Chapter Three

Cameras

“Film is Dead,” read a 1956 headline in *Daily Variety*. The “cause” of its death was the invention of the first videotape recorder. Many “deaths” later, film still survives as an acquisition medium for movies and television. However, as the quality of video continues to improve, some productions that were once shot with film are now shot with one of the many, ever-expanding flavors of video.

Advocates of both film and video argue the merits of each. Video is cheaper because it does not need to be processed as film does. The argument goes like this: if you have less financial risk, you can take more creative risk. If you are a student on a limited budget, you will appreciate the fact that you can learn with video without overtaxing your bankroll. Some digital video camcorders are very small, enabling you to shoot in places where it would be difficult to position a film camera. However, because video is inexpensive, moviemakers sometimes shoot too much and then have difficulty sorting through all the footage and editing it.

Another advantage of video is that you can see your footage right away. You do not have to wait for processing to discover your mistakes. If you see the errors immediately, you can re-shoot when it is still inexpensive and convenient to do so, rather than after you have moved from the location. Other people can avail themselves of the footage faster, too. Material shot in the morning can be in the editor’s hands by lunch, even if the editor is in another city, because digital video can be sent over the Internet.

Digital footage also meshes more easily with other digital processes. Film footage must be transferred to video before it can be placed in a computer for editing, whereas digital video footage can skip the transfer stages. It is also easier to integrate digital footage with visual effects created in a computer.

On the other hand, film has been around longer and is better understood by veteran cinematographers. Some people like the “film look” and feel that video images are too harsh.

Many advertising agencies still prefer film not only because they are comfortable with film but
because they distribute their commercials around the world. Thirty-five-millimeter film is a world standard that can be found anywhere, whereas video forms come and go, making it difficult to archive material in a form that will stand the test of time.²

In this chapter we will look at characteristics of both video and film cameras and discuss their similarities and differences. For a professional, the central question is not “is whether film is better than video.” What’s really important is to choose the right acquisition media to match the project at hand.

**Aspect Ratio**

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One of the considerations with both film and video is the basic shape of a frame, often referred to as its aspect ratio. It is the ratio of the width of the frame to its height. In film, the most popular early aspect ratio (3 units of height to every 4 units of width) was eventually adopted by the Academy of Motion Picture Arts and Sciences as the standard for theatrical films. This Academy ratio, also expressed as 1.33:1 (a square would have an aspect ratio of 1:1), has been the aspect ratio for standard 8mm, 16mm, and 35mm film.³ Although 1.33:1 was an arbitrary frame configuration, the television industry also adopted the mildly rectangular 4:3 aspect ratio when it standardized its original frame shape.

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Partly in an effort to lure television viewers back to movie theaters in the 1950s, the motion picture industry developed several widescreen aspect ratios to produce a larger, more powerful film image. One method was to mask off the top and bottom of the 35mm film frame, a procedure that created the commonly used widescreen aspect ratios of 1.85:1 in the United States and 1.66:1 in Europe. Another method involved the use of an anamorphic lens to squeeze the widescreen image optically into the film frame, and then unsqueeze it onto the movie screen with an anamorphic lens on the projector. The anamorphic widescreen process created an extremely elongated rectangular frame, with an aspect ratio of 2.35:1.⁴

Occasionally, widescreen films are shown on television (or released on DVD) in the letterbox format, which masks off the top and bottom of the frame and displays the entire widescreen image within television’s standard 1.33:1 aspect ratio. More commonly, this
translation of aspect ratios involves some loss (or even reframing) of the original film image, a process referred to as **panning and scanning**.

The aspect ratio for **high-definition television (HDTV)** is 16:9, which is about 1.78:1, so it is much closer to the widescreen film formats than the standard 1.33:1 frame size (see Figure 3.1). Most digital video cameras provide the option of shooting with either a 4:3 or 16:9 aspect ratio.

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### Formats

Film **formats** have been standardized for many years, but new video formats are introduced regularly. Film formats are determined primarily by the actual width of the film in millimeters. However, it is possible to have two formats of the same width (Super 16 and regular 16mm, for example), so film formats are also based on the differences in image area and perforations. Video formats are even more complicated. They are based on factors such as recording medium, the method used to record the video signal, and the speed of recording.

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### Film Formats

The original motion picture format, invented by Thomas Edison and George Eastman in 1889, was **35mm**, which is basically the same film format used today for most theatrical motion pictures (see Figure 3.2). Perforations (**sprocket holes**) along the sides of the film, the 1.33:1 aspect ratio, a film speed of 24 frames per second, and placement of the sound tracks were eventually standardized. In the 1920s, Eastman Kodak introduced a new format, **16mm**, which was intended to encourage amateur filmmaking. This format proved to be too costly for most amateurs, but it became the choice for many educational and training films.

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**Super 8** was introduced in 1965, and was a variation on **8mm**, which had been around since the 1930s. Both formats used film that was 8mm wide, but by repositioning sprocket holes and making them smaller, Super 8 had a larger image area. In the same way, **Super 16**,
introduced in the early 1970s, provided more image space by eliminating sprocket holes on one side of the 16mm frame. Super 16 is often used for material that are going to will be transferred to video. It is cheaper than 35mm and is of better quality than standard 16mm. Its wider aspect ratio (approximately 1.66:1) makes it a good candidate for acquiring material that is going to be shown on HDTV as well as footage that is going to be blown up to a widescreen film aspect ratio. Formats larger than 35mm (primarily 70mm) have also been developed to improve the quality of theatrical films. Because 70mm is so expensive, it is usually reserved for big budget epic productions that can truly take advantage of the more dynamic image (see Figure 3.3).

These different formats require different cameras because they must be able to hold different sizes of film. In film, the producer selects a format based on the cost and the ultimate place of exhibition. The larger the format, the greater the image resolution and the more expensive the production. Because of the enormous cost associated with theatrical film formats, student moviemakers, if they work in film at all, usually work in Super 16, regular 16mm, or Super 8. However, Super 8 has been largely superseded by video camcorders, and it is becoming increasingly difficult to purchase and process.

**Analog Video Formats**

The original video format introduced by Ampex in the 1950s used 2-inch tape and a very large recorder that was separate from the camera. Over the next forty years, numerous video formats were developed. These formats (U-matic, VHS, Super VHS, Betamax, Betacam, Hi-8, and so forth) were analog rather than digital. Today, digital video formats have made analog formats almost obsolete. See how many VHS tapes are available at your local Blockbuster.

Analog recording produces a continuous electrical signal with a shape that is defined by the video wave it is representing. Digital equipment records the video information as a series of discrete on and off pulses in the form of zeros and ones (see Figure 3.4). The digital technique produces superior picture quality and also allows recorded material to be copied with a minimal loss of quality. This is because the on and off pulses of digital can be
repeated without degradation, whereas the shape of the analog signal changes slightly as it is
dubbed from one recorder to another. If you have ever seen a fourth-generation VHS tape, you
have seen the degradation process of analog recording.

***Insert Figure 3.4 here.***

**Digital Video Formats**

Sony introduced the first digital recording format, D1, in 1986, an expensive
system that used 1/2-inch cassette tape and a recorder separated from the camera. A progression
of formats followed that were costly and were used mainly in studio configurations. Then in
1993, Sony introduced a 1/2-inch Digital Betacam format, and in 1995, both Sony and
Panasonic came out with 1/4-inch digital formats: Mini-DV and DVCAM from Sony, and
DVCPRO from Panasonic (see Figure 3.5). These latter formats were all camcorders, so they
were suitable for using in the field. Independent filmmakers started using them for movies
because their cost was lower than film equipment and their quality was better than analog.

***Insert Figure 3.5 here.***

One of the differences between Mini-DV (sometimes referred to simply as DV)
and DVCAM is the size of the tape and the speed it moves through the camera. Although both
are 1/4-inch tapes, the DV container is smaller (about 2\text{-}1/4 in. \times 2 in.) than the DVCAM container, which is about 3 \times 5 inches (see Figure 3.6).
The DV camcorders can be very portable, in part because the tape container is so small.\footnote{The
DVCPRO format uses the larger tape container, but it is not compatible with DVCAM or DV
because of the type of tape it uses and because of internal machine differences, such as the speed
at which the tape moves.}

***Insert Figure 3.6 here.***

**High-Definition Video Formats**

Video formats can be either standard definition or high definition. Standard
Standard-definition television (SDTV)—the form of television that has been used since TV’s early days, is referred to in the United States as NTSC after the National Television System Committee, which designed it. It is a system that has 525 lines for each frame of video and shows them at a rate of 30 frames per second. The lines are interlace scanned; that is, odd lines (1, 3, 5, and so on) are projected, followed by even lines (2, 4, 6, and so on). All the odd lines are called one field, as are all the even lines, so a frame is comprised of two fields. Each line is called a PAL and SECAM exist in other parts of the world. These systems have 625 lines shown in an interlaced fashion at 25 frames per second; they differ in how they handle color. They are easier to transfer to film because the 25 frames per second is close to the 24-frame-per-second rate of film.

High-definition television (HDTV) has jokingly been called “anything that is slightly better than standard definition.” It has been under development since the 1970s, and cameras to accommodate it have come and gone. HDTV has suffered from numerous political problems, and there have been so many different HDTV formats proposed that camera manufacturers have not known what path to follow. All systems proposed more lines on the screen than SD with standard definition, but the number varied—720, 1,080, and 1,125, to mention a few. The first HDTV equipment was based on analog technology, but now it is digitally based. Early HDTV systems used interlaced scanning, but some later formats used progressive scanning, wherein all the lines are placed on the screen sequentially (see Figure 3.7) just like they are on a computer monitor.

After a long shake-out period, two standards seem to dominate television: 1080i (1,080 lines of interlaced scanning) and 720p (720 lines of progressive scanning). Studies of human perception have shown that a smaller number of progressive scan lines appears to be as sharp as a higher number of interlaced scan lines. Thus moving-image sequences of 720p are subjectively about the same as 1080i moving-image sequences. Both these formats use the
widescreen (16:9) aspect ratio and in the United States, both formats broadcast at 30 frames per second. Some networks (such as CBS and NBC) use 1080i and others (such as ABC and Fox) use 720p. Many digital cameras allow the operator to choose between these two formats. Of course, there are also new formats on the horizon, such as 1080p.9

A different standard, \textbf{24p}, has emerged for digital moviemaking, however. It has 1,080 lines and progressive scanning that operates at 24 frames per second (fps), the same speed as a film camera. Some 24p cameras are standard definition DV cameras that are being used by independent filmmakers and others to produce movies that are more film-like than those produced with typical 30 fps interlaced video cameras, and some are \textit{high-definition} cameras being used for TV network programming and high-budget movies. A 24p signal, as is, cannot be sent through the television airwaves, but it is an excellent format to use to combine with film or computer-generated visual effects. It has a \textbf{refresh rate} of 72, meaning that each frame is shown three times (24 \texttimes 3 = 72), giving even greater stability to the picture. The \textbf{24P24p} format received a big boost when George Lucas used it in the 2000s to shoot the new Star Wars episodes (see Color Plate 10).\textbf{[X-ref]} \textbf{[Au: The “X-ref” means to please double-check that the color plate mentioned here is the correct one.]} Sony developed the camera, called CineAlta (see Figure 3.8), and Panavision modified it slightly so the colors would look more like those shot on film. An improved version of the CineCineAlta, one that recorded four times the information of the original CineAlta camera, was used in Robert Rodriguez’s \textit{Sin City}.10

On the low-end of high-definition video is a new prosumer format called \textbf{HDV} (see Figure 3.9). This format grew out of the DV format and uses DV cassettes to record 16:9 HDTV. The main specifications for the format were agreed to by a consortium of equipment manufacturers (Canon, Sony, and JVC primarily) and call for both 1080i and 720p recording on DV tape. Prosumer cameras from Sony (1080i and 720p) and JVC (720p) do for HDTV what the original DV format did for standard definition video: provide a low-cost entry way into HDTV production.11
There are a number of technical parameters related to various formats (especially the digital video formats) that are important to understand. They give an indication of the quality of image you can expect from a camera and you often need to know them in order to interface effectively with your editing system. Four of the most crucial technical parameters are resolution, compression, color sampling, and bit depth.

Resolution is important for all the formats discussed above. It related to how sharp the image is and it is determined by the number of pixels that can be seen across the screen (horizontal resolution) times the number of pixels that can be counted going down the screen (vertical resolution).

This is not the same thing as scan lines. We have already mentioned that the NTSC system has 525 lines down the screen. NTSC’s vertical resolution is not really 525, however, because some of the lines are used for the vertical blanking (review Figure 3.7). The vertical resolution is actually about 480 lines. Horizontal resolution depends to some degree on the quality of your TV set, but over-the-air standard definition signals have a horizontal resolution of about 300, so the overall resolution is 300 by 480. Here are the resolutions of some of the formats we have been discussing:

- VHS – 200 by 480
- Hi-8 – 400 by 480
- Mini-DV – 720 by 480
- CineAlta 24P – 1,920 by 1,080
- 35mm film – 4,000 by 3,000

The higher the resolution, the better fine details will show when projected onto a large screen. This is one reason, at least for the time being, that film is still the desired medium for
theatrical projection.

**Compression**

The various digital formats all utilize some form of a compression-decompression scheme to reduce the amount of space needed to store the video information data and the amount of bandwidth required to transport that data. There are many different methods of doing this, each employing a different codec. The term codec stands for COmpressor-DECompressor. There are different codecs for still images (such as JPEG and BMP) and for moving images (such as MPEG-1, 2, and 4).

Many factors go into compression, but one way to look at it is that some of the frame information is left out. For example, one form of compression, called spatial compression, looks for repetition among pixels. It says, “All pixels in this sky area are light blue.” Then it does not record information about each pixel. To some degree, the picture loses sharpness and definition because, in reality, some of the pixels are slightly different shades of light blue than others. With some compression systems, called lossless, all information from the original clip is preserved; and when the material is decompressed, it is back to its original quality. This limits the degree of compression that can take place, however. With lossy compression, another type of system, some of the quality does not come back. For example, if the sky actually contained 80 shades of light blue, the lossy system might restore only 65 of those shades.

You can usually choose the amount of compression you want. A high compression ratio, such as 50:1, provides a lower-quality picture than a low ratio, such as 2:1, and generally means that you have to work with an image of poor resolution. The advantage of a high compression ratio is that you can get more footage on your hard drive because it uses the data occupy less room.

**Compression ratio** is another factor. The higher the compression ratio, the more compression that is applied to the data, allowing you to store more information but reducing the quality of the image. The DV/DVCAM format has a compression ratio of 5:1 whereas a Digital
Betacam has a lower compression ratio of 4:1. The formulas (algorithms) used in different codecs produce results that can vary widely in terms of how efficient they are and what kind of image quality they produce. Ideally, the information lost through compression-decompression does not impact the remaining image quality in a way that is too readily apparent. Image quality is affected, not only because of the different degrees of compression, but also because different formats sample color and brightness information in different ways.

**Color Sampling**

Color sampling is also expressed as a ratio. The chroma sampling ratio of 4:2:0 means that the two channels of component color information (2) are sampled at half the resolution of the brightness information (4). In other words, for every four times the brightness information is sampled, each color channel is sampled twice. This works because our eye is more sensitive to brightness than to color. Full-resolution color sampling (4:4:4) would result in significantly larger files. Thus, different codecs make the trade-off between compression efficiency and image quality. The DV standard for color sampling is 4:1:1. HDV is 4:2:0.

**Bit Depth**

The bit-depth (the number of individual 0 or 1 pulses) of the sampled signal also influences overall image quality; the higher the number of bits, the better the image quality. A single bit is the smallest unit of data. An 8-bit black-and-white image would have 256 different shades of gray (2 to the eighth power). When the image is color, it would be composed of 256 bits for each primary color (red, blue, and green) or 16 million shades of gray. The two most common video bit-depths for color video are 8 and 10 bit, but 12-bit and 14-bit color are used in some formats.

**Recording Media**

Selecting a film or videotape recording medium begins with the format you choose for your production. A 35mm film camera requires 35mm film, and a Mini-DV deck requires the right size Mini-DV cassette. However, the choice of a film stock has far greater impact...
technologically and aesthetically than does the choice of a video recording medium. The film stock itself produces the image, so the selection of a particular type of film profoundly affects the picture.

**Film Stock**

Motion picture film is composed of a thin layer of light-sensitive silver halide grains suspended in gelatin, the emulsion. The layer of emulsion is supported by a flexible, transparent base of acetate. Film is threaded in the camera so the emulsion is toward the light source; the lens focuses light onto the emulsion, and a photochemical reaction occurs. The areas of the photograph (each frame of the motion picture film is an individual photograph) that receive the most light will appear darkest when the film is developed (chemically processed and stabilized) in the laboratory.

Raw (unexposed) film should be stored in the refrigerator; film stored for 6 months or more should be stored in a freezer. Always allow stored film to warm up for about an hour before using it. Once the film is exposed, it should be processed as quickly as possible; and processed film should be stored at room temperature.

For one type of film, called negative film, the image must be printed on another piece of film to produce a positive image with correct photographic tones (that is, black as black and white as white). Another type of film, called reversal, requires additional processing in the laboratory to convert the film (the original film run through the camera) into a positive image. After processing, reversal film can be viewed (or projected) without the need to make a print.

Color film stock uses three layers (yellow, cyan, and magenta) of photosensitive dyes to produce all the colors in the visible spectrum.

You can also select a film stock based on how much light you will be using. If you want to shoot where there is not much light, you need to buy a fast film stock (one more sensitive to light) that has a high exposure index (EI) or ASA (for example, ASA 400). Or you may want a slow film stock (with a lower EI, such as 50) to produce a sharper, less grainy image. Film stock is also color balanced (designed to produce the correct colors in different types of light) for
artificial (tungsten) light or for daylight. Finally, even similar film stocks from different manufacturers (like Kodak, AGFA, and Fuji) have different tonalities—the range of colors (or black and white) that they reproduce.

Film technology has not stood still during the digital revolution. The quality and grain structure of modern film stocks has greatly improved during the last few years. Fast film stocks have gotten faster and less grainy. Many of these stocks can record an expanded range from dark to bright, are less sensitive to the color shifts between daylight and artificial light, and require less light than prior film stocks. In addition, because film is usually transferred to video for editing, some film stocks are manufactured to optimize their look as they are scanned electronically.

### Video Recording Media

The old standby for video recording has been a videocassette. These come in different sizes for different formats (1/2-inch for VHS, 1/4-inch for Mini-DV, etc.). Today there are many more choices for recording video information. The quality and sensitivity of the camera and its recording format have a greater impact on the sharpness of its image and its ability to produce an image in low light than does the size or type of recording medium.

Videotape is composed of a polyester base coated along one side with a thin layer of metal oxide. More expensive videotapes usually (but not always) provide some slight gain in image quality and color rendition and a reduction in dropouts (loss of signal due to imperfections in the tape’s surface). Videotape can, of course, be recorded over and used many times. However, because videotapes show wear after being used only a few times, most professionals would never consider using “used” tape stock for an important shoot.

Tape is unlikely to remain as the main recording material for video. Other media are gradually beginning to replace it. One of the major liabilities with tape is the amount of time it takes to access individual shots. The first shot that you might want to use in editing might be at the beginning of the tape while your second shot could be near the end.

Portable hard drives, solid-state flash memory (similar to the kind of memory device used in...
digital still cameras), and optical discs offer virtually instant access to individual shots. To some extent, they can be recorded over and over many times without the kind of damage (and dropouts) common to tape.

Another reason for going to newer recording media is that the huge amounts of information that need to be recorded as image quality improves with high definition. Also, hard drives, solid-state recording devices, and optical discs can capture image information in a format that can be plugged directly into an editing system without modification. All of these new recording media allow cameras to be smaller and more rugged because they can be designed with fewer moving parts (see Figure 3.10).\textsuperscript{13}

**Insert Figure 3.10 here.**

### Camera Construction

Film camera construction leans toward the mechanical, whereas video cameras are primarily electronic. This relates, at least in part, to the fact that film cameras were developed in the late 1800s, and video cameras were a product of the mid-1900s. But the principle is the same. When the camera is pointed at a scene, the lens gathers the light reflected from that scene and focuses it on an imaging device. Film stock is the imaging device in a film camera. In a video camera, it is either a charge-coupled device (CCD) or a complementary metal-oxide semiconductor (CMOS) chip.

**H2>**Film Cameras

Film stock comes loaded on either a core or a reel (see Figure 3.11), which is placed on a feed spindle inside the camera. It is important that the stock not be exposed to light, so film is usually loaded in a dark room\textsuperscript{[Au: OK for meaning?]}. The stock is threaded through the various gears, wheels, and pins of the camera, which hold it in place and move it past the lens opening to a take-up spindle (see Figure 3.12). The camera is then sealed shut.

**Insert Figure 3.11 here.**
A motor (operated either by battery or house current) powers the camera. In the camera, the film stock stops very briefly behind the lens opening so that light coming through the lens can strike it and create the chemical reaction that eventually results in a processed image. While the camera is pulling the next frame into place, a shutter closes behind the lens opening and momentarily blocks the light. It then swings out of the way so the next frame can be exposed. This happens over and over repeatedly at the rate of 24 frames per second. Some cameras have provisions for filming in slow motion or fast motion. The motor moves the film more quickly or more slowly, but the process is the same. After the film is exposed in this manner, it is taken out of the camera (again, in the dark) and sent to a film lab for processing.

Film projectors operate in much the same way. The processed film is threaded through the projector, and each frame stops momentarily behind the lens. Light from a bulb in the projector is used to project the frame onto a screen. This, too, happens at the rate of 24 frames per second, which, to the human eye, looks like continuous movement.

### Video Cameras

Video creates the illusion of movement in a different way. The first wave of digital video cameras used CCDs to transform the light coming through the lens into electrical signals that could be recorded on videotape. A CCD sensor is a solid-state device (a chip) that contains an array of individual light-sensitive pixels. Newer CMOS chips are starting to replace CCDs in many cameras. They produce less heat, require less power, and perhaps most importantly, cost less than CCDs. Both CCDs and CMOS sensors perform the same task: turning the light coming through the lens into a recordable signal. When the image is focused on the sensor, each pixel builds up an electric charge containing color (chrominance) and brightness (luminance) information.

**Chrominance** contains two components: hue and saturation. **Hue** is the specific tint of the color (for example, yellow, brown, red); **saturation** is the intensity or purity of the color (for example, a highly saturated deep blue, or a lightly saturated pale blue). **Luminance** is
the degree of darkness or lightness of the image (color or black and white), and it has an effect on the brightness of a color (see Color Plate 1). In professional cameras there are three chips, one for each primary color—red, blue, green (see Color Plate 2). The color is broken down (in proportion to the amount of each color in a scene) with a prism block behind the lens (see Figure 3.13).

***Insert Figure 3.13 here.***

The information captured on the chip is stored momentarily in a storage area in the chip until it is read out to create the video signal. The video frame does not exist as a single, discrete frame like a motion picture frame. It is a moving dot that travels electronically and eventually lights up phosphors on the TV screen one pixel at a time, line by line.

**<H1>Time Code**

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Time code is a numbering system that provides an address number for each frame of video. Most video systems record SMPTE time code. With it, 01:02:15:10 would mean the video was at 1 hour, 2 minutes, 15 seconds, and 10 frames. Time code is laid different places on different videotape formats, such as on one of the audio channels or on a special section of the tape specifically reserved for time code. Some camcorders do not come equipped with the components for recording time code in the field, but the code can be added in postproduction. Time code is most useful for editing (see Chapter 10).

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Time code can also be recorded on solid-state devices, discs, hard drives, audiotape (see Chapter 7), or film stock. On the set, time code information can be shown on a slate. This is a device that is held in front of the camera before the action of a particular shot begins. It gives such information as the name of the production, the director, and the scene that is being recorded (see Figure 3.14). If it includes time code, everything that was recorded at the same time will have the same time code number and can be easily synced at some later date.

Time code comes from a time code generator built into a camera or some external time code device. In the case of film, the time code is recorded directly on the film stock and is visible when
the film is processed. As the film is transferred to video for editing, a time code reader picks up the numbers from the film and records them along with the picture.

Other code numbers, such as Keykode, Mr. Code, edge numbers, and Aaton dots, are part of the film process and are used for editing and for cutting the original negative so that copies of the film can be made at a laboratory. These will be discussed in later chapters.

**Viewers**

Obviously, camera operators need to be able to see what they are recording. Film cameras have an eyepiece, a small viewer through which the camera operator looks to see the image as framed with the lens. To prevent unwanted light from seeping in and to see the image properly, you need to keep your eye up against the viewer (see Figure 3.15). This makes it difficult for people to wear glasses while peering through the viewer, but most eyepieces have a diopter that can be used to adjust the viewer, to compensate for nearsightedness and farsightedness. The eyepiece also makes it so only one person at a time can see the image. Cinematographers like this feature, but directors who want control over what is shot do not.

To aid the directors, video assist has been added to the repertoire of filming. A tap is taken off the film camera right behind the lens and this image is sent to a video monitor, usually by a wireless antenna system. The director (and others) can stand by the monitor and see exactly what is being shot and can make suggestions and corrections at that time. Material shown on the monitor can also be recorded onto tape and then viewed if desired.

Television cameras have viewfinders, which display an electronic image of what is coming through the lens to the chips. Some viewfinders are very tiny—the size of a film eyepiece. Others, such as those on studio cameras, are quite large so that the image can be easily seen while standing in back of the camera operating its controls. Between the extreme sizes are...
viewfinders (usually LCD screens) that pop out to the side of the camcorder and even flip around so that people being recorded can see themselves. Camcorder viewfinders can usually display not only the picture; but they can also show information about the status of the camera—such as how charged the battery is, how much tape remains, and what filters or light settings have been selected. The viewfinder can also be used to see what has been recorded on the tape when it is played back.

When a separate monitor is set up on a video shoot (see Figure 3.16), it is usually not referred to as video assist, but if more people need to see what is being shot than can see it on the viewfinder, a monitor feed can certainly be taken from the camera with ease. Many cameras have connections that allow them to show images, including those recorded on tape, on a regular home TV set. Using your TV is a particularly effective way to log what you have shot and to make some initial editing decisions.

***Insert Figure 3.16 here.***

### Basic Camera Features

Each camera model (video or film) has slightly different features, so you should always read the manual for the particular camera you are using. However, there are general features that relate to the operation of most film or video cameras. We have already discussed some of these functions, such as the ability to shoot 16:9 or 4:3 aspect ratios, and other features are addressed in the section on lenses later in this chapter. Audio applications of cameras are covered in Chapter 7. [X-ref]

### Power

Generally, cameras (film or video) require electrical power in order to function.\(^{18}\) One form of power is DC, which comes from batteries inserted into the camera or carried in an external battery belt or shoulder pack. Most cameras have some type of adapter (or power unit) that allows the camera to use AC current, and many consumer-grade cameras provide car battery adapters that plug into the cigarette lighter. Sometimes there is a switch on the camera for selecting the type of power (AC or DC) and there is a switch that turns the power on or off. In
some cameras the on/off switch has a **standby** position that allows the camera’s circuitry to warm up without using full power.

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Some rechargeable batteries develop a “memory” problem if they are not handled properly. If a camera is used only for a brief time and then the battery is removed and placed in the charger, eventually it will not be able to accept a full charge. This can be avoided by being sure the battery is fully drained before recharging. Most cameras have some sort of indicator to let you know the battery is running low. Some batteries have their own charging units; others can be recharged using the AC adapter.

Battery manufacturers are constantly trying to improve battery performance. Anyone who has used a piece of equipment that is battery dependent knows what is desirable: a powerful, long-lasting battery that is small in size, recharges quickly, and has no memory-effect.

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**Recording Controls**

Camcorders and film cameras are designed for use by a single operator and have a trigger-like switch for starting, stopping, or pausing. Usually, a strap near the front of the camera provides support for holding the camera by hand and also places the hand close to the switch and any controls that may be needed for focusing or zooming the lens.

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A film camera only starts and stops, but a camcorder has play, record, pause, fast forward, rewind, and stop. Of course, a film camera does not need many controls because you cannot view the footage after you shoot. Film cameras do have dials that show you how many frames or feet you have shot.

Most recorders also have some sort of metering system so you can evaluate the quality of the signal you are recording. The most professional recording devices have a number of separate meters—one for the image signal and one for each of the audio channels. Others have only one meter, but it can be switched to show either video or audio. Sometimes this same meter indicates the amount of charge in the battery. Camcorders have a variety of recording inputs and outputs for video and audio. The video output is most commonly used to connect the camera to a monitor. The audio inputs are used primarily for microphones (see Chapter 7). [X-ref]
**Menus**

Most video cameras have some kind of scrollable menu system that allows the user to access various camera settings. Depending on the camera, the operator may be able to choose the aspect ratio (4:3 or 16:9), the type of scanning (progressive or interlaced), the frame rate (24 fps, 30 fps, 60 fps), and a whole variety of audio and image settings. Frequently used menu settings on a camera can often be stored as presets. It may even be possible to assign these presets to a more easily accessible button on the camera. This allows the operator to call up the preset quickly without having to burrow down through a complicated menu scheme. Some cameras also allow this information to be stored on a thumb drive or other storage device to facilitate camera setup at a different time.

**Color Rendition**

Video cameras have a number of controls to adjust the picture for proper color rendition. With film, the overall color is controlled mainly by the choice of film stock. But with video cameras, a filter wheel or a switch permits selection of filters and other settings appropriate for various lighting conditions, such as sunlight or artificial light.

A closely related function, **white balance**, enables the camera operator to make more subtle adjustments in the camera’s ability to record white correctly, even in situations in which the lighting has a different hue—such as more red at sunset, or more blue in August than in December. Most cameras sense whether the camera is being used indoors or outdoors and adjust white balance automatically, but the more subtle adjustments require operator control. To white balance, you fill the frame with something white and push the white balance button. That sets the camera circuitry to recognize white, and all other colors can be set accurately from the white setting. Or, if you want to be creative, you can white balance on some other color such as yellow. This will fool the camera circuitry into thinking yellow is white and change all other colors accordingly (see Chapter 5). Increasingly, camera manufacturers are giving the user the opportunity to subtly adjust the camera’s chrominance and luminance values, providing...
a way to create a specific “look.”

**Gain**

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The signal strength (brightness of the picture) of many portable video cameras can be increased electronically by boosting the gain. Although this allows the camera to operate effectively at lower light levels, it creates more video noise (roughly comparable to increasing the grain in a film image). Usually, a two- or three-position switch on the camera boosts the gain in large increments, such as +9 **decibels (dB)** or +18 dB.

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Most consumer cameras are equipped with an **automatic gain control (AGC)** option that continuously adjusts the signal gain as the picture changes. In situations that call for a great deal of camera movement and different light levels, problems arise because the AGC is constantly compensating for varying levels of brightness and darkness. **Being able** to turn off the automatic gain control is a valuable asset.

**Shutter Speed**

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Many video cameras also contain an electronic shutter switch for different high-speed shutter settings. The shutter reduces exposure (requiring brighter light), which sharpens detail and helps eliminate blurring in shots with fast action (such as a racing car). This shutter should not be confused with the shutter in a film camera, which shuts out light as the film is moving.

**Other Features**

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Many consumer camcorders can insert the date and time on a recording, and some models can insert titles into a shot. Another switch may record an index search pulse to help locate that position during playback. Also, digital technology has made it possible to generate a number of in-camera visual effects, such as wipes, still frames, pictures in a picture, and fades. These are fine for recording vacations and parties, but moviemakers rarely use these add-ons. Titles and special effects are better done in the editing suite. Once you have the camera set for the way you want it for a particular shot, some cameras have a switch that memorizes all the settings so you can use them again for some other shot.
<H1>Lenses</H1>

Everything that is filmed or taped passes through the lens, so it is a very important part of the camera assembly. In fact, in some ways a camera is only as good as its lens. Given the clarity possible with high-definition television, good lenses have become even more important.  

Lenses gather light reflected by a subject and concentrate it on the imaging device. A lens hood is often mounted on the front of the lens to keep stray light from hitting the lens surface and causing unwanted glare. Lenses consist of curved glass elements that turn the image upside down at the optical center of the lens and then focus it at a point where it begins its electronic or photochemical journey to being recorded. In a film camera, this focus point is the film itself; in a video camera, it is the sensor chip.

<H2>Focal Length</H2>

Most lenses on TV cameras and camcorders are zoom lenses (sometimes called variable focal length lenses), capable of capturing close-ups, wide shots, and everything in between. Other lenses, called fixed lenses (or prime lenses), are capable of capturing only one perspective. Because they have fewer elements, prime lenses tend to be sharper. They may play a greater role in high-definition shooting. If you frame a close-up with a fixed lens, you cannot keep the camera in the same position and change to a wide shot unless you change to a different lens.

With a zoom lens you can make this change, either while you are recording or between shots. To do so, you must move elements within the lens by turning a barrel on the lens. This barrel can be turned by hand, but more often the barrel is turned remotely by a servo-controlled motor (see Figure 3.17). A switch on the camera allows the operator to activate and deactivate the zoom and to control its speed. The motor allows for a smoother zoom than can be accomplished by hand.

***Insert Figure 3.17 here.***  

All lenses, zoom or fixed, have measurements that designate their focal length. One
fixed lens may be a 25mm lens, whereas another is 50mm. A variable focal length lens may have a range of 10mm to 100mm. The focal length is the distance from the optical center of the lens to the point in the camera where the image is focused. The longer the focal length, the more the shot is magnified. A 50mm lens will show greater detail, but less of a scene, than a 25mm lens. A zoom lens that is in the 100mm position will have a tighter shot than when it is in the 50mm position.

The imaging system a particular camera uses also impacts the focal length. A 50mm lens on a 35mm camera produces a very normal perspective. That same lens on a 16mm camera has a magnifying effect because the target size (the frame) that the image is being focused on is smaller. Thus, focal length is determined both by the format you are using and the length of the lens.

Zoom lenses often have a designation that specifies the zoom ratio of the closest shot to the widest shot. For example, some lenses are 5:1, whereas others are 10:1. If the widest shot on a 5:1 lens is 20mm, the tightest shot will be 100mm. If the widest shot on a 10:1 lens is 20mm, the tightest shot will be 200mm. The bigger the ratio, the greater the zooming range—and the greater the cost of the lens.

Lenses or zoom lens positions that show shots that appear to be magnified are usually referred to as telephoto; those that show views roughly as the eye sees them are normal; those with a view wider than the human eye’s are called wide-angle. The normal lens creates the most natural perspective. The telephoto makes things appear bigger, but it also foreshortens them so that they appear to be closer to each other. If the objects are moving, they will appear to move more slowly than they actually are. The opposite is true of a wide-angle lens. It makes things appear smaller, farther apart from each other, and faster than normal if an object is approaching or receding from the camera position.

In effect, a zoom lens can be thought of as a lens having the characteristics of all the prime lenses that it can mimic within the extremes of its zoom range. It is so easy to go from wide-angle to telephoto that operators sometimes do not weigh the advantages or disadvantages
of a particular focal length setting. For example, an extreme telephoto shot can seem close to the subject and can fill the screen with detail, but at the cost of foreshortened depth, difficulty in holding the camera steady, and a touchy focus. At the other extreme of the zoom range (wide-angle), the opposite may be true. For example, although there is depth, the amount of detail needed to understand what is happening may not be discernible.

Zoom lenses often have a **macro** setting that allows the lens to focus on an object very close to the front element of the lens. A knob or some other control allows you to select the macro position for the lens to create a screen-filling close-up of a small object, such as a coin or a fingernail. Digital cameras sometimes provide a digital zoom that extends the range of the optical (mechanical) zoom through digital means, usually with some loss of image quality.

Although zoom lenses are standard on most video cameras, they are not always the best lenses to use. They are more expensive, mainly because they have more elements than fixed lenses (see Figure 3.18). They need more light, because light dissipates as it goes through these dozen or so elements. They cannot be manufactured to provide an optimum picture at all focal lengths. However, zoom lenses have the obvious advantage of changing magnification easily. They are also likely to deliver more consistent color than prime lenses. Color rendition changes slightly from one lens to another, so if a 25mm lens is removed from a camera and replaced with a 50mm lens, the color recorded may change slightly.

***Insert Figure 3.18 here.***

**<H2>Focus**

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**<TX>A lens has a ring for controlling **focus**, with numbers on the ring that give distance in feet (and inches) and meters. When something is in focus, it looks sharp and clear; when it is out of focus, it appears fuzzy and ill defined. When you look in the viewfinder while turning the focus knob, you usually can discern when the picture is in focus. However, a good practice is to look at the focus ring to make sure it reads a distance about the same as the actual distance to your subject. If you are 10 feet from a subject and your focus ring reads 3 feet, something is wrong with the optics. If focus is crucial, you can run a measuring tape from a mark**
on the camera that shows the location of the camera imaging device to the subject and set the focusing ring to correspond to the measurement (see Figure 3.19).

***Insert Figure 3.19 here.***

---<TXP> Many cameras have **automatic focus** in that they discern the distance from the camera to the object and adjust the focus accordingly. However, the automatic focus can be fooled. If the object you want in focus is at the right of the frame and another object is more to the center, the lens may focus on the wrong object. As with many of the other automatic features of cameras, auto focus is often best turned off.

The focusing mechanism for a fixed focal length lens is quite simple. It merely moves the lens elements closer to or farther away from the imaging device. When the object to be placed in focus is close to the camera, the elements should be far from the imaging device. If the shot is focusing on a distant object, the elements should be closer to the film, CCD, or CMOS.

To focus a zoom lens properly, zoom in all the way (the most magnified or telephoto setting), focus, then zoom out to frame the shot. This focusing technique allows you to zoom in or out during the shot without losing focus on the subject. This type of focusing sets what is referred to as the **front focus** because it changes the glass elements at the front of the lens. Zoom lenses also have a back focus, which should be adjusted only by a qualified camera technician. If the lens is jarred, this back focus can come out of adjustment, causing a fuzzy picture.

### Aperture

---<TX> In addition to the focus ring, lenses have a ring that determines how much light is let into the camera. This ring controls the size of the **aperture**—the opening in the lens that allows light to pass. The aperture has an adjustable **diaphragm** or **iris** that opens and closes to let in more or less light. The degree to which the aperture is open is measured in **f-stops**, and these numbers appear on the aperture ring.

---<TXP> F-stops can be confusing if for no other reason than that they are depicted by rather strange numbers: 1.4, 2, 2.8, 4, 5.6, 8, 11, 16, and 22. These seemingly unrelated numbers are the product of a mathematical formula that calls for multiplying each preceding number by
the square root of 2. In this relationship, each f-stop doubles or halves the amount of light of the
f-stop next to it. This relationship adds to the confusion because the larger the f-stop number, the
smaller the aperture. In other words, there is an inverse relationship between the two. An f-stop
of 8 will let in half as much light as an f-stop of 5.6; an f-stop of 11 will let in twice as much
light as an f-stop of 16 (see Figure 3.20).

Some lenses may include a t-stop scale. T-stops are more accurate than f-stops because
they take the particular lens into account. All lenses lose a certain amount of light within the lens
itself. T-stops denote the actual amount of light transmitted (thus the t in t-stop) through a
particular lens.

Lenses are rated according to their lowest f-stop number—the greatest amount of light
they can let in. An f/1.4 lens is considered a fairly fast lens because it can open up wide enough
to let in a good deal of light. An f/4 lens is a slow lens because it can let in much less light. As
with focus, many cameras have an automatic iris that adjusts to the amount of light hitting the
image plane and sets the f-stop accordingly with a small motor that opens and closes the iris.
Again, this is fine as long as you want average exposure. But if you want the scene to look dark,
or if you have a scene with a bright background and a dark foreground, you may need to turn off
the automatic iris.

Some situations require sacrificing overall exposure for the sake of correctly exposing
the most important element in the frame. One way to make sure that your light reading is correct
under these circumstances is to zoom in on that element and look at the automatic iris reading.
Then zoom back out to your intended composition, and set the iris manually for the f-stop
reading you had when you zoomed in. This is especially helpful if you have a person standing in
front of a bright background. The automatic iris might expose for the bright background, when
what you want to be able to see is the person’s features. If you have zoomed in and set the iris for
the person’s face, the face will be the element that is properly exposed.

**Depth of Field**
Depth of field is the distance (the range, really) through which objects will appear in sharp focus in front of and behind the point at which the camera is actually focused. The depth of field varies according to the aperture, the focal length of the lens, and the distance of the camera from the subject. The longer the focal length of the lens and the wider the aperture, the shallower the depth of field will be. Thus, wide-angle (or short focal length) lenses give a greater depth of field than telephoto (or long focal length) lenses. Generally, the closer the subject is to the camera, the less the depth of field will be.

When two characters or objects are lined up at different distances from the camera, it sometimes may be necessary to split the focus to keep both subjects in clear, sharp view. This is not done by focusing on a point midway between the two; rather, it is done by focusing on a point one-third the distance behind the front subject. In other words, focus will be sharp for an area one-third in front and two-thirds behind the point of focus (see Figure 3.21).

Focal length affects depth of field because wide-angle lenses have a greater natural depth of field than telephoto lenses. They are designed to capture large, deep scenes. The smaller the aperture (and the larger the f-stop number), the greater the depth of field. A lens set at f/22 will create a greater depth of field than one set at f/2.8. This characteristic can be used to highlight certain objects in the frame by having them, and only them, in focus. Most lens manufacturers and many publications such as the American Cinematographer Manual publish depth-of-field charts that give the depth-of-field characteristics for lenses of different focal lengths under various conditions.  

One of the greatest difficulties in high-definition video is the excessive depth of field caused by the small imaging area of CCDs or CMOS chips. In order to focus the light coming through the lens onto a smaller area (at least when compared to the size of a 35mm film frame) video cameras tend to end up with a depth of field that is much greater than the same lens on a comparable film camera. Film cinematographers have always used manipulation of depth of field as one of their most prized creative tools. Doing this with
video cameras (particularly the smaller format cameras) is more difficult (see Chapter 6).

**Camera Supports**

Many elaborate pieces of equipment have been designed to support cameras, including clasps for holding a camera on an airplane wing and platforms that mount on the side of a speeding car. But the types of supporting devices most common in electronic moviemaking are somewhat less exotic.  

**Handheld Cameras**

Cameras can be placed on the shoulder or hand-held without any special support. However, it is difficult to hold them steady for any long period, especially if you must walk or move in any other way. Most camcorders have a feature called *image stabilization* that helps compensate for shaky camera movement. There are two basic types of image stabilization: electronic and optical. The *electronic stabilizer* digitally magnifies part of the image and tracks the image if the camera moves. In effect, it keeps the picture stable even though the operator’s hands are moving slightly. This type of image stabilization may impact image quality by reducing the number of pixels used to create the picture. An *optical stabilizer* uses a prism and sensors to adjust the position of the image as it falls on the sensor chip. Image stabilizers cannot handle very large variations in movement, but they are a valuable feature to look for if your movie calls for a fair amount of handholding.

Another aid to stable handholding is a *shoulder mount* attached to the camera so that it rides comfortably on the shoulder. More elaborate *body braces*, such as a Steadicam, can also help the operator reduce unwanted camera movement. The Steadicam JR, a scaled-down version of the original Steadicam, was designed specifically for lightweight consumer camcorders (see Figure 3.22).

***Insert Figure 3.22 here.***

**Tripods**

The *tripod* is a three-legged device for supporting a camera. The lengths of its
legs are adjustable so that the tripod can be level, even if the surface on which it is resting is not (see Figure 3.23). Most legs will adjust so the camera can rise from 2 to 3 feet off the ground to slightly above eye level. If a camera needs to be lower, you can use a **high hat**, a board attached to very short legs. Tripod legs have spikes or pads on the bottom so they can rest firmly on the ground or a floor. Sometimes wheels are attached to the legs to make the whole unit mobile.

***Insert Figure 3.23 here.***

 Mounted on top of the three legs is a tripod **head**, a device with a handle that allows the camera to pivot smoothly (see Figure 3.24). A screw on the head attaches it to the bottom of the camera. Some heads (usually inexpensive ones) are referred to as **friction heads** and use the resistance created by surfaces touching each other to provide smooth movement.

More expensive **fluid heads** have adjustable hydraulic resistance that allows for easy, smooth camera movements. Both types have levers or screws that control the amount of freedom the camera has; heads can be locked down so they do not move at all, or they can provide varying degrees of movement.

***Insert Figure 3.24 here.***

**<H2>Dollies and Cranes**

**<TX>**Professional **dollies** are wheeled carts that come in various sizes, from the size of a wagon to the size of a small truck. They are usually motorized and have pneumatic wheels that can be mounted on tracks for extra smoothness. Sometimes these tracks come in a suitcase and can be rolled up like garden hose. [Au: OK for meaning?] There is a pole in the middle of the dolly on which the camera is mounted. Usually, one person drives or pulls the dolly while another operates the camera. **Dollies** are excellent for moves that involve going forward and backward. Students often concoct homemade dollies from wheelchairs, grocery carts, and the like.

**<TXP>Cranes** are large pieces of equipment, like the phone company’s cherry pickers,
that can move the camera from very low to very high above the set (see Figure 3.25). Many cranes can also move forward, backward, to the side, and in arcs. Several people may be required to move a crane from one position to the next. Cranes are expensive, so they are usually rented. A less expensive alternative is a jib-arm. It is another crane-like device that attaches, typically, to a tripod base. A jib-arm allows the camera to be moved above or below the subject with the same swooping effect as a crane movement. Jibs typically have a monitoring and control system that allows the jib operator full control of a camera that is suspended some distance away, at the end of the jib-arm (see Figure 3.26).

***Insert Figure 3.25 here.***

***Insert Figure 3.26 here.***

### Care of Equipment

All equipment and supplies mentioned in this chapter should be handled and stored carefully. They represent an investment on the part of an individual, a school, or a company. Careless handling shortens their life and causes unnecessary operating problems.

One good rule is *never force anything*. If you force a knob on a tripod, you may strip the threads. If a lens ring is binding or feels excessively loose, you are going to make things worse by forcing it. Driving a lever, switch, or dial against the end of its movement range will damage the equipment.

You should also protect equipment while transporting and storing it. Whenever possible, store and carry cameras, tripods, and lenses in sturdy, well-padded cases that hold the equipment securely in place. Before putting a tripod in the case, be sure that all levers are locked, the legs are bound together, and the handle attached to the head is positioned so that it cannot be damaged.

Similarly, monitors and other pieces of equipment should have their own cases. Even with cases to protect the equipment, everything should be moved as gently as possible. For cases that have wheels, use an elevator or a ramp if available. If necessary,
simply pick up the case and carry it a short distance.

Extreme heat or cold and moisture can damage most equipment. Keep lenses away from areas of high heat because the rubber cement holding the elements in place may melt. Store tape and film in a cool place, never in a parked car where the temperature can reach high levels. Dirt is also an enemy of electronic components. Keep equipment and supplies off the ground, especially if the area has sand or loose dirt.

Lenses should be kept spotlessly clean. Although it is possible to clean a lens, doing so often is not recommended. Anything touching a lens, even a cleaning cloth, can scratch it or wear down its antireflective coating. Fingerprints are especially bad for lenses. They produce a smear on the picture, and the oil from fingers can etch the lens over time. If the lens becomes dirty, remove dust gently with a camel’s hair hairbrush. Next, place a drop of special lens cleaner on a special nonabrasive lens tissue and rub it lightly over the lens surface in a circular motion.

One of the surest signs of professionalism is the respect with which a person treats equipment.

Notes


3. Super 16, because it has only one side of perforations, has a wider frame with an aspect ratio of 1.66:1. If you want to shoot 16mm and blow up the picture to widescreen, you are better off shooting in Super 16 than regular 16. There is also a 35mm format that is only three perforations long rather than four, so the aspect ratio is close to 1.85:1. This format reduces the size of the frame and saves about 25 percent of the cost of film stock.

4. There are actually far more aspect ratios in film. Between the two extremes, the 1.33:1 Academy ratio and the Cinerama 3:1 ratio, are nine sizes. For a good historical summary of aspect ratios, see Lenny Lipton, Independent Filmmaking (New York: Simon &
5. Film formats have never been quite as standard as this discussion suggests. The number of perforations per frame has varied from two to six, and at different times in film history ultra-large-screen film formats have been introduced with film widths of 62mm, 63mm, and 65mm. The IMAX format uses several frames of 35mm film placed sideways. The Cinerama format initially required three cameras at a frame rate of 26 frames per second. In fact, much of the experimentation with large-screen formats involves increasing the frame rate to a speed higher than the customary 24 frames per second standard, which increases sharpness and clarity.

6. There were many analog formats. Those that used 1-inch tape came and went several times. In the 1960s, a 1/2-inch reel-to-reel format was developed by Sony, and a 1/4-inch reel-to-reel was developed by Akai. A number of cartridge-based formats were introduced in the 1970s and 1980s that didn’t last long. A 1/2-inch cassette format called ED-Beta was developed by Sony in the late 1980s to appeal to the education market, but this market latched on to other formats and the ED-Beta was discontinued. And on and on.

7. A Mini-DV tape container can work in a DVCAM recorder, but the larger DVCAM tape container cannot, of course, fit into a DV camera. There are, however, some DV cameras that can record DVCAM tape stock packed into the Mini-DV shell.


10. Panasonic developed a 24p camera that has 720 lines of vertical resolution, but it has not received the acceptance of the 1080 camera. For more on 24p, see “Caring in High Definition,” TV Technology, 27 November 2002, p. 18.


12. Another type of compression is temporal compression. It looks for things that don’t change from frame to frame, such as buildings behind a person who is talking. This uses keyframes—the
ones for which all data are recorded. The fewer keyframes, the smaller the data rate, but the picture quality suffers. For more on codecs, see “What’s a Codec,” *P3*, June 2005, p. 152; and “Mr. MPEG,” *DV*, August 2003, pp. 40–46.


14. The motor makes the film travel through the camera faster for slow motion and slower for fast motion. The logic behind what seems to be a contradiction has to do with projection. When film that has been shot fast (say, at 48 fps) is projected back at 24 fps, each second of film shot will take 2 seconds to be projected. When film is shot slowly (for example, at 12 fps), one second of this film would be projected in one half of a second.

15. Early researchers credited this phenomenon to the so-called persistence of vision, the capacity of the human eye to retain each image (each projected frame) for a fraction of a second. Scientists, however, are still debating precisely how this process actually works. If the film projection rate is too slow, 8 frames per second, for example, the image appears to flicker. When the speed is increased to 16 or more frames per second, the viewer no longer perceives the flickering.

16. SMPTE stands for Society of Motion Picture and Television Engineers, the group that set time code standards.

17. The authors would like to express their appreciation to Ann Lu, writer and director, and Neal Fredericks, cinematographer, for providing us with the various photos from *Dreamers*, distributed by Pathfinder Home Entertainment.

18. Some film cameras have wind-up motors.


20. Making lenses for high definition was a challenge for lensmakers. The image needed to be wider and needed to be sharp at the edges, both things that are hard to accomplish. Lensmakers have been fairly successful at conquering the problems by making the diameter of the lens larger...
than it needs to be, by using high-quality glass, and by making the lenses by hand. All of this, of course, makes HD lenses more expensive than SD lenses. See “The Long and Short of Wide-Angle Zoom,” *TV Technology*, 24 November 2004, p. 12.


22. This is tied to depth of focus, a concept that is often incorrectly confused with depth of field. Depth of focus refers to the distance between the back of the lens and the target of the camera. If this distance is changed, the depth of focus is changed, and the picture will not focus properly. The focus can be adjusted by setting the lens at infinity and zooming in on a distant object. Then adjust the distance between the lens and the CCD or CMOS (the back focus) so that the image is sharp. When you zoom out, the image should stay sharp. If it doesn’t, adjust the back focus in the zoomed-out position until the picture is sharp. Now zoom in. Continue to do this until both the zoomed-in position and the zoomed-out position yield a focused picture.

23. Internet sites that provide depth-of-field charts include [www.outsight.com](http://www.outsight.com), [www.bep.co.uk/photo](http://www.bep.co.uk/photo), and [www.johnhendry.com](http://www.johnhendry.com).


Chapter 3 Captions

<FN>Figure 3.1 <FC>A variety of aspect ratios. PICKUP ART. Old 3.9

<FN>Figure 3.2 <FC>An Arriflex camera that uses 35mm film—the format that has been in use since the beginning of moviemaking. (Photo courtesy of Arri Inc.) PICKUP PHOTO. Old 3.3

<FN>Figure 3.3 <FC>A comparison of different film formats. (Artwork by Brian Gross) NEW ART. Provided on CD-R as 03.03 formats

<FN>Figure 3.4 <FC>The difference between analog and digital. The analog signal is continuous, and the digital signal samples the sound wave. PICKUP ART. Old 3.4

<FN>Figure 3.5 <FC>A Mini-DV camcorder. (Photo courtesy of Sony) NEW PHOTO from JVC or PICKUP PHOTO. Old 3.6

<FN>Figure 3.6 <FC>A small DV tape next to the larger DVCAM tape. (Photo courtesy of Brian Gross) PICKUP PHOTO. Old 3.5

<FN>Figure 3.7 <FC>The difference between interlaced and progressive scanning. (a) For interlace, the odd field lines (1, 3, 5, and so on) are scanned, moving left to right across each line. At the end of a line, the signal goes into a blanking mode and quickly retraces back to the left edge to begin scanning the next line. This continues until all the odd-numbered lines in the first field (half of the picture) are scanned. Then the signal goes into the vertical blanking mode while it moves back to the top of the picture to begin scanning the even-numbered lines that make up the other half of the picture. The scanning process for each field takes 1/60 of a second. Combining the two fields produces the full video frame in 1/30 of a second. (b) For progressive scanning, the lines are laid down one after the other to form an entire frame. PICKUP ART. Old 3.7

<FN>Figure 3.8 <FC>The CineAlta camera 24P high-definition camera in use. PICKUP PHOTO. Old 3.8

<FN>Figure 3.9 <FC>An HDV camera. (Photo courtesy of JVC) NEW PHOTO. Provided on CD-R as 03.09 HDV camera.

<FN>Figure 3.10 <FC>Three new storage media are represented by the removable hard drive
that is in the middle of the Ikegami high-definition camera (a); the solid-state memory card being inserted in the Panasonic P2 high-definition camera (b); and the blu-ray disc being inserted into Sony’s high-definition XDCAM. (Photo (a) courtesy of Ikegami; photo (b) courtesy of Panasonic Broadcast; photo (c) courtesy of Sony) NEW PHOTOS.

Provided on the CD-R as 03.10a hard drive, 03.10b flash memory, and 03.10c blu-ray.

Figure 3.11 A core (right) and a daylight reel. (Photo courtesy of Brian Gross)

Figure 3.12 A threading pattern for film. (Artwork by Michael Swank)

Figure 3.13 A prism block separates the light coming through the lens into its red, green, and blue components. Those three signals are then sent to the appropriate red, green, and blue CCDs. Eventually, the encoder recombines the three separate color signals to produce the full-color image.

Figure 3.14 A slate with a clapper and electronic time code. (Photo courtesy of Denecke, Inc.)

Figure 3.15 The proper way to look through a film camera eyepiece. (Photo courtesy of Dark Lantern Pictures, www.dreamersthemovie.com)

Figure 3.16 Producer-Director Greg Hodson checks out a shot for a Lifetime cable TV shoot. The black cloth over his head enables him to see the image on the monitor when it is in bright outdoor light. (Photo courtesy of Dalaklis-McKeown Entertainment)

Figure 3.17 A zoom lens with servo-control mounted on the left. Note the lens hood, which keeps stray light rays from the lens surface. (Photo courtesy of Angenieux Corporation of America)

Figure 3.18 A cutaway of a zoom lens showing the many different elements within. (Photo courtesy of Canon USA Inc.)

Figure 3.19. The film camera operator is measuring the distance from the camera
lens to the tire of a car so that when the car drives into view, the tire will be in sharp focus.

NEW PHOTO. Provided on CD-R as 03.19 measuring

<FN>Figure 3.20 <FC>The thin metal blades of the lens iris open or close the aperture to different f-stops. The smaller the opening, the larger the f-stop number (and the less light the lens will allow to enter the camera). Lens speed is based on how much light a particular lens will let in at its maximum aperture. Thus, a lens with a maximum aperture of f/1.2 is faster than a lens with a maximum aperture of f/2. PICKUP ART. Old 3.19

<FN>Figure 3.21 <FC>Depth of field and the one-third principle. PICKUP ART. Old 3.20

<FN>Figure 3.22 <FC>A small Steadicam JR™ made for lightweight consumer camcorders. (Photo courtesy of Cinema Products Corporation) PICKUP PHOTO. Old 3.21

<FN>Figure 3.23 <FC>A lightweight tripod. (Photo courtesy of Miller Fluid Heads) PICKUP PHOTO. Old 3.22

<FN>Figure 3.24 <FC>A fluid head that allows smooth, fluid pans and tilts. (Photo courtesy of Miller Fluid Heads) PICKUP PHOTO. Old 3.23

<FN>Figure 3.25 <FC>A crane. Note that it has space for mounting the camera and for the operator. (Photo courtesy of Matthews Studio Equipment, Inc.) PICKUP PHOTO. Old 3.25

<FN>Figure 3.26 <FC>A jib arm mounted on a tripod. (Photo courtesy of Promax) NEW PHOTO. Provided on CD-R as 03.27 jib arm.