**Photography**

**Photography**, technique of producing permanent images on sensitized surfaces by means of the photochemical action of light or other forms of radiant energy.

In today's society, photography plays important roles as an information medium, as a tool in science and technology, and as an art form, and it is also a popular hobby. It is essential at every level of business and industry, being used in advertising, documentation, photojournalism, and many other ways. Scientific research, ranging from the study of outer space to the study of the world of subatomic particles, relies heavily on photography as a tool. In the 19th century, photography was the domain of a few professionals because it required large cameras and glass photographic plates. During the first decades of the 20th century, however, with the introduction of roll film and the box camera, it came within the reach of the public as a whole. Today the industry offers amateur and professional photographers a large variety of cameras and accessories.

**Basic Technology**

Light is the essential ingredient in photography. Nearly all forms of photography are based on the light-sensitive properties of silver-halide crystals, chemical compounds of silver and halogens (bromine, chlorine, or iodine). When photographic film, which consists of an *emulsion* (a thin layer of gelatin) and a base of transparent cellulose acetate or polyester, is exposed to light, silver-halide crystals suspended in the emulsion undergo chemical changes to form what is known as a latent image on the film. When the film is processed in a chemical agent called a developer, particles of metallic silver form in areas that were exposed to light. Intense exposure causes many particles to form, while weak exposure causes few to form. The image produced in this manner is called a negative because the tonal values of the subject photographed are reversed—that is, areas in the scene that were relatively dark appear light, and areas that were bright appear dark. The tonal values of the negative are reversed again in the photographic printing process or, when preparing color transparencies (slides), in a second development process.

Photography, then, is based on chemical and physical principles. The sensitivity of silver halides to light is the primary chemical principle. The physical principles are governed by the physics of light . The generic term *light* refers to the visible portion of a broad range of electromagnetic radiation, which includes radio waves, gamma rays, X rays, infrared, and ultraviolet rays. The human eye is sensitive to only a narrow band of electromagnetic wavelengths, called the visible spectrum. The spectrum comprises the full range of color tones. To the eye, the longest wavelengths register as red, the shortest as blue.

***Photographic Film***

Photographic films vary in the way they react to different wavelengths of visible light. Early black-and-white films were sensitive only to the shorter wavelengths of the visible spectrum—that is, to light perceived as blue. Later, colored dyes were added to film emulsions to make the silver halides responsive to light of other wavelengths. These dyes absorb light of their own color, making silver halide particles sensitive to light of that color. Orthochromatic film, incorporating yellow dyes in the emulsion and sensitive to all light but red, was the first improvement on simple blue-sensitive film.

In panchromatic film, the next major improvement, red-toned dyes were added to the emulsion, rendering the film sensitive to all visible wavelengths. Although slightly less sensitive to green tones than the orthochromatic type, panchromatic film is better able to reproduce the entire range of color tones. Thus, most films now used by amateur and professional photographers are panchromatic.

Two additional varieties of black-and-white film—process and chromogenic—have their special uses. Process film is used primarily for line reproduction of copy in the graphic arts. Such films have extremely high contrast, producing images with no tonal values between black and white. Chromogenic film produces dye images rather than silver images on the negative. Using dye couplers and silver halide in the emulsion, it can be developed by standard color-negative development processes. After development, the silver is bleached out of the film, leaving a black-and-white dye image.

Special-purpose films are sensitive to wavelengths beyond the visible spectrum. In addition to visible light, infrared film also responds to the invisible, infrared portion of the spectrum (see Infrared Photography, below).

Instant film, introduced by the Polaroid Corporation in the late 1940s, provides photographs within seconds or minutes of the taking of the picture, using a camera specially designed for this purpose. In instant film the processing chemicals and emulsion are combined in a self-contained envelope or on the print itself. Exposure, development, and printing all take place inside the camera. Polaroid, the leading manufacturer of this film, uses a conventional silver-halide emulsion. After the film is exposed and a negative image produced, the negative is sandwiched with photographic paper and processing chemicals, and a fogging agent transfers the negative image to the paper, producing a print. A number of instant films are manufactured in a 35-millimeter format, both in black and white and in color.

**Color Film**

Color films are more complex than black and white because they are designed to reproduce the full range of color tones as color, not as black, white, and gray tones. The design and composition of most color transparency films and color negative films are based on the principles of the subtractive color process, in which the three primary colors—yellow, magenta, and cyan (blue-green)—are combined with their complements to reproduce a full range of colors. Such films consist of three silver halide emulsions on a single layer. The top emulsion is sensitive only to blue. Beneath this is a yellow filter that blocks blues but transmits greens and reds to the second emulsion, which absorbs greens but not red. The bottom emulsion records reds.

When color film is exposed to light by a camera, latent black-and-white images are formed on each of the three emulsions. During processing, the chemical action of the developer creates actual images in metallic silver, just as in black-and-white processing. The developer combines with dye couplers incorporated into each of the emulsions to form cyan, magenta, and yellow images. Then the film is bleached, leaving a negative image in the primary colors. In color transparency film, unexposed silver-halide crystals not converted to metallic silver during the initial development are converted to positive images in dye and silver during a second stage of development. After the development action has been arrested, the film is bleached and the image fixed on it.

**Film and Camera Formats**

Different types of cameras require particular forms and sizes of film. Currently, the most widely used camera format is the 35 millimeter or small format, which produces 20, 24, or 36 images that each measure 24 by 36 millimeters on a roll of film. The film is wound on a spool inside a lighttight magazine or cartridge. Film for 35-millimeter cameras is also available in bulk, in long rolls that can be fed into individual cartridges and cut to length.

The next larger standard camera format, medium format, uses film sizes designated as either 120 or 220. Medium-format cameras produce images of various sizes, such as 6 by 6 centimeters or 2ј by 2ј inches, 6 by 7 centimeters, and 6 by 9 centimeters, depending on the configuration of the camera. Larger cameras, called view cameras, use sheet film. Standard sheet-film sizes correspond to standard view-camera formats: 4 by 5 inches, 5 by 7 inches, and 8 by 10 inches. Larger special-purpose view cameras, up to a 20-by-24 inch format, are in limited use.

**Film Speed**

Film is classified by speed as well as by format. Film speed is defined as an emulsion's degree of sensitivity to light, and it determines the amount of exposure required to photograph a subject under given lighting conditions. The manufacturer of the film assigns a standardized numerical rating in which high numbers correspond to “fast” emulsions and low numbers to “slow” ones. The standards set by the International Standards Organization (ISO) are used throughout the world, although some European manufacturers still use the German Industrial Standard, or Deutsche Industrie Norm (DIN). The ISO system evolved by combining the DIN system with the ASA (the industry standard previously used in the United States). The first number of an ISO rating, equivalent to an ASA rating, represents an arithmetic measure of film speed, whereas the second number, equivalent to a DIN rating, represents a logarithmic measure.

Low-speed films generally are rated from ISO 25/15 to ISO 100/21, but even slower films exist. Kodak's Rapid Process Copy Film, a special process film, has an ISO rating of 0.06/-12. Films in the ISO 125/22 to 200/24 range are considered medium speed, while films above ISO 200/24 are considered fast. In recent years, many major manufacturers have introduced superfast films with ISO ratings higher than 400/27. And certain films can be pushed well beyond their ratings by exposing them as though they had a higher rating and developing them for a greater length of time to compensate for the underexposure.

DX Coding is a recent innovation in film and camera technology. DX-coded cartridges of 35-millimeter film have printed on them a characteristic panel corresponding to an electronic code that tells the camera the ISO rating of the film as well as the number of frames on the roll. Many of the newer electronic cameras are equipped with DX sensors that electronically sense this information and automatically adjust exposures accordingly.

Differences in sensitivity of a film emulsion to light depend on various chemical additives. For example, hypersensitizing compounds increase film speed without affecting the film's color sensitivity. High-speed film can also be manufactured by increasing the concentration of large silver-halide crystals in the emulsion. In recent years, a generation of faster, more sensitive films has been created by altering the shape of crystals. Flatter silver-halide crystals offer greater surface area. Films incorporating such crystals, such as Kodak's T-grain Kodacolor films, have a correspondingly greater sensitivity to light.

The grain structure of faster films is generally heavier than that of slower films. Grain structure may give rise to a mottled pattern on prints that have been greatly enlarged. Photographs taken with slower-speed film appear less grainy when enlarged. Because of the small size of their silver-halide grains, slow-speed films generally have a higher *resolution*—that is, they can render fine details with greater sharpness—and can produce a broader range of tones than fast films. When tonal range and sharpness of detail are not as important as capturing a moving subject without blurring, fast films are used.

**Exposure Range**

Each type of film has a characteristic exposure range, or latitude of exposure. Latitude is basically the margin of error in exposure within which film, when developed and printed, can render the actual color and tonal values of the scene photographed.

The terms *overexposure* and *underexposure* are used to characterize deviations, purposeful or unintentional, from the optimum exposure. Film exposed to light for a longer time than optimal will often be “blocked up” with silver in highlight areas, resulting in a loss of contrast and sharpness and an increase in graininess. Underexposure, on the other hand, produces negatives characterized as thin, a condition in which there are not enough silver crystals for accurate rendering of dark and shadowed areas.

With films that have a narrow latitude, an exposure adjusted for a shady area is likely to result in overexposure of adjacent sunny areas. The greater a film's latitude, the greater its ability to provide satisfactory prints despite over- or underexposure. Films from which negatives are made, both color and black and white, generally offer enough latitude to allow the photographer a certain margin of error. Transparency films, from which color slides are made, generally have less latitude.

***The Camera and Its Accessories***

Modern cameras operate on the basic principle of the *camera obscura* . Light passing through a tiny hole, or *aperture,* into an otherwise lightproof box casts an image on the surface opposite the aperture. The addition of a lens sharpens the image, and film makes possible a fixed, reproducible image. The camera is the mechanism by which film can be exposed in a controlled manner. Although they differ in structural details, modern cameras consist of four basic components: body, shutter, diaphragm, and lens. Located in the body is a lightproof chamber in which film is held and exposed. Also in the body, located opposite the film and behind the lens, are the diaphragm and shutter. The lens, which is affixed to the front of the body, is actually a grouping of optical glass lenses. Housed in a metal ring or cylinder, it allows the photographer to focus an image on the film. The lens may be fixed in place or set in a movable mount. Objects located at various distances from the camera can be brought into sharp focus by adjusting the distance between the lens and the film.

The diaphragm, a circular aperture behind the lens, operates in conjunction with the shutter to admit light into the lighttight chamber. This opening may be fixed, as in many amateur cameras, or it may be adjustable. Adjustable diaphragms are composed of overlapping strips of metal or plastic that, when spread apart, form an opening of the same diameter as the lens; when meshed together, they form a small opening behind the center of the lens. The aperture openings correspond to numerical settings, called *f-stops,* on the camera or the lens.

The shutter, a spring-activated mechanical device, keeps light from entering the camera except during the interval of exposure. Most modern cameras have focal-plane or leaf shutters. Some older amateur cameras use a drop-blade shutter, consisting of a hinged piece that, when released, pulls across the diaphragm opening and exposes the film for about 1/30th of a second.

In the leaf shutter, at the moment of exposure, a cluster of meshed blades springs apart to uncover the full lens aperture and then springs shut. The focal-plane shutter consists of a black shade with a variable-size slit across its width. When released, the shade moves quickly across the film, exposing it progressively as the slit moves.

Most modern cameras also have some sort of viewing system or viewfinder to enable the photographer to see, through the lens of the camera, the scene being photographed. Single-lens reflex cameras all incorporate this design feature, and almost all general-use cameras have some form of focusing system as well as a film-advance mechanism.

**Exposure Control**

By adjusting shutter speed and diaphragm aperture, the photographer obtains just enough light to ensure a proper exposure. Shutter speed and aperture setting are directly proportional: A one-increment change in shutter speed is equal to a change of one f-stop. A “one-stop” adjustment in exposure can refer to a change in either shutter speed or aperture setting; the resulting change in the amount of light reaching the film will be the same. Thus, if the shutter speed is increased, a compensatory increase must be made in aperture size to allow the same amount of light to reach the film. Fast shutter speeds, 1/125th of a second or less, are more effective in capturing objects in motion.

In addition to regulating the intensity of the light that reaches the film, the diaphragm aperture is also used to control the depth of field. Also called the zone of focus, depth of field refers to the area in which objects recorded in the picture will be sharply focused. Decreasing the size of the aperture increases the overall depth of field; widening the aperture decreases the depth of field. When great depth of field is desired—maximum sharpness of all points in the scene, foreground to background—a small aperture and slow shutter speed are used. Since the faster shutter speeds needed to capture motion require, in compensation, larger apertures, the depth of field in such pictures is reduced. On many cameras, the lens ring contains a depth-of-field scale that shows the approximate sharp-focus zone for the different aperture settings.

**Camera Designs**

Cameras come in a variety of configurations and sizes. The first cameras, “pinhole” cameras, had no lens. The flow of light was controlled simply by blocking the pinhole. The first camera in general use, the box camera, consists of a wooden or plastic box with a simple lens and a drop-blade shutter at one end and a holder for roll film at the other. The box camera is equipped with a simple viewfinder that shows the extent of the picture area. Some models have, in addition, one or two diaphragm apertures and a simple focusing device.

The view camera, used primarily by professionals, is the camera closest in design to early cameras that is still in widespread use. Despite the unique capability of the view camera, however, other camera types, because of their greater versatility, are more commonly used by both amateurs and professionals. Chief among these are the single-lens reflex (SLR), twin-lens reflex (TLR), and rangefinder. Most SLR and rangefinder cameras use the 35-millimeter film format, while most TLR as well as some SLR and rangefinder cameras use medium-format film—that is, size 120 or 220.

*View Cameras*

View cameras are generally larger and heavier than medium- and small-format cameras and are most often used for studio, landscape, and architectural photography. These cameras use large-format films that produce either negatives or transparencies with far greater detail and sharpness than smaller format film. View cameras have a metal or wood base with a geared track on which two metal standards ride, one in front and one in back, connected by a bellows. The front standard contains the lens and shutter; the rear holds a framed ground-glass panel, in front of which the film holder is inserted. The body configuration of the view camera, unlike that of most general-purpose cameras, is adjustable. The front and rear standards can be shifted, tilted, raised, or swung, allowing the photographer excellent control of perspective and focus.

*Rangefinder Cameras*

Rangefinder cameras have a viewfinder through which the photographer sees and frames the subject or scene. The viewfinder does not, however, show the scene through the lens but instead closely approximates what the lens would record. This situation, in which the point of view of the lens does not match that of the viewfinder, results in what is known as *parallax.* At longer distances, the effects of parallax are negligible. At short distances, however, they become more pronounced, making it difficult for the photographer to frame a scene or subject with certainty.

*Reflex Cameras*

Reflex cameras, both the SLR and the TLR types, are equipped with mirrors that reflect in the viewfinder the scene to be photographed. The twin-lens reflex is box-shaped, with a viewfinder consisting of a horizontal ground-glass screen located at the top of the camera. Mounted vertically on the front panel of the camera are two lenses, one for taking photographs and the other for viewing. The lenses are coupled, so that focusing one automatically focuses the other. The image formed by the upper, or viewing, lens is reflected to the viewing screen by a fixed mirror mounted at a 45-degree angle. The photographer focuses the camera and adjusts the composition while looking at the screen. The image formed by the lower lens is focused on the film at the back of the camera. Like rangefinder cameras, TLRs are subject to parallax.

In the SLR type of reflex camera, a single lens is used for both viewing the scene and taking the photograph. A hinged mirror situated between the lens and the film reflects the image formed by the lens through a five-sided prism and onto a ground-glass screen on top of the camera. At the moment the shutter is opened, a spring automatically pulls the mirror out of the path between lens and film. Because of the prism, the image recorded on the film is almost exactly that which the camera lens “sees,” without any parallax effects.

Most SLRs are precision instruments equipped with focal-plane shutters. Many have automatic exposure-control features and built-in light meters. Most modern SLRs have electronically triggered shutters. Apertures, too, may be electronically actuated or they may be adjusted manually. Increasingly, camera manufacturers produce SLRs with automatic focusing, an innovation originally reserved for amateur cameras. Minolta's Maxxum series, Canon's EOS series, and Nikon's advanced professional camera, the F-4, all have autofocus capability and are completely electronic. Central processing units (CPUs) control the electronic functions in these cameras . Minolta's Maxxum 7000i has software “cards” that, when inserted in a slot on the side of the camera, expand the camera's capabilities .

Autofocus cameras use electronics and a CPU to sample automatically the distance between camera and subject and to determine the optimum exposure level. Most autofocus cameras bounce either an infrared light beam or ultrasonic (sonar) waves off the subject to determine distance and set the focus. Some cameras, including Canon's EOS and Nikon's SLRs, use passive autofocus systems. Instead of emitting waves or beams, these cameras automatically adjust the focus of the lens until sensors detect the area of maximum contrast in a rectangular target at the center of the focusing screen.

*Design Comparisons*

Of the three most widely used designs, the SLR is the most popular among both professionals and amateurs. Its greatest advantage is that the image seen through the viewfinder is virtually identical with that on which the lens is focused. In addition, the SLR is generally easy and fast to operate and comes with a greater variety of interchangeable lenses and accessories than the other two camera types.

The rangefinder camera, previously used by photojournalists because of its compact size and ease of operation (compared with the big, slow 4-by-5 inch press cameras used by an earlier generation) has largely been replaced by the SLR. Rangefinder cameras, however, have a simpler optical system with fewer moving parts and are thus inherently more sturdy than SLRs, in addition to being quieter and weighing less. For these reasons, some photographers, mainly professionals, continue to use them.

Compared with the other two designs, TLRs have a relatively slow focusing system. As with rangefinder cameras, fewer interchangeable lenses are available, yet the TLR remains popular. The camera produces larger negatives than most SLRs and rangefinders, an advantage when fine detail must be rendered in the final image. In recognition of this, some manufacturers—including Hasselblad, Mamiya, Bronica, and Rollei—have combined the convenience of the SLR with the medium-film format, further reducing the market for the TLR.

Some cameras are designed primarily for amateurs: They are simple to operate, and they produce photographs acceptable to the average snapshot photographer. Many “point-and-shoot” amateur cameras now employ sophisticated technology, with features such as autofocus and exposure-control systems that simplify the process of taking pictures and almost guarantee good-quality photos.