KODACHROME Film Celebrates Its Golden Anniversary

In the spring of 1935, the world was introduced to the first commercially and critically successful color photographic film—KODACHROME Film by Kodak. Critically acclaimed then for its sharpness and lack of graininess, it is still the most popular amateur and professional color slide film.

We know that this film has touched the lives of most, if not all, readers of *TECH BITS* in some way. To our younger readers, it has always been around for picture-taking—of family members, for documenting trips, and for use in the workplace. To better appreciate what this film has meant to most of us, we can reflect on what it would be like without color films and c photographs—like not having color television, or no television at all. Thus it seems appropriate to share with you some of the rather interesting highlights of its development by a couple of musicians, to examine some of the product changes KODACHROME Film has undergone since its inception, and to mention a few spin-off products that were introduced by Kodak as a result of the technology acquired during the development of KODACHROME Film.

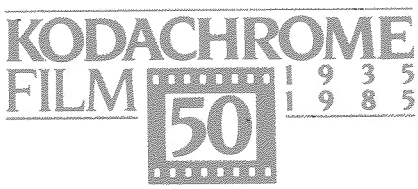
It's Really Not a Color Film!

As KODACHROME Film leaves the factory, it is a simple black-and-white film. Well, not so simple, perhaps. And, yes, it does have a yellow filter l consisting of colloidal silver. The accompanying diagram shows the basic *emulsion* configuration of our 50-year celebrant, the layer orientation of which has not changed since its introduction. Each of the three emulsion layers shown in the "Before Processing" half of the diagram is a black-and-white emulsion. Note that the red- and green-sensitive emulsion layers also retain their inherent sensitivity to blue light. (The clear gelatin layer between the middle and bottom emulsions was eliminated in 1938 when improvements no longer required such separation.) The yellow filter layer prevents any blue-light incident on the film from being transmitted to the two lower emulsions.

After processing, response of the blue-sensitive layer is revealed by a blue-absorbing yellow dye; green-absorbing magenta dye is formed in the middle layer; and a red-absorbing cyan dye is formed in the bottom layer. Having served its usefulness during exposure, the yellow filter layer is rendered colorless.

Stated simply, here's what really happens: During processing of the film, the *exposed* silver halide in each layer is developed to yield a black-and-white negative image of metallic silver. In turn, the *unexposed* silver halide in each layer is exposed or chemically fogged. As part of this reexposure step, hard, crystalline, and chemically "tough" dyes are deposited around the silver halide grains in each layer, one layer at a time. These dyes are the complementary colors: yellow (red + green), magenta (blue + red), and cyan (blue + green). Since all of the developed silver still remains in each layer, including the blue-absorbing yellow filter layer, the silver is removed by a bleaching step. The resulting positive image now consists of dyed layers only and is ready for viewing by transmitted light. The black antihalation layer coated on the base side of the film also is removed during processing.

To offset the above oversimplification of what KODACHROME Film is, let the record show that this film is, indeed, a complex product and an everyday challenge to those who labor diligently to produce and process it.



Processing still requires very careful monitoring, even though processing time now takes only 36 minutes instead of the 3½ hours of 50 years ago. For this reason, processing continues to be done by Kodak or independent photofinishers.

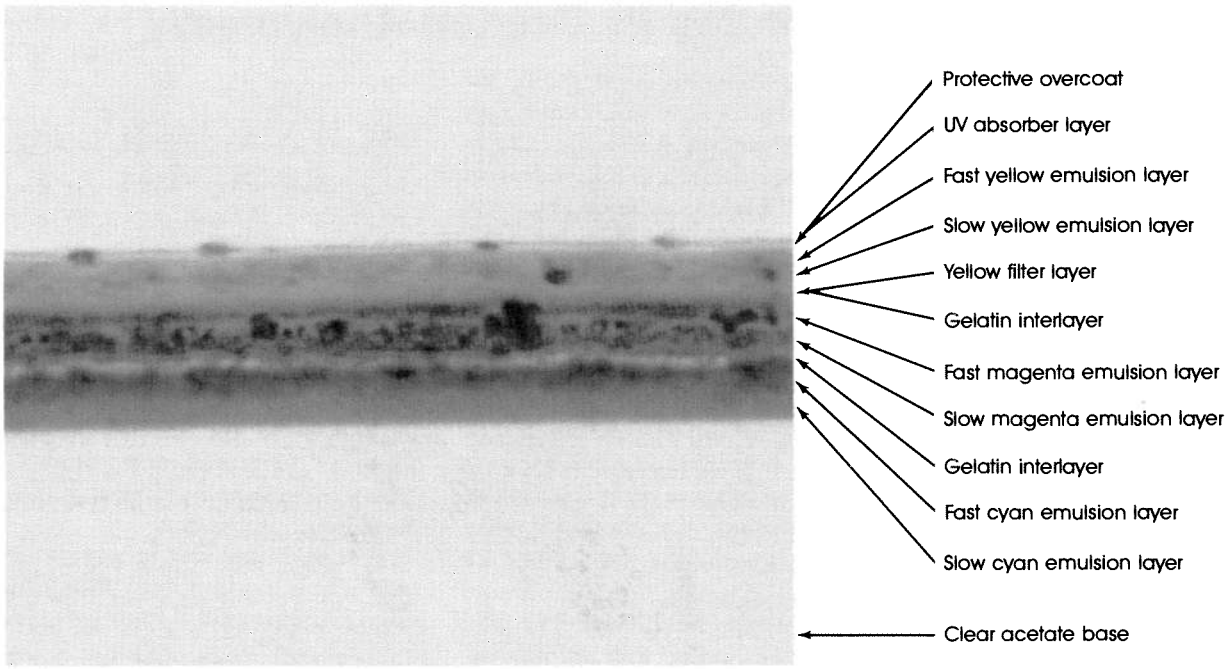
One need only look at a cross section of present-day KODACHROME 64 Film to appreciate its complexity. The original five layers, then four layers, now are 10 in number, plus a protective overcoat. The interlayers serve to protect even better the integrity and performance characteristics of the emulsion layers. Also impressive is the fact that the total thickness of the 10 layers is about 12 micrometres (about the length of four E. coli bacteria layed end to end).

Serendipity It Wasn't

"The faculty of happening upon fortunate discoveries when not in search of them" is one definition of serendipity. Some fortunate discoveries may have happened along the investigative path leading to that day in April 1935, when KODACHROME Film made its debut. If so, they may have shortened only slightly the timeline that is traceable to some 200 years before.

Diagram of Early KODACHROME Film

BEFORE PROCESSING	AFTER PROCESSING
Emulsion Sensitive to blue light	Blue absorbing (yellow) dye
Yellow filter layer	Clear
Emulsion sensitive to green (and blue) light	Green absorbing (magenta) dye
Clear gelatin layer	Clear
Emulsion sensitive to red (and blue) light	Red absorbing (cyan) dye
Transparent Base	
Dyed antihalation layer	Clear



KODACHROME 64 Film (Daylight)—A 2500 X cross section of exposed and processed modern-day KODACHROME Film. Combined thickness of the layers is about 12 micrometres.

Serious photographic history buffs will recount that the first clear record of the formation of a black-and-white image goes back to 1727. A German physician, J. H. Schulze, was experimenting on the treatment of chalk with nitric acid in which he had previously dissolved some silver. Upon exposure to sunlight the mixture turned black. By wrapping stencils around the bottle of the white mixture, he was able to produce images.

Even prior to this, a *camera obscura* was used to image a scene on a translucent screen in much the same manner as a simple, modern-day camera. The resulting image was used as a guide for making drawings of natural scenes and even portraits. The latter were often simple silhouettes cut from black paper.

Photographic history duly records a number of other significant milestones. While some early experimenters may have dreamed of making color images, their energies were devoted to making black-and-white images, and a slow process it was. Most of us remember from our American history books documentation of the Civil War of 1861-1865. Photographer Matthew Brady made his photographs on glass plates that were coated with wet-sensitized "emulsion" just prior to exposure. His darkroom was a tent set up close to the action.

While the development of black-and-white photographic materials progressed, serious thinking about color processes had begun. In 1861, J. Clerk Maxwell demonstrated that all colors may be matched by mixing in various proportions light of the three primary colors—a pure red, a pure green, and a pure blue. Using colored solutions as filters, he photographed a scene on three glass plates. From these negatives he made positive plates. With three lanterns for illumination, the positive images were projected on a screen through the same filter solutions used to make the original negatives. By overlapping the projected beams he was able to combine colors in this first demonstration of the additive method of producing color images.

Another milestone was the introduction of the first Kodak camera in 1888, eight years after George Eastman founded Eastman Kodak Company.

In 1913 Kodak produced the first panchromatic emulsion with sufficient sensitivity to red, green, and blue light to make an early version of an additive 35 mm color motion-picture film.

The Quest for Color Prints

Then, as now, people wanted color pictures to hold in their hands or hang on the wall. The idea of a "subtractive" color process attracted interest and was pursued vigorously. If negatives were made in the manner of Maxwell's demonstration and printed onto paper using dyes complementary to the color of the filters used in making the negatives, a color print would result. This is the way pl i-thographers still make the color illustrations we find in books, magazines, and other printed matter.

If only there was a way to combine the three emulsions needed to record separately the red, green, and blue components of light reflected from a scene and then to generate the required complementary colors—cyan, magenta and yellow...

Enter the Musicians

Leopold D. Mannes and Leo Godowsky, Jr. (see separate article in this issue), both accomplished professional musicians, had been experimenting with multiple emulsion-layer films in their spare time as a means of making

a color film. In 1922 their work became known to the director of the Kodak Research Laboratories, Dr. C. E. K. Mees, and Kodak founder George Eastman, who provided assistance in a variety of ways. Between the time they joined the staff of the Research Laboratories in 1930 and 1935, they enjoyed every available resource to further their work.

These newly found colleagues worked to improve existing emulsions and to coat them in the very thin uniform multilayers that were needed; others made and tested many new dyes. But Mannes and Godowsky concentrated their efforts on perfecting the processing techniques that would prove to be the key to success in making KODACHROME Film.

The first format for KODACHROME Film was 16 mm, but more products soon were added to the line, as were nonsensitized support items. A number of these products have been listed chronologically on the following page.

A Surge in Visual Communication

Two events that impacted most on the scientific community, and specifically the biomedical photographer, were the introduction of the 2 x 2-inch READY-MOUNTS and the slide projector.

When KODACHROME Film was introduced, acetate film already had replaced highly inflammable nitrate base for black-and-white motion-picture films. The propitious availability of this new color film on safety base simplified equipment and techniques for making and using visual aids in communicating information in the natural and health sciences. With the soon-to-follow 35mm KODACHROME Film, slide mounts to hold them, and a convenient means for projecting 2 x 2-inch slides, a surge in color visual communications began.

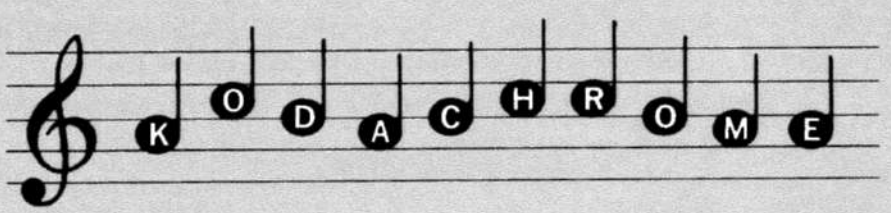
Color film provided a new means for visualizing subtle color variations in biomedical studies, and for the first time photomicrographers had an effective way to record in natural color that which previously could be viewed only through the microscope.

Lecturers Lives Made Easier

Quite apart from its value as a recording medium, KODACHROME Film in still format (135 or 828 size) was also popular for a prosaic reason rather than a technical one. To quote H. Lou Gibson, R.B.P., F.B.P.A., editor and consultant, "Back in those days I often set out on a lecture trip with $3\frac{1}{4}$ x 4-inch glass slides in two wooden boxes—combined weight, 126 pounds. Thanks to the invention of the READY-MOUNTS, such loads became unnecessary. The weight of my same two lectures, duped and loaded into one KODAK CAROUSEL Slide Tray, was reduced to just 21 ounces. Need more be said!"

Today, of course, most technical societies stipulate that the standard equipment for still projection for platform presentations is a projector for 135-size slides.

They Whistled While They Worked



Leopold Godowsky, Jr. (left in photo) and Leopold Mannes were 16-year-old schoolboy musicians in 1916 when they began their quest for a better way to make color pictures—prompted, we're told, by having viewed an oddly colored, short motion picture titled "Our Navy." Initially encouraged by their high-school physics instructor, they continued their photographic experiments while becoming accomplished professional musicians.

Mannes was the son of David Mannes, head of the Mannes School of Music in New York. His uncle was Walter Damrosch, one-time conductor of the New York Symphony Orchestra. Godowsky's father was a noted pianist, composer, and conductor, and his brother-in-law was the famous composer George Gershwin.

"Those musicians," as they came to be known after joining the staff of the Kodak Research Laboratories in 1930, reportedly whistled classical music to time the development of their plates in the requisite "total darkness." In 1973, popular musician Paul Simon recorded his song "KODACHROME," which quickly rose to the top of the music charts where it remained for weeks. In his song, Simon proclaims that KODACHROME Film "makes you think all the world's a sunny day." Thus a popular song praised the popular product conceived by two talented musicians nearly 40 years earlier.

KODACHROME Film 1935-1985
A Colorful Chronology

Year	Event
1935	16 mm film, daylight type
1936	16 mm film, Type A, for photoflood lights
	8 mm film, daylight and Type A
	Still films, daylight and Type A (135 and 828 sizes)
1937	KODASLIDE Projector for showing 2 x 2-inch glass slides; also metal frames for mounting glass slides
1938	Professional sheet films, daylight and Type B
	Duplicating film for 16 mm originals
1939	KODASLIDE Projector, Model 2, for small group/home use
	KODAK READY-MOUNTS (customer 2 x 2-inch slides returned mounted)
	Illuminator for viewing professional color sheet films
	Color temperature meter for evaluating incident light
	Seven color compensating filters for correcting color temperature of studio lighting
	How-to pamphlet for professional film users
1941	Opaque-base direct-positive print films for making prints from slide and sheet film transparencies
1955	KODACHROME Films sold in U.S. without cost of processing included
	Papers and chemicals sold for making color prints from slides
	Arrangements began for processing KODACHROME Film by processing laboratories other than KODAK
1958	CAVALCADE Projector, Model 500, for manual/automatic advance of slides
1961	KODACHROME II Film (improved color rendition, less graininess, 2½ times' former speeds) began to replace KODACHROME Films in all formats
	KODAK CAROUSEL Projector introduced revolutionary tray storage/automatic projection of slides
1962	KODACHROME-X Film, with 2½ times' speed increase, offered as alternative to KODACHROME II Film; also available in new 126 size for amateur cameras
1965	Improved Type A in super 8 size, with drop-in-load feature for super 8 cameras
1972	KODACHROME-X Film made available in new 110-size cartridges, along with 30 mm square mounts (adaptable to 2 x 2-size mounts) and CAROUSEL Pocket Projector for viewing
1974	KODACHROME 25 Films replaced KODACHROME II Films (both daylight)
	KODACHROME 64 Film (Daylight) replaced KODACHROME-X Film with improved sharpness and graininess characteristics
	KODACHROME 40 Films (Type A) replaced and improved upon KODACHROME II Films (Type A) in 8 mm, 16 mm, and super 8
1983	KODACHROME 25 and 64 Professional Films announced with special features for those who "work the way professional photographers work"
1985	50th Anniversary Celebration of KODACHROME Film

NOTE: It would be remiss not to mention the introduction in 1942 of KODACOLOR Film, which incorporated the color couplers in the emulsion layers; also the introduction of EKTACHROME Films in 1946 and 1947, which were the first color films that could be processed by the user. The technologies that made these films possible evolved from the work done to launch KODACHROME Film some years earlier and, as with KODACHROME Film, each of these films has been improved over the years.