solve this vexing situation by introducing an open format that they hope will be universally adopted by the camera manufacturers (see Chapter 8's section on Working with RAW File Formats).

Opening Files

Regardless of the type of file you are working with, all computer files have what are called *file headers*, which is the portion of the file that tells the computer what the file is, what program created it, the date it was created, and so on. Although the files themselves can easily go back and forth between various computer systems, the file headers do not always properly work. When one double-clicks on a file, the computer reads the header and attempts to guess what to do with the file. Sometimes it guesses wrong. If you have trouble opening a file, open it within the application.

Once an image file is downloaded to your computer and opened, digital imaging software can be used to change size, colors, contrast, and other image characteristics. Software can also be used to drastically alter and/or combine images or to create a new image that did not previously exist in reality.

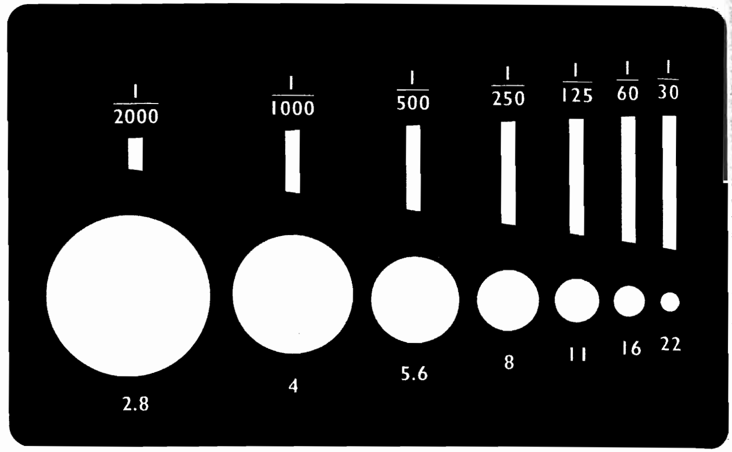
The Lens System and Exposure

The heart of the digital camera is its lens, which is made of optical-quality glass shaped to bend light rays to form an image. The camera lens system collects light rays coming from a subject in front of the camera and projects them as images onto a sensor, at the back of the camera. In this way, the lens gathers enough light to make an exposure in only a fraction of a second. Without a lens, an exposure could be several minutes long, and it would not form a sharp image. The lens also determines the field of view and influences the depth of field in the scene.

A similar effect, known as a *mirage*, can occur naturally. For instance, people standing on the shore of Lake Erie in Cleveland have been known to see the distant sweep of the Canadian shore some 50 miles away. This is the result of an atmospheric inversion, in which a layer of cold air blankets the lake, topped by layers of increasingly warm air. When this happens, it can cause the light that filters through these layers from across the lake to bend, forming a lens that can create the illusion of distant objects. The air has to be extremely calm for the mirage to appear. If the wind blows, it distorts or dissolves the image.

Aperture

A key component of the lens system is the aperture, which is an adjustable opening created by an adjustable diaphragm, usually an overlapping circle of metal leaves. The aperture determines the amount of light entering the lens and on most cameras can be controlled either automatically and/or manually. When it is widened (opened), it permits more light to pass through the lens. When it is closed (stopped down), it reduces the amount of light passing through the lens. The various sizes of an aperture are called *f-stops*. On most adjustable cameras, the f-stops range from 1.4 or 1.8 to 22 or 32. DSLRs generally have the ability to set the aperture opening at any point in the aperture range of the lens, such as f/8-1/2 or f/13. The selected aperture generally appears inside the viewfinder and/or in the data-panel readout display. The smaller the f-stop number, the larger the size of the lens aperture. Like shutter speeds, each f-stop lets in either twice as much light as the preceding setting or half as much light as the next higher setting. For example, if you open up the setting from f/11 to f/8, the aperture admits twice as much light into the camera. If you stop down the setting from f/11 to f/16, the aperture lets half as much light into the camera (see Figure 3.12).



3.12 The relationship between shutter speed, f-stops, and exposure. **This illustration shows seven different combinations of f-stop and shutter speed that all equal the same exposure for an outdoor photograph made during a cloudless mid- to late afternoon day. In any given situation, there are many combinations that can provide an accurate exposure. An exposure of f/2.8 at 1/2000 second is technically the same as f22 at 1/30 second, although the resulting images would not appear the same due to the differences in depth of field and shutter speed.**

Aperture/F-Stop Control/Shutter Control/Exposure Modes

The Aperture priority mode allows one to choose the aperture while the camera controls the shutter speed. The Shutter priority mode allows one to choose the shutter speed while the camera controls the aperture or f-stop. The Program mode automatically sets both the aperture and shutter speed. The Manual mode allows one to set both the aperture and shutter speed through an exposure display in the viewfinder and/or in the data-panel readout display.

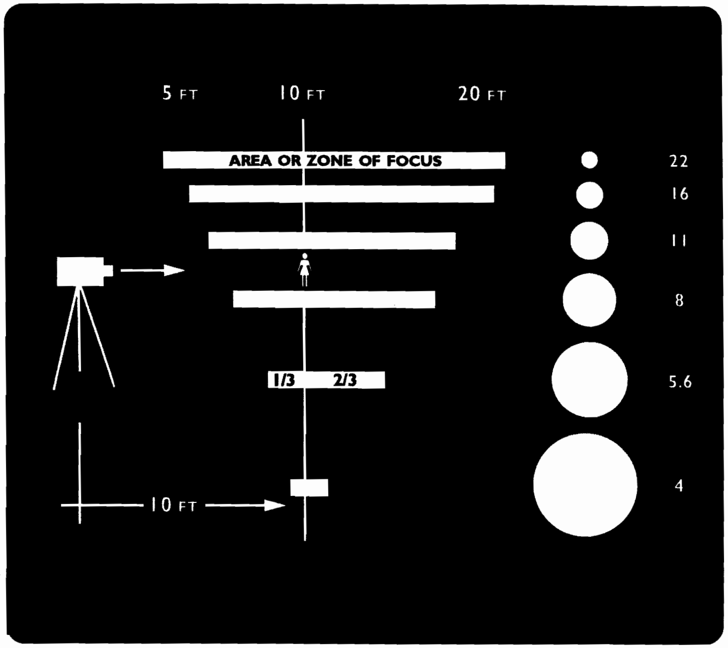
A camera's built-in light meter automatically determines exposure by selecting a combination of f-stop and shutter speed based on similar situations in the camera's internal database. Shutter speeds control exposure by varying the duration of time the shutter is open. Typically, DSLR cameras have shutter speeds that range from 1/4000 second to 30 seconds. Faster shutter speeds are used to ensure the image is sharp when either the cameraperson or the subject is moving. F-stops control exposure by letting in greater or lesser amounts of light. Smaller f-stop numbers, such as f/2.8, let in more light, thus requiring a faster shutter speed (less light) to obtain a proper exposure. F/22 lets in much less light than f/2.8, thereby requiring a much longer exposure or duration of time. Modern DSLR lenses have f-stops that range, on average, from f/1.2 to f/32.

Depth of Field

Changes in the size of the aperture affect the overall sharpness of the picture. As the aperture becomes physically smaller, the area of sharpness in front of and behind the point of focus becomes greater. This area of acceptable sharpness is called *depth of field* (see Figure 3.14). It extends from the nearest part of the subject area in focus to the farthest part in focus. A small aperture, such as f/11 or f/16, gives more depth of field than a large aperture. For example, a landscape photograph made with a small aperture, f/16, will have great depth of field, bringing subjects both in the foreground and in the background in focus. As you open up the aperture, the area in focus becomes shallower. At f/2 or f/4, the subject will be in focus, but objects in the foreground and background may be soft, not in sharp focus. For instance, a close-up photograph of a person's face may have a shallow depth of field (with the background behind the person visible but out of focus).

Digital cameras have smaller image sensors and smaller lenses than 35 mm film cameras. The smaller sensors and lenses tend to create a much smaller *circle of confusion,* which is the circle of light formed by the lens in which the light rays are unfocused. The smaller the digital sensor, the smaller the circle of confusion, and therefore smaller the area with unfocused light rays. This can make it almost impossible to obtain a shallow depth of field (the range of distance between the nearest and farthest points from the camera that is rendered acceptably sharp). For instance, many digital cameras make it extremely difficult to create the soft-focus background that is *de rigeur* in portraiture and nature photographs. To attempt shallow depth of field, use your lens's longest focal length and largest f-stop possible. The smaller image sensors and lenses of inexpensive and proconsumer digital cameras will dramatically increase the depth of field, which can make a digital f/4 the equivalent of f/22 on a 35 mm film camera. This can be controlled with post-capture software filters such as Lens Blur (see Chapter 4's section on Digital Filters and Plugins).

3.13 "This work looks at how humans live with animals, how they define us, and how we define them in relation to us. I explore simulation, consumption, destruction, and reconstruction of the natural world while seeking to understand how the human connection to the rest of nature is often developed through assimilation and appropriation. Under existing fluorescent lights, I squatted to be at the pig's eye level and opened my lens to the widest aperture so their eyes would be sharp and everything else would fall out of focus."
© Colleen Plumb. *Meat Packer*, 2003. 30 × 30 inches. Inkjet print.



3.14 Depth of field and the zone of focus. Focusing on a subject creates a "point of focus," which is minimally in focus regardless of the f-stop or aperture used. The point of focus begins a zone of focus, and it radiates from that point, moving both in front of and behind the subject. Figure 3.14 shows that the zone of focus is not evenly distributed from the point of focus (10 feet) but is distributed one-third toward the camera and two-thirds behind the point of focus (subject). Also, as the camera gets closer to the subject, the amount of inherent depth of field drops off at any f-stop.

F/22 gives the greatest depth of field, often referred to as *extended depth of field*. All subjects within this zone of focus will be sharp, with equal prominence, and thus will visually live within the same contextual space. F/4 gives the shortest depth of field, referred to as *limited depth of field*. A short or limited depth of field helps isolate a subject from the background or foreground, giving it more visual emphasis.

Box 3.3 Hints to Control Depth of Field

To create images with limited depth of field, get very close to your subject (2–4 feet) and use the large f-stops such as f/2, f/2.8, f/4, or f/5.6. This will put the background out of focus, thus emphasizing the main subject.

To create images with extended depth of field, move back from the main subject (8–15 feet) and use the small f-stops such as f/8, f/11, f/16, or f/22. All subjects within this zone of focus will visually relate to one another because of their equal prominence.

Remember: To maintain proper exposure when adjusting the f-stop in manual mode (M), be sure to change the shutter speed. Use aperture preferred mode (AP) when experimenting with apertures.

Hold the camera absolutely still when using f/16 or f/22, as the shutter speed may drop below 1/30 of a second, and any camera movement will affect overall sharpness.

Focal Length

What Focal Length Establishes

Lenses are described by their focal length, which is the distance in millimeters (mm) between the lens and the image it forms on the sensor or film when it is sharply focused at infinity (the farthest possible visual distance). Focal length determines the angle of view — how much a lens sees — which controls what portion of a scene will be captured. The portion that gets recorded is also dependent on the size of the sensor or film. The lens's focal length determines the magnification, that is, the size of the image that the lens forms.

The Focal Length Rule

As the focal length of a lens increases, its angle of view decreases because the magnification increases, which results in the object's becoming larger in size. Focal length also affects perspective. As the focal length and magnification of a lens increase, the image becomes more compressed, resulting in less visual distinction and separation between the foreground, middle ground, and background.

35mm Film Camera Equivalencies

One often sees 35mm film camera lens equivalencies given to digital camera lens focal lengths. This can be traced back to 1924 when Leica Camera, formally Ernst Leitz, invented the first practical 35mm hand-held camera that used roll film capable of recording 36 exposures. These first Leica cameras utilized existing 35mm-wide movie film manufactured by Eastman Kodak, which produced a 24 × 36mm recording area when exposed between the film's sprocket holes. Historically, this 24 × 36mm image area has been used to determine the angle view or look associated with any normal, wide-angle, or telephoto lens used over the years with the traditional 35mm film camera (see the section on Types of Lenses).

Angle of View

The expected angle of view or look associated with normal, wide-angle, or telephoto lenses has changed with digital photography because the image sensor in most cameras is smaller than the historical 24 × 36mm recording area, making the focal length of digital camera lenses numerically longer (more telephoto) than their film camera equivalents. For example, a 50mm lens, having an angle of view of about 47 degrees, was considered to be the normal lens for a 35mm film camera. If your digital camera has an image sensor that is smaller than the customary 24 × 36mm recording area, the DSLR lens will effectively become more telephoto, creating a smaller angle of view (see the next section on Calculating the Picture Angle). Camera manufacturers do produce expensive, full-frame DSLRs whose image sensors are equivalent to the 35mm film size, making their angle of view the same as the 35mm film cameras. Table 3.1 shows some typical angles of view from 35mm film format designations and their equivalent digital designations.

Calculating the Picture Angle Factor/Sensor Equivalency

Unless the image sensor in your digital camera is the exact size of a comparable film format, the image area covered by your digital lens will differ from that of a 35mm film camera. The smaller sensor size of most digital cameras gives them a narrower angle of view (more telephoto), essentially cropping (reducing) the area of view. A "crop" or picture angle factor has been developed to provide a lens millimeter equivalency between the full-frame 35mm film format lenses and any size digital sensor. By multiplying the sensor equivalency by the 35mm film camera lens size, one can determine the new digital focal length of a film lens when used on a particular digital camera. For instance, a 50mm lens combined with an image sensor having a picture angle factor of 1.6 becomes an 80mm lens (50 × 1.6 = 80).

Table 3.1 Angle of View Equivalency Table

Angle of View	35mm Film SLR	DSLR (1.6X)
(114°–94°) Super Wide Angle	14mm–20mm	8.7mm–12.5mm
(84°–63°) Wide Angle	24mm–35mm	15mm–21.8mm
(47°) Normal Lens	50mm	31mm
(28°–8°) Telephoto	85mm–300mm	53.1mm–187.5mm
(6°–3°) Super Telephoto	400mm–1000mm	250mm–625mm

As there is no standard sensor size, the angle of view at any given focal length will vary from camera to camera, depending on the size of the sensor. If the same 50mm lens is combined with an image sensor that has a picture angle factor of 1.5, it then becomes a 75mm lens (50 × 1.5 = 75).

When a 35mm film camera lens is used on a DSLR that does not have a full-frame 24 × 36mm sensor, the focal length of the lens increases by a specific factor (X) that is determined by the size of the sensor, which in turn reduces its angle of view and thereby makes the lens more telephoto. Based on 35mm film SLR lens standards, Table 3.2 shows what millimeter lens is needed to maintain the same angle of view with a DSLR lens, based on a DSLR having a crop/picture angle factor of 1.6X. Check your camera manual to determine its exact sensor size, which will give you the proper picture angle factor.

Table 3.2 Focal Length Conversion Table

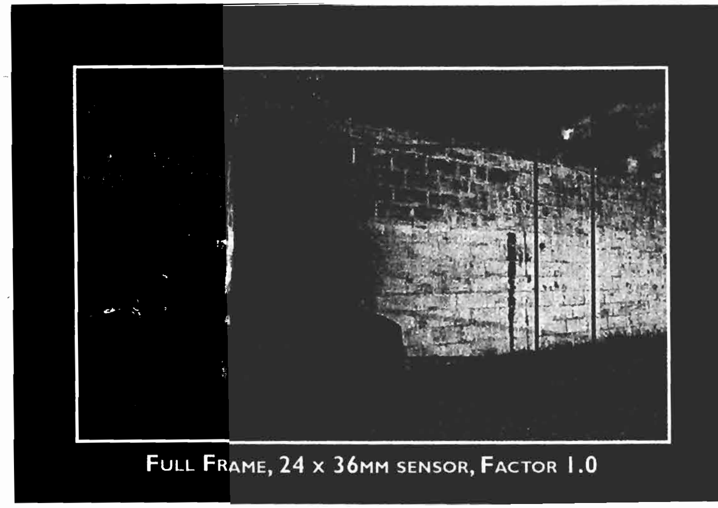
35mm Film SLR		DSLR (1.6X)
14mm–20mm	=	21mm–30mm
24mm–35mm	=	36mm–52mm
50mm, Normal	=	75mm, Normal
85mm–300mm	=	127mm–450mm
400mm–1000mm	=	600mm–1500mm

This proper picture-angle factor also applies to DSLRs that will accept older film camera lenses. For example, suppose you want to determine the digital equivalency of a 24mm wide-angle film lens that is compatible with a DSLR that has a crop/picture angle factor of 1.6. You would multiply 1.6 by 24mm and discover that this lens now becomes a 38mm lens on this digital camera, giving it a narrower angle of view and thus a more telephoto effect. To calculate what lens you would need to create the same wide-angle view as the 24mm lens did on a film camera, you would divide 24mm by 1.6, which shows you that a 15mm film lens is required. When using a film SLR lens on a DSLR camera, what is seen in the viewfinder is directly captured by the digital sensor. What you see is what you get, and there is no need to mentally crop the picture, but you will notice that the angle of view or the look has changed.

Focusing the Image

In addition to concentrating the incoming rays of light, the camera lens serves to focus them on the sensor. As light rays pass through the aperture into the camera, the lens bends them so that they form a sharp image. The sharpness of the image depends on the distance between the object and the lens and between the lens and the sensor. DSLRs have a focusing control that changes the lens-to-sensor distance, either automatically and/or manually, thereby allowing a sharp image of the subject to be formed at various distances. Inexpensive cameras may have a fixed focus or zone control that sets the focus for predetermined close-up, portrait, or landscape distances. With a manual focus camera, you select the part of the scene you want to be sharpest and adjust the lens barrel to obtain that result.

DSLR cameras use ground-glass viewing screens to show you how your picture will appear. Light coming through the lens strikes a translucent piece of glass that has been ground. This ground glass creates a surface on which the photographer, looking through the viewfinder or monitor on the back of the camera, can see and focus an image. The lens barrel can be automatically and/or manually controlled until the image appears at the desired level of sharpness. Ground-glass focusing can be aided by a microprism: a small circle in the center portion of the viewfinder that appears dotted until the image is focused. Sometimes a split-image focusing aid is used instead, whereby the image appears to be slightly out of register until it is focused. Rangefinder cameras rely on split-image focusing, which operates by superimposing two images of the same scene.



3.15 Image Factors Sensor Equivalency: Full-frame image sensors compared with smaller image sensors. The white rectangle shows what a full-frame DSLR or 35 mm film camera will record. The inner red frames show what a DSLR having a smaller digital sensor and corresponding image factors of 1.6X and 1.8X will record. This factor (which can be found in your camera manual) is sometimes called the *crop factor*, but no cropping is involved. The angle of view visible in the camera viewfinder will only be more or less than one expects.

Autofocus Modes

The majority of DSLRs have two focusing modes: Manual and Autofocus. Most DSLRs either have an active (infrared) autofocus (AF) or a passive autofocus system, which automatically focuses on objects at a certain distance from the lens. Active autofocus sends out a beam of red light that the camera uses to measure and set the distance of the subject. In passive autofocus, light that is naturally reflected by the subject is used to read the contrast of a scene and set the focus. Some cameras have an eye-activated autofocus system. Move your eye to the viewfinder and the camera focuses on whatever it is pointing at, based on your AF zone selections (see below), which can be turned off to prevent it from focusing every time something is near the viewfinder.

DSLRs usually have a variety of autofocusing zones. In single-area focus, the camera focuses on a subject in the selected area only; in area focus, the camera uses information from multiple focus areas to determine the focus; and in closest-subject focus, the camera automatically selects the focus area that has the subject closest to the camera. Pressing the shutter release button halfway down will lock autofocus at a specific distance. Autofocus options often include Single-servo and Continuous-servo focus settings. Single-servo locks the focus at the time of exposure. Continuous-servo allows the camera to focus constantly while the shutter-release button is pressed halfway, which is useful when photographing moving subjects. The downside of continuous focus is that it drains the battery faster and can be noisy. DSLRs offer an AF Assist Lamp, which flashes a small amount of light as a focusing aid, allowing the autofocus to function in low-light situations. Some cameras have specialty modes, such as face detection (FD), which gives precedence to the faces in an image, ensuring that they come out looking crisp and well lighted. The camera can pick out faces in a scene and is not thrown off by eyeglasses.

Types of Lenses

The lens defines the fundamental image characteristics of magnification, angle of view, and perspective; hence, lenses are designed for different purposes. A change in focal length allows you to come closer to the subject or to move away from it and therefore also has an indirect effect on an image's perspective. DSLR cameras typically use interchangeable lenses. Inexpensive cameras, such as in cell phones, often have fixed focal-length lenses, but the vast majority of all digital cameras come with either an interchangeable or fixed zoom lens that allows the focal length to be varied.

Zoom Lenses

In pre-digital times, most cameras came with a fixed focus lens, which required the photographer to physically move to change the distance between the camera and the subject. Today, most digital cameras have a zoom lens that covers the physical distance for you by combining a range of focal lengths into a single lens, providing both wide-angle and telephoto coverage. When using film cameras, photographers were aware of the focal length (angle of view) of the lens they were using. With digital cameras' different sensor sizes, little attention is paid to focal length, due to the lack of a standard formula for focal length to angle of view. Instead, we simply adjust the focal length as we compose the scene. Once photographers wrote down their exposure information to learn what combinations of aperture and shutter speed worked best for them in certain situations. Today's digital camera lens does not have an aperture ring. Instead, this information is shown in its data display. Now digital cameras automatically record the exposure information — lens focal length, aperture, shutter speed, and other camera functions of each exposure — for later reference (see later section on Metadata). This abundance of data is rarely analyzed because the automatic features on digital cameras can deliver good results 99 percent of the time. Nevertheless, the optical characteristics of lenses remain the same as in the past, and having a conscious awareness of their qualities can be useful in making stronger compositions and creating a more personal vision.

Normal Lens

In traditional 35 mm film photography, lenses with a focal length of 50 mm are referred to as "normal" because they work without reduction or magnification and generate two-dimensional images in a manner camera manufacturers considered similar to how humans see a scene with our naked eyes, which encompasses a picture angle of about 47 degrees. The straightforward optical qualities and minimal amount of distortion of a normal lens allows the formation of what was considered a natural photographic representation of the size relationships of the subjects that make up a composition.

A DSLR with a 35 mm equivalent size sensor also continues this tradition of using a 50 mm lens as its normal focal length. However, most DSLRs use a smaller size sensor, which needs a shorter focal length lens, somewhere in the range of 31 to 38 mm, to produce the same angle of view (47 degrees). This is because the smaller sensor multiplies the focal length of a 35 mm lens by about 1.5X, 1.5X is the sensor factor and can vary.

There are digital camera lenses designed to reduce the size of the image-forming circle as compared with regular 35 mm lenses. This decreases the telephoto effect and thereby allows for wider angles of view; plus, it trims down a lens's size and weight. For instance, a 12 mm digital lens used on a camera with a sensor factor of 1.5X would have an angle of view of 99 degrees. Check your manufacturer's website for details.

Wide-Angle Lens

Wide-angle lenses (short focal length) capture a broader view of a scene than a standard lens does by making subjects appear smaller than they would with a normal lens. A wide-angle focal length is handy for large scenes and in locations where it is not possible for one to move back far enough to photograph the entire scene. Wide-angle lenses encourage a photographer to step into the scene to fill the frame. Getting closer to your subject gives the composition a sense of involvement, by placing the viewer inside the action rather than at a distance from it.

Wide-angle lenses capture more subject detail by providing greater depth of field (the area of acceptable sharpness) at any given f-stop than a normal or telephoto lens. For instance, if you set your zoom lens to its widest focal length, focus on a subject 6 feet away, and stop down to f/11, it should render everything from about 3 feet to infinity in acceptable sharpness. This can be a very effective device in making dramatic near–far compositional relationships. For example, a landscape composition would have the predominant features in the foreground and a wide expanse in the background both sharply in focus. A moderately wide-angle focal length is an excellent starting place for environmental portraiture, compositions of people and their surroundings, because it has broader coverage than a normal focal length and produces minimum distortion, thus allowing both the people and the immediate area to be in critical focus. A wide-angle focal length allows one to photograph in confined interior spaces and to take in multi-story buildings. However, one must pay attention to the distortion of straight lines that can occur from "barrel distortion" with wide-angle lenses, which can be corrected (if desired) by careful composition or later with imaging software. An extremely wide-angle focal length offers tremendous depth of field, thus permitting one to get very close to a subject and produce exaggerated size relationships, unusual perspectives (due to distortion), and an intimate viewing experience which can be intentionally used to generate visual interest.

Because most pocket digital cameras have image sensors smaller than the 35 mm standard (which enhances the telephoto capabilities of the lens at the expense of reducing wide-angle coverage), an auxiliary wide-angle lens attachment is usually required to achieve wide-angle capabilities.

3.16 "I photographed the miniaturized interiors of my sister's old dollhouses with an ultra-wide-angle lens to suggest that they may be intimately occupied by the viewer. The scenes are intended to evoke deep unconscious fears and desires and explore tensions between childhood innocence and aggression. Gigantisized artifacts, elements, and unseen destructive entities act out against the unassuming environments. These transgressions reference adult anxieties that emerge early in life — desires for power and control; fears of natural disasters; domestic violence; understanding of our own potential for destruction; and the unknowable terrors that threaten to invade the tranquility of our insulated spaces of domesticity."

© Mark Slankard. *Bathroom with Twin Pop*, from the series *Minor Invasions*, 2005. 12 × 18 inches. Chromogenic color print (Duratran).

Telephoto Lens

Telephoto lenses (long focal length) have a narrower picture angle than a normal lens and make subjects appear larger. Telephoto lenses have less depth of field at any given aperture than normal or wide-angle lenses, allowing the subject to be sharp while the foreground and background are out of focus, making the subject clearly stand out. The limited depth of field means that focus is critical. Unlike wide-angle lenses that stretch space, telephoto lenses compress visual space, making subjects appear closer together than they really are. This can be useful in creating visual interest through unusual perspective. On the down side, telephoto lenses magnify lens movement so they require faster shutter speeds (see the shutter speed rule) or blurring will result. Telephoto lenses tend to be bulky, heavy, and are not as fast, having a higher starting aperture, than other lenses and often require a tripod or other support.

A telephoto is useful when it is not possible to get physically close to a subject, allowing photographers to take detailed pictures of distant subjects. A short telephoto focal length is excellent for portraiture. It permits a photographer to stand back from the subject and delivers a highly naturalistic rendition of the human face, avoiding the distortion typical of shorter focal lengths which exaggerate whatever is closest to the lens, usually the nose and chin. Wide-angle focal lengths also tend to stretch the shape of the human head, giving it an unnatural appearance. A longer focal length is good for tight compositions of small objects because you don't have to be right on top of the subject to fill the frame. The extra working space also leaves room for the placement of artificial lighting or the use of flash. A longer focal length is commonly used to capture close-range sports action. Wildlife photographers regularly use extremely long focal-length lenses to make close-up views of distance animals.

Special-Use Lenses

A macro lens, which is used in extreme close-up photography, focuses on subjects from a close distance, often allowing small subjects to be photographed 1:1. Most digital cameras have a Macro mode, which facilitates close-up work (see Chapter 9).

A *fisheye lens* has a super-wide angle of view — up to 180 degrees. It produces tremendous depth of field and extremely exaggerates the differences in size between subjects that are close to the camera and those that are farther away.

A *perspective control lens* shifts up, down, or sideways to correct for perspective distortion caused by parallel lines, such as on buildings, which tilt toward each other if the camera is tilted. Such a lens works properly only with a DSLR.

Ultimately, there is no such thing as a "normal" lens. Normalcy depends on how one sees the world. Some prefer wide-open expanses while others like a tighter, narrower view. Vision is not fixed. It can change depending on the subject or the maker's state of mind. When possible, you should experiment by using different focal lengths or physically changing the camera-to-subject distance to see how it affects your composition and the results you desire.

Shutter

Along with aperture, the shutter is the other key component of the imaging system, for it controls the amount of time (shutter speed) that the light-forming image strikes the sensor. Typically, DSLRs allow exposures as long as 30 seconds to as fast as 1/8000 of a second in small increments of time such as 1/60, 1/80, 1/100, or 1/125 of a second. They usually have a B (bulb setting), which allows the shutter to remain open as long as the shutter release button is held down. DSLRs may use a combined mechanical and CCD electronic shutter that turns the sensor off and on to control exposure time.

Shutter Speed Control

Shutter speeds can be controlled through the Shutter Priority mode: you choose the shutter speed via the command dial, and then the camera automatically selects the aperture. Or you can set it in Manual mode. The selected shutter speed generally appears in the data-panel readout display.

As the shutter speed increases, the amount of light reaching the sensor decreases. For example, a shutter speed of 1/125 of a second lets in twice the amount of light as a shutter speed of 1/250 of a second and half the amount of a shutter speed of 1/60 of a second. Slow shutter speeds will allow moving objects to blur, while high shutter speeds can be used to freeze motion.

Box 3.4 Shutter Speed Rule

Using a shutter speed equal to or greater than the focal length of the lens will help to ensure sharp, shake-free exposures.

To avoid blurry images caused by camera shake, follow the *shutter speed rule*: Use a shutter speed equal to or greater than the focal length of the lens. For example, when photographing with a 125 mm focal length, use a shutter speed of 1/125 of a second or higher.

Shutter Lag

Shutter lag is the time difference between when the shutter is pressed and when the camera actually captures the image, a gap of time that often makes you miss the moment you wished to record. Shutter lag is due to the camera having to calculate the exposure, set the white balance, focus the lens, charge the sensor, and transmit the capture data to the circuitry of the camera for processing and storage. It is more pronounced with smaller inexpensive cameras, whereas high-quality DSLRs have little or no shutter lag.

Camera Movement

Sometimes dim lighting conditions prevent one from following the shutter speed rule. To make imagemaking possible in such instances, many digital cameras offer an optical image stabilization option, which helps eliminate blurry photographs caused by camera movement. This feature works by means of a built-in gyro sensor that detects any hand movement and relays a signal to a tiny microcomputer inside the camera, which instantly calculates the compensation needed. A linear motor then shifts the lens as necessary to guide incoming light from the image straight to the CCD.

Shutter Modes

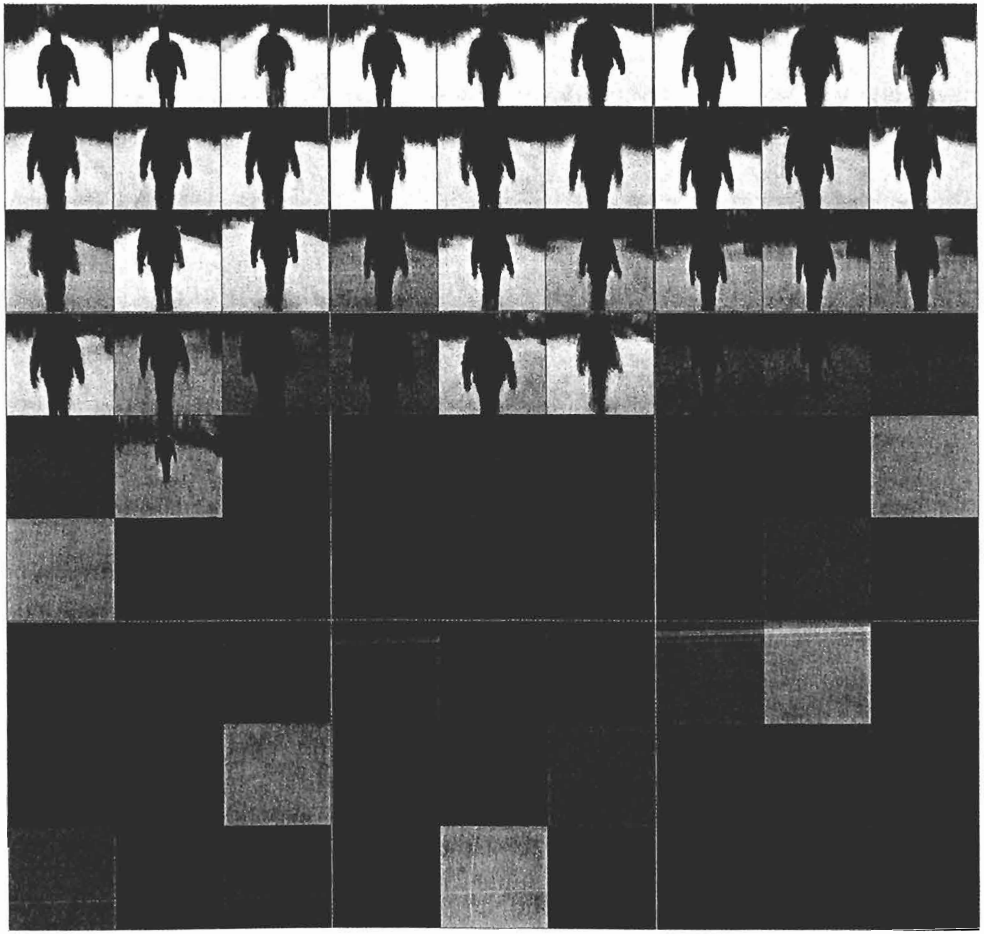
The shutter may be programmed for different shooting modes. *Single frame* takes one photograph each time the shutter release button is pressed. *Continuous* records photographs at faster rates, such as three frames per second, while the shutter release button is held down. *Self-timer* automatically fires the shutter about 10 seconds after the shutter release button is pressed, which is good for self-portraits or to reduce camera shake. The camera is usually placed on a tripod or a flat, level surface when in this mode. Some cameras also have an optional delayed remote control feature, which fires the shutter with a hand-held remote control. Some allow multiple exposures in one image, with the ability to automatically compensate for the multiple exposures. The selected shooting modes appear in the data-panel readout display.

In addition, many cameras offer Motion Image, which records short bursts of low-resolution moving images. Many cameras with this feature also have a microphone for recording audio when using the motion and still image recording features and a speaker to listen to the audio recorded on your motion and still image recording segments as you play them back on the monitor screen.

Determining Exposure

Proper exposure chiefly depends on (1) the lighting, (2) the subject, and (3) the desired depth of field. Each of these factors may require an adjustment in aperture size or shutter speed. You need to choose a combination of settings that will meet all your requirements (see Chapter 4).

The amount of light in a scene affects both shutter speed and aperture size. On a cloudy, overcast day, you would reduce the shutter speed and increase the f-stop. On a bright, sunny day, you would use a fast shutter speed and a small aperture.



3.17 The walking sequence was made using the camera's continuous shutter mode during the late afternoon on the winter solstice. "The principal function of the woman in a grid of multiple frames is to draw us into the landscape. We see her through the monoptical eye, the conventions of a moving (digital) camera which follows behind. Layered with the set of walking images is the representation of a kind of parallel, 'perfect' world, in this case the numeric world of the daily Sudoku puzzle, starting at 100% opacity in the upper left to 20% in the last walking image."
© MANUAL (Suzanne Bloom and Ed Hill). *Solstice 12.21.05/Daily Sudoku 12.21.05*, 2006. 34-1/2 × 35-3/4 inches. Inkjet print. Courtesy of Moody Gallery, Houston, TX.

The type of subject to be photographed may require an adjustment in the shutter speed, and depth of field may determine the aperture size. If the subject is moving, you must increase the shutter speed to stop the action. If you want greater depth of field in your photograph, you need to select a small aperture.

If you adjust either the shutter speed or the aperture size, you must also adjust the other to maintain the proper exposure. A fast shutter speed stops the action, but it also reduces the light reaching the sensor. To make up for this reduction in light, you should increase the f-stop. Similarly, a small aperture increases depth of field, but reduces the amount of incoming light. Therefore, you should change to a slower shutter speed.

Suppose you want to photograph your dog on a sunny day. A suitable exposure might be a shutter speed of 1/125 and an aperture of f/11. If your dog is moving, you might increase the shutter speed to 1/250. This speed is twice as fast as 1/125, and so half as much light will reach the digital sensor. You should make the aperture twice as large by setting it at f/8.

You may want the photo to include a bone on the ground in front of your dog, and also the bushes in the background. To make sure these extra subjects are in acceptable focus, you can increase depth of field by reducing the aperture size. At a setting of f/16, the sensor will receive half as much light as it did at f/11. You should also change the shutter to the next slowest speed, doubling the length of the exposure time. At a slow shutter speed, however, movement by your dog or the camera may cause blurring to occur. A better option in this situation might be to retain the faster shutter speed and increase your ISO setting. For details, see Chapter 4, Exposure and Filters.

Digital Camera Features

Resolution

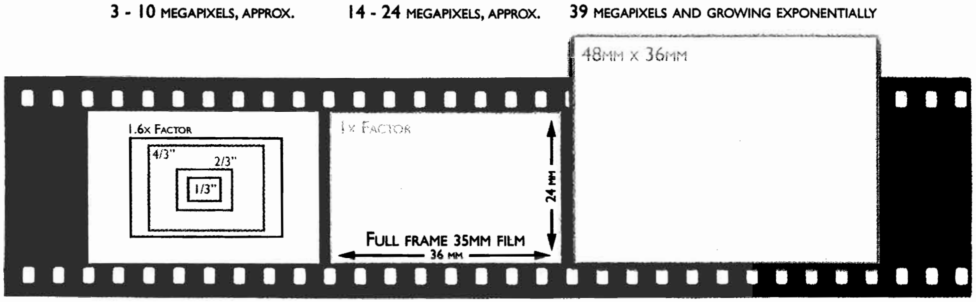
When choosing a digital camera, the key feature to consider, after optical quality, is the resolution that is measured in millions of pixels, known as *megapixels*. Generally, 1-megapixel digital cameras can create 2 × 1 inch prints at 300 PPI, without cropping, which are almost

Table 3.3 Camera Resolutions, Sensor Size, and Megapixels

Resolution, Megapixels	Digital Sensor Size, PPI	Largest Print Size at 300 PPI, Approx.
3.3 MP	1536 × 2048	4 × 7 INCHES
6.1 MP	2000 × 3008	6 × 10 INCHES
8.2 MP	2448 × 3264	7 × 11 INCHES
10 MP	2592 × 3872	8 × 12 INCHES
14 MP	3024 × 4536	11 × 15 INCHES
20 MP	3712 × 5248	12 × 18 INCHES
39 MP	5412 × 7212	16 × 22 INCHES

indistinguishable from 100 ISO 35 mm film. Digital cameras with 3 and 4 megapixels can make indistinguishable prints up to 5 × 7 or even 8 × 10 inches. Cameras with 5 or more megapixels have no problem producing 8 × 10 inch prints that are almost indistinguishable from film. The main advantage of choosing a digital camera with more megapixels is it allows you to crop more freely to produce high-quality 8 × 10 inch prints from selected areas of your image file. The camera only records resolution measured in megapixels (see Table 3.3).

The resolution of digital cameras is a gauge for comparing the image sharpness or detail. Digital resolution is determined by the number of light-sensitive pixels that convert light into electrons in the camera's image sensor. On a computer screen, a pixel is one of the tiny points of light that make up the image. The greater the number of pixels, the higher the resolution. On a digital camera, a pixel is a photodiode that records the color and brightness of the light



AS TECHNOLOGY ADVANCES AND SENSOR SIZE GROWS PAST TRADITIONAL FILM SIZES SENSORS WILL BE CALLED BY THEIR REAL DIMENSIONS LIKE FILM HAS BEEN SINCE ITS INVENTION. NO MORE ENCRYPTED CONVERSIONS LIKE 4/3" OR 1.6 FACTOR. JUST REAL DIMENSIONS!

3.18 This figure illustrates the relative size of several standard sensor sizes in both compact and single-lens reflex (DSLR) digital cameras today. Inexpensive compact digital cameras of fewer than 5 megapixels have very small digital sensors. These small sensors are often given an imperial fraction designation such as 1/3, 2/3, or 4/3. This type of measurement originates from the 1950s, during the time of early video imaging vacuum tubes for television. Trying to infer a relationship between the fraction and the actual diagonal size of these small sensors is futile, and we accept these sensors as small and capable of producing only 4 × 6 inch photographic-quality prints.

that hits it. For instance, a resolution of 1600 × 1200 indicates that the digital camera produces images at a maximum of 1600 horizontal pixels by 1200 vertical pixels, or 2.1 megapixels, compared with 20 million pixels for 35 mm color transparency film. DSLRs offer a selection of image sizes such as Large (3000 × 2000 pixels), for making 11 × 14 inch prints; Medium (2250 × 1500 pixels), for making 8 × 10 inch prints; and Small (1500 × 1000 pixels), suitable for email attachments or web pages.

Pro-consumer DSLR sensors are compared directly with the size of 35 mm film and have either a 1.5X, 1.6X, or 1.8X factor. Some high-end professional models have a digital sensor of 1X, which means the sensor is the same size as the image area of 35 mm film (24 × 36 mm). When the sensor size becomes larger than 35 mm film, sensors are then designated by their actual millimeter size. See Hasselblad's medium-format camera with a sensor size of 36 × 48 mm, shown earlier in Figure 3.6; it costs more than many full-sized automobiles!

Larger sensors are much more expensive to make, which sometimes makes large-sensor cameras cost-prohibitive even to professional photographers. Squeezing more pixels into a smaller-sized sensor has an adverse effect by increasing noise (see Figure 3.20). Manufacturers engage in a constant balancing act between cost, sensor size, and number of pixels. Fewer pixels in a larger sensor size will always create less noise or unwanted artifacts. This advantage is always offset by an increase in cost.

Monitor

The vast majority of digital cameras has a monitor on the back of the camera, which shows the image that the lens focuses on. Some can be moved in a variety of positions, thus increasing the framing options by letting one compose while holding the camera above your head or below your waist. When not in use, the monitor should be kept clean and protected with a detachable, transparent monitor cover. Some digital cameras have both a monitor and an optical viewfinder. Others have only a monitor or electronic viewfinder (EVF) (see Chapter 4).

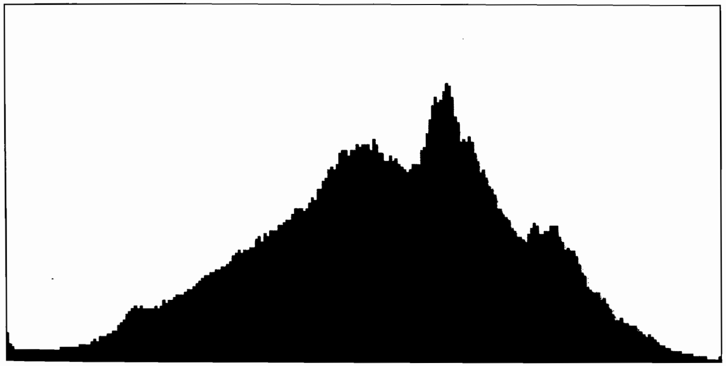
Compact and superzoom cameras and some DSLRs have a "live" monitor that is active whenever the camera is turned on. This allows one to compose an image without using an optical viewfinder, which has been eliminated on many cameras, and also lets you see previously recorded images in the camera's memory card so you can review your work as you make it. Monitors on most DSLRs are not live and only allow you to view previously made exposures. However, an after-market live screen can be added to the eyepiece of most DSLRs.

Composition guidelines can be displayed in the monitor and/or in the viewfinder. These thin horizontal and vertical lines make it easier to compose and/or to hold the cameral level. Monitors can quickly drain batteries; therefore, many DSLRs have a battery-saving option control that allows you to turn the monitor off or to program the length of time the monitor stays on.

Video screens, whether in cameras, cell phones, laptops, or electronic billboards, have become de facto windows of the digital age, and many people prefer using the screen to compose their images. Instead of peering through the keyhole of a viewfinder, a monitor allows one to hold a camera at arms' length, which invites more interaction with the subject while promoting more opportunities for creative compositions. On the down side, certain monitors (LCDs, or liquid crystal displays) can be difficult to see in bright light or at certain angles; they use a great deal of battery power and are not an accurate guide of color, tonal values, or focus. In the end, choosing between an optical viewfinder or a screen comes down to a matter of personal preference and the type of picture-making situation you find yourself in (see section in Chapter 4 on Using a Camera Monitor).

Monitor Playback Mode and Histogram

The monitor can display an image both while it is being recorded and afterward when the playback button is pressed. The playback mode offers other options, such as viewing all the images on the memory card as well as all the shooting data, from exposure information to image size, plus the histogram of each image. A histogram is a graph that shows the distribution of the tones in the image, known as *brightness range* (see Chapter 4, Figure 4.2). The horizontal axis corresponds to pixel brightness, with dark tones to the left and bright tones to the right. The vertical axis shows the number of pixels of each brightness in the image. The monitor allows for single-image playback and multi-image thumbnails, typically in groups of four or nine images. There are controls that allow you to zoom in and enlarge an image. Selected images can be deleted and/or protected from erasure.



3.19 "Observing how digital photographers evaluate the quality of their images by looking at the histogram to see the distributions of highlights, shadows, and mid-tones brought to mind Ansel Adams's Zone System. Then my thoughts turned to the language of histograms — the "peaks," "spikes," and "valleys" that compose these small charts. In them I saw landscapes, and I began to connect them to Adams's love of natural form and photographic technology. I acquired a book of Adams's favorite images, scanned the images, and evaluated the histograms, looking for a variety that alluded to a simple, graphic landscape form. Using screen capture, I "grabbed" the histograms and then reopened them in Photoshop where I resized them to a suitable print quality. Lastly I paired the histogram with the title of its original Adams image and added "(2006)" to the ends of the titles to denote that this was a contemporary re-envisioning of Adams's work. Digital technologies have not only changed the way photographs are made and how photographers work, but they've given us new tools with which to reinterpret the history and aesthetics of the medium. The works of the past are not finished; new interpretations are waiting to be made. Digital technologies continue to influence the way photographers work today; so too can they change the works of past image-makers."
© Luke Strosnider. *Dune, White Sands National Monument, New Mexico, circa 1942*, from the series *Ansel Adams/New Landscapes*, 2006. 11 × 17 inches. Inkjet print.

See Chapter 4 for details about how to use the camera monitor to help determine proper exposure.

Various camera menus can also be displayed. These include the Setup menu for basic camera programming, including formatting of memory cards and setting the date and time; the Shooting menu which controls such functions as noise reduction and image optimization; the Custom Setting menu which controls the fine details of the camera's operation, from grid display to whether the camera makes a noise when the shutter is depressed or not; and the Playback menu which offers options for managing the images stored on the memory card and for playing pictures back in various formats such as automated slide shows. The monitor can be programmed to turn off automatically to save battery power.

Metadata/EXIF

Metadata (also known as *shooting data*) is the data that describes the data recorded by the camera that gives details about the shooting conditions for each exposure, which is attached in a file that uses an industry standard awkwardly known as the EXIF. Typically, metadata records the shooting information such as the camera model, serial number, time stamp, the aperture and shutter speed, lens focal length, sensitivity, white balance, and whether the flash was used. It is also usually possible to add keywords, copyright, GPS coordinates, and other information useful when later searching for files. Metadata can usually be accessed via the Playback mode in the monitor after each exposure and later during image processing.

Optical and Digital Zoom

Digital cameras are equipped with optical zoom, digital zoom, or both. Optical zoom physically magnifies the subject by moving the lens elements to the desired magnification. Regardless of whether the zoom is set at wide-angle or telephoto settings, the resolution of the image remains the same.

Digital zoom electronically magnifies the image by increasing the number of pixels until the desired magnification occurs using interpolation. Interpolating is a set of mathematical algorithms automatically applied when the original pixel dimensions are changed for resizing. For instance, an image can be increased from 1000 pixels to 2000 pixels by generating a new pixel by using the average of the value of the two pixels on either side of the one to be created. Digital zoom constructs, or interpolates, pixels to zoom in on a subject, which results in loss of surrounding pixels and decreased resolution and degrades the overall image quality because the program "guesses" or makes up information that was not in the original.

Digital ISO/Sensitivity

Digital cameras allow users to adjust for different lighting conditions by changing the aperture and the shutter speed. Digital cameras use the ISO (International Standards Organization) designation to describe sensitivity to light and the resulting effect on an image. Typical ISO numbers are 50, 100, 200, 400, 800, and 1600. The higher the ISO number, the more sensitive the CCD is to light, allowing pictures to be made in low light conditions without a tripod or flash. Increasing the ISO also amplifies digital noise (see the next section: Digital Aberrations).

To compensate for varying light levels, digital cameras adjust the electrical gain of the signal from the sensor. Increasing the gain amplifies the power of the signal *after* it has been captured on the image sensor. The ISO of any individual frame can be changed. For example, one frame can be exposed outside at ISO 100 while another frame may be exposed indoors at ISO 800. ISO can be selected manually or automatically, where the camera automatically varies the sensitivity to ensure proper exposure and flash levels.

Digital Aberrations: Noise, Banding, Blooming, and Spots

Increasing the ISO has side effects. The higher the ISO setting, the greater the likelihood that pictures will contain "noise" in the form of randomly spaced, brightly colored pixels. Digital noise occurs most often in brightly lit or dark scenes where some pixels function incorrectly, resulting in "dead" or "hot" pixels. Hot pixels are bright white, whereas dead pixels lack all color. Using ISO 400 and higher or working in dim light may degrade the image quality with noise. Noise is a factor with all digital cameras, but it is reduced with higher megapixel cameras (see Figure 3.20). Many digital camera manufacturers suggest turning off "image sharpening" features, as these will exacerbate the noise problem (see section on Sharpening Mode). Imaging software programs usually have a Noise filter that can help reduce noise by discarding pixels that are too different from adjacent pixels.

Banding, unpredicted bands that appear in areas with no detail, is also more likely to occur at a higher ISO. Blown-out highlights that lack all detail and have spread or "bloomed" into adjacent image areas are caused by overexposure; this is known as *blooming*. Bracketing and exposure compensation are recommended to keep blooming in check. Most DSLRs can be custom programmed to automatically carry out these tasks.

DSLR cameras are designed for use with interchangeable lenses, and foreign matter can enter the camera when lenses are changed. Once inside the camera, foreign matter can adhere to the sensor or its low-pass filter, which is designed to help prevent moiré (an interference pattern of irregular, wavy lines). Dirt can adhere directly to the sensor and may appear as spots in images taken under certain conditions. These spots can be eliminated with imaging software. To reduce the chance of this occurring, point the camera down when changing lenses, try not to change lenses in dusty conditions, and use a clean body cap when there is no lens attached to the camera body. Check your specific camera manual for cleaning instructions.

White Balance

Digital cameras can automatically or manually adjust the color balance of each frame electronically, according to the color temperature of the light coming through the lens. One image can be white balanced for daylight, while the next one can be white balanced for incandescent (indoor) light. Better cameras have a larger variety of settings for different lighting sources; these can include any of the following: daylight, cloudy, shade, incandescent, and fluorescent (see Table 3.4). High-end digital cameras also offer white balance bracketing for mixed lighting sources. Learning how to adjust and control the white balance can mean the difference between capturing a spectacular sunset or having the camera automatically "correct" it down to gray sky.

Table 3.4 Common Digital White Balance Controls

Control	Description
Auto	White balance is automatically measured and adjusted.
Preset	White balance is manually measured and adjusted in the same lighting as the subject (a gray card is recommended as a target). This is useful under mixed-light conditions.
Daylight	Preset for daylight. Subsets let you make the image either more red (warm) or blue (cool).
Incandescent	Preset for incandescent (tungsten) light.
Fluorescent	Preset for fluorescent light. May have subsets for FL1 (white), FL2 (neutral), or FL3 (daylight) fluorescent lights. Check the camera owner's manual for the correct setting designations.
Cloudy	Preset for cloudy or overcast skies.
Shade	Preset for shade.
Flash	Preset for flash photography.
Bracket	Makes three different white balance exposures (selected value, reddish, and bluish).

Metering Modes

DSLRs have outstanding metering capabilities and options. Most offer *Matrix metering*, which uses the sensor to set exposure based on a variety of information from all areas of the frame, which is effective where the composition is dominated by bright and dark areas; *Center-weighted*, where the camera meters the entire frame but assigns the greatest weight to the center area, which is excellent for portraits; and *Spot*, where the camera meters a small circle (about 1 percent of the frame), which is helpful when the background is much brighter or darker than the subject. In particular modes, such as Aperture or Shutter Priority, the metering mode determines how the camera sets the exposure. In certain programs, such as Closest subject, the camera also selects the metering mode (Spot).

Aspect Modes

Some digital cameras allow you to select from different shooting aspect ratios, such as 16:9, 3:2, or 4:3, which alter the width and height of the image frame. For instance, the 16:9 mode allows you to make dramatic, wide panoramic images.

Color Modes

Digital cameras have image-processing algorithms designed to achieve accurate color, but there are variables within these programs and within the scene that may produce distinct color variations. Professional cameras offer a range of application modes. For instance, one mode might be optimized to set the hue and chroma values for skin tones in portraits. A second mode could be Adobe RGB gamut–based, which gives a wider range of color for output on color printers. A third mode could be optimized for outdoor landscape or nature work. Lastly, there can be a black-and-white mode.

Image Enhancement Modes

Digital cameras have programming modes that automatically optimize contrast, hue (color), outlines, and saturation based on the scene being recorded. Standard exposure modes include *Normal*, suggested for most situations; *Vivid*, which enhances the contrast, saturation, and sharpness to produce more vibrant reds, greens, and blues; *Sharp*, which sharpens outlines by making edges look more distinct; *Soft*, which softens outlines to ensure smooth, natural-looking flesh tones; *Direct Print*, which optimizes images for printing "as is" directly from the picture file; *Portrait*, which lowers contrast and softens background details while providing natural-looking skin color and texture; *Landscape*, which enhances saturation and sharpness to produce more vibrant blues and greens; and Custom, which allows you to customize color, contrast, saturation, and sharpness. Additionally, some cameras provide a monochrome image profile for making black-and-white images, which often can be tweaked to adjust sharpness, contrast, filter effects, and toning (see Table 3.5).

Table 3.5 Major Image Enhancement Modes

Enhancement Mode	Use
Normal	Suggested for most situations
Vivid	Enhances the contrast, saturation, and sharpness to produce more vibrant reds, greens, and blues
Sharp	Sharpens outlines by making edges look more distinct
Soft	Softens outlines to ensure smooth, natural-looking flesh tones
Direct Print	Optimizes images for printing "as is" directly from the picture file
Portrait	Lowers contrast and softens background details while providing natural-looking skin color and texture
Landscape	Enhances saturation and sharpness to produce more vibrant blues and greens
Custom	Customizes color, contrast, saturation, and sharpness
Monochrome	For black-and-white images

3.20 Images were shot on an overcast day with a man seated inside a darkly lit pickup truck. ISO was set to 1600 for greater depth of field during flash exposure. Higher ISO settings allowed for more detail in surrounding ambient light areas not affected by flash.

ISO 1600 WITH NOISE REDUCTION WITH SOME LOSS OF SHARPNESS

ISO 1600, NOISE IS MOST APPARENT IN THE SHADOWS

Sharpening Mode

Sharpening increases the contrast of pixels around the edges of objects to amplify the image's apparent definition or sharpness and is most noticeable around the borders of light and dark areas. Digital photographs appear somewhat soft in focus because the image formed by the sensor is mosaic in nature, like classic tile pictures found in ancient Pompeii. Most digital cameras interpolate this mosaic into a smooth picture, but sharp edges get slightly blurred during the process. Some cameras sharpen the image as part of their software; others allow you to control the degree of sharpening (if any) you want the camera to do. Usually, however, you'll want to fine-tune this process in your imaging software program as part of your processing. Many imagemakers prefer not to have the camera do any sharpening, but choose instead to precisely sharpen only as needed with their imaging software, as over-sharpening can excessively accentuate pixels, calling attention to them and thereby making an image appear exceedingly "digital."

DSLRs typically offer an array of sharpening modes including *Auto*, in which the camera automatically adjusts sharpening according to the subject, with results varying from image to image; *Normal*, where all images are sharpened by the same amount; *Low*, where images are sharpened by less than the standard amount; *Medium Low*, where images are sharpened by slightly less than the standard amount; *Medium High*, where images are sharpened by slightly more than the standard amount; *High*, where images are sharpened more than the standard amount; and *None*, where images are not sharpened at all.

Noise Reduction

Noise, in the form of randomly spaced, brightly colored pixels, may appear in an image capture when using an ISO of 400 or higher or in exposures of one second or longer. Quality cameras offer different levels of noise reduction levels: *Normal, High, Low,* and *Off*. Typically, noise reduction comes at the expense of sharpness. Cameras with excellent noise reduction capabilities are excellent when photographing in available or low-light situations. It is advisable to test your camera before using the noise reduction settings in critical situations, so you will know what to expect. Noise reduction software is also available for post-capture work (see Figure 3.20).

Image Stabilization

Many digital cameras with long (telephoto) focal-length zoom lenses have optical image stabilization or a variant such as anti-shake. Some systems are built into the camera body, while others are incorporated into each lens and are designed to deliver sharper pictures by counteracting camera shake.

Image-stabilized cameras and lenses use two tiny gyros that process camera movement and send a signal via a servomotor to move lens elements, a prism, or the sensor plane in the opposite direction that the camera moves. Basically, when you move one way, it moves the other way. This helps steady the image projected onto the sensor, which compensates for high-frequency vibration, such as hand shake that becomes noticeable during long exposures and when using long focal lengths.

Typically, optical image stabilization can allow you to take handheld shots at almost two shutter speeds slower than recommended. This is very useful when photographing moving subjects in low-light conditions or when panning and/or using long focal lengths (see Chapter 6). Stabilization gives huge improvements in sharpness between 1/2 of a second and 1/15 of a second with normal lenses and good results with telephoto lenses up to 1/500 of a second.

Flash

Most DSLRs have a small, built-in electronic flash that can be used effectively when subjects are 3 to 15 feet from the camera, focal lengths are no wider than 28 mm, and there is inadequate natural light. These little onboard units are good for fill flash, which can add a controlled amount of artificial daylight-balanced electric flash light to properly expose backlit subjects, bring out a subject that is in the shadows, or add a catch light to a subject's eyes. It is also referred to as flash-fill, fill-in flash, and balanced-fill flash. Most DSLRs can perform this function automatically and some allow manual override for custom results (for details see Chapter 4, Electronic Flash). DSLRs are often equipped with a "hot shoe" which will automatically synchronize very wide-angle lenses and larger optional flash units that cover greater distance.

Most DSLRs have a choice of flash sync modes, which allow the flash to synchronize with the shutter so that the flash goes off while the shutter is fully open. These modes include *Front-curtain sync*, used in most general, dim-lighting situations or when the subject is backlit; *Red-eye reduction*, which fires a small light about 1 second before the flash, causing the pupils in the subject's eyes to contract and thereby reducing the red effect sometimes caused by flash; *Slow-sync*, which is used with long shutter speeds to record both the subject and the background in low-light conditions or at night, usually with a tripod; *Slow-sync with red-eye reduction*, which combines both features; *Rear-curtain sync*, where the flash fires just before the shutter closes, producing a stream of light following a moving subject, usually with a tripod; *Slow rear-curtain sync*, which records both subject and background; and *Off*, where the flash will not fire so exposure can be made with available light only. In certain shooting modes, such as

3.21 Owens is widely known for his book *Suburbia* (1972) which presents an ironic tension between the idealism of his subjects who view their suburban homes as the realization of the American Dream and the detached superficiality of this lifestyle. This humorous image is part of a new documentary project showing the New Suburbia with a focus on the daily life of people in north Texas. It was made using his camera's built-in flash to bring out the detail in the statue of the longhorn cow in the foreground.

© Bill Owens. *Model Home, Plano, TX*, from the series *The New Suburbia*, 2006. Dimensions vary. Digital file. Courtesy of James Cohan Gallery, New York.

3.22 "This series of digitally enhanced images is based on notions of *familiarity, presence, artifice, and location* provoked by manufactured tourist imagery, especially 19th-century painted backdrops of exotic locations, and its significance on our perceptions of personal experiences. The location within the images has been constructed to simultaneously resemble nowhere and everywhere; this apparent recognition frames the encounter, attempting to construct nostalgia for a place never visited. The figure is artificially placed in the Xcape to reinforce the significance or insignificance of the vista by reenacting the posture of gazing meaningfully toward it. Here the model was photographed on nine separate occasions and locations utilizing natural lighting in conjunction with slow and rear flash."

© Martin Kruck. *Xcape #6*, 2005. 70 × 118 inches. Inkjet print.

Automatic, the flash will pop up and fire automatically when the program senses there is not enough light.

Memory Buffer

Higher-end digital cameras have a memory buffer for the temporary storage of images, allowing shooting to continue while the images are saved to the memory card. The camera will hold a number of these files in the buffer, depending on the quality (size) of the file. When the buffer is full, the shutter is disabled until enough data has been transferred to the memory card to make space for another image. This recording time can be as short as a few seconds or as long as many minutes and depends on the type of camera buffer and the speed of the memory card.