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8 Electronic Cameras

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Measure Up? Page 140

Low-Cost Printers

Image Quality and
Speed Tested



Photography w i t h o u t

Film

These days, many photographs captured on film end up as computer images—so why shouldn't they start out that way, too?

That's the question many professional photographers, publishers, and illustrators are asking themselves, now that electronic cameras are becoming more affordable. Although electronic cameras have been around for years, Apple Computer's recently released QuickTake 100 is widely considered to be the first to offer both ease of use and good color-image quality for less than \$1000.

Electronic cameras combine photographic optics with computer imaging—

MACWORLD EVALUATES DIGITAL AND STILL-VIDEO CAMERAS

and do away with film expenses, caustic chemicals, and processing delays. For economy-minded amateurs and deadline-driven professionals—and for anyone who wants to include images in computer-generated documents—a filmless camera seems like a dream come true.

To find out how well electronic cameras deliver on their promises, I spent two months working with seven models (all under \$10,000): Apple's QuickTake 100, Canon USA's RC-570, Dycam's Dycam Model 3, Eastman Kodak's DCS 200, Fuji Photo Film's Fujix DS-100, Logitech's FotoMan Plus (which is identical to the Dycam Model 3 except for the software that comes with it), and Sony Electronics' MVC-7000. I also tested a preproduction unit of Leaf Systems' Lumina

digital camera/three-pass scanner (see "Leaf's Lumina: Something Completely Different"). At press time, Kodak announced it was replacing the DCS 200 with the DCS 420, a similar but upgraded version of the digital camera. See "Kodak's Latest Digital Camera," *Graphics* news, for more information.

For my tests, I photographed a variety of indoor and outdoor scenes to assess each camera's image quality and ease of use, and I put the image-transfer hardware and software most cameras provide through their paces. In addition, *Macworld* asked San Francisco-based professional photographer Stan Musilek to use the cameras in his studio and offer his impressions (see "Comparing Image Quality").

The verdict? There's room for improvement in both cost and image quality. For example, the most exciting new offering, the QuickTake 100 (\$749), costs much more than a 35mm single-lens reflex (SLR) camera that accepts inter-

How Digital and Film Cameras Compare

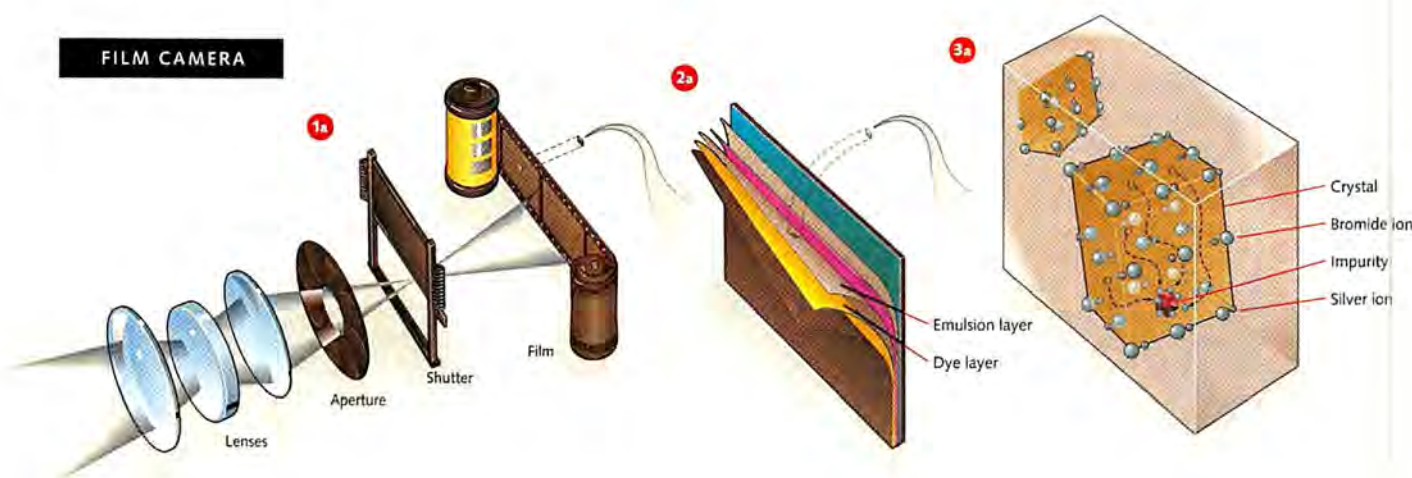
Digital cameras bring photography into the computer age, yet they operate on the same basic principles as traditional cameras. Some key differences make digital cameras better suited for electronic publishing. Below, we show the two image-capture methods at the moment light enters the camera.

The medium is the difference
The two cameras use very different media to capture an image. In a traditional camera the medium is **film**; in a digital camera it's a **charge-coupled device (CCD)**.

2a) Film is made of multiple layers: outside protective layers and inner **emulsion layers**. (The emulsion is a gelatin filled with light-sensitive crystals.) Color film pairs three emulsion layers—each sensitive to one of the primary colors (cyan, magenta, or yellow)—with three **dye layers**, which color the emulsion. The image forms on the emulsion layer.

Most of the parts are the same

1a and 1b) Because both cameras are based on the same principles, they share many of the same components: **lenses** focus incoming light; an **aperture** controls the amount of light entering the camera; a **shutter** controls the length of time that light comes through the aperture; and a photo-sensitive medium captures an image. But the similarities end here.



changeable lenses, yet the QuickTake is a snapshot-grade camera with a fixed-focus, plastic lens. (If you own a Power Mac, you'll need to get the latest version of Apple's QuickTake Software; otherwise, the camera won't work with your computer. See this month's "Bugs and Turkeys" in *News* for more information.)

As a result, the most compelling arguments for today's electronic cameras aren't centered around image quality but around deadlines and convenience. With a filmless camera, you can see an image moments, sometimes seconds, after you take it. And an electronic camera eliminates the multistep process of taking a photo, having it developed, then scanning the film and tweaking the image on screen to obtain a high-quality digital version.

Behind the Lens

Shopping for an electronic camera means considering the conventional camera issues—lens quality and characteristics, exposure controls, size, and weight—as well as factors unique to the electronic models: imaging method, the way images

are stored, and the way you transfer them to the Mac.

Electronic cameras share a common characteristic with video cameras and scanners: they contain a *charge-coupled device* (CCD), a chip containing photo-sensitive cells that generates voltage when struck by light (see "How Digital and Film Cameras Compare").

The field of filmless cameras is divided into two main camps: still-video and digital. A still-video camera is like a camcorder without a tape drive: it generates an analog video signal that you can display on a TV monitor, record with a video recorder, or capture with an AV Mac or a video-capture card in a standard Mac. The still-video cameras I tested include Sony's MVC-7000 (\$8000) and Canon's RC-570 (\$4688). Both cameras provide a composite-video-input jack. The Sony also accepts an optional S-video adapter, while the Canon RC-570 includes an S-Video-input port. (S-Video generally provides a sharper image.)

Still-video cameras have some inherent limitations. These cameras use CCDs

designed to capture a full frame in two passes, grabbing first the even-numbered scan lines and then the odd-numbered ones. To accommodate this *interlacing*, a still-video camera's CCD has smaller light-sensitive cells than the *full-frame* CCDs used by most digital cameras. To compensate, a still-video camera has to do more manipulation of the CCD's data, making images more prone to undesirable artifacts: fuzzy fringes surrounding the objects in a high-contrast scene, or vibrant colors that bleed slightly into surrounding areas (see "Comparing Image Quality").

A digital camera's CCD and its support circuitry are designed from the ground up to deliver a digital result. Because the CCD doesn't require the additional elements needed for interlacing, its light-sensitive cells can be larger and closer together.

Another factor behind image quality is the CCD's size. Each of the CCD's photosensitive cells corresponds to a single pixel in the final image; the more cells the CCD provides, the higher the poten-

2b) A CCD is a multilayered silicon chip. In one layer, a grid of **electrodes** divides the surface into pixels. Each electrode is connected to **leads**, which carry a voltage. A **color filter layer** determines which primary color (in this case red, green, or blue) each pixel senses. The image forms on a layer of **silicon substrate**.

Image resolution in film is determined at the crystal level and is very high. Film can respond to a broader range of lighting conditions than a CCD, but it must be developed after exposure. Scanning adds yet another step for

electronic publishers. In a CCD, image resolution is determined at the pixel level and is much lower than in film, but images captured by a CCD are immediately ready for use in electronic publishing.

What happens when light strikes

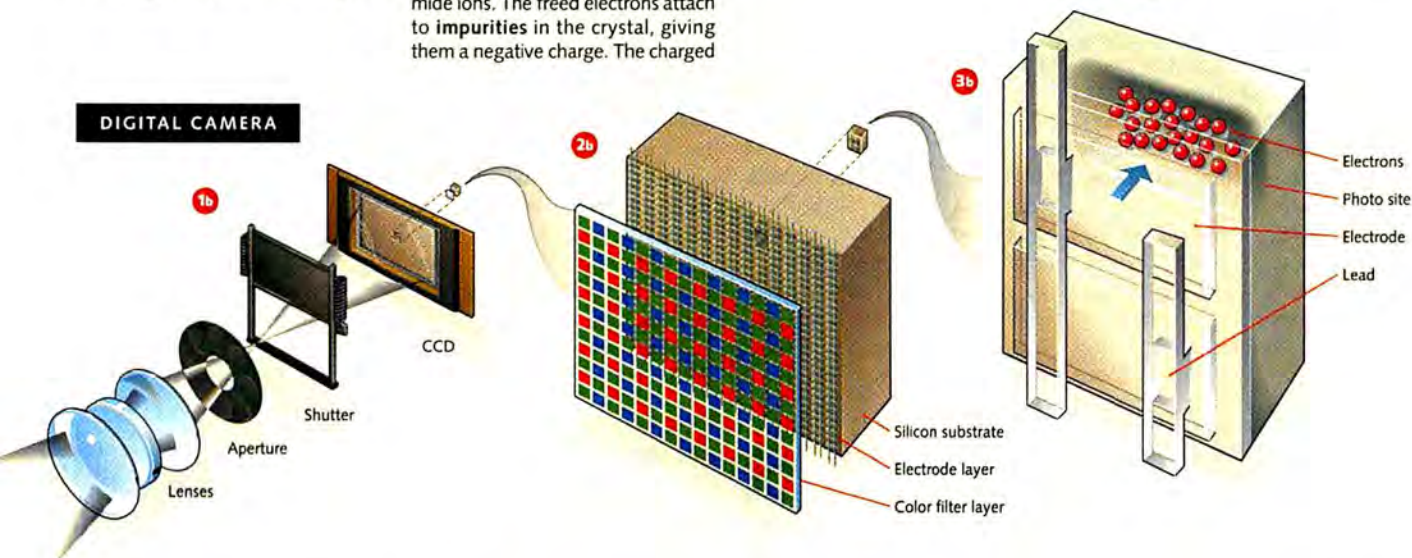
The medium's job is to record the various levels of light in the scene being photographed.

3a) Film reacts to light chemically. The crystals in the emulsion contain **silver** and **bromide ions**. When light particles strike a **crystal**, they free electrons (not shown) from the bromide ions. The freed electrons attach to **impurities** in the crystal, giving them a negative charge. The charged

impurities attract submicroscopic clusters of positively charged silver ions. The stronger the light, the bigger the cluster. In exposed film these differences are too subtle to see. The development process (not shown) exaggerates the differences by enlarging the clusters, which determine how light or dark each point of the image becomes.

3b) A CCD reacts to light electro-magnetically. Light particles pass through the CCD, freeing **electrons** in the silicon substrate. A voltage ap-

plied to the electrodes draws freed electrons together in special areas (called **photo sites**) in the silicon substrate. The stronger the light, the greater the number of electrons drawn together at that site. The CCD transfers captured electrons, one by one, to an analog-to-digital converter, which assigns each site a digital value corresponding to the number of electrons the site holds. In this form the image is saved to disk and is ready for use in electronic publishing. The number of electrons in a photo site determines how light or dark each pixel in the image is.



tial resolution of its image—and the larger you can scale the image without distortion. For example, Logitech's Foto-Man Plus, a low-end, black-and-white digital camera, uses a 178,560-pixel CCD, while the CCD in Kodak's DCS 200 has over 1.5 million pixels. As impressive as that sounds, consider that fine-grain 35mm slide film has an estimated resolution equivalent to 20 million pixels.

Storing Images

A lowly roll of film can store more images than almost any filmless camera. Digital images devour storage space, and to hold them, filmless cameras use either battery-powered memory chips or small floppy or even hard disks.

Of the cameras tested, three store images in internal memory (called EPROM—Erasable Programmable Read Only Memory): the QuickTake 100, the Dycam Model 3, and Logitech's Foto-Man Plus. The Fujix DS-100 uses slide-in memory cards, each about the size of a business card and powered by a coin-size lithium battery.

LEAF'S LUMINA: SOMETHING COMPLETELY DIFFERENT

Leam Systems' \$7500 Lumina takes a unique approach to providing higher resolution and better image quality than any under-\$10,000 digital camera provides. The Lumina uses a 2700-cell array that moves across the imaging field in 3400 steps to yield resolution equivalent to a 9,180,000-pixel CCD. A complete exposure takes roughly three minutes.

The Lumina connects to the Mac's SCSI port and provides no internal image memory—the camera must always be tethered to a Mac. The Lumina accepts

standard Nikon-mount lenses and has through-the-lens viewing, but the viewfinder objects appear upside-down, which makes it awkward to set up a shoot. An included Adobe Photoshop plug-in lets you adjust color balance and exposure and activate the scanning process.

You can use a Lumina on a copy stand as a substitute for a scanner; put a small light box on the copy stand's base and you can scan transparencies and negatives. But compared with scanners, the Lumina has some drawbacks. Light-

ing flat artwork to avoid glare and uneven illumination requires trial and error. Also, you must be careful to mount the Lumina so that its CCD's focal plane is exactly parallel to your copy stand's base; otherwise, you'll introduce distortion.

The Lumina seems best suited to photographers who want to generate high-quality images in the studio and may also want to do some scanning. It isn't perfect, but it is the least-expensive tool available for getting professional-quality digital results in the studio.

Comparing Image Quality

Images 1 through 8 represent raw Linotronic output—no retouching, no color correction—from the electronic files generated by each of the cameras

reviewed. San Francisco-based photographer Stan Musilek tested each camera using its highest image-quality level under the same studio conditions: flashes off; continuous, flicker-free studio lighting to simulate daylight; cameras positioned roughly 4 feet from the still life; f11 aperture (or as close as possible); 1/4-second exposure.

Musilek's comments on the printed images and his experiences using the cameras are encapsulated in the following captions. The image's original file size (before resizing) is also listed.

Image 9, taken with the QuickTake 100, was manipulated in Adobe Photoshop by Jeff Sacilotto, *Macworld's* editorial production manager. His goal was to approximate the quality of the 4-by-5 film transparency (image number 10). Sacilotto was able to correct the QuickTake image's color so that it more closely resembled the original image. But Photoshop's Sharpen filter couldn't enhance the QuickTake photo's image detail to the same level as the transparency.

1. Apple QuickTake 100 Although the files it generates are only about 900K, the photos looked "great" on screen and printed well, too, Musilek said. The output image "was a little dark, but that's easy to fix in Photoshop." File size: 900K.

2. Canon RC-570 When viewed on screen, the Canon still-video images weren't as good as those from the QuickTake, and

the contrast of the printed image "was too far off." File size: 849K.

3. Dycam Model 3 Musilek had difficulty turning off the camera's flash. "We had to tape over it; there was no other way to turn it off," he said. The final image "didn't look much better than a photocopy." File size: 531K.

4. Eastman Kodak DCS 200 The image needs some color correction, but the large files generated by the DCS 200 give the user "plenty of color information to work with." File size: 4.41MB.

5. Fujix DS-100 Musilek and his staff "had problems with the Fujix's focus. We used its autofocus, but the images looked soft, so we reshot it using manual focus, and it still didn't come out that sharp." The resulting image "could be sharpened" in Photoshop, "but it wouldn't really be worth it." File size: 915K.

6. Leaf Lumina The Leaf captures images just as a scanner

does, in three passes; as a result, "it took 14 minutes to get one exposure." The final image "needs a little color correction—it's a bit too green—but otherwise it's very sharp and detailed." (Tests were performed on a pre-production model.) File size: 20.5MB.

7. Logitech FotoMan Plus The Logitech and Dycam cameras produce images that are "OK" if reproduced in real-estate fliers or as small images in newsletters. But the QuickTake costs about the same and produces good color images, Musilek noted. File size: 175K.

8. Sony MVC-7000 "I'm surprised at how well it printed, given the file's low resolution. I'd lower the contrast a bit in Photoshop, but that's about it." For images that will "live on screen," in multimedia CD-ROMs or presentations, the Sony is "the best camera." File size: 865K.



1. Apple QuickTake 100



2. Canon RC-570



3. Dycam Model 3



4. Eastman Kodak DCS 200

One drawback to storing images in memory is the need to transfer them to the Mac when you reach the camera's capacity; once the memory is full, you can't take more photos until you free up some storage space. (This doesn't apply to the Fujix DS-100; when its memory card is full, eject it and insert another.)

The Apple and Fuji cameras provide multiple image-size options. The QuickTake 100, for example, holds either 8 photos at 640 by 480 pixels or 32 photos

at 320 by 240 pixels. The Fujix DS-100 lets you delete individual images to free up memory for new ones. With the Apple, Dycam, and Logitech cameras, you have to delete all the images to free up memory.

To reduce storage requirements, the Dycam, Logitech, and Apple cameras compress one image as soon as you take it. The Logitech and Dycam models require roughly ten seconds to compress one image and become ready to take another.

The QuickTake 100 is ready much faster—generally within a few seconds (the exact time depends on the image). By comparison, the Fujix DS-100 and Canon RC-570 offer continuous-photo modes in which you can capture two images per second.

The Sony and Canon cameras store images on 2-inch floppies that hold up to 25 or 50 images, depending on whether you shoot in *frame* or *field* modes. Frame mode provides better image quality by



5. Fujix DS-100



6. Leaf Lumina



7. Logitech FotoMan Plus



8. Sony MVC-7000



9. QuickTake 100, enhanced in Adobe Photoshop



10. Original 4-by-5 transparency

Focus on Electronic Cameras

Company	Product	Company's Suggested Price	Lens Type	Minimum Focus Distance/ f-Stop Range	Shutter Speed Range (in seconds)	Effective ISO Rating	Built-in Flash/ Recycle Time (in seconds)
DIGITAL							
Apple Computer	QuickTake 100	\$749	fixed focus; not interchangeable	4"/f2.8-f16	1/30-1/125	85	yes/7
Dycam	Dycam Model 3	\$695*	fixed focus; not interchangeable ^c	3"/f4.5	2 1/2-1/2000	200	yes/7
Eastman Kodak	DCS 200 ^b	\$9995	autofocus or manual focus; interchangeable	3"/f2.2-f22	4-1/3000	50-400	no/NA
Fuji Photo Film	Fujix DS-100	\$3200	autofocus; zoom	1.18"/f2-f11	1/4-1/750	100	yes/3
Leaf Systems	Lumina	\$7500	manual focus; interchangeable	NA ^f	NA	NA	no/NA
Logitech	FotoMan Plus	\$799	fixed focus; not interchangeable ^c	3"/f4.5	2 1/2-1/2000	200	yes/7
STILL-VIDEO							
Canon USA	RC-570	\$4688	autofocus; zoom; not interchangeable ^c	1.8"/f2.5-f2.7	1/30-1/500	70-140	yes/0.3
Sony Electronics	MVC-7000	\$8000	manual focus; zoom; interchangeable	1"/f1.8-f22	1/4-1/2000	100-800	no/NA

NA = not applicable. * The smallest number represents the maximum number of high-resolution images the camera can capture at one time. ^b The Dycam Model 4, a 24-bit color digital camera (\$795), snap-on wide-angle or telephoto adapters. ^c Recently replaced by the DCS 420. ^f Lens not included.

combining two interlaced fields from the CCD, but uses twice the disk space in the camera. You can mix image modes on a single floppy and delete individual images. And when a floppy fills, you can eject it and insert a new one.

The Kodak DCS 200 is the only camera tested that accepts an optional internal hard drive and connects to an external SCSI drive. The model I evaluated had an 80MB hard drive capable of storing up to 50 images. (The new DCS 420 uses PCMCIA storage instead.)

The primary drawback of storing images on floppy or hard drives is that the drives can fail from too much physical abuse. Disk drives also require more power than memory chips, and this means less time between battery charges if you frequently insert and eject disks or review your pictures.

From Camera to Mac

So how do you get images from the camera into the Mac—and how long does the transfer take? Depends on the camera. All of the cameras tested, except the Sony MVC-7000, include or accept cables and image-transfer utilities; the MVC-7000 relies on a video-input jack.

All the image-transfer utilities work similarly: a window displays thumbnail versions of the stored images; double-clicking on a thumbnail downloads the image. Some utilities have image-enhancement features such as brightness and contrast adjustments, but you'll want a program such as Adobe Photoshop for serious image editing.

For transferring images, the Canon RC-570 uses a NuBus board whose cable attaches to a connector in the camera's battery chamber. That the board requires a NuBus-equipped Mac means you can't transfer images to a PowerBook when you're on the road. On the plus side,

Canon's transfer utility is the best of the bunch, offering features that let you add antialiased (smooth-edged) text to images, resize images, and even save a sequence of images as a QuickTime movie—a capability that lets you use the camera to make time-lapse movies.

Fuji sells a \$2000 interface for the Fujix DS-100 that provides a front-panel slot for the camera's memory card. The size of a large hardcover dictionary, the DP-100 Memory Card Processor connects to the Mac's SCSI port, a scheme that yields faster image transfers than the serial connections used by most other cameras. The DP-100 includes a transfer utility as well as an Adobe Photoshop plug-in module that lets you import images using Photoshop's Acquire command. (Kodak's DCS 200 also includes a Photoshop Acquire plug-in, as does Canon's SV-Mac interface board.) The DP-100 also sports output jacks for RGB, composite, and S-Video.

The DS-100 and RC-570 also provide video-out jacks (composite and S-Video for the DS-100, composite for the RC-570). You can connect either camera to a VCR, TV monitor, or any Mac equipped with video-input hardware. Buttons on both cameras let you review your shots. Numerous TV manufacturers sell tiny, battery-powered color video monitors; often used with camcorders, they make perfect preview devices for a filmless camera with a video-out jack.

If your images will wind up in a multimedia production or an on-screen presentation instead of being printed, you can use a video-out port instead of an image-transfer utility to move images to the Mac: just capture the image with your frame-grabber software. (With an AV Mac, for instance, use the Video Monitor application.) This is faster than using a transfer utility, but the video image's res-

olution is only 72 dpi—usually too low for printing.

Sony doesn't offer a transfer utility or Mac interface for the otherwise excellent MVC-7000—its video-out jack is the only way to move images to the Mac. The camera is superb, however, for images that will be viewed on a monitor, and it also has the unique capability of being able to work as a video camera. Connect the MVC-7000 to a videocassette recorder and record full-motion video. Connect it to a TV monitor and you have a closed-circuit TV system. Attach it to an AV Mac or a frame grabber and you can digitize live video. Its live-video capabilities make the MVC-7000 very appealing for QuickTime and video work.

The Camera Angle

Enough of CCDs, transfer utilities, and video jacks—how do these things stack up as cameras? The low-end and midrange units compare to typical auto-everything 35mm cameras, providing built-in flash units and using noninterchangeable lenses. The Dycam and Logitech cameras are the simplest, each sporting just one button: the shutter release. The remaining cameras in this category provide additional controls for disabling the automatic flash, activating self-timer mode, and choosing an image-quality mode. The settings of these functions appear on a small display screen, which also displays low-battery warnings and other messages.

Canon's RC-570, Fuji's DS-100, and Sony's MVC-7000 provide zoom lenses; the rest provide fixed-focal-length lenses that are roughly equivalent to a normal or slightly wide-angle lens on a 35mm camera. The Fujix DS-100 is the only midrange camera tested that provides through-the-lens viewing—you see exactly what the CCD will record. The remaining low-end and midrange cameras

Storage Method/ Image Capacity ^a	Macintosh Interface Method	Phone	Toll-Free Phone
internal memory/8 or 32	modem or printer port	408/996-1010	800/767-2775
internal memory/32	modem or printer port	818/998-8008	none
internal hard drive/50	SCSI port	716/724-4000	800/242-2424, ext. 77
memory cards/21	video input or SCSI memory card reader	914/789-8100	800/755-3854
NA	SCSI port	508/460-8300	800/685-9462
internal memory/32	modem or printer port	510/795-8500	800/231-7717
video floppy disk/25 or 50	S-Video port or SV-Mac NuBus board	516/328-5960	800/221-3333, ext. 313
video floppy disk/25 or 50	video input port; S-Video- input port optional	201/930-7796	800/222-7669

^a is expected to be available for the Macintosh in August. ^b Although its lenses are not interchangeable, this camera accepts

provide a separate viewfinder, which means at close shooting distances, you might accidentally chop off a head or miss part of the image. The viewfinders in the Canon RC-570 and Logitech/Dycam cameras provide lines that let you compensate for this parallax phenomenon; Apple's QuickTake 100 does not.

Each of the low-end and midrange cameras is compact enough to fit in a briefcase. The Apple QuickTake 100 earns extra points for using standard AA batteries. The camera includes three rechargeable NiCad batteries, but if you lose them or can't wait for a recharge, you can use standard AA alkaline cells.

Canon and Fuji use proprietary rechargeable batteries, so be sure to take some extras along for extended photo shoots. All of the cameras tested can also operate from AC power when used with their battery chargers or adapters. (The QuickTake 100 uses the same AC adapter as a PowerBook.)

The Canon RC-570 loses points for its poor battery-chamber design. It's easy to insert the battery upside down—a mistake you won't catch until you replace the removable door and try unsuccessfully to turn the camera on. The fact that the door is removable—therefore easy to lose—is another drawback, especially since you have to remove the door and set it aside when using the SV Mac digitizing board.

The Sony MVC-7000 and the Kodak DCS 200 have the same amenities found on a 35mm SLR camera. Both accept a variety of lenses designed for Nikon or Canon bayonet mounts. (The Kodak DCS 200 actually uses a Nikon 8008 body.) Both provide through-the-lens viewing, hot shoes for attaching flash units, and center-weighted or spot metering options. Unlike the other cameras, both also allow you to specify a desired ISO rating in order to control depth of

field (the distance range within which objects will be in focus).

The Sony MVC-7000 is a sumo-size camera that weighs nearly 6 pounds, including the 8mm-to-48mm zoom lens that's standard equipment. The DCS 200 is more manageable, weighing 4 pounds and sporting rounded contours that make the camera more comfortable to hold.

The Last Word

Who should consider the current crop of cameras? Low-end and midrange models are best for business and industrial applications: real-estate agents snapping houses for listing sheets and databases; insurance-claims adjusters recording dents and accident scenes; personnel departments snapping photos for ID badges; and any professional wanting a fast way to include images in documents such as reports, newsletters, and brochures.

In this league, the QuickTake 100 is the best. The Canon RC-570's image quality is inferior, but the camera's zoom lens, floppy drive, video-input jack, and the superb SV-Mac board and transfer utility make it a much more versatile system. Indeed, the ideal filmless camera would combine the RC-570's goodies with the QuickTake 100's image quality and superior industrial design.

The Fujix DS-100's image quality sits in between that of the QuickTake 100 and the Canon RC-570. The DS-100's memory cards eliminate broken floppy worries, and the camera provides a more sophisticated lens and SLR viewing. But the DS-100 is costly, especially considering you need the \$2000 DP-100 Memory Card Processor to transfer images to the Mac. Don't bother with the Dycam or Logitech models; they cost roughly the same as the QuickTake 100 but render images that are infinitely inferior.

The high-end cameras are well suited to newspaper photojournalism, law-enforcement and military-documentation applications, scientific and medical imaging, and low-budget catalog and newspaper advertising photography. Of the two high-end models evaluated (the Kodak DCS 200 and the Sony MVC-7000), the DCS 200 is better, thanks to its smaller size and lower weight, its SCSI interface and optional internal hard drive, and image quality. With new and enhanced features, such as PCMCIA storage and faster image-capture speed, the new DCS 420 should be even better. The Sony MVC-7000's video features make it a strong contender for multimedia developers, however.

Regardless of the advantages digital and still-video cameras offer, don't expect them to supplant film anytime soon. Consider the components required: a computer with good graphics capabilities and lots of storage, color-calibration software, image-enhancement software, image-database software, and a continuous-tone printer. Throw in the expertise needed to use it all, and you're likely to have a new appreciation for the simple slogan that helped George Eastman build his photographic empire: "You push the button, we do the rest." **m**

Contributing editor JIM HEID has worked as a darkroom technician. His latest books are *Macworld Complete Mac Handbook Plus Interactive CD*, third edition (1994), and the forthcoming *Macworld Word 6 Companion*, both published by IDG Books Worldwide.

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ELECTRONIC CAMERAS



For business imaging, location and prop testing, or deadline-intensive photography—the best uses for electronic cameras today—one camera stands out.

Apple QuickTake 100 A disposable camera provides better image quality, but the QuickTake 100 breaks new ground nonetheless by offering good color digital images for under \$1000. **Company:** Apple Computer. **Company's suggested price:** \$749.